Agricultural Conservation Planning Framework User Guide for Field Staff

What a Non-GIS Specialist Needs to Know

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Introduction

The purpose of this user guide is to serve as a reference for conservation practitioners working with the Agricultural Conservation Planning Framework (ACPF) and ACPF results in a watershed context. This user guide is not written for ArcGIS users, but for field staff and watershed planners who work with GIS specialists and ACPF results to implement conservation plans and practices. The user guide reviews the results from each of the ACPF toolboxes to provide an understanding of how these results are created, what goes into producing them, and to encourage conservation practitioners to understand how they may be used to inform conservation planning, broadly speaking.

The intention of this user guide is to familiarize conservation practitioners with information about what's going on behind the scenes in the ACPF toolboxes so practitioners can work with a GIS specialist running the ACPF to get the best results possible for watersheds of interest.

Throughout this guide, we use the terms "ACPF technician" to refer to the GIS specialist who is running the ACPF for a watershed. We also use the term "ACPF user" to refer to the conservation practitioner who is using the ACPF results in a watershed planning and implementation context. We recognize the official titles of these individuals will differ depending on the state, organization, or watershed, and that in some cases this is the same individual. We use these terms as a general category, as this user guide is intended for ACPF users to guide them through working with an ACPF technician in running the ACPF.

Additional information about the ACPF, including resources and case examples, is available on our website, acpf4watersheds.org.

Digital Elevation Model Preparation (Tool drawer 1)

The DEM Preparation Tool drawer is a series of tools to guide users through the steps needed to create a usable digital elevation model (DEM) product for use within ACPF. A DEM is a representation of the topographic surface of the Earth and is used in the ACPF to inform users of local elevation and where water is likely to move across the landscape. The DEM Preparation tool drawer is important to enhance the ability of the DEM to accurately represent hydrologic flow routing in a watershed.

High resolution (1-2 meter per pixel for the ACPF is suggested) LiDAR-derived elevation data provide the best representation of a land's surface, but it needs to be modified by the ACPF technician using this first tool drawer. Because LiDAR data are sensor-based, the data will likely reflect where infrastructure that could impact hydrologic flow (e.g., bridges and culverts) exist on the landscape, which means an ACPF technician needs to edit the DEM prior to running the ACPF siting tools.

The DEM Preparation Tool drawer helps the ACPF technician hydro-modify or correct the DEM to include these additional factors so that ACPF results are based on more accurate surface water flow paths. This is often the most important and time-consuming portion of the ACPF analysis because it requires the ACPF technician to iteratively review the data for infrastructure, make corrections, and review hydrology. While this is done by the ACPF technician, it is helpful for users of ACPF results to know what is being done to produce the results because it may help to identify potential mistakes. For example, if a cut adjacent to a culvert has been missed, water may not flow as a user would expect, given their knowledge of the watershed. This tool drawer requires a close working relationship with the ACPF technician to ensure good ACPF results because different technicians can make different decisions during this phase that can impact the results.

Develop Stream Network and Catchments (Tool drawer 2)

The second tool drawer – Develop Stream Network and Catchments Toolbox – is a set of tools to guide ACPF technicians through the process of delineating perennial stream networks based on the hydro-conditioned DEM made with the previous DEM Preparation Tool drawer. The tool drawer walks the ACPF technician through the process of defining stream locations, classifying them as perennial, intermittent, or ephemeral, and aligning them with larger water bodies on the corrected DEM.

One part of this tool drawer requires ACPF technicians to manually classify different stream segments in the watershed as either perennial or ephemeral (Fig. 1). The classification of stream segments as perennial or ephemeral is important because the classification impacts which conservation practices may be identified by the ACPF in various parts of the landscape. For example, some of the later tools require practices to be along a perennial stream network (e.g., riparian and saturated buffers). If no perennial stream segment is identified in a sub-catchment, no riparian practices will be sited there. Alternatively, for example, the nutrient removal wetland tool only identifies opportunities for wetlands along concentrated flowpaths – not perennial stream segments. It's important for the ACPF user, with on-the-ground knowledge of the watershed, to review the stream segment classifications and affirm their accuracy.

Figure 1. Image of an ACPF technician defining the stream network in a watershed. In this instance, the ACPF technician used the split tool to differentiate the portion of a stream that is perennial and the portion that is ephemeral. When you zoom in on the landscape you can see that the left-hand portion of the field has a ditch where the water flows, whereas the right-hand portion of the stream doesn't have a riparian corridor.

Field Characterization (Tool drawer 3)

The third toolbox is the Field Characterization Tool drawer. The third tool drawer uses inputs derived from prior steps to identify by-field characteristics associated with slope, subsurface tile drainage, and runoff risk. These by-field characteristics can inform ACPF users where there may be increased risk associated with soil and nutrient loss – and thus negative soil and water quality impacts – in agricultural watersheds. In this tool drawer, outputs are displayed field-by-field. This is valuable since conservation and land management decisions often follow field and property boundaries.

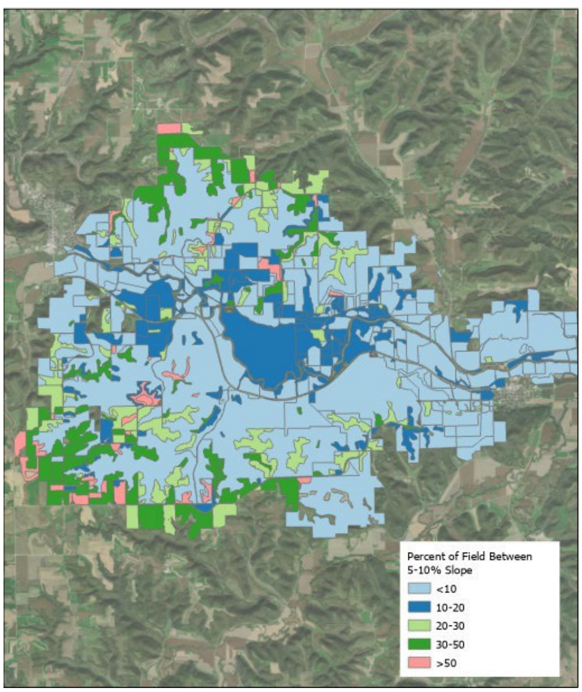
Field Characterization – Slope Assessment

The first tool in the tool drawer is the Slope Assessment Tool, which identifies the percent rise and by-field slope statistics. The ACPF technician can choose what slope values to highlight to produce maps showing the flattest fields or those with steep slopes. The ACPF user should work with the ACPF technician to inform which data may be most relevant and useful for their purpose.

The inputs required for this tool include the field boundaries and hydro-enforced DEM. The outputs generated by this tool include the slope raster, in percent rise, and by-field slope table. The slope table includes the following data for each field, which can be joined to the field boundary layer and displayed visually (Fig. 2):

- Mean and 75th percentile slope of the field
- % of field < 1% slope
- % of field 1 –2% slope
- % of field 2 –5% slope
- % of field 5 –10% slope
- % of field 10 –15% slope
- % of field > 15% slope

Figure 2. Example map displaying the by-field slope table and field boundary layer.



Field Characteristics – Tile Drainage Classification

This tool identifies fields that are likely to have subsurface drainage tile because they have poorly drained soil types and are relatively flat. The inputs for this tool include the field boundaries, soils data, and slope table. The output generated by this tool is a drainage table, where agricultural fields are classified as not likely OR likely to have tile drainage. The drainage table also includes information about the proportion of each field with various soil attributes related to drainage (e.g., hydric, dual drainage, seasonal high-water table, etc.).

The classification is based on:

1. Slope (greater than 90% of the field is less than 5% slope)
2. Soil attributes (ACPF technicians can choose one of four options):
    a. The field has a mean hydric soils percentage greater than 10%;
    b. More than 40% of the field consists of a dual drainage hydrologic group class soil; and
    c. More than 40% of the field has a seasonal high-water table (less than 50cm).
    d. Poorly drained soils occupy greater than 40% of the field

ACPF technicians can choose which soils conditions to use based on their local landscapes. Like the by-field slope table, the drainage table can be joined with the field boundary layer and displayed visually.

Field Characteristics – Runoff Risk Assessment

The Runoff Risk Assessment Tool is used to qualitatively classify a given field according to its risk of direct runoff contribution to stream channels in the watershed. The resulting outputs can be used by ACPF users to highlight which fields would most benefit from conservation practices that address runoff.

The tool uses the distance to stream raster and the slope table calculated earlier. The minimum distance to a stream is translated into a sediment delivery ratio for each field. The slope steepness of each field is the 75th percentile slope value (in percent rise). By using these two inputs, the tool creates a classification matrix that classifies each field by its runoff risk. Each field is classified as very high, high, moderate, or low risk. Unless defined by the user, thresholds for a field's ranking of slope and proximity to a stream will default to: 20% - high, 40% - medium, and 40% - low. This classification matrix is used to put each field into 1 of 4 categories from low risk to very high risk for contributing runoff to a stream.

The inputs for this tool include the field boundaries, distance to stream raster, and slope table. The output generated by this tool is a runoff risk table, where agriculture fields are classified according to their runoff risk as very high, high, moderate, and low. Like the prior two tools, the runoff risk table can be joined with the field boundary layer and displayed visually. This map and the slope assessment map can be helpful for planners in getting a feel for the watershed and determining which people you want to reach out to in implementation.

Precision Conservation Practice Siting Tools (Tool drawer 4)

The previous three tool drawers – DEM Preparation, Stream Network and Catchments, and Field Characterization – are all completed to set up the practice siting tools in the Precision Conservation Practice Siting Tool drawer, the Impoundment Siting Toolbox, and the Riparian Assessment Toolbox.

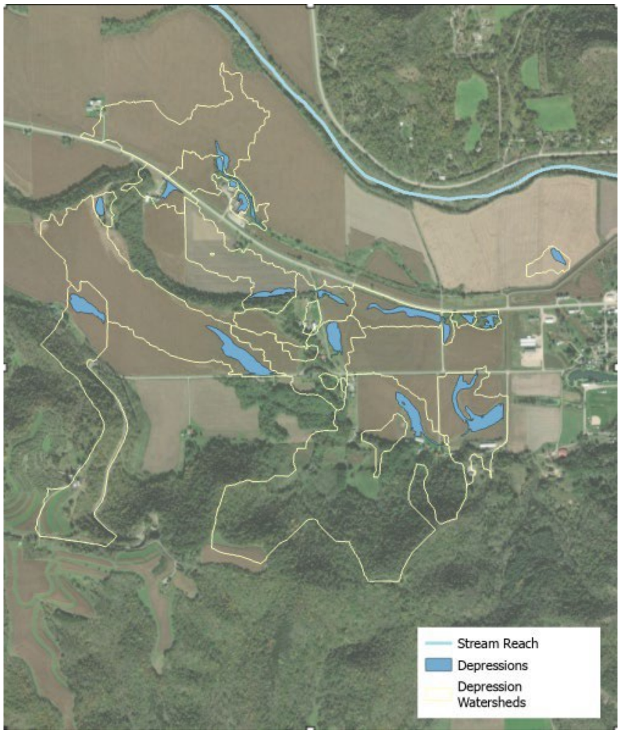
Practice siting tools identify approximate locations of opportunities for conservation practices. The ACPF is not a practice design tool, and all identified opportunities should be assessed and visited by conservation planning practitioners with local knowledge.

Depressions

Depressions are common in the glacial landscapes of the Midwest. The relatively low sloped, hummocky topography leads to depression areas that are poorly drained and may not be connected to the stream network. It is common for depressions to have poorly drained and hydric soils. Cropping of the features often requires surface drains to allow these areas to be farmable. Conservation practices like blind inlets, grass buffers, and wetlands can be good options for depressional areas. Potential benefits are reduced sediment and phosphorus loads, nitrate reduction, and increased water storage and habitat.

- Tool Inputs: Unfilled DEM, soil raster, field boundaries, stream reach (optional), waterbody layer (optional), and Z-factor.
- Tool Outputs: Depression polygons and depression drainage area polygons (this is the contributing area around the depression; Fig. 3).
  - Each depression is given a unique ID and mean percent hydric soil and maximum depth in cm is provided.
  - The drainage area of each depression is determined in hectares and produced as a separate shapefile.
  - Depressions are converted to polygons and the polygons are evaluated against gSSURGO data and DEM to determine hydric soil percent and range of depth.
  - The results data may be used to identify opportunities for underground outlets (NRCS CPS 620) and wetland restoration (NRCS CPS 657).
- Example modifications that can be made by the ACPF technician:
  - The default hydric soil in depression percent is 60%, meaning that if 60% of the depression has hydric soil it will be flagged as a candidate for having a practice installed.
  - The default minimum depth of depression in centimeters is 30 cm.
  - The default minimum area of depression in acres is 0.25 acres.
  - Each of the defaults can be changed by the technicians.
  - To be identified as a depression site, depressions must be on agricultural fields, can't intersect the stream reach, and cannot be centered within a waterbody.

Figure 3. Example of depression and depression drainage polygons on an output.



Drainage Water Management

Drainage water management (DWM) is an edge-of-field practice that can also be referred to as controlled drainage or a drainage control structure. It is installed in-line with drainage tile. Adjustable gates allow the water table to be controlled in-field which reduces nutrient loads to watersheds by increasing infiltration in-field. This is a water management practice but, in some cases, there may be agronomic benefits as well by making water more available to crops in the growing season.

This practice needs to be managed throughout the course of the year by adjusting the gates to better control in-field water saturation. The DWM tool does not outline specific locations for DWM, however it does outline factors that can help facilitate the planning process.

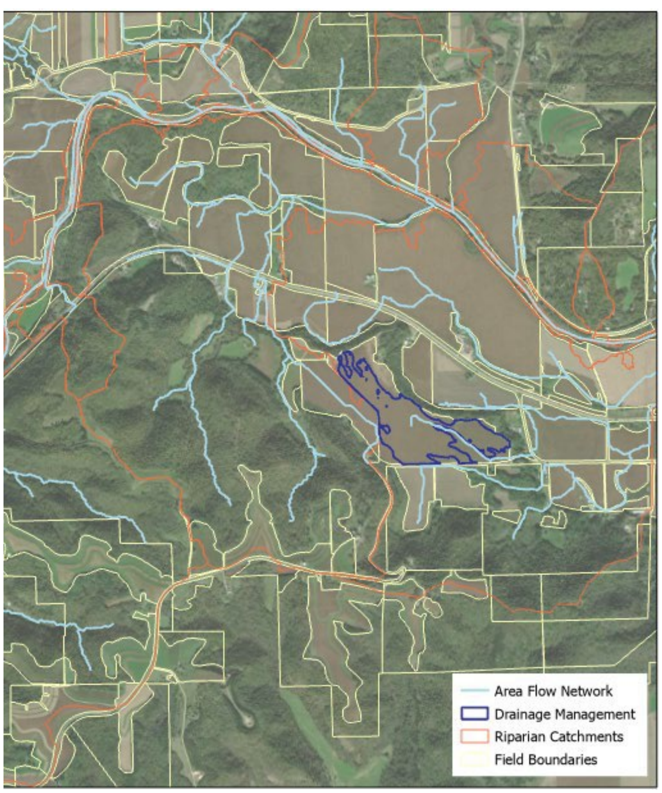
- Tool Inputs: Field boundaries, unfilled DEM, drainage table, Z-factor, and contour interval.
    - Contour zones or user-defined areas flagged as potential sites for DWM. As noted above, this tool doesn't show where a structure should go. Instead, it identifies fields that are suitable based on the input conditions set. Planning and installation for DWM requires further planning. Contour zones show users the area where the DWM control structures will be backing up water.
        - ACPF technicians, in cooperation with ACPF users, set the contour interval (between 0.3 and 1.5 m. The default is 1 m). Each contour represents the hypothetical area of the water table that would be impacted with installation of a drainage water management structure. The larger the contour interval chosen, the more control gate structures will be needed, and more fields will be identified as opportunities. The smaller the contour interval chosen the fewer

fields will be identified as opportunities. A smaller contour interval is suggested for a watershed containing very flat fields. A single control gate (dependent on its size) usually controls about a 0.5-m change in elevation. The minimum acreage within the field that the contour interval must occupy to qualify as a candidate can also be determined by the technician.

- The field is sliced into that number of equal-interval elevation zones and analyzed for suitability based on the extent.
- This tool is based on the results of the Tile Drainage Classification Tool in the Field Characterization Tool drawer. In the Tile Drainage Classification Tool technicians base the likelihood of tile classification off of 1) slope (greater than 90% of the field is less than 5% slope) and/or 2) soil attributes (technicians can choose one of three options 1) the field has a mean hydric soils percentage greater than 10%; 2) more than 40% of the field consists of a dual drainage hydrologic group class soil; and 3) more than 40% of the field has a seasonal high-water table (less than 50cm).) Technicians can choose whether they use both conditions or just one condition based on their local conditions. This helps technicians determine if a field is likely to have tile drainage or not.

- Tool Outputs: Drainage Management polygons
  - The results data may be used to identify opportunities for drainage water management (NRCS CPS 544).

Figure 4. Example output from the DWM Tool displaying the contour intervals showing the different elevations across the field in yellow. This map also contains the field boundary, riparian catchments, and stream reach layers.



Grassed Waterways

Grassed waterways are a popular practice used to reduce erosion from concentrated flow or gully erosion. Growing grasses can reduce mean velocity of runoff which discourages soil detachment. Flowing water flattens the grass and creates a kind of protective mat that protects the soil. The fibrous root systems of grasses lead to increased soil strength which can limit detachment of soil particles that otherwise may be prone to occur with seepage from the soil surface under saturated conditions. That said, grassed waterways are designed to reduce runoff and are not meant to trap sediment or nutrients.

- Tool Inputs: Field boundaries, stream power index (SPI) raster, streams layer, waterbodies (optional), depressions (optional).
    - Stream power index (SPI) that measures the erosive power of flowing water by considering the slope and amount of land draining to a point on the landscape. A map of SPI shows where gullies are likely to form.
        - Technicians set the SPI threshold and input waterbodies or depression polygons to ensure grass waterway are not sited in these locations. The smaller the threshold the more pixels will display as potential grass waterway sites. It can be helpful to create multiple thresholds outputs to visualize when planning for conservation.
- Tool Outputs: Grassed Waterway polylines
    - Potential locations for grassed waterways must be in agricultural fields and must be greater than 50 meters.
    - The results data may be used to identify opportunities for grassed waterways (NRCS CPS 412).

Figure 5. Example of the grass waterway outputs.

Contoured Buffer Strips

Contour buffer strips are an in-field practice that slows flow and trap/filter out sediment and nutrients. Unlike traditional buffer strips at the edge-of-the-field, these strips follow contours to intercept runoff perpendicular to flow. Contour buffer strips are most applicable in landscapes with topographic relief.

- Tool Inputs: Field boundary layer, slope raster and table, unfilled DEM, flow accumulation raster, Z-factor, and buffer width.
  - The tool will not place a contour buffer strip in a concentrated flow path with more than 2 acres of upland drainage area.
  - This tool complements grassed waterway placements.
  - If you are working in a very flat area, you may not get an output from this tool, which relies on slopes greater than 4% in crop fields (pasture and non-agricultural land are excluded from this analysis).
  - The only modification that can be made by the ACPF technician to this tool is to modify buffer widths to align with the field's topography.
- Tool Outputs: Contour buffer strip polygons
  - The results data may be used to identify opportunities for contour buffer strips (NRCS CPS 332).

Edge-of-field Bioreactors

Bioreactors are an edge-of-field practice that intercept subsurface tile drainage and use buried wood chips to remove nitrate from subsurface tile drain flow.

- Tool Inputs: Field boundaries, unfilled DEM, flow direction raster, flow accumulation raster, drainage table, soils raster, and Z-factor.
  - Bioreactor locations must be at the downflow of a tiled agricultural field.
  - The installation location must have an upland drainage area of at least 10 acres and less than 90% of the soils around the installation location should not be hydric.
  - Bioreactor surface area default is 0.5% of the drainage area.
  - There are no modifications that can be made to the bioreactor tool, but the parameters made when running the tile drainage classification tool can impact the siting recommendations (i.e., a site will not be identified if the field is not labeled as agricultural, has too many hydric soils or too small a contributing area).
- Tool Outputs: Potential bioreactor locations and table with bioreactor sizing recommendations including drainage area in acres, surface area of the bioreactor in acres and percent hydric soils around the potential bioreactor.
  - The results data may be used to identify opportunities for denitrifying bioreactors (NRCS CPS 605).

Figure 6. Outputs from the Bioreactor Tool. The small orange polygons are the potential bioreactor locations.

Impoundment Siting Tools (Tool drawer 5)

This tool drawer focuses on practices that use impoundments to hold water back on the landscape such as nutrient removal wetlands (NRWs), water and sediment control basins (WASCOBs), and farm ponds, which all function in a similar way in that a structure is used to impede the movement of water through the watershed. The main difference between these practices is the size of the practice and the treated area on the landscape where the practice is appropriate.

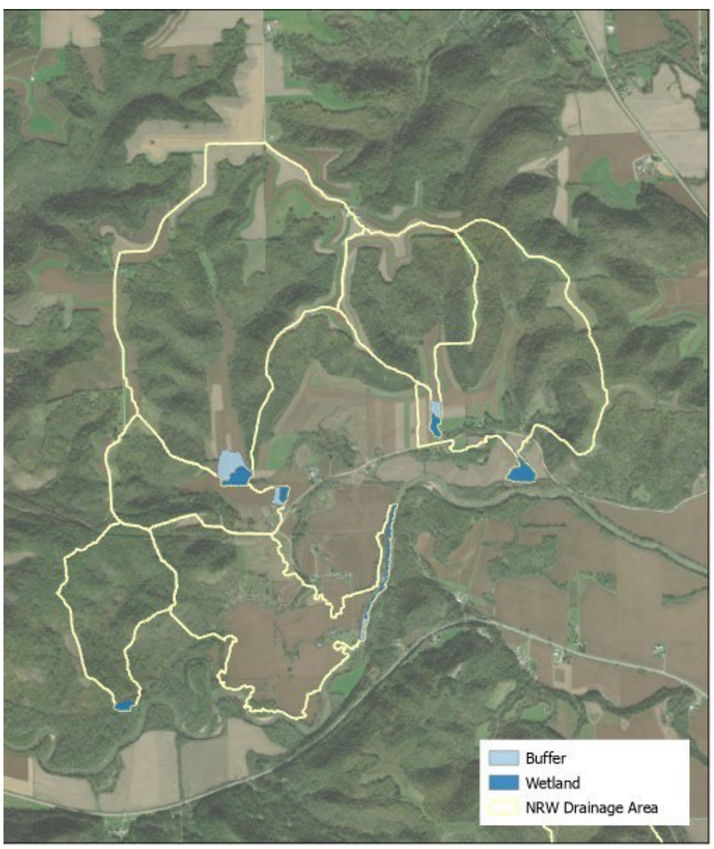
Nutrient Removal Wetland

Wetlands serve an environmental function by reducing nitrate as well as providing flood storage. The nutrient removal wetland tool identifies depressional areas that occur along concentrated flow paths that are suited for constructing treatment wetlands or restoring wetlands.

- Tool Inputs: Unfilled DEM, flow direction raster, flow accumulation raster, watershed boundaries, stream reach (optional), roads (optional), water bodies (optional), and several technician/user decisions (i.e., Z-factor, spacing, impoundment height, and buffer height).
  - Siting considerations include water flow paths and accumulation, spacing along flow path, impoundment height, and buffer height. A minimum of 60 hectares must be drained and the bank height must be less than 4m.
  - Example modifications that can be made by ACPF technician:
    - Incorporate a roads layer to avoid siting wetlands across roads.
    - Incorporate a large water body polygon to avoid wetlands next to lakes.

        - Incorporate stream reach to avoid flooding streams or siting next to wide rivers.
        - Decrease spacing to sample more sites along flow path.
        - Change based goals or program goals i.e. increased impoundment height results in larger and deeper wetland pools while increased buffer height results in larger vegetative buffer and flood storage capacity.
        - A site will not be suggested if the wetland drainage ratio is outside the 0.5-2% or if the buffer area is less than 4x the wetland pool.
- Tool Outputs: NRW polygons and NRW drainage area polygons
    - Table associated with polygons that provides details about the size of the drainage area, wetland, and associated buffer, as well as permanent and variable water storage capacity of the wetland and the buffer zone.
    - The results data may be used to identify opportunities for constructed wetlands (NRCS CPS 656), wetland creation (658), wetland restoration and CREP wetlands (NRCS CPS 657).

Figure 7. Map output from the Nutrient Removal Wetland Tool. The dark blue area is where the nutrient removal wetland would be. The light blue area is the buffer area around the wetland where it has wetland vegetation and variable storage capacity for water during large storm events. The polygon outlined in yellow is the wetland drainage area.



Water and Sediment Control Basins

Water and sediment control basins (WASCOBs) are a commonly installed in-field practice in the Midwest that reduces sediment and phosphorus loads. WASCOBs attenuate peak runoff discharge and reduce the risk of gully formation down gradient. WASCOBs are smaller than nutrient removal wetlands and the water doesn't stay in the basin for very long.

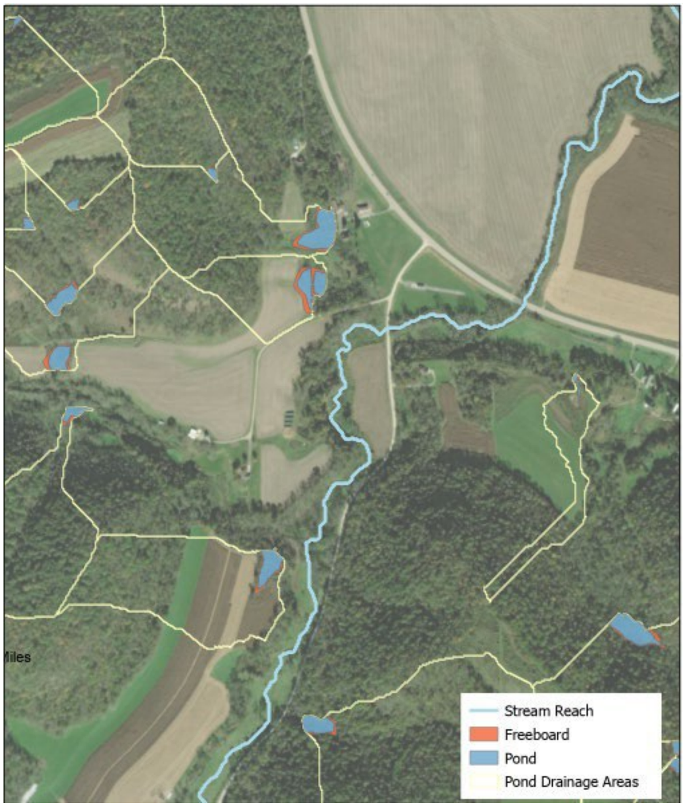
- Tool Input: Unfilled DEM, flow accumulation raster, flow direction raster, field boundaries, stream reach, and watershed boundary.
    - To be identified as a potential site, the height of each side of the drainageway must be at least the height of the embankment and the height of each side of the drainageway cannot exceed 2 times the height of the embankment.
    - For a WASCOB to be sited, the sub-catchment must be 2-50 aces of contributing area flowing into the WASCOB, flow paths have points generated approximately every 200 feet.
    - 100 meter transects are drawn perpendicular to mean direction of the flow and the elevation prolife of the transect is evaluating in siting potential WASCOB locations.
    - Embankment height can be modified and range from 1-4.5 meters. The smaller the height the more likely it will result in a train of WASCOBs as opposed to one large WASCOB.
- Tool Output: Polyline attribute at the location of the potential impoundment and area behind impoundment for the WASCOB.
    - The tool produces WASCOB polylines with the contributing area, in acres, upstream of each WASCOB, elevation at the center of the drainageway in vertical map units, embankment height, and height on the left and right banks of the drainage.
    - The tool also produces WASCOB polygons with potential storage volume in acre feet of each basin and surface area in hectares.
    - A lot of times you see a train of WASCOBs where one flows into another, into another, along a flow-path.
    - The results data may be used to identify opportunities for WASCOBs (NRCS CPS 638).

Farm Ponds

Farm ponds are constructed impoundments that can capture surface runoff, trap sediment, provide irrigation, and enhance biodiversity. ACPF looks for ideal conditions along flow paths for farm ponds - areas that have a narrow section of valley for a dam, steep side slopes, flat valley floor, and 5-100 acres of contributing drainage area. Farm ponds require a smaller drainage area than nutrient removal wetlands and WASCOBs.

- Tool Inputs: Unfilled DEM, flow direction raster, flow accumulation raster, watershed boundaries, and roads. Roads are optional but help to avoid siting farm ponds crossing one.
- Tool Outputs: Feature class of potential farm pond locations (including 1 vertical meter of vegetated freeboard buffer area around the pond). There is an attribute table with pond dimensions.
    - The results data may be used to identify opportunities for farm ponds (NRCS CPS 378).

Figure 8. Example Farm Pond Output



Riparian Assessment Tools (Tool drawer 6)

Riparian Function Assessment

The riparian corridor can be an effective location for enhancing conservation impacts. The opportunities outlined in the riparian function assessment focus on managing vegetation in a riparian zone and usually do not require farmland to be taken out of production. Where terrain characteristics are suitable, deep-rooted vegetation can be plated to stabilize streambanks or facilitate de-nitrification of the riparian zone. In other cases, different types of vegetation may be preferable depending on that specific watersheds' characteristics. The Riparian Function Assessment Tool is used to plan site-specific designs for riparian buffers; the Riparian Function Assessment Tool uses data from previous steps in the Riparian Assessment Toolbox.

- Tool Inputs: Streams reach, riparian catchments, and height above channel raster layer.
    - The tool analyzes two variables for each riparian catchment:
        - The potential for the riparian zone within each catchment to provide denitrification of shallow groundwater. This is based on the width of the low-lying land (< 1.5m height) within 90m of the stream. The topography of the land

near the riparian zone impacts the level at which shallow groundwater may be present.

    - The amount of drainage area passing through the riparian zone from each catchment (equal to the size of the riparian catchment). Larger catchments naturally have larger quantities of runoff passing through their respective riparian corridors.
    - While there are no modifications that can be made to the settings of this tool, technicians may find that some sub-catchments in the watershed are not classified or have a NULL value assigned to it. This is because there is no section of the stream reach layer that extends into that sub-catchment, and therefore, there is no riparian corridor to design a buffer for in that area. The extent of the stream reach layer is determined by the technician and manually defined prior to running the tools. It is important that this step is completed accurately before the Riparian Function Assessment Tool is run to avoid NULL classifications in sub-catchments that do contain a riparian corridor.
  - Each variable is ranked into a **high, medium, or low category**, and a cross classification matrix is then applied to map the relative correspondence of potential runoff contributions with the extent of low-lying areas (where the water table is likely to be shallow and subject to influence of plant roots) throughout the riparian corridors in the watershed. The results of the cross classification can be used to identify opportunities to improve riparian management by installing permanent vegetation in ways specifically designed to intercept surface runoff, influence shallow groundwater in low-lying areas, and stabilize stream banks, in places where consequent water quality benefits can be best realized.
- Tool Outputs: A riparian function assessment table, noting where opportunities exist to intercept surface runoff, shallow groundwater, both runoff and groundwater, and where neither opportunity exists but riparian plants can be designed to reduce bank erosion. Each sub-catchment is categorized as ideal for one of five categories: 1) Critical Zone, 2) Multi-Species Buffer, 3) Stiff-Stemmed Grassed, 4) Deep-Rooted Vegetation and 5) Stream Bank Stabilization.
  - The riparian function table can be joined to one of the spatial layers that share the "riparianid" field in its attribute table. By joining the table to the Riparian Assessment Polygon layer, users can visualize what type of management strategy should work best for the different sections of the stream reach (See Figure 10). The table can also be joined to the riparian catchments layer which can be useful in visualizing the contributing acres to the riparian corridor for each segment (See Figure 11). This is useful in the planning phase because planners can get a sense of how large of a buffer region is needed in the design to accommodate the expected runoff delivery to the riparian corridor.
  - The results data may be used to identify opportunities for riparian forest buffers (NRCS CPS 391), filter strips (NRCS CPS 393), and streambank erosion (NRCS CPS 580).

Figure 9. The Riparian Function Assessment Output Table

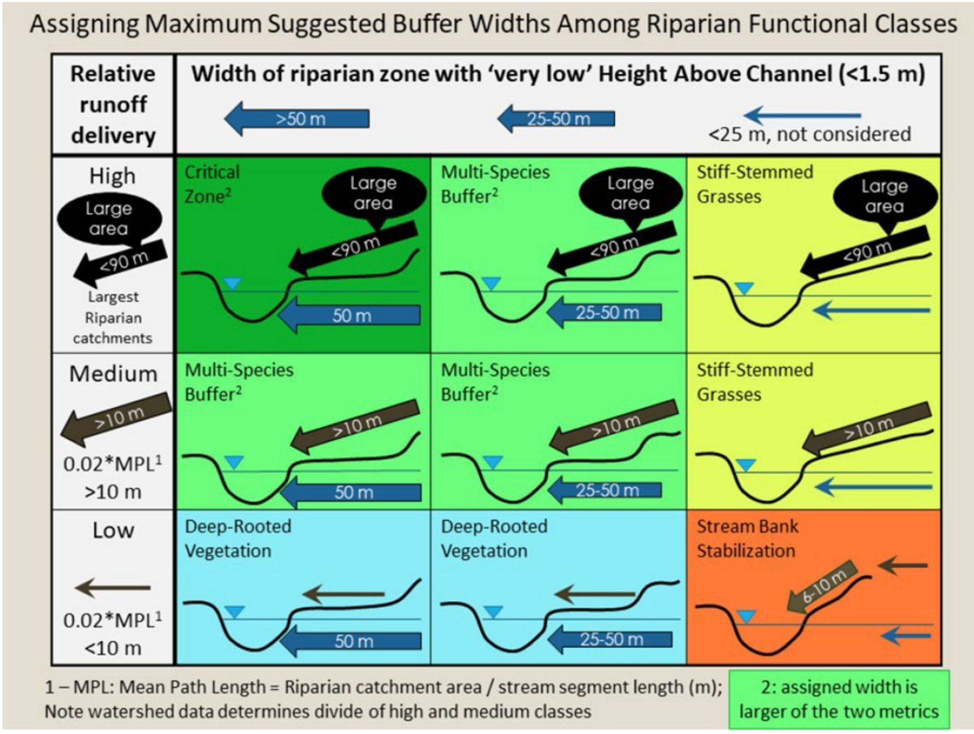


Figure 10. Example of the Riparian Function Table joined to the riparian assessment polygon layer to visualize the specific sections of the stream reach.

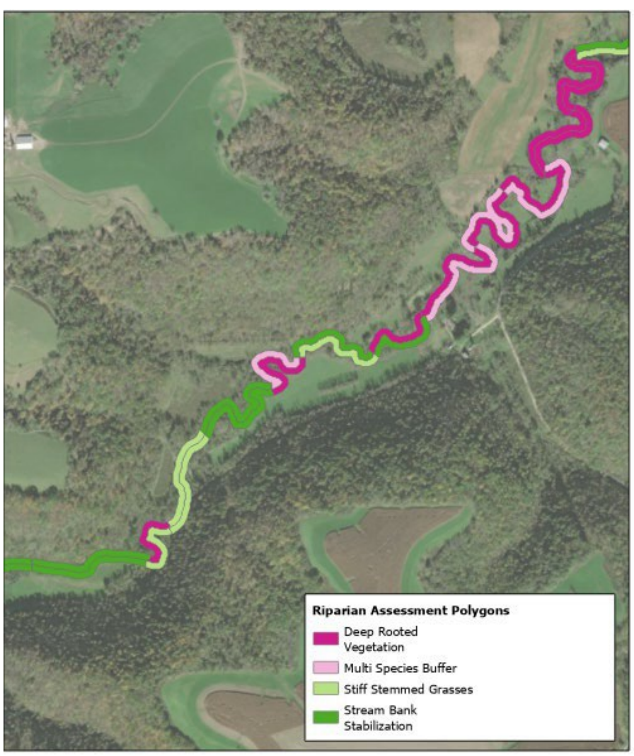
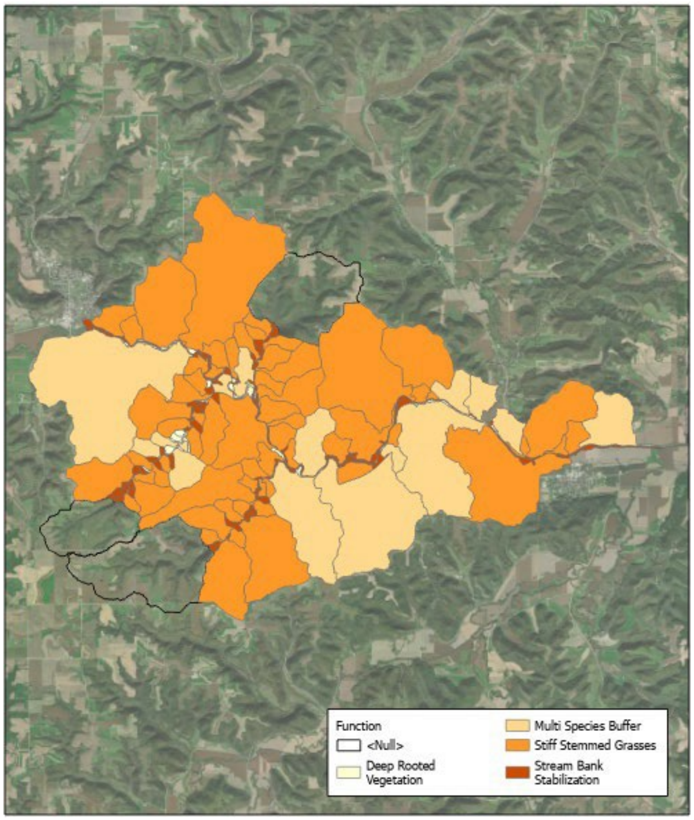


Figure 11. Example of the riparian function table joined with the riparian catchments layer to visual the contributing areas to riparian corridors in the watershed.



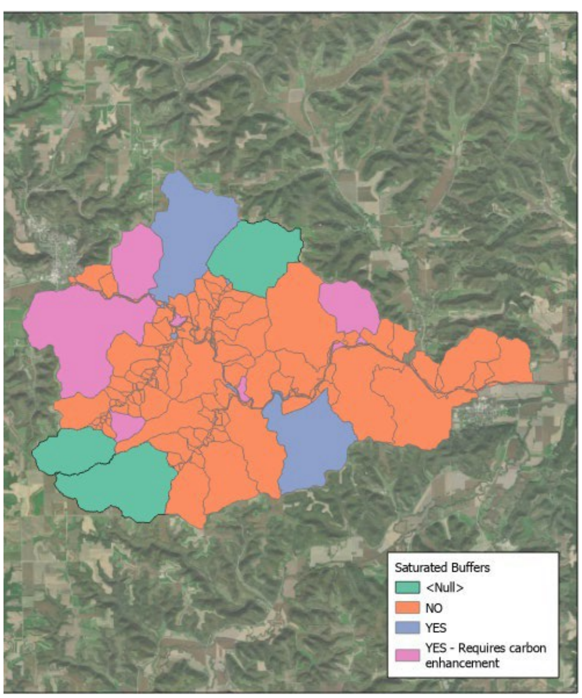
Saturated Buffers

A saturated buffer is an edge-of-field practice that can remove excess nutrients from subsurface tile drainage water before it can make its way into a receiving steam or ditch. This practice also utilizes a drainage control structure. However, in this case it is used to redirect tile drainage water through a riparian buffer zone. Perforated pipes connected to a drainage control structure distribute water through the riparian zone. These distribution pipes run parallel to the receiving stream or ditch and allow water to saturate the riparian zone. The water in this zone is then able to slowly infiltrate trough the riparian buffer into the receiving stream. Specific soil attributes and terrain characteristics need to be present in the riparian zone (defined as a 90m buffer around the stream reach layer) for this practice to work as it was designed. The Saturated Buffer Tool helps guide planners to potential locations where saturated buffers may work in a watershed.

- Tool Inputs: Stream reach, riparian catchments, unfilled DEM, slope raster, soils raster and tables, and land use raster.
    - To qualify as a candidate site for a saturated buffer, the riparian zone must meet three criteria. In general, these criteria help ensure that:
        - Stream bank heights are <12 ft (default, can range from 8 to 14 feet), so that risks of bank failure/ collapse resulting from raising the water table are minimized.

        - Slopes within the riparian zone are 'dominantly' in the range of 2-8%; this is meant to minimize risks of inundating adjacent field crops but also avoid areas steep enough that there is a risk of erosion and surface seepage flows.
    - Example modifications that can be made by a technician:
        - The Saturated Buffer Tool can be run using the default settings, but technicians can also adjust these parameters to accommodate local planning requirements:
            - The minimum organic matter percent can range from 1.5% to 5.1%.
            - The maximum percent of course soils can range from 50% to 75%.
            - The minimum percent of riparian zone that must contain slopes between 2 and 8% can range from 25% to 75%.
            - Maximum bank height can range from 8ft to 14ft.
- Tool Outputs: An output table noting whether each riparian corridor segment is suitable for a saturated buffer. Each corridor segment is flagged Yes, No, or Yes – requires carbon enhancement. (In these cases, there needs to be a certain amount of soil organic matter for de-nitrification to occur)
    - Like the Riparian Function Assessment, the output table can be joined to one of the spatial layers that share the "riparianid" field in its attribute table. By joining the table to the Riparian Assessment Polygon layer, users can visualize which stream segments have riparian corridor attributes that could potentially accommodate a saturated buffer.
    - The table can also be joined to the riparian catchments layer which can be useful in visualizing the contributing acres to the riparian corridor for each segment.
    - The results data may be used to identify opportunities for saturated buffers (NRCS CPS 604).

Figure 12. Example of the saturated buffer table joined with the riparian catchments to visualize which stream segments have could potentially accommodate a saturated buffer.



Two-Stage Ditches

A two-stage ditch is a modification of the traditional trapezoidal ditch design to provide a low-flow channel and a vegetated bench that is flooded during higher flows. The vegetation provides some slowing of water where sediments and other heavier material in the flow might settle. A two-stage ditch is an in-channel practice. Where installed, two-stage ditches have been shown to reduce wetness in adjacent fields with subsurface drainage, particularly where tile outlets were frequently under water. Additional benefits include increased bank stability and reduced maintenance costs, reduced downstream export of nutrients and sediment, and improved plant-soil-water interactions within the ditch.

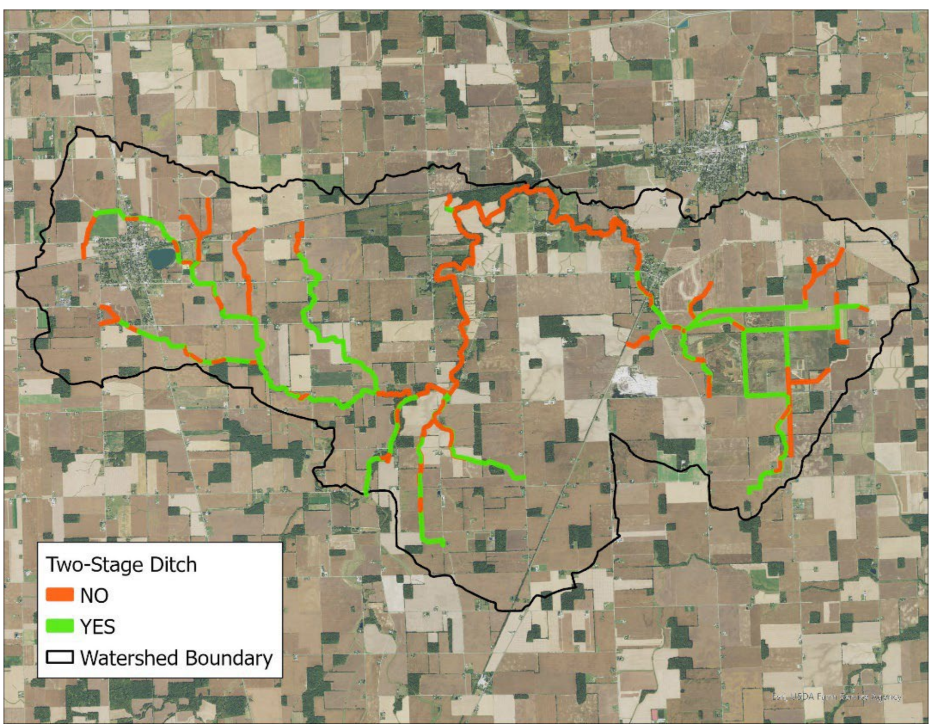
Two-stage ditches are best suited adjacent to fairly flat fields with subsurface drainage installed. Installation often requires widening of the existing channel, and costs for installation and maintenance vary based on the existing ditch size and topography. The Two-Stage Ditch Tool is like the Saturated Buffer tool and helps guide planners to potential locations where two-stage ditches may work in a watershed.

- Tool Inputs: Stream reach, riparian catchments, unfilled DEM, slope raster, soils raster and tables, and land use raster.
    - To qualify as a candidate site for a two-stage ditch, the riparian zone must meet five criteria. In general, these criteria help ensure that:
        - The drainage area is between .5 and 10 square miles. This prevents the siting of ditch systems with either minimal flow and inadequate sediment supply, or larger channels that would take a lot of land out of production.
        - Stream bank heights are > 4 ft (default, can range from 3-5 ft) and are < 12 ft (default, can range from 8 to 25 feet). The minimum bank height ensures adequate ditch depth to allow for both a low-flow channel and floodplain bench to be constructed, while the maximum bank height is meant primarily to prevent siting along very deep ditches, which may require a substantial amount of land to be taken out of production.
        - Channel slope is < 2%, to prevent siting along steeper channels that have the potential for imbalanced stream loads.
        - Slopes within the riparian zone are 'dominantly' < 5% slope; this is meant to avoid adjacent crop areas steep enough that there is a risk of erosion, as well as to prevent the need for grade-control structures.
        - Agricultural land must exist (either cropland or pasture) within each riparian zone.
    - Example modifications that can be made by a technician:
        - The Two-Stage Ditch Tool can be run using the default settings, but technicians can also adjust these parameters to accommodate local planning requirements:
            - The minimum percent of riparian zone that must contain slopes < 5% can range from 25% to 75%.
            - The minimum bank height can range from 3 ft to 5 ft.
            - The maximum bank height can range from 8 ft to 25 ft.
    - Additional Considerations:

- Vegetation is the key to bench and bank stability for two-stage ditches, and the practice is therefore appropriate for sites where good aquatic habitat is already present or desired. Sandier soils might not be well-suited for this practice unless vegetation can establish quickly. While not included in the tool as a required criterion, the mean sand content of near-stream riparian soils (within 20 meters of the stream) is calculated for each unique stream section.

- Tool Outputs: An output table noting whether each riparian corridor segment is suitable for a two-stage ditch. Each corridor segment is flagged Yes / No for two-stage ditch suitability.
  - Like the Riparian Function Assessment and Saturated Buffer Tool, the output table can be joined to one of the spatial layers that share the "riparianid" field in its attribute table. By joining the table to the Riparian Assessment Polygon layer, users can visualize which stream segments have riparian corridor attributes that could potentially accommodate a saturated buffer.
  - The table can also be joined to the riparian catchments layer which can be useful in visualizing the contributing acres to the riparian corridor for each segment.
  - The results data may be used to identify opportunities for two-stage ditches (NRCS CPS 582).

Figure 12. Example of the two-stage ditch table joined with the riparian assessment polygon layer to visualize which stream segments could potentially accommodate a two-stage ditch.



Soil Vulnerability Index (Tool drawer 7)

The Soil Vulnerability Index (SVI) was originally developed by the NRCS to provide a straightforward approach to vulnerable area identification while minimizing accessibility issues associated with complicated models and input data.

The SVI is a crisp-based ruleset that examines three primary soil properties (hydrologic soil group, slope, and whole soil erodibility, or KW-factor) to classify each component of a map unit into a vulnerability classification (high, moderately high, moderate, and low). The classification is applied to three dimensions of SVI: vulnerability to surface loss, vulnerability to subsurface loss on undrained soils, and vulnerability to subsurface loss on drained soils. Adjustments are made to the SVI classification based on the existence of organic soils and karst bedrock. Please see the SVI User Manual 3.0 for a more detailed description

The ACPF provides two approaches for mapping SVI within a watershed, described by:

- Map unit-based SVI. This mirrors the current NRCS approach and utilizes SSURGO soils data exclusively. SVI output is tied to the soil map unit.
- Pixel-based SVI. This combines SSURGO soils data with high-resolution topographic information to produce a more spatially explicit SVI at a sub-map unit scale. SVI output is tied to DEM resolution. Pixel-based SVI outputs can be used to characterize fields by SVI vulnerability.

Map Unit Based Soil Vulnerability Index

Two map unit-based SVI tools are included in the ACPF and are designed to be run in sequence.
The “Map Unit Soil Vulnerability Index – Calculate SVI for All Components” tool downloads the required SSURGO soils data for all components of all map units in the watershed and assigns each component an SVI vulnerability classification. Each component receives a classification for the SVI risk categories of: Surface Loss, Subsurface loss - Undrained, and Subsurface loss – Drained. This approach utilizes information contained with the SSURGO database exclusively and therefore results will be identical to the NRCS SVI approach.

Within the map-unit based approach, artificial drainage classification follows the NRCS SVI definition, and is defined as those components with a representative slope <= 3 % and a soil drainage class of somewhat poorly drained, poorly drained, or very poorly drained.

- Tool Inputs: soils raster.
- Tool Outputs: A table containing SVI classification for each component of all map units in the watershed.

The “Map Unit Soil Vulnerability Index – Summarize Map Unit SVI” tool summarizes the SVI distribution within each map unit. This allows for the dominant condition within each map unit to be visualized. The component-scale information is maintained in tabular format and allows each map unit to be queried to understand sub map unit level vulnerability.

- Tool Inputs: Component table with SVI vulnerability classes populated.

- Tool Outputs: A table containing SVI summary information for each map unit. This includes the dominant SVI classification for Surface Loss, Subsurface Loss - Undrained, and Subsurface Loss – Drained conditions within each map unit, as well as the percent of the map unit falling in each vulnerability class.

Figure 13. Output of Map-Unit Based SVI for Surface Loss. Map Units are displayed by their dominant condition.

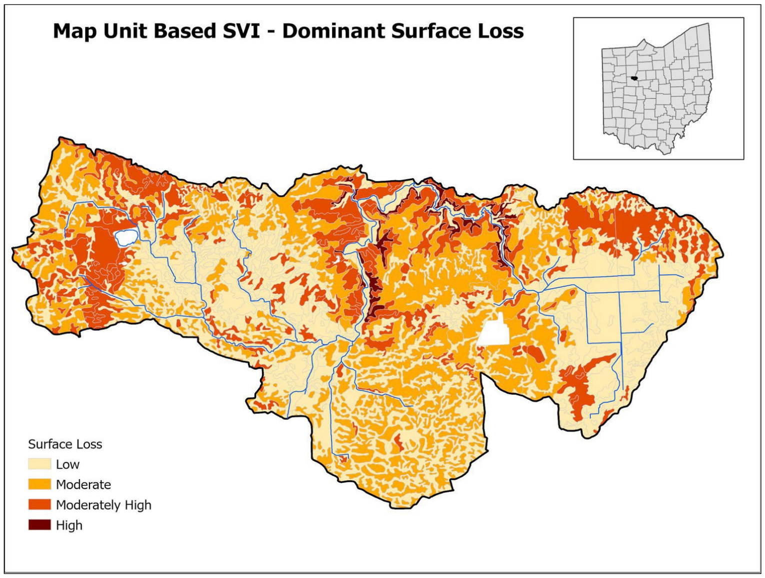
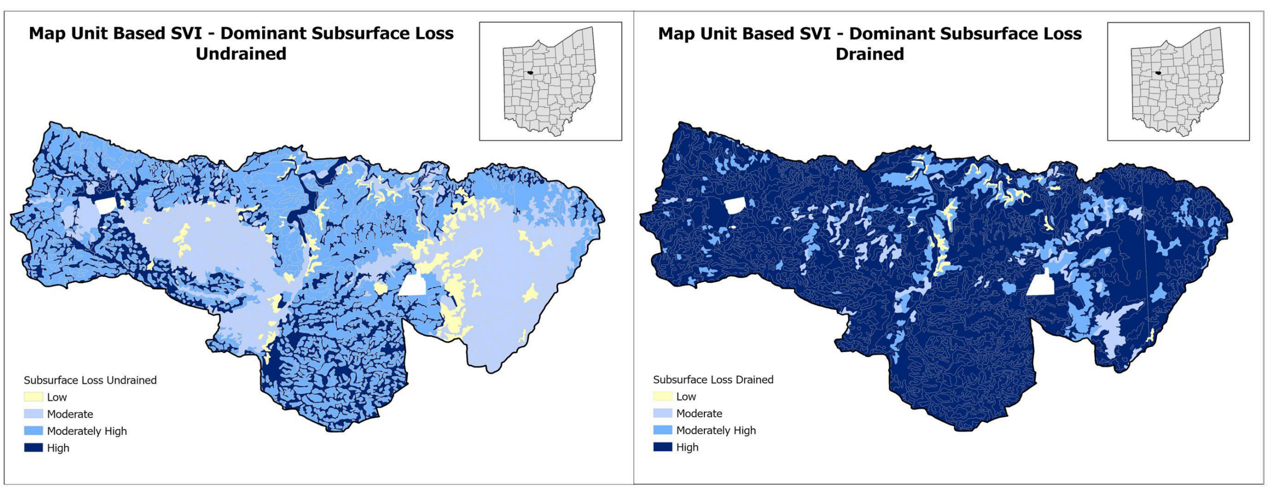


Figure 14. Output of Map-Unit Based SVI for Subsurface Loss undrained (left) and drained (right) condition. Map Units are displayed by their dominant condition.



Pixel Based Soil Vulnerability Index

Feedback from conservation planners has suggested that inclusion of slope derived from high-resolution elevation data sources rather than the SSURGO database would improve the applicability of SVI outputs at a local level. The non-spatial characteristic of soil components, however, prevents this information from being combined with high-resolution topographic information. To combine disparate datasets with mismatching spatial scales, soil properties associated with the dominant component of each map unit are assumed for the entire spatial extent of the map unit, then combined on a pixel-by-pixel basis with a slope raster derived from a high-resolution DEM. This data integration allows for the generation of SVI vulnerability surfaces at a resolution equal to that of the input DEM and enables landscape characterization to occur at scales other than the soil map unit.

Three pixel-based SVI tools are included in the ACPF and are designed to be run in sequence.

The “By Pixel SVI - Get Soils Data for Dominant Component” tool downloads the required SSURGO soils data for just the dominant component of all map units in the watershed.

- Tool Inputs: soils raster.
- Tool Outputs: An output table containing required SSURGO attributes for just the dominant component of all map units in the watershed.

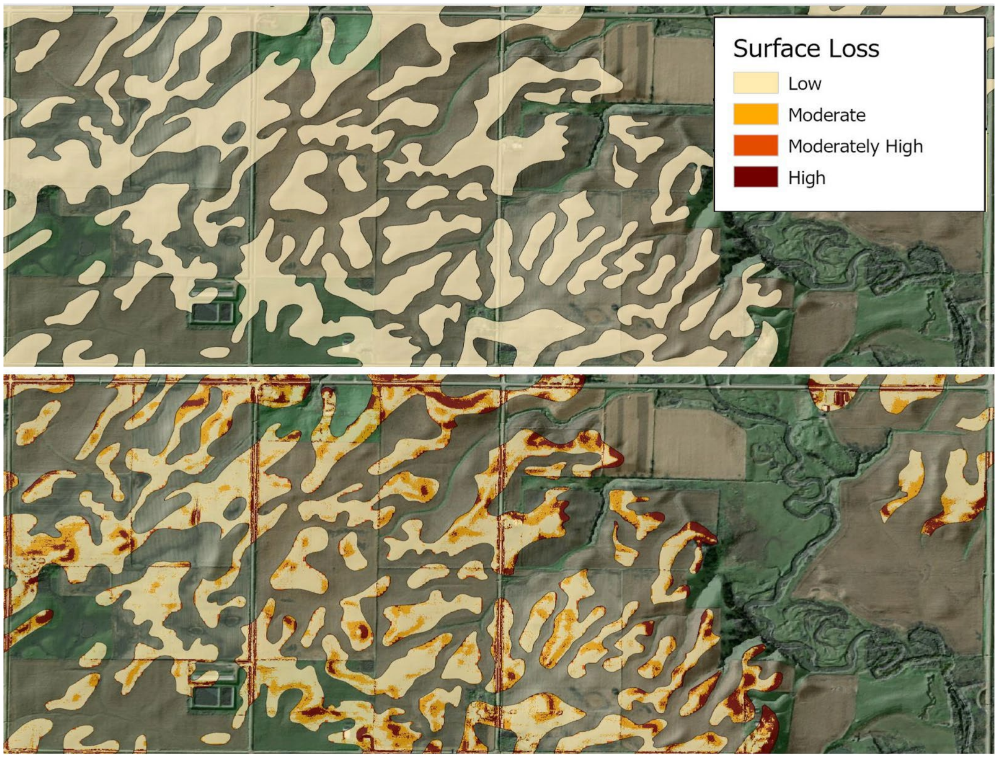
The “By Pixel SVI – Generate By-Pixel SVI Rasters” tool combines soils information for just the dominant component of each map unit with high resolution topographic information on a pixel-by-pixel basis. The output of the tool is two raster surfaces representing SVI surface loss vulnerability and SVI subsurface loss – undrained vulnerability.

The SVI definition of surface runoff vulnerability places more emphasis on slope than does the subsurface loss vulnerability, which emphasizes hydrologic group over the other primary variables. As a result, more differences will be observed for surface loss outputs when comparing the map unit versus pixel-based approach.

The pixel-based SVI approach uses the ACPF artificial drainage classification, which classifies "fields” as tile-drained, versus the NRCS approach, which classifies “map units” as tile-drained. As a result, a raster representing SVI subsurface loss vulnerability assuming drained conditions is not created as an output of this tool.

- Tool Inputs: slope raster, soils raster, and table containing required SVI soils attributes for just the dominant component of all map units in the watershed.
- Tool Outputs: Two rasters representing 1) SVI surface loss vulnerability and 2) SVI subsurface loss – undrained vulnerability. Rasters will have the same resolution as the input DEM.

Figure 15. Comparison of Map-Unit (top) vs. Pixel-Based (bottom) SVI Surface Loss for a single map unit. The map unit output is displaying the dominant condition among all components in the map unit, while the pixel-based output is displaying the pixel-based SVI surface loss raster.

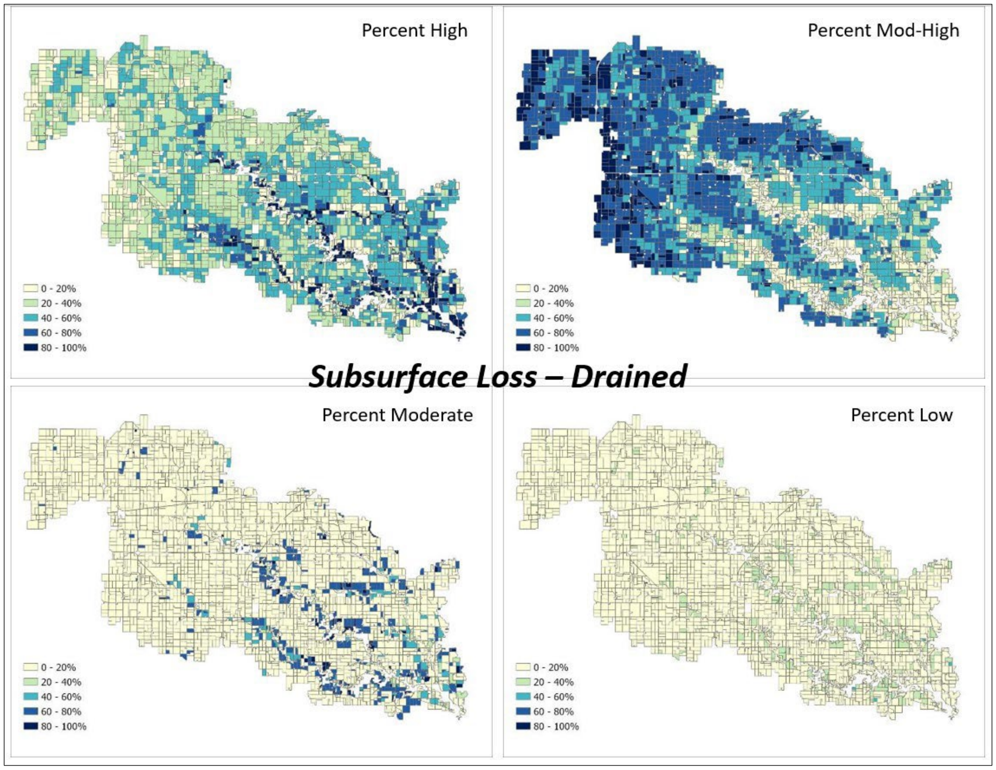


The "By Pixel SVI - Summarize Field SVI" tool generates an output table summarizing the distribution of SVI vulnerability within each field, as determined from the By-Pixel SVI vulnerability rasters. Summary information includes the dominant SVI classification for Surface Loss and Subsurface Loss (assuming undrained conditions), as well as the percent of the field falling in each vulnerability class.

Field-scale summaries of SVI subsurface loss vulnerability assuming undrained conditions, which are in tabular form, are adjusted to account for the presence of artificial drainage at the field level using the ACPF drainage classification. SVI subsurface loss vulnerability for drained conditions using the pixel-based approach can therefore only be visualized at the field scale.

- Tool Inputs: field boundaries, drainage table, and SVI pixel-based rasters for surface loss and subsurface loss – undrained condition.
- Tool Outputs: A table containing SVI summary information for each field. This includes the dominant SVI classification for Surface Loss, Subsurface Loss - Undrained, and Subsurface Loss – Drained conditions within each field, as well as the percent of the field falling in each vulnerability class.

Figure 15. Field-scale summary of SVI subsurface loss assuming drained conditions. Each panel shows the percent of each field receiving a high (top left), moderately high (top right), moderate (bottom left), and low (bottom right) vulnerability classification.



Additional Resources

Looking for additional resources?

Using ACPF in Watershed Planning and Implementation Resources

- ACPF Use Examples/Case Studies
  - The ACPF National Hub has created a series of case studies outlining the diverse ways in which the ACPF has been used in a conservation and watershed planning context. Review the case studies for ideas on how to incorporate ACPF into your work and for tips from other users.
- Tips for Using ACPF with Stakeholders
  - What are the keys to success, when it comes to collaborating with farmers, landowners, drainage inspectors, crop advisors, local government personnel, non-profit professionals, community volunteers, and all the stakeholders who are critical to watershed planning in your community? Researchers at Purdue University spoke with GIS technicians, watershed coordinators, and conservation planners from across the region to learn what has worked for them when engaging diverse stakeholders around conservation using the ACPF.
- A Guide to Using ACPF in US EPA Nine Element Watershed Planning
  - The ACPF team, along with our partners, developed a graphic outlining how ACPF can be used in the EPA Nine Element Watershed Planning process.
- Using the APCF in Farm/Field Scale Conservation Planning
  - The ACPF team, along with our partners, developed a graphic outlining how ACPF can be used in the NRCS farm-scale Nine-Step Conservation Planning Process.
- Using the ACPF in Areawide Conservation Planning
  - The ACPF team, along with our partners, developed a graphic outlining how ACPF can be used in the NRCS area-wide Nine-Step Conservation Planning Process.

Technical Resources

- ACPF User Manual
  - This resource is similar to this guide but goes into additional detail and is designed for technicians to use and refer back to while using the ACPF.
- Guide for Landscape specific decisions
  - Colleagues at the University of Minnesota Water Resources Center, with support from USDA NRCS, developed a guide for making landscape-specific adaptations to the ACPF. This guide helps users take advantage of the flexibility built into the ACPF toolbox and develop meaningful strategies within the targeted sub-watershed using the ACPF toolbox BMP siting outputs.
- Technical Training Online Course
  - This online asynchronous course is based on the training videos created by the team at the National Laboratory for Agriculture and the Environment of the USDA ARS in Ames, Iowa. The course is divided into 7 modules and includes how to download the ACPF toolbox and the core data and run the ecological tools on your chosen watershed. It can be taken at your own pace and allows you to jump to specific sections or go through the full course from start to finish!

- The science behind the tools – Peer reviewed publications

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