Bone Lake
Watershed Assessment

Watershed Delineation
Agriculture Conservation Planning Framework
Identification of Internally Drained Areas
Flow Accumulation Mapping

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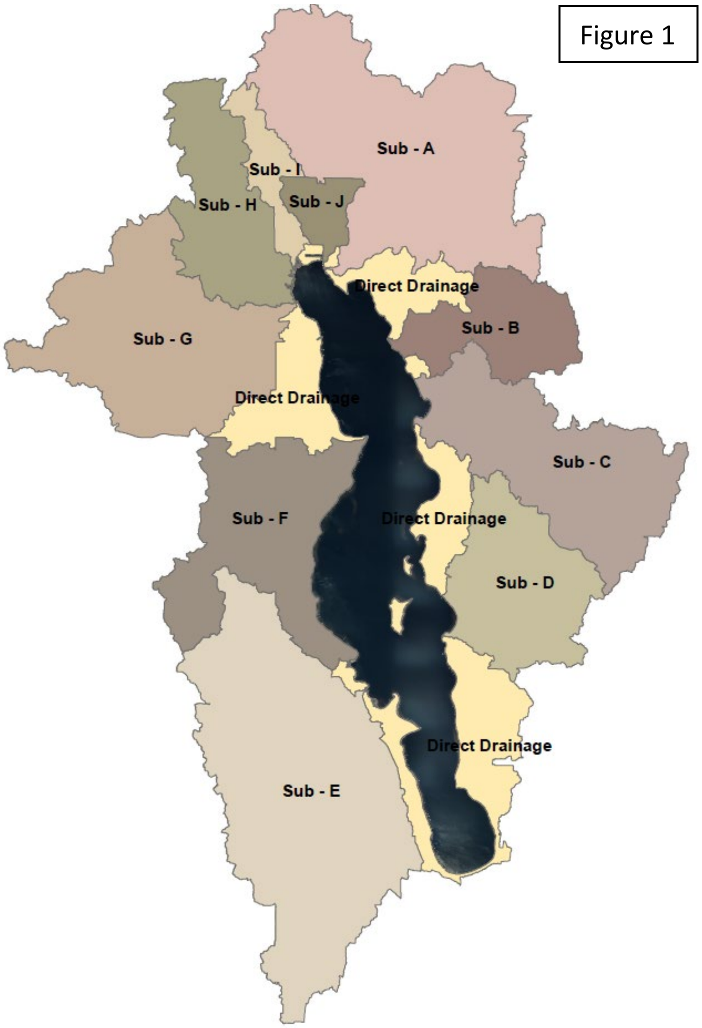
Bone Lake Watershed

The area of land that drains to a lake is called a watershed. The ArcMap spatial Analyst Toolbox and LiDAR elevation data was used to delineate the watershed for Bone Lake. Identification of culverts underneath roads is important for watershed delineation. When delineating watersheds from elevation data, computer software perceives roads as dams which prevent the flow of water. Field verification was used to identify culvert locations within the watershed to allow for accurate watershed delineation. The area of land contributing to Bone Lake is 10,284 acres (11,993 total watershed size including Bone Lake) and can be split into 11 subwatersheds (figure 1).

Figure 1



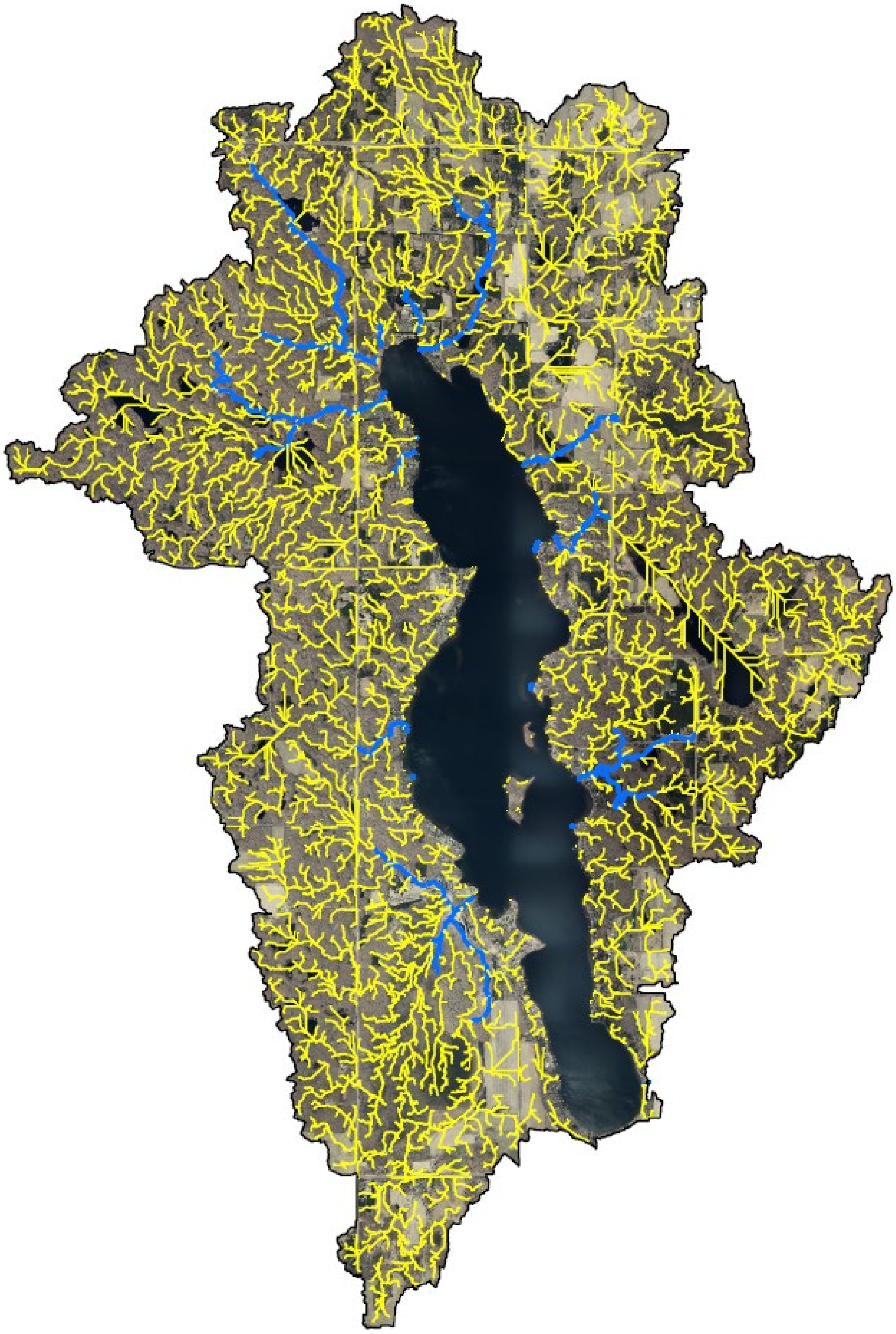
Sub Watershed Modeling

The Bone Lake Watershed was divided into eleven sub watersheds. Sub watershed boundaries are determined by examining where perennial (flowing year-round) or intermittent streams meet on the landscape. This allows watershed managers to further analyze smaller areas (sub watershed) and prioritize areas to all allocate funds. The Bone Lake Watershed does not have any perennial streams so ephemeral streams (only flowing after rain events or spring snow melt) were used for subwatershed delineation.

Sub Watershed	Acres
Direct Drainage	1,276
Sub Watershed A	1,670
Sub Watershed B	475
Sub Watershed C	1,051
Sub Watershed D	715
Sub Watershed E	2,000
Sub Watershed F	906
Sub Watershed G	1,218
Sub Watershed H	634
Sub Watershed I	187
Sub Watershed J	145

Flow Accumulation

Figure 2



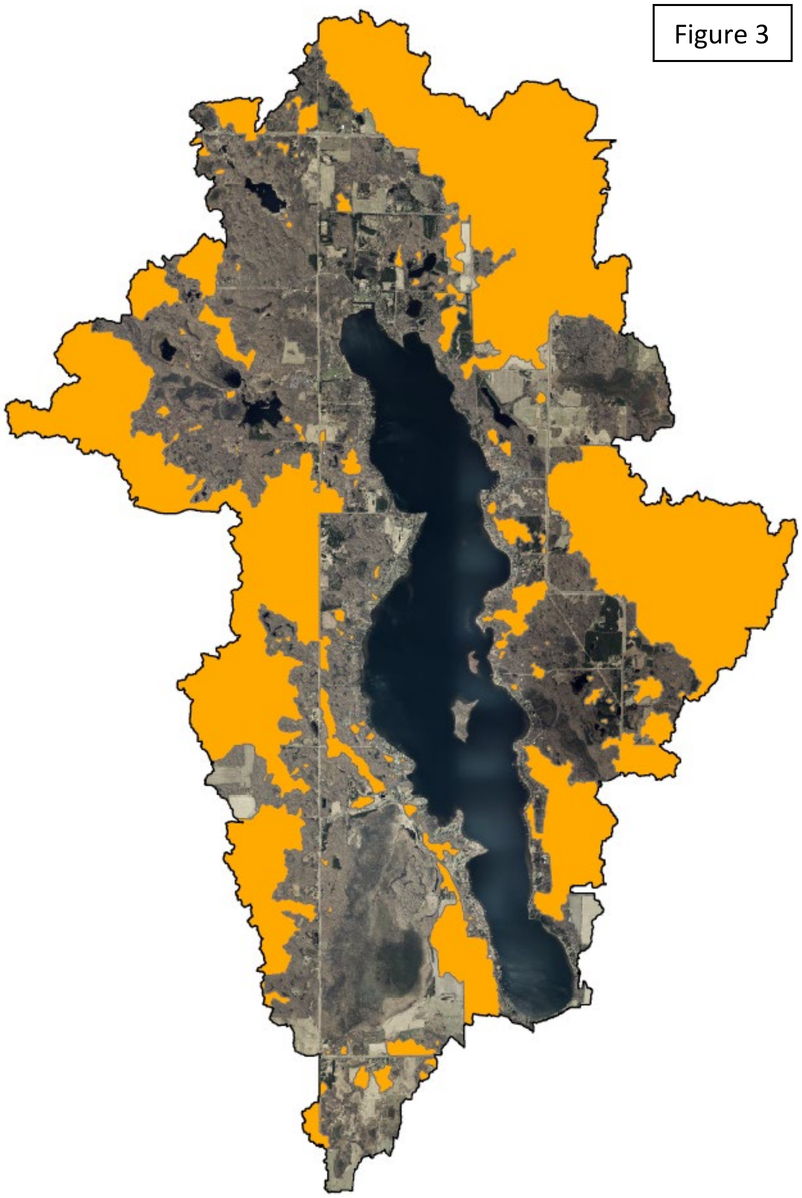
Flow accumulation is important in watershed mapping and planning. Flow accumulation maps show where water runs on the surface of the earth and eventually creates a channel. In figure 2, the yellow lines represent overland flow paths where it is unlikely a visible channel exists on the landscape; whereas, the blue lines represent visible channels. These flow paths and channels will carry water to Bone Lake during heavy rains and spring snow melt.

Flow path identification is crucial to the sitting of conservation best management practices. This report covers the sitting of conservation best management practices associated with agriculture, however these flow paths can also be used to assist in the sitting of urban/residential best management practices.

Internally Drained Areas

The Bone Lake Watershed is a unique landscape because part of the landscape is internally drained. Internally drained areas are depressions on the landscape that accumulate water during rainfall events and spring snowmelt. These depressions are deep enough that water is not able to exit the depression. Therefore, water that

Figure 3



accumulates in internally drained areas infiltrates into the ground rather than contributing to overland runoff/flow to a lake or river.

To determine the internally drained areas, the Wisconsin DNR's Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) toolbox was used. EVAAL uses a curve number-based estimation of runoff for a given frequency and duration of precipitation. The frequency and duration of the storm will allow for variation in the surface water runoff which could increase or decrease internally drained areas.

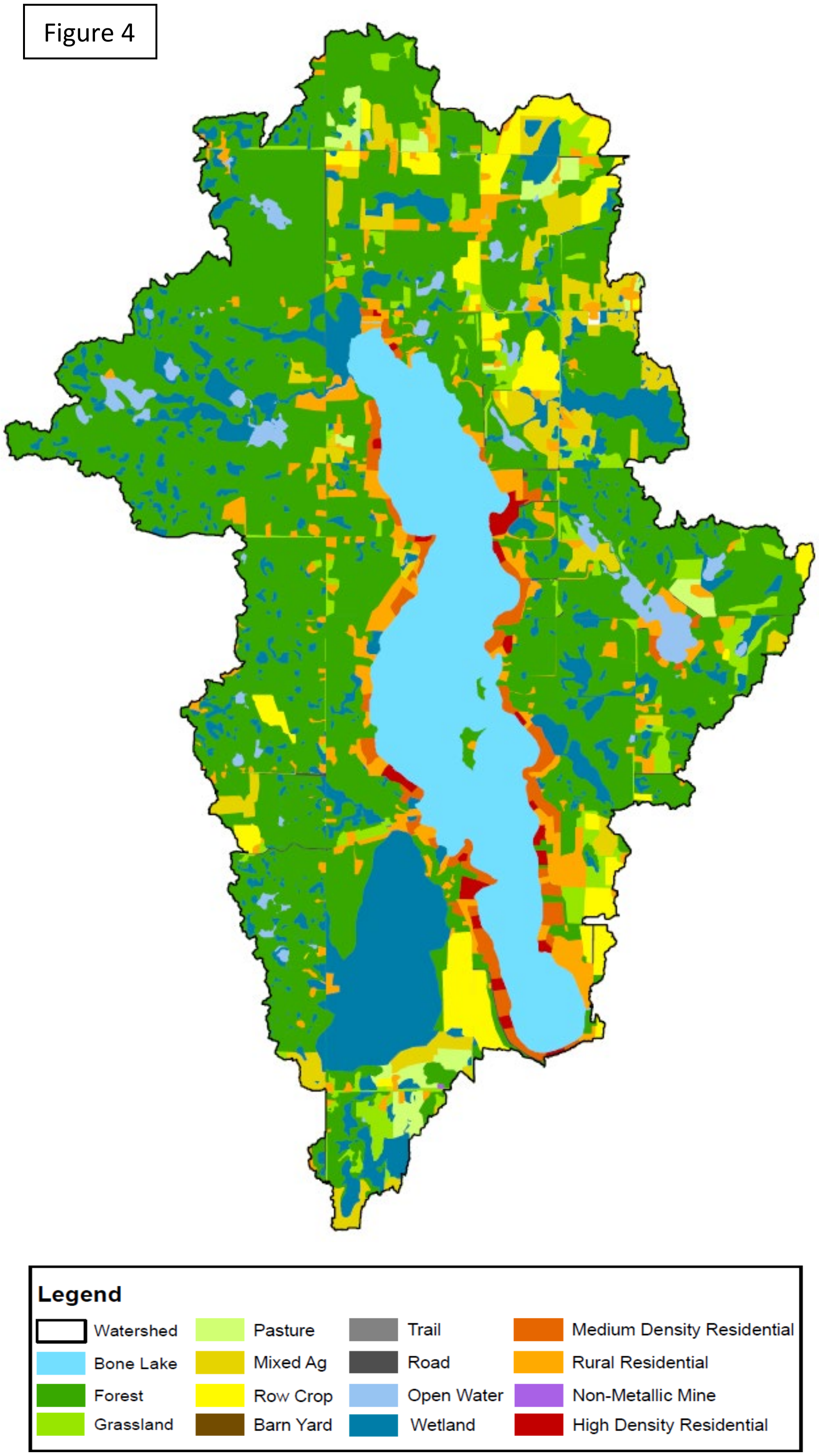
Internally drained areas are modeled based on storm intensity. For this project, a 10-year storm with a duration of 24 hours was used to model internally drained areas. This is equivalent to 4.2 inches of rain falling within a 24-hour period. This storm intensity is commonly used for design standards and is what conservation practices are designed to withstand. The areas in orange in figure 3 are internally drained based on this storm intensity

In total, 4,366 acres (42%) of the Bone Lake Watershed is internally drained. If 4.2 inches (or less) of rain falls in the watershed within a 24-hour timeframe these acres will not contribute runoff to Bone Lake. One way to prioritize project installation would be to focus more effort on the land within the watershed that contributes runoff/flow to the lake during lower intensity/duration events. It is important not to entirely discount internally drained areas because under high storm intensity events or snow melt events runoff from these areas would contribute to Bone Lake.

Land Use

When creating a nutrient budget (estimated nutrients entering the lake) land use is very important to get an accurate representation of the land cover in the watershed. The land use was delineated using the Polk County 2020 leaf off aerial imagery.

Figure 4



Land Use	Acres
Forest	5518
Wetland	1732
Bone Lake	1709
Rural Residential	721
Mixed Agriculture	518
Row Crop	483
Grassland	424
Open Water	276
Medium Density Residential	215
Pasture	169
Road	147
High Density Residential	80
Non-Metallic Mine	0.72
Total (Includes Bone Lake)	**11,993**

ACPF

The Agriculture Conservation Planning Framework (ACPF) is a toolbox in ArcMap used to identify and prioritize conservation best management practices on the landscape at a watershed scale. Hard conservation practices include grass waterways and water and sediment control basins, whereas soft practices include no-till and cover crops. ACPF determines exact locations for hard practices and ACPF outputs can be interpreted to identify fields suitable for soft practices. Implementing a combination of hard and soft practices will have a positive impact on water quality in the Bone Lake Watershed. ACPF uses high resolution LiDAR elevation data (3D model of the earth's surface), and a user supplied culvert inventory to determine surface water runoff flow paths on the landscape. Once the flow paths are created, the program prescribes conservation practices on the landscape based on slope, soils, field boundaries, and relevance to flow paths. This program is agriculture based, so the practices suggested are designed for and located within agricultural fields.

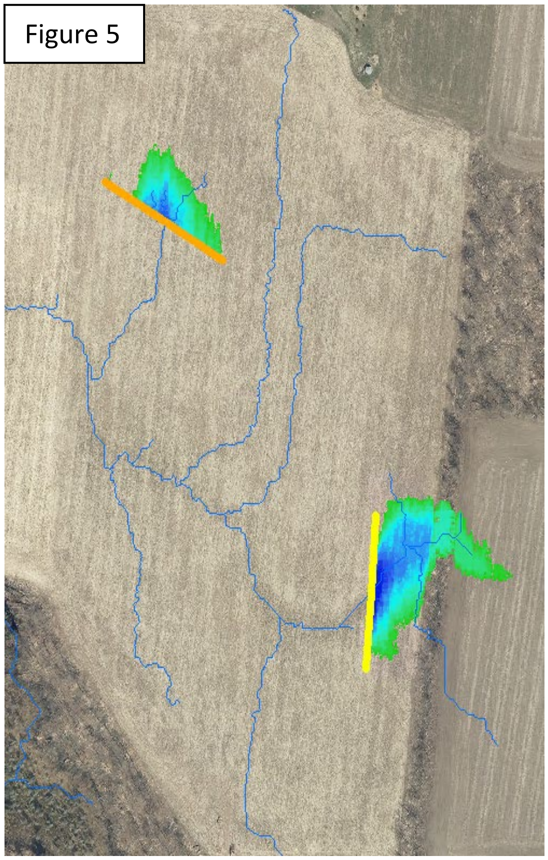
ACPF was used to identify and prioritize agricultural conservation practices within the Bone Lake Watershed. The program recommended a variety of conservation practices for implementation including water and sediment control basins, contour buffer strips, grass waterways, and sediment ponds. The following summary of each practice will include how each conservation practice works, in-field examples, and the number of potential practices identified within the watershed. ACPF prioritizes practices with adjustable criteria. The practices displayed are color coordinated based on priority, with green being lowest concern, yellow being moderate concern, orange being moderately high concern, and red being high concern. Distance to stream and field runoff risk are used to rank the priority level of conservation practices. ACPF also produces a map showing height above channel, or meters above the surface water elevation.

The outputs of ACPF allow for the prioritization of conservation practices that reduce runoff, erosion, and nutrient/sediment loading to surface waters. It is important to consider all the outputs of ACPF because the implementation of agricultural best management practices requires landowner participation and can directly impact the yields and economics for an agricultural system. Implementation of best management practices may not be possible in the highest priority areas, so it is important not to overlook lower ranked areas which will still result in a positive impact. Field verification is needed to verify the location and type conservation practice best suited for sites. The geospatial data from ACPF will be kept with the Land and Water Resources Department for landowner confidentiality; however, the will be made available to the Bone Lake board members associated with watershed improvement.

Water and Sediment Control Basin

A water and sediment control basin (WASCOB) is a 5 foot or higher embankment (yellow/orange lines in figure 5) built perpendicular to a flow path (blue line in figure 5) in an agricultural field or an area receiving runoff from an agricultural field. During a rainfall event, WASCOBs collect water in a pooling area (dark blue to green area in figure 5) and then allow the water to slowly flow through a pipe, reducing the volume of water within the flow path and reducing erosion. WASCOBs can slow down peak discharge (runoff) and reduce phosphorus loading, soil erosion, and gully formation.

Figure 5



The embankment height can be changed to increase the size of the WASCOB. A larger embankment will allow for more water to be stored during a precipitation event, which will control runoff from a greater area of the watershed.

In the Bone Lake watershed 41 potential locations for WASCOBs were identified in agricultural fields. The prescribed WASCOBs in figure 5 are ranked as moderate, and moderately high concern. Rankings consider slope steepness and proximity to stream.

ACPF ranks the WASCOBs by the number of contributing acres, or area of land that drains to each WASCOB. This ranking system is assuming the largest WASCOB will have the greatest impact on water quality. However, a smaller contributing area with poorer soil conditions, steeper slope, or closer proximity to a tributary may have a greater impact on water quality. All sites should be field verified to prioritize the order of project implementation.

Contour Buffer Strips

Figure 6

Contour buffer strips are strips of perennial vegetation planted parallel to the contour line (red and green lines in figure 6) that intercept the flow of surface runoff. Contour buffer strips are often alternated throughout a field to allow for farming practices to continue between the buffer strips. This practice uses permanent vegetation to reduce the overall length of farmed land on a slope which reduces the accumulation and speed of runoff. This practice reduces erosion and overall runoff volume, improving water quality, and preventing the formation of gullies.

A total of 48 contour buffer strips were identified in the Bone Lake Watershed. These practices were categorized based off runoff risk potential and slope. Runoff risk is the risk of direct runoff contributing to stream channels within the watershed.

In figure 6, ACPF prescribed multiple buffer strips in one field with one field with a designation of low due to the shallow slope of the field and relevance to surface waters. If these practices were installed at this location the multiple strips of vegetation will significantly reduce the surface runoff within the field.

Grass Waterways

Figure 7

Grass waterways are installed within a concentrated flow path in an agricultural field where there is a high probability of concentrated runoff. Grass waterways are planted with perennial grasses and are maintained in permanent vegetation. Installing grass waterways in areas where concentrated water flows through a field ensures that water is moving within a vegetated flow path (rather than over bare soil) which reduces the velocity of water and the risk of erosion and gully formation. The deep roots of the grasses keep the soil in place and reduce the amount of soil being transported by water in a runoff event. However, grass waterways do not trap or store water and sediment; rather, they are reducing sediment loss where erosion and runoff has a high probability of occurring on the landscape.

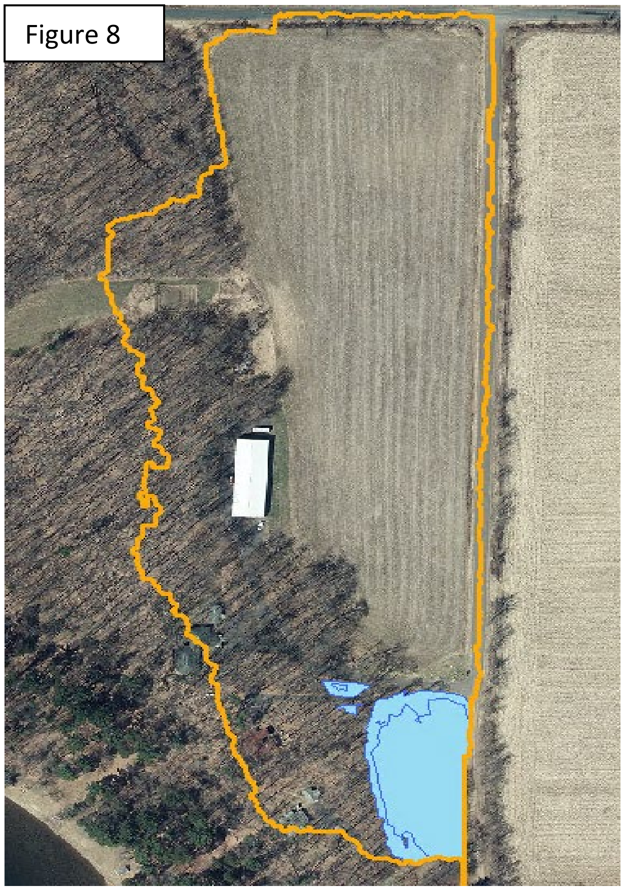
ACPF identified 104 locations within the Bone Lake Watershed where grass waterways could potentially be implemented. Figure 7 contains networks of grass waterways within the same field and the ranking is based off the mean slope of the field. In the aerial photo, the area of moist soil indicates a drainage area and on the wet years is most likely not being farmed and would be a great location for a grass waterway.

Since ACPF suggests multiple waterways in this location with a designation of medium priority a site visit would be needed to assess the feasibility of the project and identify the grass waterway network that would be effective for this location. The implementation of grass waterways will reduce soil erosion within fields, resulting in a reduction in nutrients entering surface waters.

Sediment Ponds

Sediment ponds are depressions that are created in areas of higher slopes where other practices are not suitable. They are designed to catch runoff, reduce erosion, and allow for sediment and nutrients to settle out before entering surface waters. The outlet of the pond is reinforced to ensure no erosion occurs when the pond reaches maximum capacity and outlets to surface water. Sediment ponds can catch runoff from five to one hundred acres of contributing area (drainage area).

Figure 8



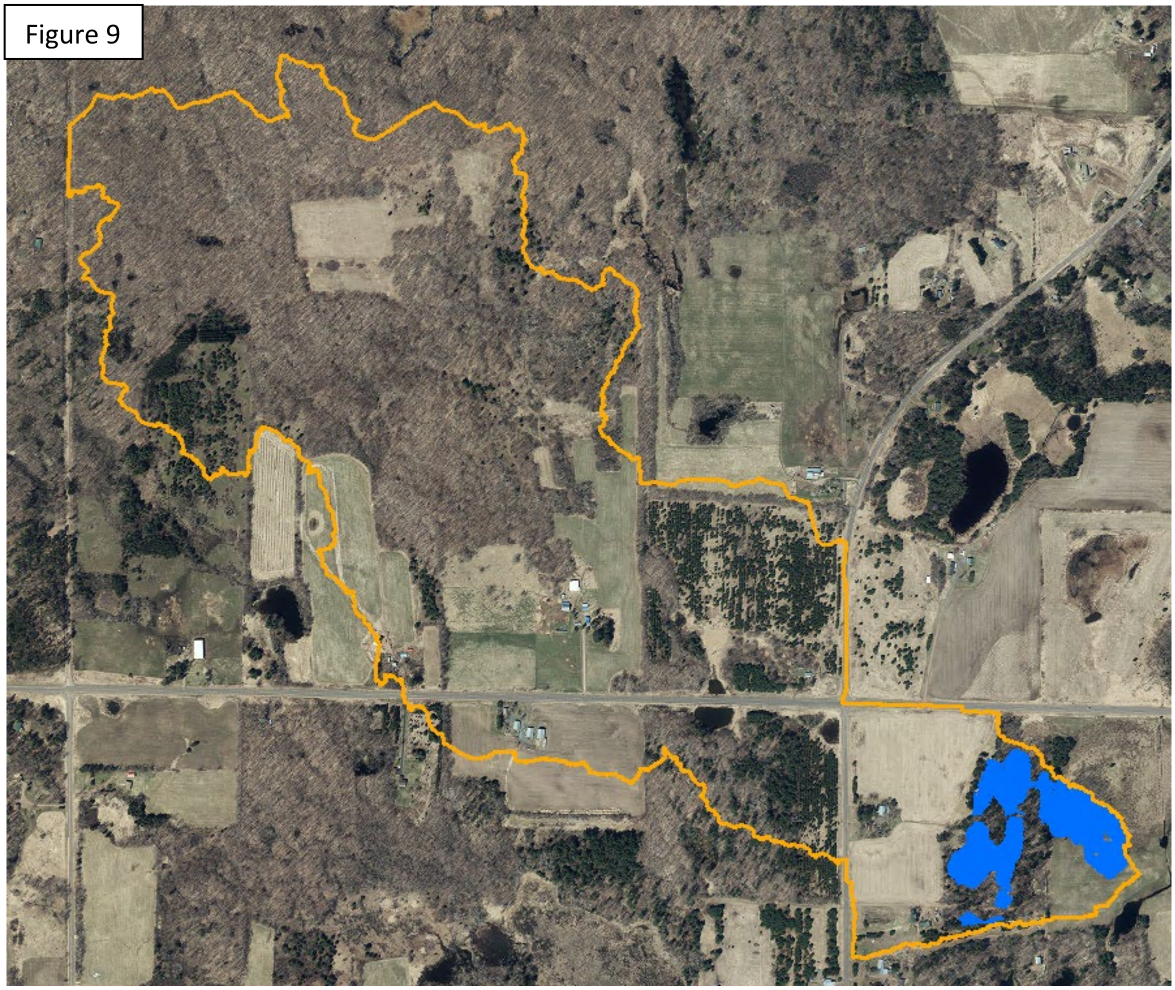
There were 81 areas in the Bone Watershed that ACPF identified as suitable for a sediment pond. In figure 8 the blue area is the prescribed location for the sediment pond, and the orange line is the drainage area for the pond. If overland flow occurs during a rainfall event, any rainwater that falls within the orange area will drain to the pond.

The prescribed practice location in figure 8 is an ideal location for the installation of a sediment removal pond. Almost the entire contributing area to this pond is agricultural land and the installation of the pond would not take any land out of production making the proposed project more appealing to the landowner. Implementing this practice in this location would keep nutrients and sediment from entering surface water and reduce the overall impact from the agricultural practices occurring in this field.

Nutrient Removal Wetlands

Nutrient removal wetlands are much like the previously discussed sediment ponds. However, nutrient removal wetlands typically do not have standing water other than after large rain events or spring melt whereas sediment ponds contain water most of the year. In figure 9 the blue area is the wetland, and the orange line is the drainage area for the pond with a large area including agricultural lands. Wetlands are also full of native plants which use nutrients as well as increase wildlife and habitat. Nutrient removal wetlands are designed to have a significant impact on reducing the amount of phosphorous and nitrogen entering surface waters as well as ground water recharge. ACPF identified 13 areas where nutrient removal wetlands could be implemented that would be receiving agricultural runoff.

Figure 9



Field Runoff Risk

This tool is used to identify areas of concern by ranking agricultural fields based on their runoff potential and the risk of direct runoff contributing to stream channels within the watershed. This tool takes into consideration slope, soil type, and land use classification (row crop or pasture) in the ranking process. This portion of ACPF can be paired with the results from other models, such as EVAAL, to pinpoint fields in the watershed of most concern that would benefit from implementation of conservation practices.

In figure 10 each defined field is given a runoff risk classification. Multiple fields in figure 10 are ranked as low (green), which is partly due to the shallow slope and proximity to flow paths. The fields ranked as moderate (yellow) and high (red) are steeper fields with a closer proximity to a major flow path contributing to Bone Lake.

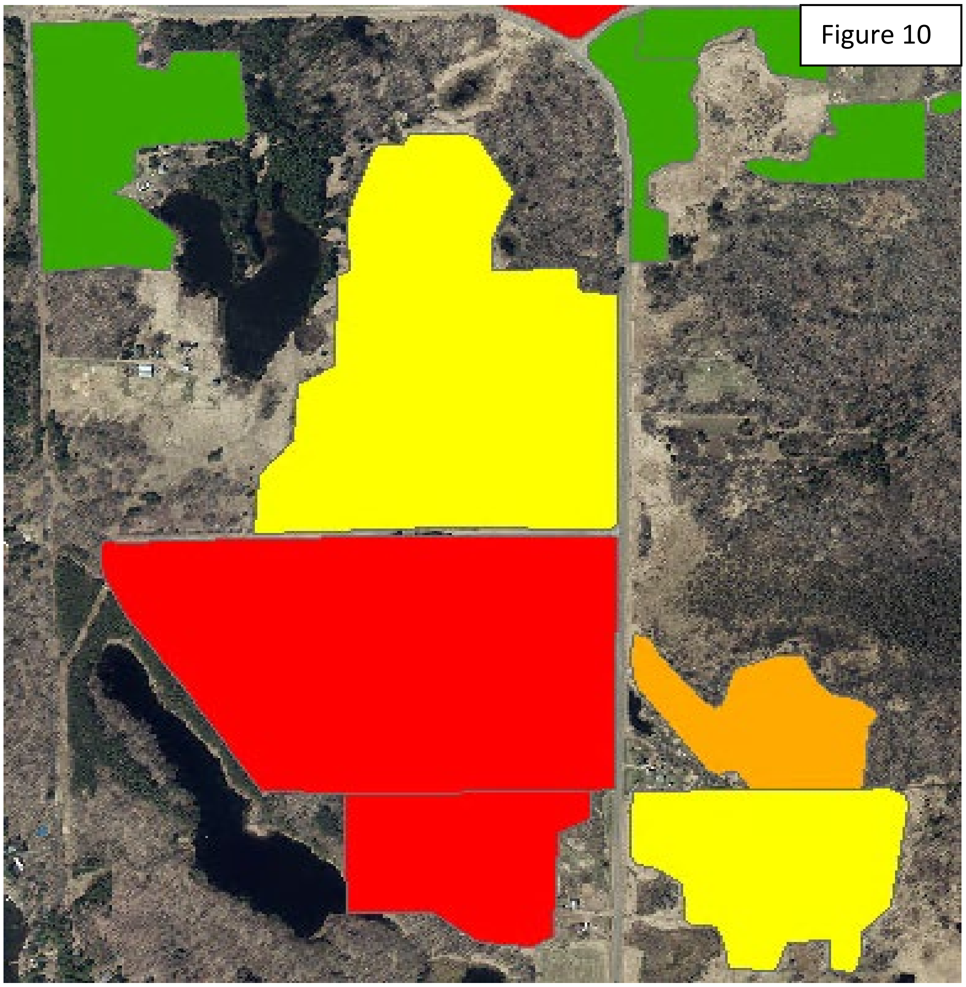


Figure 10

Fields classified as having high runoff risk would be excellent candidates for the implementation of no-till or cover crops. No-till planting is a conservation practice where crops are grown without the use of soil tillage (figure 11). Soil tillage is a common agricultural practice used to loosen soil, incorporate crop residue and plant nutrients (fertilizer and manure), and prepare a suitable seed bed for planting the crop. However, tillage increases the potential of soil erosion and nutrient runoff. Tillage breaks the soil structure, inhibits the process of soil aggregation, and reduces surface crop residue. Tilled soil is left exposed and is more susceptible to the erosive forces of wind and water.

Planting cover crops (as seen in figure 12) is another conservation practice that can reduce agriculture's impact on water quality. Cover crops are plants that are grown outside of the main production crop specifically for their benefits to the soil. The primary benefit of cover crops is the reduction of erosion. Cover crops reduce erosion because the vegetation and roots protect the soil from early spring and late fall rains when the primary crop is not growing. Cover crops can increase infiltration, capture unused nutrients, build soil structure, promote soil bacteria and fungi growth, break compaction layers, suppress weeds, and provide many other benefits to the soil and environment.

With limited agricultural land in the Bone Laked Watershed, promoting cover crops and no till to all the agricultural producers would be beneficial to improving water quality in the watershed.

Figure 11

Figure 12

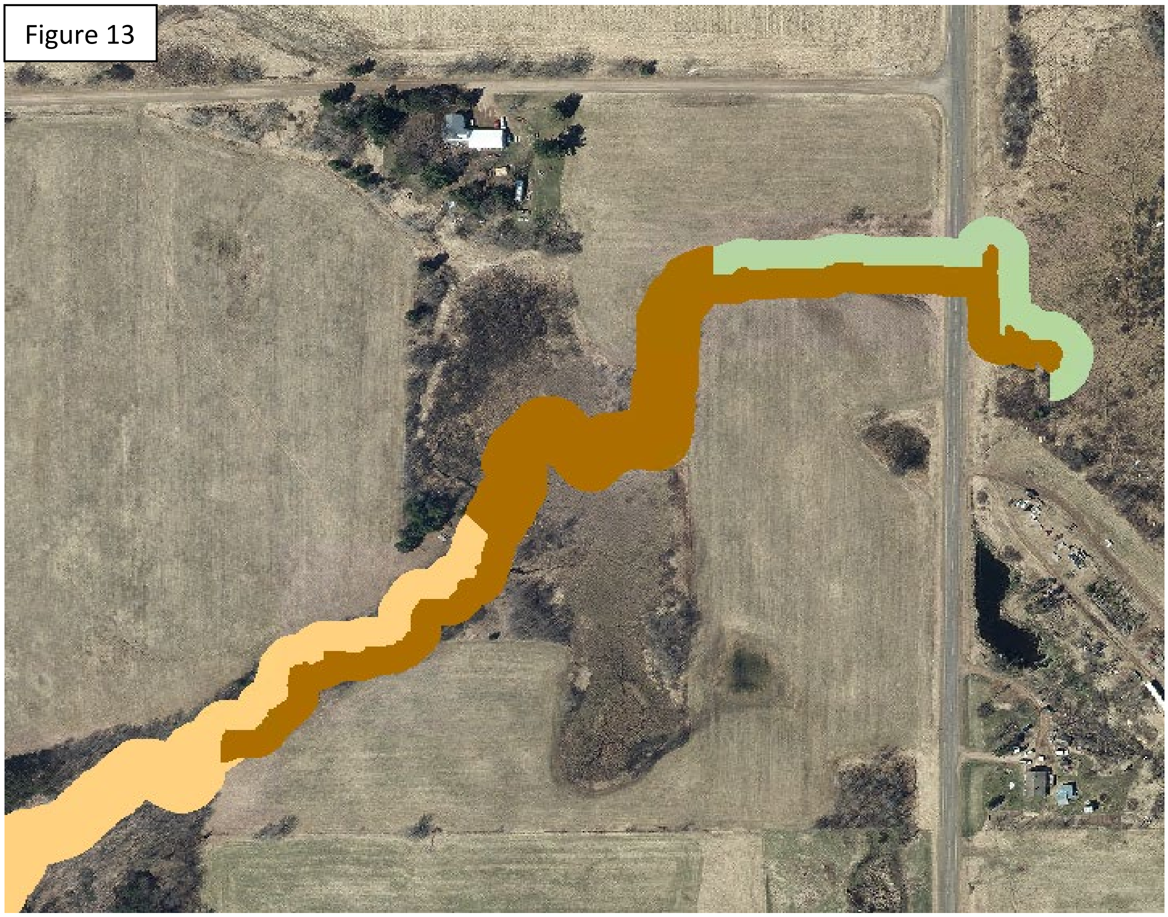
Riparian Attribute Polygons

The riparian attribute polygons tool splits the main tributaries and waterbodies into 250-meter stream corridor segments and creates a 15-meter buffer area on each side of the stream/waterbody as displayed in figure 13. Three factors are determined for each 250 x 15-meter stream segment: preferred buffer type, desired buffer width, and runoff risk.

The preferred buffer type is determined using slope, land use, and soils. The three main buffer types include deep rooted vegetation, multiple species vegetation, and stream bank stabilization.

In areas where deep-rooted vegetation, multispecies buffer, and stiff steamed grasses are prescribed by ACPF, the program believes there is an opportunity for the buffer to intercept surface runoff and/or shallow ground water. When none of these opportunities are possible, the stream bank stabilization designation is given. Site visits will still need to be conducted to address site suitability and identify the best practice or buffer for the specific site.

Figure 13



An additional output from the riparian attribute polygons tool is the prescription of a desired buffer width in meters along the main stream segment. ACPF takes into consideration the amount of low-lying land surrounding the stream segment as well as the amount of potential surface water runoff that enters the 200-meter stream segment and determines the natural capacity for a riparian zone to provide water quality benefits through a riparian buffer.

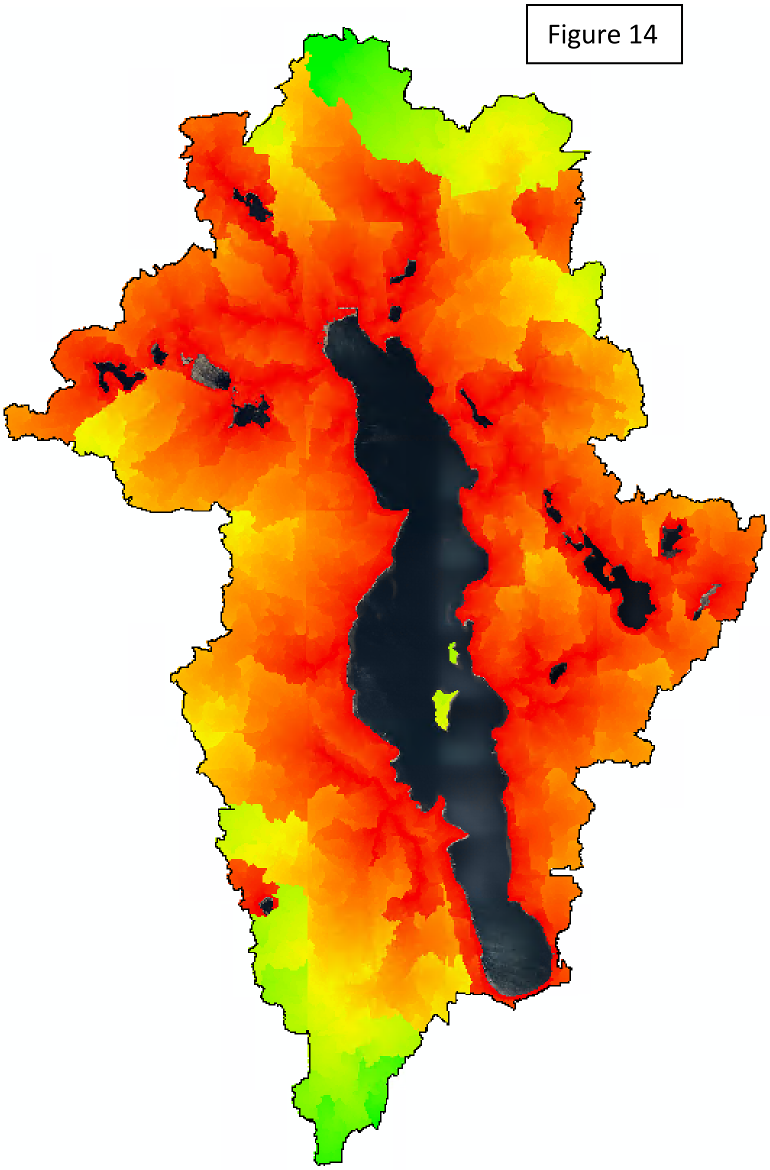
For each individual stream segment, ACPF provides a designated riparian buffer width in meters. In the Bone Lake watershed, the range of buffer was from 6 meters to 90 meters with the average being 21 meters. Many of the areas that would benefit from a substantial buffer are surrounded by woods and wetlands. Areas around the stream bank that are already surrounded by natural areas are already beneficial to overall water quality and ideally, these areas would stay undeveloped.

In an agricultural setting, a 90-meter buffer may be an unrealistic option for a producer, considering these acres would no longer be used for crop production and would have a financial impact on the producer. The areas with the greatest buffer width may be the areas to focus on for implementation, working with the producer to identify a width that benefits water quality and is a manageable size for the producer.

Distance to Stream

The distance to stream output uses flow direction, stream reach, and slope to determine the relative risk of sediment delivery to Bone via tributaries. The tool ranks the land in the watershed according to the distance from the main streams in meters.

Figure 14



The distance to stream output is displayed on a scale from dark red to light green. Dark red areas represent the main flow path or areas likely to have the most impact (nutrient loading) on the lake. The light green represents the areas of the watershed that are likely to have the least impact (nutrient loading) on the lake.

The distance to stream map (figure 14) can be used to prioritize where to implement conservation practices, with areas in red being the most critical for implementation due to the proximity to the drainage network. Even though the green areas are the farthest from the stream and likely have the lowest impact to Bone Lake, they should not be overlooked. The areas in green overlap with the internally drained areas which do still contribute runoff during snowmelt and larger than 10 year 24-hour storms. Implementation in the green areas could still be important and beneficial in watershed management. The Bone Lake watershed is unique in the fact that it has a complex drainage network making nearly all the watershed an area of high concern for project implementation. However, this is also beneficial for watershed management because it gives ample opportunity for the implementation conservation practices that will have a significant benefit to surface water.

Conclusion

The Bone Lake Watershed is 10,284 acres (11,993 total watershed size including Bone Lake) and has relatively lower agricultural land compared to other watersheds in the Polk County. ACPF identified a small number of high priority practices throughout the watershed which creates focus areas for best management practice implementation. Since agricultural producers in the watershed are limited, building strong relationships with the producers is critical to successful project implementation.

ACPF only sites agricultural best management practices but additional outputs from the program can be very useful in watershed improvement projects. The distance to stream raster highlights the shoreline of Bone Lake as having a greater influence on water quality as compared to other areas in the watershed. This is largely due to the absence of perennial tributaries which allow for a direct influx of nutrients.

Improving water quality on a watershed wide scale requires a combination of best management practices including agricultural, shoreline, and residential. Implementing these practices in conjunction with one another will significantly reduce nutrient loading to Bone Lake.

The Wisconsin Department of Natural Resources surface water grant program has funding to implement agricultural and shoreline best management practices. Larger scale projects need to be shovel ready (completed engineered designed plans) before an implementation grant will be awarded. However, a planning grant can be applied for to cover the costs of the design work.

Not all shoreline improvement projects require engineered plans. The Healthy Lakes Grant provides shoreland property owners up to \$1,000 per practice (rain garden, 350 ft^2 native planting, diversion, rock infiltration, and fish sticks). The eligible practices have simple designs and are meant to be installed by the landowner. The funding can be used for a contractor but typically the overall project cost is greater when a contractor is completing the work.

Improving water quality is a long-term project and takes years of good land management to see results. The implementation table on the next page outlines the steps moving forward to implement conservation best management practices prescribed by ACPF.

Implementation Table

Step 1. Outreach	Timeline	$ Estimate	Volunteer hours	Partners	Funding sources
A. Draft and send a letter to landowners to gauge interest in installing ag BMP's	2025	$1 per letter	2-6	LWRD	District/ WDNR
Step 2. Site Visits Who will be responsible for this step?	**Timeline**	**$ Estimate**	**Volunteer hours**	**Partners**	**Funding sources**
A. Arrange site visits with landowners	2025	$	1-4	LWRD	District/ WDNR
B. Complete site visits with landowners	2025	$		LWRD	District/ WDNR
C. Receive landowner commitment	2025	No cost		LWRD	District/ WDNR
Goal 3. Design	**Timeline**	**$ Estimate**	**Volunteer Hours**	**Partners**	**Funding Sources**
A. Determine and secure funding sources to cover design costs	2025-2026	$		LWRD	District/ WDNR
B. Complete designs for conservation BMP's	2026	$-$$		LWRD	WDNR
Goal 4. Implementation	**Timeline**	**$ Estimate**	**Volunteer Hours**	**Partners**	**Funding Sources**
A. Install conservation BMP's	2026-2027	$-$$$		LWRD	District/ WDNR

District = Bone Lake Protection and Rehabilitation District
WDNR = Wisconsin Department of Natural Resources
LWRD = Polk County Land and Water Resources Department