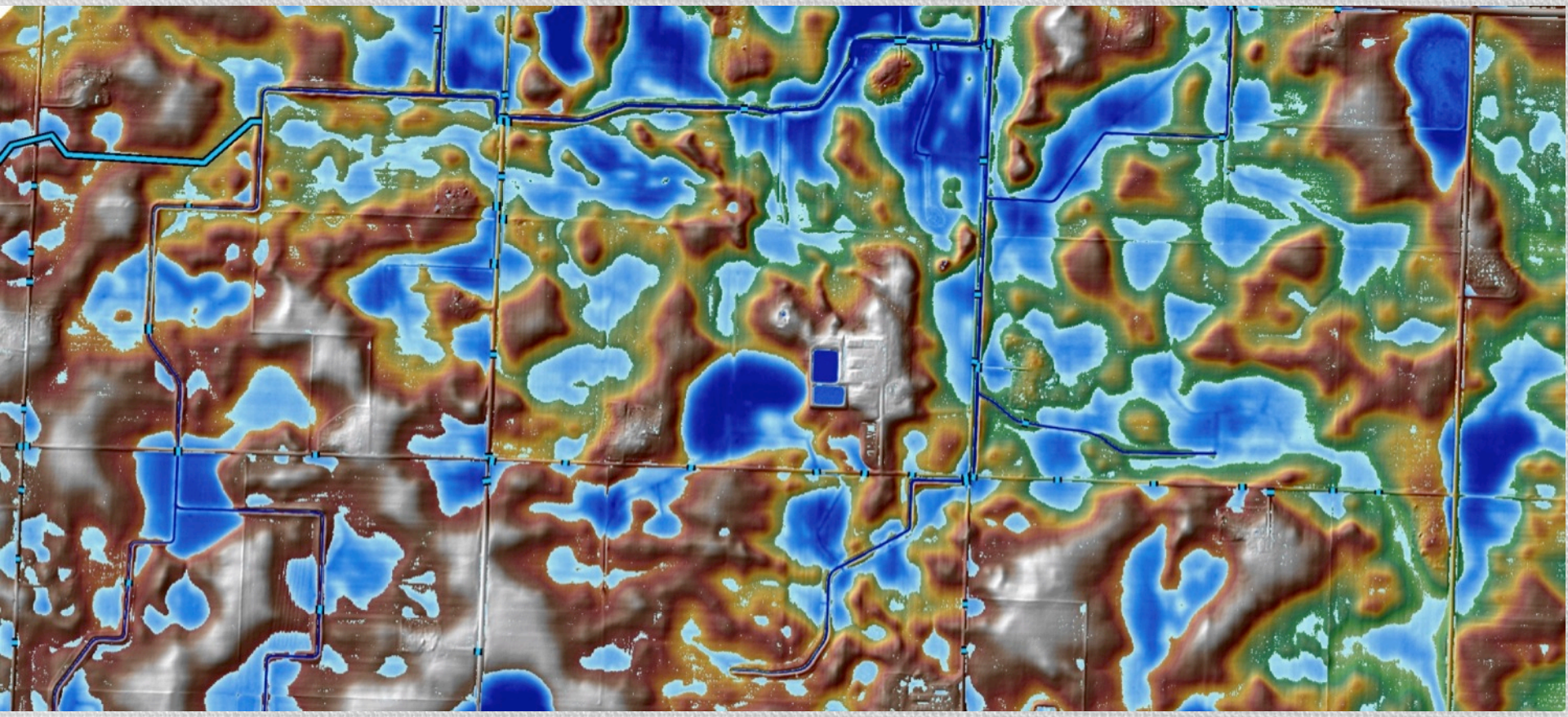
Terrain Analysis

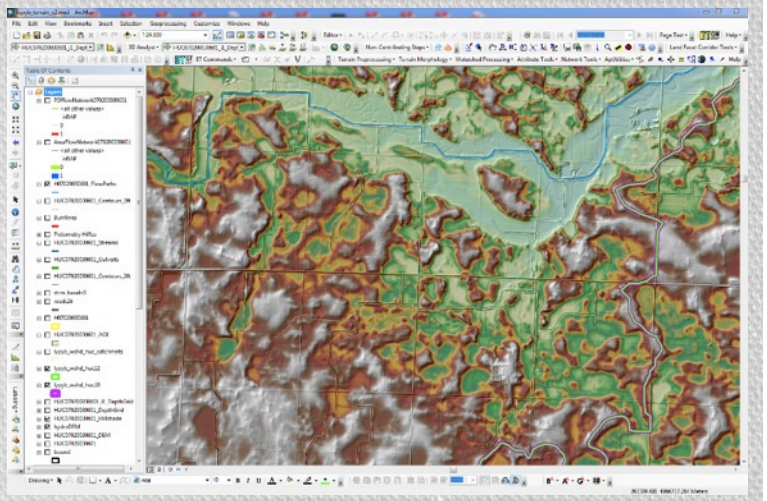
Trout Brook – Cannon River



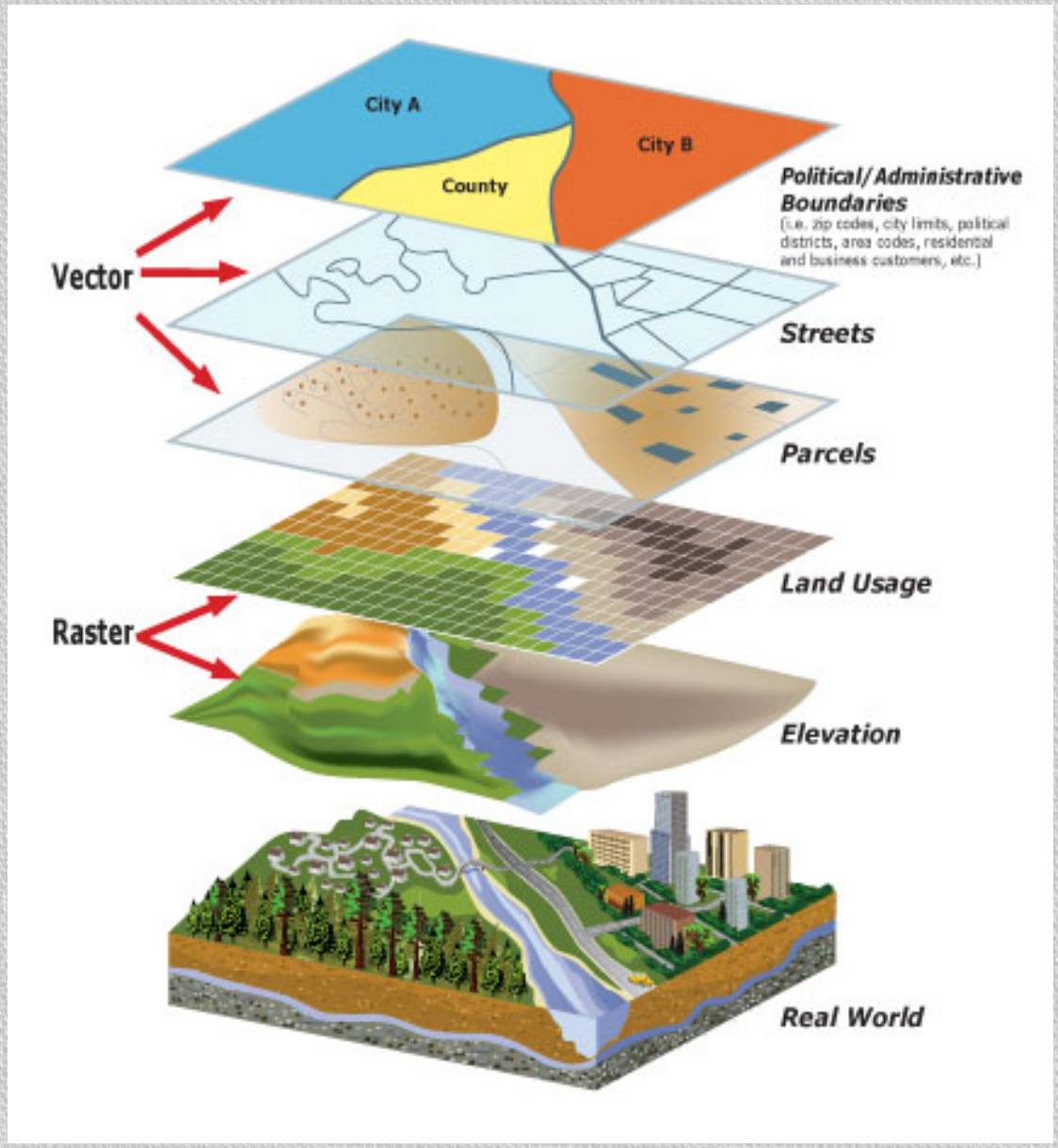
Water Resources Center Minnesota State University, Mankato
Jessica Nelson, Rick Moore, Andrew Meyer

Agricultural Conservation Planning Framework
National Laboratory for Agriculture and the Environment
U.S. Department of Agriculture, Agriculture Research Service
Mark Tomer, Sarah Porter, David James, and Kathy Boomer (TNC)

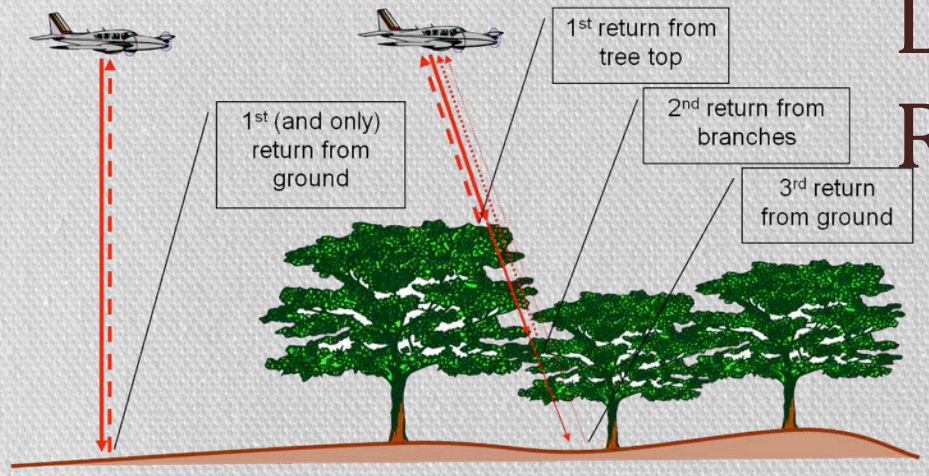
Geographic Information Systems (GIS)

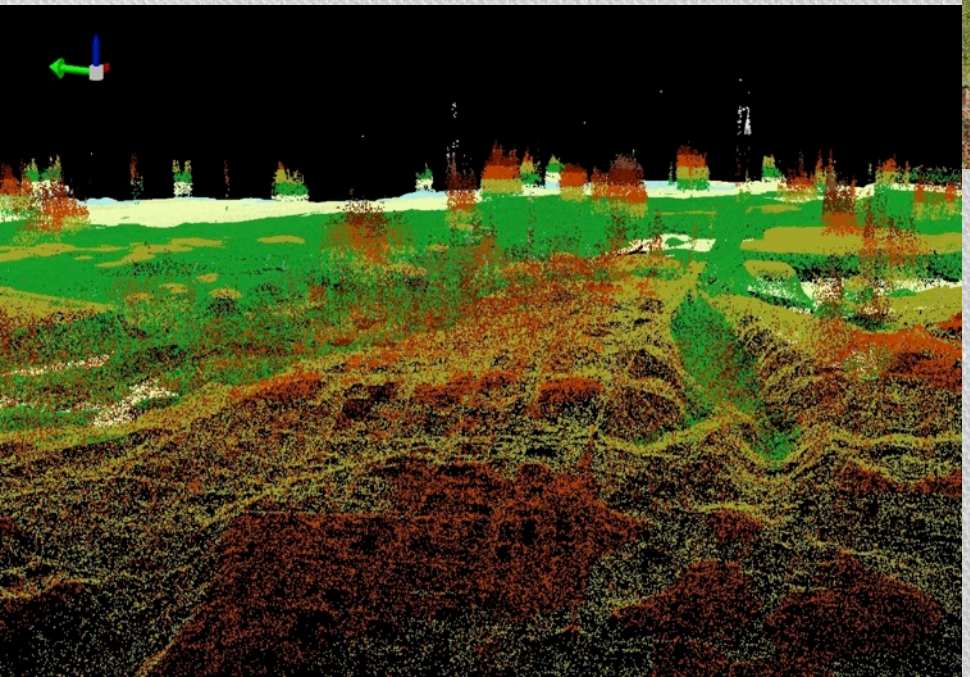


A GIS combines layers of information about a place to give you a better understanding of that place.



Light Detection and Ranging (LiDAR)





- Lidar: pulsed laser used to measure ranges (distance)
- Lidar data can be used to vegetation intensity through series of algorithms

Terrain Analysis

Trout Brook – Cannon River Terrain Analysis

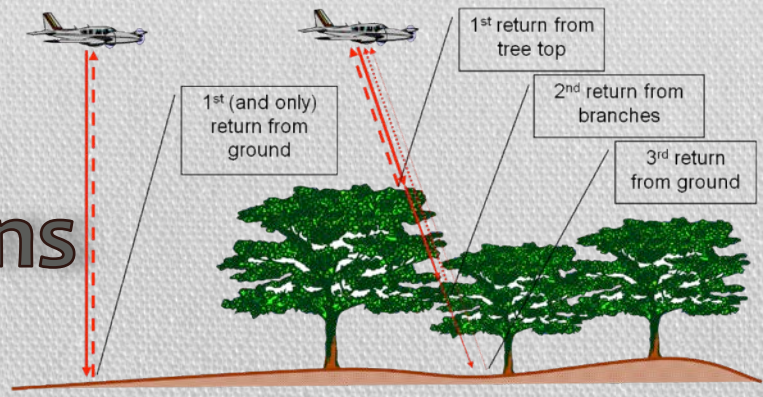
Creation of Burnlines/Culvert Inventory and Hydrologically corrected DEM's

- Culvert/Burnlines inventory featuring culverts, drain tiles, and other water conveyance features.
- Local assistance in identifying and verifying of culverts and conveyance features.

- Calculating the secondary attributes using the hydrologically corrected DEM's
  - Stream Power Index and Compound Topographic Index analysis

- Identify focus areas for Different Conservation BMP's
  - Identify sensitive focus areas
  - Identification and mapping of these focus areas.

Terrain Analysis Definitions

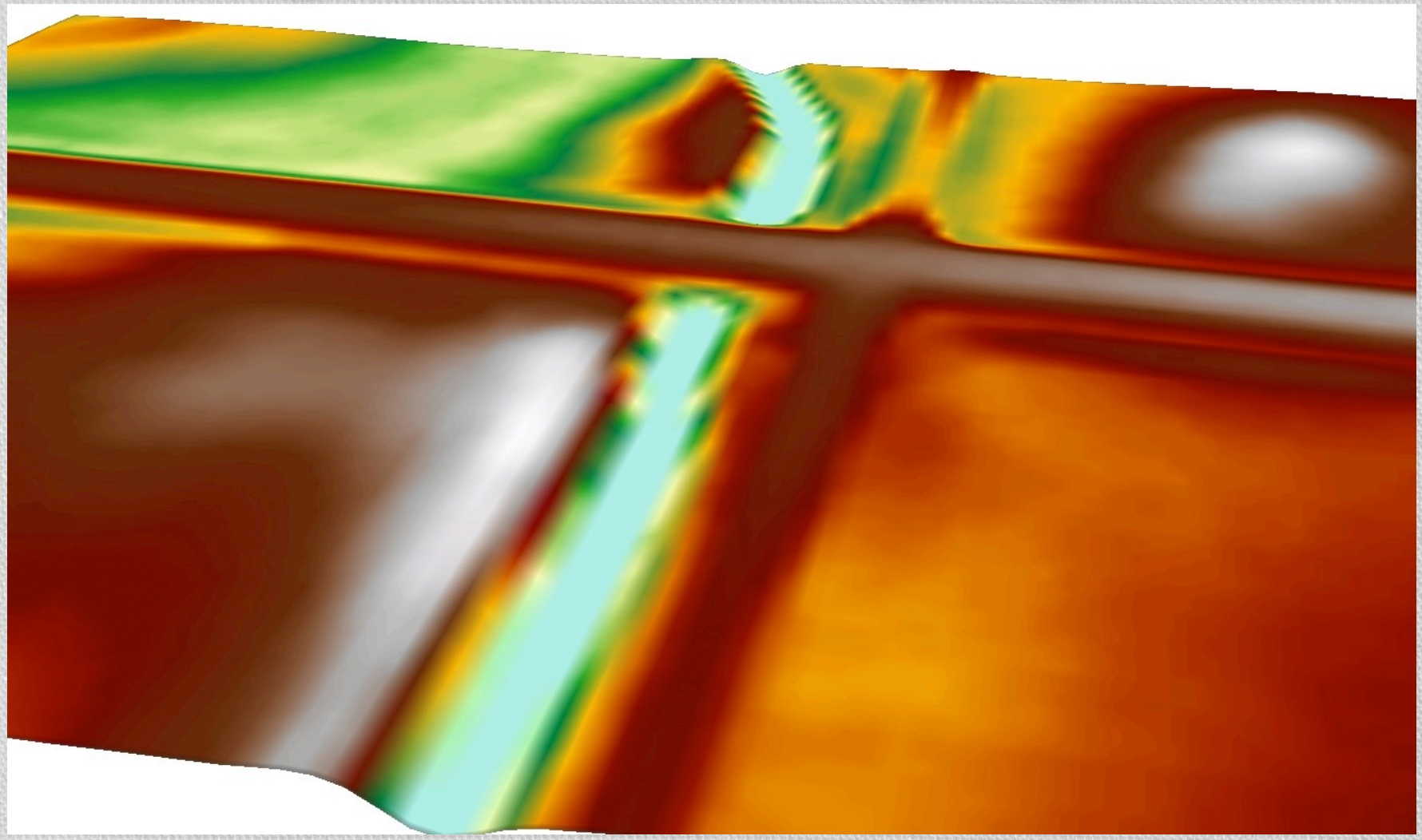


- **LIDAR (Light Detection and Ranging)**
  - A system for measuring the location of a reflecting object by emitting timed pulses of laser light and measuring the time between emission and reception of reflected pulses. The measured time interval is converted to distance.
- **Terrain Analysis**
  - Use of remote sensing data for mapping, analyzing, and interpretation of geographic information on the natural and man-made features of the terrain often utilized in land use planning, forest site assessment, wildlife habitat, water quality and soil conservation management.
  - GIS software may be applied to derive primary and secondary terrain attributes to describe the morphology of the landscape and the influence of topography on environmental processes.
- **Hydrologic Conditioning**
  - The process of modifying the elevation values in a DEM through raster processing and or interpolation to make the DEM more suitable for most hydrologic analyses. The modification process typically involves breeching digital dams (lowering the outlet) and elevating user-defined sinks to ensure that water flow paths are accurately represented in the conditioned DEM. Hydrologic conditioning is sometimes referred to as hydrologic correction and DEM drainage enforcement.
- **DEM (Digital Elevation Model)**
  - An elevation model of the bare earth surface created for use in computer software having regularly spaced horizontal grid cells (x and y) and an associated vertical (z) value representing elevation for each cell.

- "Digital Dams"
  - Culverts, bridges, any subsurface drainage alterations
  - Creates errors in subwatershed areas at points downstream

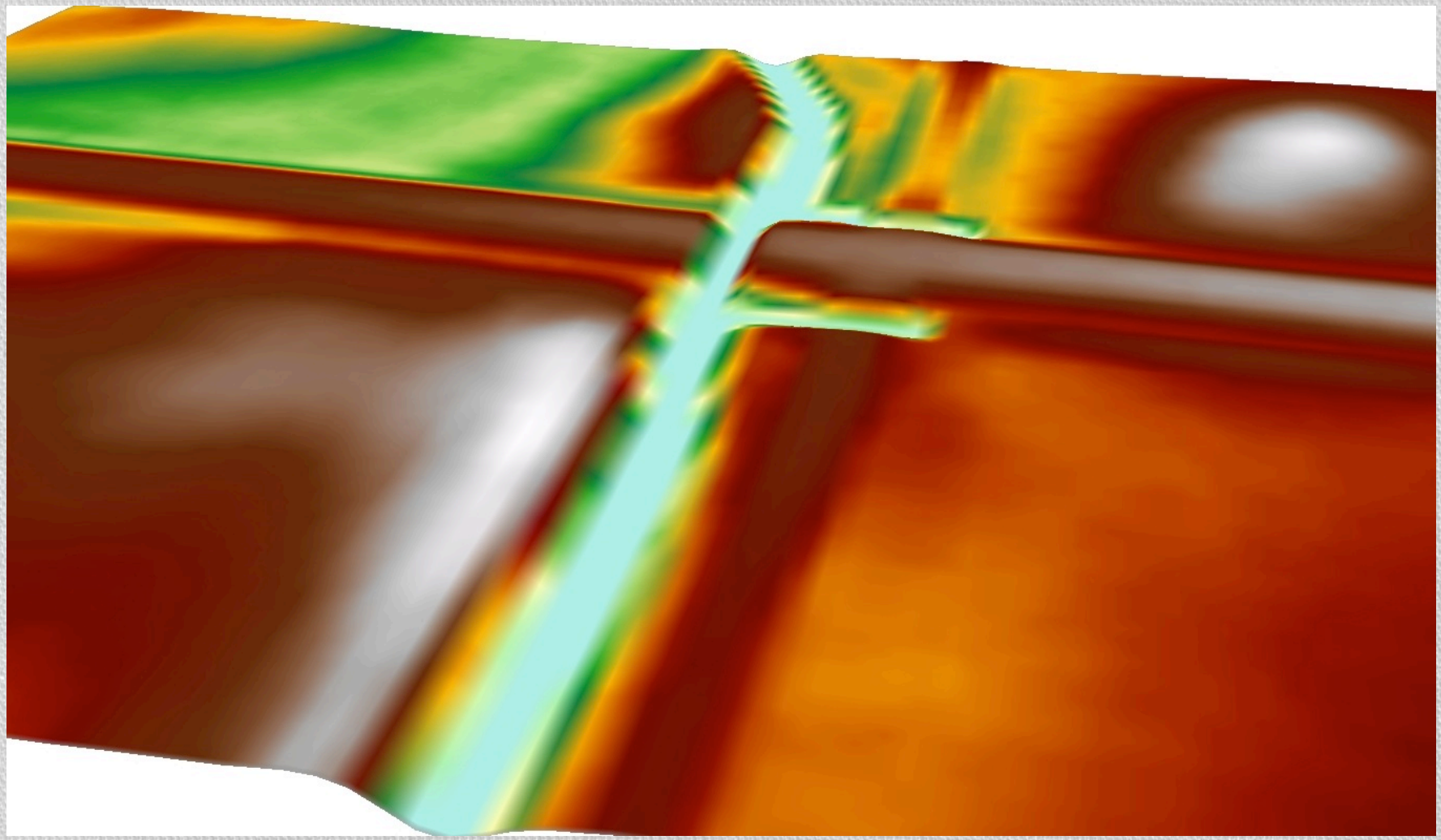
Terrain Analysis – Hydrologic Conditioning

Hydrologic Conditioning Digital Dams



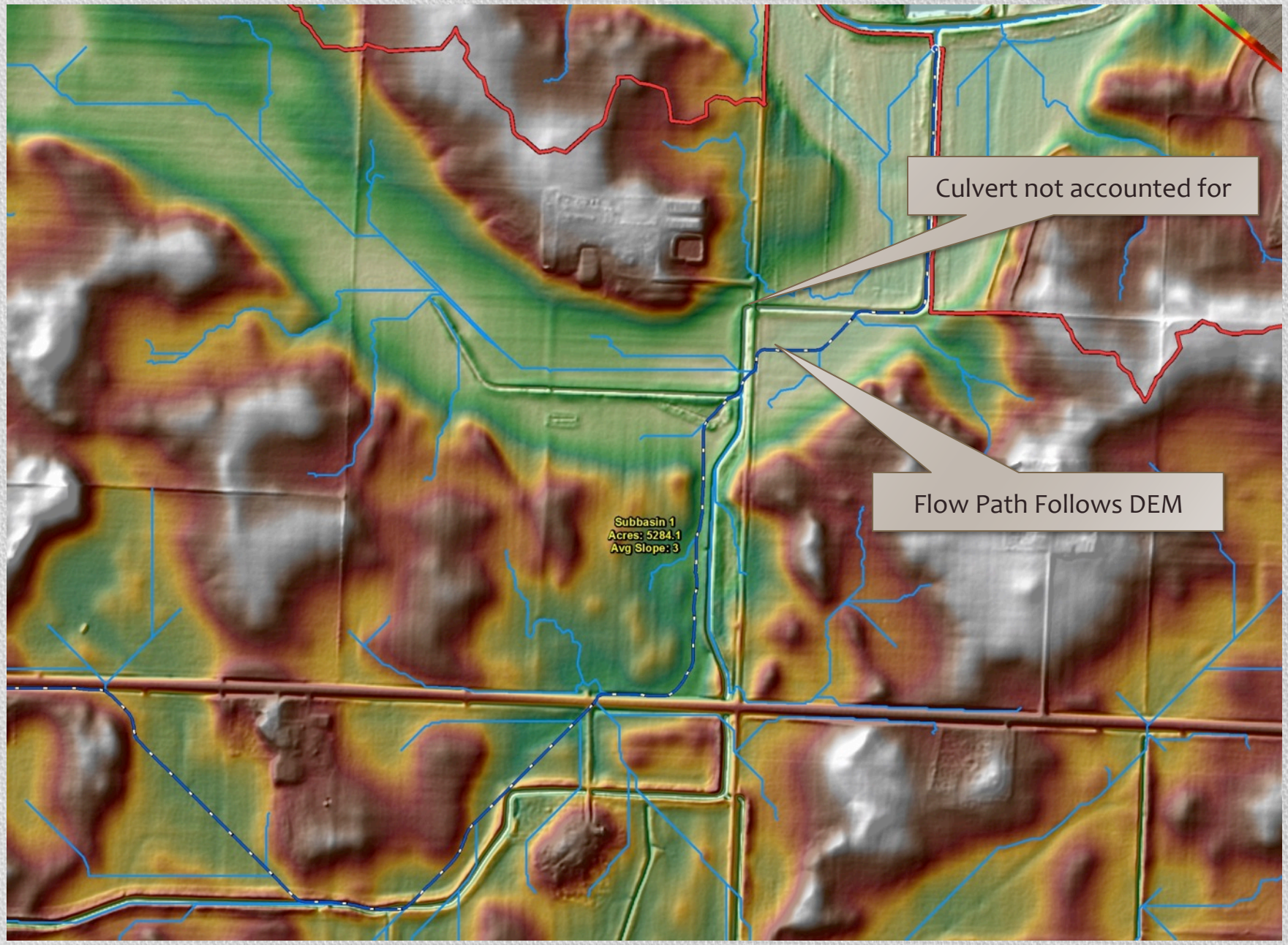
- "Digital Dams"
  - Culverts, bridges, any subsurface drainage alterations
  - Creates errors in subwatershed areas at points downstream

Hydrologic Conditioning Digital Dams

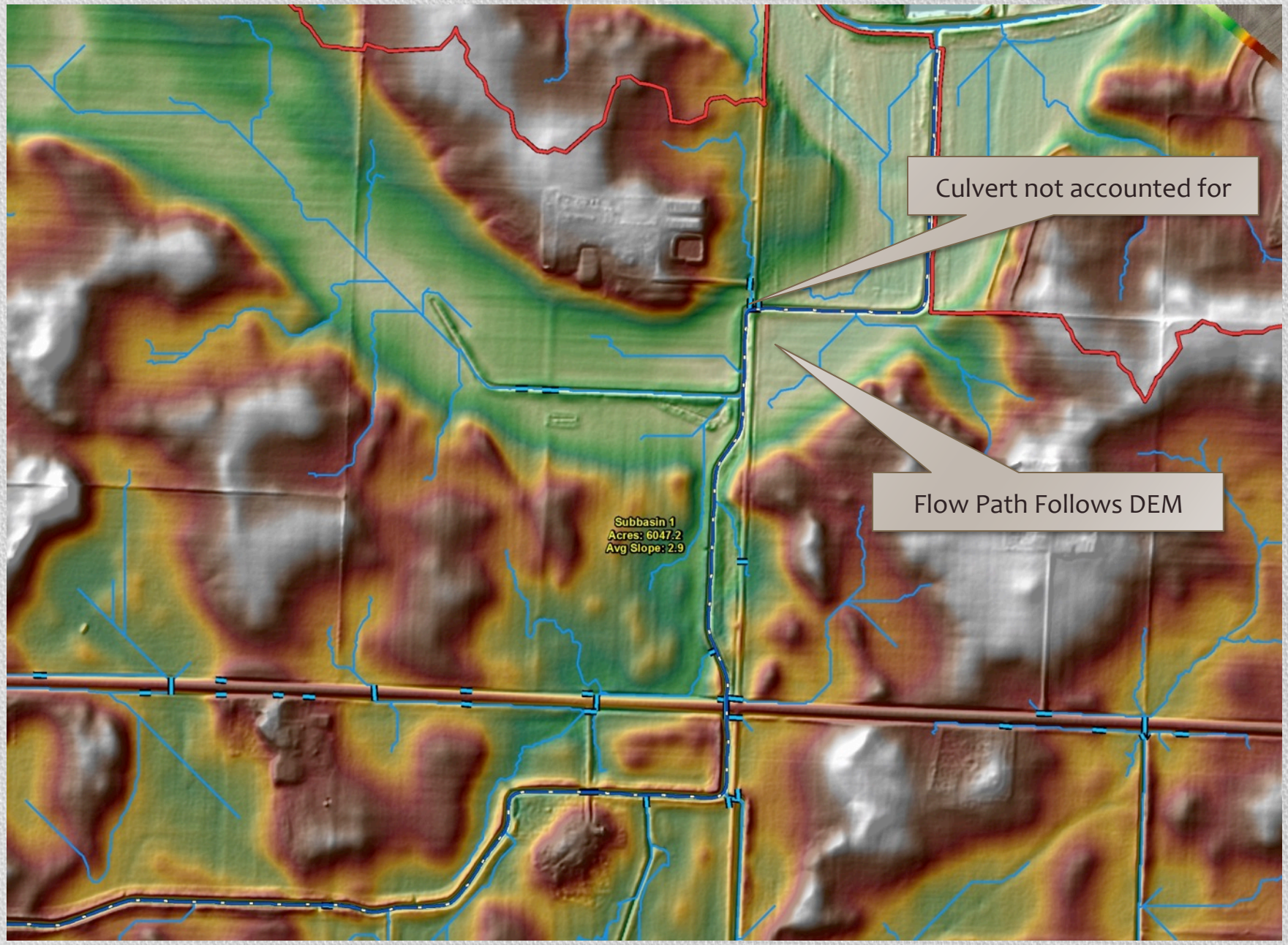


- "Digital Dams"
  - Culverts, bridges, any subsurface drainage alterations
  - Creates errors in subwatershed areas at points downstream

Impacts of Reconditioning

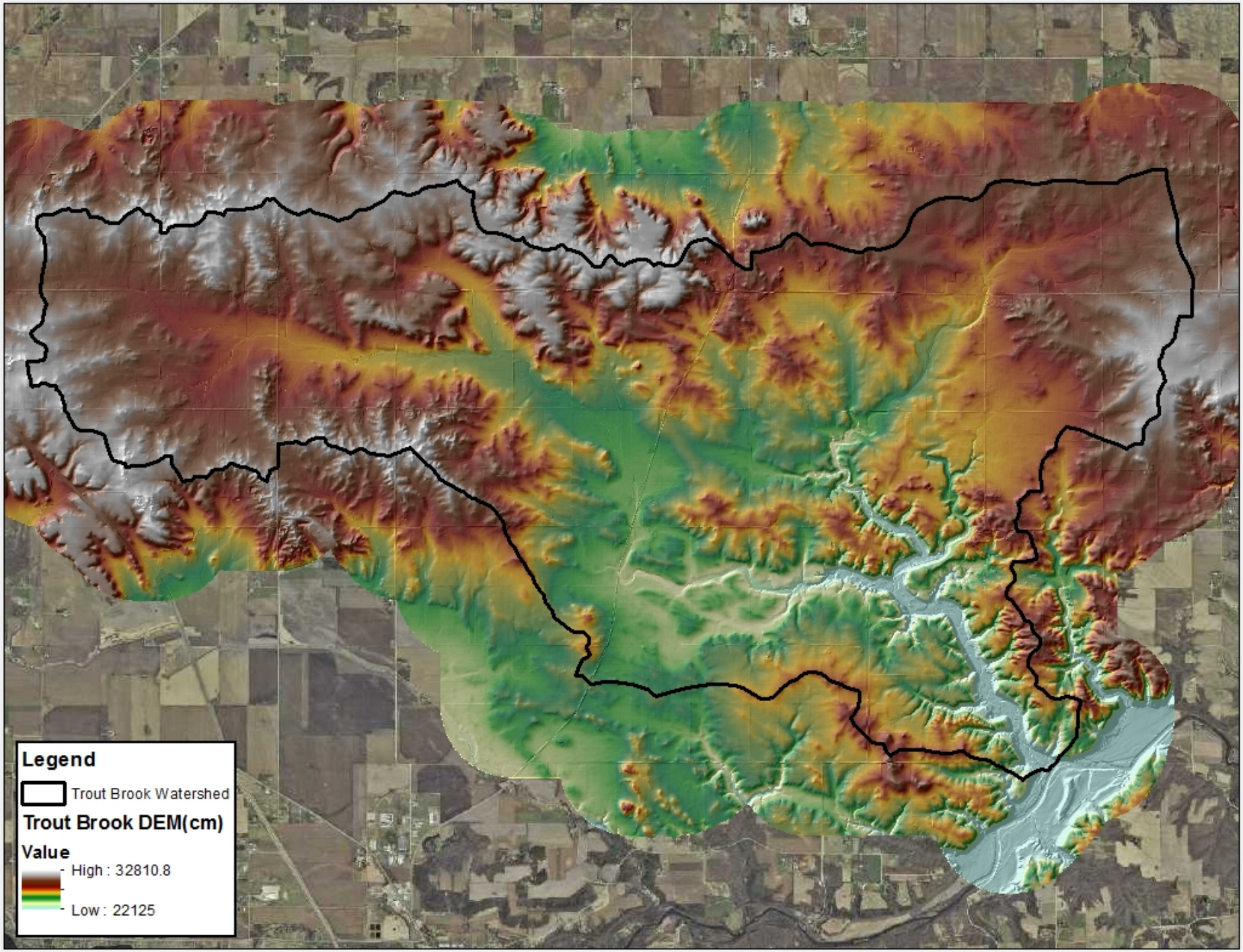


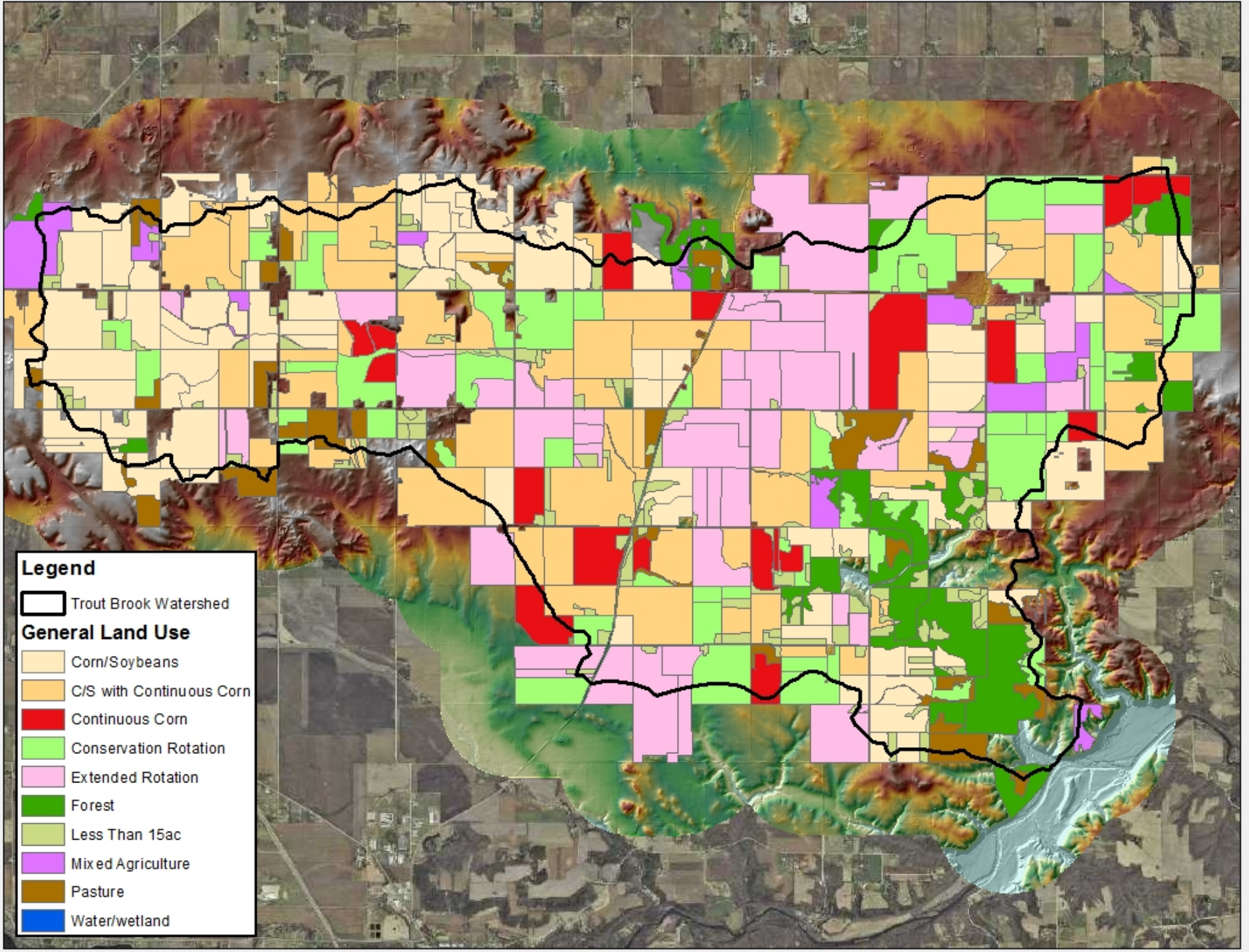
Impacts of Reconditioning

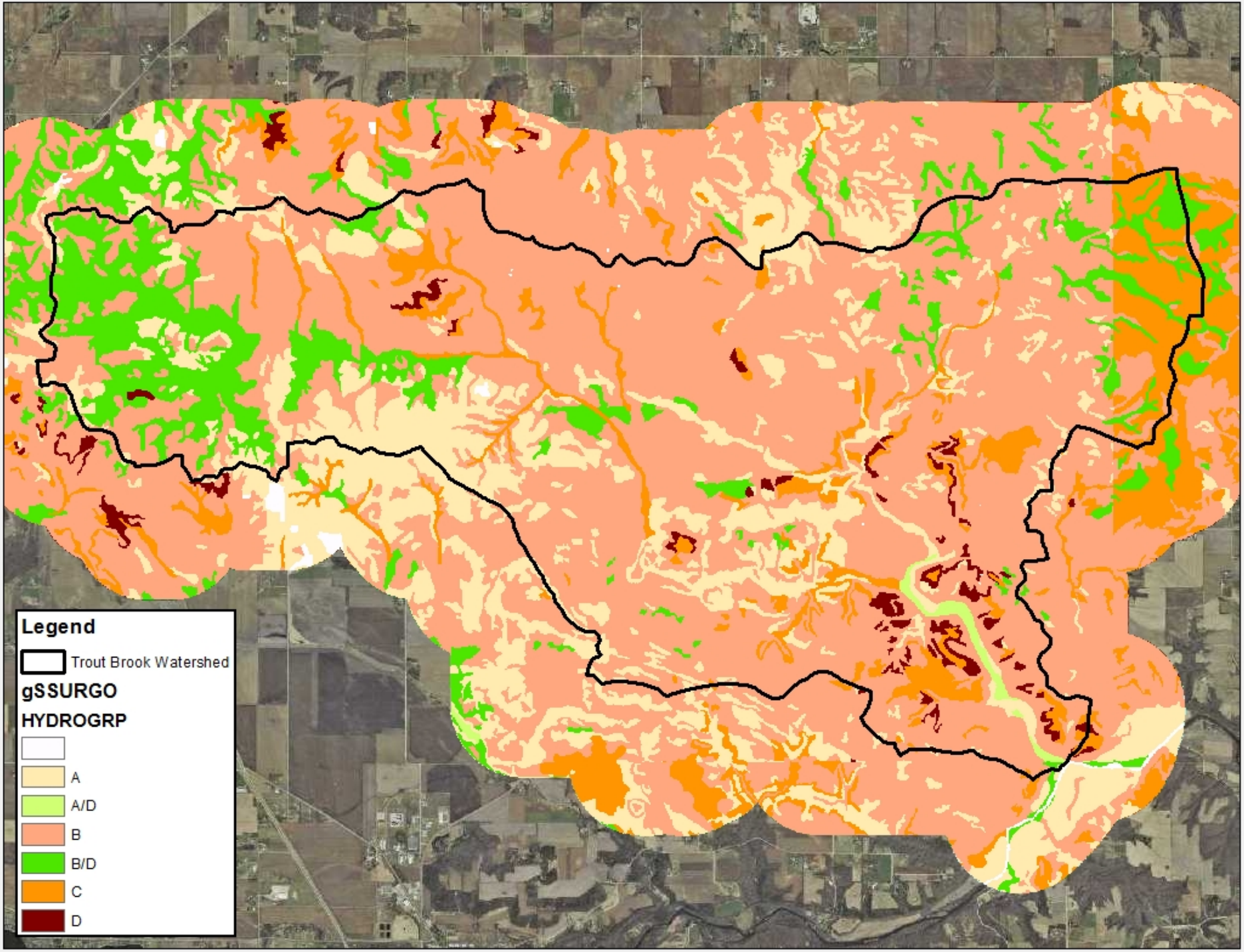


Data Sets

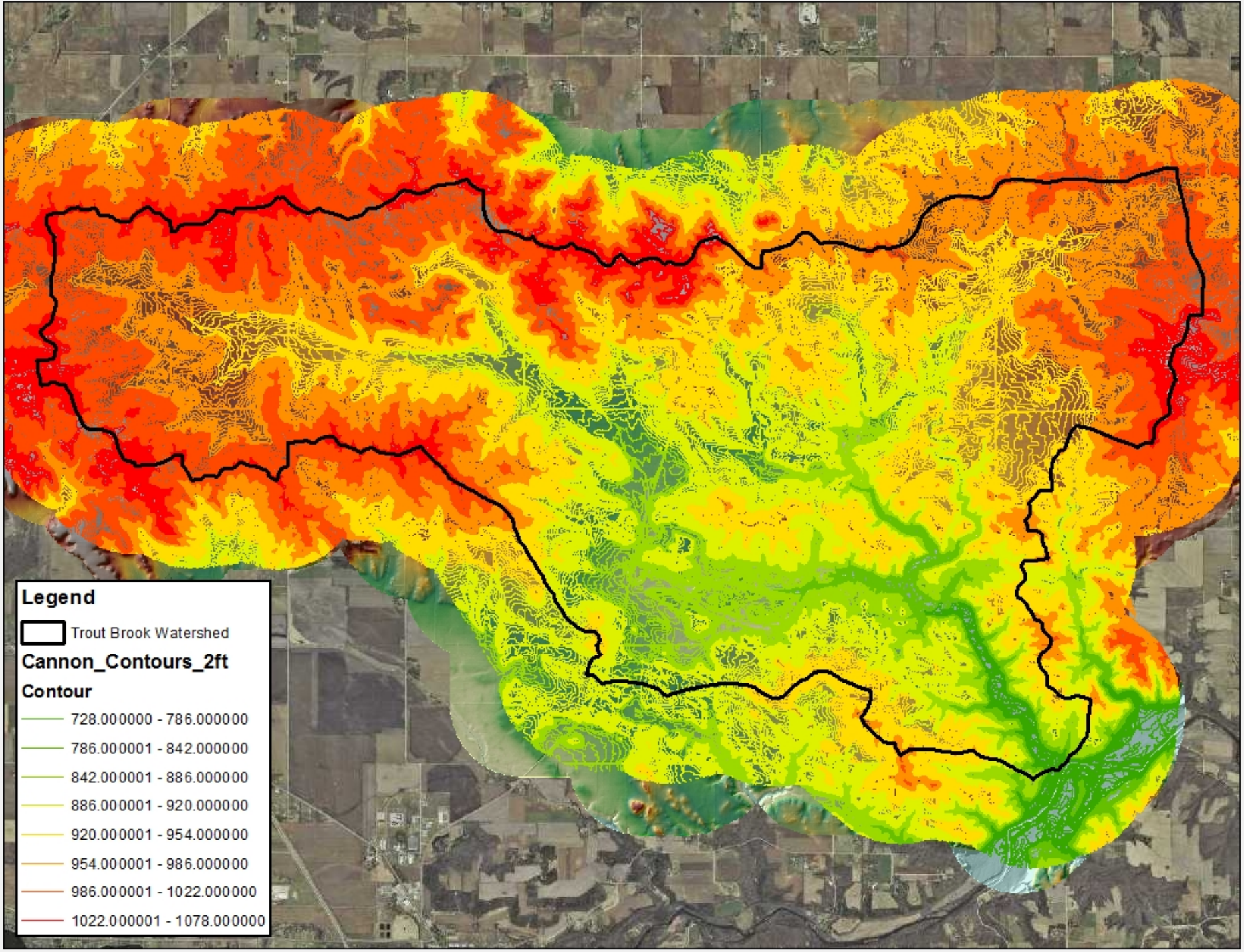
Input data include a LiDAR-derived digital elevation model (DEM), agricultural field boundaries with land use information, and SSURGO soil survey data.

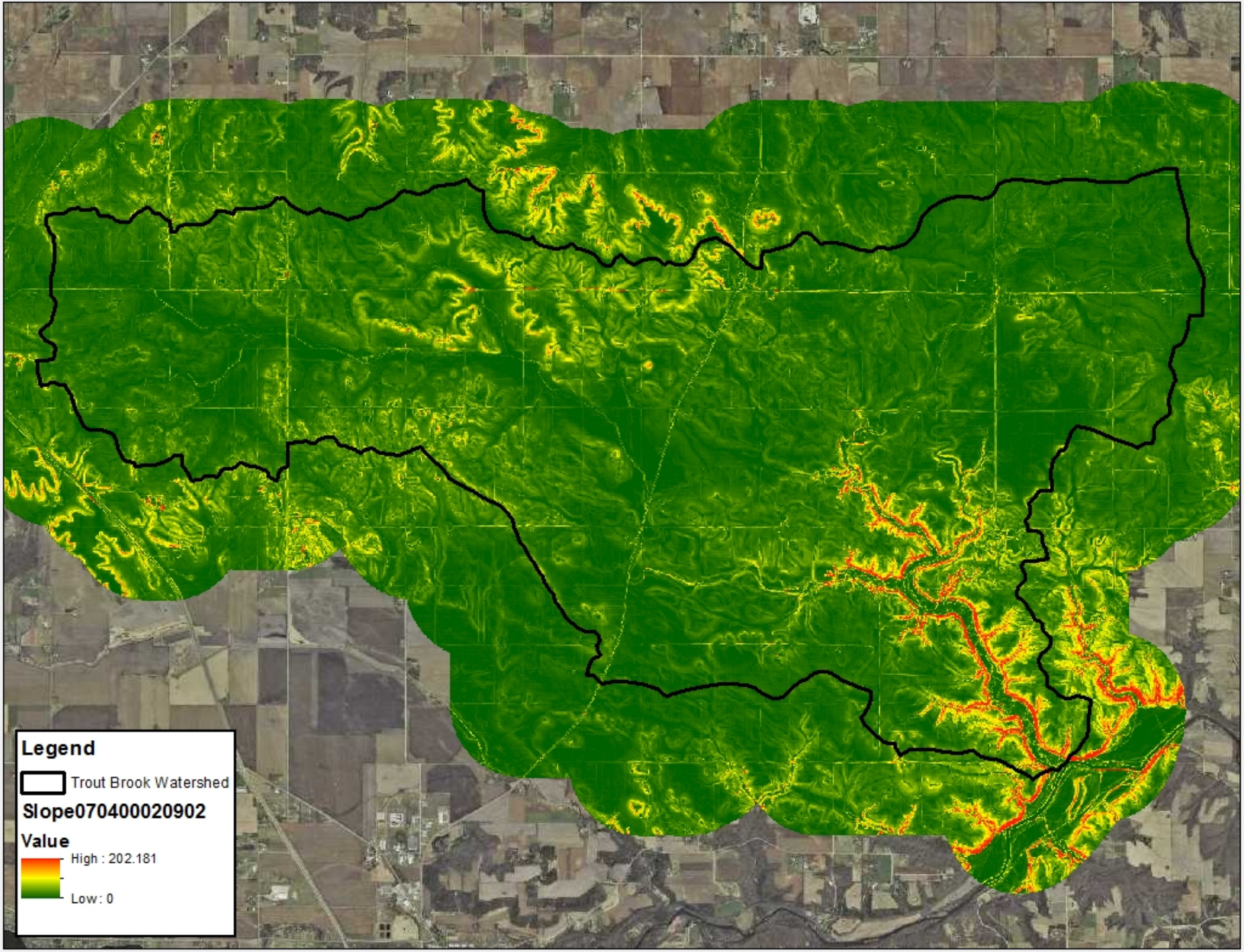

Legend
Trout Brook Watershed
Trout Brook DEM(cm)
Value
High : 32810.8
Low : 22125


Legend
Trout Brook Watershed
General Land Use
Corn/Soybeans
C/S with Continuous Corn
Continuous Corn
Conservation Rotation
Extended Rotation
Forest
Less Than 15ac
Mixed Agriculture
Pasture
Water/wetland


Legend
Trout Brook Watershed
gSSURGO
HYDROGRP
A
A/D
B
B/D
C
D

Contours & Slope


Legend
Trout Brook Watershed
Cannon_Contours_2ft
Contour
728.000000 - 786.000000
786.000001 - 842.000000
842.000001 - 886.000000
886.000001 - 920.000000
920.000001 - 954.000000
954.000001 - 986.000000
986.000001 - 1022.000000
1022.000001 - 1078.000000


Legend
Trout Brook Watershed
Slope070400020902
Value
High : 202.181
Low : 0

SPI - Stream Power Index

Stream Power Index

Measurement of potential energy of water as it flows over bare ground

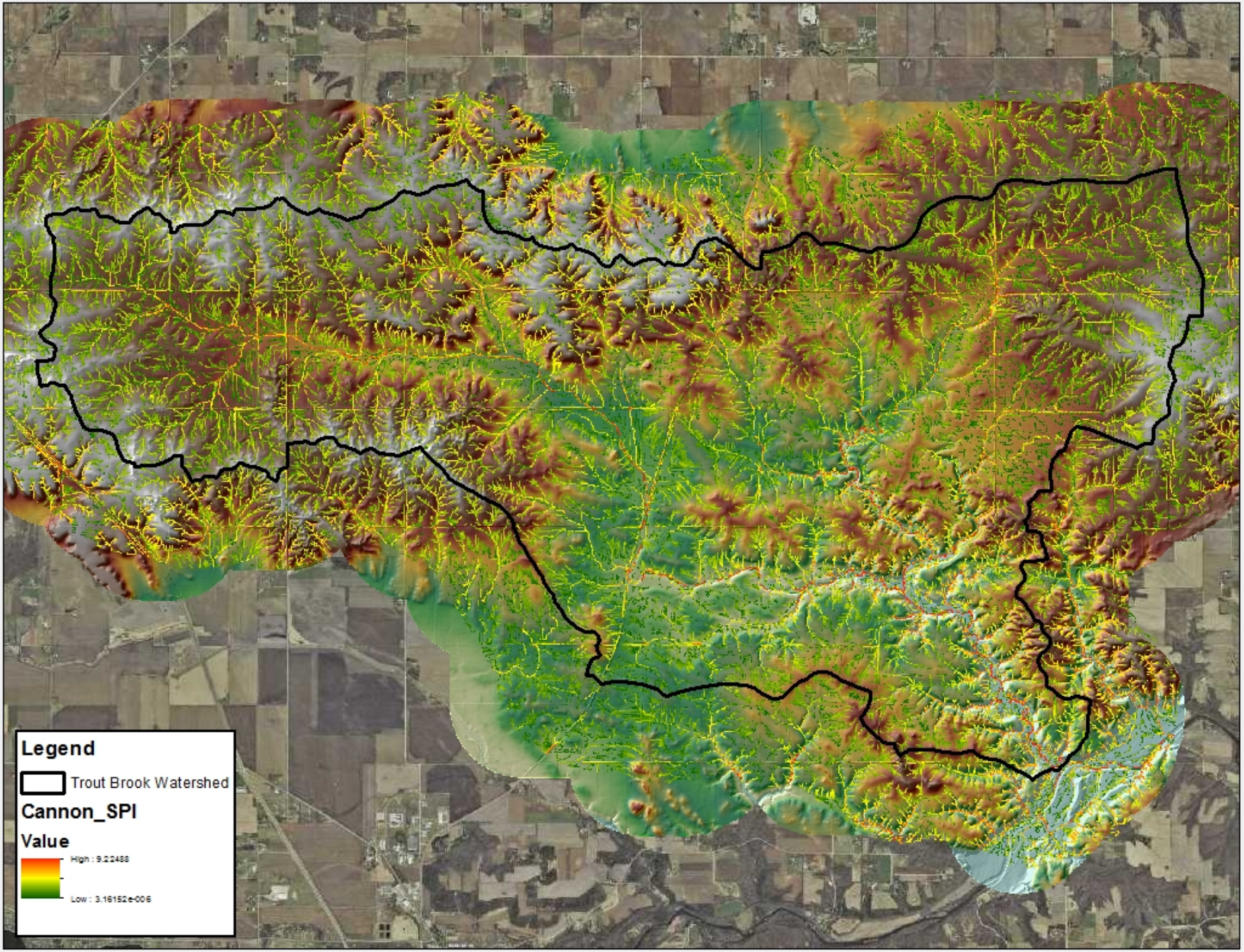
$$SPI = \ln[(\text{flow accumulation}) \times (\text{slope})]$$

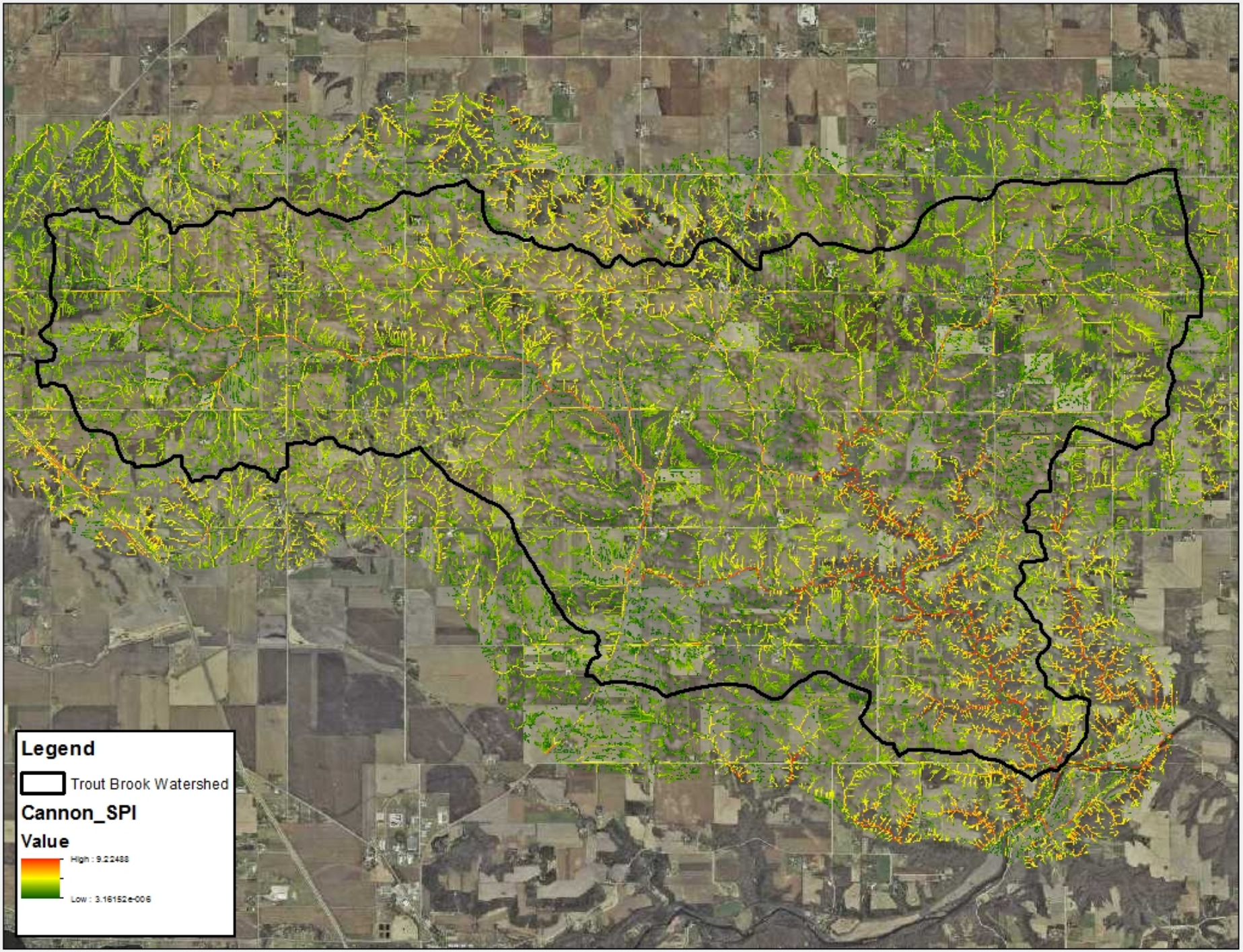
Amount of water expected

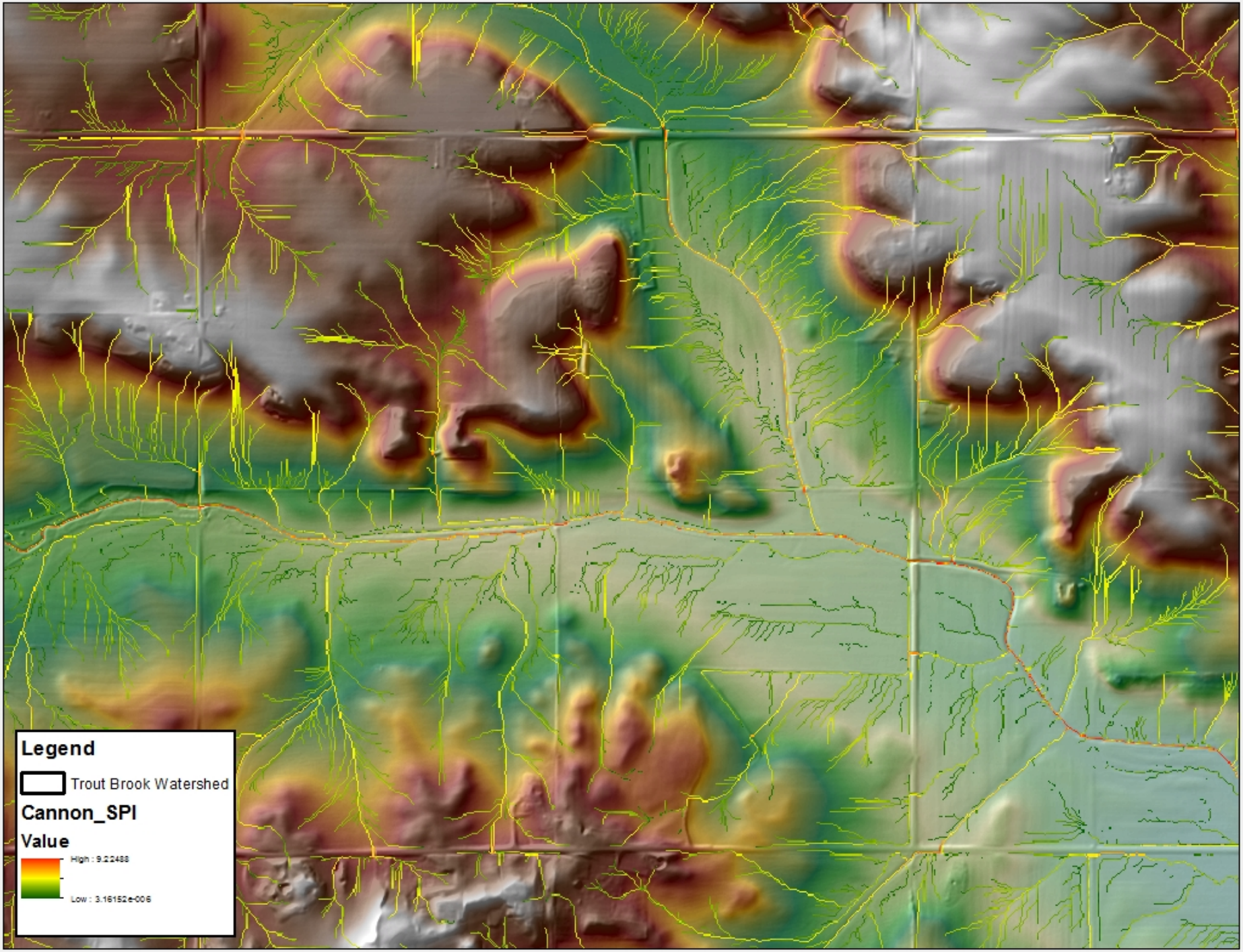
Slope of flow path

Purpose: Identify locations with high potential for gully erosion

Photo credit: http://www.mngeo.state.mn.us/chouse/elevation/uses/lidar_uses_waterquality.html


Legend
Trout Brook Watershed
Cannon_SPI
Value
High : 9.22488
Low : 3.16152e-006


Legend
Trout Brook Watershed
Cannon_SPI
Value
High : 9.22488
Low : 3.16152e-006


Legend
Trout Brook Watershed
Cannon_SPI
Value
High : 9.22488
Low : 3.16152e-006

Legend
Trout Brook Watershed
Cannon_SPI
Value
High : 9.22488
Low : 3.16152e-006

CTI - Compound Topographic Index

Compound Topographic Index

Indicator of potential saturated and unsaturated areas within a catchment area (e.g. watershed)

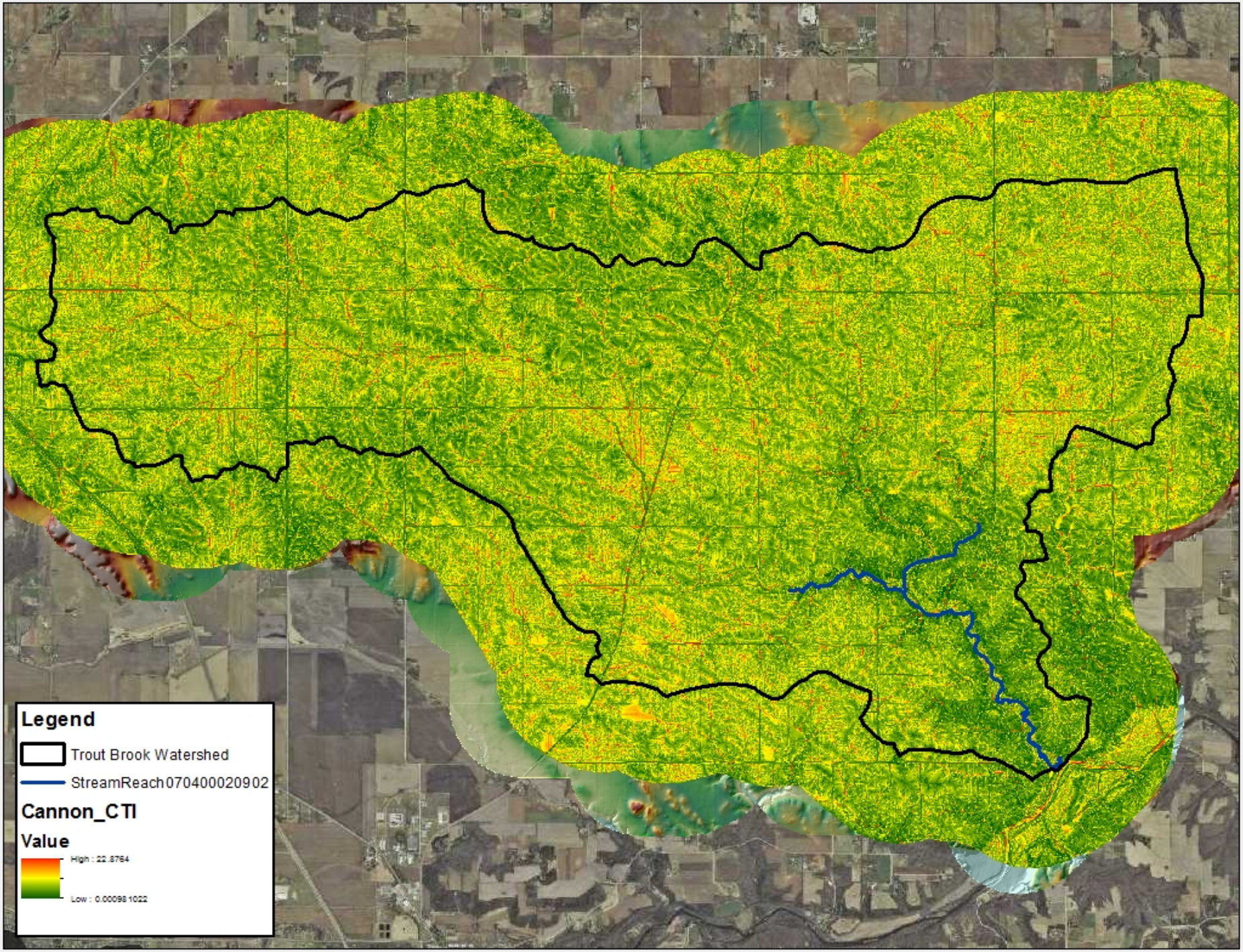
$$CTI = \ln[(As)/(Tan(B)]$$

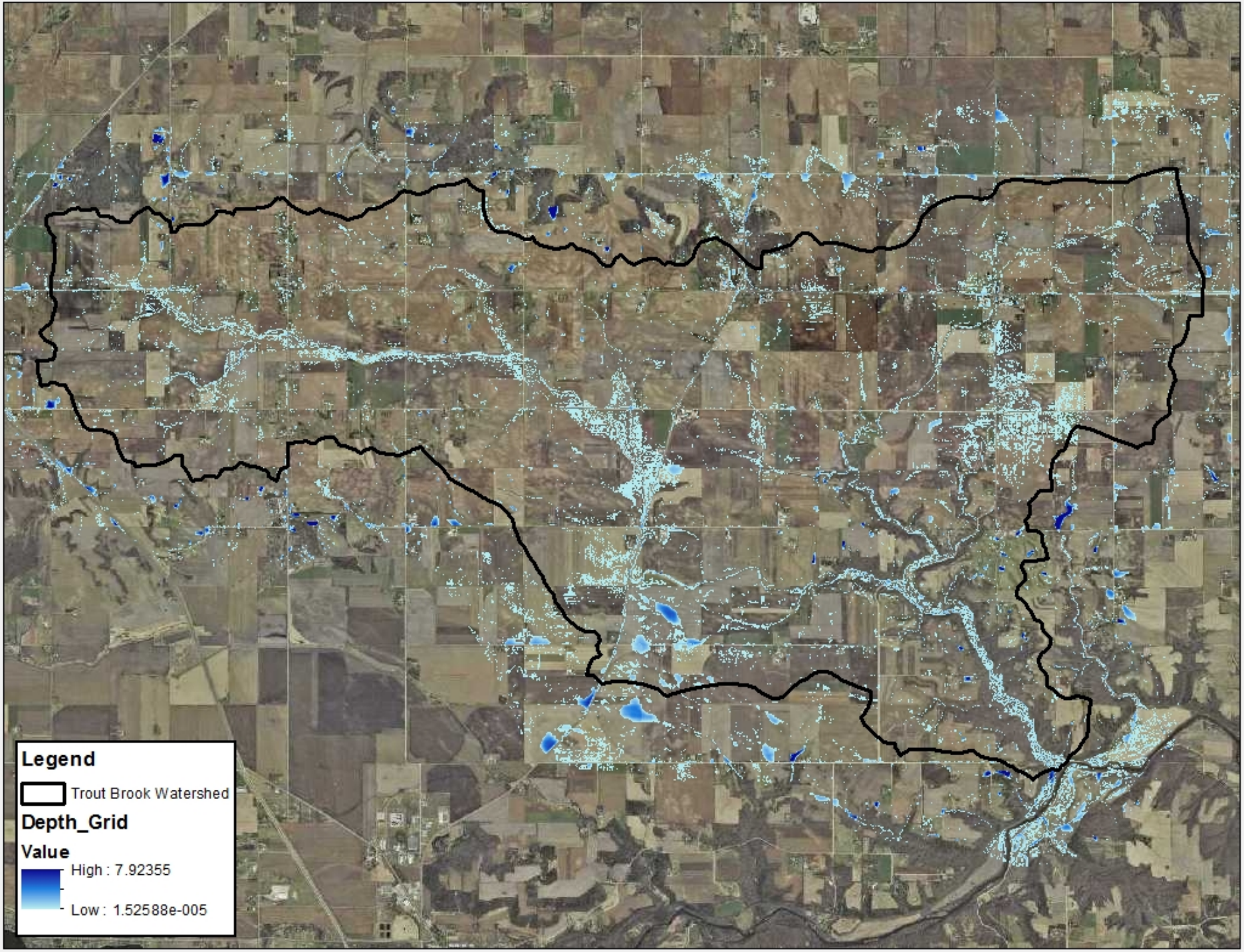
Upslope Contributing Area

Slope of flow path

Purpose: Areas with low CTI values represent places with small catchments, and steep slopes or hills Areas with high CTI values represent places with large catchments, and gentle slopes are depressions or plains

Photo credit: http://www.mngeo.state.mn.us/chouse/elevation/uses/lidar_uses_waterquality.html


Legend
Trout Brook Watershed
StreamReach070400020902
Cannon_CTI
Value
High : 22.8764
Low : 0.00098 1022


Legend
Trout Brook Watershed
Depth_Grid
Value
High : 7.92355
Low : 1.52588e-005

Precision Conservation Framework

By Mark Tomer, ARS, Ames, IA

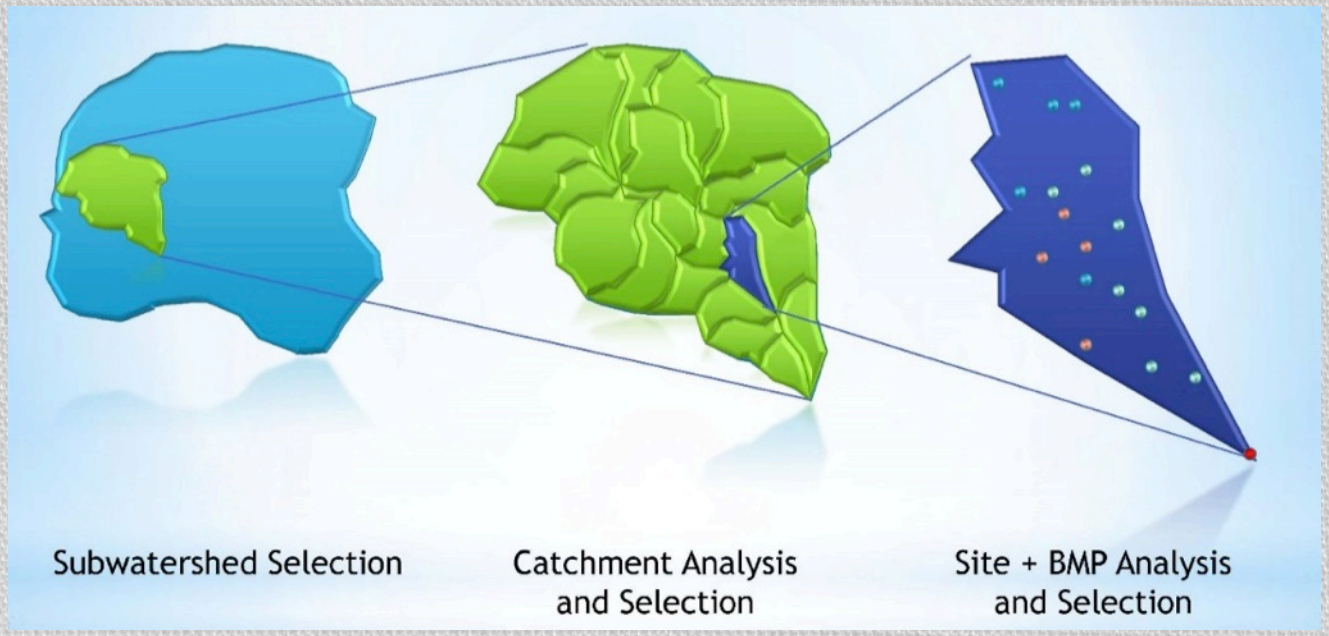
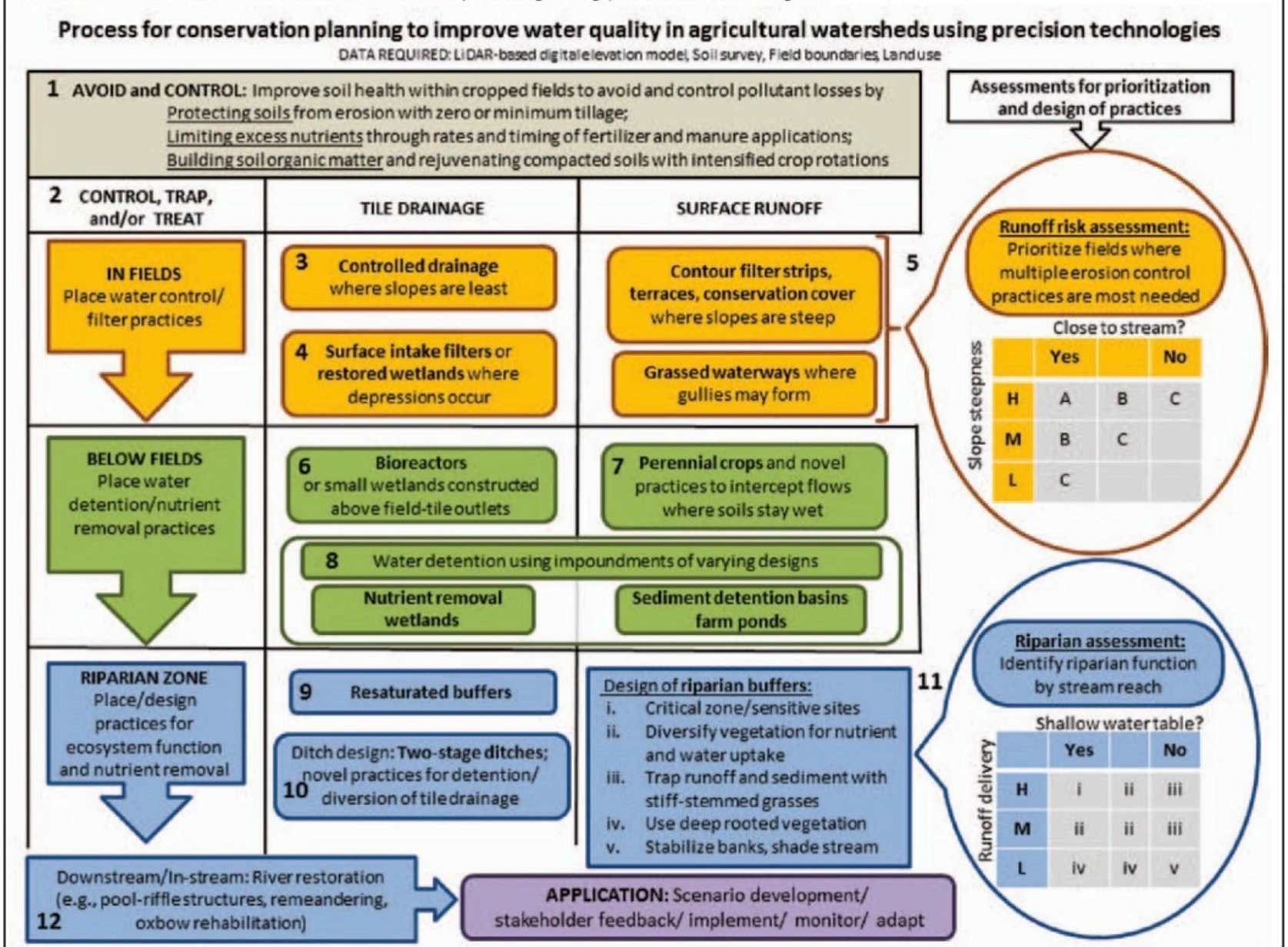


Figure 2

A framework for watershed-scale conservation planning using precision technologies.



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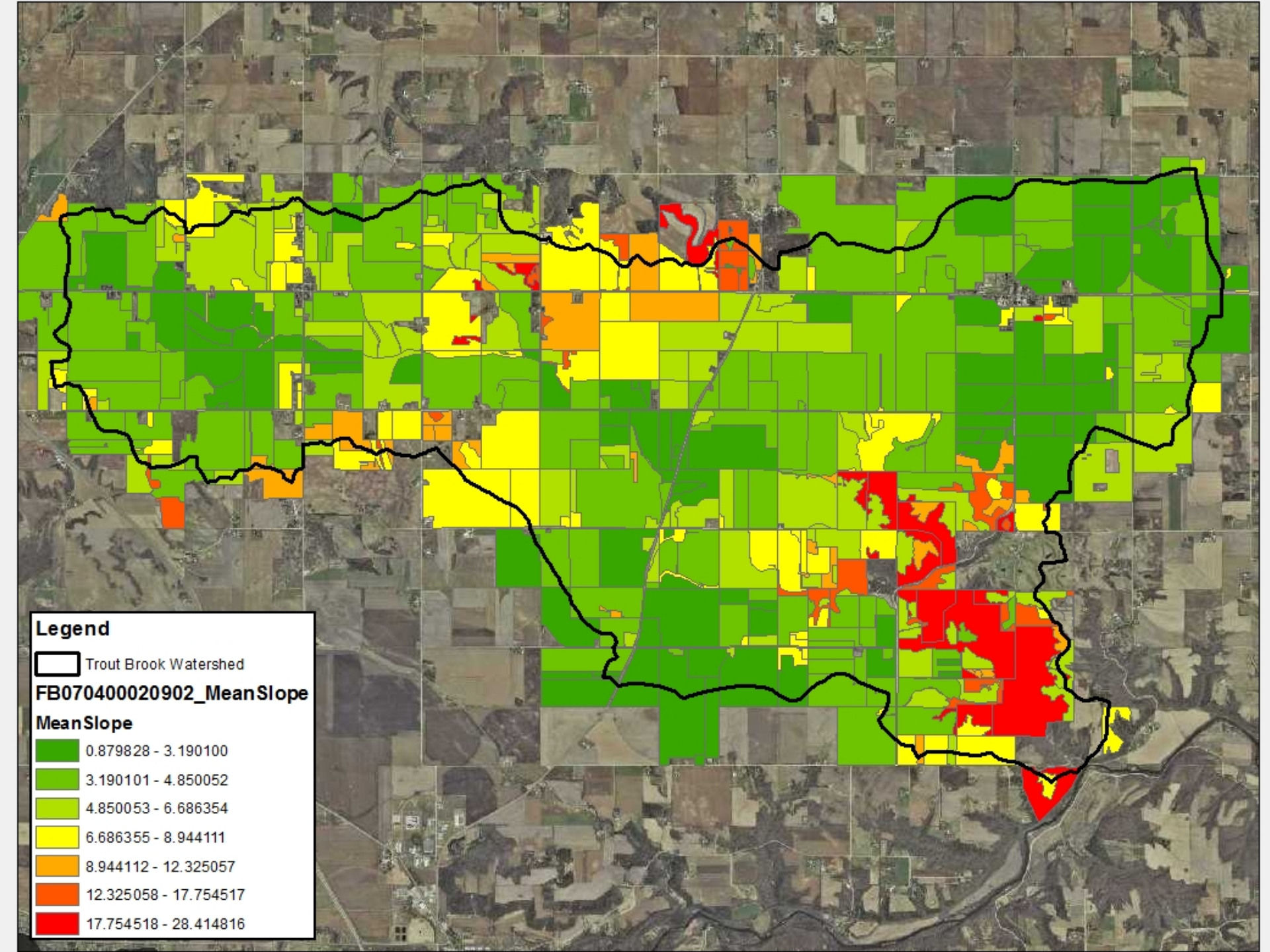
Journal of Soil and Water Conservation 68(5):113A-120A www.

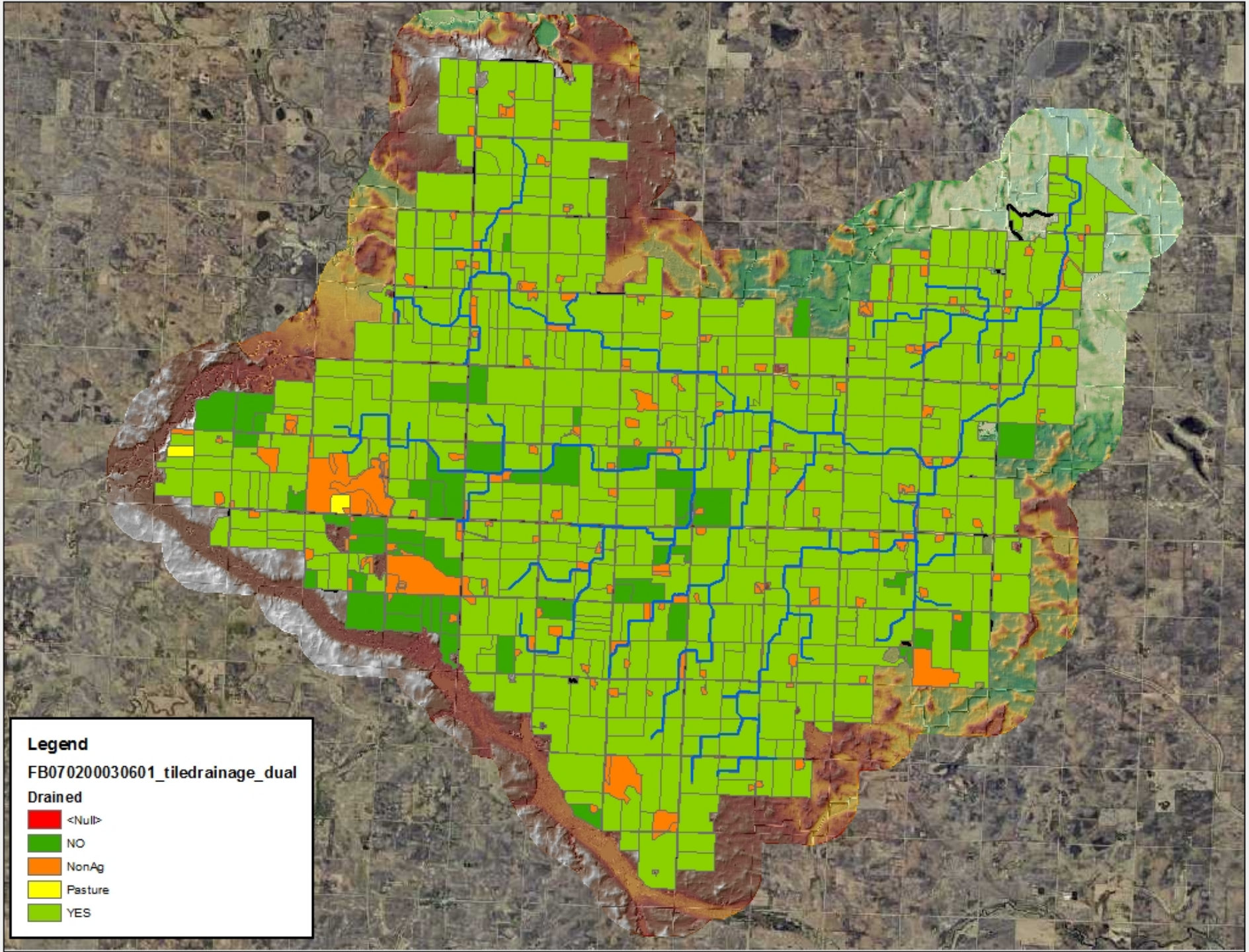
By-Field Slope Statistics

Field Characterization


Legend
Trout Brook Watershed
FB070400020902_MeanSlope
MeanSlope
0.879828 - 3.190100
3.190101 - 4.850052
4.850053 - 6.686354
6.686355 - 8.944111
8.944112 - 12.325057
12.325058 - 17.754517
17.754518 - 28.414816

Tile Drainage Determination

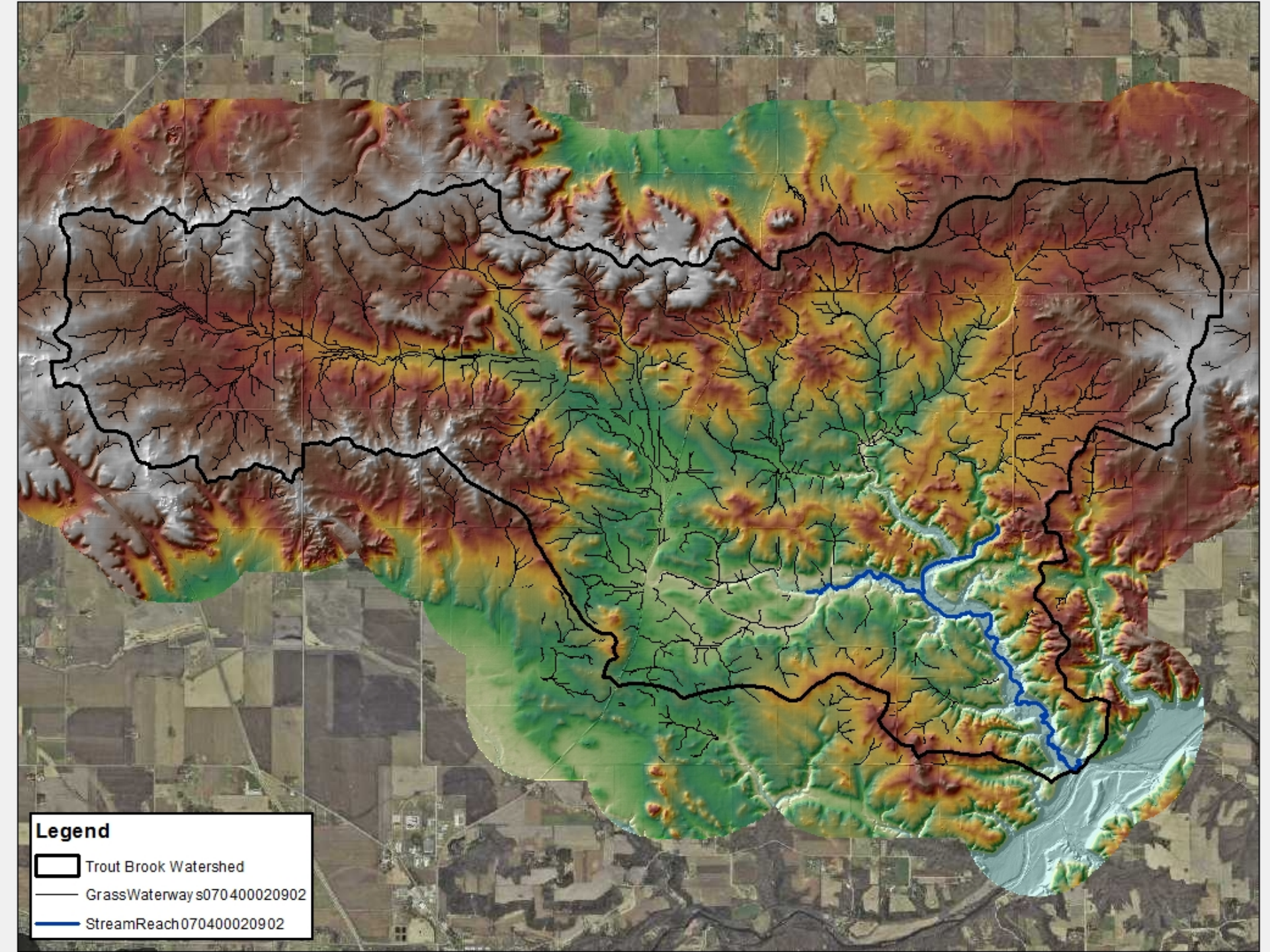
Field Characterization

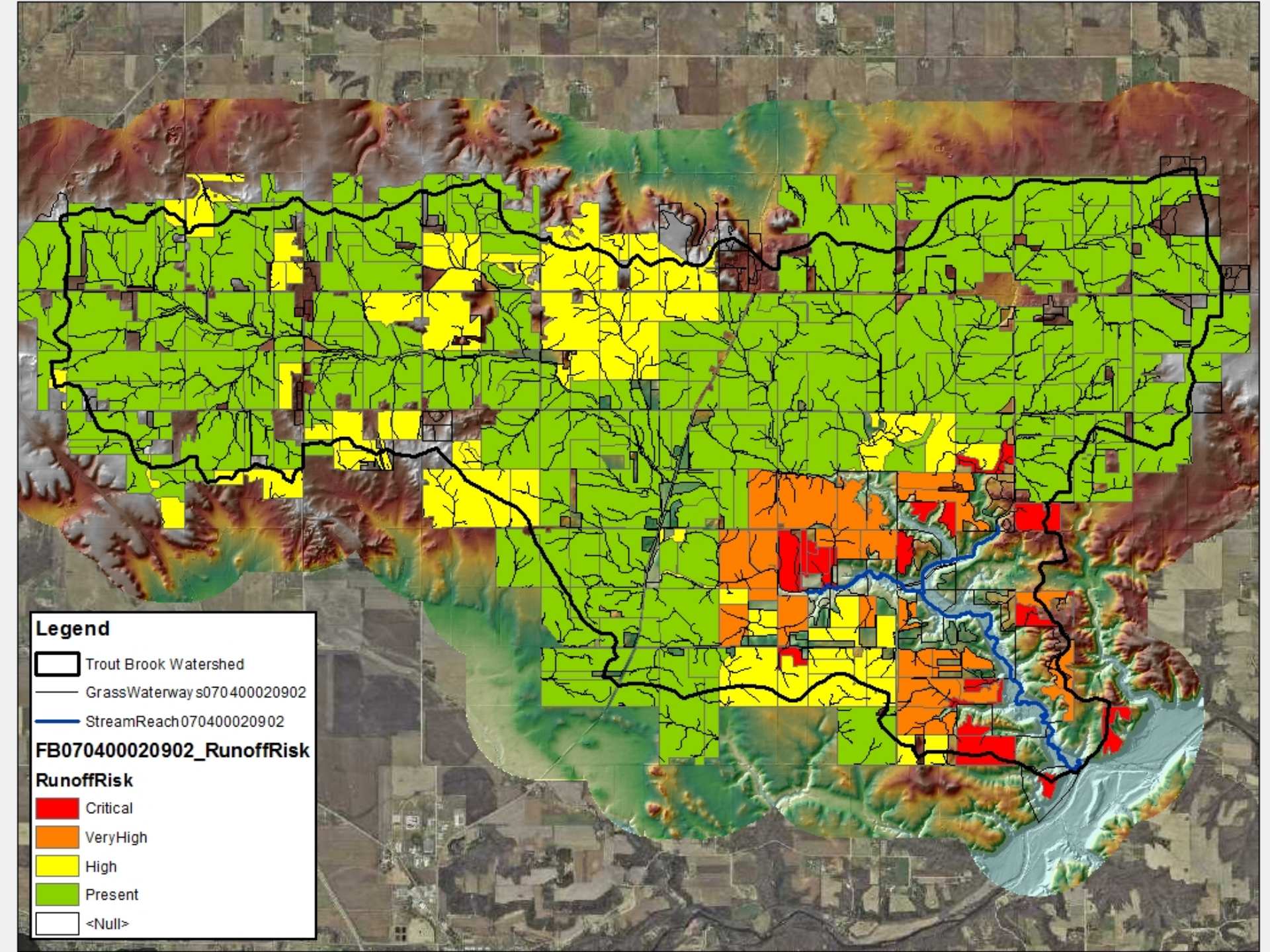

Legend
FB070200030601_tiledrainage_dual
Drained
<Null>
NO
NonAg
Pasture
YES

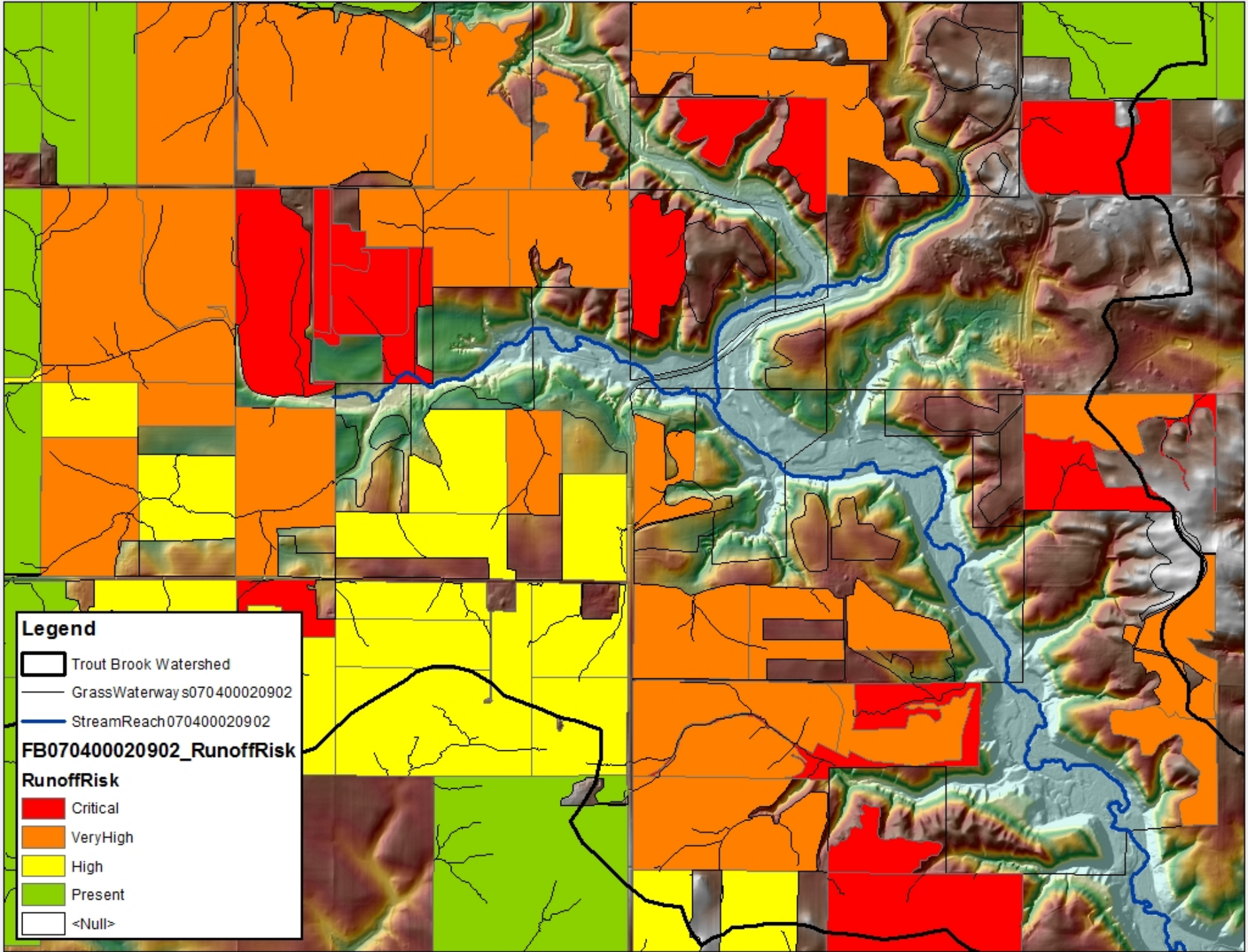
Runoff Risk Assessment & Grassed Waterways

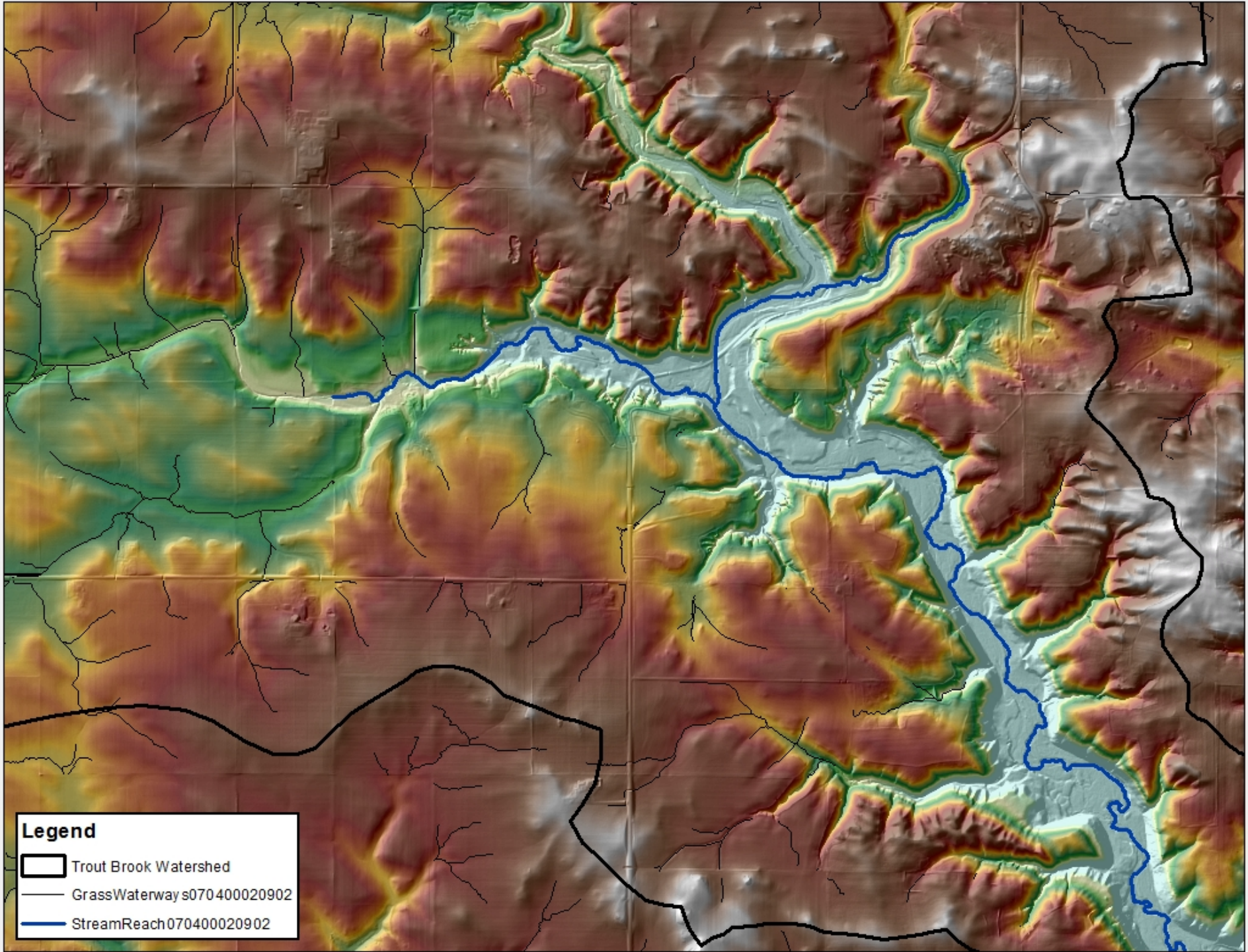
Field Characterization

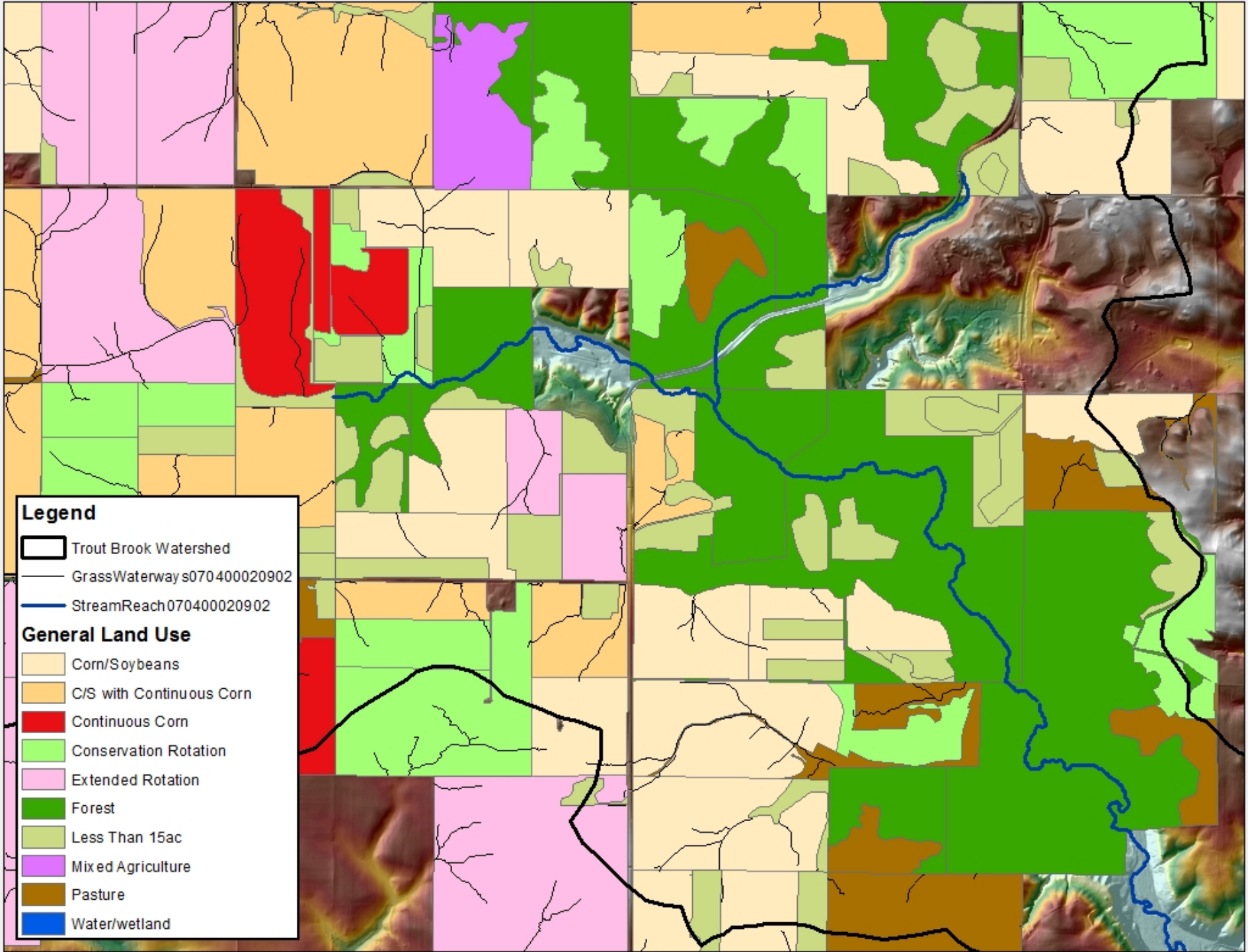
The cross classification of the “Runoff Risk Assessment” matrix classifies each field according to its runoff risk. A more-detailed look at the within field topography and flow accumulation can then identify which conservation practices may be most suitable in a given field. This image shows possible locations for grassed waterways, located along areas where channelized flow may occur .


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902
FB070400020902_RunoffRisk
RunoffRisk
Critical
VeryHigh
High
Present
<Null>


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902
FB070400020902_RunoffRisk
RunoffRisk
Critical
VeryHigh
High
Present
<Null>


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902

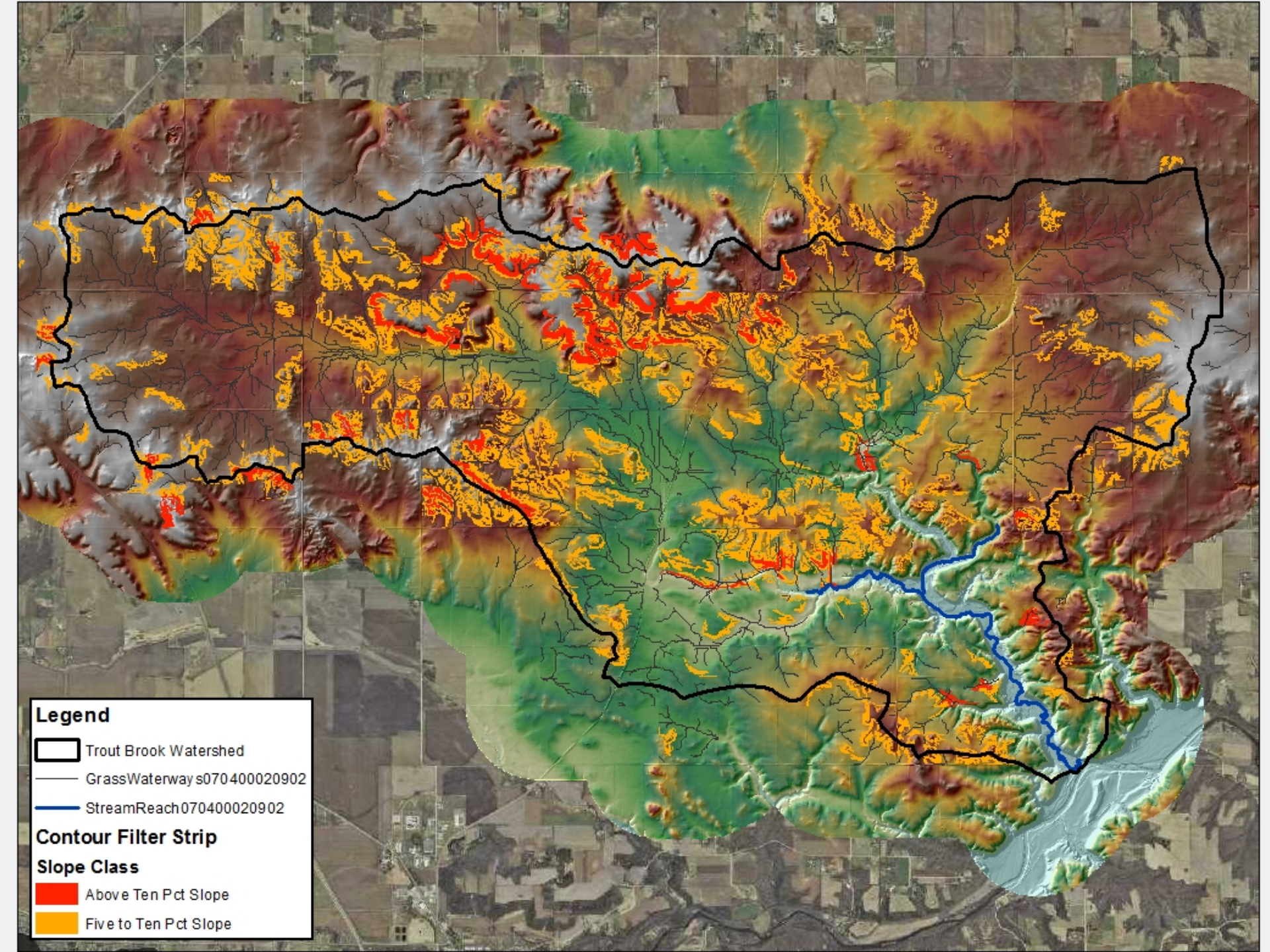

Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902
General Land Use
Corn/Soybeans
C/S with Continuous Corn
Continuous Corn
Conservation Rotation
Extended Rotation
Forest
Less Than 15ac
Mixed Agriculture
Pasture
Water/wetland

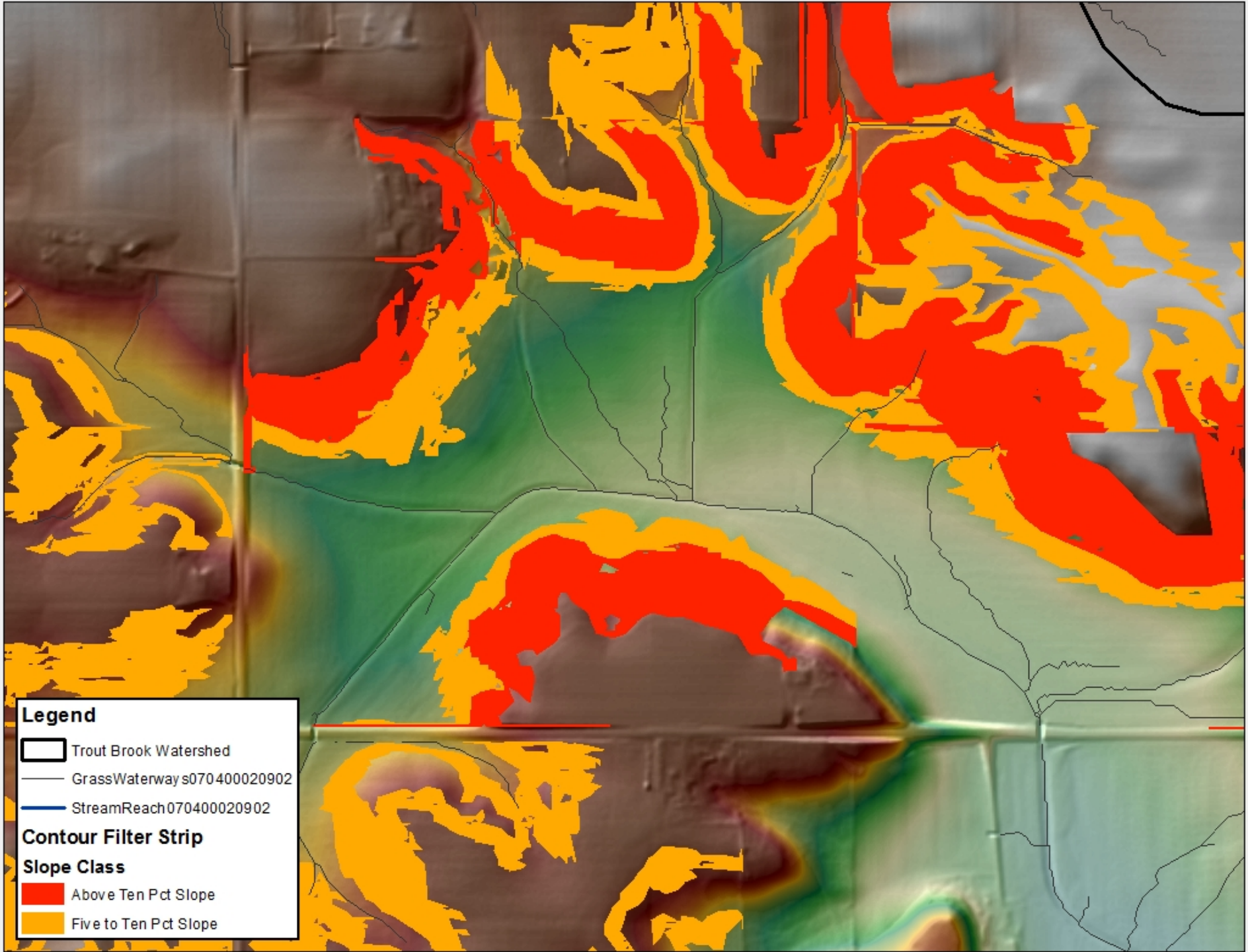
Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902

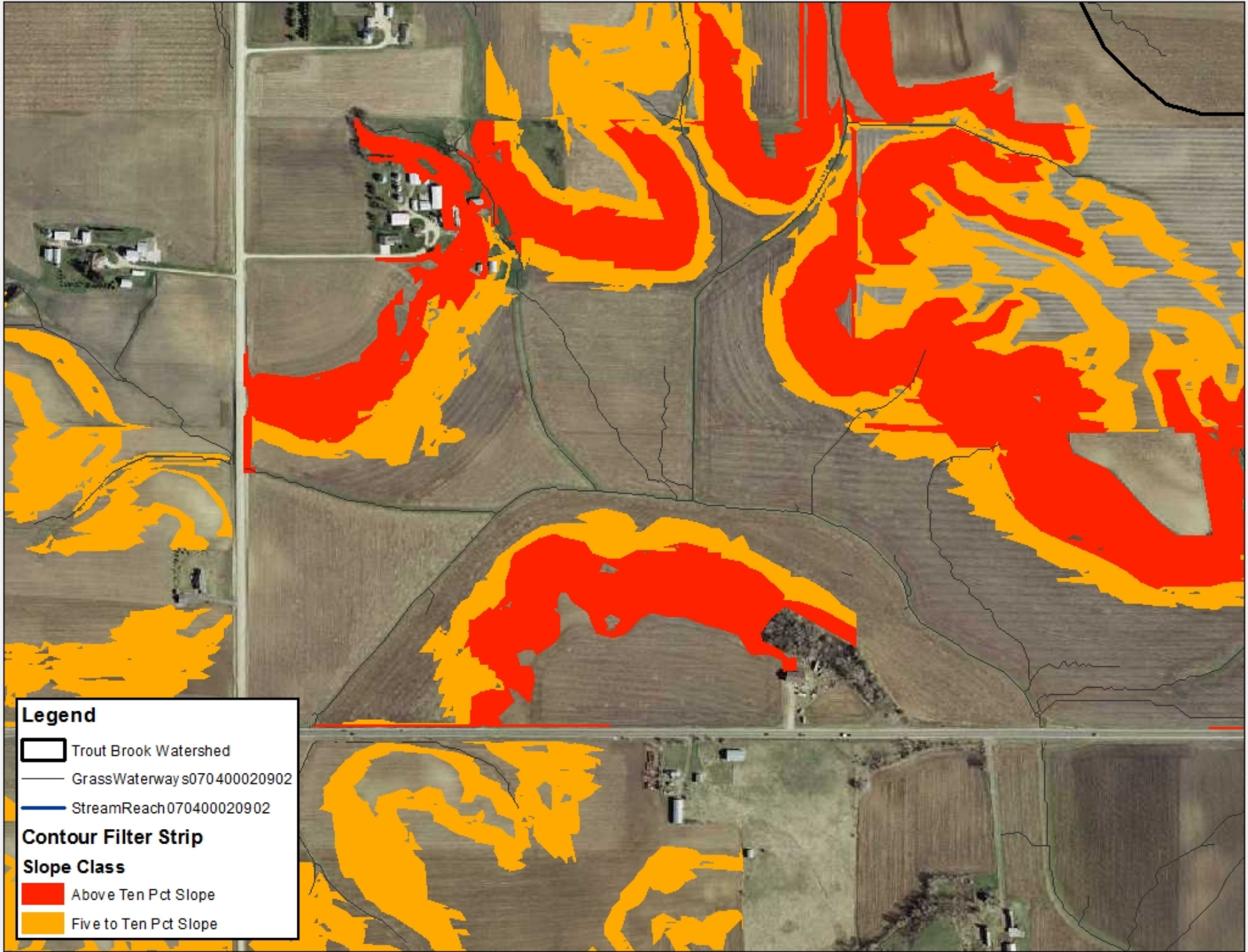
Contour Filter Strips

Precision Conservation Practice Siting

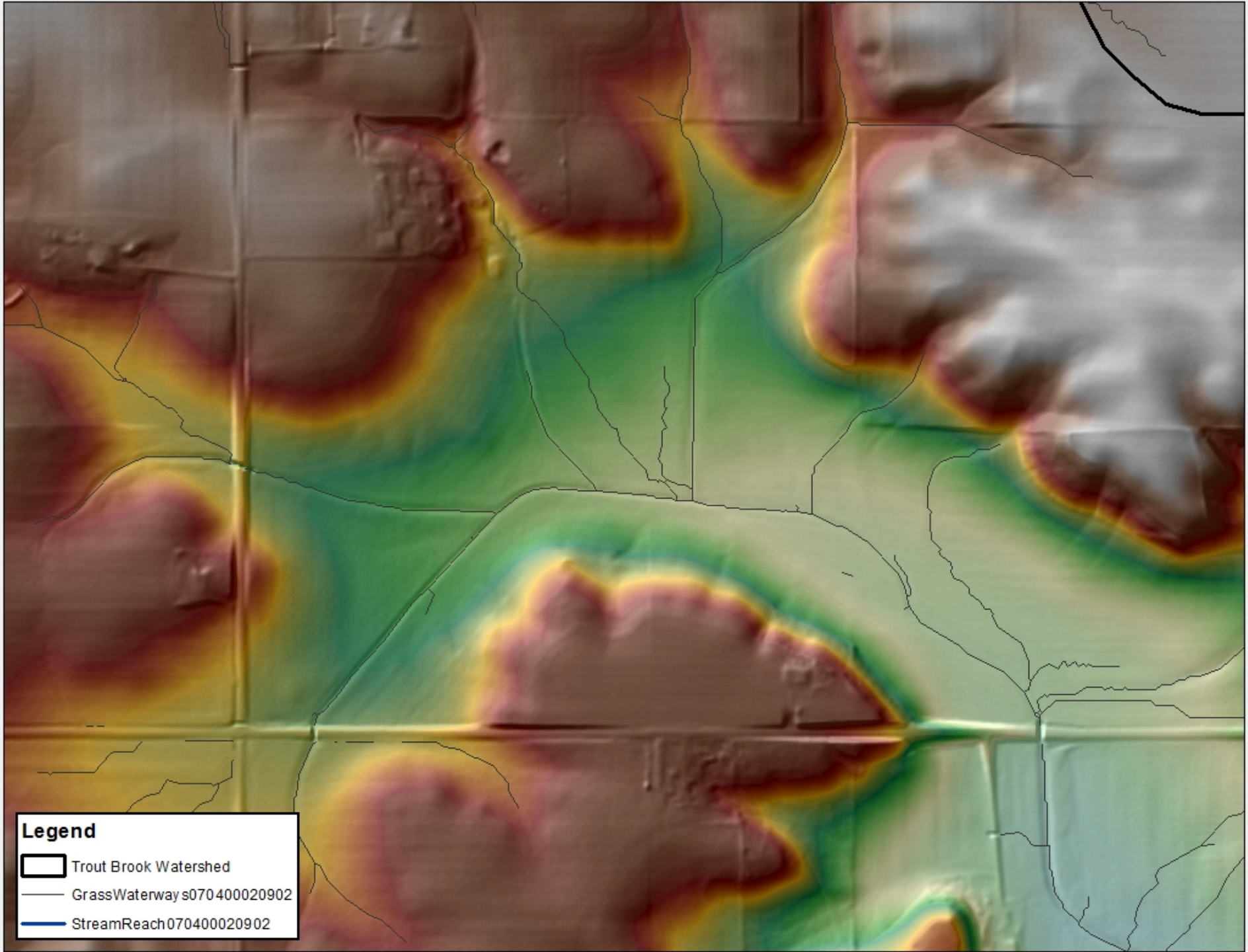
- Contour filter strips are strips of perennial vegetation alternated down a slope with wider cultivated strips that are farmed on the contour. Similar to grassed waterways, contour filter strips are in-field runoff control practices, designed to decrease the occurrence of concentrated flow and reduce sheet and rill erosion.
- The contour filter strip tool identifies contiguous areas of high slopes (> 5%) in agricultural fields. Contour buffer strips and/or terraces (more suited to steeper ground) placed within these areas are beneficial for reducing sheet and rill erosion.


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902
Contour Filter Strip
Slope Class
Above Ten Pct Slope
Five to Ten Pct Slope


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902
Contour Filter Strip
Slope Class
Above Ten Pct Slope
Five to Ten Pct Slope


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902
Contour Filter Strip
Slope Class
Above Ten Pct Slope
Five to Ten Pct Slope

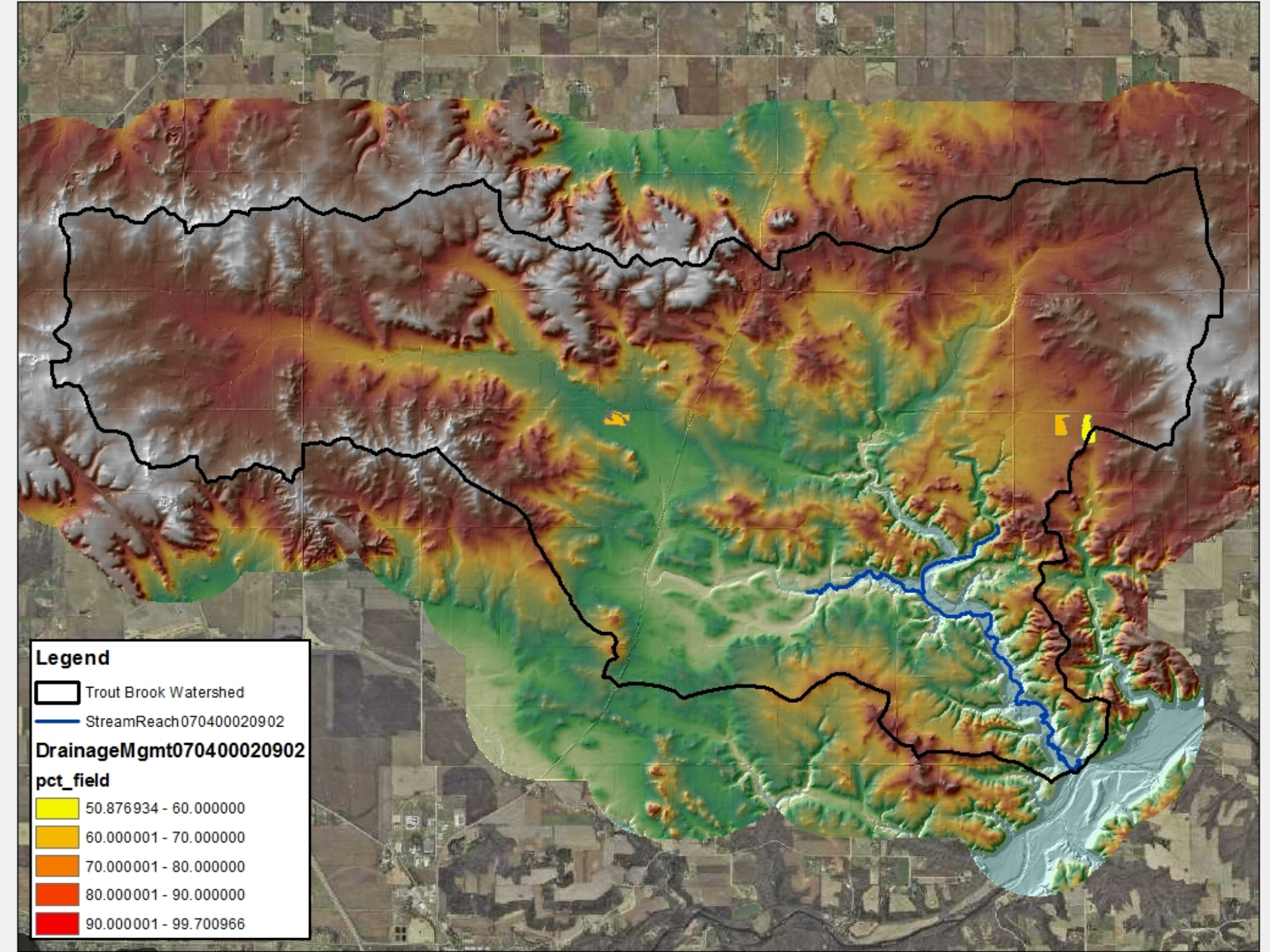
Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902


Legend
Trout Brook Watershed
GrassWaterways070400020902
StreamReach070400020902

Drainage Water Management

Precision Conservation Practice Siting

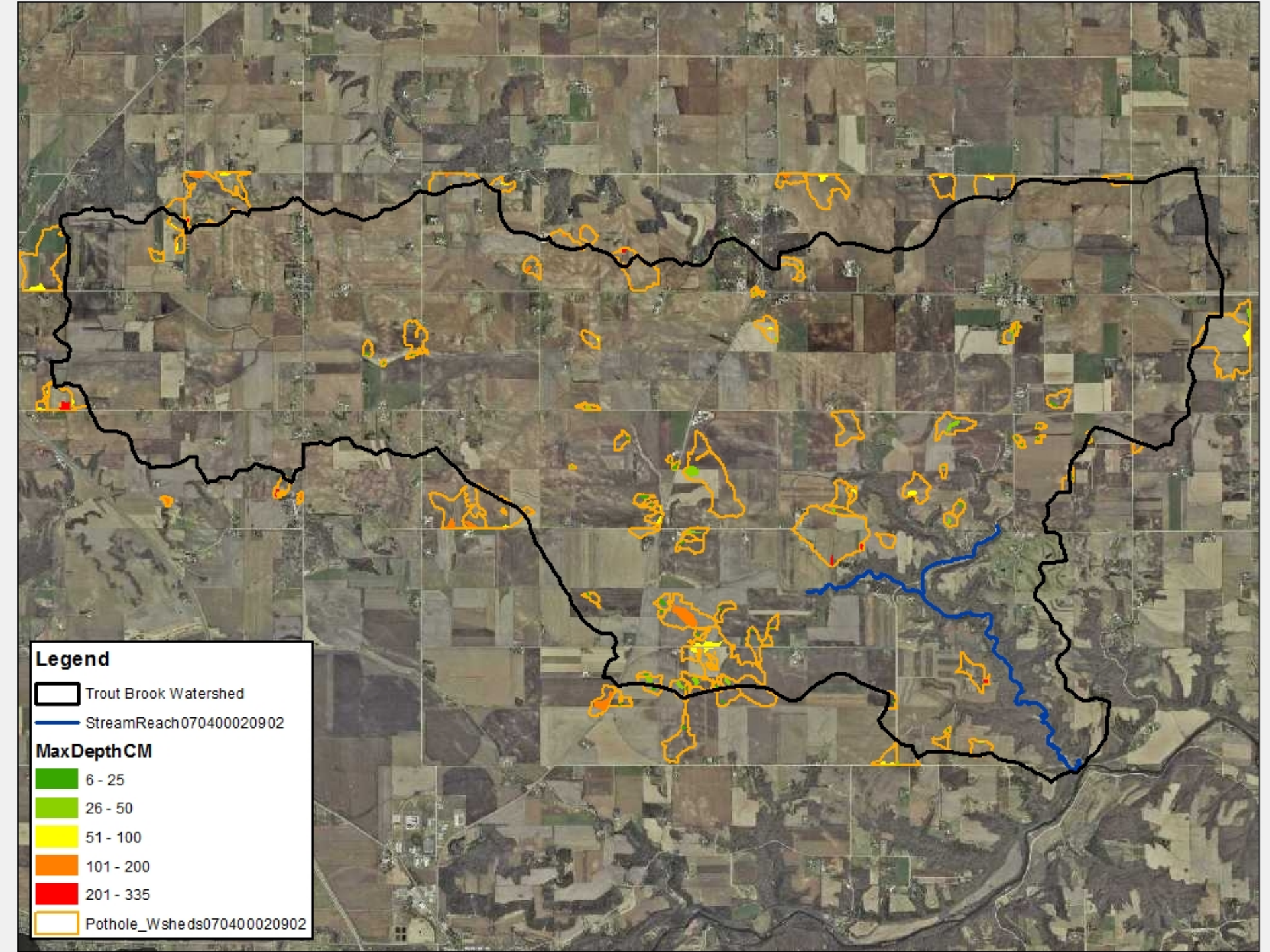
Controlled drainage may be used on fields with flat topography (typically one percent or less slope, such as in flood plains and on flat fields typical of the large areas of the glaciated Midwest. The practice can be expensive to design and install in areas with slopes steeper than about one percent because of the number of control structures required in a typical field. A single control gate (dependent on its size) can influence the water table within approximately .5 meter change in elevation. To identify fields potentially suited to this practice, the Drainage Water Management tool identifies the largest area within any 1-meter (3.3 ft) contour interval (representing the addition of 2 control-gate structures), within each tile-drained, agricultural field.


Legend
Trout Brook Watershed
StreamReach070400020902
DrainageMgmt070400020902
pct_field
50.876934 - 60.000000
60.000001 - 70.000000
70.000001 - 80.000000
80.000001 - 90.000000
90.000001 - 99.700966

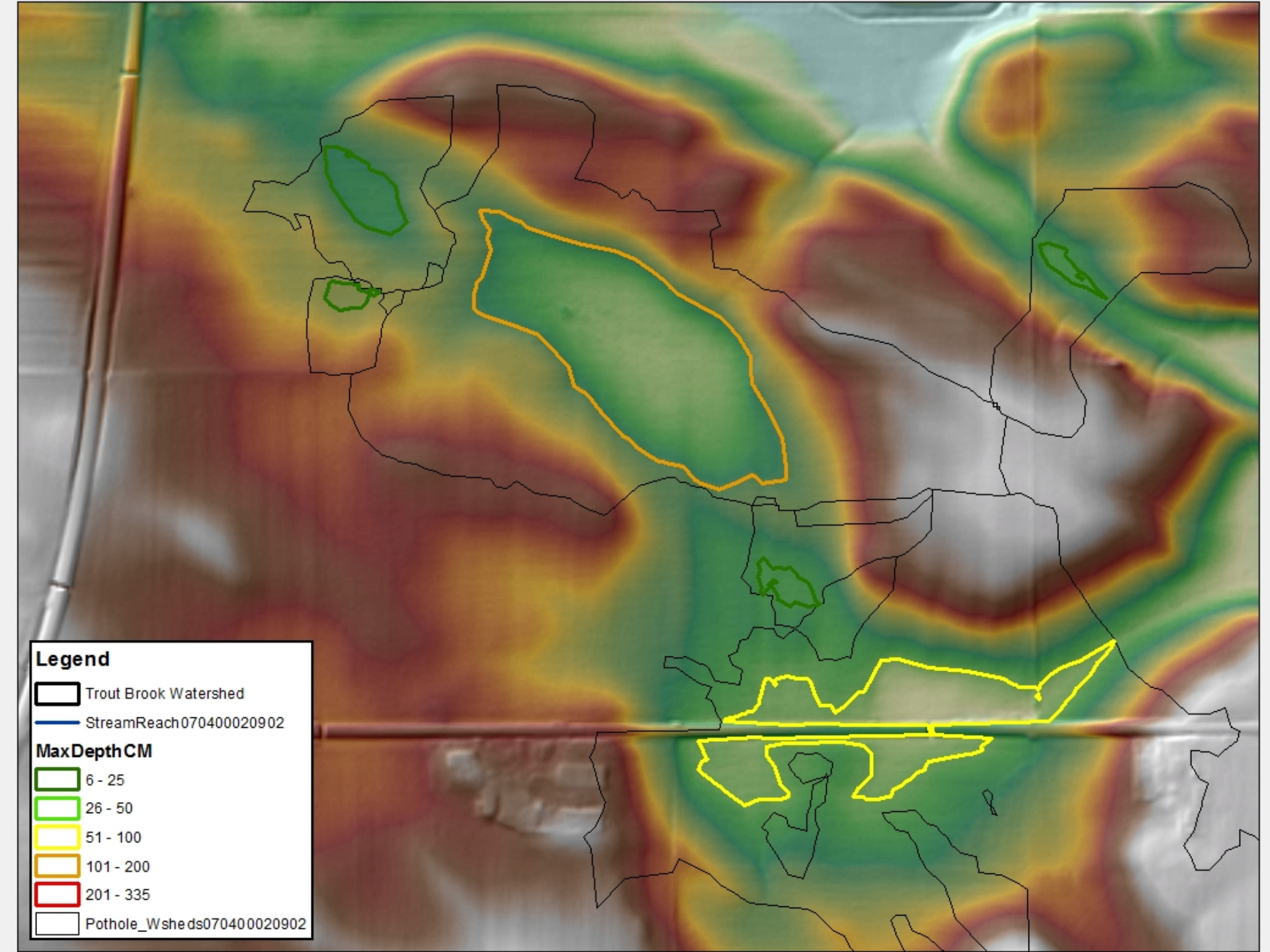
Pothole Identification

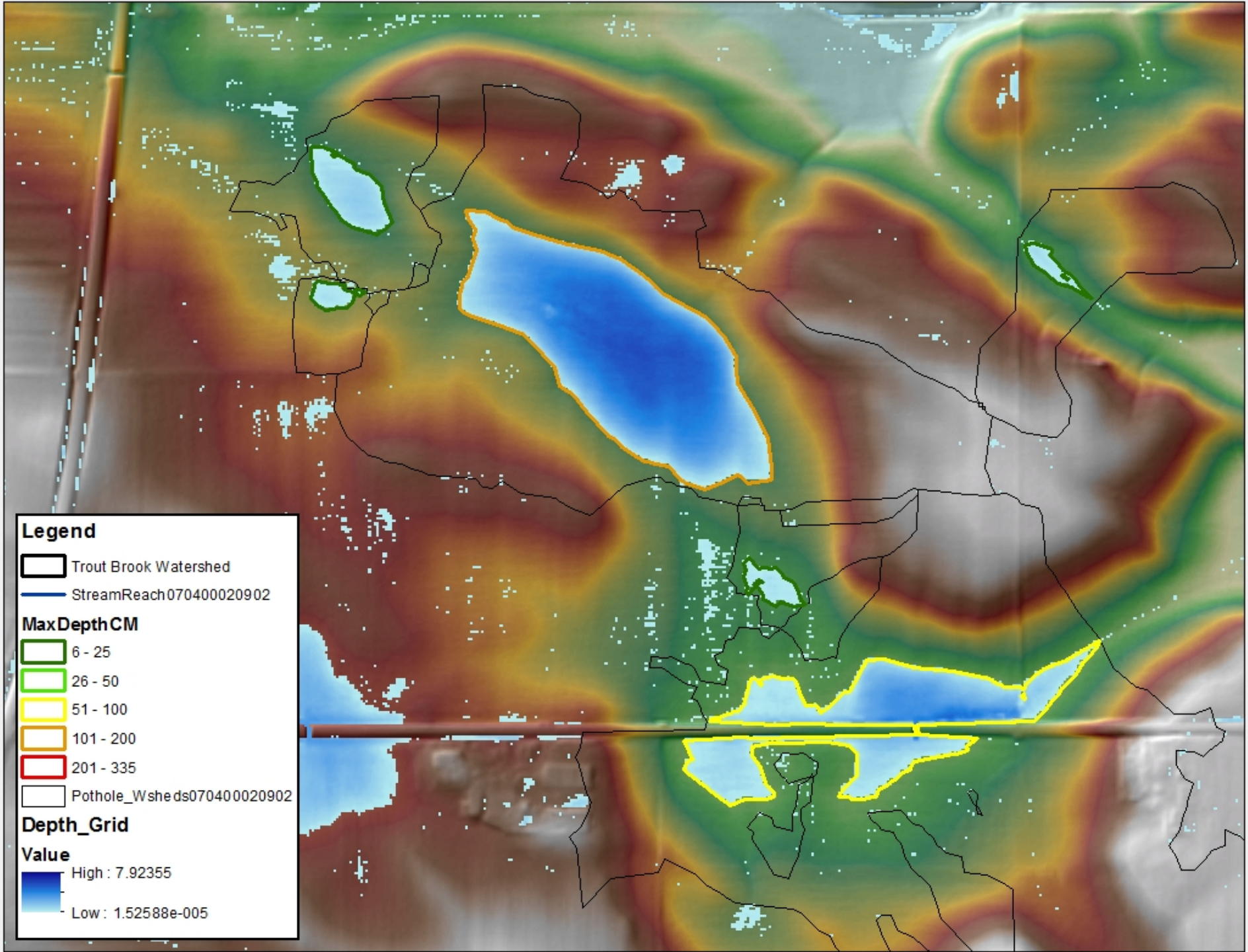
Precision Conservation Practice Siting

Depressions are common in the glacial landscapes of the Midwest and present challenges for managing water quality and wetness of fields. We have shaded depressions based on the depth of the depression observed using LiDAR imagery. Installation of filter strips could be prioritized for those depressions receiving runoff from the largest drainage areas.


Legend
Trout Brook Watershed
StreamReach070400020902
MaxDepthCM
6 - 25
26 - 50
51 - 100
101 - 200
201 - 335
Pothole_Wsheds070400020902

Legend
Trout Brook Watershed
StreamReach070400020902
MaxDepthCM
6 - 25
26 - 50
51 - 100
101 - 200
201 - 335
Pothole_Wsheds070400020902

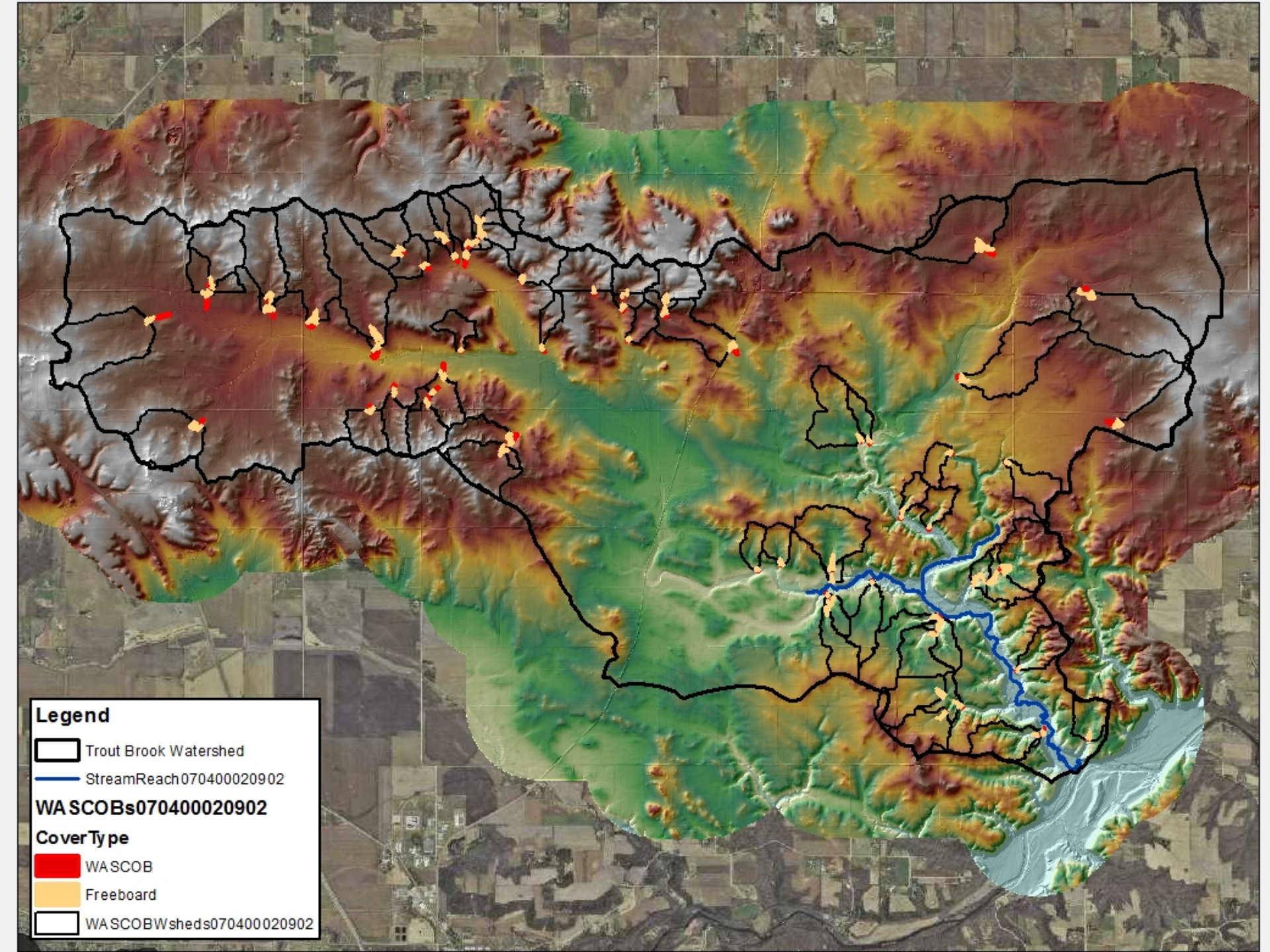

Legend
Trout Brook Watershed
StreamReach070400020902
MaxDepthCM
6 - 25
26 - 50
51 - 100
101 - 200
201 - 335
Pothole_Wsheds070400020902


Legend
Trout Brook Watershed
StreamReach070400020902
MaxDepthCM
6 - 25
26 - 50
51 - 100
101 - 200
201 - 335
Pothole_Wsheds070400020902
Depth_Grid
Value
High : 7.92355
Low : 1.52588e-005

WASCOB's - Water and Sediment Control Basins

Impound Siting

Water and sediment control basins (WASCOBS, or 'sediment detention basins) are placed along waterways to detain runoff water the opportunity for sediment to settle out to avoid its delivery to the stream channel. The set of criteria used are similar to that used to locate wetlands, but the idea is to have somewhat deeper water (to provide a depth and storage volume for sediment to settle to the bottom) and a smaller surface area. These basins can (and should) be placed along ephemeral drainage ways that are somewhat more incised than those selected for wetlands.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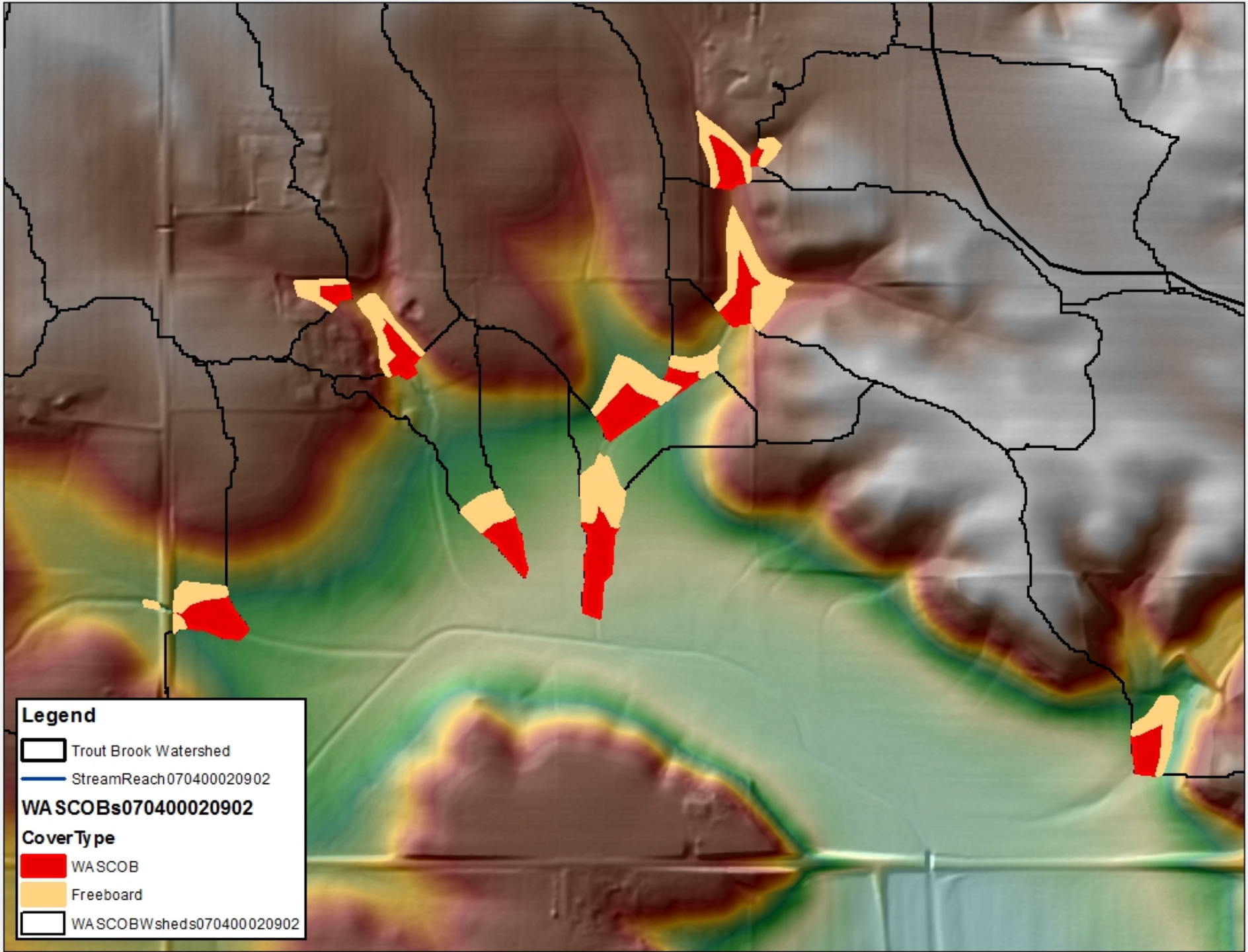
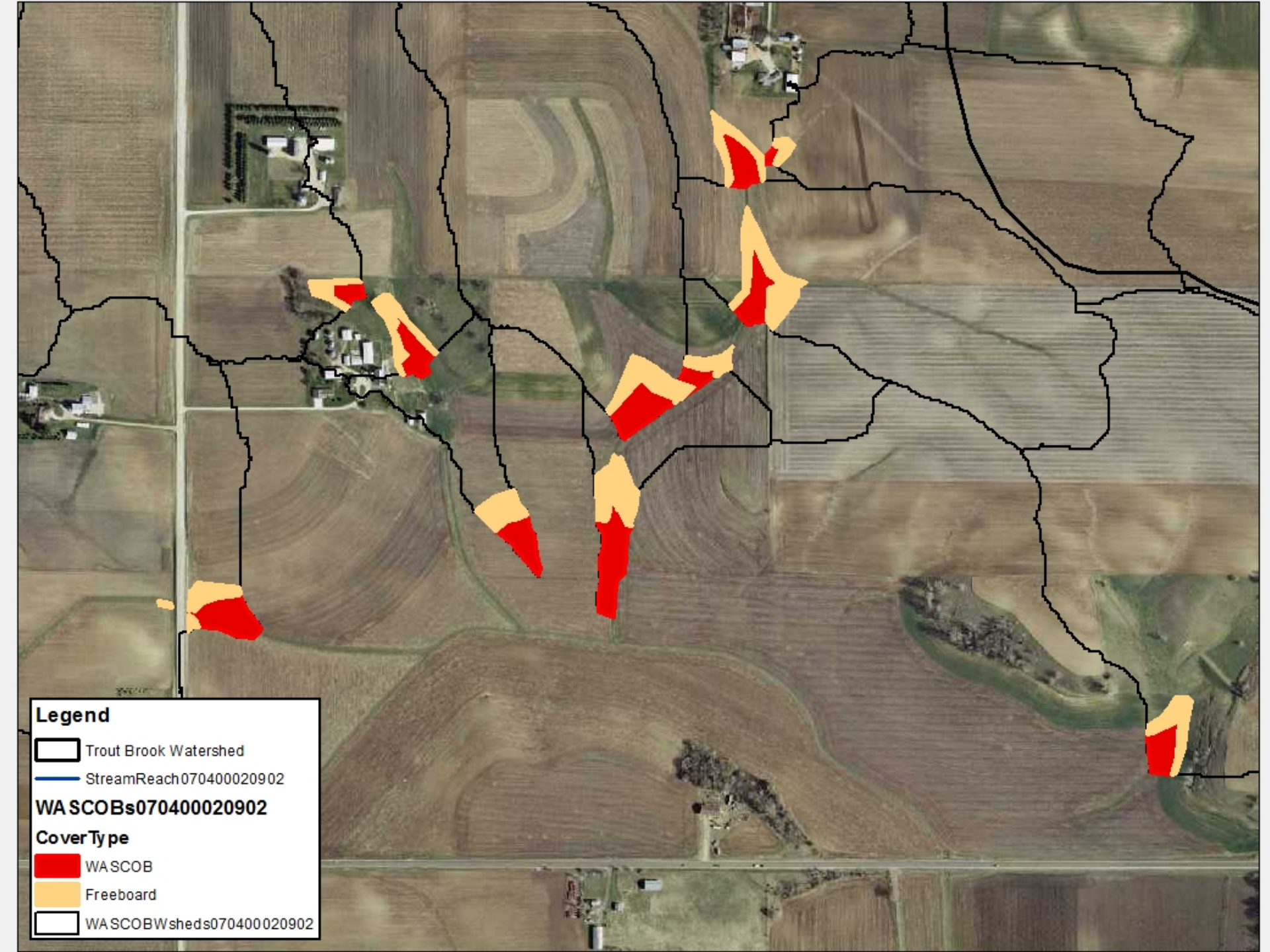
Trout Brook Watershed
StreamReach070400020902
WASCOBs070400020902
CoverType
WASCOB
Freeboard
WASCOBWsheds070400020902


Legend
Trout Brook Watershed
StreamReach070400020902
WASCOBs070400020902
CoverType
WASCOB
Freeboard
WASCOBWsheds070400020902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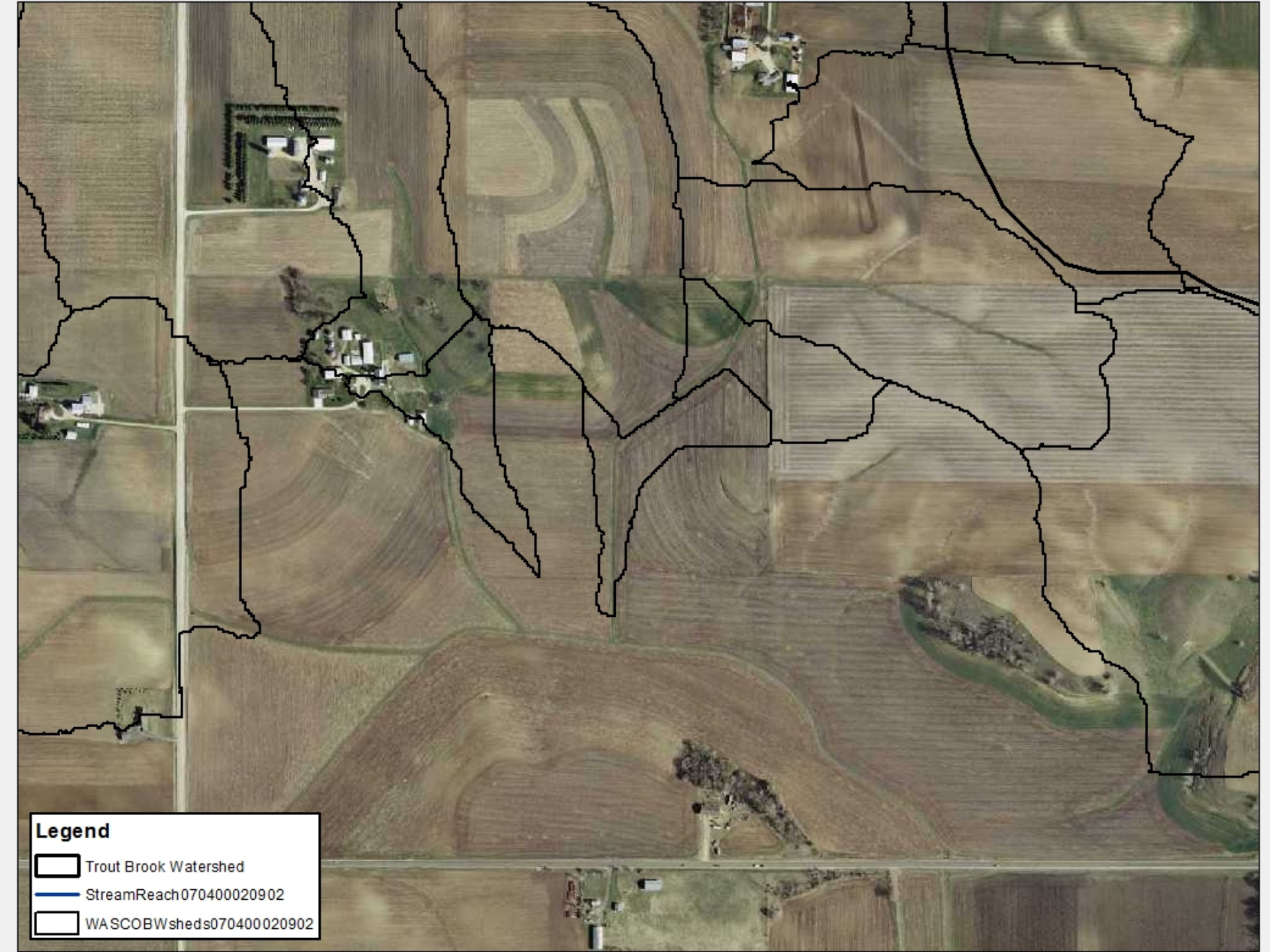
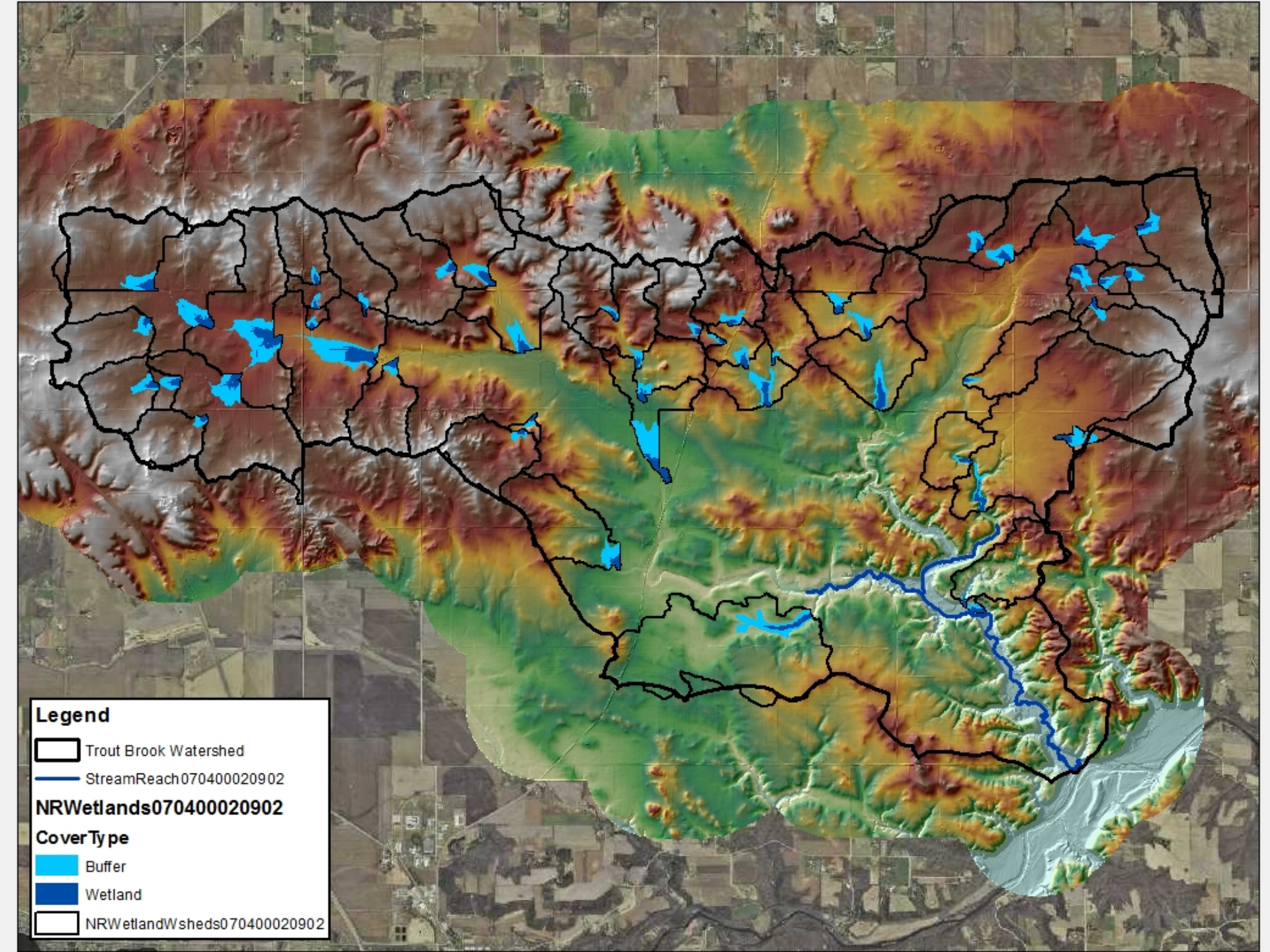
WASCOBs070400020902
CoverType
WASCOB
Freeboard
WASCOBWsheds070400020902

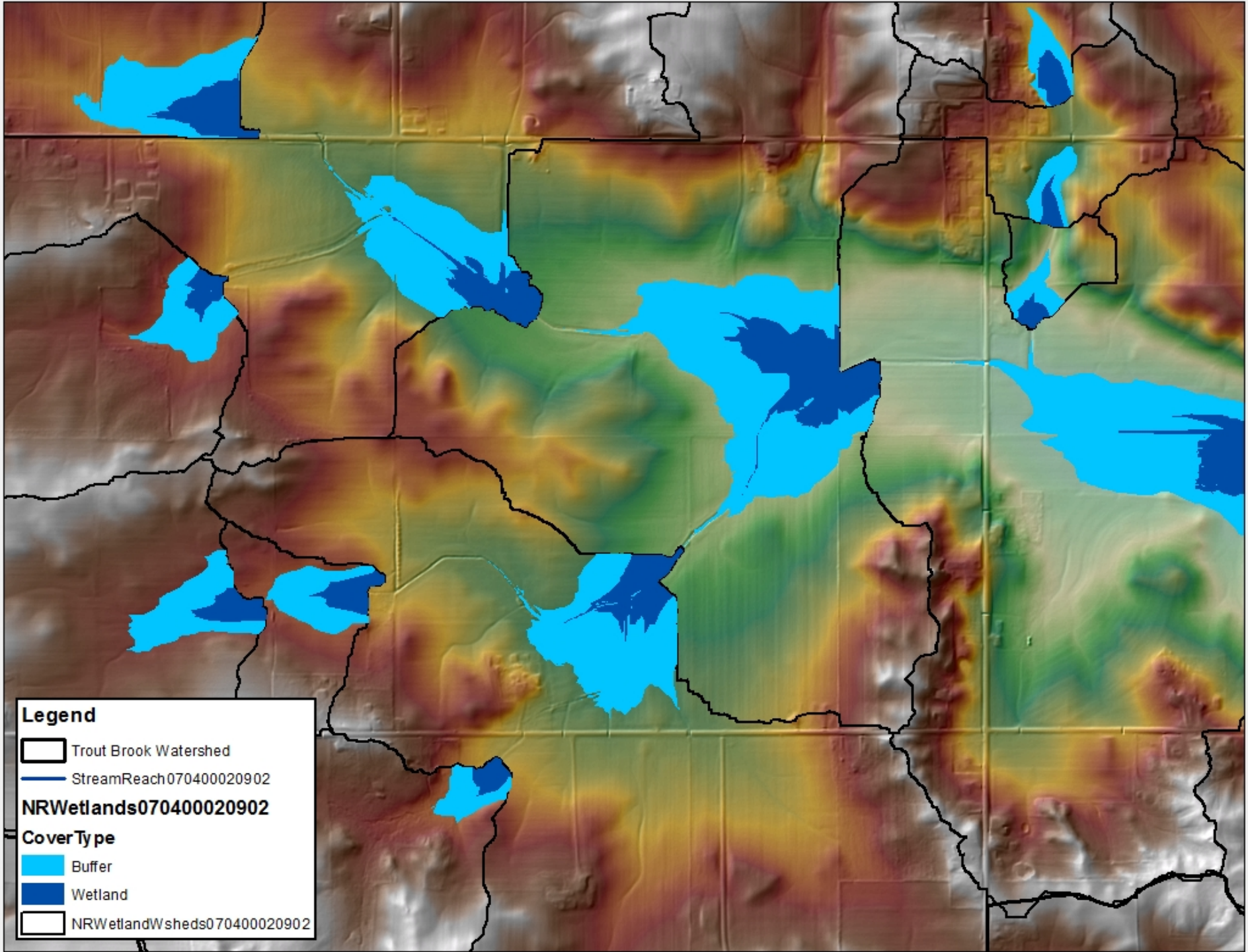

Legend
Trout Brook Watershed
StreamReach070400020902
WASCOBWsheds070400020902

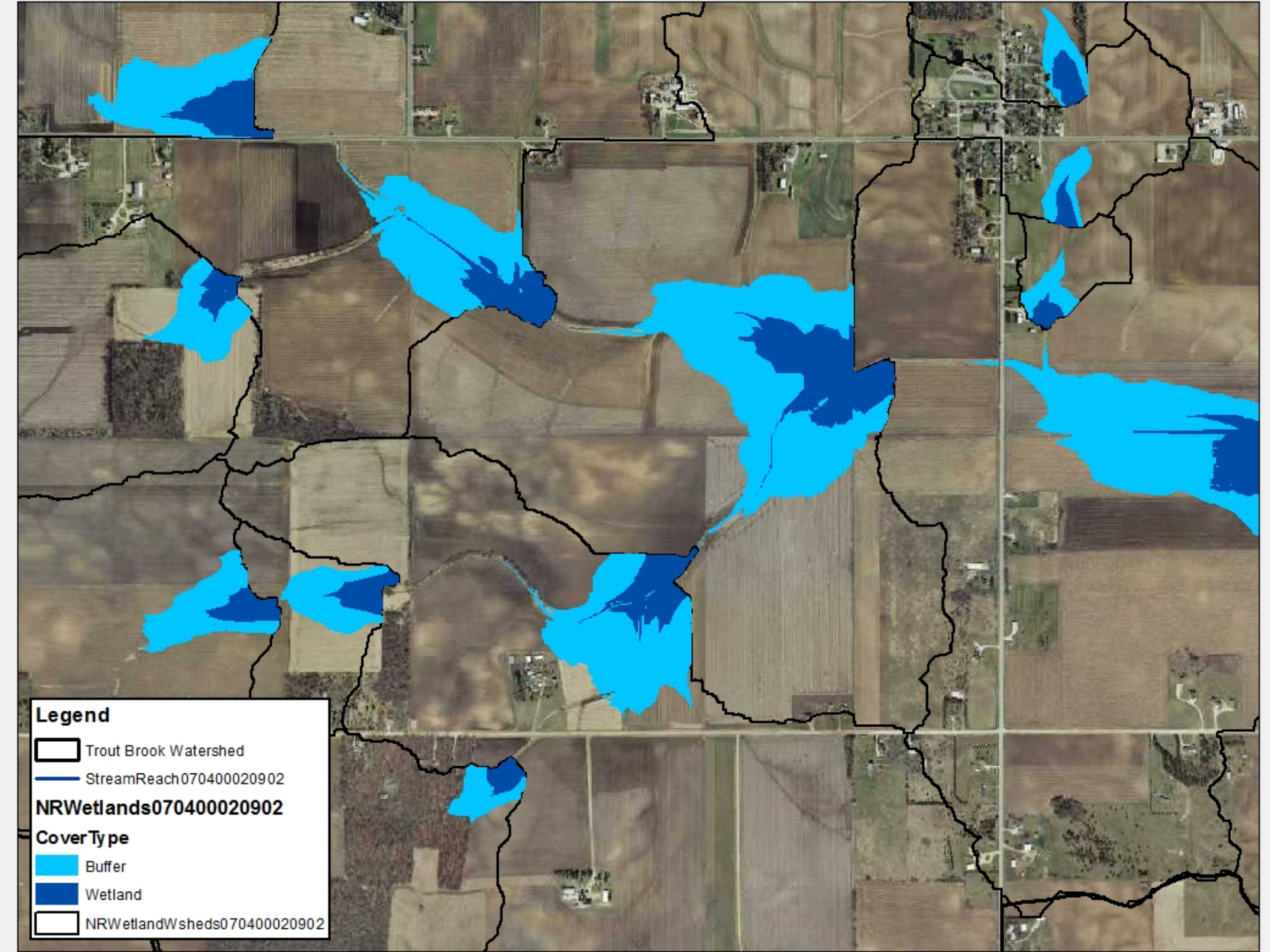
Nutrient Removal Wetlands

Impound Siting

- Wetlands can be strategically located below tile drained fields and designed to provide an off-site strategy for reducing nitrate from tile drainage water. It may also be possible to place sediment detention structures in these areas to reduce phosphorus loss from the watershed. This map shows nutrient removal wetlands that could be placed below fields in this watershed that are most likely to be tile drained. We recognize that this is a highly permeable landscape and that the feasibility of installing wetlands may be low in some of these locations.


Legend
Trout Brook Watershed
StreamReach070400020902
NRWetlands070400020902
CoverType
Buffer
Wetland
NRWetlandWsheds070400020902


Legend
Trout Brook Watershed
StreamReach070400020902
NRWetlands070400020902
CoverType
Buffer
Wetland
NRWetlandWsheds070400020902


Legend
Trout Brook Watershed
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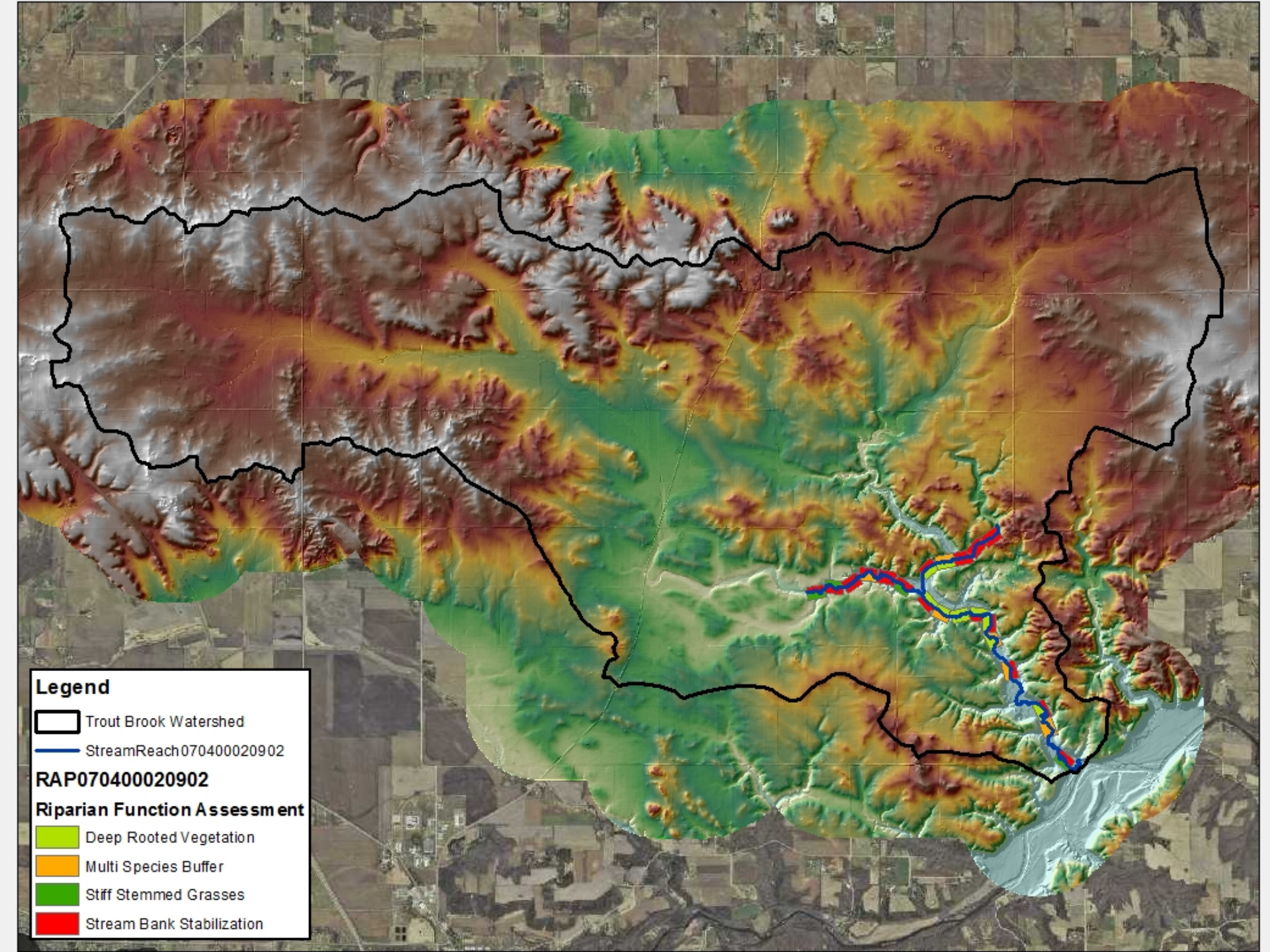
NRWetlands070400020902
CoverType
Buffer
Wetland
NRWetlandWsheds070400020902

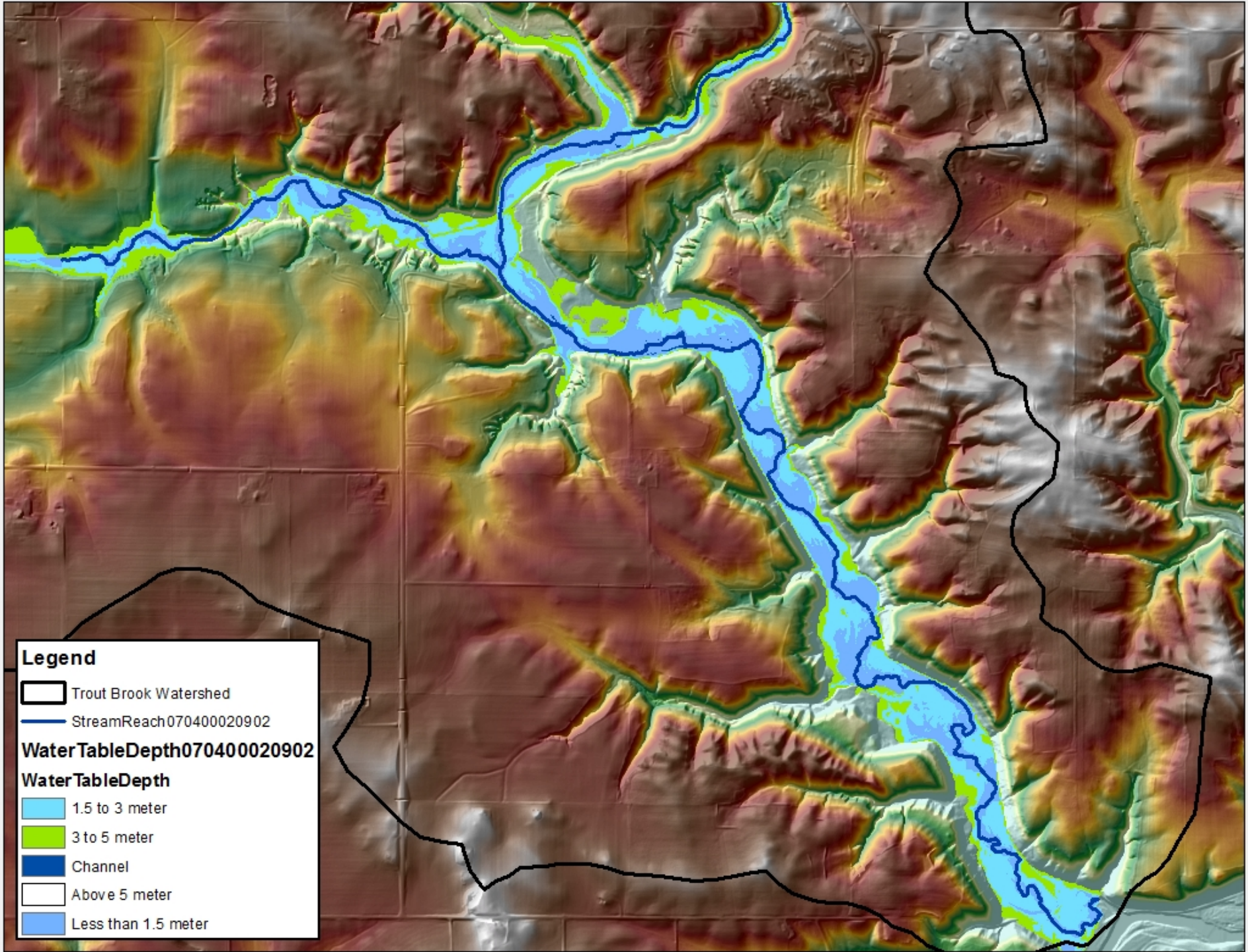
Legend
Trout Brook Watershed
StreamReach070400020902
NRWetlandWsheds070400020902

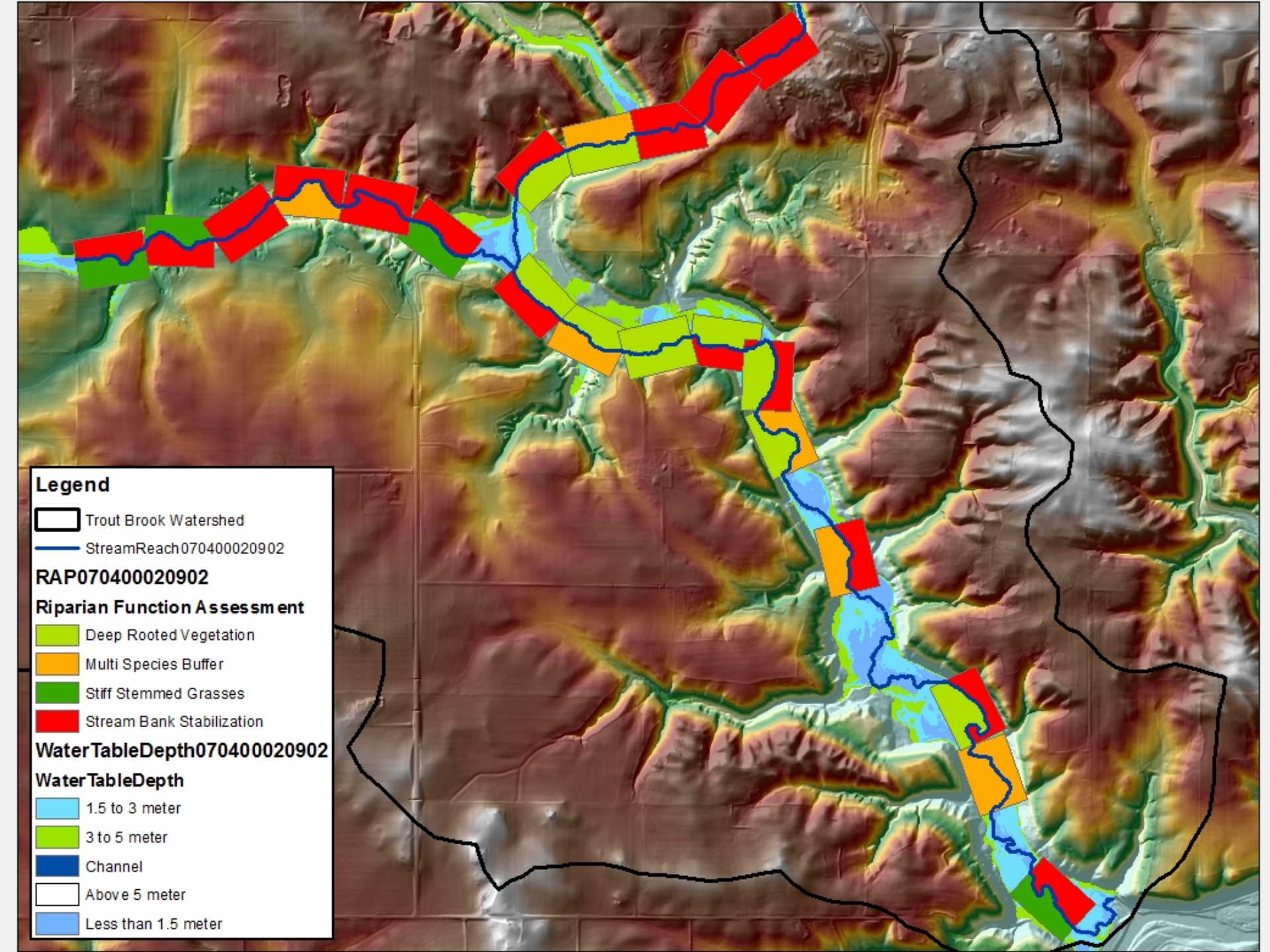
Riparian Function Assessment

Riparian Characterization

Along a watershed's network of riparian corridors, there are varying opportunities to stabilize streambanks, intercept surface runoff, and influence shallow groundwater. Our objective was to classify these riparian management opportunities and develop a mapping aid for watershed planning. This approach identifies the likely distributions of surface runoff contributions and shallow water tables in a watershed, delineates and tabulates results along both banks of the channels, and applies a cross classification that conveys recommendations for buffer vegetation and width.


Legend
Trout Brook Watershed
StreamReach070400020902
RAP070400020902
Riparian Function Assessment
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization


Legend
Trout Brook Watershed
StreamReach070400020902
WaterTableDepth070400020902
WaterTableDepth
1.5 to 3 meter
3 to 5 meter
Channel
Above 5 meter
Less than 1.5 meter


Legend
Trout Brook Watershed
StreamReach070400020902
RAP070400020902
Riparian Function Assessment
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
WaterTableDepth070400020902
WaterTableDepth
1.5 to 3 meter
3 to 5 meter
Channel
Above 5 meter
Less than 1.5 meter

Terrain Analysis Applications

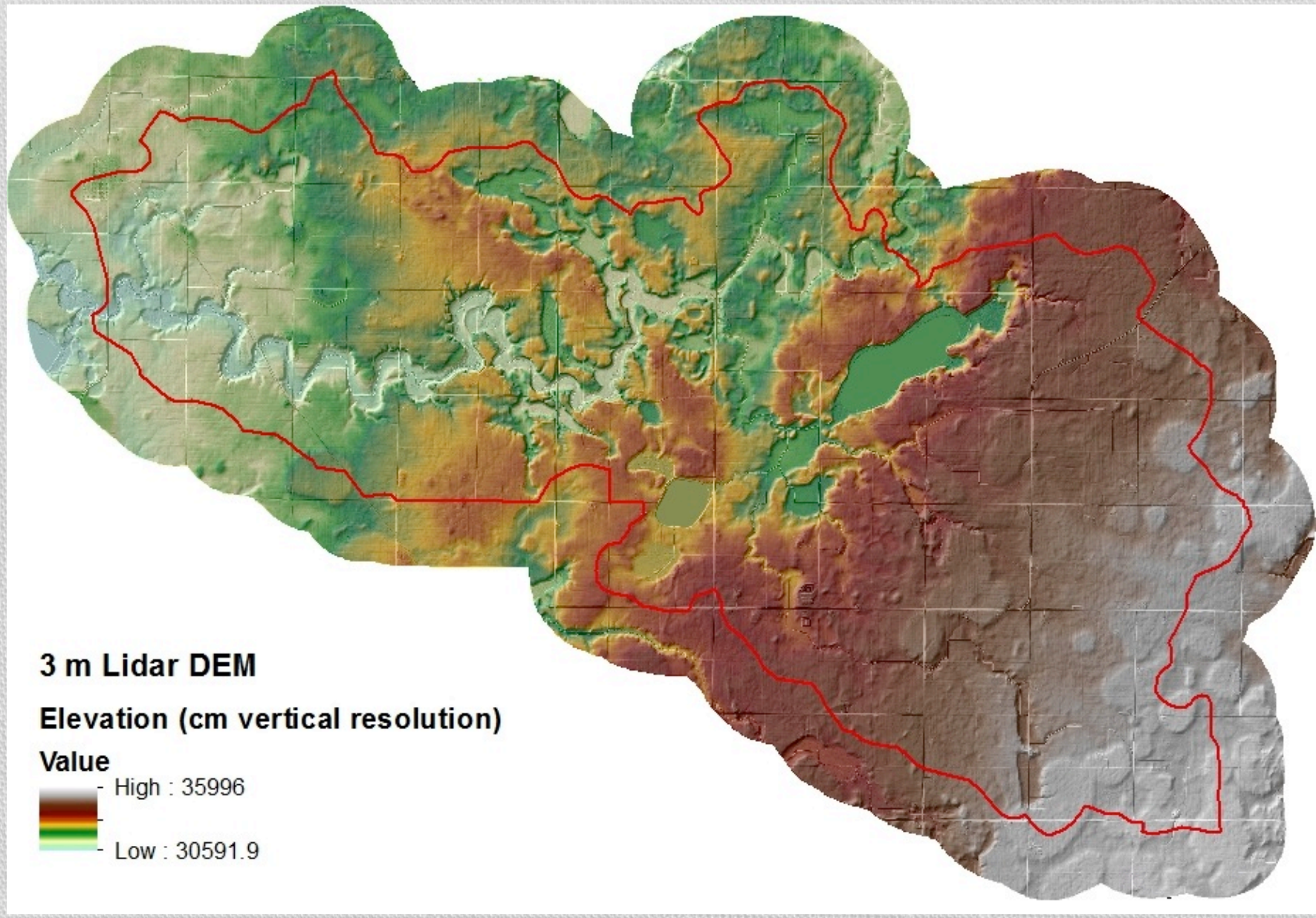
Value-added LiDAR Analysis

- Richard Moore
- Andrew Meyer
- Jessica Nelson
- Water Resources Center
- 507-389-5492

AGRICULTURAL CONSERVATION PLANNING ANALYSIS

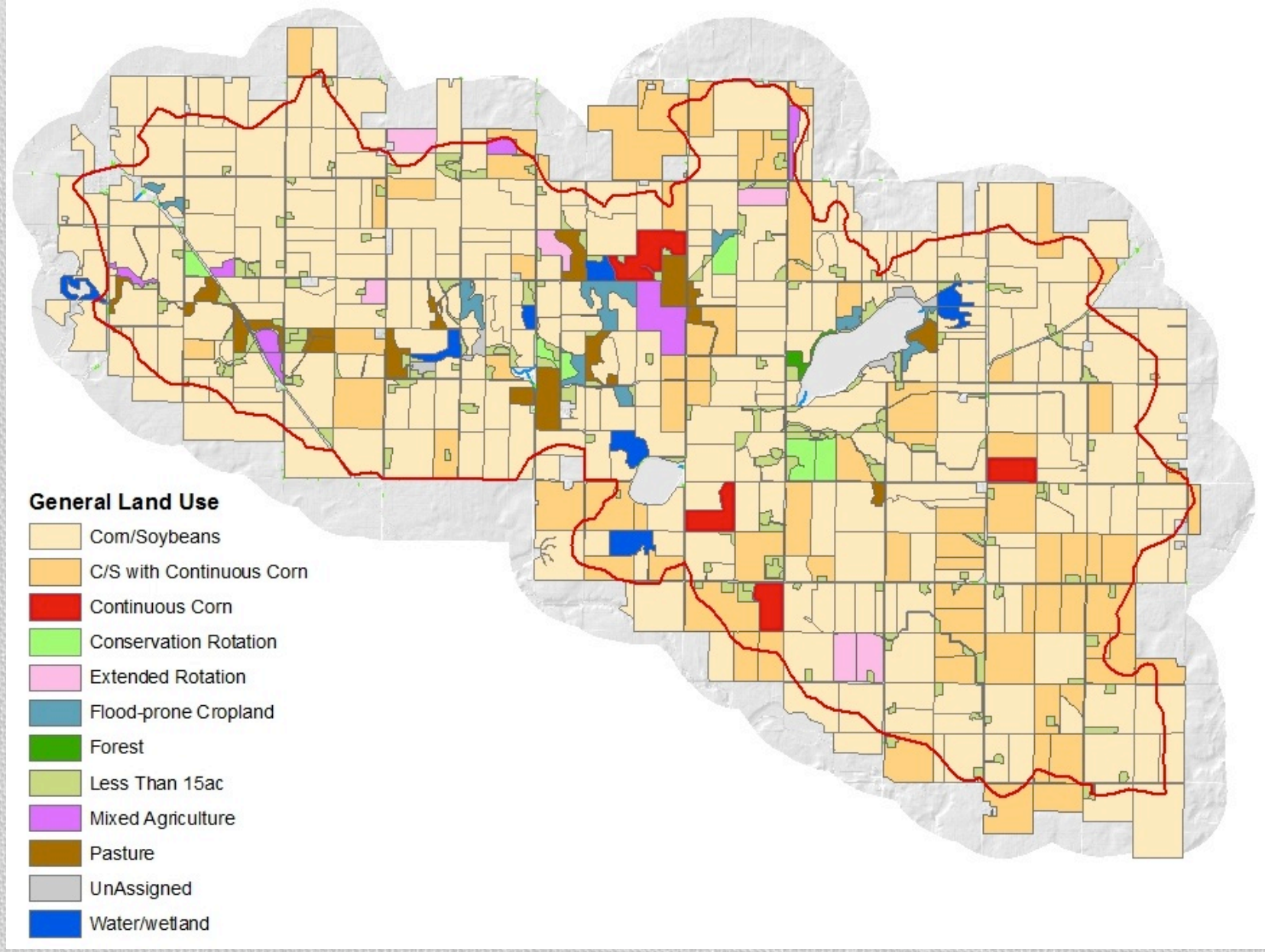
Targeting using:
Agricultural Conservation Planning Framework
Agricultural Conservation Planning Toolbox
National Laboratory for Agriculture and the Environment
U.S. Department of Agriculture, Agriculture Research Service
Mark Tomer, Sarah Porter, David James, and Kathy Boomer (TNC)

Elevation



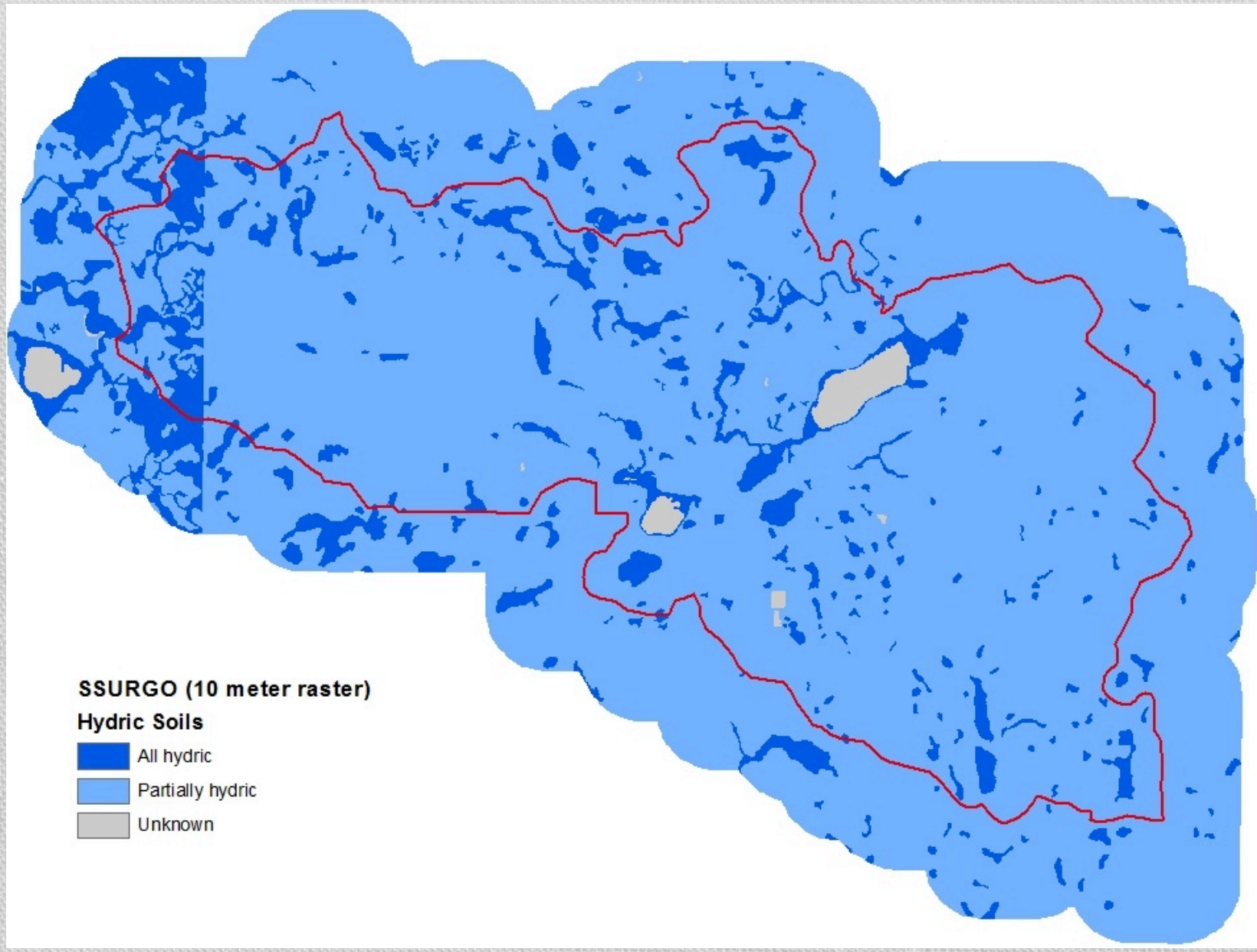
Input data include a LiDAR-derived digital elevation model (DEM), agricultural field boundaries with land use information, and SSURGO soil survey data.

General Land Use



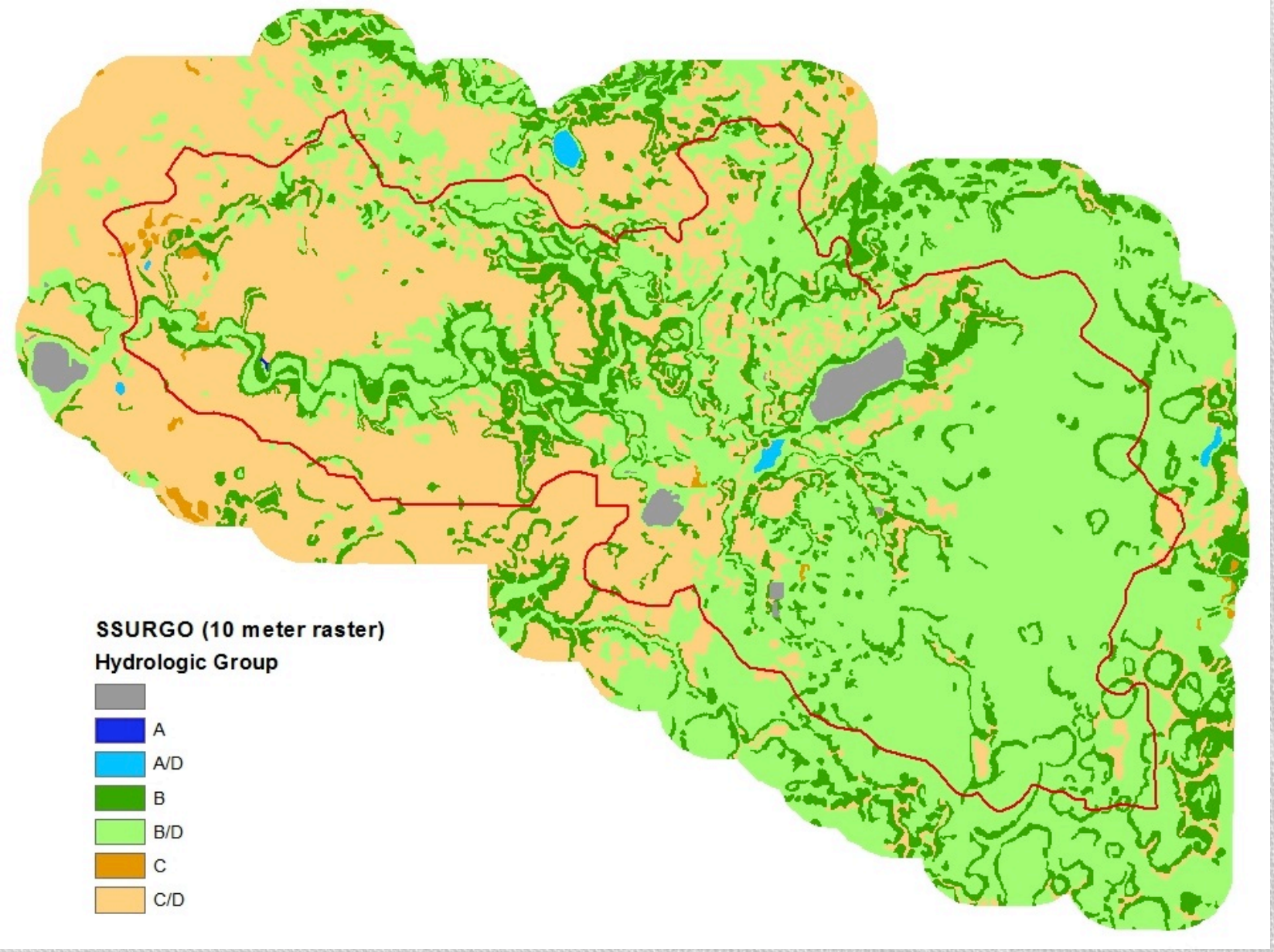
Input data include a LiDAR-derived digital elevation model (DEM), agricultural field boundaries with land use information, and SSURGO soil survey data.

SSURGO – hydric soils

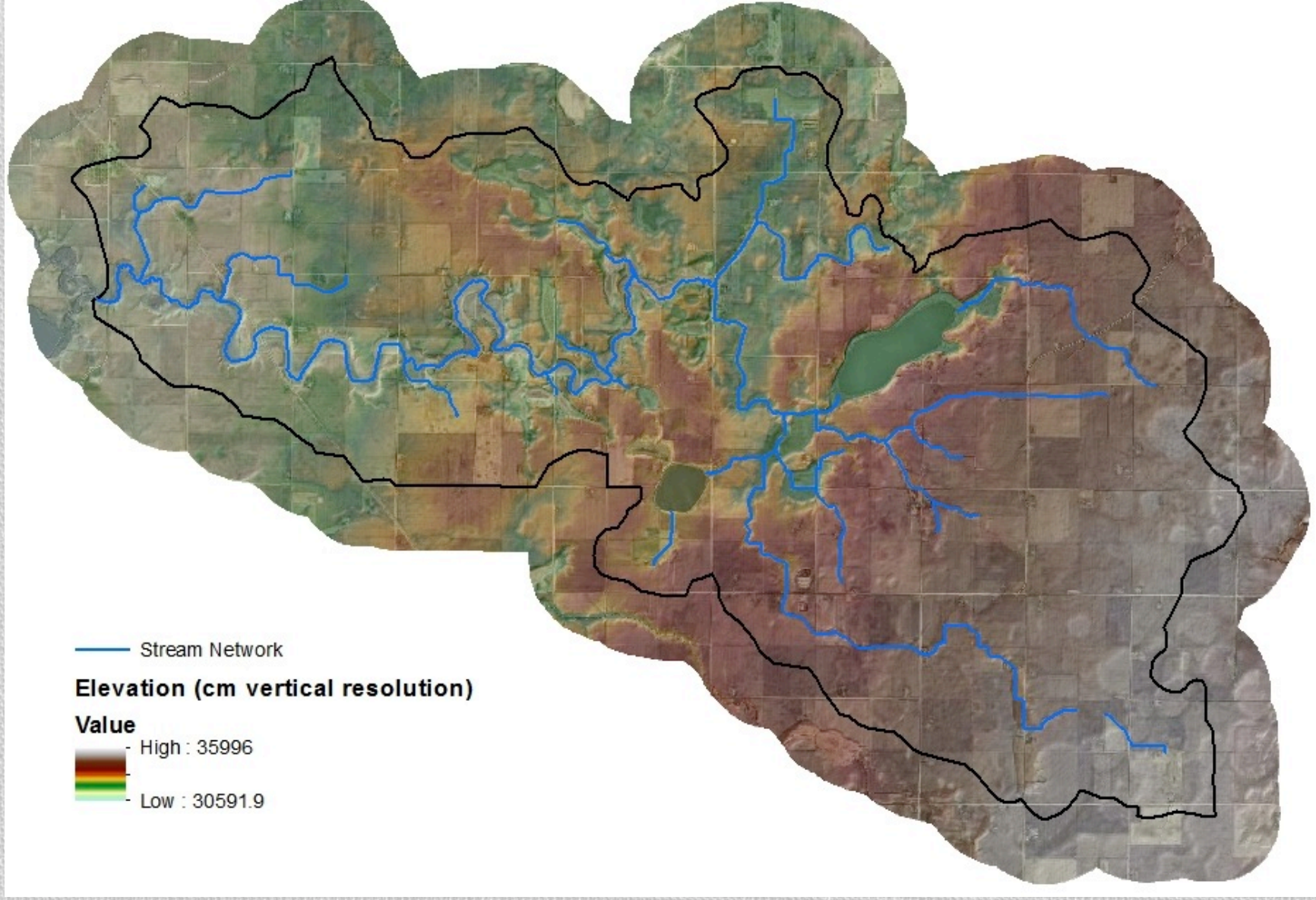


Input data include a LiDAR-derived digital elevation model (DEM), agricultural field boundaries with land use information, and SSURGO soil survey data.

Hydrologic Group

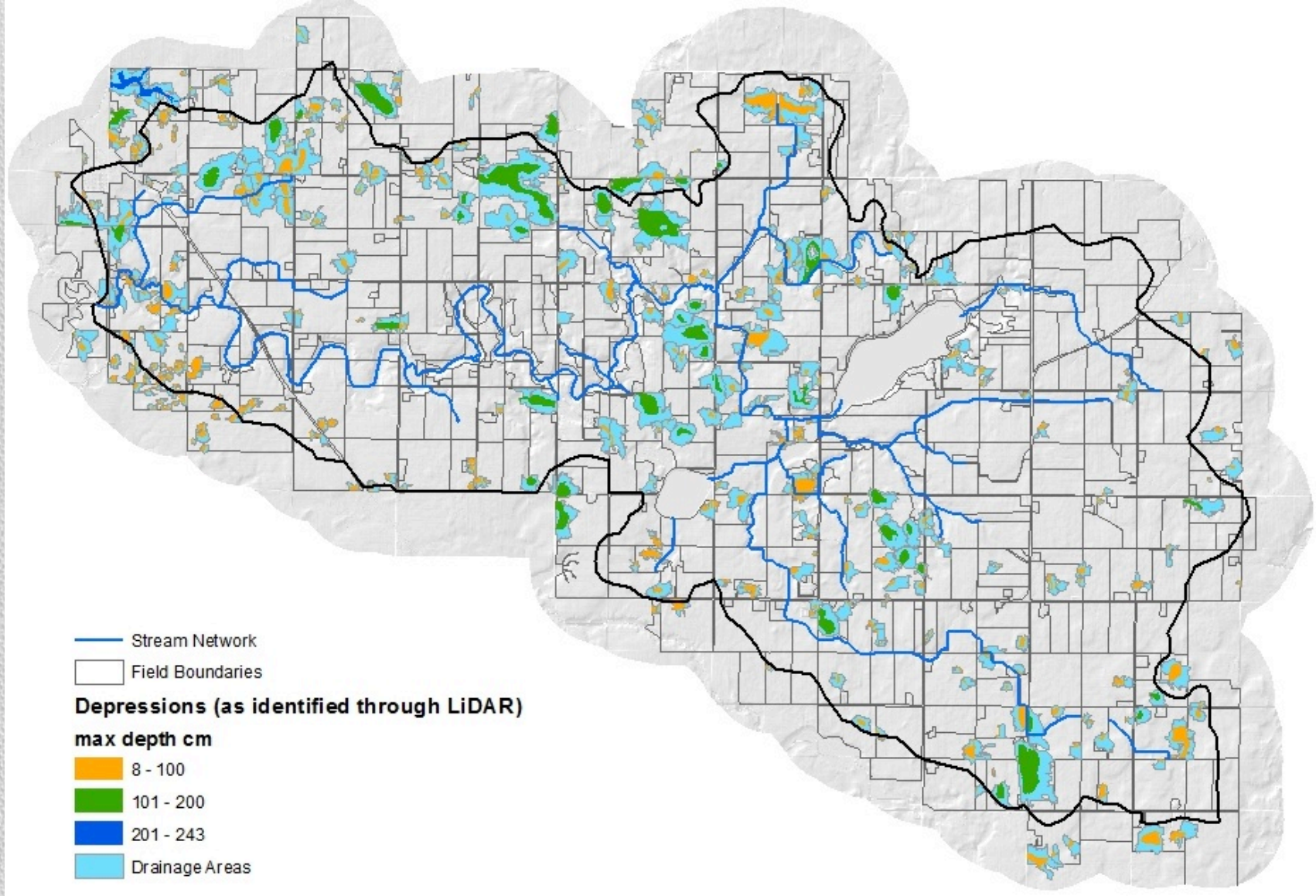


Stream Network



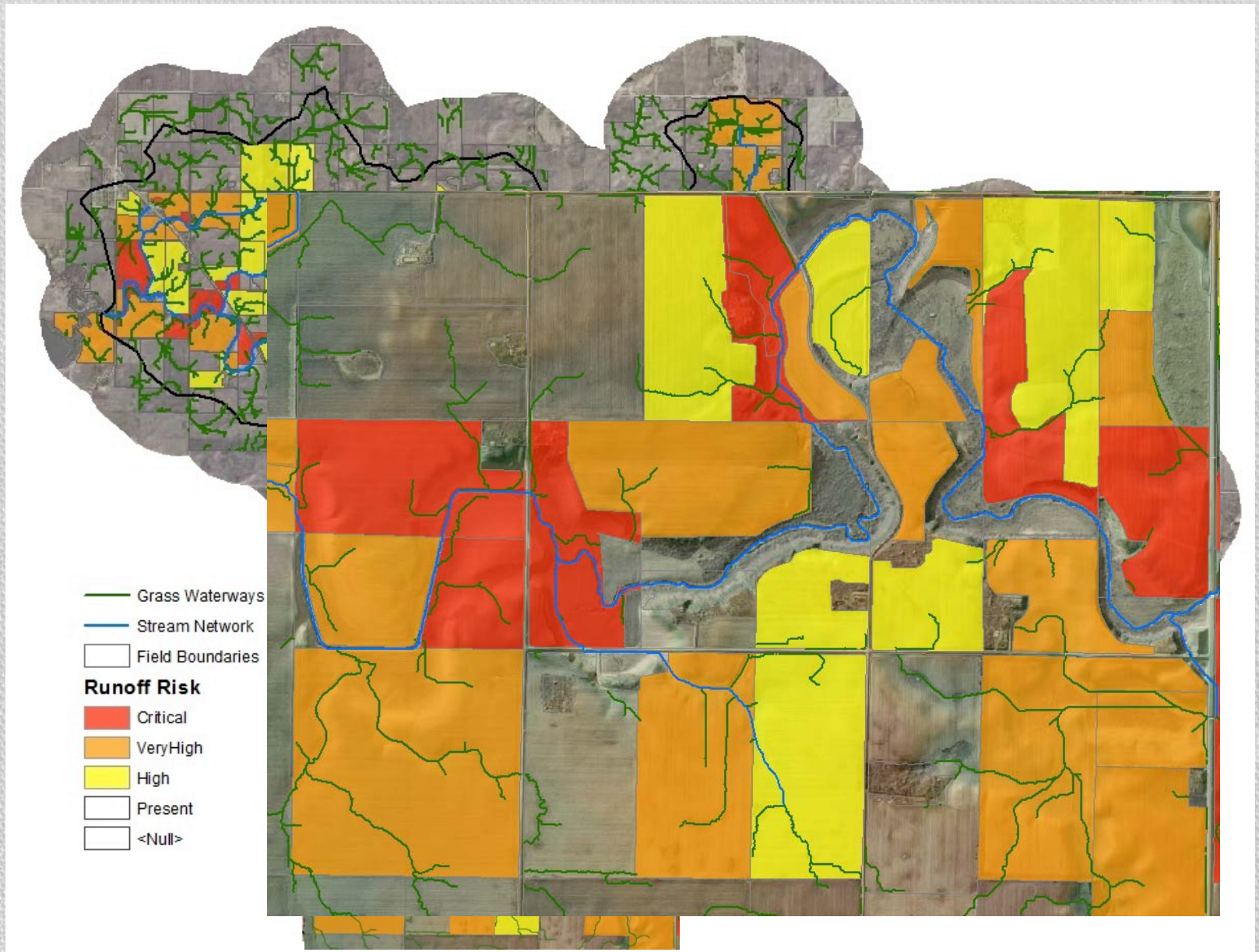
Processing the elevation data for hydrologic modeling, and mapping the location of the stream network as accurately as possible, are critical steps to ensure that the suggested practice placements from application of the framework can be realistic. The hydrologic processing was performed on the 3 m DEM to generate flow direction and flow accumulation grids.

Surface Depressions



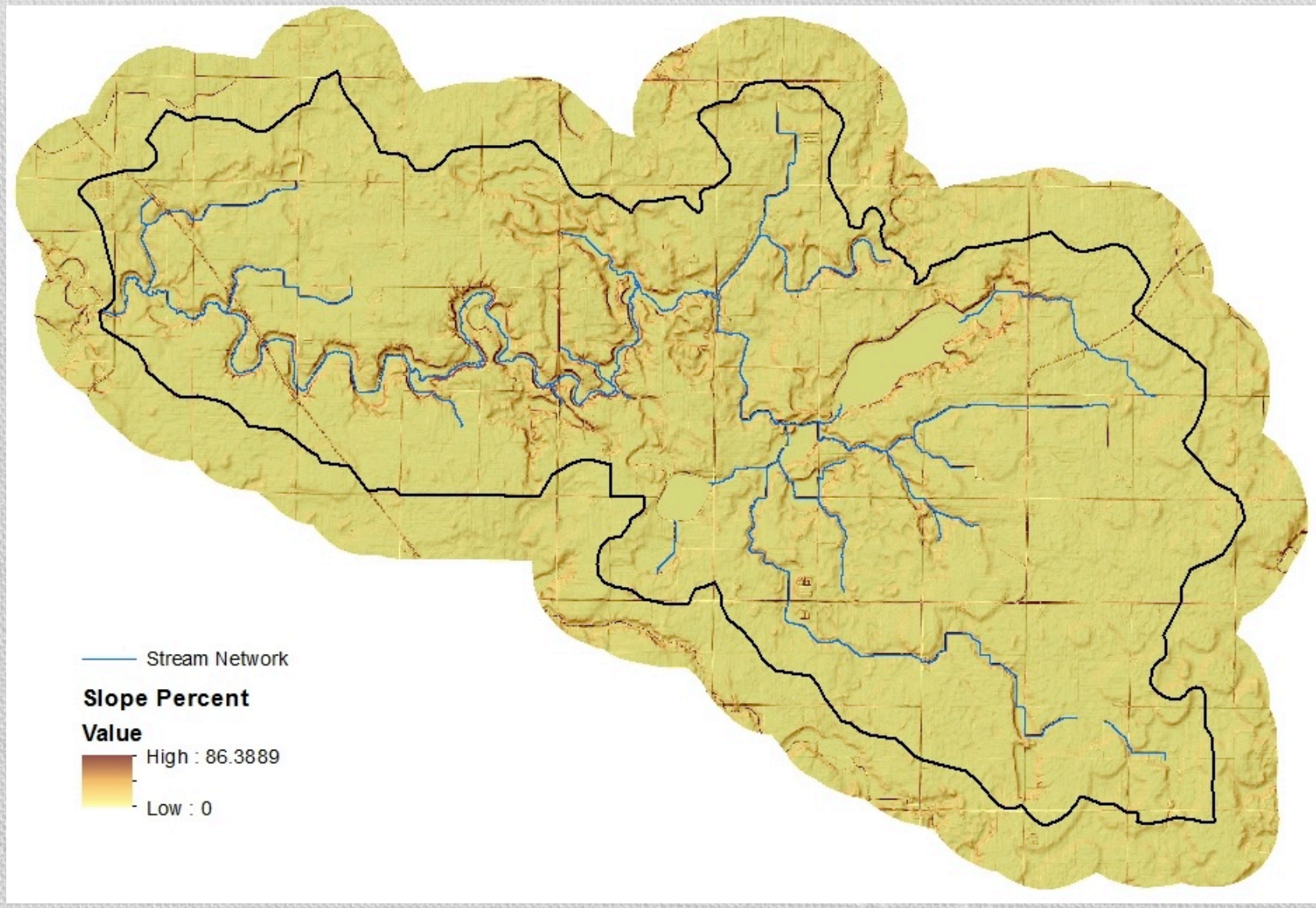
Depressions are common in the glacial landscapes of the Midwest and present challenges for managing water quality and wetness of fields. We have shaded depressions in the Bull Run based on the depth of the depression observed using LiDAR imagery. Installation of filter strips could be prioritized for those depressions receiving runoff from the largest drainage areas.

Runoff Risk Assessment

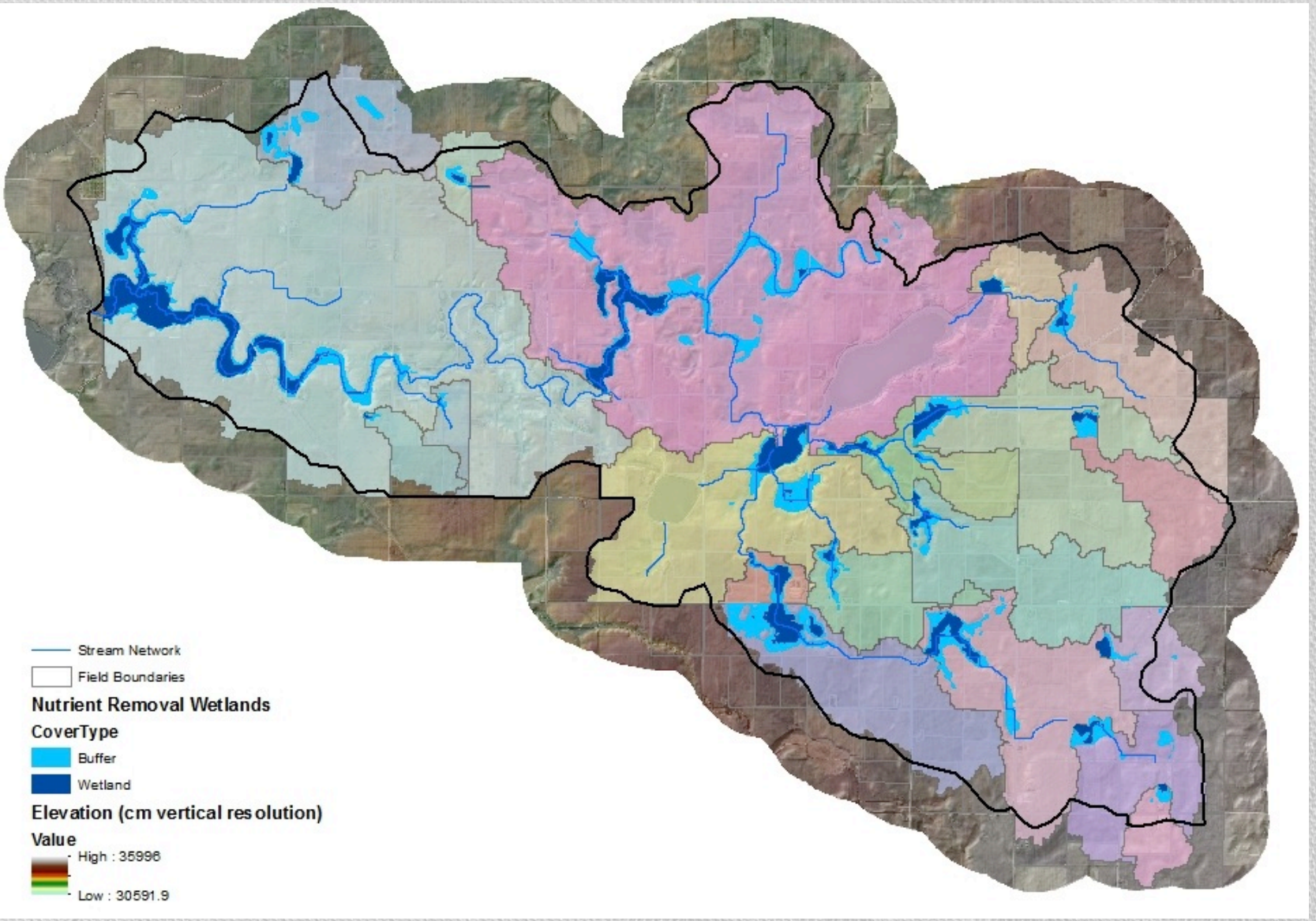


The cross classification of the "Runoff Risk Assessment" matrix classifies each field according to its runoff risk. A more-detailed look at the within field topography and flow accumulation can then identify which conservation practices may be most suitable in a given field. This image shows possible locations for grassed waterways, located along areas where channelized flow may occur .

Slope



Nutrient Removal Wetlands



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WASCOBs

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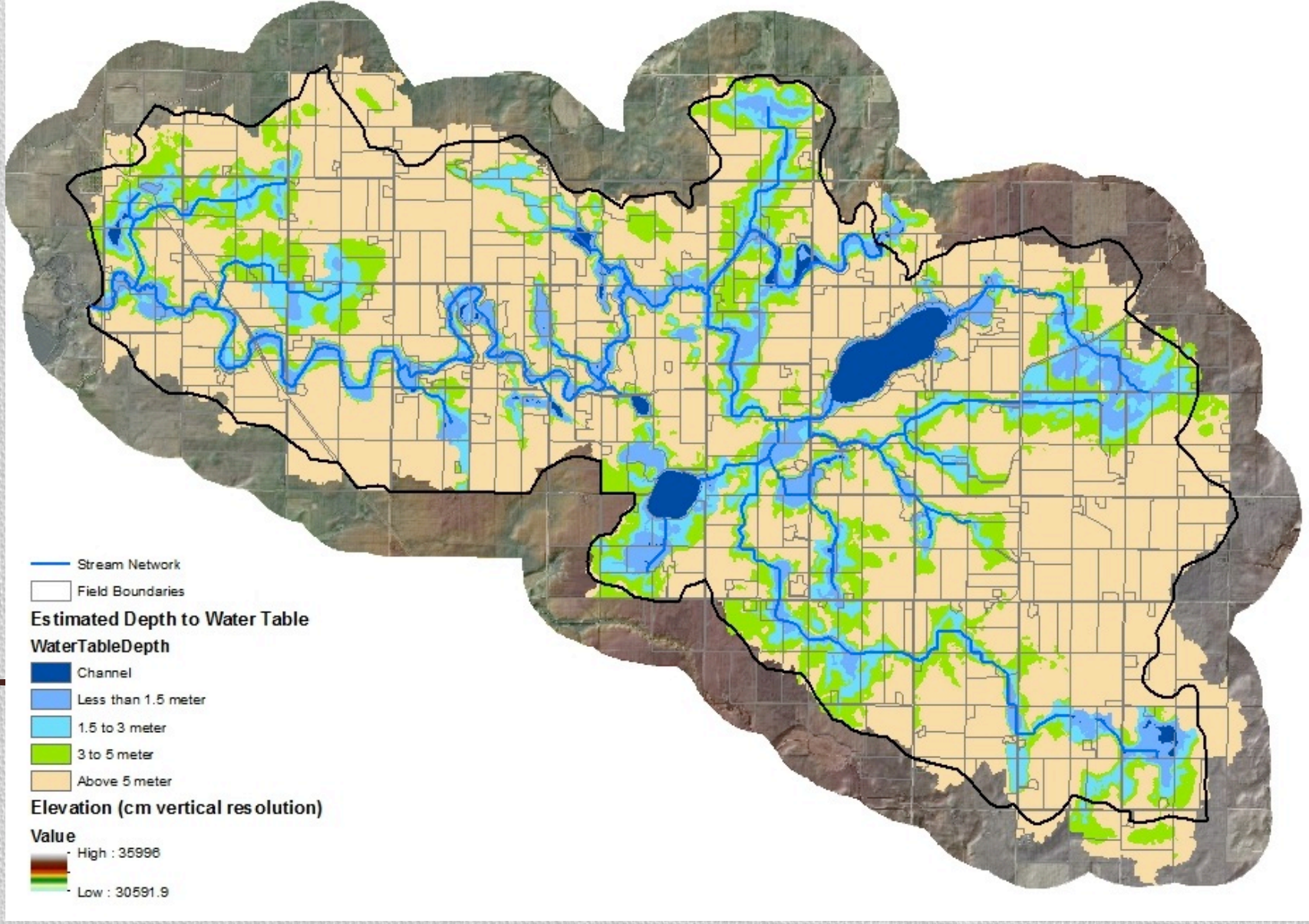
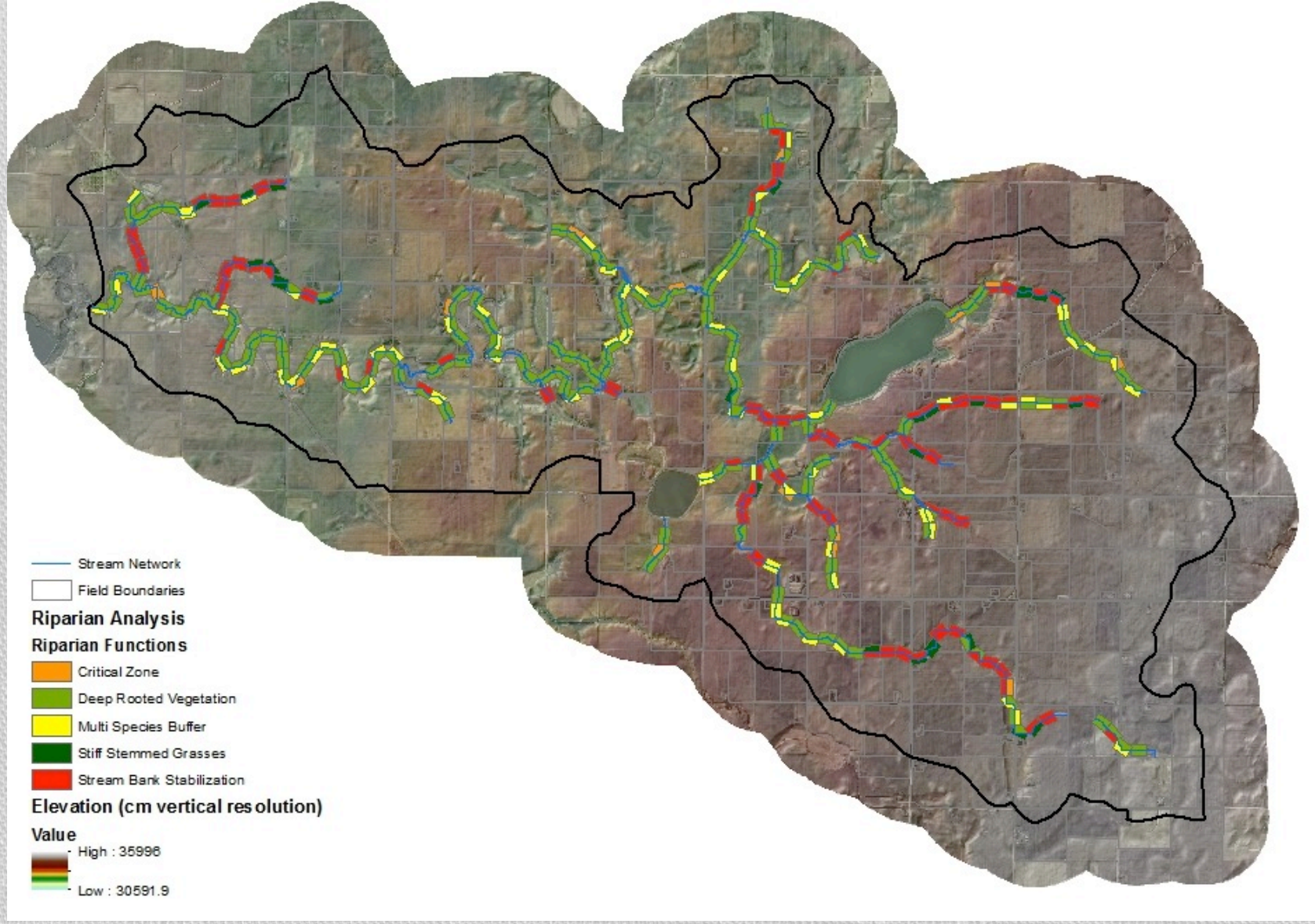
Est. Depth to Water Table



A raster of estimated depth to water table was developed by calculating elevation differences between each grid cell and the stream-channel grid cell that would receive overland flow from that cell. These elevation difference values were then reclassified into the depth categories shown on the map. These results are used to suggest sites for several types of riparian-zone conservation practices on subsequent maps.

Riparian Analysis



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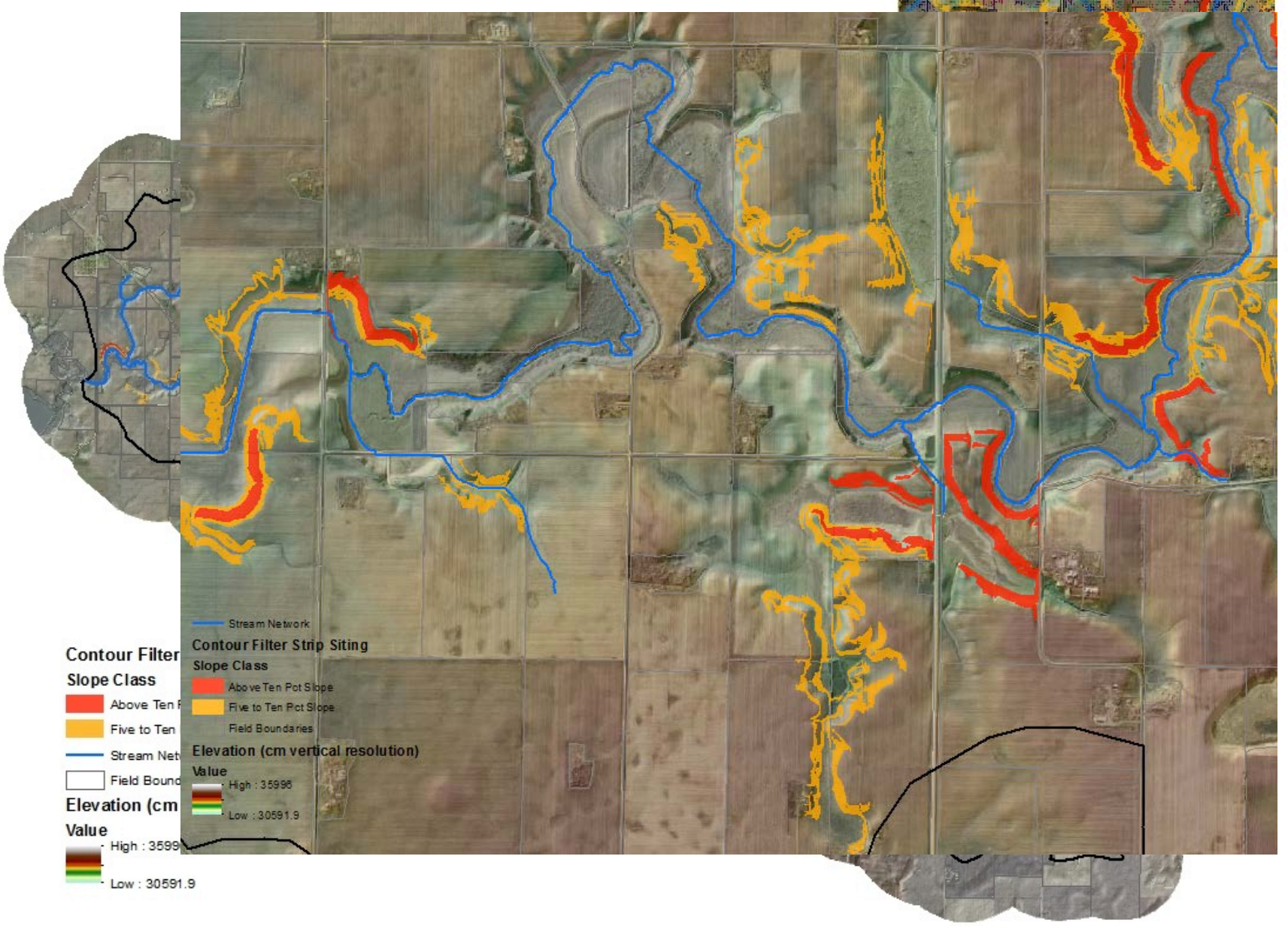
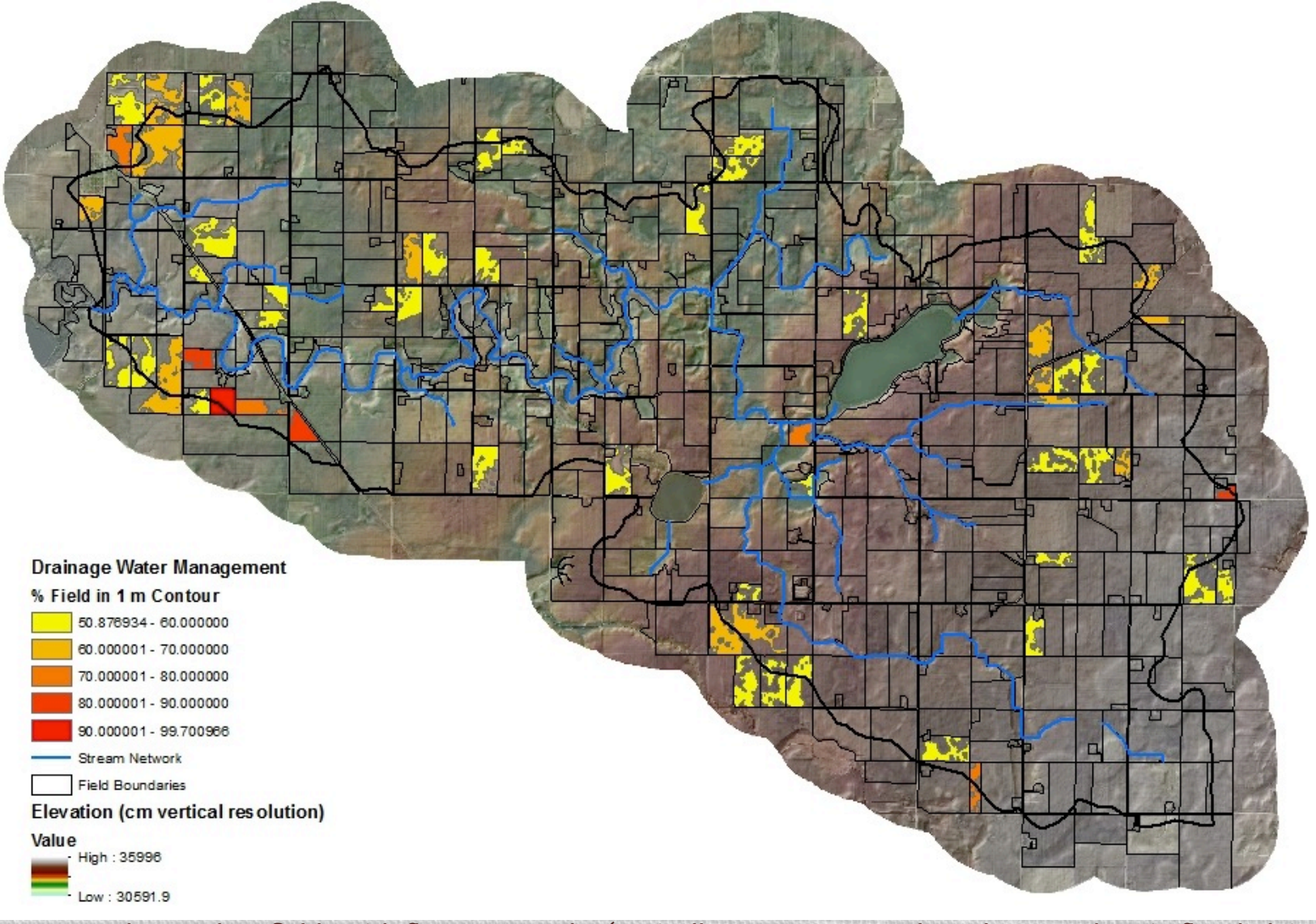
Contour Filter Strip Siting



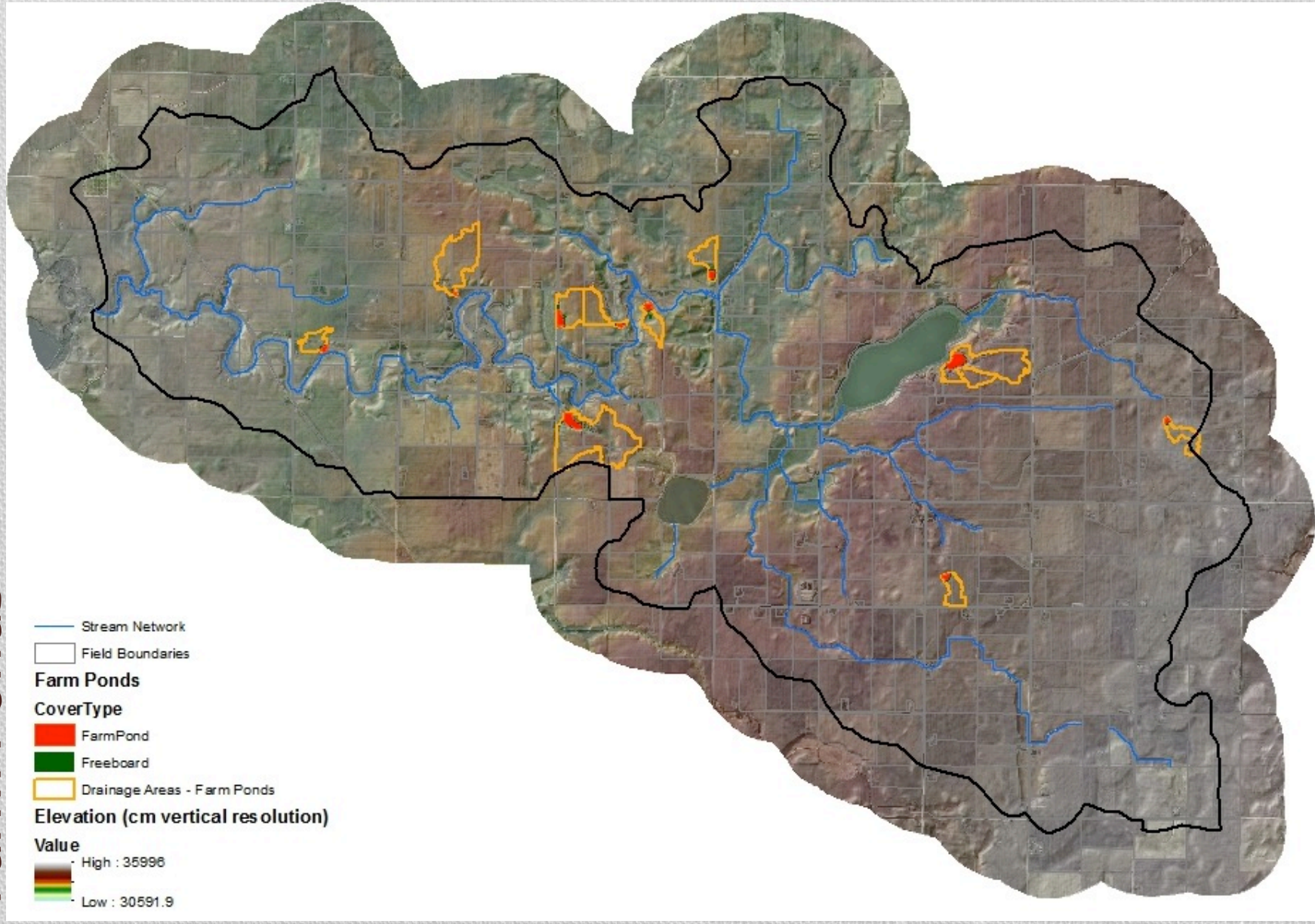
- Contour filter strips are strips of perennial vegetation alternated down a slope with wider cultivated strips that are farmed on the contour. Similar to grassed waterways, contour filter strips are in-field runoff control practices, designed to decrease the occurrence of concentrated flow and reduce sheet and rill erosion.
- The contour filter strip tool identifies contiguous areas of high slopes (> 5%) in agricultural fields. Contour buffer strips and/or terraces (more suited to steeper ground) placed within these areas are beneficial for reducing sheet and rill erosion.

Drainage Water Mgmt



Controlled drainage may be used on fields with flat topography (typically one percent or less slope, such as in flood plains and on flat fields typical of the large areas of the glaciated Midwest. The practice can be expensive to design and install in areas with slopes steeper than about one percent because of the number of control structures required in a typical field. A single control gate (dependent on its size) can influence the water table within approximately .5 meter change in elevation. To identify fields potentially suited to this practice, the Drainage Water Management tool identifies the largest area within any 1-meter (3.3 ft) contour interval (representing the addition of 2 control-gate structures), within each tile-drained, agricultural field.

Farm Ponds



Farm ponds serve a function of both sediment detention and nutrient removal, and offer the possibility to stock fish. Farm ponds are in-field conservation practices, and as such a smaller drainage area range (10 – 100 HA) is used to identify collective flow pathways. This siting tool allows the user to sample locations along collective flow pathways for suitability of farm ponds.