

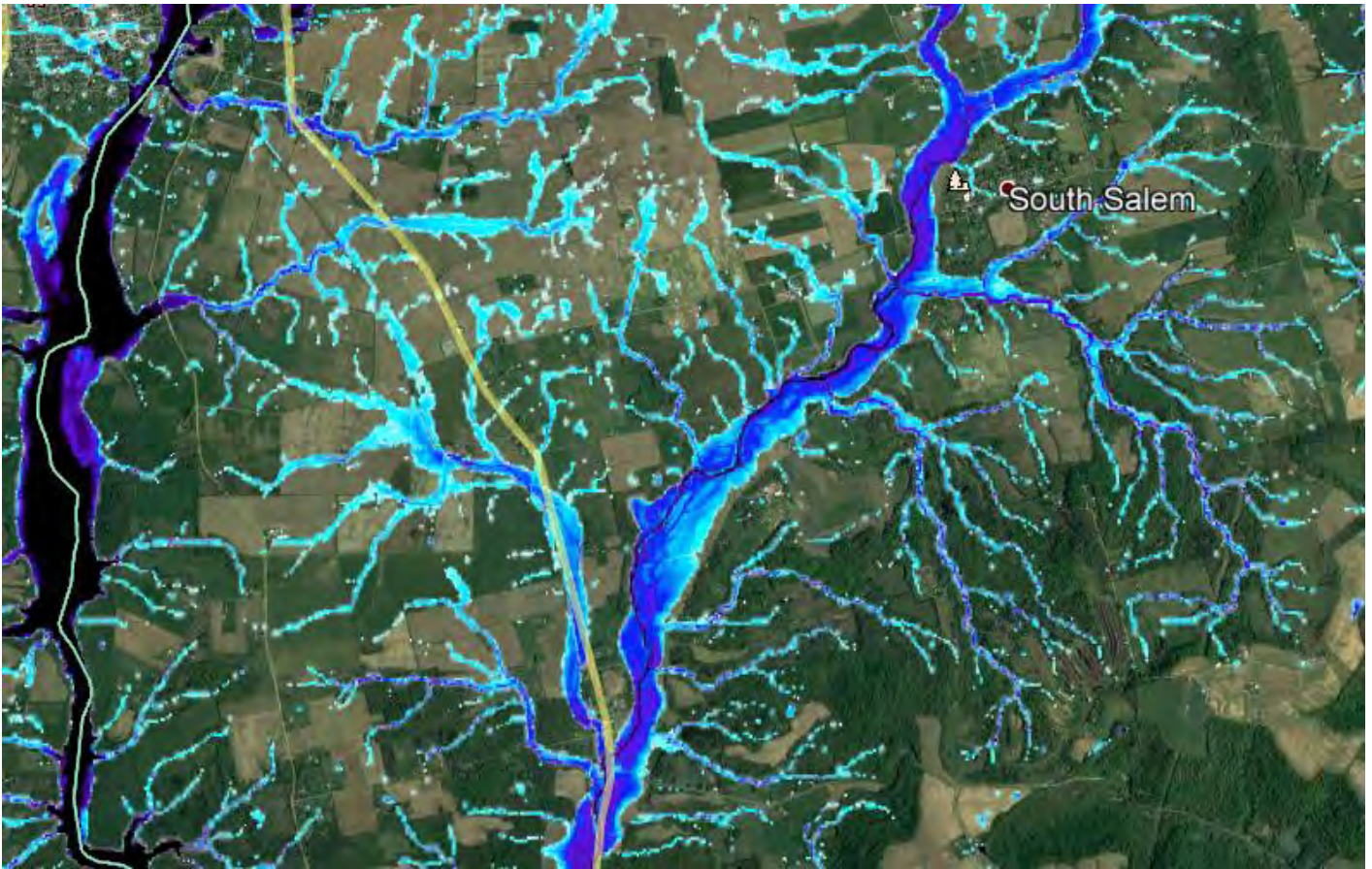


Ross County Solar

Exhibit R

Hydrology Study

Case No. 20-1380-EL-BGN



PRELIMINARY HYDROLOGY STUDY

Ross County Solar

Ross County, Ohio

AUGUST, 2020

PREPARED FOR:



PREPARED BY:

Westwood

Preliminary Hydrology Study

Ross County Solar

Ross County, Ohio

Prepared For:

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Project Number: R0028444.00

Date: August 20, 2020

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- Exhibit 5: Curve Number and Topographic Source Map
- Exhibit 6: 100-Year Max Flood Depth Map
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- Exhibit 7: 100-Year Peak Velocity Map
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Appendices

- Appendix A: NOAA Atlas 14 Precipitation Data
- Appendix B: Curve Number Table
- Appendix C: FEMA Flood Insurance Rate Map (FIRM)
- Appendix D: Stream Stats

Executive Summary

The purpose of the study is to analyze and review the existing hydrology of the Ross County Solar project ("the project") and any impacts that the hydrology may play in the design of the proposed solar array. This report was prepared to be used by the project team in the design and layout of the project and not intended for submittal to reviewing agencies for stormwater permitting.

The project site is proposed on approximately 10.5 square miles and is located a third mile southeast of the city of Greenfield in Ross County, Ohio. The site is located on relatively flat land that generally slopes to the southeast toward Buckskin Creek. The project has a HUC-12 boundary bisecting it north-south. The modeled watershed area encompasses approximately 67 square miles and generally slopes southeast.

FEMA has completed a study to determine flood hazards for the selected location. The project area is located adjacent to an area of FEMA Zone A; however, this flood zone is constrained to the floodplain of its respective reach, and the land on which the project is located is at a higher elevation than the extents of the floodplains. Therefore, the project area does not contain any FEMA Zones. No preliminary or pending FEMA data was located that will affect the project area.

The majority of the proposed solar facility will consist of above ground mounted solar modules. Low growing vegetation will be planted below the modules and will make up a majority of the site's land cover. A small amount of impervious surface will also be added from the gravel access roads and electrical equipment pads, but typically only makes up approximately 3-5% of the total project area. The project should be designed to minimize grading and maintain existing drainage patterns.

The hydrologic modeling in this report was created using FLO-2D modeling software. FLO-2D was used to review the overall watershed drainage to and through the project to determine if any overland runoff causes flooding, high velocity, or scour impacts to the site.

The analysis shows low to moderate water depths and low velocities (Exhibits 6 through 7A) across the majority of the site. Higher flood depths exist within man made drainage ditches, and the two creeks, Paint Creek and Buckskin Creek, located adjacent to the site. Minimal velocities and scour are expected on site due to the flat terrain. Based on experience with similar projects, the majority of the site is suitable for the planned development by avoiding or designing to areas of high flood depths.

Data Sources

TABLE 1: DATA SOURCES

Task	Format	Source	Use
Elevation	LAS Point File	Ohio Geographically Referenced Information Program	FLO-2D Model Elevations
Elevation	3-Meter DEM	USGS	FLO-2D Model Elevations
Crop Data	Shapefile	USDA 2013 Crop Data Layer	Landcover
Soils	Shapefile	USGS SSURGO Dataset	Curve Numbers
Precipitation	PDF File	NOAA Atlas 14	Design Storms
HUC-12 Drainage Boundary	Shapefile	USGS	Define Model Extents
2014 Aerial Photography	ArcGIS Map Service	USDA FSA	Reference
FEMA Flood Zones	PDF; Shapefile	FEMA	Reference
Site Boundary	Ross_County_Solar_Area.kmz	Geronimo Energy	Define Model Extents
Culvert Locating and Sizing	Aerial Imagery	Google Earth	Culvert Modeling

Existing Conditions

The project area is located approximately one third mile southeast of the city of Greenfield in Ross County, Ohio. The project site is approximately 10.5 square miles in size, and is located on relatively flat terrain that generally slopes to the southeast.

Watershed Hydrology

The modeled watershed area encompasses approximately 67 square miles that generally slopes to the southeast. Paint Creek to the west of the project flows southeast into Paint Creek Lake where the water forms a reservoir with overflow outlets to accommodate large storm events. Rattlesnake Creek flow from the west and joins Paint Creek in Paint Creek Lake Buckskin Creek flows south adjacent to the project on the east.

Onsite Conditions

The project is located on a relatively flat area with a HUC-12 boundary bisecting it north-south. The site generally drains southeast toward Buckskin Creek. Some portions of the project receive offsite flows but these drainage areas are fairly small. In general, the site is relatively flat with slopes of less than 3%. This can cause onsite ponding in larger storm events. The site also contains manmade drainage ditches that have the potential to see higher flood depths. The landcover on the project area is primarily cultivated indicating row crop operations (Exhibit 4) and has soils that are primarily clay generally belonging to Hydrologic Soil Group C/D and D which have low infiltration rates (Exhibit 3). The main potential hydrologic issues on site are flooding and erosive velocities.

FEMA Flood Zones

FEMA has completed a study to determine flood hazards for the selected location; the project area is covered by panel 39141C0300D. Data from panel 39071C0175E was also used due to its overlapping area and close proximity to the project. This Flood Insurance Rate Maps (FIRM) have been digitized and the flood zones can be seen in Exhibits 2 and 6. The southeast corner of the easternmost parcel contains FEMA Zone A areas surrounding Paint Creek and Buckskin Creek. A FEMA Zone A flood hazard is a 100-year flood hazard with no base flood elevation determined. No preliminary or pending FEMA changes are proposed within the project area.

Proposed Conditions

The majority of the proposed solar facility will consist of above ground mounted solar modules and solar panels. The layout has not yet been finalized. Low growing vegetation will be planted below the modules and will make up a majority of the land cover. A small amount of impervious surface will be added from the gravel access roads and electrical equipment pads. The project should be designed to minimize grading and maintain existing drainage patterns. Drain tile will be avoided or repaired where practicable per the drain tile mitigation plan established for the Project.

Post-Construction Stormwater Management

A preliminary Stormwater Management Plan has been prepared for the project that details the proposed post-construction stormwater management for the project based on the preliminary site design.

FLO-2D Modeling

FLO-2D is a physical process model that routes rainfall runoff and flood hydrographs over flow surfaces or in channels using the dynamic wave approximation to the momentum equation. FLO-2D offers advantages over 1-D models and unit hydrograph methods by allowing for breakout flows and visualization of flows across a potential site. This is particularly useful on a flat site that receives offsite flows, such as the project site. The primary inputs are a DTM (elevation data), curve numbers and precipitation. Major culverts impacting the site were modeled based on aerial imagery provided by Google Earth (Exhibits 6-8).

Because of the size of the modeled watershed and complex flow paths through the project, to the site a FLO-2D model with 50' grid cells was utilized to determine flow depths and velocities throughout the site.

Elevation Data

The elevation data input into the FLO-2D model was LAS point data from the Ohio Geographically Referenced Information Program, and 3-meter DEM data from USGS (Exhibit 5), which was incorporated into the DTM using the export to xyz function in Global Mapper. These XYZ files are read directly into FLO-2D where the elevation of each grid cell is determined through an interpolation of elevation points within a radius proportional to the grid cell size.

Watershed Soils and Land Cover

USDA-NRCS SSURGO soil data provides soil types within the project boundary and full coverage of the contributing watershed. Soils are primarily classified as Hydrologic Soil Group C/D in the project boundary (Exhibit 3). Land cover was obtained from the USDA 2013 Crop Data Layer. Exhibit 4 displays the land cover classes for the entire watershed. Curve numbers were applied to each grid cell in the FLO-2D model based on intersecting the grid with the curve numbers (Exhibit 5).

Precipitation

Precipitation data was downloaded from the NOAA Atlas 14 (Appendix A) and used for the FLO-2D analysis for the 100-year, 24-hour storm. Using the 100-year rainfall depth of 5.9 inches for this location allows for the best initial analysis in order to determine the worst areas of flooding and erosion. Rainfall inputs were distributed based on a nested Atlas 14 distribution pattern.

Inflows

Paint Creek enters the modeled watershed from the north and flows southeast of the project area. USGS Stream Gauge Station reports a 100-year peak flood of 19,000 cfs (Appendix D). Another USGS stream report was used for Rattlesnake Creek which enters the site in the west and flows southeast with a 100-year peak flood of 22,900 cfs. Inflow hydrographs were created using this data and added to the model (Exhibit 6).

Flood Analysis Results

Existing Conditions Flood Analysis

The analysis shows low to moderate water depths and low velocities (Exhibits 6 through 7A) across the majority of the site. During a 100-year storm, the flood depths across the majority of the project area are less than 0.5 feet with velocities less than 1 foot/second with the exception of natural swales running through the site which contain depths up to 6 feet deep, and velocities of up to 4 feet/second. The flood extents in the project line up with the FEMA flood extent

shapes. See Exhibits 6 through 7A for FEMA comparisons, areas within the project with higher flood depths and velocities. Minimal scour is expected on site (Exhibit 8). The scour depths calculated for this project consist of local scour only and are based on unarmored soils and pile bases in order to provide the most conservative local scour results. Due to the low infiltration rates of the onsite soils and flatness of the terrain prolonged periods of ponding should be expected after rainfalls.

Recommendations

Based on experience on similar projects, the site is suitable for the planned development and hydrologic concerns can be addressed by either avoiding areas of high flood depths or through detailed engineering design.

Next Steps

1. Final engineering design should account for the flood depths and velocities presented in Exhibits 6-7.
2. Facilities to be elevated 1' above the 100-year, 24-hour peak flood elevations.
3. Stormwater management should be revisited to ensure the final design meets the local and state requirements.

Included Output Files

1. Shapefile of 100-year Rain Event Flow Depth
2020-07-30_Ross County_PrelimFlowDepthatCell_100yr.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Max Flow Depth (Feet)
2. KMZ of 100-year Rain Event Flow Depth
2020-07-30_Ross County_PrelimFlowDepth_100yr.kmz
Overlay in Google Earth for graphical representation.
3. Shapefile of 100-year Rain Event Velocity
2020-07-30_Ross County_PrelimVelocityatCell_100yr.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Velocity (FPS)
4. KMZ of 100-year Rain Event Velocity
2020-07-30_Ross County_PrelimVelocity_100yr.kmz
Overlay in Google Earth for graphical representation.

KMZ Legend

Depth (FT)

≤ 0.5'
> 0.5'
1' +
2' +
3' +
4' +
5' +
10' +
≥ 15'

KMZ Legend

Velocity (FPS)

< 1
1 +
2 +
3 +
4 +
5 +
6 +
8 +
10 +
12 +
15 +
≥ 20

References Cited

National Engineering Handbook, Part 630 Hydrology. Chapter 9 Hydrologic Soil-Cover Complexes. USDA. NRCS. 210-VI-NEH, July 2004

USDA Geospatial Data Gateway, 3-meter DEM, Elevation data, Accessed July 2020, <https://datagateway.nrcs.usda.gov/>

Web soil survey. Retrieved July 2020, from <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>

NOAA Atlas 14 Point Precipitation Frequency Estimates. Retrieved July 2020 from <https://hdsc.nws.noaa.gov/hdsc/pfds/>

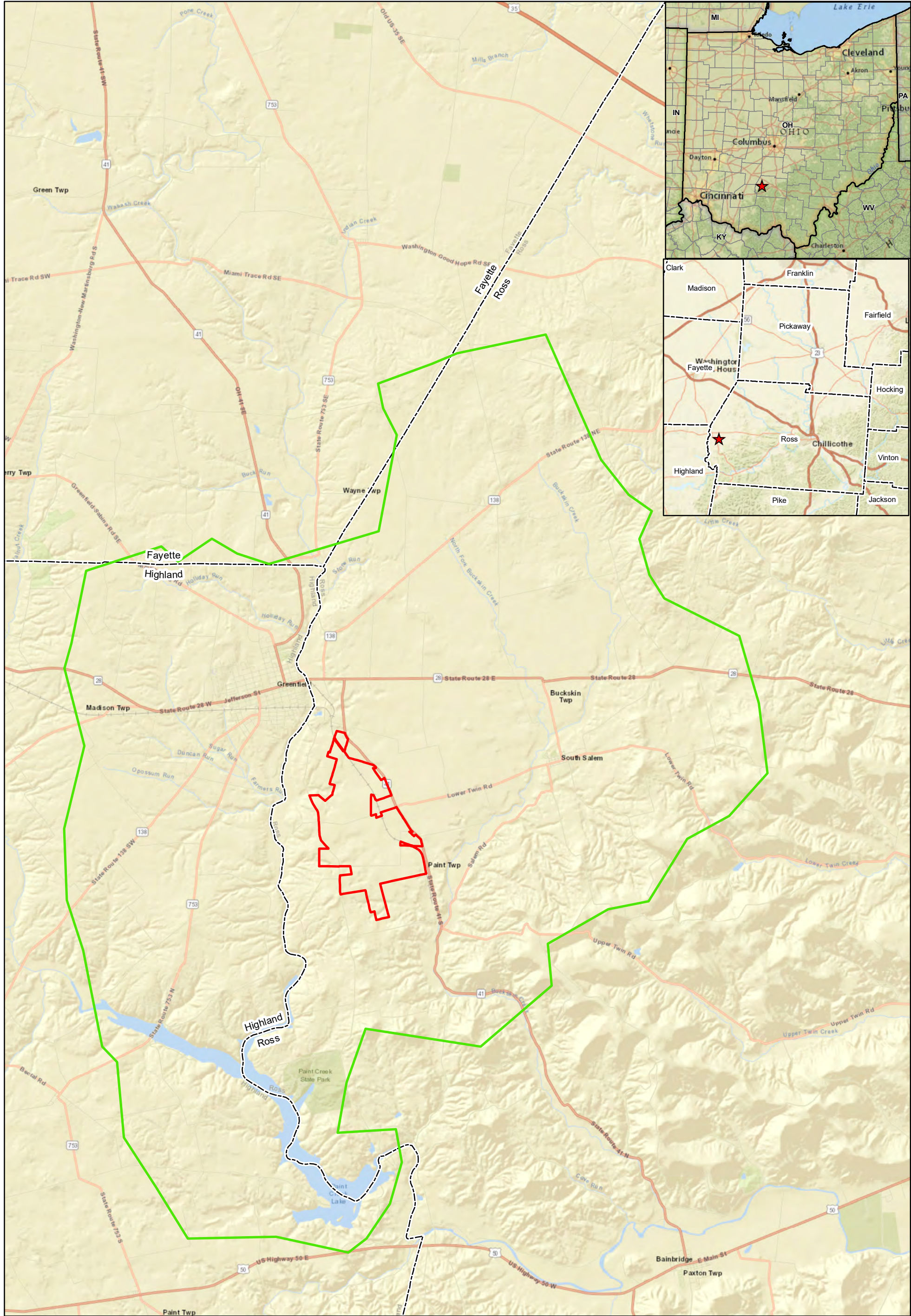
USGS. USGS water resources: About USGS water resources. Retrieved July 2020, from <https://water.usgs.gov/GIS/huc.html>

USDA 2013 Crop Data Layer, Landcover data, retrieved July 2020, from https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php

FEMA Flood Insurance Rate Maps, retrieved July 2020 from <https://msc.fema.gov/portal/advanceSearch#searchresultsanchor>

The background of the slide is a dark red topographic map with intricate, lighter red contour lines. A dashed red line runs diagonally from the top center towards the bottom left. An 'x' mark is located on this line in the middle section, and a solid red dot is positioned further down the line towards the bottom left corner.

Exhibits



Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

Westwood

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Legend

- Project Area
- FLO-2D Boundary
- County Boundary



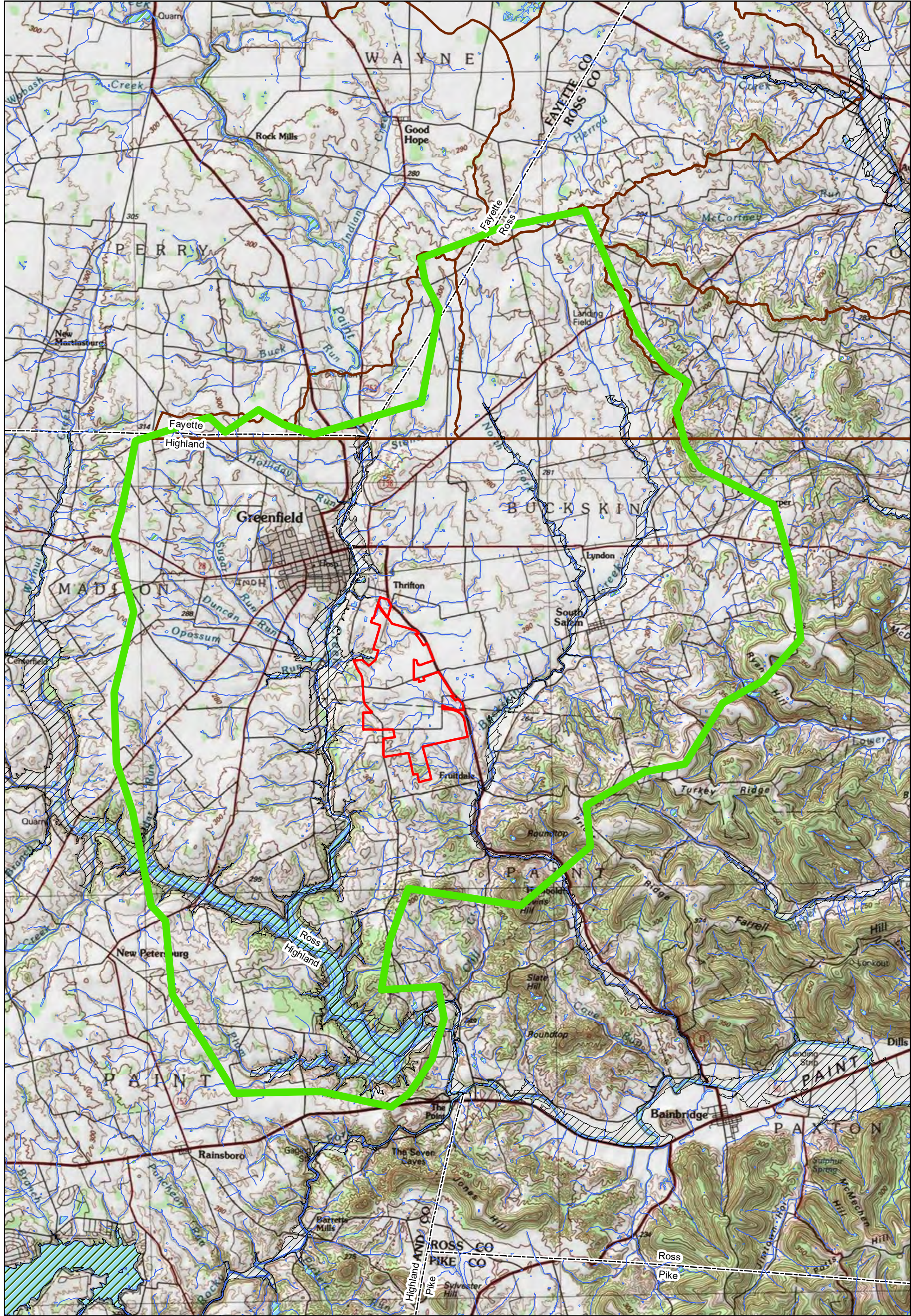
0 7,000 Feet

Ross County Solar Project

Ross County, Ohio







Exhibit 1: Location Map

July 30, 2020





Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

Legend

- | | | | |
|---|-----------------|---|----------------|
|  | Project Area |  | HUC12 Boundary |
|  | FLO-2D Boundary |  | NWI Wetlands |
|  | County Boundary |  | NHD Flowline |

FEMA Flood Zones

- | | |
|--|----|
|  | A |
|  | AE |

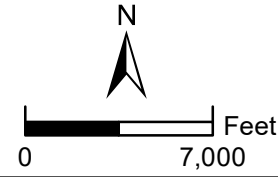
Westwood
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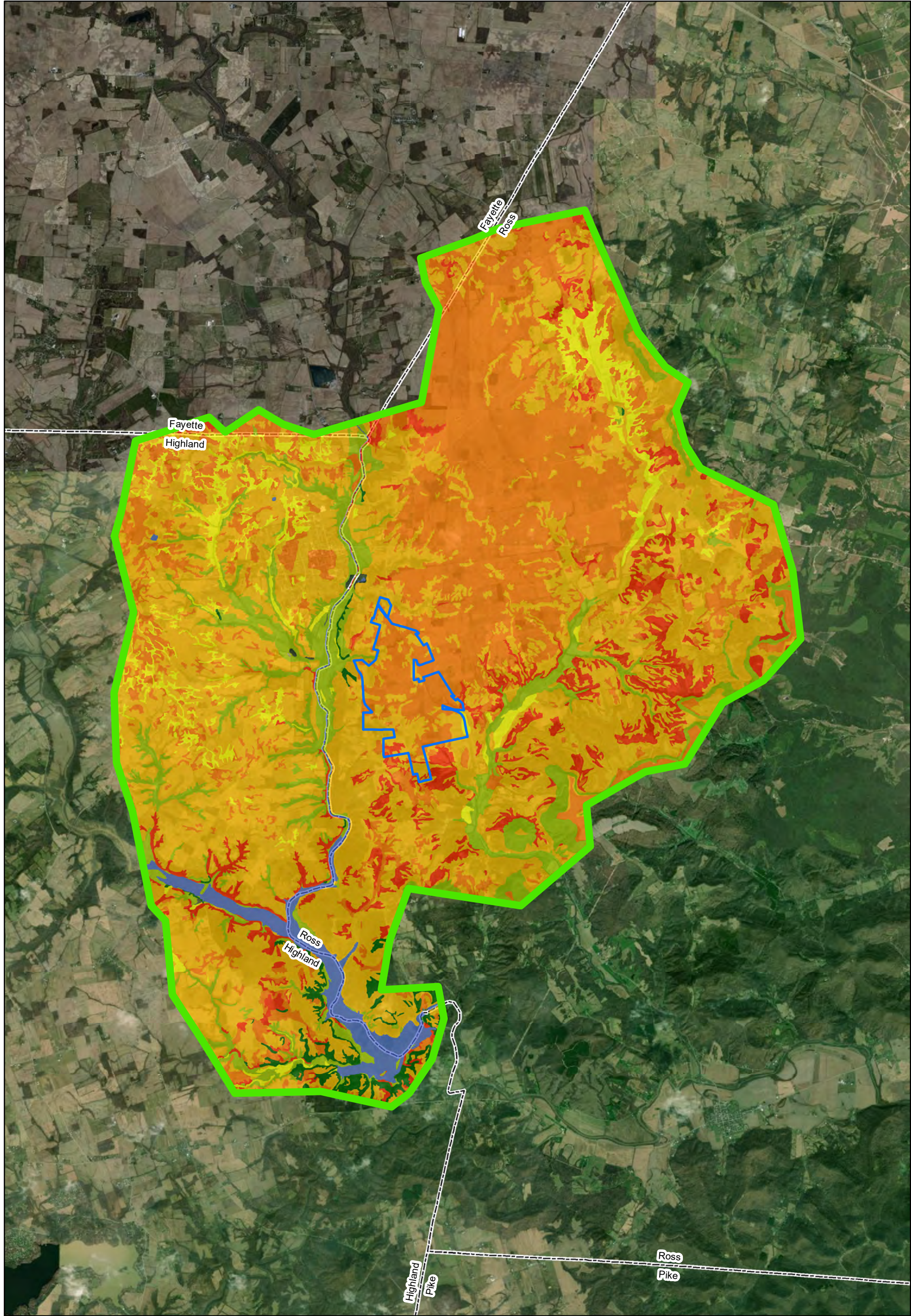
Ross County Solar Project

Ross County, Ohio

Exhibit 2: Base Map

July 31, 2020








Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).


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Legend

-  Project Area
-  FLO-2D Boundary
-  County Boundary

Hydrologic Soil Group

-  A
-  A/D

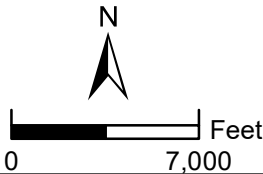
-  B
-  B/D
-  C
-  C/D
-  D
-  W

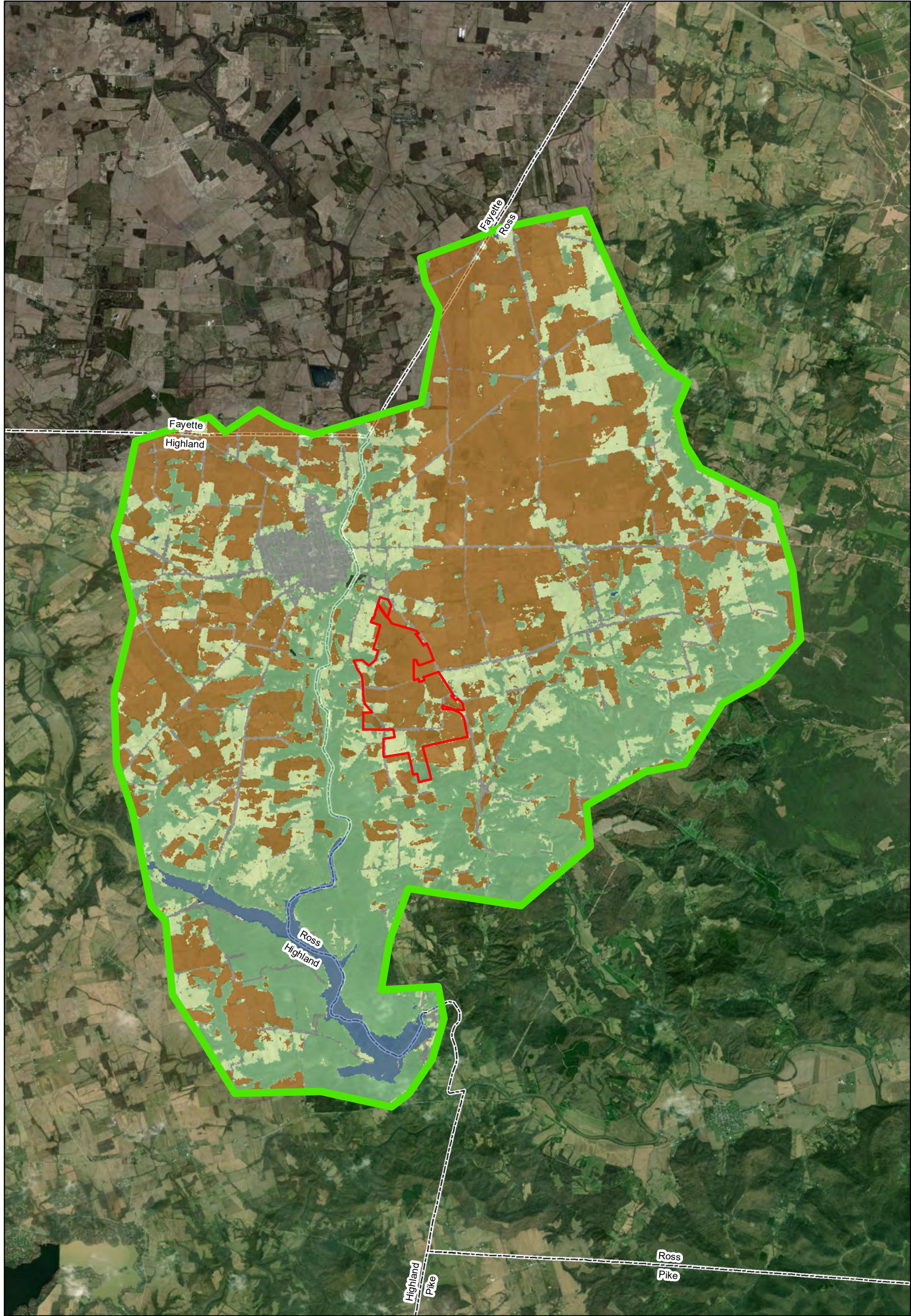
Ross County Solar Project

Ross County, Ohio

Exhibit 3: Soils Map

July 31, 2020





Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

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Legend

- Project Area
- FLO-2D Boundary
- County Boundary

Landcover

- Barren
- Cultivated
- Developed

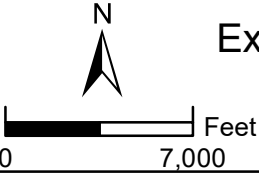
- Fallow
- Forested
- Prairie/Pasture

- Shrubland
- Water
- Wetland

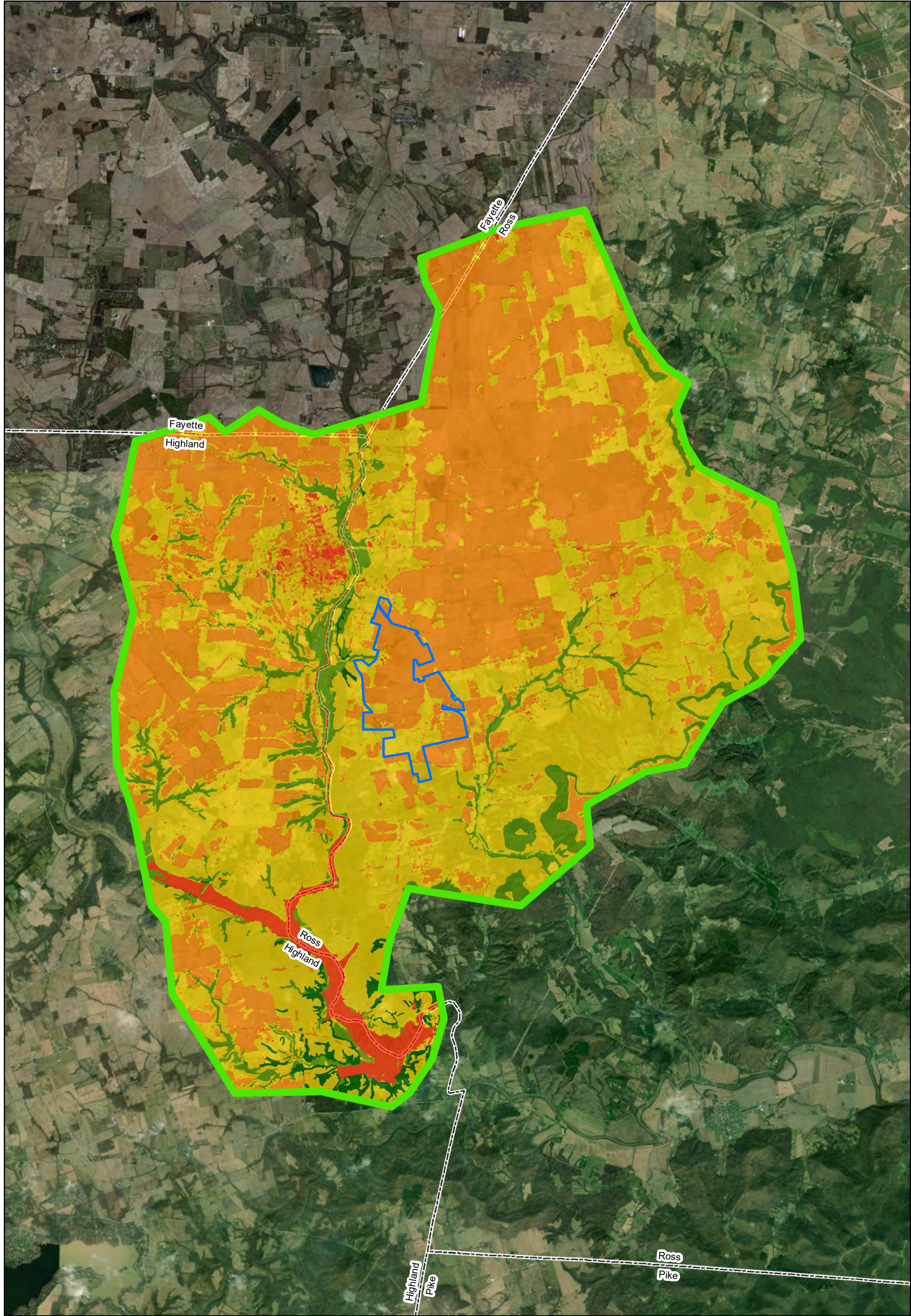
Ross County Solar Project

Ross County, Ohio

Exhibit 4: Landcover Map



July 31, 2020









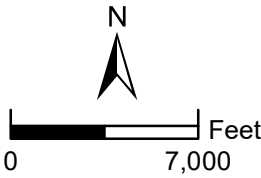
Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

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Legend

-  Project Area
-  FLO-2D Boundary
-  County Boundary

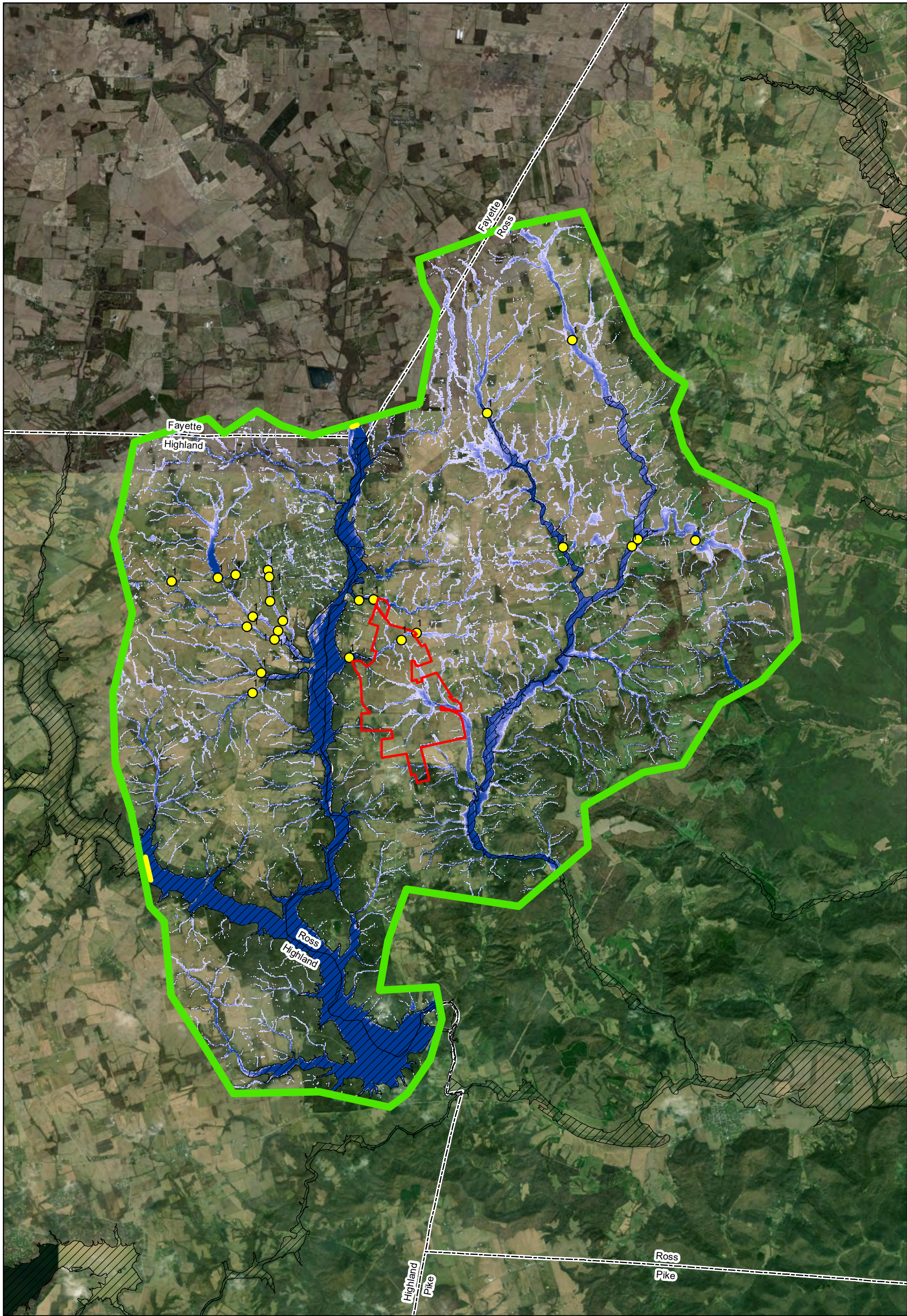
Curve Number	
	40 - 49
	50 - 59
	60 - 69
	70 - 79
	80 - 89
	90 - 99



Ross County Solar Project

Ross County, Ohio

Exhibit 5: Curve Number and
Topographic Source Map
July 31, 2020



Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

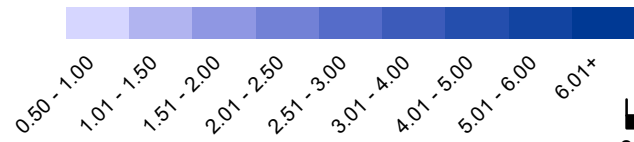
Legend

- Project Area
- FLO-2D Boundary
- County Boundary

- FEMA Flood Zones**
- A
 - AE

- Modeled Culverts
- Inflow Locations

Max Flow Depth (ft)



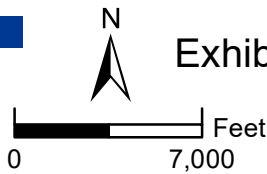
Ross County Solar Project

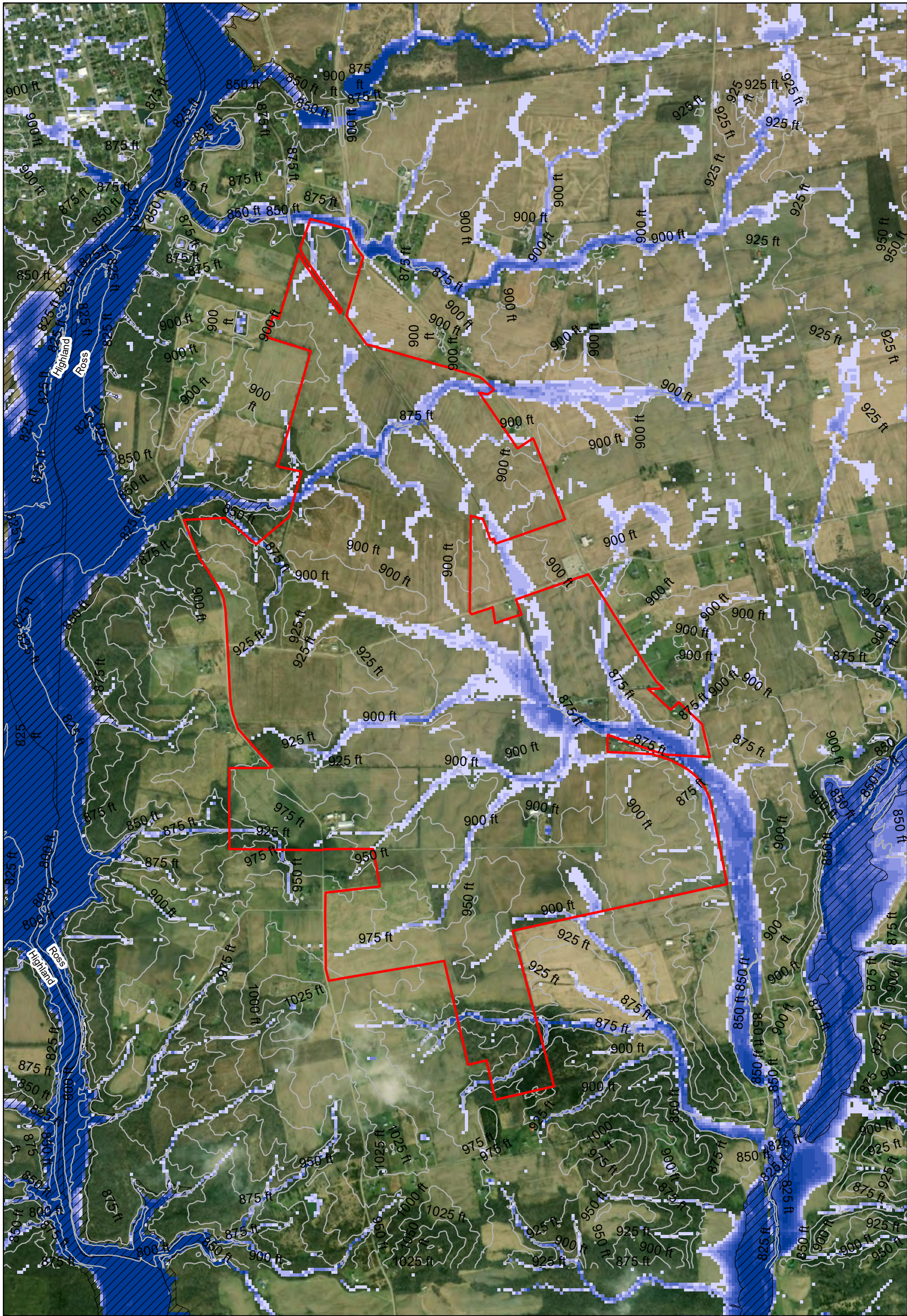
Ross County, Ohio

Exhibit 6: 100-Year Max Water Depth Map

July 31, 2020

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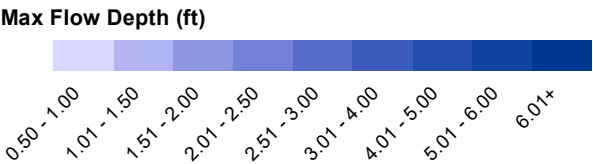


Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

Legend

- Project Area
- FLO-2D Boundary
- County Boundary

- FEMA Flood Zones**
- A
 - AE
- Contours**
-

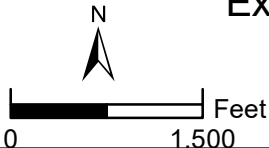


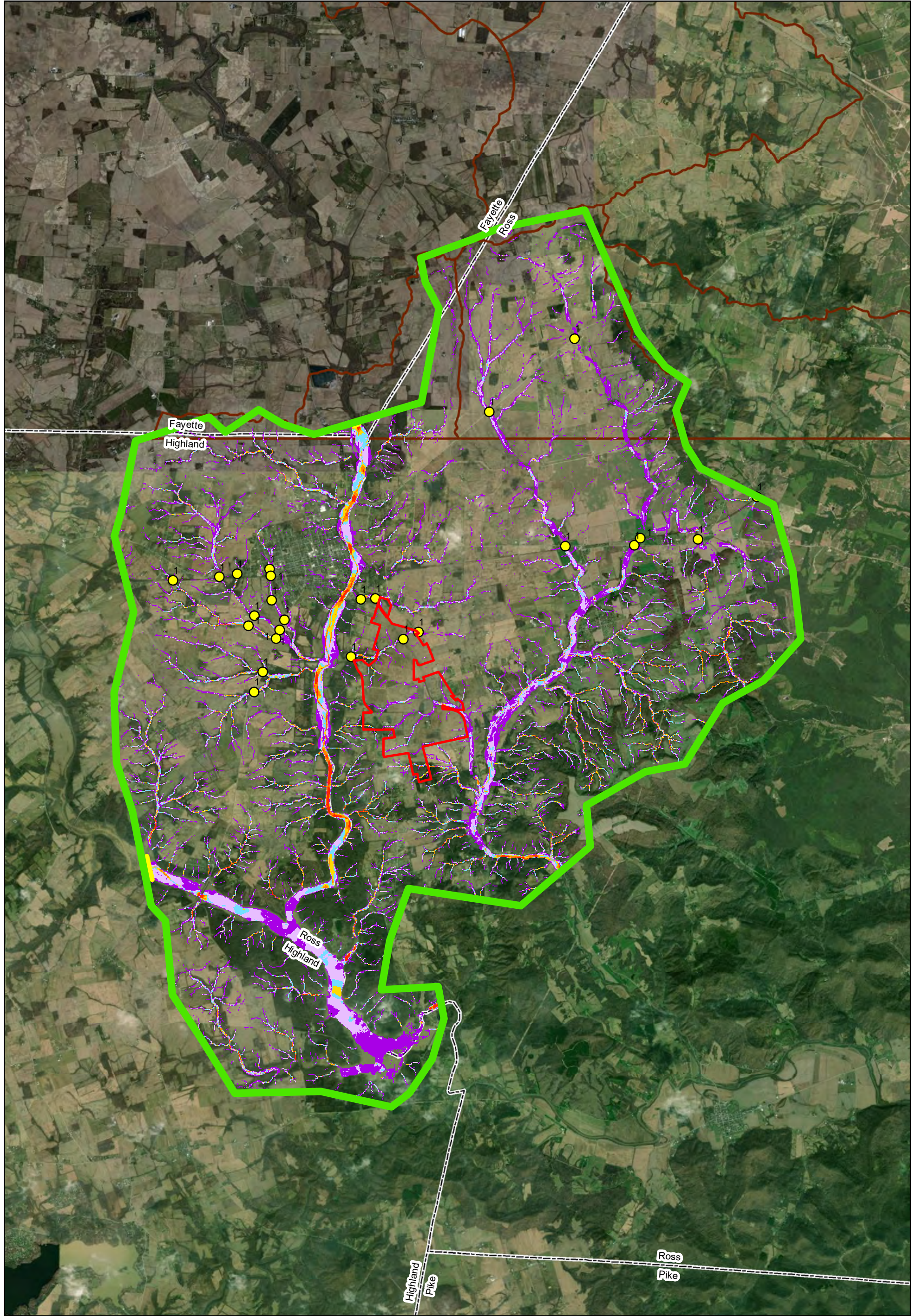
Ross County Solar Project

Ross County, Ohio

**Exhibit 6A: 100-Year
Max Water Depth
Project Area Map**

July 31, 2020





Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

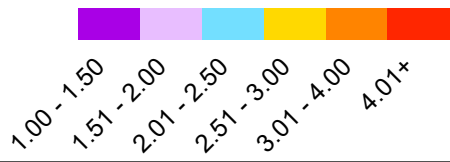
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Legend

- Project Area
- FLO-2D Boundary
- County Boundary

- Modeled Culverts
- Inflow Locations

Peak Velocity (fps)

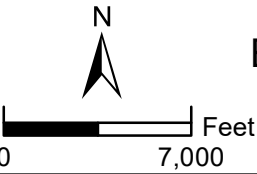


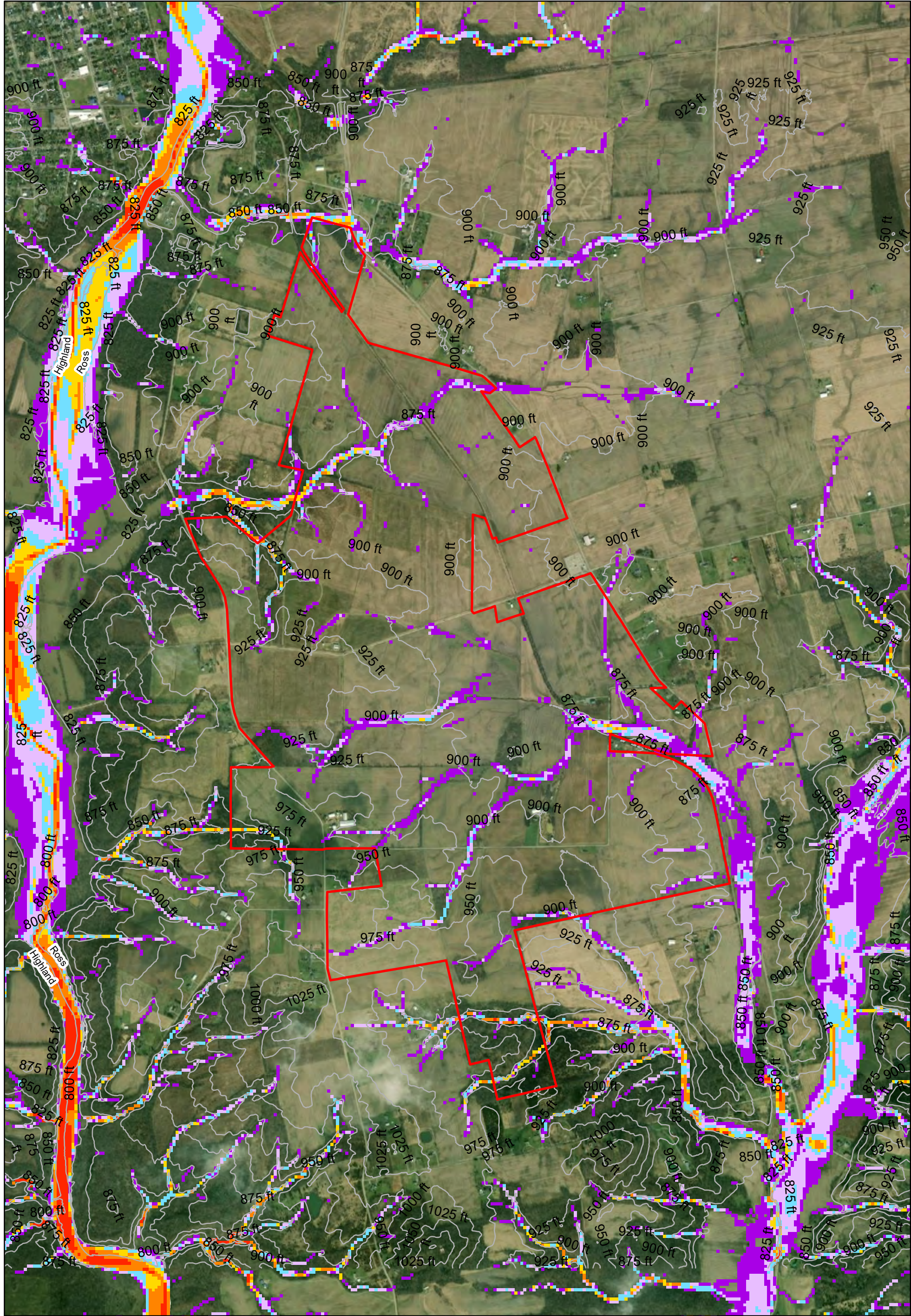
Ross County Solar Project

Ross County, Ohio

Exhibit 7: Existing 100-Year Peak Velocity Map

August 5, 2020





Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).

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Legend

- Project Area
- FLO-2D Boundary
- County Boundary
- Contours

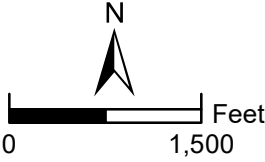
Peak Velocity (fps)

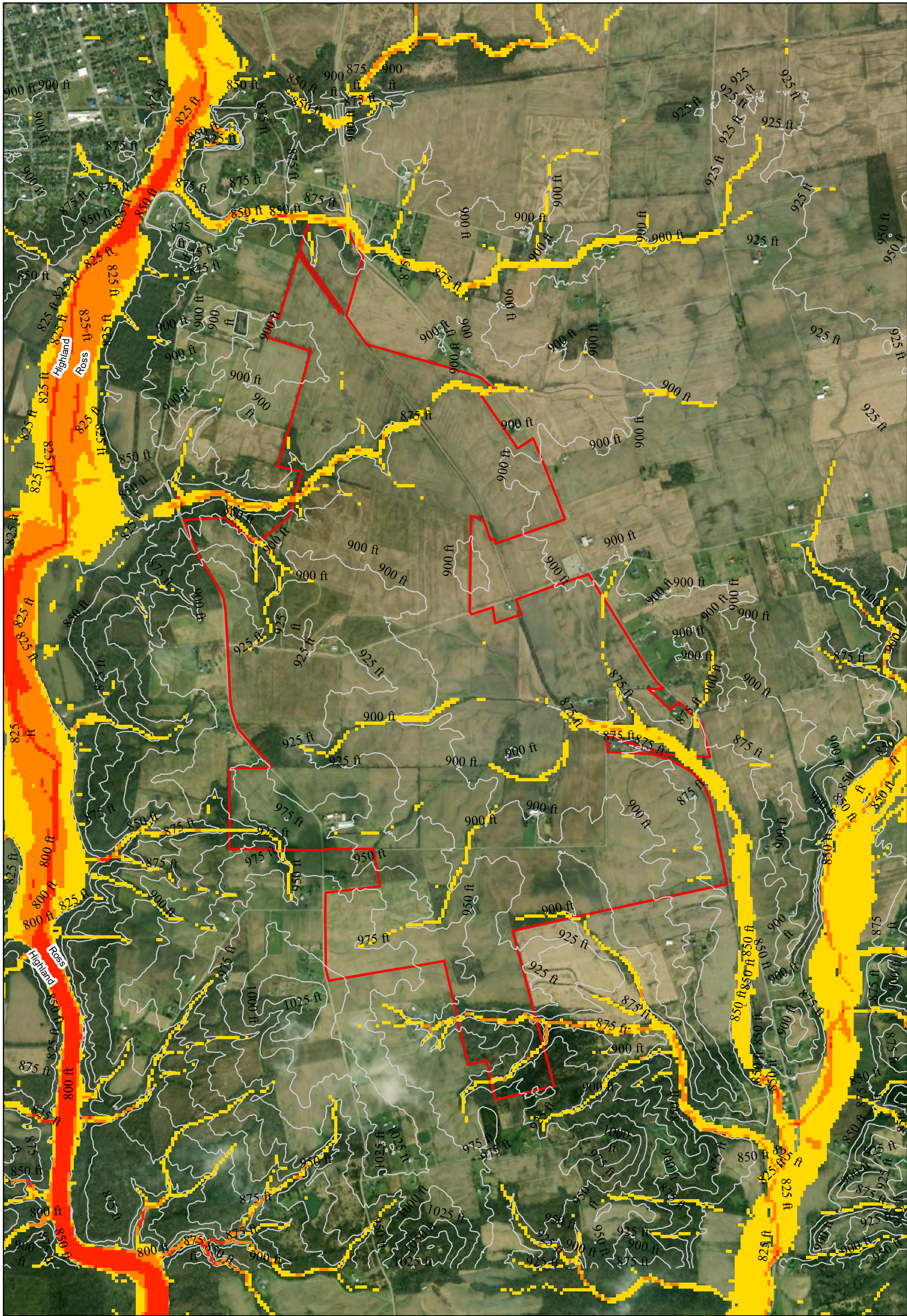


Ross County Solar Project

Ross County, Ohio

Exhibit 7A: 100-Year
Peak Velocity Project
Area Map
August 6, 2020










Data Source(s): Westwood (2018); ESRI WMS World Streets Basemap Imagery (Accessed 2018).



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Legend

-  Project Area
-  FLO-2D Boundary
-  County Boundary

 Contours

Scour (ft)
 1.00 - 1.50

 1.51 - 2.00
 2.01+


 Feet
0 1,500

Ross County Solar Project

Ross County, Ohio

**Exhibit 8: 100-Year
Max Scour Map**

August 6, 2020



Appendix A

Atlas 14 Rainfall Data



NOAA Atlas 14, Volume 2, Version 3
Location name: Greenfield, Ohio, USA*
Latitude: 39.3386°, Longitude: -83.3496°
Elevation: 906.79 ft**
 * source: ESRI Maps
 ** source: USGS



POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

[PF tabular](#) | [PF graphical](#) | [Maps & aerals](#)

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.363 (0.329-0.402)	0.431 (0.390-0.477)	0.515 (0.467-0.569)	0.582 (0.525-0.641)	0.667 (0.600-0.735)	0.732 (0.656-0.806)	0.797 (0.710-0.876)	0.864 (0.766-0.950)	0.954 (0.839-1.05)	1.02 (0.893-1.12)
10-min	0.564 (0.511-0.625)	0.673 (0.609-0.745)	0.801 (0.725-0.884)	0.898 (0.811-0.990)	1.02 (0.917-1.12)	1.11 (0.994-1.22)	1.20 (1.07-1.32)	1.29 (1.14-1.42)	1.40 (1.23-1.54)	1.49 (1.30-1.64)
15-min	0.691 (0.626-0.766)	0.823 (0.744-0.911)	0.983 (0.890-1.09)	1.11 (0.997-1.22)	1.26 (1.13-1.39)	1.37 (1.23-1.51)	1.49 (1.33-1.64)	1.60 (1.42-1.76)	1.75 (1.54-1.93)	1.86 (1.63-2.05)
30-min	0.915 (0.828-1.01)	1.10 (0.996-1.22)	1.35 (1.22-1.49)	1.54 (1.39-1.69)	1.78 (1.60-1.96)	1.96 (1.76-2.16)	2.15 (1.92-2.37)	2.34 (2.08-2.57)	2.59 (2.28-2.85)	2.79 (2.44-3.07)
60-min	1.12 (1.01-1.24)	1.35 (1.22-1.50)	1.69 (1.53-1.87)	1.95 (1.76-2.15)	2.31 (2.08-2.54)	2.59 (2.32-2.85)	2.88 (2.56-3.16)	3.18 (2.82-3.49)	3.59 (3.16-3.95)	3.91 (3.42-4.31)
2-hr	1.30 (1.17-1.43)	1.57 (1.42-1.73)	1.96 (1.77-2.16)	2.28 (2.06-2.51)	2.73 (2.45-3.00)	3.10 (2.77-3.40)	3.48 (3.10-3.82)	3.89 (3.45-4.28)	4.47 (3.93-4.91)	4.94 (4.31-5.43)
3-hr	1.37 (1.25-1.52)	1.66 (1.50-1.84)	2.07 (1.88-2.29)	2.42 (2.18-2.67)	2.91 (2.61-3.20)	3.31 (2.96-3.64)	3.74 (3.33-4.12)	4.20 (3.72-4.62)	4.86 (4.26-5.34)	5.40 (4.71-5.94)
6-hr	1.64 (1.48-1.82)	1.97 (1.79-2.18)	2.45 (2.22-2.72)	2.86 (2.58-3.16)	3.44 (3.09-3.79)	3.92 (3.51-4.31)	4.44 (3.95-4.87)	5.00 (4.42-5.47)	5.80 (5.08-6.34)	6.47 (5.62-7.06)
12-hr	1.93 (1.76-2.13)	2.32 (2.11-2.56)	2.87 (2.61-3.16)	3.34 (3.03-3.67)	4.00 (3.61-4.39)	4.55 (4.09-4.99)	5.14 (4.60-5.63)	5.77 (5.13-6.31)	6.68 (5.88-7.30)	7.44 (6.49-8.12)
24-hr	2.25 (2.09-2.44)	2.70 (2.50-2.93)	3.34 (3.09-3.62)	3.87 (3.57-4.19)	4.62 (4.24-4.99)	5.24 (4.79-5.66)	5.90 (5.37-6.37)	6.61 (5.96-7.13)	7.62 (6.80-8.23)	8.45 (7.47-9.15)
2-day	2.63 (2.45-2.83)	3.15 (2.94-3.39)	3.87 (3.60-4.16)	4.45 (4.13-4.78)	5.26 (4.86-5.65)	5.92 (5.45-6.36)	6.61 (6.06-7.11)	7.34 (6.68-7.91)	8.35 (7.53-9.03)	9.17 (8.19-9.94)
3-day	2.83 (2.64-3.04)	3.38 (3.15-3.63)	4.13 (3.85-4.44)	4.73 (4.40-5.08)	5.57 (5.16-5.98)	6.24 (5.76-6.70)	6.94 (6.38-7.46)	7.67 (7.01-8.24)	8.68 (7.85-9.36)	9.49 (8.51-10.3)
4-day	3.02 (2.82-3.24)	3.61 (3.37-3.87)	4.39 (4.10-4.72)	5.02 (4.67-5.38)	5.88 (5.46-6.30)	6.57 (6.08-7.04)	7.28 (6.70-7.80)	8.01 (7.33-8.59)	9.01 (8.18-9.70)	9.80 (8.83-10.6)
7-day	3.60 (3.36-3.86)	4.28 (4.01-4.59)	5.18 (4.84-5.55)	5.92 (5.52-6.33)	6.94 (6.45-7.43)	7.78 (7.20-8.31)	8.65 (7.96-9.25)	9.55 (8.74-10.2)	10.8 (9.80-11.6)	11.8 (10.6-12.7)
10-day	4.09 (3.83-4.36)	4.85 (4.55-5.18)	5.85 (5.48-6.24)	6.65 (6.22-7.09)	7.77 (7.24-8.27)	8.67 (8.05-9.23)	9.60 (8.87-10.2)	10.6 (9.70-11.3)	11.9 (10.8-12.8)	13.0 (11.7-13.9)
20-day	5.66 (5.33-6.04)	6.70 (6.30-7.15)	7.94 (7.45-8.46)	8.90 (8.36-9.49)	10.2 (9.54-10.9)	11.2 (10.5-11.9)	12.2 (11.4-13.0)	13.2 (12.3-14.1)	14.6 (13.4-15.6)	15.6 (14.3-16.7)
30-day	7.11 (6.73-7.55)	8.39 (7.93-8.90)	9.80 (9.25-10.4)	10.9 (10.3-11.5)	12.3 (11.6-13.1)	13.4 (12.6-14.2)	14.5 (13.6-15.4)	15.6 (14.5-16.5)	16.9 (15.7-18.0)	18.0 (16.6-19.2)
45-day	9.09 (8.62-9.59)	10.7 (10.1-11.3)	12.3 (11.6-12.9)	13.5 (12.8-14.2)	15.0 (14.2-15.8)	16.1 (15.2-17.0)	17.2 (16.2-18.1)	18.2 (17.1-19.2)	19.4 (18.2-20.6)	20.3 (19.0-21.6)
60-day	11.0 (10.4-11.5)	12.8 (12.2-13.5)	14.6 (13.9-15.4)	16.0 (15.2-16.8)	17.6 (16.7-18.6)	18.9 (17.9-19.9)	20.0 (18.9-21.1)	21.1 (19.8-22.2)	22.4 (21.0-23.6)	23.3 (21.8-24.6)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

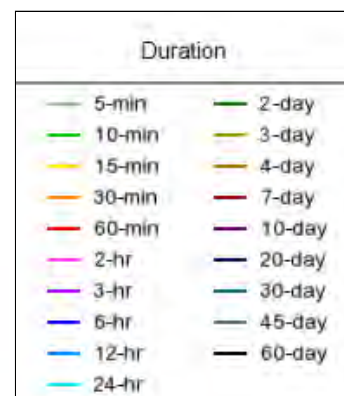
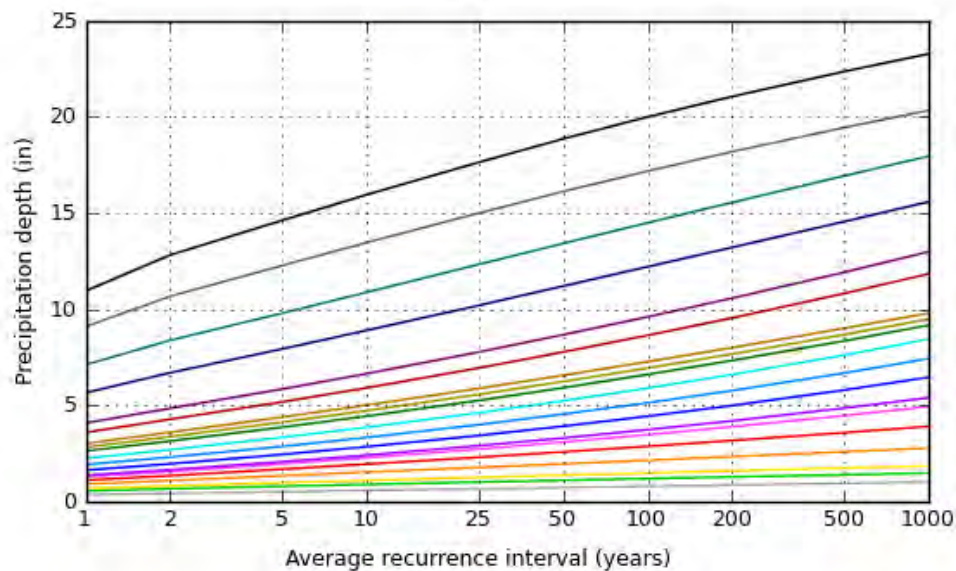
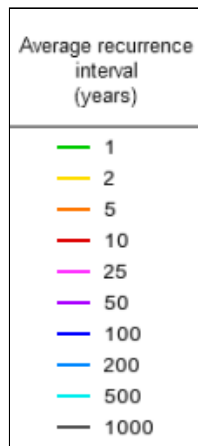
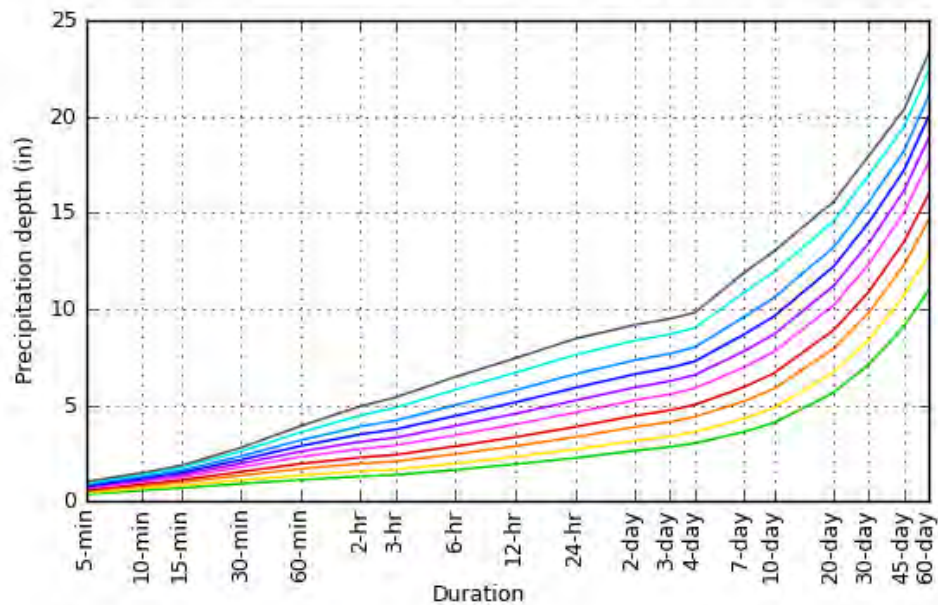
Please refer to NOAA Atlas 14 document for more information.

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PF graphical

PDS-based depth-duration-frequency (DDF) curves

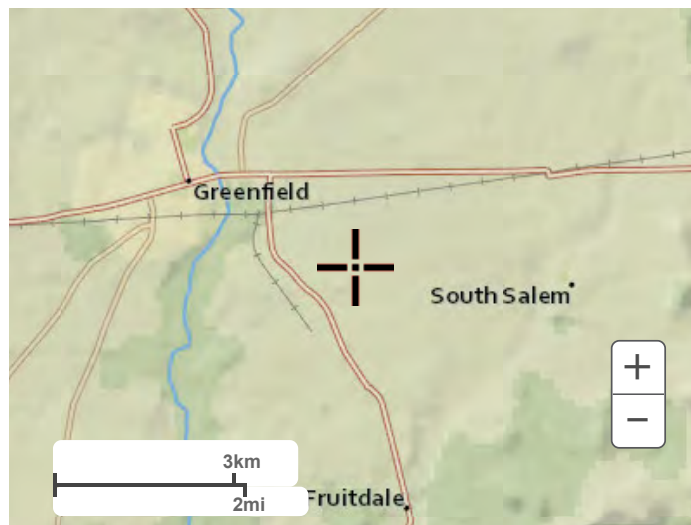
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NOAA Atlas 14, Volume 2, Version 3

Created (GMT): Wed Jul 15 14:22:08 2020

[Back to Top](#)**Maps & arials****Small scale terrain**



Large scale terrain



Large scale map



Large scale aerial

[Back to Top](#)

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[National Weather Service](#)
[National Water Center](#)
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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Appendix B

Curve Number Table

Table 1. Standard Curve Numbers

Class	Value	Classification Description [NLCD 2006]	Curve Number				
			Soil Type*				
			A	B	C	D	W
Water	11	Open Water - areas of open water, generally with less than 25% cover of vegetation or soil.	98	98	98	98	100
	12	Perennial Ice/Snow - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.	98	98	98	98	100
Developed	21	Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	46	65	77	82	100
	22	Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.	61	75	83	87	100
	23	Developed, Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.	77	85	90	95	100
	24	Developed High Intensity -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.	89	92	94	95	100
Barren	31	Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.	77	86	91	94	100
Forest	41	Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.	43	55	70	77	100
	42	Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.	43	55	70	77	100
	43	Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.	43	55	70	77	100
Shrubland	51	Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.	43	48	65	73	100
	52	Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.	43	48	65	73	100
Herbaceous	71	Grassland/Herbaceous - areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.	43	58	71	78	100
	72	Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.	43	58	71	78	100
	73	Lichens - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.	43	48	65	73	100
	74	Moss - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.	43	48	65	73	100
Planted/Cultivated	81	Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.	43	58	71	78	100
	82	Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.	67	78	85	89	100
	83	Small Grains	63	75	83	87	100
Wetlands	91	Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	45	66	77	83	100
	92	Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	45	66	77	83	100

*A/D, B/D and C/D soils lumped as D soils, W denotes water

**Curve Numbers for NLCD Codes 41-81 have been increased from 30 to 43 as many of these areas are partially grazed Woods-grass combination.



Appendix C

FEMA FIRM Panels

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only to landward of 0.0 North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Ohio State Plane South zone 5001 (FIPSZONE 3402). The **horizontal datum** was NAD83. Differences in datum, spheroid, projection or state plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov/> or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, NNGS12
National Geodetic Survey
SSM-C-46202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242 or visit its website at <http://www.ngs.noaa.gov/>.

Base Map information shown on this FIRM was derived from imagery provided by Ross County Soil and Conservation District Map Department and dated 2008.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodways and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

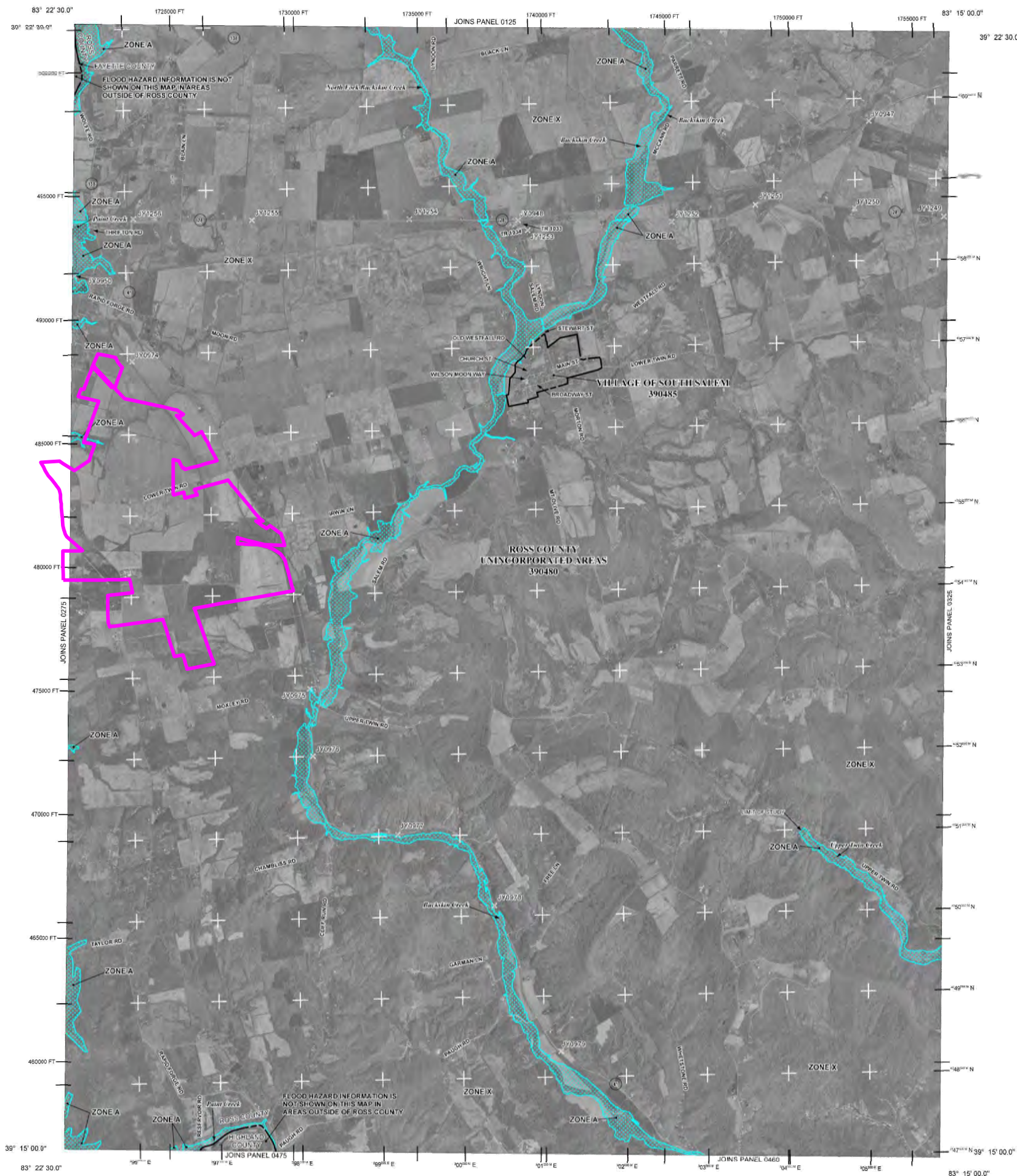
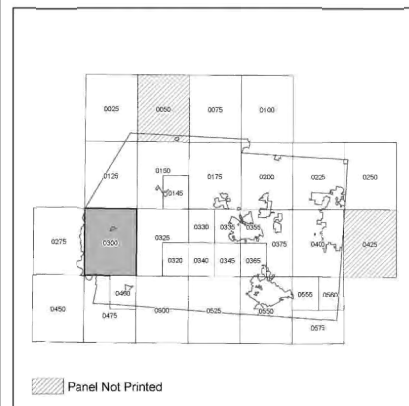
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9919 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at <http://msc.fema.gov/>.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA-MAP (1-877-336-2827) or visit the FEMA website at <http://www.fema.gov/business/nfp/>.

The **profile base lines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the "profile base line", in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

PANEL INDEX



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard may include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

- ZONE A** No base flood elevations determined.
- ZONE AE** Base Flood Elevations determined.
- ZONE AH** Flood depths of 1 to 3 feet (usually areas of banded); base flood elevations determined.
- ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. The areas of unusual low flooding, wherever also determined.
- ZONE AR** Area of special flood hazard formerly protected from the 1% annual chance flood event by a flood control system that was subsequently determined to be inadequate. The former flood control system is being retained to provide protection from the 1% annual chance of greater flood.
- ZONE A99** Area to be protected for 99 annual chance flood events by a Federal flood protection system under construction; no Base Flood Elevations determined.
- ZONE V** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachments so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

- ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

- ZONE X** Areas determined to be outside of the 0.2% annual chance floodplain.
- ZONE D** Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary Dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- Base Flood Elevation line and value; elevation in feet* (EL 10)
- Base Flood Elevation value where uniform within zone; elevation in feet*

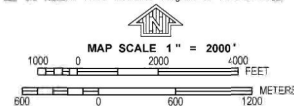
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- Cross section line
- Transect line
- Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
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- 4877000 M
- 2250000 FT
- KA0015 X
- M1.5
- River Mile

- MAP REPOSITORY**
Refer to listing of Map Repositories on Map Index
- EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP**
April 2, 2003

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
July 22, 2010 - to update corporate limits, to change Special Flood Hazard Areas, to add roads and rail names, to incorporate previously issued Letters of Map Revision, and to reflect updated topographic information.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6632.



NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0300D

FIRM

FLOOD INSURANCE RATE MAP
ROSS COUNTY, OHIO
AND INCORPORATED AREAS

PANEL 300 OF 575
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS			
COMMUNITY	NUMBER	PANEL	SUFFIX
ROSS COUNTY	390480	0300	D
SOUTH SALEM, VILLAGE OF	390485	0300	D

Notice to User: The Map Number shown below should be used when placing map orders. The Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
39141C0300D
MAP REVISED
JULY 22, 2010

Federal Emergency Management Agency



Appendix D

Streamstats Report

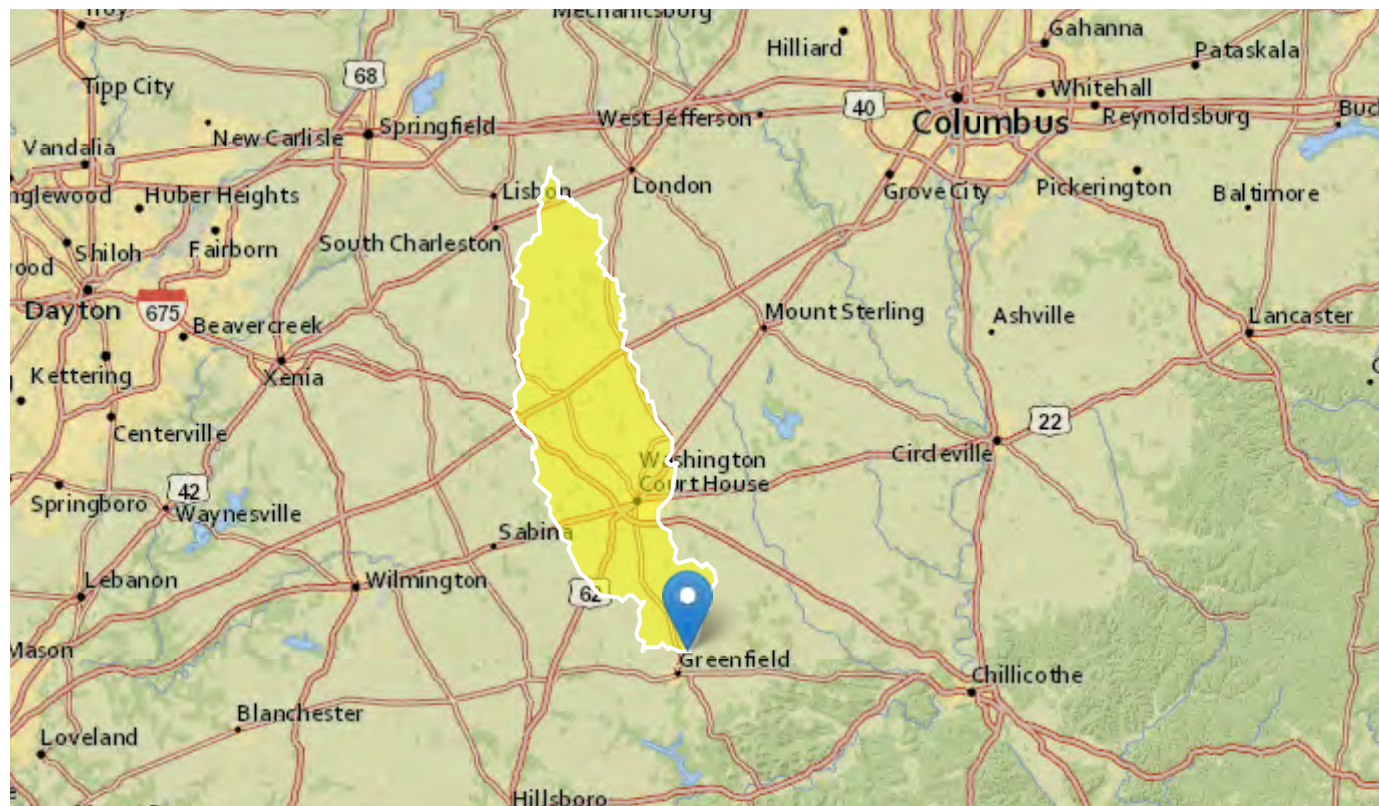
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Workspace ID: OH20200714204913725000

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Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	249	square miles
OHREGC	Ohio Region C Indicator	0	dimensionless
OHREGA	Ohio Region A Indicator	1	dimensionless
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	3.94	feet per mi
LC92STOR	Percentage of water bodies and wetlands determined from the NLCD	0.15	percent

Peak-Flow Statistics Parameters^[Peak Flow Full Model Reg A SIR2019 5018]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	249	square miles	0.04	5989
OHREGC	Ohio Region C Indicator 1 if in C else 0	0	dimensionless	0	1
OHREGA	Ohio Region A Indicator 1 if in A else 0	1	dimensionless	0	1
CSL1085LFP	Stream Slope 10 and 85 Longest Flow Path	3.94	feet per mi	1.53	516
LC92STOR	Percent Storage from NLCD1992	0.15	percent	0	25.35

Peak-Flow Statistics Flow Report^[Peak Flow Full Model Reg A SIR2019 5018]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	5690	ft ³ /s	3010	10700	40.1
5 Year Peak Flood	8650	ft ³ /s	4790	15600	37.2
10 Year Peak Flood	10900	ft ³ /s	5990	19700	37.6
25 Year Peak Flood	13900	ft ³ /s	7630	25500	38.1
50 Year Peak Flood	16400	ft ³ /s	8880	30300	37.8
100 Year Peak Flood	19000	ft ³ /s	10200	35400	39.6
500 Year Peak Flood	25600	ft ³ /s	13600	48100	40.3

Peak-Flow Statistics Citations

Koltun, G.F., 2019, Flood-frequency estimates for Ohio streamgages based on data through water year 2015 and techniques for estimating flood-frequency characteristics of rural, unregulated Ohio streams: U.S. Geological Survey Scientific Investigations Report 2019–5018, xx p. (<https://dx.doi.org/10.3133/sir20195018>)

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Application Version: 4.3.11

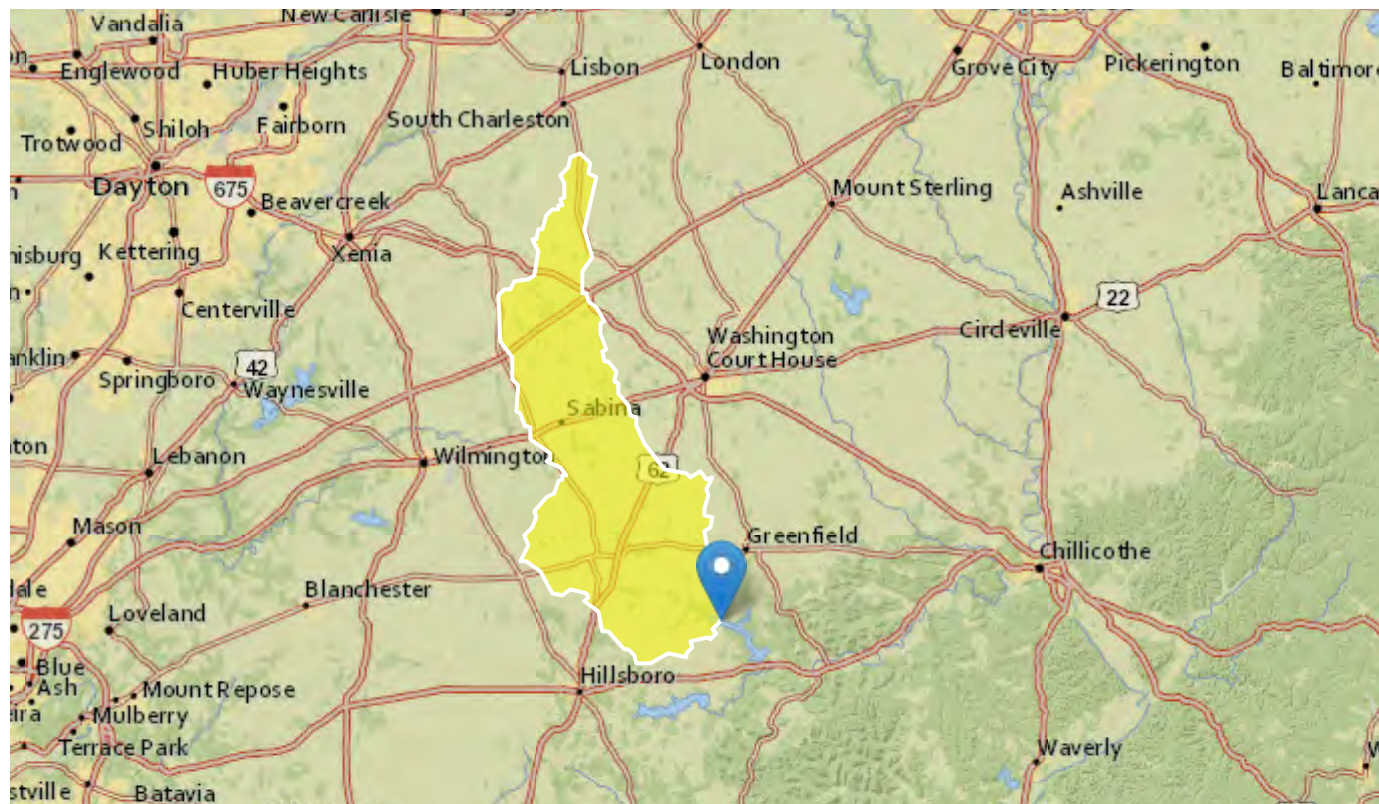
StreamStats Report

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Workspace ID: OH20200723191313273000

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Time: 2020-07-23 14:13:30 -0500



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	276	square miles
OHREGC	Ohio Region C Indicator	0	dimensionless
OHREGA	Ohio Region A Indicator	1	dimensionless
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	6.74	feet per mi
LC92STOR	Percentage of water bodies and wetlands determined from the NLCD	0.28	percent

Peak-Flow Statistics Parameters[100 Percent (276 square miles) Peak Flow Full Model Reg A SIR2019 5018]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	276	square miles	0.04	5989
OHREGC	Ohio Region C Indicator 1 if in C else 0	0	dimensionless	0	1
OHREGA	Ohio Region A Indicator 1 if in A else 0	1	dimensionless	0	1
CSL1085LFP	Stream Slope 10 and 85 Longest Flow Path	6.74	feet per mi	1.53	516
LC92STOR	Percent Storage from NLCD1992	0.28	percent	0	25.35

Peak-Flow Statistics Flow Report[100 Percent (276 square miles) Peak Flow Full Model Reg A SIR2019 5018]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	6630	ft ³ /s	3510	12500	40.1
5 Year Peak Flood	10200	ft ³ /s	5670	18500	37.2
10 Year Peak Flood	13000	ft ³ /s	7140	23600	37.6
25 Year Peak Flood	16700	ft ³ /s	9160	30600	38.1
50 Year Peak Flood	19800	ft ³ /s	10700	36500	37.8
100 Year Peak Flood	22900	ft ³ /s	12300	42800	39.6
500 Year Peak Flood	31000	ft ³ /s	16500	58300	40.3

Peak-Flow Statistics Citations

Koltun, G.F., 2019, Flood-frequency estimates for Ohio streamgages based on data through water year 2015 and techniques for estimating flood-frequency characteristics of rural, unregulated Ohio streams: U.S. Geological Survey Scientific Investigations Report 2019–5018, xx p. (<https://dx.doi.org/10.3133/sir20195018>)

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Summary: Application Application Exhibit R electronically filed by Mr. Michael J. Settineri on behalf of Ross County Solar, LLC