Four Lakes Task Force and

Spicer Group, Inc.

Pre- and Post-Disaster Wetland Analysis

Prepared by:

merjent

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1.0 INTRODUCTION

1.1 STUDY BACKGROUND

Merjent, Inc. (Merjent) was contracted by Spicer Group, Inc. (Spicer) and the Four Lakes Task Force to complete several desktop wetland analyses of the area impacted by the May 2020 disaster. Desktop analyses included a review of a variety of data resources to determine the extent of:

1. Pre-disaster wetlands, including wetland community type.
2. Post-disaster wetland, including wetland community type.
3. Pre-disaster waterbodies (surface waters).
4. Post-disaster waterbodies (surface waters).

Using this data, calculations were performed and a variety of data resources were reviewed with the goal of determining the possible extent of:

1. Wetlands potentially impacted as a result of the disaster.
2. Post-disaster wetlands created as a result of waterbody drawdowns.
3. Extent of surface water area lost as a result of the disaster.

1.2 QUALLIFICATIONS

This scope of work was executed by the following wetland professionals.

Robb Roos, PWS – Project Manager and Field Biologist:

Mr. Roos is a Senior Project Manager and Field Biologist with over 10 years of experience in environmental project management for various clients throughout the United States. He is a Professional Wetland Scientist that is highly skilled in wetland delineation methodologies and regularly instructs wetland delineation courses for cross-agency practice groups. Additionally, Mr. Roos is a qualified threatened and endangered species surveyor and botanist, having experience with multiple terrestrial and wetland species. He routinely conducts endangered resources reviews and habitat assessments for all project types.

Ken Leister, CWB – Deputy Project Manager and Field Biologist

Mr. Leister is a Senior Analyst, Project Manager, and Field Biologist with over 10 years of experience in ecological resource assessments for clients across various industries. Mr. Leister is a Certified Wildlife Biologist and has experience conducting field surveys for a range of ecological resources. Past project work has included wetland delineation, general endangered species assessments and species-specific surveys for federally- and state- listed endangered species including bats, birds, reptiles, and plants.

Jameson Loesch – Senior GIS Analyst

Mr. Loesch is Senior geographic information system (GIS) Analyst with over 10 years of experience conducting environmental reviews for several clients throughout the United States. His expertise focuses on utilizing GIS and other geospatial tools to make environmental review and decision making more efficient and effective during the planning, permitting, construction, and post-construction phases of projects. Mr. Loesch has extensive experience through all phases of the environmental permitting process having worked as a field lead coordinating and conducting wetland delineations, botanical surveys, rare species surveys, and construction site compliance monitoring; as a GIS project manager developing site, access, and stormwater plans, while also conducting in depth desktop reviews and managing geospatial data in support of routing, planning, and permitting needs; and as a lead in the development of permit applications and enforcement at the local, state, and federal levels. Mr. Loesch is also experienced in conducting threatened/endangered species reviews, having completed a mix of desktop reviews, field surveys, agency consultations, and coordination with clients to ensure proper planning and compliance on over 1,000 projects to date.

Becky Norris – GIS Analyst and Field Biologist

Ms. Norris is a GIS Analyst and Field Biologist with over five years of experience in GIS, data analysis, and technical support for several projects throughout the United States. Ms. Norris regularly conducts and performs GIS management for wetland delineations, habitat assessments, and other field surveys. In particular, she specializes in preparing comprehensive environmental impact analysis reports for federal and state permit applications.

2.0 METHODS

2.1 REVIEW AREA

A review area was defined prior to beginning the evaluation. This review area consists of 1) the Wixom Lake flowage, 2) the Sanford Lake flowage, and 3) four dam sites where construction will be required as a part of ongoing dam safety efforts.

These three location review areas were defined using the following criteria. The review area is depicted on all figures and shapefiles included as a part of this report.

Wixom Lake Flowage:

The review area consisted of a 1-mile radius from surface waters that were visually present and adjacent to those properties listed on the Four Lake Task Force's Special Assessment District, or 'SAD' (FLTF, 2021). The SAD identifies parcels with dedicated access to affected waterfront. Pre-disaster Google Earth™ aerial imagery (c. 2019) was used to identify surface water limits in support of establishing the review area. Based on a review of this aerial imagery, it was not apparent that any wetlands or surface waters were affected beyond this established review area.

The Wixom Lake flowage review area encompasses the following waterbodies and their direct tributaries:

- Tobacco River from the City of Beaverton to its confluence with Wixom Lake
- Wixom Lake from the Edenville dam north to the Tittabawassee River
- Tittabawassee River from Wixom Lake to the Smallwood Dam

Sanford Lake Flowage:

The review area consisted of a 0.5-mile radius from surface waters that were visually present and adjacent to those properties listed on the Four Lake Task Force's SAD (FLTF, 2021). The SAD identifies parcels with dedicated access to the affected waterfront. Pre-disaster Google Earth™ aerial imagery (c. 2019) was used to identify surface water limits in support of establishing the review area.

A 0.5-mile review radius, which is half the size of the review radius for the Wixom Lake flowage, was established for the Sanford Lake flowage. This reduced review area was chosen as the Sanford Lake SAD and preliminary aerial imagery review did not identify a network of affected waters beyond 0.5 mile from the affected surface waters. Additionally, the Sanford Lake flowage is a more linear feature than the Wixom Lake flowage with less natural meanders and naturally occurring riparian wetlands. Based on a review of this aerial imagery, it was not apparent that any wetlands or surface waters were affected beyond this established review area.

The Sanford Lake flowage review area encompasses Sanford Lake, from the Edenville Dam south to the Sanford Dam, and its direct tributaries.

Dam Sites:

The review areas of the four dam sites were selected to show a conservative requirement for potential construction activities. These areas are defined below.

- **Secord Dam:** A 19-acre area was reviewed that encompasses Secord Dam and its potential construction limits.

- **Smallwood Dam:** A 67-acre area was reviewed that encompasses Smallwood Dam and its potential construction limits. This area is included within the review area defined for the Wixom Lake flowage.

- **Edenville Dam:** A 243-acre area was reviewed that encompasses Edenville Dam and its potential construction limits. This area is included within the review areas for both the Wixom Lake and Sanford Lake flowages.

- **Sanford Dam:** A 34-acre area was reviewed that encompasses Sanford Dam and its potential construction limits. This area is included within the review area for the Sanford Lake flowage.

2.2 BACKGROUND DATA

Following the establishment of a suitable review area, Merjent gathered available data and imagery resources to begin a detailed assessment of potential wetland and surface water locations pre- and post-disaster. The following data resources were reviewed:

Wetland Data

- EGLE Wetlands Map Viewer – National Wetland Inventory (NWI) (2005)
- EGLE Wetlands Map Viewer – Part 303 Final Wetlands Inventory
- US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey
- US Geological Survey (USGS) National Hydrography Dataset (NHD)

Imagery

- Drone Imagery collected for each dam site (November 2020)
- Eagleview™ CONNECTExplorer™ Historic Oblique Imagery
- ESRI World Imagery Basemap and Clarity Basemap Maxar Vivid Imagery (2015)
- Gladwin County GIS
- Google Earth™ Historic Imagery (multiple years)
- Michigan Department of Natural Resources (MIDNR) ‘Best Available Imagery’
- Midland County GIS
- National Agriculture Imagery Program (NAIP) Imagery (September 2018), including the following images derived from these images:
- USA NAIP Imagery Color-infrared

LiDAR

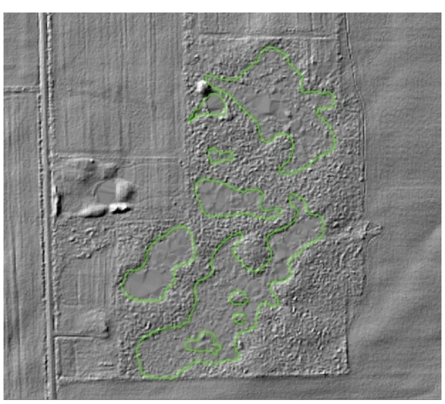
- NRCS LiDAR Elevation Datasets – Bare Earth Digital Elevation Model (DEM) from pre-disaster dates (several)
- Bare Earth Hillshade Dataset – derived from NRCS Bare Earth DEM
- LiDAR Bare Earth DEM (August 2020)
- Midland County LiDAR Elevation Dataset

Using the information listed above, Merjent's professional wetland scientists and wetland GIS analysts determined the probable extent of pre- and post-disaster wetlands within the review area. Wetlands were further identified by their Cowardin (1979) classification system community type (e.g., Palustrine Emergent [PEM], Palustrine Scrub-Shrub [PSS], Palustrine Forested [PFO]). Not all data resources were used to evaluate the extent of pre- and post-disaster wetland and surface water locations. Certain resources were more valuable than others depending on location being reviewed.

2.3 IMAGERY AND LIDAR REVIEW

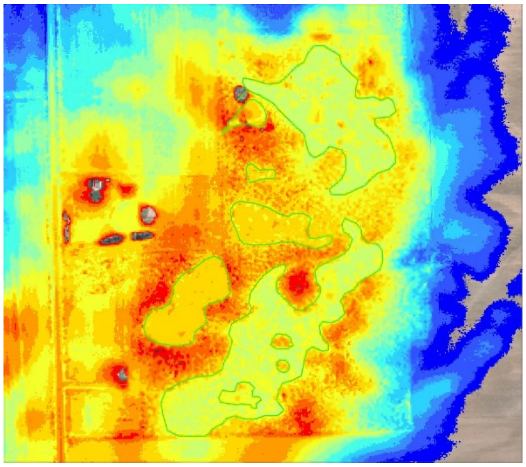
Examples of the imagery and LiDAR data derivative outputs that were reviewed are provided below. A combination of these resources was reviewed to assist in determination of the potential extent of pre- and post-disaster wetlands within the review area. Actual mapped pre-disaster wetlands are identified in green.

Color-infrared Imagery (CIR) consists of red, green, and near infrared bands. Near infrared wavelengths are reflected especially well by living plant material. This allows it to be a good indicator for plant health and it can be a valuable tool for identifying stressed vegetation and different vegetation species.

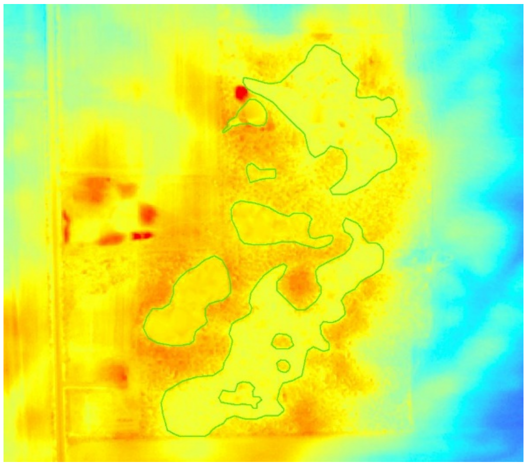


Hillshade Dataset is developed using a LiDAR DEM. This black and white imagery displays elevation changes throughout the landscape. A hillshade uses a hypothetical light source that 'shines' at an area from a set azimuth. This casts a shadow across the imagery which highlights changes in elevation and slope over a landscape. This imagery was a primary resource used to identify potential wetlands throughout the review area.

Google Earth™, NAIP Leaf-off, and Michigan DNR Imager was reviewed to identify classic wetland signatures consistent with the off-site review of wetlands consistent with the U.S. Army Corps of Engineers' (USACEs) offsite hydrology and wetland determination guidance (USACE-MBWSR, 2016). While primarily used in an agricultural setting, this method identifies potential wetlands using aerial signatures such as saturation, inundation, vegetation pattern and texture, or crop stress visible on aerial imagery.



LiDAR Classified is a method of symbolizing LiDAR data. Similar in visual appearance to LiDAR Stretch, this displays high (red) and low (blue) elevations based on cell values in the DEM. This method of visualizing the data groups ranges of cell values into defined classes. The user can set the range of cell values and the number of classes that those values are grouped into. This allows for further refinement of the displayed data beyond that of the LiDAR Stretch method. This imagery was a primary source used to identify potential wetlands throughout the review area.

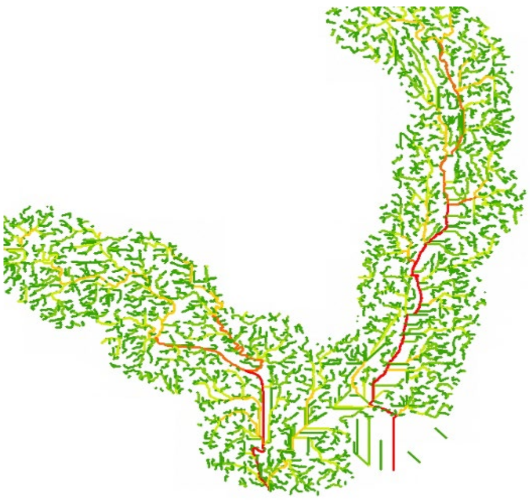


LiDAR Stretch is a method of symbolizing LiDAR data. Values of the data are displayed along a color ramp, which allows for more gradual changes in the way the data is displayed. This example image identifies high (red) and low (blue) elevations based on cell values in the digital elevation model. This method of displaying elevation data was a primary source used to identify potential wetlands throughout the review area.

2.3.1 Micro-Watershed Analysis

A micro-watershed analysis was completed using a variety of ESRI ArcGIS tools. This evaluation identifies the small catchment areas throughout the review area and is intended to delineate which wetlands have a direct connection with an affected surface water and which do not. This allows the reviewer to narrow their focus when identifying areas where surface water level decreases may have impacted adjacent, hydrologically connected wetlands.

This data identifies the lowest elevation pathways within each micro-catchment area and their flow order, from initial catchment point (dark green) to final collection point (dark red). For example, initial catchment areas may be in highlands or atop hills, while final collection points are likely to be first order streams such as the Tittabawassee River. The examples pictured below are from a portion of the Wixom Lake flowage review area.

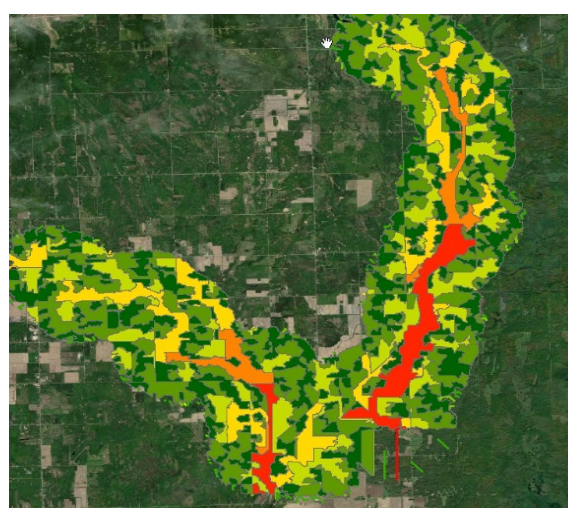


Flow Accumulation Pathing: Depicted here is an ArcGIS model developed by Merjent to identify flow accumulation across the review area. Using the *ESRI's Hydrology Toolset*, the LiDAR DEM was edited with the *Fill Tool* which fills in any 'sinks' or imperfections in the dataset. Then, the *Flow Direction Tool* is used to create a raster of the flow direction from each pixel in the DEM to its steepest downslope neighbor. Next, the *Flow Accumulation Tool* was used to calculate the accumulated value of all cells flowing into cells flowing to downslope neighboring cells. The output derived raster was converted to a vector polyline dataset that displays the routes of accumulation of all water within the reviewed watershed areas.

Then, each flow line was given an 'order' using the *Stream Order Tool,* which uses the created flow accumulation polylines as an input. Finally, pour points were mapped at the confluences of the stream order dataset. This developed an input for the Micro-Catchment Area analysis discussed below.

Micro-Catchment Areas: The *Watershed Tool,* which uses the flow direction raster and pour points mentioned above, was used to create micro-catchment areas on a micro-watershed scale. An example of this is depicted to the right. This data identifies the lowest elevation micro-catchment areas and their flow order from initial catchment point (dark green) to final collection catchment (dark red).

When overlain with mapped wetlands, this information is useful to help determine those that may be directly impacted by the impoundment drainage that occurred as a result of the disaster



2.3.2 Antecedent Precipitation Analysis

Recent precipitation data was compared with historic precipitation data for August 2020 to help understand onsite hydrologic conditions at the time of the post-disaster LiDAR data collection date. This analysis gathered long-term rainfall records from the 30 years prior to the year of data collection. This analysis was run for both Gladwin and Midland Counties using NRCS WETS (Wetland Tables) weather station data (NRCS, 2020). This data was compared to actual rainfall totals from the three months prior to the LiDAR data being captured; this comparison indicated normal precipitation and climatic conditions at the time of collection in both Gladwin and Midland Counties. Because normal conditions were present, this LiDAR data was used to define the 'new normal' extent of surface water following the disaster. This information was used, in part, to identify the possible extent of wetlands post-disaster that may extend landward from the new surface water elevations. The antecedent hydrologic condition analyses are provided in Tables 2.3.2-1 and 2.3.2-2 below.

Table 2.3.2-1: Antecedent Precipitation Analysis for Gladwin, Gladwin County, Michigan (August 2020)

	Long-term rainfall records (1989-2019)								
WETS Station Gladwin, MI	**Month**	**<30%**	**Mean**	**>30%**	**Actual**	**Condition**	**Condition Value**	**Weight**	**Value X Weight**
3rd Prior Month	May	2.60	3.67	4.34	**6.72**	Wet	3	1	3
2nd Prior Month	June	2.53	3.56	4.21	**1.74**	Dry	1	2	2
1st Prior Month	July	2.23	3.14	3.71	**2.80**	Normal	2	3	6
								Sum:	**11**
							Antecedent Precipitation Condition at Location:		**Normal**

Table 2.3.2-2: Antecedent Precipitation Analysis for Midland, Midland County, Michigan (August 2020)

	Long-term rainfall records (1989-2019)								
WETS Station Midland, MI	**Month**	**<30%**	**Mean**	**>30%**	**Actual**	**Condition**	**Condition Value**	**Weight**	**Value X Weight**
3rd Prior Month	May	2.64	3.59	4.22	**7.20**	Wet	3	1	3
2nd Prior Month	June	2.42	3.60	4.31	**1.54**	Dry	1	2	2
1st Prior Month	July	1.91	2.67	3.16	**3.17**	Wet	3	3	9
								Sum:	**14**
							Antecedent Precipitation Condition at Location:		**Normal**

2.4 SURFACE WATER ANALYSIS

To analyze the surface water levels pre- and post-disaster, the LiDAR DEM was run through ESRI's *Slope Tool*. The *Slope Tool* analyzes surface elevations and identifies the slope of each pixel of the raster surface. This results in the degree of slope for each pixel. Once slopes have been identified for each pixel across the review area, the data is reclassified by dividing all pixel values into two separate categories. Every slope value of <0.3 was assigned into one category, and every slope value >0.3 was placed into the other category. The result of this is a display of all areas that are essentially flat. Flat areas are consistent with the slope that would be present on the surface of a waterbody. Next, this data was run through the *Majority Filter Tool,* which reduces any noise or outliers in the data. Then, the output raster was converted to a vector polygon layer and a final quality check was performed throughout the dataset to identify and edit any visible discrepancies in the data.

LiDAR data collected both pre- and post-disaster was reviewed to determine the actual elevations of surface water levels throughout most of the review area with one exception; post-disaster LiDAR data was not available for the northernmost portions of the Tobacco River and its tributaries. The LiDAR data's extent covers all other areas up to a point along the Tobacco River that is located 1.13 miles south of the Dale Road bridge crossing near Beaverton, Michigan. Therefore, this portion of the surface water level analysis was not included in the surface water level assessment or any wetland analysis performed in relation to post-disaster surface water analysis.

Using this data, the boundaries of surface water present pre- and post-disaster were mapped to calculate total acreages pre- and post-disaster. This data is displayed within the shapefiles provided as a part of this report submittal. Additionally, post-disaster surface water area was subtracted from pre-disaster surface water area to identify areas of newly exposed land. This information was used to support the post-disaster wetland analysis where newly created wetlands may have emerged following the surface water drawdowns.

2.5 WETLAND ANALYSIS

2.5.1 Pre-disaster Wetlands

Merjent's GIS analysts and wetland scientists evaluated the review area for the potential extent of wetlands present pre-disaster. For consistency of the review, the same two reviewers covered the entire review area. The review area was divided into 40-acre review quadrats. Next, the reviewer focused on one quadrat at a time and identified any obvious wetland signatures that were present using several aerial imagery resources. These include visual wetland hydrology indicators such as saturation, inundation, and changes in vegetation composition. Next, the reviewer looked at the NWI and NHD layers to see if any previously mapped wetlands or surface waters were present. Following this, color-infrared imagery was reviewed to see if any wetland patterns were present that confirmed the initial wetland findings. Once potential wetland locations were noted, derivatives from the LiDAR DEM were overlain atop the quadrat. This data was used to look for consistent indications of low elevation areas among the quadrat's landscape. Using the aggregate of all background data reviews, a final pre-disaster wetland polygon was mapped.

2.5.2 Pre-disaster Impacted Wetlands

To identify pre-disaster potentially impacted wetlands, the ArcGIS *Zonal Statistics Tool* was used using the pre-disaster LiDAR DEM as an input to identify the lowest elevation of each pre-disaster wetland polygon. Next, the reviewers evaluated the accumulation paths for each catchment to see which way water flows throughout the system. Then, the difference between the nearest surface water elevation and the lowest wetland elevation point was calculated for each wetland polygon. For this study, potentially impacted wetlands were identified at three different levels including 1-, 2-, and 3-foot elevation differences from the pre-disaster surface water elevations. Identifying potential wetlands at these three intervals provides a range of potential impacts. According to the Michigan Department of Environment, Great Lakes, and Energy's *Wetland Mitigation Banking Agreement Example*, wetlands require saturation within the upper 12 inches of the soil surface for varying periods during the growing season. Therefore, this analysis accounts for potential ranges in soil saturation at varying assessment levels. If any point of the wetland was within this elevation difference, the entire wetland is being considered potentially impacted to some degree.

As noted in the surface water analysis above, post-disaster LiDAR data was not available for the northernmost portions of the Tobacco River and its tributaries. The LiDAR data's extent covers all other areas up to a point along the Tobacco River that is located 1.13 miles south of the Dale Road bridge crossing near Beaverton, Michigan. Wetlands within the catchment areas (per the micro-catchment area assessment) that emptied into any portions of the Tobacco River upstream of this point were not evaluated when determining potential pre-disaster wetland impacts when compared to created wetlands to provide a consistent review area for analysis.

A quality assurance and control check was performed on the results of this exercise. Potentially impacted wetlands were reviewed for evidence of direct hydrologic connection to surface waters using a variety of aerial imagery resources and then by using the results of the micro-catchment area analysis. While reasonably accurate, minor corrections to the potential extent of post-disaster wetlands were made.

2.5.3 Post-disaster Created Wetlands

The following resources were reviewed to identify potential wetlands created as a part of the water drawdown post-disaster. Areas historically inundated by water due to impoundments had significant water elevation decreases. In areas immediately adjacent to the new waterbody (surface water) extents, wetlands may have formed on the newly dried out impoundment or waterway beds.

Merjent's GIS Analysts ran the *Contours Tool* in ArcGIS using the post-disaster LiDAR DEM as an input. Then, elevations ranging from 0- to 3-foot increases from the post-disaster surface water levels were identified as potential areas where wetlands may have been created post-disaster.

As noted in the surface water analysis above, post-disaster LiDAR data was not available for the northernmost portions of the Tobacco River and its tributaries. The LiDAR data's extent covers all other areas up to a point along the Tobacco River that is located 1.13 miles south of the Dale Road bridge crossing near Beaverton, Michigan. Wetlands within the catchment areas (per the micro-catchment area assessment) that emptied into any portions of the Tobacco River upstream of this point were not evaluated when determining potential post-disaster created wetlands.

2.6 DAM SITES

The pre-disaster wetland analysis consistent with the methods listed above was completed for each of the four dam site review areas: Secord, Smallwood, Edenville, and Sanford. For these sites, post-disaster drone imagery was available beginning in November 2020. This imagery, in addition to LiDAR DEM (2020), was evaluated to perform a desktop wetland determination of current, post-disaster conditions at the four dam site review areas. This method identified potential wetlands using aerial signatures such as saturation visible on aerial imagery, inundation visible on aerial imagery, and by assessing vegetation patterns. Not all wetlands identified may be regulated.

3.0 RESULTS

3.1 REVIEW AREA

The review area totals 43,457.9 acres, comprised of the Wixom Lake flowage review area of 33,562.1 acres and the Sanford Lake flowage review area of 9,895.8 acres. The dam site review areas are contained within these acreages except for Secord Dam, which is located several miles north of the impacted flowages.

3.2 SURFACE WATER

Prior to the disaster, approximately 3,755.5 acres of surface water was present within the review area, including surface waters occurring within connected features such as tributaries and lakes. This area consists of 2,172.8 surface water acres within the Wixom Lake area and 1,582.7 surface water acres within the Sanford Lake flowage review area.

Following the disaster, approximately 1,147.6 acres of surface water were present within the review area, consisting of 662.6 surface water acres within the Wixom Lake review area and 485.0 surface water acres within the Sanford Lake flowage review area.

In total, the approximate decrease in surface water acres across the review area was 2,607.9 acres, a decrease in 69.4% of surface water acreage. This consists of a loss of 1,510.2 surface water acres (69.5%) within the Wixom Lake flowage area and a loss of 1,097.7 surface water acres (69.4%) within the Sanford Lake flowage area.

This reduction in surface water levels created approximately 2,607.9 acres of newly exposed soil surface areas that were once submerged on a regular basis, some of which may have developed into new wetland areas. Estimated net change (Δ) in wetland surface water area is presented in Table 3.2-1.

Table 3.2-1: Pre- and Post-Disaster Surface Water Analysis

Flowage Area	Pre-Disaster (Acres)	Post-Disaster (Acres)	Δ (Acres)
Wixom Lake	2,172.8	662.6	-1,510.2
Sanford Lake	1,582.7	485.0	-1,097.7
Totals	**3,755.5**	**1,147.6**	**-2,607.9**

4.0 WETLANDS

In summation, the area of pre-disaster wetlands potentially impacted by the disaster ranges from 2,046.9 to 9,726.2 acres. Following the disaster, approximately 389.1 acres of new wetland was formed on newly exposed soil areas of the impoundment.

4.1.1 Pre-disaster Wetlands

In total, 2,072 wetlands totaling 9,726.2 acres were potentially present pre-disaster within the review area. A summary of these potential pre-disaster wetlands by community type and flowage is presented in Tables 3.3.2-1, 3.3.2-2, and 3.3.2-3 in comparison to post-disaster wetland data.

4.1.2 Post-disaster Impacted Wetlands

In total, approximately 2,046.9 to 3,161.9 acres of wetland were potentially impacted by the disaster event. A summary of these potential post-disaster wetlands impacts by community type and flowage is presented in comparison to pre-disaster wetland data in Tables 3.3.2-1, 3.3.2-2, and 3.3.2-3. This data has been summarized by review of 1-, 2-, and 3-foot elevation models related to the post-disaster surface water elevations. This provides a range of potential pre-disaster wetland impacts. Estimated net change (Δ) in wetland acreage is presented within the tables below.

To best evaluate a consistent review area where LiDAR data was available from both pre- and post-disaster, impacts associated with the upstream reaches of the Tobacco River within the Wixom Lake flowage were not included in this summary.

Table 3.3.2-1: Post-Disaster Impacted Wetland Analysis (1 Foot)

	Pre-Disaster				Post-Disaster (Non-Impacted)				
Flowage Area	PEM (Acres)	PSS (Acres)	PFO (Acres)	PUB (Acres)	PEM (Acres)	PSS (Acres)	PFO (Acres)	PUB (Acres)	Δ (Acres)
Wixom Lake	901.5	285.4	6,688.1	81.6	811.0	241.6	5,139.2	81.6	-1,683.2
Sanford Lake	121.5	162.6	1,457.2	28.3	104.7	142.9	1,130.3	28.0	-363.7
Totals	**1,023.0**	**448.0**	**8,145.3**	**109.9**	**915.7**	**384.5**	**6,269.5**	**109.6**	**-2,046.9**

Potential impacted wetlands by community type across both flowages using a 1-foot model are displayed below:

- 107.3 acres of PEM
- 63.5 acres of PSS
- 1,875.8 acres of PFO
- 0.3 acre of PUB

Table 3.3.2-2: Post-Disaster Impacted Wetland Analysis (2-Foot)

	Pre-Disaster				Post-Disaster (Non-Impacted)				
Flowage Area	**PEM (Acres)**	**PSS (Acres)**	**PFO (Acres)**	**PUB (Acres)**	**PEM (Acres)**	**PSS (Acres)**	**PFO (Acres)**	**PUB (Acres)**	**Δ (Acres)**
Wixom Lake	901.5	285.4	6,688.1	81.6	804.8	240.4	4,252.6	81.6	-2,577.2
Sanford Lake	121.5	162.6	1,457.2	28.3	104.4	142.3	1,124.2	28.0	-370.7
Totals	**1,023.0**	**448.0**	**8,145.3**	**109.9**	**909.2**	**382.7**	**5,376.8**	**109.6**	**-2,947.9**

Potential impacted wetlands by community type across both flowages using a 2-foot model are displayed below:

- 113.8 acres of PEM
- 65.3 acres of PSS
- 2,768.5 acres of PFO
- 0.3 acre of PUB

Table 3.3.2-3: Post-Disaster Impacted Wetland Analysis (3-Foot)

	Pre-Disaster				Post-Disaster (Non-Impacted)				
Flowage Area	**PEM (Acres)**	**PSS (Acres)**	**PFO (Acres)**	**PUB (Acres)**	**PEM (Acres)**	**PSS (Acres)**	**PFO (Acres)**	**PUB (Acres)**	**Δ (Acres)**
Wixom Lake	901.5	285.4	6,688.1	81.6	804.4	237.9	4,126.4	80.1	-2,707.8
Sanford Lake	121.5	162.6	1,457.2	28.3	104.4	141.2	1,042.0	27.9	-454.1
Totals	**1,023.0**	**448.0**	**8,145.3**	**109.9**	**908.8**	**379.1**	**5,168.4**	**108.0**	**-3,161.9**

Potential impacted wetlands by community type across both flowages using a 2-foot model are displayed below:

- 114.2 acres of PEM
- 68.9 acres of PSS
- 2,976.9 acres of PFO
- 1.9 acre of PUB

4.1.3 Post-disaster Created Wetlands

In total, approximately 389.1 acres of new or 'created' wetlands were formed as a result of the disaster. This value consists of 135.3 acres within the Wixom Lake flowage and 253.8 acres within the Sanford Lake flowage. These wetlands were all noted as being of PEM wetland community type as they are newly formed wetlands originating on the exposed soil flats that were previously inundated by the impoundments. These values indicate all elevations within 3 feet of the new surface water elevation levels. Estimated net change (Δ) in wetland acreage is associated with created wetlands is presented in Table 3.3.3-1.

To best evaluate a consistent review area where LiDAR data was available from both pre- and post-disaster, impacts associated with the upstream reaches of the Tobacco River within the Wixom Lake flowage were not included in this summary.

Table 3.3.3-1: Post-Disaster Created Wetland Analysis

	Pre-Disaster				Post-Disaster Created				
Flowage Area	PEM (Acres)	PSS (Acres)	PFO (Acres)	PUB (Acres)	PEM (Acres)	PSS (Acres)	PFO (Acres)	PUB (Acres)	Δ (Acres)
Wixom Lake	901.5	285.4	6,688.1	81.61	1,036.8	0.00	0.00	0.00	+135.3
Sanford Lake	121.5	162.6	1,457.2	28.3	375.3	0.00	0.00	0.00	+253.8
Totals	**1,023.0**	**448.0**	**8,145.3**	**109.91**	**1,412.1**	**0.00**	**0.00**	**0.00**	**+389.1**

4.2 DAM SITES

4.2.1 Pre-Disaster

Potential pre-disaster wetlands were identified at each dam site. Pre-disaster wetlands are assumed to be the same extent as post-disaster wetlands for the Secord Dam site as that location was not influenced by the disaster. A summary of these potential pre-disaster wetlands by community type and flowage is presented in Table 3.4.2-1.

4.2.2 Post-Disaster

Potential post-disaster wetlands were identified at each dam site. A summary of these potential post-disaster wetlands by community type and dam site are presented in Table 3.4.2-1.

Following the disaster, approximately 20.44 acres of potential wetland were lost across the dam sites. The Smallwood and Edenville Dam sites experienced significant changes in wetland and wetland community type acreages. Estimated net change (Δ) in wetland acreage is presented in Table 3.4.2-1.

At the Smallwood Dam site, approximately 4.87 acres of PEM wetland was added to the site while at the same time 3.46 acres of PFO wetland were removed from the site. PFO wetland was lost due to the removal of trees onsite either from the disaster itself or other onsite activities as many of these forested areas were not present in the November 2020 drone imagery. This pre-disaster PFO acreage was added onto the PEM wetland acreage at the site post-disaster. Additionally, a 1.42-acre area that was previously inundated with surface water by the Smallwood Dam impoundment has been drained to the point where surface soils were exposed, and additional PEM wetland was formed or created.

At the Edenville Dam site, the draining of the impoundment exposed significant amounts of soil; however, due to the steep gradation of the river channel and its embankments in the area, wetlands were lost rather than formed. Pre-disaster, wetlands were formed within riparian habitats associated with the impoundment. The significant drawdown of water (>10 feet at times) appears to have drained these wetlands and created approximately 22.02 acres of upland area where primarily forested wetlands once occurred.

Table 3.4.2-1: Post-Disaster Wetland Analysis of the Dam Sites

	Pre-Disaster				Post-Disaster				
Dam Site	PEM (Acres)	PSS (Acres)	PFO (Acres)	PUB (Acres)	PEM (Acres)	PSS (Acres)	PFO (Acres)	PUB (Acres)	Δ (Acres)
Secord	0.42	0.00	0.80	0.00	0.42	0.00	0.80	0.00	0.00
Smallwood	1.27	0.00	5.70	0.00	6.14	0.00	2.24	0.00	+1.41
Edenville	0.00	0.03	32.55	0.16	6.23	0.56	3.93	0.00	-22.02

	Pre-Disaster				Post-Disaster				
Dam Site	**PEM (Acres)**	**PSS (Acres)**	**PFO (Acres)**	**PUB (Acres)**	**PEM (Acres)**	**PSS (Acres)**	**PFO (Acres)**	**PUB (Acres)**	**Δ (Acres)**
Sanford	0.01	0.00	1.91	0.00	2.08	0.00	0.00	0.00	+0.16

4.3 DELIVERABLES

The following files have been sent to Spicer for incorporation into their GIS files.

- Review area,
- Pre- and post-disaster surface water extent, and
- Pre- and post-disaster wetland extent by wetland community type, including potentially impacted wetlands and created wetlands.

5.0 NOTES

The analysis of pre- and post-disaster wetlands is only as accurate as the data available for use. Field verification of wetland boundaries should be conducted to verify the findings presented within this report.

Following data analysis, it appears that significantly greater impacts to wetlands were experienced as a result of the disaster than new wetlands were created. This is, in part, due to the contours of the pre-disaster surface water areas and associated lake and stream bottoms. When water decreases, bottomland flats are exposed. However, these exposures that are situated in elevations adjacent to the post-disaster surface water levels tend to only occur sparsely throughout the review area. The primary post-disaster exposed soils appear to be situated in a landscape position and elevation that would create upland conditions.

The degree to which a wetland may have been impacted is unknown at this time and may be difficult to determine unless pre-disaster studies are available for wetlands in the area. Although impacted wetlands may have been affected, it is not known if the entire wetland complex may have been impacted. However, for the purposes of this study, the entire wetland was identified as being potentially impacted as some portion of its hydrology was likely impacted and it is unknown at this time to what extent these impacts will have on the wetland over time (e.g., decreased hydrology, vegetation stress, and associated invasion by exotic species, etc.). Field verification should be completed over several years to determine the extent of impacts to these wetlands.

In some areas it was initially thought that wetlands were not affected because of a road and/or culvert that appeared to impede surface water drainage along some of the tributaries associated with the flowages. Although the water level at these areas remained mostly the same compared to other areas where it dropped completely, it still measured a drop of 1.5 to three feet. This decrease in water level, while not as significant as the major impoundments within the flowages, would still have an impact on adjacent wetlands.

6.0 REFERENCES

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