Disaster Proofing Critical Facilities of Outagamie County

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InterEGR 303 – Applied Leadership Competencies in Engineering

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Abstract:

Outagamie County is currently in the process of updating their five-year hazard mitigation plan from 2017. In the past five years, both the flood risk and critical facilities in Outagamie County have changed. While the current hazard mitigation plan contains a lot of technical information regarding the hazards, critical facilities, and mitigation efforts from 2017 in Outagamie County, the mitigation plan is long and not the easiest for a lay person to understand. As a result, Outagamie County requested a re-evaluation of critical facilities and flood risks in the county. This report focuses on the risks posed to both farmland and roads throughout the county. Using floodplain data, satellite imaging, and future rainfall predictions, the most critical roads and farmland were identified. Once critical roads and farmland were identified, a final deliverable was created that highlights the at-risk roads and farmland and overlays the highlighted maps onto a map of the county.

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Introduction:

In 2017, Outagamie County released a new five-year hazard mitigation plan. Now that it has been five years, the county is in the process of updating the mitigation plan. One of the main components of the hazard mitigation plan is the identification of critical facilities and the flood risk to those critical facilities. However, the critical facilities and flood risks in Outagamie County have changed in the past five years since the last hazard mitigation plan was made. Therefore, Outagamie County has requested a re-evaluation of critical facilities in the county and the flood risks associated with those critical facilities. Critical facilities are identified as infrastructure that affects the most people or at the greatest risk of repeated disaster. In the last Hazard Mitigation Plan from 2017, Critical facilities such as airports and dams were identified. In the new hazard mitigation plan, the county placed an emphasis on identifying critical roads and farmland that are at the greatest risk of flooding. As a result, our team was tasked with identifying the areas of farmland and roads that were at the greatest risk of flooding and creating a deliverable that could be appended to the updated hazard mitigation plan.

Background:

Outagamie County, located in northeast Wisconsin, has experienced flooding in the past and is currently dealing with a significant risk of flooding in the ensuing 30 years. A danger of severe impact greater than 26% exists for about 9% of the county's properties (Risk Factor). In addition to causing property damage, flooding can hinder access to utilities, emergency services, and transportation. Due to these risks, it is important for areas with flooding risk to have hazard mitigation plans in place. For our project we were tasked with providing some resources that the county could use to assist their official hazard mitigation efforts.

To understand flooding risks in a county it is first beneficial to understand FEMA flood zones. FEMA (Federal Emergency Management Agency) is the government agency responsible for the hazard preparation, protection, response, and recovery. One of the hazards FEMA is responsible for is flooding, which is the focus of this project. Figure 1 below provides an overview of the flood zone designations. In this report, we focus on high-risk flood zones which are designated as Special Flood Hazard Areas (SFHA). The high-risk zones of importance to Wisconsin are zones that start with an A, or non-coastal high-risk zones.

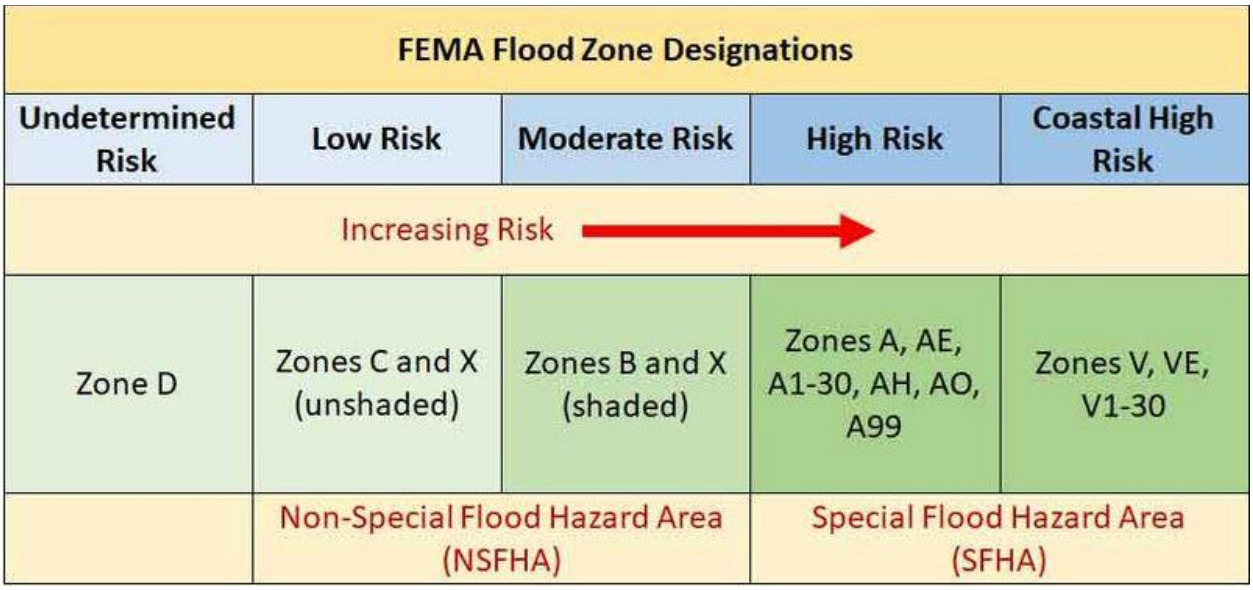


Figure 1: FEMA flood zone designations

A high-risk zone means that there is a 1% annual risk of flooding within that area. Storm events which lead to a 1% flood risk flood are called 100-year floods, since there is estimated to be one flood every 100 years. Another way to visualize a 1% flood risk is that if you have a 30-year mortgage in a 1% flood risk zone, there is a 26% chance that you will deal with a flood over the span of that mortgage. This risk is substantial to the average farmer or homeowner, and therefore public education about flood zones can be a good first step towards hazard mitigation.

Another aspect we investigated was the potential increased flood risk in the future. Flood zones are designated based on historical data, however due to climate change significant rain events and annual precipitation are both trending upwards. Figure 2 provides information on the historical and future projections for rainfall across Wisconsin. It is apparent that the amount of precipitation in the state has increased over the past 68 years and will continue to increase into

the future. Figure 3 shows the number of significant rain events (>1 in) per year in the state and future projections. More significant rain events means that there is a larger chance of storms that can trigger a 100-year flood. The increase in 100-year flooding events means that zones designated in the past by FEMA may be out of date. More areas could be at risk than what has been previously assigned, and this means more areas should be considered for flood mitigation.

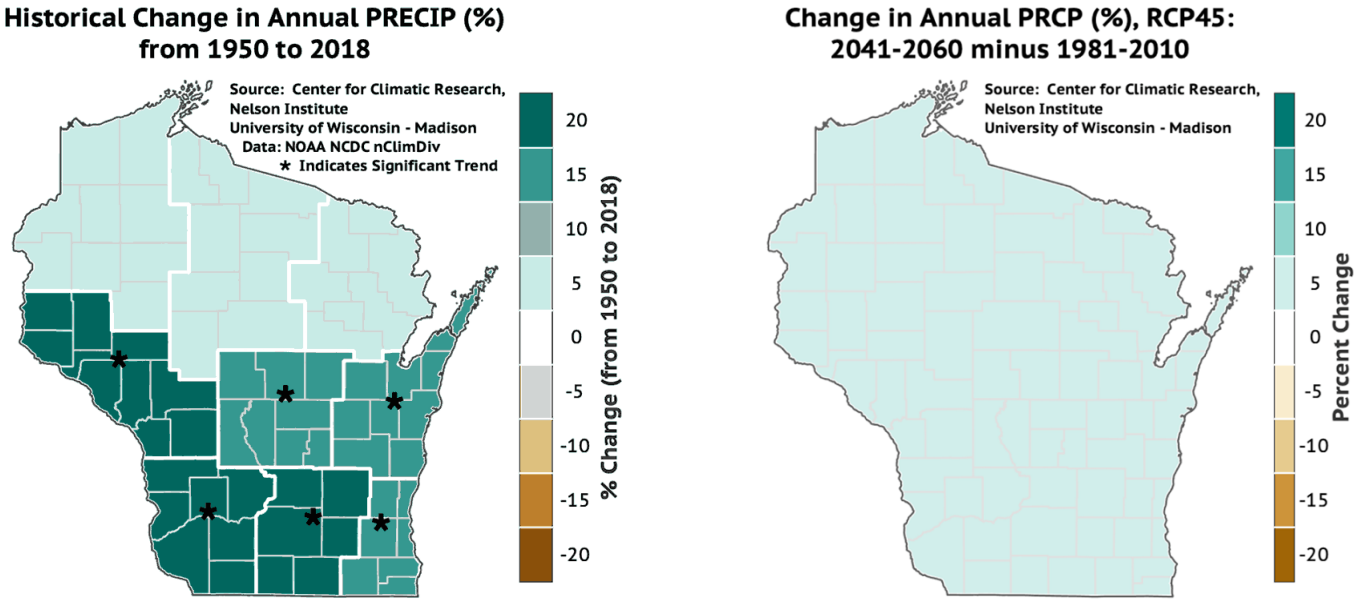


Figure 2: Historical and future annual change in precipitation across Wisconsin

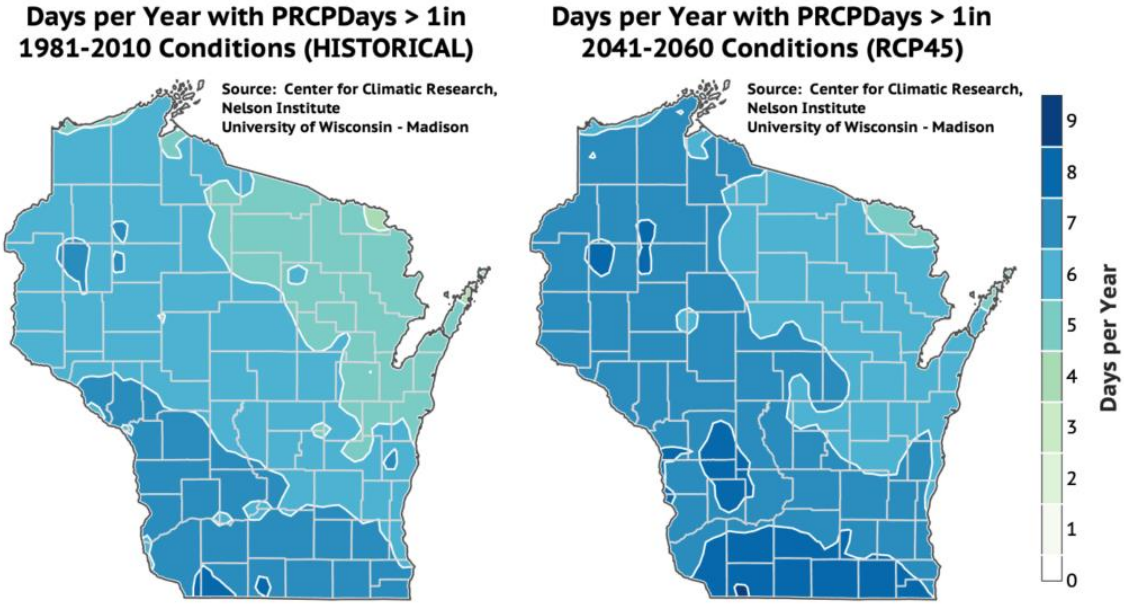


Figure 3: Significant precipitation events per year in Wisconsin, historical and future projections

Outagamie County is aware of the risks and dangers associated with flooding and has been utilizing Hazard Mitigation Plans (HMP). This plan is used for a period of five years, after which

it must be updated. The current HMP was last updated in September 2017. Aiming to get financing to protect the county, Outagamie County wants to create an updated HMP that addresses all current and potential flood hazards to important infrastructure. Where are the regions that pose the greatest risk? What is at risk? The new HMP will go in-depth into these issues.

Unfortunately, a problem occurs when attempting to explain technical material to an audience who could be less knowledgeable about the subject. The county expressed their need to have a more understandable and accessible component in their HMP to support their funding proposal. Our aim was to produce a document that would more clearly and intuitively illustrate the county's flooding threats.

Analysis:

Looking at Outagamie County, it was evident that there were too many critical facilities to focus on in the timeframe of the project. Therefore, to begin the project, our group first communicated with Outagamie County to determine which facilities were the most critical. At the conclusion of that meeting, it was evident that the county desired the critical evaluation of flood risks to roads and farmland throughout the county. To determine the flood risk everywhere in the county, our group was provided with historic rainfall data as well as graphic information system (GIS) data. The GIS data provided displayed the flood plain data for the county and highlighted areas of the county corresponding to the flood risk in that area. Figure 4 shows an example of the GIS map we used. Based on the GIS data, it was evident that the northwestern corner of Outagamie County had the greatest flood risk, so our group decided to focus our efforts on that portion of the county.

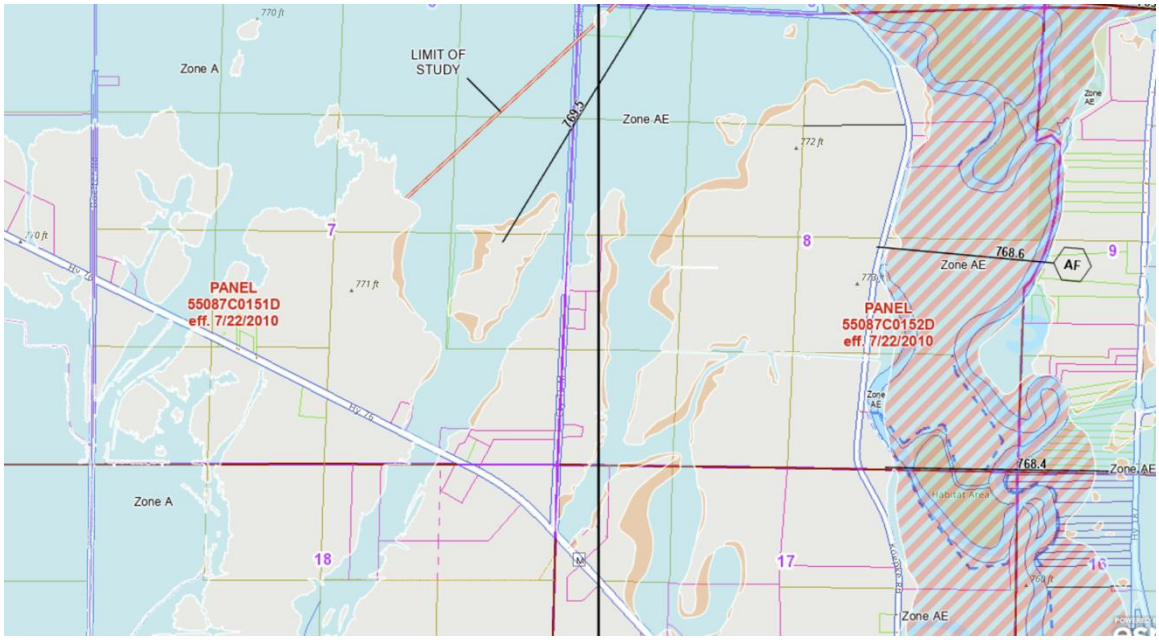


Figure 4: GIS map example for flood risk in Outagamie County

To identify sections of roads that were at the greatest flood risk, each member of our group focused on a couple county highways in the northwestern corner of Outagamie County. Each member then followed the assigned county highways on the GIS floodplain data and identified the portions of roadway that intersected the areas with the greatest flood risk. The sections of highway that had the greatest risk were then highlighted on a map of the county.

Identifying which areas of farmland were at greatest risk proved to be more involved than identifying roads at risk of flooding. Because the flood plain data provided did not differentiate between what land was being used for, there needed to be a combination of both satellite imaging and the flood plain data provided. The farmland with the greatest risk of flooding was identified as the farmland that lay near the few rivers flowing through the northwestern portion of the county. The farmland that was most at risk was identified by following the rivers on the flood plain maps, finding where the highest flood risks were, and checking the satellite imaging to check if that flood risk corresponded to farmland. If it did, that portion of the map would be

marked as farmland with a high flood risk. Once both the map of high flood risk roads and the map of high flood risk farmland were complete, the two maps were overlayed on top of each other to create a single, comprehensive map that identifies both the farmland and roads that have the greatest flood risk. The full map was then split into four smaller sections for a more detailed view of each portion of the county that was identified as having a critical facility with a flood risk (Appendix 1). This map was finally converted into a scalable PDF for ease of use in any type of deliverable Outagamie County desires to create.

Recommendations and Conclusions:

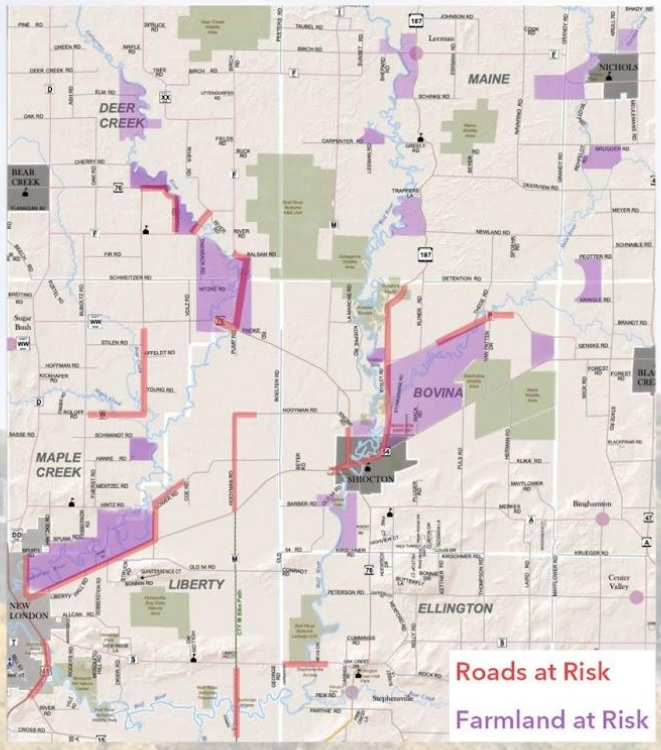
The goals of this project were two-fold. We provided background information about why flooding is a risk in Outagamie County and the consequences of flooding. Then, we produced a deliverable that characterizes the flood risks on roads and farmland in a specific high-risk area of the county. The overall purpose of these 2 deliverables was to provide information that was easily accessible and understandable for people who may not have a background in hazard mitigation. This will be a useful starting point for county officials who are trying to determine where to focus their efforts and money. It will also be a useful tool for educating stakeholders who oversee designating money but are not interested in the specifics of flood mitigation outlined in a long hazard mitigation plan.

For flooding risk, there is clear evidence from FEMA flood zone designations that areas of the county, specifically in the northwest region, are at high risk of flooding. There are numerous rivers and lowlands in this region, and many roads and areas of farmland overlap floodplains. There are also cities which are at a particularly high risk due to their location next to rivers.

Regarding mitigation in this region, we base our recommendations off previous actions that have been taken by the county. Since our scope of service was a broad assignment to the whole county, we do not have specific actions for individual municipalities. The needs for each should be tailored to the individual risks and hazards present. Our research led us to some mitigation techniques which will be useful across the whole county. One mitigation method is supplying sandbags to high-risk municipalities. This strategy would be most beneficial for areas where residential areas are at high risk for flooding. Smaller towns are more likely to be lacking these resources, and the county should make sure that supply is maintained across the region. Another important mitigation strategy is road and bridge inspections. These inspections should be carried out to determine where the infrastructure is at risk of failure in the case of a flood. Inspections will help designate money where it is needed the most and keep major failures from occurring which would be a risk to public safety. Finally, the construction of retention basins around areas where there has been historical flooding can be beneficial. This will again be based on specific situations that are made apparent by municipalities. Retention basins can mitigate the flood risk of specific lowland areas that frequently experience flooding during significant precipitation events.

Our final deliverable is presented in Figure 5 on the next page. This final deliverable highlights roads and farmland in SFHA zones in an easy-to-read format. The goal of this deliverable is to provide a tool for educating the average person on the risks of flooding in the northwest region of Outagamie County. It provides an initial breakdown on where officials should look to focus attention and will make it easier to characterize the individual risks over a large land area.

Understanding Flood Risk to Roads & Farmland in Outagamie County



Outagamie County has over 120 critical facilities in high risk Flood Zone Designations.

In addition to these critical facilities, the map to the right highlights major roads and farmland also located high risk Flood Zone Designations.

High risk Flood Designation Zones have a 1% annual chance of exceeding the flood elevation of the last 100-year flood.

Outagamie County can reduce the risk of property damage and transportation interruptions by limiting development in high risk Flood Designation Zones and ensuring current developments are engineered to withstand floodwaters.

RECOVERY MITIGATION RESPONSE PREPAREDNESS
OUTAGAMIE COUNTY EMERGENCY MANAGEMENT

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Figure 5: Flood risk map final deliverable

References:

1. Kowalzek-Adrians, Angela. “Outagamie County, Wisconsin Hazard Mitigation Plan 2017-2022.” *Outagamie County*, 16 Sept. 2017, https://www.outagamie.org/home/showpublisheddocument/66067/636960316148500000.
2. Outagamie County, Wisconsin flood factor® report. Risk Factor. (n.d.). Retrieved December 8, 2022, from https://riskfactor.com/county/Outagamie%20County-Wisconsin/55087_fsid/flood#flood_risk_overview

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Kara Homa - Outagamie County Development and Land Services Director
Dane Mattila – Instructor and Initial Point of Contact

Appendix A: Preliminary Mapping Process

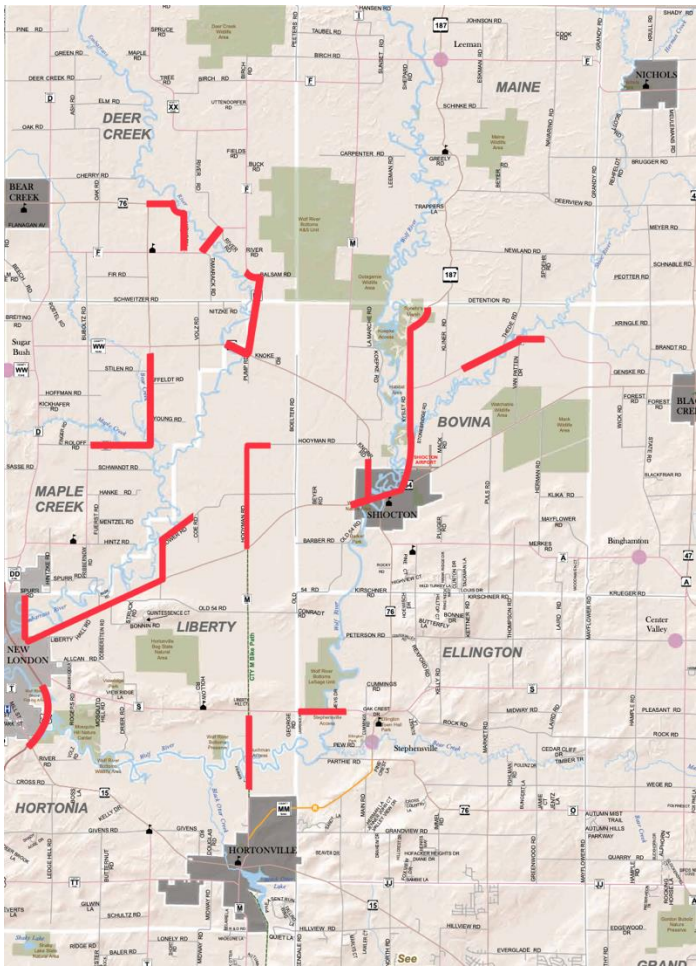

Figure A1: Roads at risk of flooding (NW area of Outagamie County)

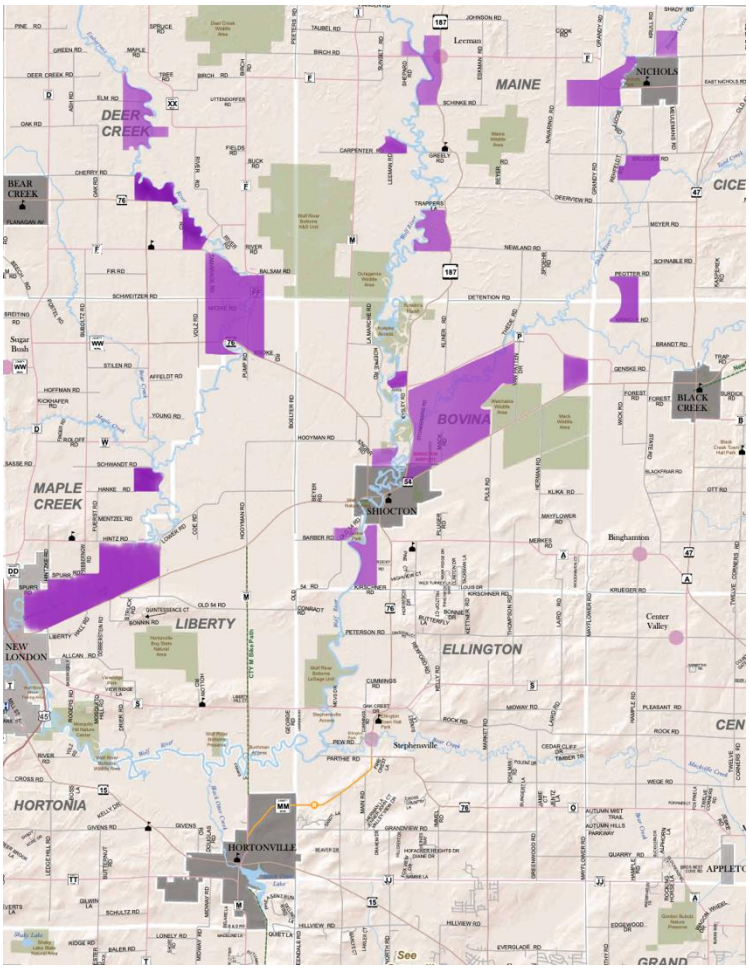

Figure A2: Farmlands at risk of flooding (NW area of Outagamie County)

```
In[ ]:= roads = <image> ; farmland = <image> ; (*Import Maps With Highlighted Roads & Farmlands*)

        farmlands = ImageAlign[roads, farmland]; (*Return a Version of Farmland Map That is Perfectly Aligned With the Roads Map*)

In[ ]:= f[pixel1_, pixel2_] := (pixel1 + pixel2) / 2; (*Define Function to Overlay Both Maps*)

In[ ]:= overlay = Blend[{farmlands, roads}] // ImageAdjust (*Overlay Both Maps*)

In[ ]:= {{q1, q2}, {q3, q4}} = ImagePartition[overlay, Scaled[{1 / 2, 1 / 2}]]; (*Split Overlayed Map Into Four Equal Sections*)
        ImagePartition[overlay, Scaled[{1 / 2, 1 / 2}]] // Grid

In[ ]:= q4map = Sharpen[Table[Rasterize[q4, ImageResolution → r], {r, {2500}}][[1]]] (*Increase  Resolution of Each Section of the Map*)

        Export["q1Map2.jpg", q1map, ImageResolution → 2000] (*Export Maps With Desired Resolution*)

        overlaymap = Sharpen[Table[Rasterize[overlay, ImageResolution → r], {r, {1500}}][[1]]] (*Increase Resolution of Overlayed Map*)

        Export["OverlayMap2.png", overlaymap, ImageResolution → 2000] (*Export Map With Desired Resolution*)
```

Figure A3: Code used to create final deliverable (Software: Mathematica)