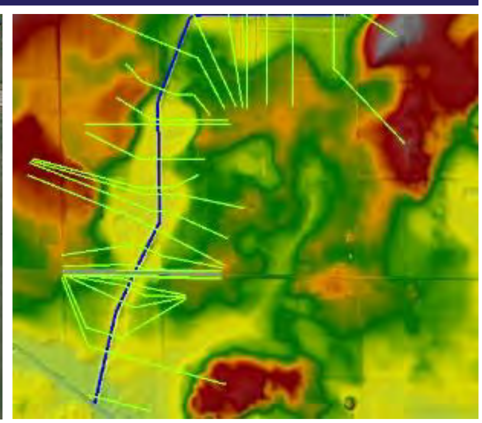
RUTLAND FLOOD STUDY

PREPARED BY FRESHWATER ENGINEERING



Prepared for:
Beth Hamacher
Stoughton, WI

April 2021

FRESHWATER ENGINEERING

April 16, 2021

Beth Hamacher
705 Hilldale Ln.
Stoughton, WI 53589
(608) 620-0496

RE: Rutland Floodplain Encroachment Study

Dear Ms. Hamacher,

FreshWater Engineering is pleased to submit this flood study on an unnamed tributary leading into Badfish Creek. The purpose of this study was to determine if a home that has been proposed for construction on a lot in the Town of Rutland is within the 1% annual chance (100-year) floodplain.

This study uses standard hydraulic modeling techniques to simulate the 1% annual chance flood on the unnamed tributary. The 2016 FEMA Flood Insurance Study (FIS) report for Dane County and 2017 Dane County Lidar were used to develop the model. The unnamed tributary was modeled with HEC-RAS v 5.0.7.

The findings of the study show that the inundation extent of the 1% annual chance event does not include the proposed site for construction. The study shows that the proposed structure on the site would not be located in the 1% annual chance floodplain and therefore is not subject to National Flood Insurance Program (NFIP) requirements.

We look forward to further discussing the project findings with you. Feel free to contact me should you have any questions or require additional information.

Sincerely,

Laura Rozumalski, P.E.
President and Principal Engineer
LRozumalski@FreshWaterEng.com
608-616-0128

Contents

1 Introduction

The purpose of this flood study is to determine if the proposed lot for construction is in the 1% annual chance (AC) floodplain. The 1% AC flood, also referred to as the 100-year flood or base flood, is a flood that has a one percent chance of occurring in a given year. The parcel is currently partially-covered by a Zone A FEMA-designated flood hazard. The Zone A designation indicates that the exact regulatory flood elevation has not been established, as opposed to a Zone AE designation, which indicates that a flood study determined the water surface elevation (WSE) at the site for the 1% AC flood.

Property owners with mortgages from federally-regulated lenders must buy flood insurance if their property lies in Zone A or Zone AE and their community participates in the National Flood Insurance Program (NFIP). For the purposes of this study, it is important to determine the base flood elevation (BFE) on the property in order to understand if proposed structures would be located in the 100-year floodplain.

This study uses watershed characteristics and established flood flows documented for the nearby Oregon Branch of Badfish Creek in order to determine 1% AC flood flows in the unnamed tributary and ultimately find the extent of the 1% AC floodplain for the unnamed tributary near the property of concern.

2 Study Area

The area investigated for this study consists of an unnamed tributary leading into Badfish Creek in southern Dane County in the Town of Rutland. The blue line in *Figure 1* is the unnamed tributary. In total, the tributary is approximately 2 miles long. The property of concern is denoted by the white dot in the figure below and lies on the south side of CTH A, approximately 1.7 miles downstream from the channel beginning. There is also a structure that currently sits on the property west of the driveway access point.

The tributary consists of a series of man-made ditches used for farming drainage which lead into a vegetated channel. The channel is surrounded by deciduous trees and vegetation. The lateral extents of the trees surrounding the channel range from around 70 ft to around 200 ft in some areas; other reaches are surrounded by cropland. Outside of the channel, the land is primarily used for agriculture.

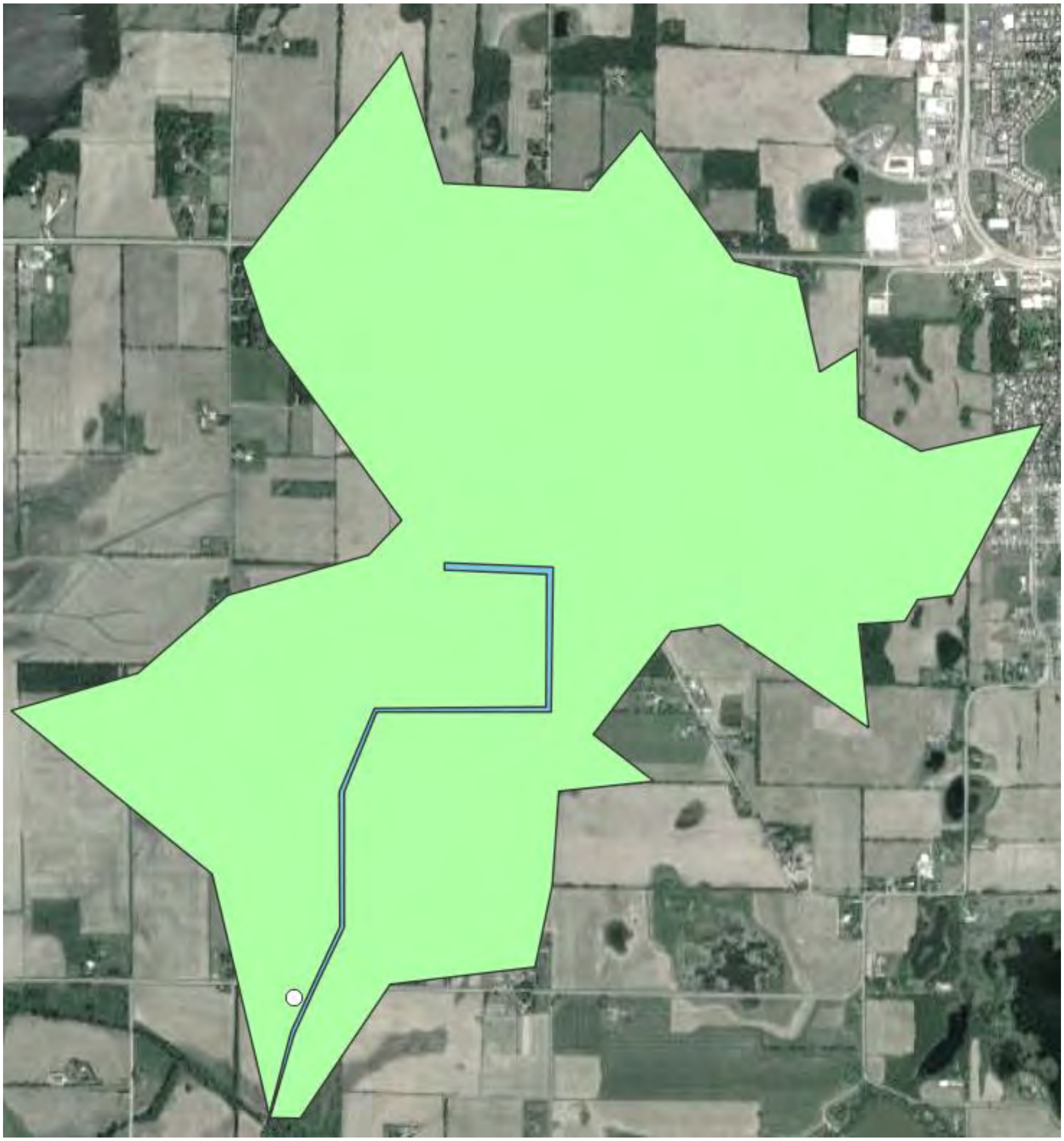


Figure 1. Locations of unnamed tributary and property with respect to watershed.

The light green shape in *Figure 1* is the watershed boundary of the unnamed tributary. Using QGIS, topographic lines were extracted using publicly-available 2017 Dane County Lidar information. Using the topography, the watershed area was calculated to be approximately 2.5 square miles. This calculation was verified using an online tool called “Model My Watershed,” which provides watershed characteristics, including drainage areas and land use. This tool gave an area of approximately 2.4 square miles. Additionally, the tool provided the land use characteristics of the study area, which is composed of 71% cultivated crops, 17.2% pasture/hay, 3% herbaceous wetlands, 2.75% deciduous forest, and 2.3% low intensity development.

3 Methods

3.1 Existing Studies

A previous hydrologic and hydraulic analysis of the Oregon Branch of Badfish Creek was conducted in order to determine the flood inundation extents near Oregon, WI. The 2016 FEMA FIS for Dane County contains information on the 10-,2-,1-, and 0.2-percent AC discharges, flood profiles, and channel information for the Oregon Branch of Badfish Creek. For the purposes of this study, only the 1% AC discharges were evaluated.

3.2 Vertical Datum

All elevations in this study refer to the NAVD88 vertical datum.

3.3 Hydrologic Analysis

The FEMA-determined discharge values in cubic feet per second (cfs) and associated drainage areas for the Oregon Branch of Badfish Creek, which starts in the town of Oregon, WI are shown in *Table 1* below. In addition, a stream discharge value for USGS stream gage station 05430100 was used in the analysis. A drainage area to discharge comparison was used to obtain discharges for the unnamed tributary (FEMA, 2016).

Table 1. Drainage areas and peak discharges for the Oregon Branch of Badfish Creek in Dane County (from FEMA, 2016).

Location (Hereafter denoted as the number in parenthesis)	***Drainage Area (square miles)***	***1% Annual Chance Peak Discharge (cfs)***
Badfish Creek USGS stream gage station 05430100, 2500' ft downstream of CTH A (1)	*39.8*	*1160*
Oregon Branch of Badfish Creek at tributary 1900' downstream of STH 138 (2)	*29.6*	*898*
Oregon Branch of Badfish Creek at tributary 1900' downstream of Highway 14 (3)	*23.9*	*782*
Oregon Branch of Badfish Creek at tributary 1900' downstream of Highway 14 (4)	*20.4*	*637*
Oregon Branch of Badfish Creek at culvert outlet at Oak st. (5)	*12.3*	*225*
Oregon Branch of Badfish Creek at culvert inlet at Oak st. (6)	*11.1*	*168*
Oregon Branch of Badfish Creek approximately 1100' upstream of North Burr Oak Avenue (7)	*10.8*	*256*
Oregon Branch of Badfish Creek approximately 0.5 mile upstream of North Burr Oak Avenue (8)	*9.2*	*140*

The "Model My Watershed" tool was also utilized in order to find the watershed characteristics of the Oregon Branch of Badfish Creek. In total, the watershed for the Oregon Branch is around

34.75 square miles. The land is composed of 55.5% cultivated crops, 13.75% pasture/hay, 8.25% deciduous forest, 6.5% low intensity development, 5.75% developed open space, and 3% herbaceous wetlands. The Wisconsin Department of Natural Resources (WDNR) maintains the Surface Water Data Viewer, which provided a similar watershed area, stating that the Oregon Branch drains approximately 30 square miles of primarily agricultural land.

In general, the unnamed tributary's watershed and the Oregon Branch of Badfish Creek watershed have similar land use characteristics. For the Oregon Branch, the main land use is cultivated crops and pasture/hay, which makes up around 70% of the watershed area. In the unnamed tributary, the main land use is also cultivated crops and pasture/hay, making up approximately 88% of its watershed. Therefore, utilizing the discharge-area ratio method provided fair approximations of the 1% AC discharge in the unnamed tributary.

The discharge-area ratio method provides a simple approximation of 1% AC flows. *Table 2* provides the discharge estimates based on the discharge-area ratio method. A value of 2.4 square miles was used for the unnamed tributary's watershed area. The general equation used is shown below:

$$Y_M = \left(\frac{A_y}{A_x}\right) \times X_M$$

Where:

$A_Y = Area\ of\ site\ of\ interest\ (mi^2)$

$A_X = Area\ of\ known\ site\ (mi^2)$

$X_M = Discharge\ at\ known\ site\ (cfs)$

$Y_M = Discharge\ at\ site\ of\ interest\ (cfs)$

Example Calculation (Location 1):

$A_Y = 2.4\ mi^2$

$A_X = 39.8\ mi^2$

$X_M = 1160\ cfs$

$Y_M = \left(\frac{2.4}{39.8}\right) \times 1160$

$Y_M = 69.95$

Table 2. Estimated 1% AC peak discharges for the unnamed tributary of Badfish Creek in Dane County based on known characteristics of the Oregon Branch of Badfish Creek.

	Reference Watershed		Unnamed Tributary	
Location	**Drainage Area [mi²]**	**1% AC Discharge [cfs]**	**Drainage Area [mi²]**	**Estimated 1% AC Discharge [cfs]**
1	39.8	1160	2.4	69.95
2	29.6	898	2.4	72.81
3	23.9	782	2.4	79.50
4	20.4	637	2.4	75.94
5	12.3	225	2.4	43.90
6	11.1	168	2.4	36.32
7	10.8	256	2.4	56.88
8	9.2	140	2.4	36.50

The average of the estimated 1% AC peak discharges for the unnamed tributary is approximately 59 cfs. This value was used in the steady flow analysis in HEC-RAS.

3.4 Hydraulic Analysis

Hydraulic analysis of the unnamed tributary was performed using HEC-RAS v. 5.0.7 using a one-dimensional steady flow analysis. The average of the estimated 1% AC peak discharges for the unnamed tributary shown in *Table 2* above was approximately 59 cfs. This value was used in the steady flow analysis in HEC-RAS.

Cross-sections, bank lines, and flow paths were generated in HEC-RAS Mapper using a digital elevation model (DEM) created from 2017 Lidar data. A screenshot of the HEC-RAS model along with the locations of the unnamed tributary, culvert, CTH A, and property can be seen in *Figure 2* below. The background of *Figure 2* and *Figure 6* is the DEM or terrain that was extracted from Dane County 2017 Lidar. The DEM has a spatial resolution of 2 feet. The color changes of the DEM represent changes in elevation following color scale shown in the bottom right corner of *Figure 2*, with light green representing areas of low elevations and gray and white representing areas of higher elevations in units of feet.

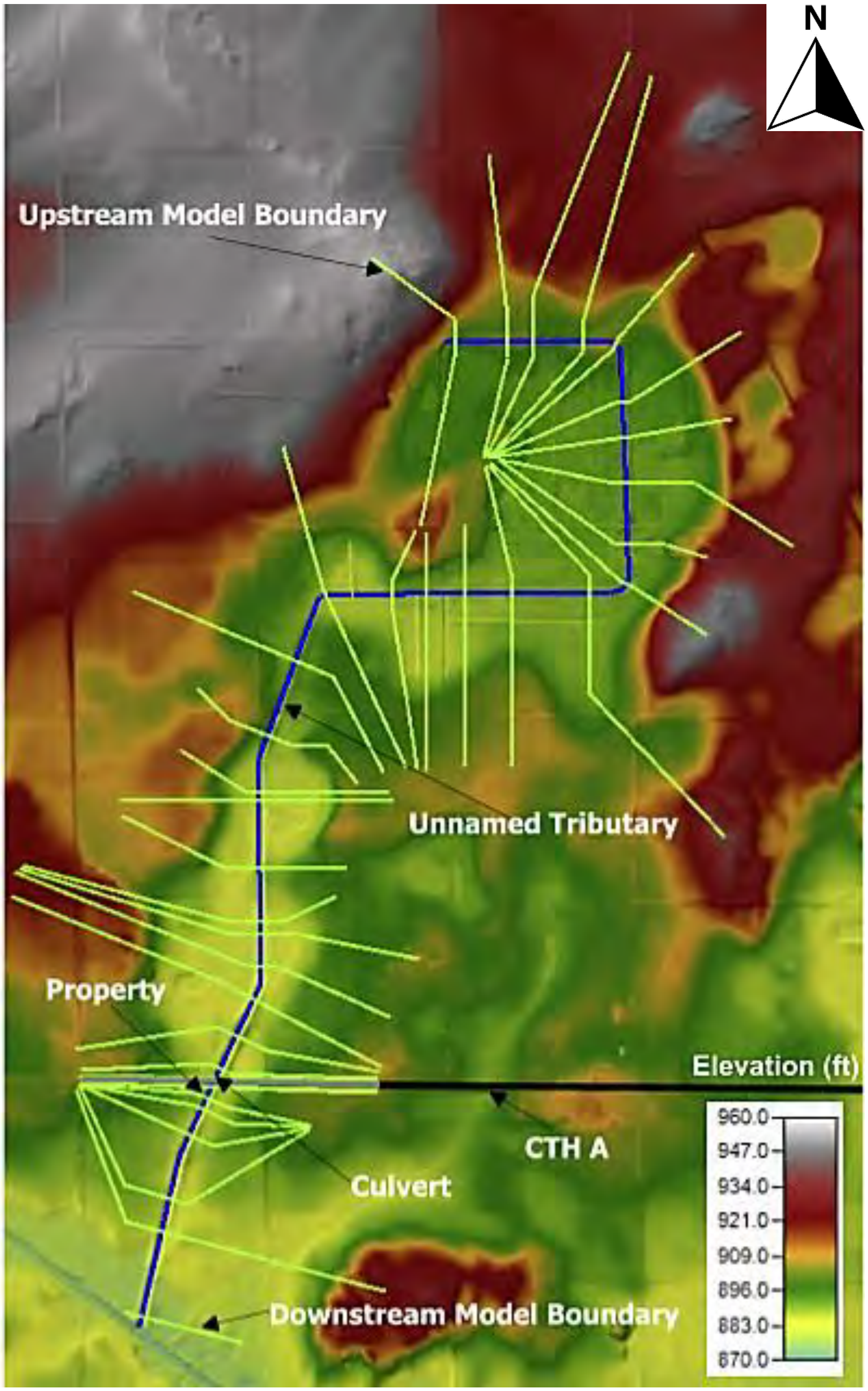


Figure 2. Screenshot of the HEC-RAS model along with locations of the unnamed tributary, culvert, CTH A, and the property.

Cross sections were cut at intervals of approximately 200 to 500 ft. Cross sections were also cut as needed near bridges. Ineffective flow areas and a road crossing with a culvert were identified and added in the HEC-RAS geometry editor. Ineffective flow areas are used to identify areas where ponding occurs outside of the main channel in the overbanks.

The unnamed tributary flows through one culvert under CTH A right before the study area. FW performed a site visit to determine culvert dimensions. Upon inspection, the culvert was a concrete rectangular box culvert approximately 6.5' wide, 4' tall, and 24' long, and had approximately an inch of sediment accumulation.

Manning's 'n' roughness values were determined from inspection of aerial photos and engineering judgement of channel and floodplain areas. The main channel was assigned a roughness value of 0.030 and overbank areas were assigned roughness values based on land type. For this study area, a Manning's 'n' value of 0.034 used for the overbank areas. This was found by assessing the land use of the unnamed tributary's watershed, which is composed of approximately 71% cultivated crops and 17% pasture, which have manning's 'n' values of 0.035 and 0.030 respectively.

The downstream boundary condition for the unnamed tributary was chosen to be a normal depth with a slope value of 0.004846 ft/ft. This represents the average slope of the channel bottom near the downstream extent of the study area.

4 Results

The FEMA floodplain map is shown in *Figure 3* for comparison with the results of this study. The FEMA map shows a portion of the property of interest lying within the extent of the 1% AC event in Zone A. Again the Zone A determination indicates that a base flood elevation has not been set or explicitly modeled. By contrast, this study found conducted the necessary modeling evaluation and determined the extent of the 1% AC event does not inundate the property of interest.

Comparison of the results of this model to the 1% AC event in the FEMA FIS report show significant differences in floodplain extent on the property. *Figure 4* show the FIRM Zone A inundation (purple) and HEC-RAS model inundation extents (light blue). The FIRM Zone A designation shows flood inundation that is 6-7 feet above the modeled WSE. When comparing the FIRM flood inundation extents to the topography extracted from 2017 Lidar shown in *Figure 4*, the FIRM inundation extents cross multiple contour lines, inundating relatively high land surfaces while leaving comparatively low elevations dry. Therefore, the FEMA Zone A designation is inconsistent with the most recent topography data extracted from 2017 Lidar.

This inconsistency is likely due to the lack of data available at the time the FIRM was created. Topographic data used in this study is from 2017 Lidar and more accurately reflects current terrain than what was used to establish the Zone A extents in the FIRM. This study includes the most recent Lidar data available for Dane County and uses more advanced and accurate tools to determine the extents of the 1% AC flood.

Results of the hydraulic model for the 1% AC event in the unnamed tributary are provided in *Table A1* in Appendix A. The flood extents and maximum WSE's of the 1% AC event for the property of concern along with 2-foot contour intervals extracted from 2017 Lidar are shown in *Figure 5*. *Figure 6* shows the flood extents and flood depths for the entire modeling reach.

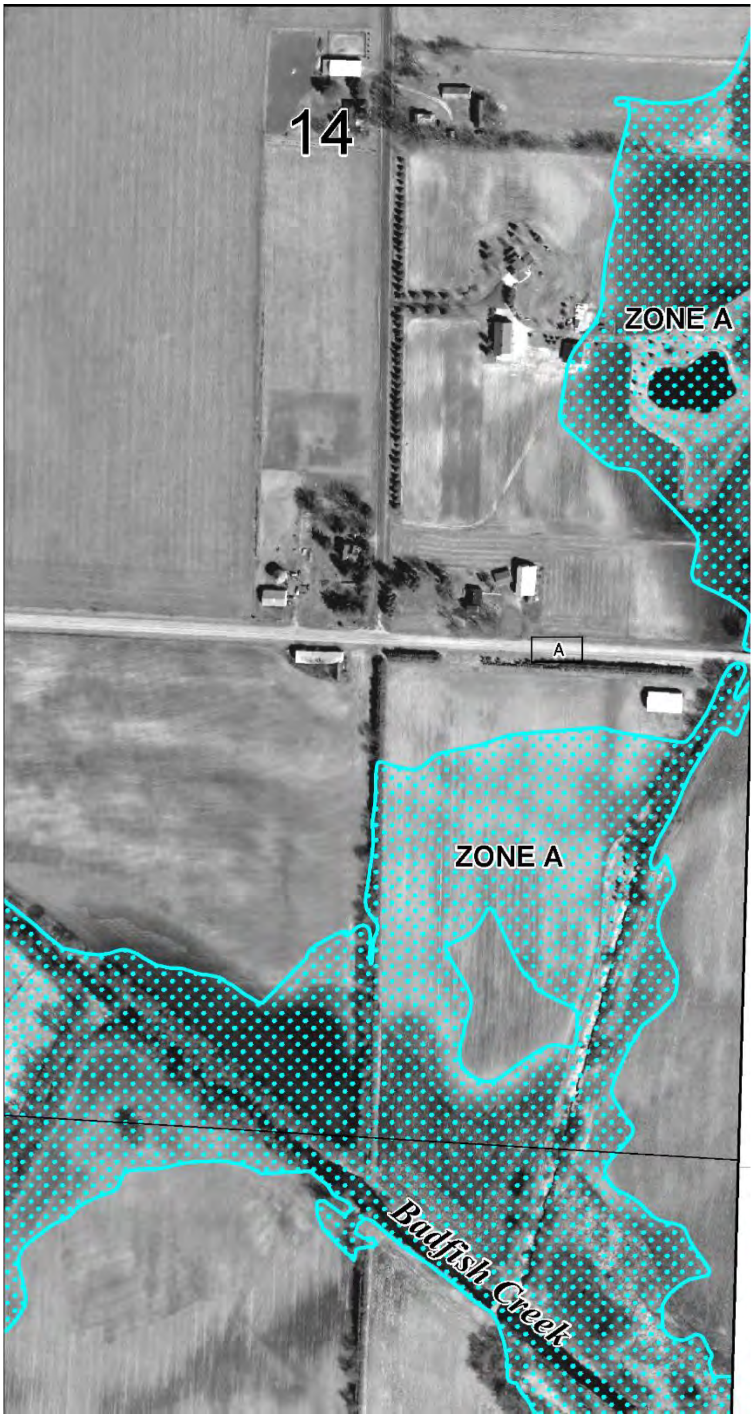


Figure 3. A portion of FIRM panel 55025C0618H showing FEMA designated Zone A boundary on property.

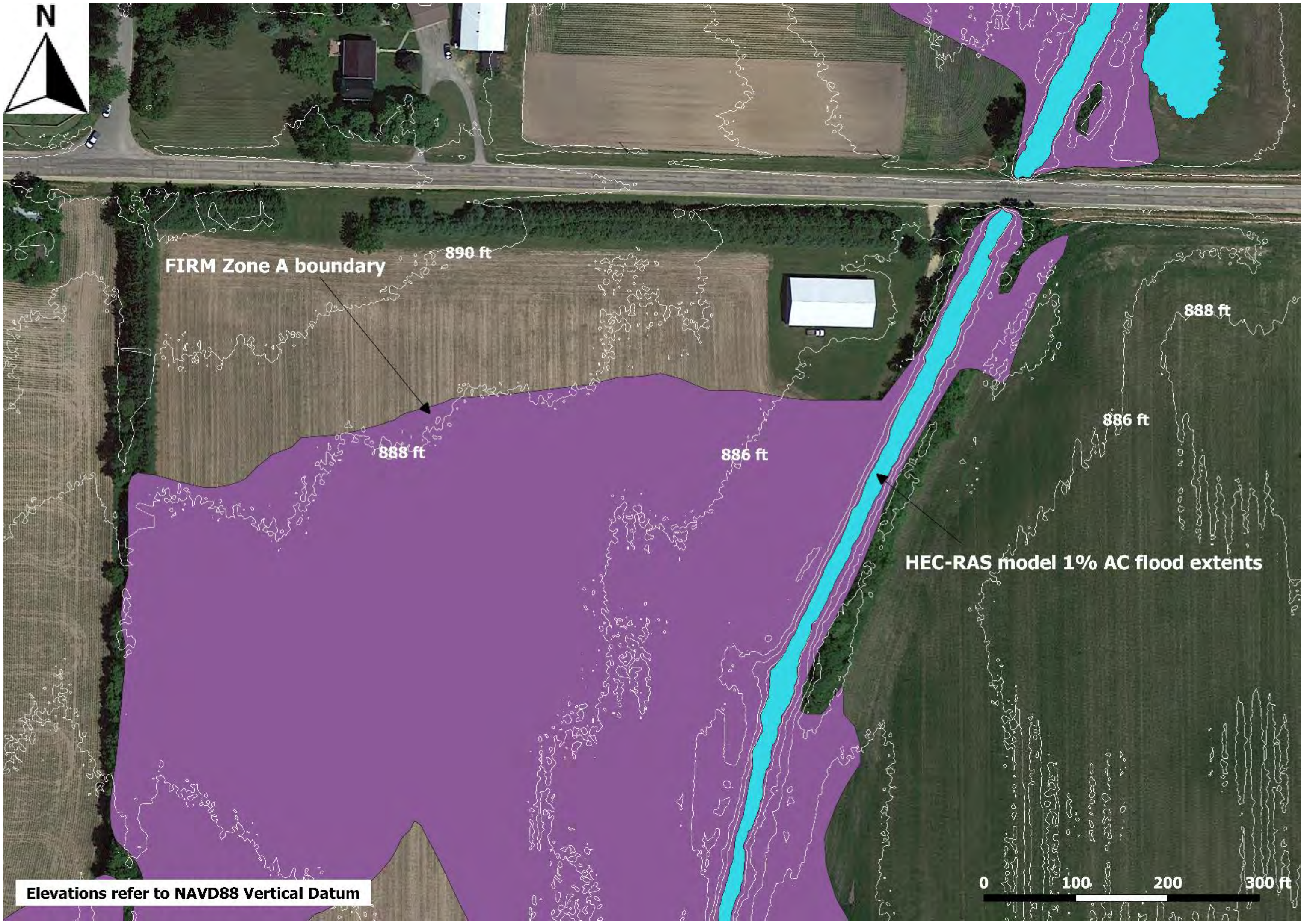


Figure 4. HEC-RAS model 1% AC flood extents (light blue) along with FIRM Zone A flood extents (purple) and 2-foot contour intervals extracted from 2017 LiDAR.

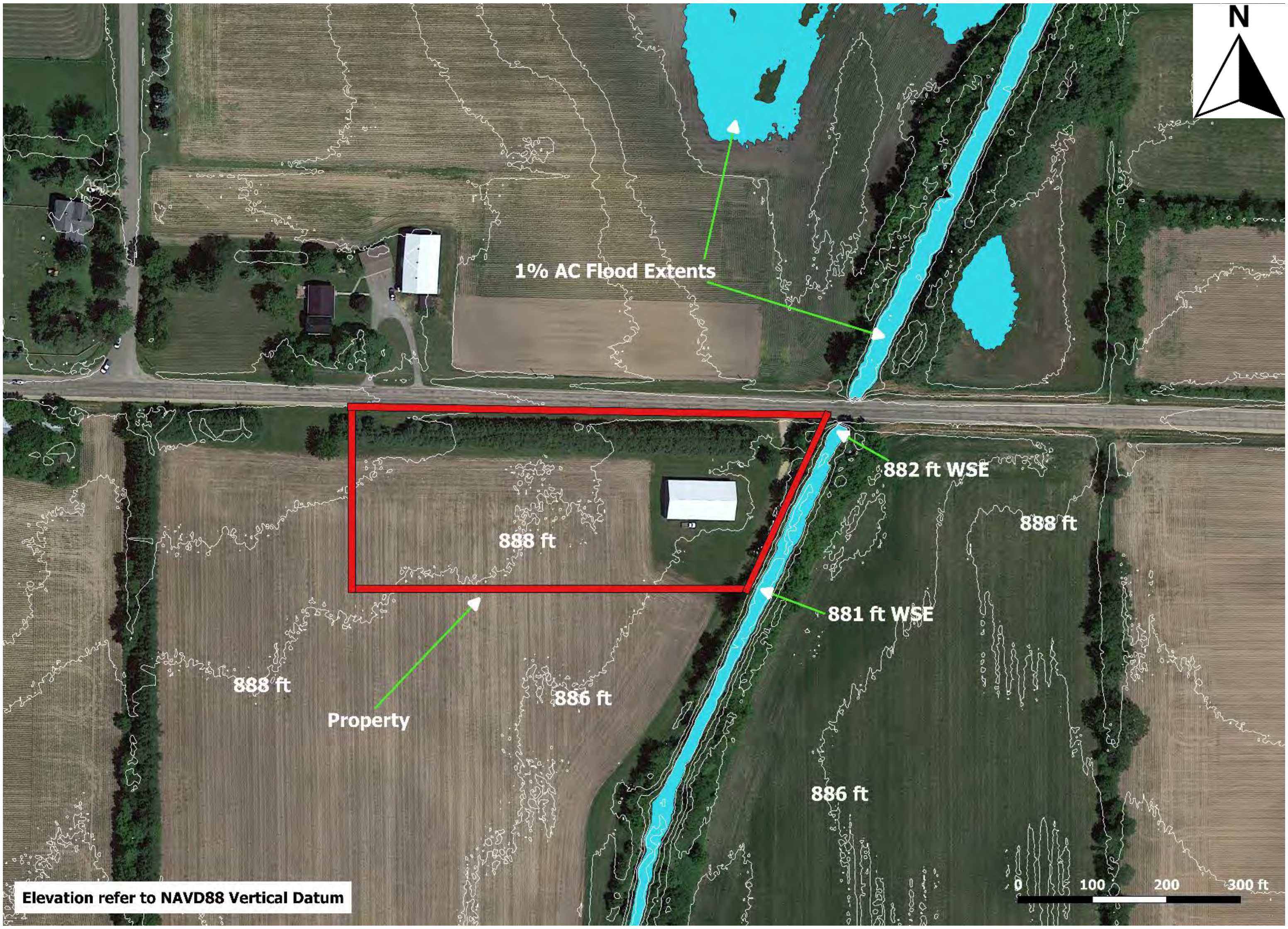


Figure 5. Maximum 1% AC flood WSE (ft) near property boundary along with 2-foot contour intervals extracted from 2017 LiDAR.

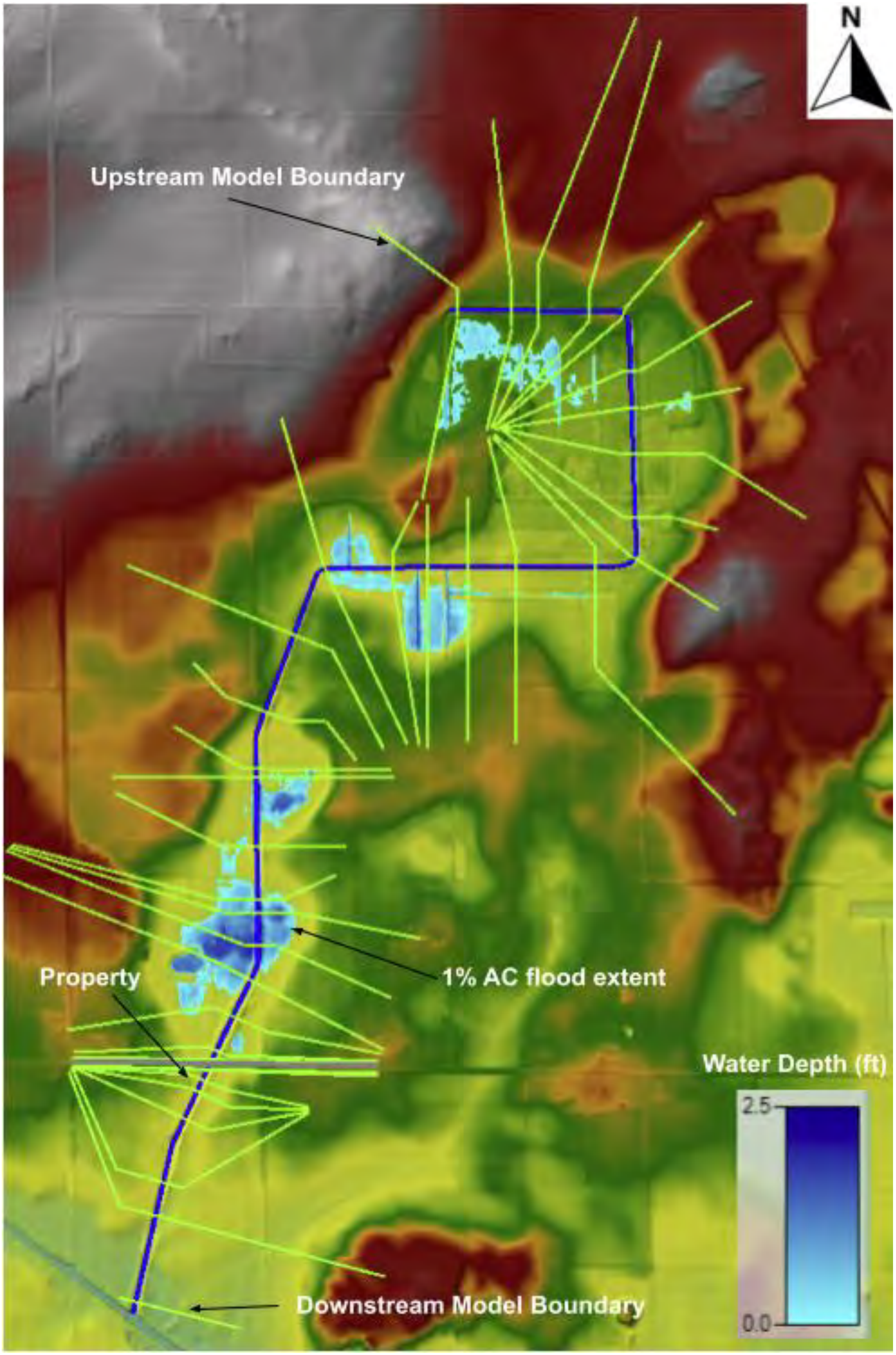


Figure 6.1% AC flood inundation extents and depths for entire HEC-RAS model.

5 Summary

FreshWater Engineering conducted a flood study for a property located just south of CTH A in the Town of Rutland near Stoughton, Wisconsin to determine if the property lies in the 1% AC floodplain.

This study finds that the area on the property is not inundated by the 1% AC event. This finding differs from the FEMA FIS floodplain boundary, which was based on approximate floodplain extents without specific evaluations of local flood levels. The approximate information placed the Hamacher property in a special flood hazard area with unknown water surface elevations. The FW study provides water surface elevations, inundation extents, and water depths that indicate a narrower floodplain south of CTH A, which would remove the Hamacher property from the 1% AC flood extents and associated regulations.

6 References

Federal Emergency Management Agency (FEMA), *Flood Insurance Study for Dane County, Wisconsin, and Incorporated Areas*, Flood Insurance Study Number 55105CV001D, 2016.

Appendix A

Table A1. Steady flow model results for the unnamed tributary.

River Station	Q Total (cfs)	W.S.E. (ft)	Vel. Channel (ft/s)	Flow Area (sq. ft)	Top Width Act. (ft)
10562.41	59	888.65	0.46	130.95	343.48
10191.16	59	888.4	1.58	49.22	144.89
10011.66	59	888.02	1.32	52.68	210.75
9644.89	59	887.79	0.69	127.36	298.4
9412.36	59	887.64	1.27	55.48	156.89
8977.04	59	887.13	1.36	64.32	188.45
8720.82	59	886.86	1.6	45.39	247.73
8399.32	59	886.24	2.24	26.36	34.21
7951.68	59	885.85	1.39	42.37	27.34
7671.29	59	885.68	1.69	34.88	24.02
7386.07	59	885.48	1.69	34.82	36.92
6833.61	59	885.23	1.32	44.85	41.9
6497.84	59	884.95	2.33	25.32	201.42
6216.13	59	884.94	0.62	206.27	479.65
5981.27	59	884.87	1.45	43.54	62.2
5506.75	59	884.64	1.46	45.67	93.93
4977.25	59	884.23	1.82	32.35	23.61
4405.07	59	883.69	1.96	30.15	19.68
3985.36	59	883.51	1.15	51.13	126.05
3927.96	59	883.49	1.19	53.64	341.41
3442.18	59	883.34	1.2	59.85	107.42

3065.02	59	883.32	0.49	223.68	402.12
2968.63	59	883.32	0.15	535.82	535.1
2740.69	59	883.32	0.1	799.99	673.4
2491.21	59	883.27	1.62	36.35	450.86
2209.93	59	883.08	1.52	38.91	149.61
1945.53	59	883	1.14	51.67	28.74
1889.23	59	882.98	1.09	54.11	31.96
1868	59	882.93	1.78	33.15	22
1860	Culvert				
1833	59	881.92	3.51	16.8	18.76
1822.05	59	881.9	2.5	23.59	21.5
1762.24	59	881.82	1.89	31.26	21.98
1627.96	59	881.52	2.91	20.26	20.95
1420.31	59	880.58	3.47	17.02	16.7
941.09	59	878.02	3.96	14.88	12.7
699.83	59	877.02	3.16	18.68	16.43
80.02	59	874.4	3.56	16.56	15.26