



Building a Better World  
for All of Us®

October 3, 2019

RE: City of Hudson, Wisconsin  
Downtown Floodway Study  
SEH No. HUDSO 147395 14.00

Mr. Michael Johnson  
Community Development Director  
City of Hudson  
505 Third Street  
Hudson, WI 54016

Dear Mr. Johnson:

This letter report has been prepared in accordance with the Floodway Study Letter of Engagement dated July 5, 2018. This engineering study has been completed to satisfy the requirements for determination of the floodway and flood-fringe limits in the General Floodplain District for the St. Croix River through the study reach within the City of Hudson. This letter report summarizes the analysis and results of the study.

## BACKGROUND

The reach of the St. Croix River covered under this study is approximately 7,300 feet, extending from the I-94 Bridge crossing at the downstream end to approximately St. Croix Street at the upstream end of the study reach. The effective Flood Insurance Study (FIS, 55109CV000A dated March 16, 2009) and Flood Insurance Rate Maps (FIRMs, 27163C 0357E, 27163C 0359E, dated March 16, 2009) provide the regulatory Base Flood Elevations (BFEs) and flood profiles but do not delineate a floodway. The St. Croix River in the study reach exhibits hydraulic characteristics more closely to that of an impoundment than riverine system due to the fact that the water surface elevations are controlled primarily by backwater from the Mississippi River, approximately 16 miles downstream of the I-94 Bridge crossing.

The water surface profile slope for the regional flood is very flat from the confluence with the Mississippi River upstream to the City of Stillwater, Minnesota (approximately 0.06 feet per mile). Given this flat water surface profile, hydraulic modeling was not utilized by FEMA to develop the BFEs for the St. Croix River within this reach. Instead a straight line interpolation was performed from the gage in Stillwater to the confluence with the Mississippi River. The very flat water surface profile also results in negligible flood profile impacts associated with fill or hydraulic structures throughout this reach, impacts much less than standard hydraulic modeling results would indicate. Due in part to these factors, no official delineation of floodway or flood-fringe areas has been depicted on FIRMs for the St. Croix River through this area.

Given the absence of a floodway determination, areas along this stretch of the St. Croix River are subject to the floodplain zoning requirements of the General Floodplain District (GFP). Under this zoning district, all development applications for property within the floodplain require individual determination of the floodway and flood-fringe limits for each project. The purpose of this study is to provide a delineation of the floodway and flood-fringe areas to satisfy the requirements of the City Floodplain Zoning ordinance section 253-5.4 for the downtown area of Hudson adjacent to the St. Croix River. Since the City of Hudson's Floodplain Zoning ordinance is compliant with the State of Wisconsin model ordinance, this

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would also ensure compliance with state of Wisconsin floodplain requirements and ultimately the FEMA National Flood Insurance Program (NFIP).

## ANALYSIS

### Hydrology

The discharge rates utilized for this study were taken from the effective discharges listed in the FIS, which gives peak discharge rates for the St. Croix River at St. Croix Falls. This is the only published discharge rate for the St. Croix River for the entire reach from St. Croix Falls downstream to the confluence with the Mississippi River. The summary of discharges from the FIS is included below.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (sq. miles)	Peak Discharges (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
St. Croix River at St. Croix Falls	5,930	39,300	47,800	61,000	77,000

No description of the hydrologic analyses to obtain the effective discharge rates for the St. Croix River is listed in the effective FIS for St Croix County. A description of the hydrologic analysis for the St. Croix River is described in the effective FIS (27163CV000A) for Washington County, Minnesota (effective date of February 3, 2010). An excerpt on the hydrologic analysis for the St. Croix River from the Washington County FIS is contained below.

*A flood-flow frequency analysis at the City of Prescott, with the combined flow of the St. Croix and Mississippi Rivers, was completed by the USGS in November 1971 for the lower St Croix River. This will affect the flood-frequency analysis throughout the reach extending through the City of Stillwater. The 1-percent-annual-chance flood discharge of 200,000 cfs is in close agreement with the discharges used by the USACE to develop a 1-percent-annual-chance flood profiles of the Mississippi River downstream from the City of Prescott.*

*The 1-percent-annual-chance flood discharge for the St. Croix River was based on an analysis of available records (1902-05, 1910-70) obtained at the USGS gaging station at St. Croix Falls, Wisconsin (gage no. 05340500). The 1-percent-annual-chance flood was coordinated in accordance with the inter-agency agreement.*

*For both gaging stations, flood-flow frequency analysis were made in accordance with the recommendations contained in Bulletin #17 (Water Resources Council, 1976) of the Water Resources Council (WRC).*

For this study we propose to continue to utilize the discharge rates from the effective FIS for St. Croix County, with no updates or modifications.

### Hydraulics

The USACE HEC-RAS, version 5.0.3, hydraulic model was utilized to develop a base existing conditions hydraulic model, since no effective hydraulic model exists for the study reach, for this analysis.

Cross-sections were developed based on available information, with bathymetric data estimated based on depth maps from the Minnesota DNR Lakefinder website, this bathymetry covers both the Minnesota and Wisconsin sides of the river. We were unable to locate any bathymetric information for the study reach from the Wisconsin DNR. The cross-section locations developed for this study are depicted on Figure 2. Lidar information from the Minnesota DNR MnTOPO website along with data provided by St. Croix County was utilized in conjunction with the bathymetric information to develop cross-sections for the hydraulic modeling.

Two discharge rates were modeled for the analysis, the first a 10-year discharge rate of 39,300 cfs and the second the regional flood (100-year) discharge of 61,000 cfs. Starting water surface elevations for the model were taken from the FIS for St. Croix County and were found to be 691.7 for the regional flood and 687.1 for the 10-year discharge all referenced to the North American Vertical Datum of 1988 (NAVD88).

#### Floodway Delineation

The floodway extents were estimated according to the methodology outlined in Wisconsin Administrative Code Section NR116.07(4)(d) which states that the hydraulic floodway lines shall be determined from the limits of effective flow based on the calculated regional flood water surface profile. Transitions in the hydraulic floodway, or limits of effective flow, should account for natural obstructions and transitions to flow such as road approach grades or bridges. The limits of effective flow under the regional discharge were established by utilizing the compiled topographic information to determine flow obstructions under the regional flood and then flow transitions between the obstructions were estimated following guidelines in the HEC-RAS Hydraulic Reference Manual.

#### Assumptions

Manning's coefficients for the analysis were first estimated based on a review of aerial photography and consultation of *Open-Channel Hydraulics* (Chow, 1959) and the *USGS Water-Supply Paper 2339*, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood plains." The Manning's coefficients along with the contraction and expansion coefficients were then minimized in an attempt to calibrate the model results to the effective BFEs (Figure 20P, 55109CV000A, 3/16/2009) and regional flood profile. Manning's coefficients of 0.06 for the overbank areas and 0.024 for the channel were utilized and contraction and expansion coefficients were set at 0.1 and 0.3, respectively.

Figure 3 depicts the estimated limits of effective flow (areas not actively conveying water) based on the calculated regional flood water surface profile and accounting for flow transitions due to obstructions to flow such as the railroad grade fill at the upstream end of the study reach and I-94 Bridge fill at the downstream end. It should be noted that based on the ineffective flow limits, the majority of the eastern shoreline of the St. Croix River through the study reach appears to be within an area of ineffective flow. Because ineffective flow areas do not actively convey water, encroachments into the ineffective areas do not effect hydraulic capacity under the regional flood and could therefore be deemed flood-fringe.

#### RECOMMENDATIONS

The recommended floodway limits through the study reach are depicted on Figure 1, areas landward of this floodway delineation can be characterized as flood fringe for floodplain zoning applications.

Upon review and approval of the proposed administrative floodway extents by the City and Wisconsin DNR, we recommend that this study be adopted into the City's floodplain management ordinance and Figure 1 be utilized as the Floodway delineation for administration of the floodplain zoning regulations for the City of Hudson.

Mr. Michael Johnson  
October 3, 2019  
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SEH appreciates the opportunity to assist with the completion of this important study. If you have any questions regarding the analysis or results, please feel free to contact me at 651.490.2125 or via e-mail at [bwoznak@sehinc.com](mailto:bwoznak@sehinc.com).

Sincerely,

SHORT ELLIOTT HENDRICKSON INC.



Brad T Woznak, PE,PH,CFM  
Senior Professional Engineer

btw

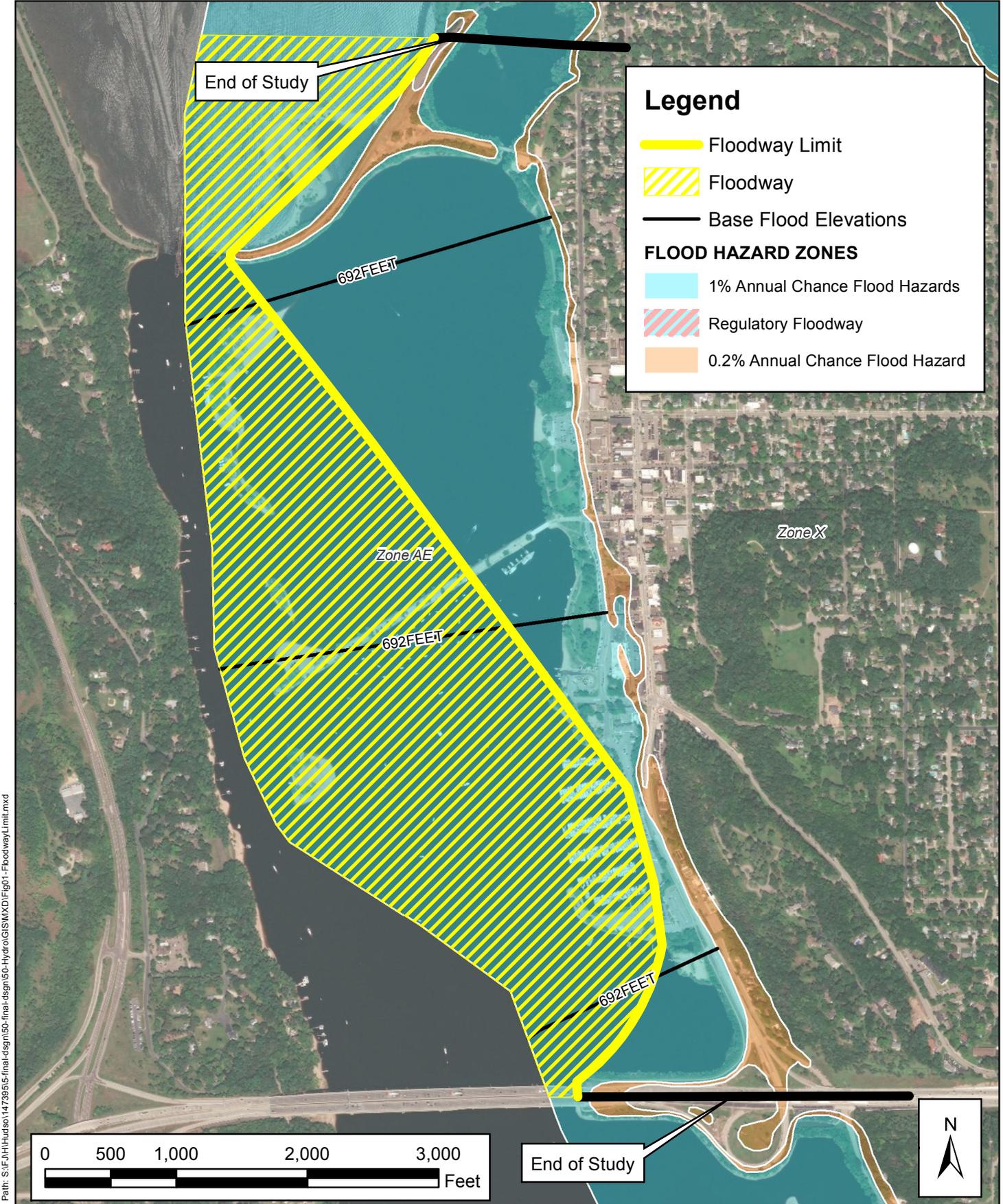
Attachment

c: Michael Rogney, PE – Water Management Engineer, Wisconsin DNR  
John Parotti, PE – SEH  
David Schofield, PE - SEH

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Table 2. HEC-RAS Analysis Results

HEC-RAS Plan: Existing River: St Croix River Reach: Hudson Reach													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	FIS WS	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Hudson Reach	11729.39	10 Year	39300.00	649.67	687.26		659.86	687.27	0.000002	0.68	57774.10	4003.90	0.03
Hudson Reach	11729.39	100 Year	61000.00	649.67	691.91		662.33	691.92	0.000003	0.84	72388.30	4077.33	0.03
Hudson Reach	11261.54	10 Year	39300.00	659.67	687.25		666.35	687.26	0.000004	0.84	46948.04	3519.83	0.04
Hudson Reach	11261.54	100 Year	61000.00	659.67	691.90		668.28	691.92	0.000004	1.03	59336.76	3557.23	0.04
Hudson Reach	10704	10 Year	39300.00	659.67	687.23		668.84	687.26	0.000011	1.27	31112.81	3250.91	0.06
Hudson Reach	10704	100 Year	61000.00	659.67	691.88		671.12	691.91	0.000011	1.51	40804.81	3374.81	0.06
Hudson Reach	10313.04	10 Year	39300.00	664.67	687.22		669.64	687.25	0.000010	1.36	28985.59	3356.98	0.06
Hudson Reach	10313.04	100 Year	61000.00	664.67	691.86		671.03	691.91	0.000012	1.68	36760.88	3447.22	0.06
Hudson Reach	10086.69	10 Year	39300.00	659.67	687.14	687.2	670.39	687.24	0.000037	2.59	15243.12	3021.55	0.11
Hudson Reach	10086.69	100 Year	61000.00	659.67	691.73	691.8	672.48	691.89	0.000043	3.19	19366.80	3170.12	0.12
Hudson Reach	10052.57 Railroad		Bridge										
Hudson Reach	9977.537	10 Year	39300.00	646.67	687.09		667.99	687.22	0.000038	2.97	13236.60	3401.72	0.11
Hudson Reach	9977.537	100 Year	61000.00	646.67	691.63		670.94	691.86	0.000049	3.83	15941.63	3460.78	0.13
Hudson Reach	9613.35	10 Year	39300.00	659.67	687.13		667.08	687.19	0.000017	1.98	19878.68	3322.97	0.08
Hudson Reach	9613.35	100 Year	61000.00	659.67	691.71		670.13	691.81	0.000022	2.52	24161.40	3420.85	0.09
Hudson Reach	9093.69	10 Year	39300.00	659.67	687.12		668.68	687.18	0.000024	1.87	21042.37	3356.24	0.08
Hudson Reach	9093.69	100 Year	61000.00	659.67	691.71		671.12	691.79	0.000024	2.22	27431.69	3392.59	0.09
Hudson Reach	8581.992	10 Year	39300.00	664.67	687.13		672.18	687.16	0.000016	1.50	26267.41	3091.95	0.07
Hudson Reach	8581.992	100 Year	61000.00	664.67	691.72		675.58	691.77	0.000016	1.78	34478.90	3209.31	0.07
Hudson Reach	8016.595	10 Year	39300.00	669.67	687.12		674.81	687.15	0.000015	1.44	27867.94	2994.20	0.07
Hudson Reach	8016.595	100 Year	61000.00	669.67	691.72		675.68	691.76	0.000015	1.69	37220.21	3130.40	0.07
Hudson Reach	7553.319	10 Year	39300.00	669.67	687.13		671.88	687.14	0.000006	1.05	37725.04	3163.02	0.04
Hudson Reach	7553.319	100 Year	61000.00	669.67	691.73		672.65	691.75	0.000007	1.29	47979.81	3244.79	0.05
Hudson Reach	7099.667	10 Year	39300.00	669.67	687.12		673.25	687.14	0.000008	1.09	36134.68	3013.14	0.05
Hudson Reach	7099.667	100 Year	61000.00	669.67	691.72		674.20	691.75	0.000008	1.29	47380.02	3358.92	0.05
Hudson Reach	6621.329	10 Year	39300.00	669.67	687.12		673.09	687.14	0.000006	0.95	41401.00	3204.30	0.04
Hudson Reach	6621.329	100 Year	61000.00	669.67	691.72		673.98	691.74	0.000006	1.14	53805.89	3234.70	0.04
Hudson Reach	6413.572	10 Year	39300.00	669.67	687.12		671.69	687.13	0.000004	0.86	46004.42	3072.18	0.04
Hudson Reach	6413.572	100 Year	61000.00	669.67	691.73		672.37	691.74	0.000005	1.05	58842.13	3219.31	0.04
Hudson Reach	6210.57	10 Year	39300.00	669.67	687.12		673.21	687.13	0.000006	0.93	42550.16	3119.50	0.04
Hudson Reach	6210.57	100 Year	61000.00	669.67	691.72		674.08	691.74	0.000006	1.10	55920.05	3131.61	0.04
Hudson Reach	5734.59	10 Year	39300.00	669.67	687.12		672.08	687.13	0.000004	0.80	49522.26	3216.80	0.04
Hudson Reach	5734.59	100 Year	61000.00	669.67	691.72		672.85	691.74	0.000004	0.96	64036.95	3230.90	0.04
Hudson Reach	5141.289	10 Year	39300.00	669.67	687.12		671.53	687.13	0.000003	0.75	52686.71	3197.91	0.03
Hudson Reach	5141.289	100 Year	61000.00	669.67	691.72		672.16	691.73	0.000004	0.91	67171.53	3221.04	0.03
Hudson Reach	4050.014	10 Year	39300.00	669.67	687.11		671.96	687.12	0.000006	0.95	42202.92	3048.32	0.04
Hudson Reach	4050.014	100 Year	61000.00	669.67	691.71		672.73	691.73	0.000006	1.15	56262.79	3151.79	0.04
Hudson Reach	3524.057	10 Year	39300.00	664.67	687.11		669.32	687.12	0.000003	0.76	51844.95	3240.09	0.03
Hudson Reach	3524.057	100 Year	61000.00	664.67	691.71		670.24	691.72	0.000004	0.95	65435.21	3278.60	0.03
Hudson Reach	3139.851	10 Year	39300.00	663.67	687.11		669.02	687.12	0.000003	0.80	49532.18	3344.15	0.03
Hudson Reach	3139.851	100 Year	61000.00	663.67	691.71		669.97	691.72	0.000004	1.01	62071.12	3366.10	0.04
Hudson Reach	2592.062	10 Year	39300.00	669.67	687.09		672.13	687.11	0.000009	1.19	33624.15	2115.48	0.05
Hudson Reach	2592.062	100 Year	61000.00	669.67	691.69		672.99	691.72	0.000009	1.45	43386.30	2184.00	0.06
Hudson Reach	2465.227 94		Bridge										
Hudson Reach	2342.229	10 Year	39300.00	669.67	687.09	687.1	672.17	687.11	0.000009	1.20	33792.57	2164.20	0.05
Hudson Reach	2342.229	100 Year	61000.00	669.67	691.68	691.7	673.00	691.72	0.000009	1.45	43791.87	2794.32	0.06
Hudson Reach	1541.706	10 Year	39300.00	659.67	687.10		666.17	687.10	0.000002	0.70	56280.57	3966.05	0.03
Hudson Reach	1541.706	100 Year	61000.00	659.67	691.69		667.12	691.71	0.000003	0.90	68101.85	4018.08	0.03
Hudson Reach	540.4286	10 Year	39300.00	619.67	687.10		625.93	687.10	0.000000	0.31	126479.50	3942.73	0.01
Hudson Reach	540.4286	100 Year	61000.00	619.67	691.70		627.61	691.70	0.000000	0.43	140465.40	3976.39	0.01



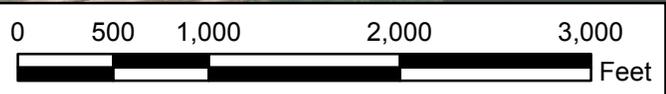
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**Legend**

- Floodway Limit
- Floodway
- Base Flood Elevations

**FLOOD HAZARD ZONES**

- 1% Annual Chance Flood Hazards
- Regulatory Floodway
- 0.2% Annual Chance Flood Hazard



End of Study



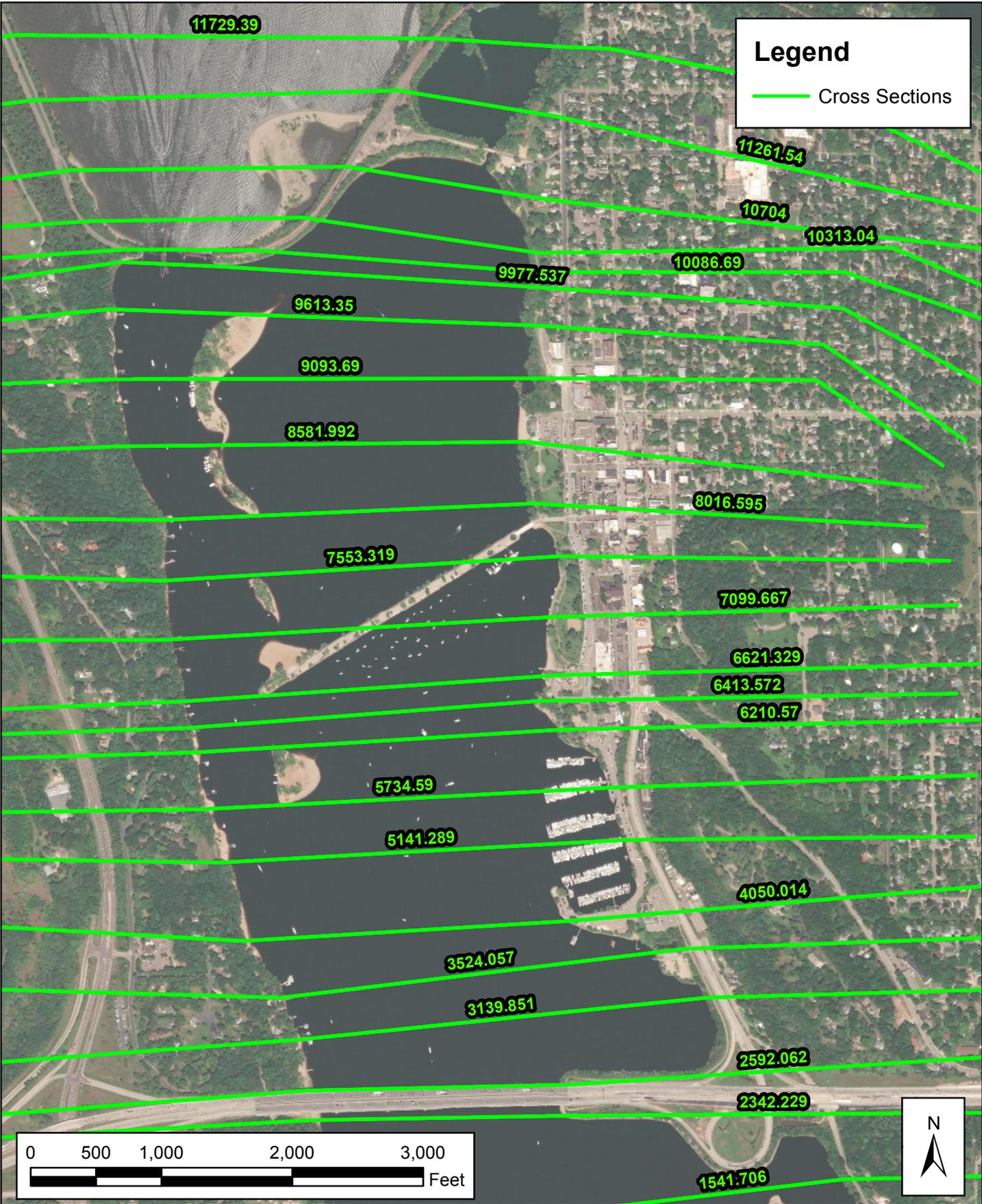
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Print Date: 10/3/2019  
Map by: eerdahl  
Projection:  
Source:

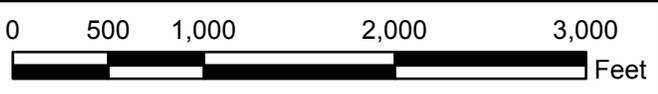
**FLOODWAY LIMIT**  
**HUDSON FLOODWAY STUDY**  
Hudson, Wisconsin

**Figure 1**

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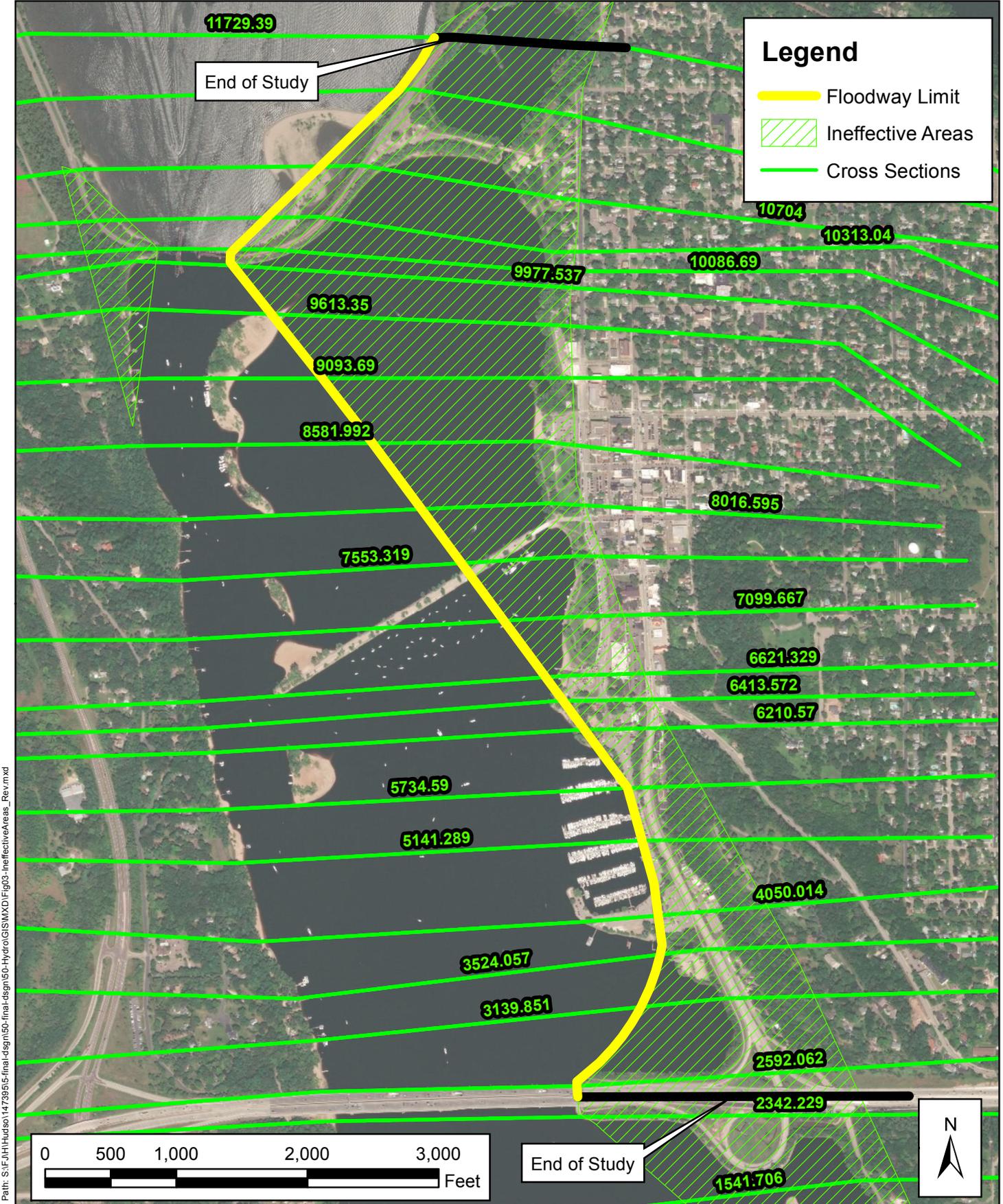
**Legend**  
 — Cross Sections



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	<p>3535 VADNAIS CENTER DR.        ST. PAUL, MN 55110        PHONE: (651) 490-2000        FAX: (888) 908-8166        TF: (800) 325-2055        www.sehinc.com</p>	<p>Project: HUDSO 147395        Print Date: 10/3/2019        Map by: eerdahl        Projection:        Source:</p>	<p><b>CROSS SECTIONS</b>        HUDSON FLOODWAY STUDY        Hudson, Wisconsin</p>	<p>Figure        2</p>
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	<p>3535 VADNAIS CENTER DR. ST. PAUL, MN 55110 PHONE: (651) 490-2000 FAX: (888) 908-8166 TF: (800) 325-2055 www.sehinc.com</p>	<p>Project: HUDSO 147395 Print Date: 10/1/2019 Map by: eerdahl Projection: Source:</p>	<p><b>INEFFECTIVE AREAS</b> HUDSON FLOODWAY STUDY Hudson, Wisconsin</p>	<p>Figure 3</p>
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**State of Wisconsin**  
**DEPARTMENT OF NATURAL RESOURCES**  
**West Central Region**  
**1300 W. Clairemont Ave**  
**Eau Claire, WI 54701**

**Tony Evers, Governor**  
**Preston D. Cole, Secretary**  
Telephone 608-266-2621  
Toll Free 1-888-936-7463  
TTY Access via relay - 711



October 16, 2019

FAD ID #20240

Michael Johnson  
Community Development Director  
City of Hudson  
505 Third Street  
Hudson, WI 54016

Subject: St. Croix River Floodway Delineation, City of Hudson, St. Croix County, Wisconsin – Floodplain Analysis Conditional Approval

Dear Mr. Johnson,

The Department of Natural Resources has reviewed the floodplain analysis prepared by Brad T. Woznak, P.E., P.H., CFM of Short Elliot Hendrickson, Inc., to delineate an administrative floodway for the St. Croix River within the City of Hudson limits. The analysis was completed on behalf of the City of Hudson, located in Section 24, Township 29 North, Range 20 West, City of Hudson, St. Croix County, Wisconsin.

According to the March 26, 2009 Flood Insurance Study (FIS) for St. Croix County, “No floodway was computed for the Apple River, Lowes Creek, Otter Creek and the St. Croix River.” It is believed that the reason for this was due to the fact a formal hydraulic analysis was not completed for the St. Croix River. Rather, according to the Washington County, Minnesota FIS, the Regional Flood Elevation (RFE) profile was linearly interpolated from the confluence of the Mississippi River to Stillwater, MN. The scope of the October 3, 2019 floodplain analysis, completed by Short Elliot Hendrickson, Inc., is within an area that is known as “Lake St. Croix” due to the flat characteristics this section of the St. Croix River exhibits.

The March 26, 2009 FIS for St. Croix County does contain a flood profile table; however, formal cross sections were never established. This is evident in the FIS, due to the lack of a floodway data table for the St. Croix River. According to the October 3, 2019 report from Short Elliot Hendrickson, Inc., the scope of the analysis included inputting cross sectional topographic data into the U.S. Army Corps of Engineers HEC-RAS version 5.0.3 software. The analysis assumes a regional flood discharge of 61,000 cfs, which was taken from the March 26, 2009 St. Croix County FIS. It appears that the St. Croix County FIS lacks specific assumptions on how the regional flood discharge was computed, however a more descriptive was found in the Washington County, MN FIS.

Per the October 3, 2019 report from Short Elliot Hendrickson, Inc., the floodway extents for the scope of the analysis, were estimated in accordance with the methodology outlined in NR 116.07(4)(d) Wisconsin Administrative Code. To briefly summarize, NR 116.07(4)(d) states that hydraulic floodway lines shall be

determined by using transitions associated with obstructions to flow such as road approach grades, bridges or natural restrictions. Based on the submittal from Short Elliot Hendrickson, Inc., the limits of effective flow for the administrative floodway were assumed by using transitions such as those associated with the upstream railroad bridge and the I-94 bridge (i.e. contraction & expansion).

The analysis was modeled using one plan, which includes the assumed effective flow (i.e. floodway) limits. The limits, however, appear to be calibrated to replicate the existing regional flood profile in the March 26, 2009 FIS for St. Croix County.

The final floodplain analysis and report titled "City of Hudson, Wisconsin Downtown Floodway Study" was submitted to the Department on October 3, 2019. The Department will consider the assumptions applied in the analysis sufficient, therefore conditionally approving the study as complying with Wisconsin Administrative Code NR 116 technical standards for application of the City of Hudson's Floodplain Zoning Ordinance.

The following conditions must be met:

1. The October 3, 2019 analysis must be adopted into the City of Hudson's Floodplain Ordinance and results therein.
  - a. Please ensure that the Class II noticing requirements are met
  - b. Please submit the final ordinance adoption to the Department for approval

If you have any questions about this approval, please feel free to contact me at 715-210-2609 or [Michael.Rogney@wisconsin.gov](mailto:Michael.Rogney@wisconsin.gov).

Sincerely,



Michael Rogney, P.E.  
Water Management Engineer  
Wisconsin Department of Natural Resources  
Eau Claire Service Center

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