DRAFT

Technical Feasibility Report

Ebner Coulee Floodway FIRM Remapping

La Crosse, WI

LACRS 142540 | August 22, 2017

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August 22, 2017

RE: Ebner Coulee Floodway FIRM Remapping
Technical Feasibility Report
La Crosse, WI
SEH No. LACRS 142540 4.00

Mr. Bernard Lenz
City of La Crosse
400 La Crosse Street
La Crosse, WI 54601

Dear Mr. Lenz:

Attached please find a Draft submittal of the Technical Feasibility Report for the Ebner Coulee FIRM remapping study. This report is intended to provide a summary of the modeling process and results along with an estimation of what a proposed FIRM revision would look like along with highlighting the differences between the effective FIRM and potential mapping revisions.

Please feel free to contact me if you have any questions or would like any additional information. We will be pleased to meet with you at your earliest convenience to discuss this report.

Sincerely,

Brad Woznak,PE,PH,CFM
Senior Professional Engineer

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Technical Feasibility Report

Technical Feasibility Report
La Crosse, WI

Prepared for:
City of La Crosse

Prepared by:
Short Elliott Hendrickson Inc.
3535 Vadnais Center Drive
St Paul, MN 55110
651.490.2000

I, Brad Woznak,PE,PH,CFM, hereby certify that I am a registered Professional Engineer in the State of Wisconsin in accordance with ch. A-E 4, Wis. Adm. Code and that this report has been prepared in accordance with the Rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code.

Brad Woznak,PE,PH,CFM	PE Number	Date
Senior Professional Engineer		

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Technical Feasibility Report

Ebner Coulee Floodway FIRM Remapping

Prepared for City of La Crosse

1 Purpose of the Study

The purpose of this project is to reevaluate and update the hydrologic and hydraulic analysis of the Ebner Coulee watershed and floodplain using an updated modeling methodology to more accurately depict the flow and conveyance conditions of this complex urban floodplain system. The analysis was performed on behalf of the City of La Crosse, Wisconsin by Short Elliott Hendrickson Inc. (SEH). The goal of this reevaluation study is to determine if use of an alternate hydrology method and the inclusion of additional topographic mapping in the upper part of the watershed would result in significantly different mapping of the 1-percent floodplain as compared to FEMA's effective Flood Insurance Rate Map (FIRM) for the area.

1.1 Background Information

The Ebner Coulee system in this area has been modeled multiple times in an effort to represent flooding conditions of this complex system. The system was initially studied by the US Army Corps of Engineers in the late 1970s or early 1980s utilizing the programs available at that time including the USACE program HEC-1 for development of the inflow hydrographs, USACE "Spill" program for estimation of the flow splits in the system, USACE HEC-2 model for estimation of the backwater impacts on the floodwater conveyance systems, and the USACE UNET model for estimation of water surface elevations and flow attenuation in the "ponded" areas of the floodplain. This methodology appears to still be the effective methodology for the area north of Jackson Street for the effective FEMA Flood Insurance Study (FIS), which is dated January 6, 2012. The area north of Jackson Street was re-evaluated by Mead & Hunt for the City of La Crosse in 1998 with the hydrologic analysis utilizing HEC-1 for development of the inflow hydrograph and HEC-RAS for the hydraulic analysis of the system. Based on available information, it appears that neither flow attenuation nor storage routing was utilized to attenuate the inflow hydrograph as it moves through the system.

The original hydrologic analysis of Ebner Coulee was supported based on calculations utilizing the Bureau of Public Roads Method, also called the Cook Method, with scaling of the flood frequency information from Gilmore Creek in Winona, MN. Subsequent hydrologic analyses by both the USACE analyses and the update by Mead & Hunt utilized the SCS unit hydrograph method for estimation of the inflow hydrographs for analysis of the Ebner Coulee system, with peak flow rates similar to those developed in the original analysis. In a letter dated September 29, 1994, Mr. Charles Melching, Ph.D., PE, hydraulic engineer at the USGS, recommended an alternative method such as the USGS developed regional regression equations for estimation of the peak flow rates for watersheds as steep as Ebner Coulee (Appendix A). The hydrologic analysis for this study will utilize the current version of the USGS regional regression equations for Wisconsin (Flood-Frequency Characteristics of Wisconsin Streams; USGS Water-Resources Investigations Report 03-4250).

Since completion of the effective FEMA hydrology and hydraulic studies, updated modeling methodologies that allow for both unsteady flow routing of hydrographs through a system and two-dimensional flow capabilities have been incorporated into the HEC-RAS program which allows for an inflow hydrograph to be routed over a two dimensional terrain surface. This study will combine the revised hydrologic analysis following the USGS regional regression methods with the unsteady, two-dimensional flow capabilities of the HEC-RAS model in an effort to provide a better representation of the flow characteristics within the Ebner Coulee system.

2 Hydrologic and Hydraulic Study

2.1 Hydrologic Analysis

The drainage area to the upstream limit of the Ebner Coulee study reach was delineated as part of this study utilizing available LIDAR topographic data and determined to be 0.61 square miles. The drainage area to the downstream limit of the model at Farnam Street was estimated at 1.13 square miles. The drainage area listed in the effective FIS is 0.9 square miles for all of the Ebner Coulee reach studied, which appears to be calculated to the point near the end of the lettered cross-sections at Jackson Street. Two inflow hydrographs were developed for this study, one for the upstream 0.61 square mile watershed added at the upstream model limits and a second to account for additional flow from the total 0.88 square mile watershed (near FEMA cross-section A). Initially the additional flow was to be added to the main channel between FEMA lettered cross-sections A and B, but based on the initial results of the two-dimensional HEC-RAS model, this flow is unable to enter the Ebner Coulee main channel and likely stays on the west side of the railroad tracks and therefore is not entered into the modeling.

The peak flow rates for this study were calculated using the regression equations and methodology provided in the USGS Water-Resources Investigations Report 03-4250. Data for input into the regression equations was estimated using GIS from a LIDAR-derived DEM and available land use information, in lieu of utilizing the . Table 1 provides a summary of the calculated peak flow rates from the USGS regression equations from this analysis along with the peak flow rates given in the effective FIS.

Table 1 – Summary of Peak Flow Rates

Source	Location	Drainage Area (sq mi.)	Peak Flow (cfs)
Effective FIS	All Locations	0.9	1430
USGS Regression Equations	Upstream Limit	0.6	360
USGS Regression Equations	Jackson Street	0.9	428[1]

[1] Flow from additional drainage area as calculated from the USGS regional regression equations based on the additional contributing area, which due to initial 2D analysis is not added to the modeling.

A check for the statistical significance of the calculated peak flow rates was also completed according to the language provided in FEMA's Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C. It was determined that a new flood insurance study could be warranted based on the calculated peak flow rates versus those used in the effective FIS.

The hydrologic analysis was completed as an initial task to this study and is summarized in detail in a memorandum dated August 18, 2017 to Mr. Bernard Lenz (Appendix B). A figure showing the drainage area delineation is also included in Appendix B.

2.2 Hydraulic Analysis

2.2.1 Model Structure and Geometric Data

This analysis includes the Ebner Coulee system within the City of La Crosse from approximately 1,500 feet east of 29th Street S at the upstream limit to Farnam Street at the downstream limit, shown on Figure 1. Ebner Coulee leaves the steeper bluff area approximately 950 feet east of 29th Street S and enters a leveed channel that runs west to 500 feet downstream of 29th Street S, where it makes a ninety degree turn southward to follows east of and along an existing railroad track. The channel flows approximately 2,500 feet south to Farnam Street, where it enters an 8-foot by 10-foot reinforced concrete box culvert.

Three hydraulic models were prepared as part of this analysis, and are described in the following sections of this Report. Each model incorporates the revised hydrology described previously in this report, but has a unique structure which allows for the floodplain boundary to be estimated using different methodologies. Two of the models incorporate two-dimensional hydraulic computations, which can be leveraged to better represent the complex flow conditions present in the Ebner Coulee system. If it is determined that this project is to move forward with a Letter of Map Revision (LOMR) submittal to FEMA, it may be necessary to convert any two-dimensional modeling results back into a one-dimensional model because current FEMA regulatory framework (particularly for Floodway determination) is based on a one-dimensional modeling approach.

2.2.1.1 One-dimensional HEC-RAS model

The effective FIS model is a one-dimensional model with two separate reaches to represent the Ebner Coulee system: one reach to capture the conveyance down the main channel of Ebner Coulee, and the second reach to represent the flow that breaks out from the main channel and is conveyed in the southerly direction along 28th Street S. The geometric data included in the effective FIS model also included lateral structures to represent the levees along the channel, which controlled the flow between the main channel and the 28th Street reach. The only modification made to this model for this study was to incorporate the lower flow rates calculated using the USGS regression equations to evaluate the effects of the lower discharge rates on the calculated water surface elevations.

2.2.1.2 One-dimensional / Two-dimensional Integrated HEC-RAS model

An integrated one-dimensional / two-dimensional (1D/2D) HEC-RAS model was also developed to analyze the performance of the Ebner Coulee system. This integrated 1D/2D model incorporated the main channel cross-section geometry from the effective FIS hydraulic model along with the 1D hydraulic structure calculations along the main channel where flow is largely one-dimensional. This model also allows for two-dimensional calculations in the overbank areas where more complex flow patterns exist and the general direction of the flow may not be as easily discerned.

The upstream boundary condition was defined using the revised flow hydrograph developed as part of this study, which is shown on Figure 3 of the hydrologic memorandum included in Appendix B of this report. This flow hydrograph was routed into the one-dimensional channel at the upstream limit of the model, and the flow split occurring throughout the system was defined by the lateral structures along the 1D/2D interface. Flow exceeding the capacity of the main channel was routed over the lateral structures into the 2D flow area.

For this modeling approach, the main Ebner Coulee channel and channel structures are captured in the one-dimensional portion of the model and overbank area previously modeled with a separate channel reach along 28th Street S is modeled with the two-dimensional capabilities of HEC-RAS.

2.2.1.3 Two-dimensional Only HEC-RAS model

A two-dimensional only HEC-RAS model was developed primarily to evaluate the potential flow patterns and areas in which channel flow can break out and interact with the adjacent floodplain with the underlying terrain surface as determined by the model with minimal “influence” by the modeler. This approach also allows for the “visualization” of potential flow breakout areas.

The upstream boundary condition was defined using the revised flow hydrograph developed as part of this study, which is shown on Figure 3 of the hydrologic memorandum included in Appendix B of this report. This flow hydrograph was routed into the two-dimensional model in the main channel at the upstream limit of the model, and the flow split occurring throughout the system was defined by two-dimensional model mesh. Two-dimensional cell faces were aligned with ridges including the existing levees to ensure proper flow routing. Flow exceeding the capacity of the main channel was routed into the residential areas along Ebner Coulee which were also represented with the 2D flow area.

2.2.2 Vertical Datum

All vertical geometry data, water surface profile elevations, and flood boundary elevations used in the model input and results are referenced to NAVD88. For the City of La Crosse, NGVD29 and NAVD88 are approximately the same vertical elevation, with a conversion of +0.01 feet from NGVD29 to NAVD88 listed in Table 12 of the effective FIS.

2.2.3 Special Modeling Considerations

Neither the effective hydrologic or hydraulic models, nor the modeling completed for this study accounts for the potential of overland flow removal from the floodplain due to the storm sewer system along 28th Street S. While it is likely that the storm sewer size is not sufficient enough to provide a significant reduction of flood elevations or extents, it may be desirable to investigate the potential effects of the underlying storm sewer prior to pursuit of a LOMR.

2.3 Study Results

2.3.1 Revised Flood Boundary Results

2.3.1.1 One-dimensional HEC-RAS model

Figure 2 shows the results of the one-dimensional HEC-RAS model with the yellow depicting the effective FEMA 1-percent floodplain, and the blue showing the revised 1-percent floodplain based on updated modeling results from this study. Based on these modeling results, approximately 10 acres could be removed from floodplain and 20 residential structures removed as depicted on Figure 2.

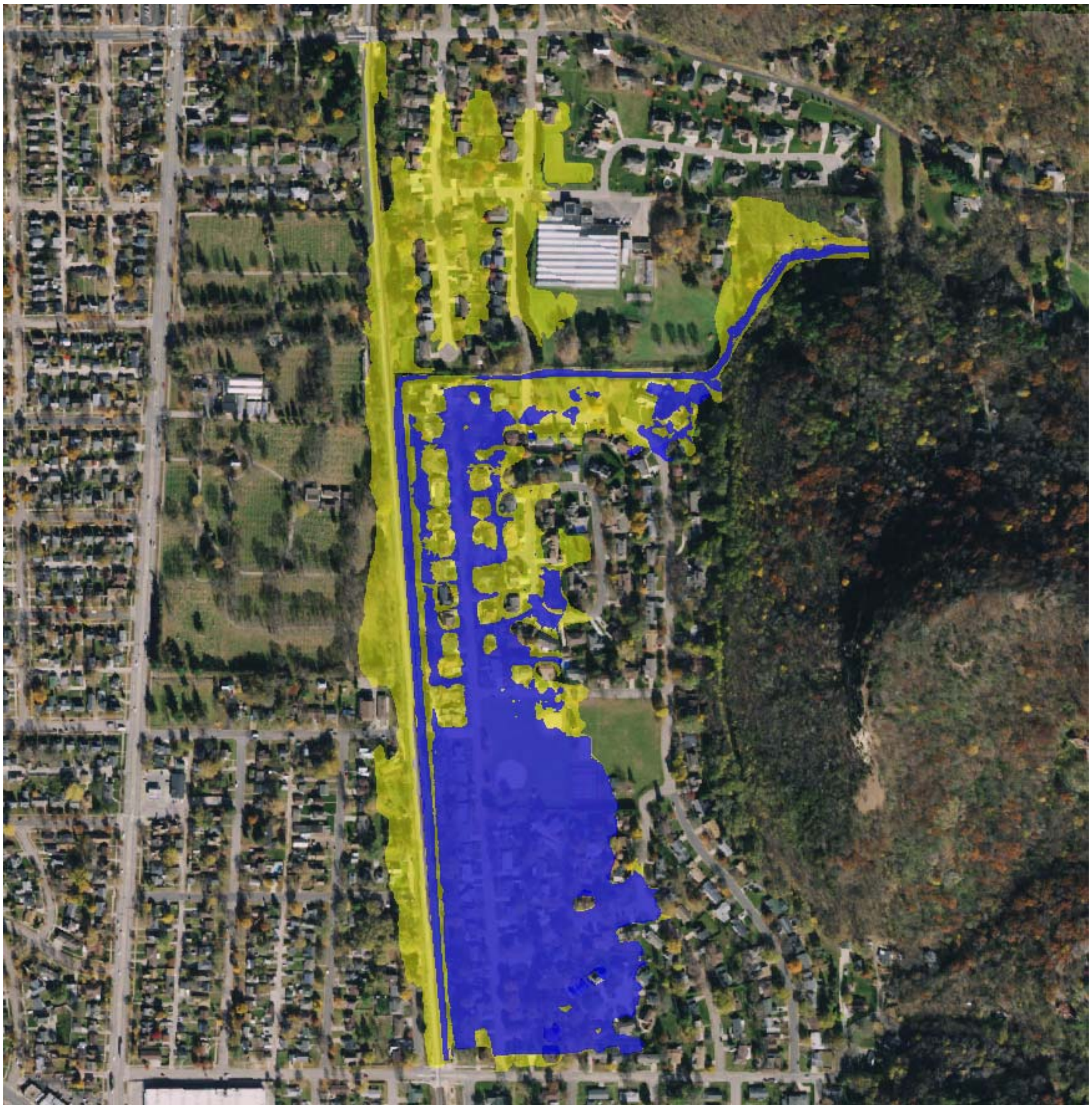


Figure 2 – Results of 1D HEC-RAS Model

2.3.1.2 One-dimensional / Two-dimensional Integrated HEC-RAS model

Figure 3 shows the results of the one-dimensional/two-dimensional integrated HEC-RAS model with the yellow depicting the effective FEMA 1-percent floodplain, and the blue showing the revised 1-percent floodplain based on modeling results from this study. Based on these modeling results, approximately 14 acres could be removed from floodplain and 24 residential structures removed as depicted on Figure 3.

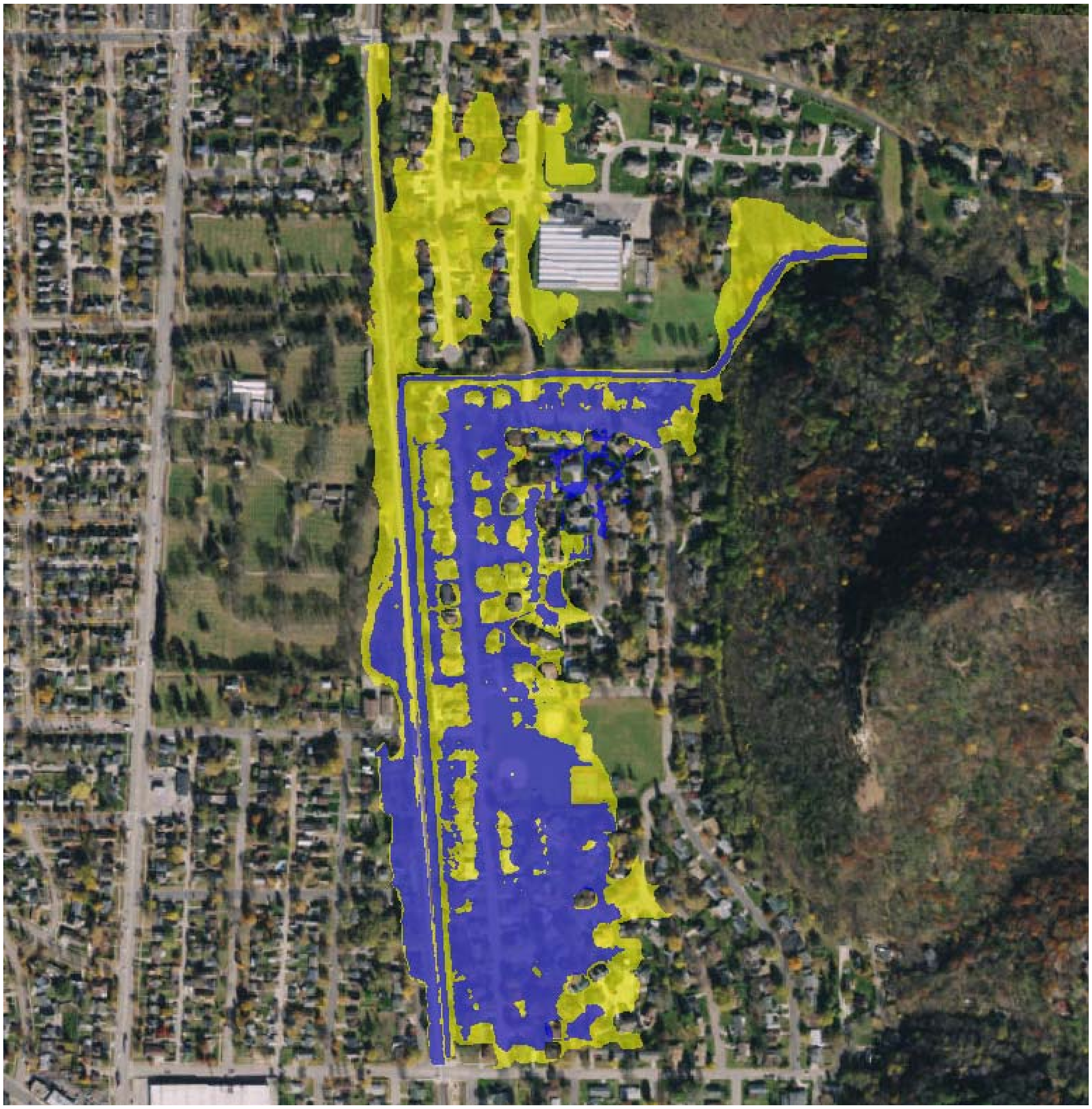


Figure 3 – Results of 1D/2D Integrated HEC-RAS Model

2.3.1.3 Two-dimensional Only HEC-RAS model

Figure 4 shows the results of the two-dimensional HEC-RAS model with the yellow depicting the effective FEMA 1-percent floodplain, and the blue showing the revised 1-percent floodplain based on updated modeling results from this study. Based on these modeling results, approximately 12 acres could be removed from floodplain and 22 residential structures removed as depicted on Figure 4.

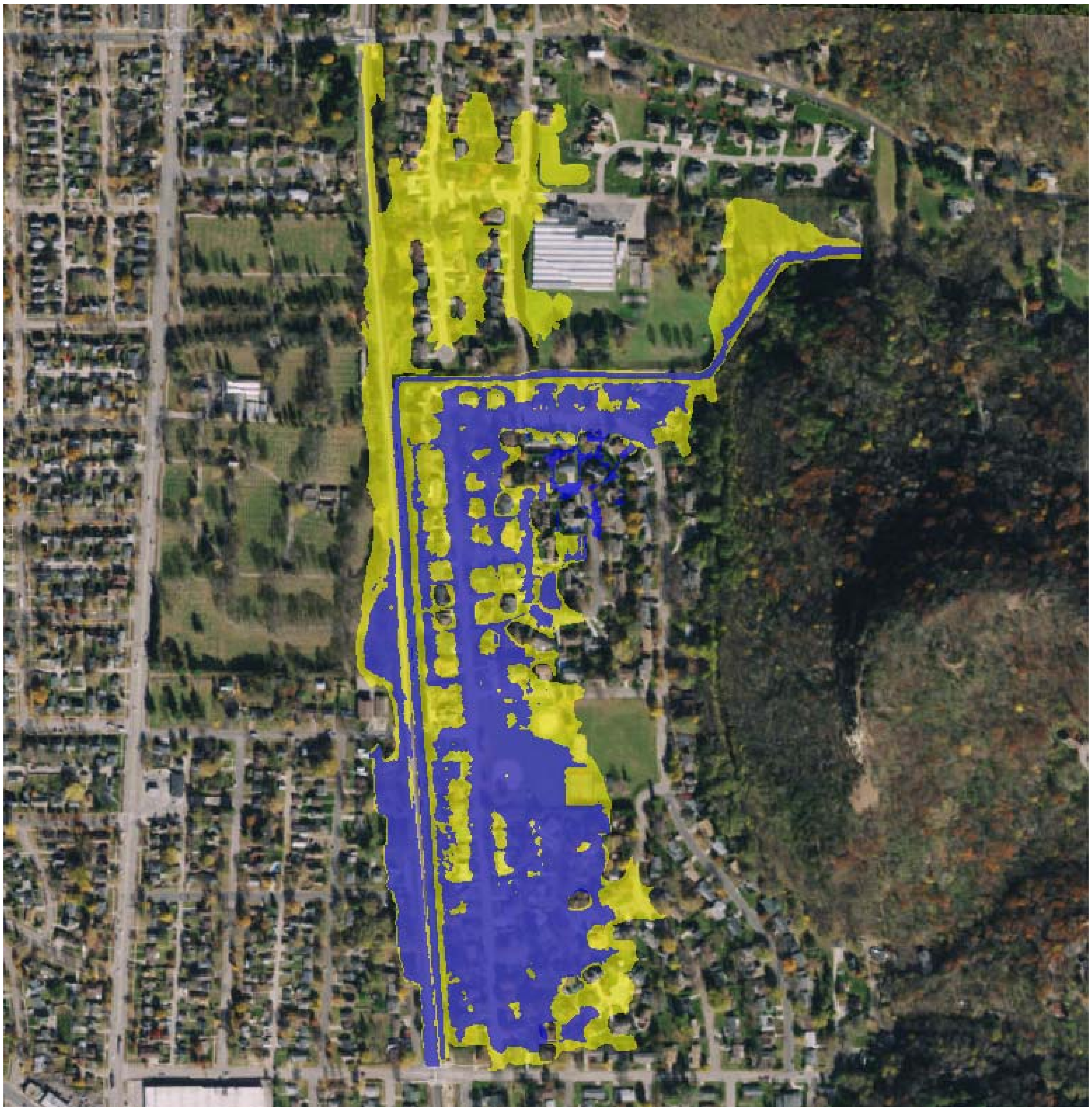


Figure 4 – Results of 2D HEC-RAS Model

2.3.2 Revised Flood Elevation Results

Table 2 – Summary of Hydraulic Modeling Results for Left Overbank Area of Ebner Coulee (Residential Area along 28th Street S East of Ebner Coulee main channel)

FIS Cross-section	Water Surface Elevations (feet, NAVD88)			
	FIS	1D Steady Model	1D/2D Model	2D Only Model
A	659.6	657.4	656.9	657.0
B	659.7	658.3	658.3	658.4
C	660.5	659.0	658.9	659.3
D	661.6	659.9	660.0	660.2
E	662.4	661.1	660.9	661.1
F	664.7	663.1	663.8	663.9
G	665.9	664.3	665.5	665.3
H	667.9	666.3	666.6	666.4

2.4 Anticipated LOMR Process

While the results of the 1D/2D and 2D only HEC-RAS modeling along with the updated hydrologic analysis may better represent the Ebner Coulee system, moving the project forward to a LOMR will most easily be accomplished with conversion back to a one-dimensional only model. The most appropriate means for capturing this would be to update the topography for the effective HEC-RAS model and “calibrate” the results and flow rates within the model to those given by the two-dimensional modeling methodologies.

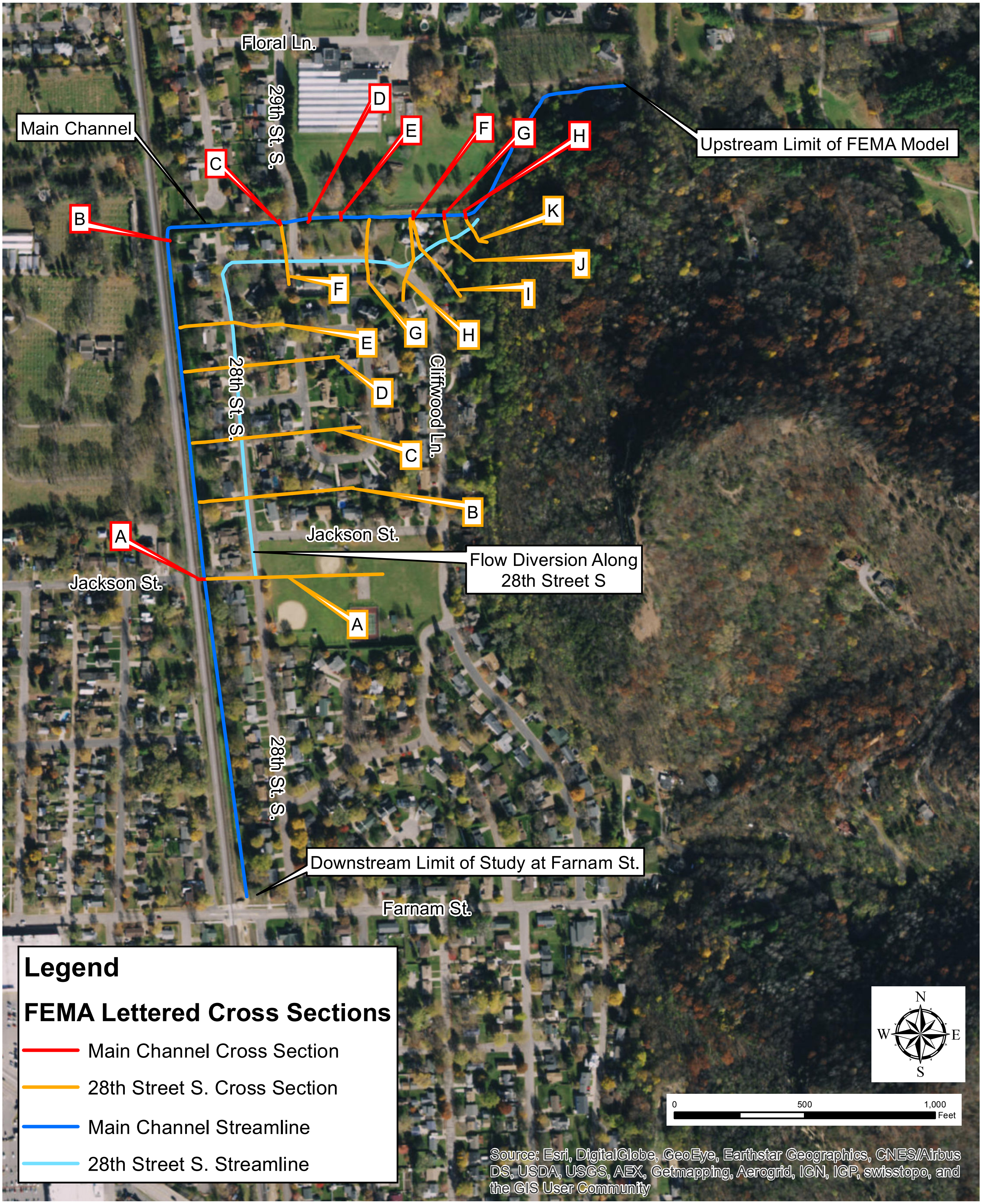
As FEMA policies become updated to address two-dimensional modeling, it may become possible to utilize an integrated 1D/2D model or 2D only as the effective model for the Ebner Coulee system.

If the results depicted in this study appear adequate enough, the next step in the process will be to open dialogue with Wisconsin DNR staff on the preliminary results of this study and anticipated desire of the City to move forward with a LOMR from FEMA.

btw

Figures

Figure 1 – Ebner Coulee System Overview Map



Path: D:\La Crosse RAS 2D\GIS\Feasibility Report Figure1.mxd

SEH

Project Number: 142540
Print Date: 8/22/2017

Map by: rpichelmann
Projection: NAD1983 StatePlane WI South
Source: ESRI, FEMA & SEH

EBNER COULEE FLOODWAY FIRM REMAPPING

La Crosse, WI

FIGURE 1

System Overview

Appendix A

September 29, 1994 Letter from USGS to Wisconsin DNR

CC: LARRY KIRCH

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Water Resources Division
102 East Main Street, 4th Floor
Urbana, Illinois 61801

September 29, 1994

Mr. Robert Watson, P.E.
Assistant-Chief Dam Safety-Floodplain Management Section
Bureau of Water Regulation and Zoning
Wisconsin Department of Natural Resources
101 South Webster Street
Box 7921
Madison, Wisconsin 53707

Dear Mr. Watson:

This letter is in response to your July 1, 1994 letter reviewing the "Hydrologic Analysis of Ebner Coulee at LaCrosse, Wisconsin" that was submitted to Gary Lepak of Wisconsin Department of Natural Resources (WDNR) by the U.S. Geological Survey (USGS) on April 1, 1994. Pages 1 and 2 of your letter indicate that redoing the hydrologic analysis of Ebner Coulee is beyond the scope of the study originally recommended to the Federal Emergency Management Agency (FEMA) by WDNR. Complete details of the WDNR proposal to FEMA were not available to the Illinois District of the USGS. Therefore, the project proposal prepared by the Illinois District of the USGS to FEMA indicated that a review of the hydrologic procedures applied in the original Flood Insurance Study was needed for several reasons (discussed in detail below). Because FEMA did not contend this issue, the new hydrologic analysis was done.

The primary reason the new hydrologic analysis was done was that sufficient information to reproduce the design hydrographs applied in the original floodplain delineation was not provided in the Flood Insurance Study report (Federal Emergency Management Agency, 1984) and supporting reports (U.S. Army Corps of Engineers, 1976 and 1967). In particular, no information is given regarding (1) the loss rates applied to the design rain storms, and (2) the temporal distribution and duration of the design storm. The selection of the loss rates is extremely important to the determination of the volume of runoff and the peak discharge. The primary evidence supporting the design hydrographs applied in the original Flood Insurance Study were the results of the Bureau of Public Roads method, the Cook method, and scaling of flood frequency from Gilmore Creek at Winona, Minnesota. This support was questionable because the Bureau of Public Roads and Cook methods are highly empirical and inappropriate for a watershed as steep as Ebner Coulee, and the scaling procedures applied are inconsistent with current recommended procedures. Further, the results of the hydrologic analysis done by the consultants who designed the Ebner Coulee box culvert differed significantly from the original Flood Insurance Study. These analyses raised concerns in the City of La Crosse regarding the original hydrologic analysis.

RECEIVED
OCT 3 1994
By____

Upon detailed review of the procedures applied in the original Flood Insurance Study additional inconsistencies were found in the application of the methods. These inconsistencies were of two general types: inconsistencies with respect to current practice and inconsistencies in the computational results and procedures. The scaling of flood-frequency information from Gilmore Creek at Winona, Minnesota involved inconsistencies with respect to current practice for floodplain delineation. The Gilmore Creek flood-frequency analysis was done graphically. This procedure was acceptable at the time the analysis was done (1967) because the U.S. Water Resources Council had not yet recommended that the Log Pearson Type III approach be used for all flood studies. However, at the time the Flood Insurance Study was done the Log Pearson Type III approach was the standard for all flood studies, and it seems recomputation of the flood frequency by this approach would have been appropriate. Further, the area scaling ratio applied in the original Flood Insurance Study has been superseded by the equations developed by Krug and others (1986).

The computations for the synthetic-hydrograph methods were inconsistent in the procedures applied and the computational results. For the Rational Method, in order to obtain a peak discharge of 1,010 cubic feet per second (ft^3/s) for an area of 470 acres with a runoff coefficient of 0.41 the design rainfall must be 5.24 inches per hour (in./hr). This value is considerably less than the 5.85 in./hr obtained from U.S. National Weather Service Technical Publication 40 (Hershfield, 1961) for a storm duration of 20 minutes at La Crosse, Wisconsin. For the Clark Unit Hydrograph Method, the hydrographs measured on Gilmore Creek were computed in a questionable manner so that the unit hydrographs determined from the five largest floods would have nearly identical peak-discharges. Further, the optimal value of the watershed storage coefficient determined for Gilmore Creek by the U.S. Army Corps of Engineers (1976) was much higher than that determined by the USGS by calibration of HEC-1 to the five largest floods. The storage coefficient applied to Ebner Coulee, as a result of the analysis done by the U.S. Army Corps of Engineers (1976), seems unrealistically high for such a steep, small watershed.

On page 2 of your letter it is implied that the USGS analysis seems predisposed to reducing the peak discharges and the width of the regulatory floodplain. This is incorrect. The quote from page 1 of the Hydrology Report must be read in full context, specifically:

> "Whereas the 10-percent exceedance probability flood is considerably less than the 1-percent exceedance probability flood used to define the regulatory floodplain, operation of the box culvert <u>could potentially</u> lead to a significant reduction of the regulatory floodplain."

This is a fairly obvious statement that improvements in drainage could reduce the regulatory floodplain. This was the motivation for doing the reevaluation of the floodplain along Ebner Coulee. The later statements in the Hydrology Report speculating that the design discharges applied in the original Flood Insurance Study might be unrealistically high were made on the basis of the results of the scaling of frequency data from hydrologically similar watersheds and the results of TR55 simulation. These results indicated that the best estimate of the 1-percent exceedance-probability flood is around 1,050 ft^3/s as opposed to the 1,430 ft^3/s applied in the original Flood Insurance Study. In fact for some of the synthetic methods applied, 1,430 ft^3/s was greater than the 0.002-percent exceedance-probability flood. 0.2%?

The point is well taken on page 2 of your letter regarding the volume of runoff being at least as important if not more important than the peak discharge. However, three factors should be considered. First, computation of the volume of direct runoff is highly dependent on the loss rates applied, which are not reported in the original Flood Insurance Study. Second, because the synthetic hydrograph methods applied are based on the Unit Hydrograph the volume of direct runoff is directly proportional to the magnitude of the peak discharge if the shapes of the design hydrographs are similar. Thus, if the peak discharge decreased 40 percent, the volume of direct runoff would also decrease 40 percent. The attached figure compares the one-percent exceedance-probability flood computed with TR55 and that determined in the original Flood Insurance Study (the TR55 result was shifted 7 hours so that the peak times of the two hydrographs are similar). It can be seen that the peak regions of the hydrographs are similar but the rising and recession limbs of the hydrographs are significantly different. Despite these differences in shape, the ratio of the depth of direct runoff 3.40 in./2.48 in. = 1.37 is similar to the ratio of the peak discharges 1,430 ft^3/s/1,030 ft^3/s = 1.39. Third, the volume of spill is also related to the amount of time that the runoff rate exceeds the capacity of leveed Ebner Coulee channel. Computation of spill for a flatter, more attenuated hydrograph, such as estimated in TR55, would result in more water remaining in the main channel of Ebner Coulee and less water spilling into the flood-prone neighborhoods upstream of the entrance to the box culvert.

Finally, the USGS is the nation's earth-science agency. The mission of the USGS is to collect and analyze data and present the results of these analyses to cooperating agencies and the general public in an unbiased, scientific way that allows users to make informed decisions on water-resources issues. Therefore, the USGS normally does not make recommendations regarding how the results of data collection and analyses done by the USGS should be applied. Further, the FEMA Guidelines and Specifications for Study Contractors indicate that if questions arise regarding the appropriate analyses (hydrologic or hydraulic) to apply these questions should be submitted to the Regional Project Officer for resolution. It is our understanding that WDNR acts as Regional Project Officer for FEMA. Thus, the "Hydrologic Analysis of Ebner Coulee at La Crosse, Wisconsin" was submitted to Gary Lepak for review and comment.

Your letter advises that application of the hydrologic analyses from the original Flood Insurance Study is preferred. Therefore, the USGS will continue the study applying the hydrographs computed in the original Flood Insurance Study as input to Ebner Coulee as simulated with a combination of HEC-1 and HEC-2. The HEC-2 models provided to the USGS on computer diskette along with your letter will be modified to account for the operation of the box culvert.

Finally, it would be greatly appreciated if WDNR could send electronic copies of the HEC-1 output containing the design hydrographs applied as input to Ebner Coulee in the original Flood Insurance Study if available. These hydrographs may be included in the microfiche documents that detail the original Flood Insurance Study. However, electronic copies of this information would greatly facilitate the completion of the project.

Thank you very much for your comments. I hope this letter clears up any misunderstandings between WDNR and the USGS regarding the reasons for and results of the "Hydrologic Analysis of Ebner Coulee at La Crosse, Wisconsin." If WDNR has any questions regarding this letter or the progress of the remapping project, please call me at (217) 398-5374.

Sincerely,

Charles S. Melching

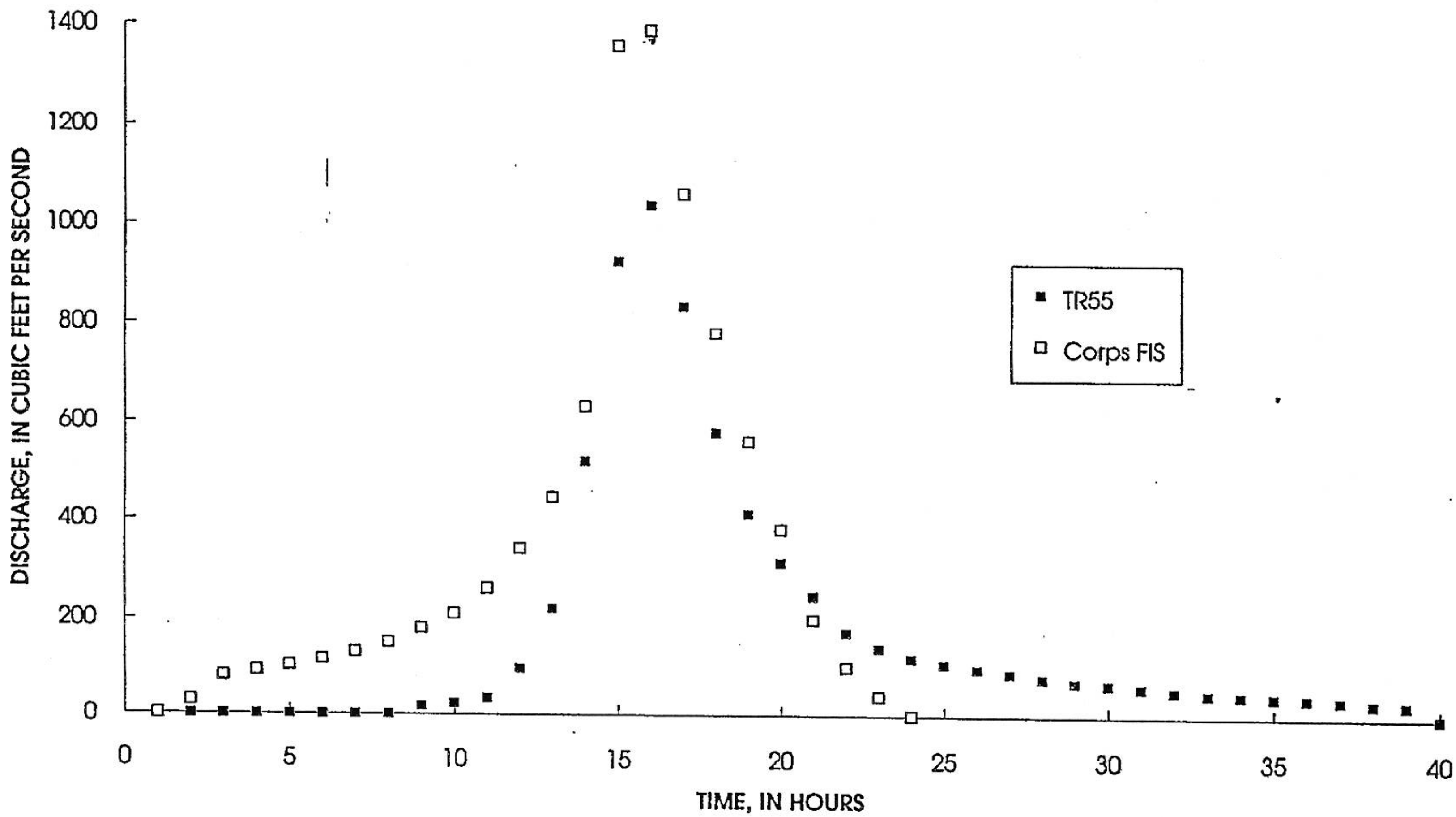
Charles S. Melching, Ph.D., P.E.
Hydraulic Engineer

copy to: Mr. Larry Kirch
City Planner
400 La Crosse St.
La Crosse, WI 54601

Mr. Eric Berman
Federal Emergency
Management Agency
Natural Hazards Division
175 W. Jackson Blvd.
Chicago, IL 60604

Mr. Todd Stuntebeck
U.S. Geological Survey
6417 Normandy Lane
Madison, WI 53719-1133

Comparison of one-percent exceedance-probability flood computed with TR55 and the Clark unit hydrograph method in the original Flood Insurance Study (FIS)



References Cited

Federal Emergency Management Agency, 1984, Flood insurance study, City of La Crosse, Wisconsin.

Krug, W. R., Conger, D. H., and Gebert, W. A., 1992, Flood-frequency characteristics of Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Report 91-4128, 185 p.

U.S. Army Corps of Engineers, 1967, Report of the survey of State Road and Ebner Coulees, Wisconsin for flood control: St. Paul District, St. Paul, Minnesota.

U.S. Army Corps of Engineers, 1976, Flood control-State Road and Ebner Coulees, Wisconsin, General design memorandum, Phase 1, Plan formulation and hydrology: St. Paul District, St. Paul, Minnesota.

Appendix B

August 18, 2017 SEH Hydrologic Analysis Summary Memorandum

Building a Better World for All of Us®

MEMORANDUM

TO: Mr. Bernard Lenz

FROM: Brad Woznak, PE, PH, CFM

DATE: August 18, 2017

RE: Ebner Coulee Floodway FIRM Remapping: Hydrologic Analysis

Background

The City of La Crosse has engaged SEH to determine the feasibility of submitting a Letter of Map Revision (LOMR) to FEMA for the Ebner Coulee Floodway and Floodplain. The City has requested that this work be completed in phases, with the first task focusing on the hydrology of the Ebner Coulee system. The peak discharge rates for Ebner Coulee reported in the effective FEMA Flood Insurance Study (FIS) were supported using the Bureau of Public Roads Method, also called the Cook Method, with scaling of flood frequency from Gilmore Creek at Winona, MN. According to a letter from the USGS to the WiDNR dated September 29, 1994, "the Bureau of Public Roads and Cook methods are highly empirical and inappropriate for a watershed as steep as Ebner Coulee, and the [flood frequency] scaling procedures applied are inconsistent with current recommended procedures."

In order to determine the feasibility of submitting a LOMR to FEMA based primarily on revised hydrology, SEH has reviewed the existing FEMA Flood Insurance Study (FIS) and model information, and estimated new peak flow values entering the modeled area using the methods described in Water Resources Investigation Report 03-4250 "Flood-Frequency Characteristics of Wisconsin Streams". A new flood hydrograph was then developed using HEC-HMS, and FEMA's guidelines were used to determine if the results are statistically significant enough to warrant modification of the FIS/FIRM. This memorandum provides a summary of the hydrologic analysis completed by SEH.

Hydrology Analysis

Data Collection

The effective FIS was obtained from the FEMA web portal and the effective HEC-RAS model was obtained from the Wisconsin DNR through the Surface Water Data Viewer tool. FEMA GIS data including the Special Flood Hazard Area map, cross-sections, and streamline were also obtained and will be used as a starting point for any future modifications to the hydraulic model. The City of La Crosse GIS staff provided a one meter resolution LiDAR-derived DEM for the county and the city. The city's storm sewer GIS database was also provided.

Review of Existing FIS and Available Models

The FEMA effective HEC-RAS model extends from Farnam Street (downstream limit) to 950 feet east of 29th Street S (upstream limit); this is where Ebner Coulee leaves the bluff area and enters the flatter residential area. Figure 1. (attached) shows the FEMA lettered cross-sections and streamlines. There are two streamlines; the north and west streamline is for the main channel, and the south and east streamline is for flow that diverts out of the main channel and flows through the residential area. Some flow also diverts to the north and is included in the FEMA mapping, but the cross-sections do not extend to the north.

The drainage area listed in Table 8 (included below) of the La Crosse County FIS is 0.9 square miles for all flows in the Ebner Coulee main channel and Ebner Coulee Southeast bank models. Based on modern LiDAR data, the drainage area to the upstream limit of the model is 0.61 square miles, and the drainage area to the downstream limit of the model at Farnam Street is 1.13 square miles, as shown in Figure 1 (attached). The drainage area to FEMA's most downstream lettered cross-section, A, was calculated using LiDAR to be 0.88 square miles. Based on this LiDAR calculation and USGS quad maps, it appears that the drainage area of 0.9 square miles indicated in the FIS was originally calculated to the point at the end of the lettered cross-sections near Jackson Street, and then reported in the FIS as the drainage area for all parts of the model. An approach such as this is often taken as a conservative means used to account for all runoff that may be entering the system and entering it into the model at the upstream end of the study reach. In this case, the unsteady UNET model utilizes the available watershed storage to attenuate peak flows as they move through the system.

Our approach varies from this in that we will develop two inflow hydrographs; one for the upstream 0.61 square mile watershed, and another for the total 0.88 square mile watershed. The upstream hydrograph will be added to the model within Ebner Coulee at the upstream limits of the study and the second flow hydrograph will be added to the model at the point where that flow enters the system.

Table 8 of the Effective FEMA FIS – Summary of Discharges

		Peak Discharges (cubic feet per second)			
Flooding Source and Location	Drainage Area (square miles)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
EBNER COULEE MAIN CHANNEL					
Upstream of Overflow to Ebner Coulee Southeast Bank	0.9	N/A	N/A	1,430	N/A
Upstream of South 29th Street	0.9	N/A	N/A	301	N/A
Approximately 1240 feet Upstream of Farnam Street	0.9	N/A	N/A	247	N/A
EBNER COULEE SOUTHEAST BANK					
Upstream of South 29th Street	0.9	N/A	N/A	820	N/A
Approximately 1260 feet Upstream of Farnam Street	0.9	N/A	N/A	836	N/A

Table 8 of the La Crosse County FIS shows that for the 1% Annual Chance Flood, a peak discharge rate of 1430 cfs was used for the main channel of Ebner Coulee upstream of the overflow location. Table 8 also shows that less than 300 cfs of the 1430 cfs starting flow remains in the channel by the time it reaches Jackson Street. The remainder overflows out of the main channel and is modeled separately. The focus of Task 1 is only to estimate the peak flow at the upstream end of the modeled reach, a two-dimensional HEC-RAS model will be utilized to estimate the flow characteristics for the floodplain and channel conveyance systems as part of Task 2.

USGS Regression Analysis & Flood-Frequency Equations using W-RIR 03-4250

Regression equations are relations between flood-frequency and drainage-basin characteristics that have been developed by a multiple-regression analysis. The peak flow in Ebner Coulee was estimated using the regression equations and methodology provided in USGS Water-Resources Investigations Report 03-4250. This process involved delineating a new watershed to the upstream limit of the effective HEC-RAS model based on the LiDAR-derived DEM, and estimating the percentage of forested area and the approximate slope through the watershed using GIS. The watershed draining to the upstream limit of the model is 0.61 square miles as shown in Figure 1 (attached). The flood-frequency equations provided in the USGS document were then used to estimate the peak discharge rates. Table 1 shows the resulting peak flow for the 100-year event. Plus and minus one standard error were also calculated using the ESE (equivalent standard error) provided in the USGS document; this is also shown in Table 1.

Table 1: Regression Analysis & Flood-Frequency Equation Results

Source	Location	Drainage Area (SqMi)	Peak Flow (cfs)	ESE (%)	Minus 1 Standard Error (cfs)	Plus 1 Standard Error(cfs)
FEMA Effective	All Locations	0.9	1430.0			
Regression Eq.	Upstream Limit of Fema Model	0.61	360.8	44	202.0	519.5
Regression Eq.	Jackson Street	0.88	428.5	44	240.0	617.0
Regression Eq.	Farnman Street	1.13	494.7	44	277.0	712.3

Check for Statistical Significance per FEMA Guidelines
According to language provided in FEMA's Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C, the hydrologic analysis should base the test for significance on the confidence limits, plus or minus one standard error, of the more recent analysis:

> *"The Mapping Partner performing the hydrologic analysis should base the test for significance on the confidence limits of the more recent analysis. Plus or minus one standard error, which is equivalent to a 68-percent confidence interval, should be used to determine if the effective and new base flood discharges are significantly different. If the effective base flood discharges are within the 68-percent confidence interval (one standard error) of the new base flood discharges, the new estimates are not considered statistically different and there is no need for a new study based only on changes in the flood discharges. If the effective discharges fall outside the 68-percent confidence interval (one standard error) of the new discharges, the estimates are considered significantly different and a new study may be warranted based on changes in the flood discharges."*

Figure 2 (below) shows that the effective 100 year peak flow of 1430 cfs is well above the flow calculated in the regression analysis, and also well outside of the 68-percent confidence interval (one standard error); indicating a new study is warranted based on the changes in the flood discharges alone.

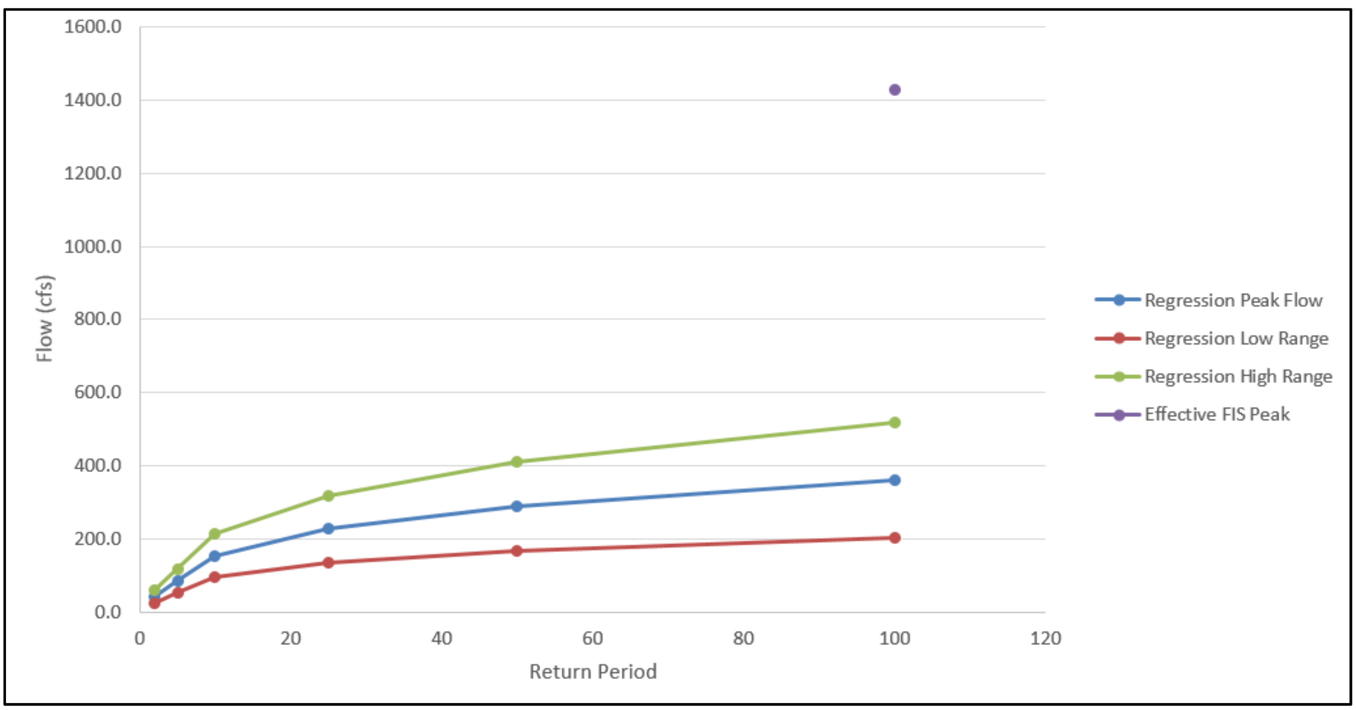


Figure 2: Statistical Summary

HEC-HMS Model

A HEC-HMS model was created to develop inflow hydrographs that could be associated with the calculated regression equation peak flows and used in an unsteady HEC-RAS analysis. Figure 3 (included on the following page) shows the inflow hydrograph developed using HEC-HMS, matching the regression equation peak flow estimate for the upstream limit of the Ebner Coulee hydraulic model. This hydrograph will be used in future hydraulic analyses.

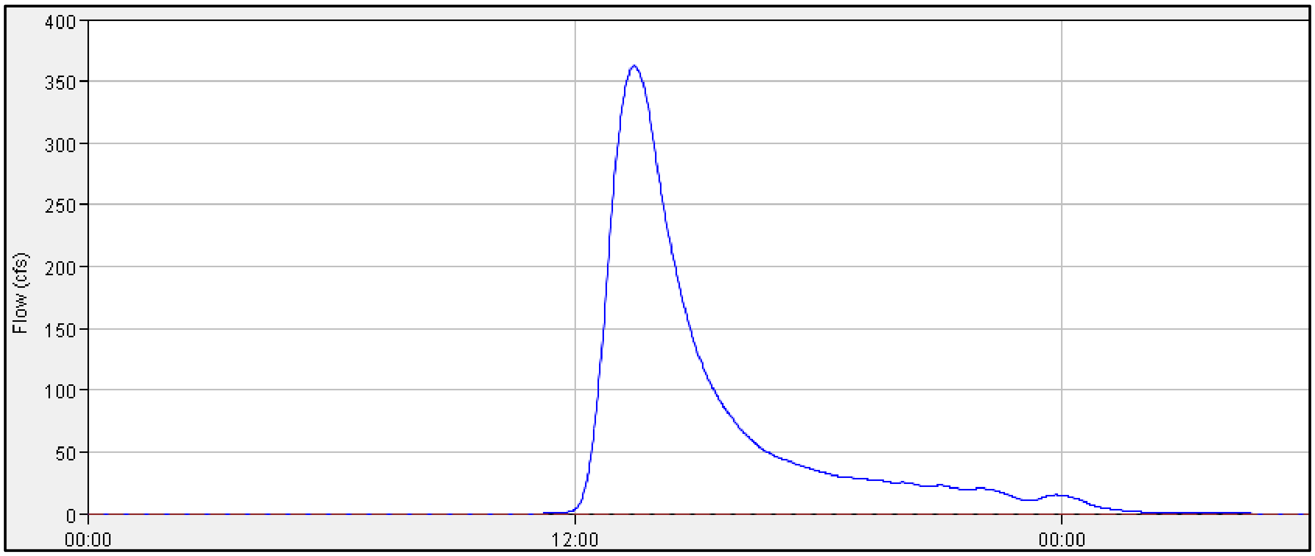


Figure 3: Ebner Coulee Inflow Hydrograph based on Regression Peak Flow Rate

R.M.
Attachment

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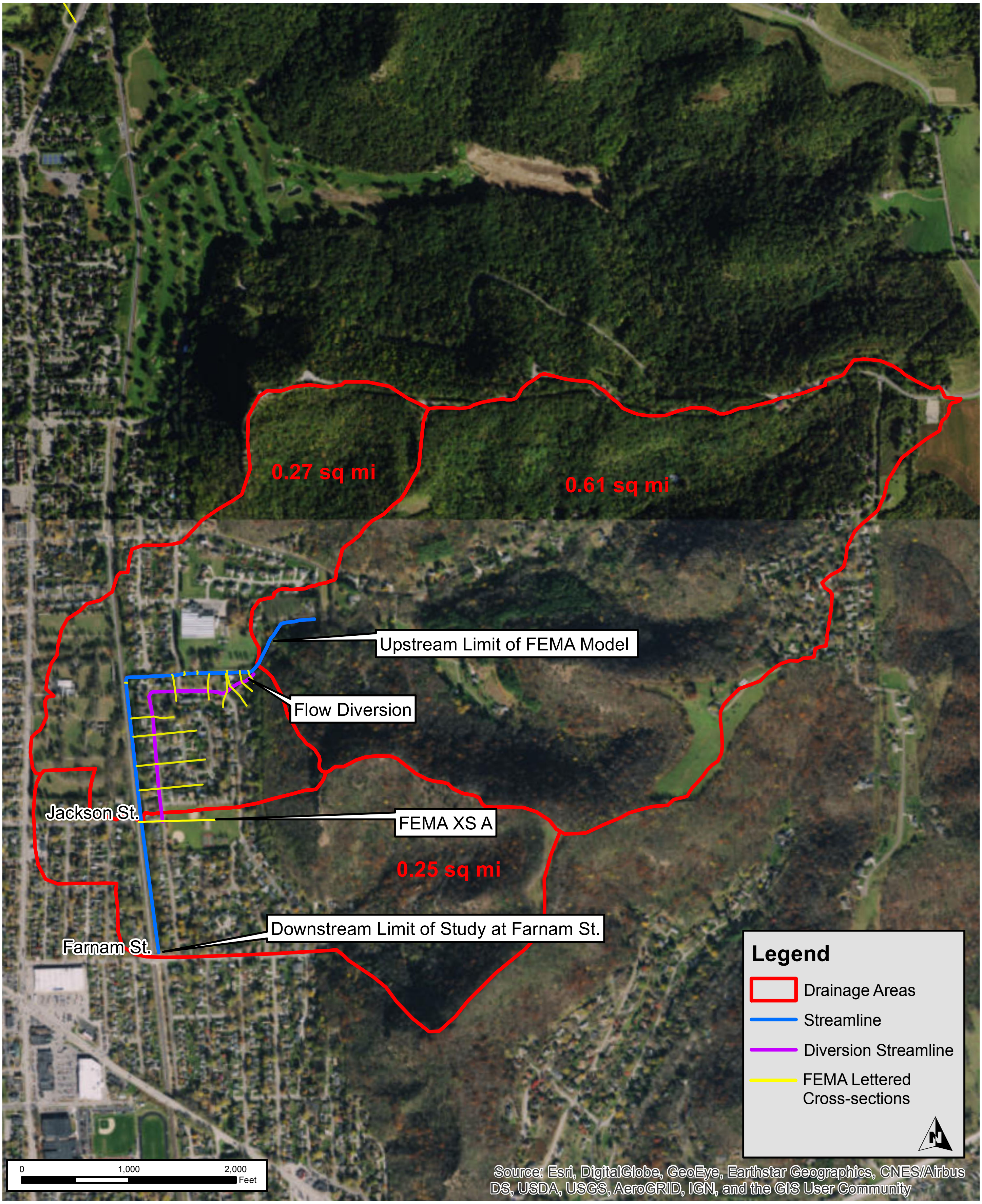

Path: S:\KO\L\lacrs\142540\5-final-dsgn\50-final-dsgn\90-GIS\Figure1.mxd

Project Number: 142540
Print Date: 8/3/2017

Map by: rmondloch
Projection: NAD_1983_StatePlane_Wisconsin_South_FIPS_4803_Feet
Source: ESRI, FEMA & SEH

SEH

Ebner Coulee
La Crosse, WI

FIGURE 1
Drainage Areas

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