Instruction to Newspaper - Publish the Notice on April 1, 2026. The applicant is responsible for payment.

Notice of Hearing on Request for Variance from
South Dakota Safety of Dams Rules Requested by City of Mitchell

Notice is given that the City of Mitchell, c/o Mayor Hanson, 612 North Main St., Mitchell SD, 57301 has petitioned the Water Management Board to grant a variance from the Safety of Dams Rules, Section 74:02:08:07 Minimum Spillway Design Flood Requirements for the Lake Mitchell Dam. The petition is based on South Dakota Codified Law (SDCL) 46-7-5.3, which states that the Water Management Board may grant a variance upon the finding that failure of the dam due to inadequate spillway capacity will not increase the potential for damage from flooding to downstream residents or property.

Lake Mitchell Dam is an intermediate sized, category 1 (high hazard) dam, which is a dam whose failure may cause loss of life. The dam is 55 feet heigh and impounds approximately 8,960 acre-feet of water at the spillway elevation, located in the W 1/2 Section 10-T103N R60W in Davison County. An updated hydrologic and hydraulic analysis of the dam shows the dam is not capable of passing 50% of the Probable Maximum Flood (PMF) as required by Administrative Rule of South Dakota (ARSD) 74:02:08:07. This request for a variance from minimum spillway design requirements is to allow Lake Mitchell Dam to retain the current spillway capacity of 23% of the updated PMF.

Computer analyses were performed using HEC-RAS 2D for information both with, and without, a dam breach. The analyses included modeling a dam breach with a 23% PMF storm event and modeling the dam modified to pass the 50% PMF event without dam failure. The results indicate that requiring an increase in spillway capacity to bypass a 50% PMF runoff event as required by rules increases the danger to downstream residences from flooding.

This request to obtain a variance is made pursuant to SDCL 46-2-9, 46-2-17, 46-2A-1 thru 46-2A-6, 46-7-3 thru 46-7-5.3; ARSD 74:02:08:07.

Pursuant to SDCL 46-2A-2 and 46-7-5.3 the Acting Chief Engineer of the Water Rights Program recommends that the request for a variance to ARSD 74:02:08:07 be GRANTED subject to qualifications, since the failure of the dam due to inadequate spillway capacity will not increase the potential for damage from flooding to downstream residents or property. The Acting Chief Engineer's recommendation with qualifications, the petition, and staff report are available at https://danr.sd.gov/public or contact Amanda Dewell for this information, or other information, at the Water Rights Program address provided below or by email at amanda.dewell@state.sd.us.

The request for a variance will be considered by the Water Management Board at 9:40 AM (Central Time), May 6, 2026, Floyd Mathew Training Center, Joe Foss Building, 523 E. Capitol, Pierre SD.

The recommendation of the Acting Chief Engineer is not final or binding upon the Board and the Board is authorized to 1) grant, 2) grant with qualifications, 3) defer, or 4) deny this request for a variance upon reaching a conclusion based on the facts presented at the public hearing.

Any interested person who may be affected by the Board decision in a way that will cause injury that is unique from any injury caused to the general public, within the regulatory authority of the Board, intending to participate in the hearing, present evidence, and cross-examine witnesses in accordance with SDCL Chapter 1-26, must file a written petition to intervene with both the City of Mitchell and the Acting Chief Engineer by April 13, 2026. The petition may be informal but must include the petitioner's reason for opposition of the variance request, signature, and contact information of legal counsel, if obtained.

The May 6, 2026, hearing date will be automatically delayed for at least 20 days upon written request to the Acting Chief Engineer from the applicant or any interested person opposing the petition or the recommendation of the Acting Chief Engineer. The request for a delay must be filed by April 13, 2026.

Any interested person may file a comment on the request for variance with the Acting Chief Engineer. The comment shall be filed on a form provided by the Acting Chief Engineer and is available online at https://danr.sd.gov/public or by calling (605) 773-3352 or writing the Acting Chief Engineer at the address provided above. Filing a comment does not make the commenter a party of record or a participant in the hearing. Any comment must be filed by April 13, 2026.

The mailing address for the Acting Chief Engineer is: DANR – Water Rights Program, 523 E Capitol Ave, Pierre SD 57501, while the mailing address for the City of Mitchell is listed above.

The hearing is an adversary proceeding and any party has the right to be present at the hearing and to be represented by a lawyer. An individual may represent themselves pro se, while a legal entity like the City of Mitchell needs to be represented by legal counsel. These and other due process rights will be forfeited if they are not exercised at the hearing and decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law.

Notice is given to individuals with disabilities that the meeting is being held in a physically accessible location. Individuals requiring assistive technology or other services in order to participate in the meeting or materials in an alternate format should contact Brian Walsh, by calling (605) 773-5559 or by email at Brian.Walsh@state.sd.us as soon as possible but no later than two business days prior to the meeting in order to ensure accommodations are available.

Under SDCL 1-26-17(7) notices must state that "if the amount in controversy exceeds $2,500.00 or if a property right may be terminated, any party to the contested case may require the agency to use the Office of Hearing Examiners by giving notice of the request to the agency no later than ten days after service of a notice of hearing issued pursuant to SDCL 1-26-17." This is a Notice of Hearing, service is being provided by publication, and the applicable date to give notice to the Acting Chief Engineer is April 13, 2026.

As applicable, the following provides the legal authority and jurisdiction under which the hearing will be held and the particular statutes and rules pertaining to this request for variance: SDCL 1-26-16 thru 1-26-28; SDCL 46-1-14, 46-2-9, 46-2-11, 46-2-17; Chapter 46-2A; and Board Rules ARSD Chapter 74:02:08.

Published once at an approximate cost of_________.

City of Mitchell · Office of the Mayor
612 North Main Street · Mitchell, SD 57301
Phone: 605-995-8420
CityOfMitchell.org

Mitchell
SOUTH DAKOTA

February 27, 2026

South Dakota Department of Agriculture and Natural Resources
Attn: Chief Engineer, Adam Mathiowetz
523 East Capitol Avenue
Pierre, South Dakota 57501

RECEIVED
MAR - 2 2026
OFFICE OF WATER

Re: Petition for Variance from Minimum Spillway Design Requirements
Lake Mitchell Dam (NID ID: SD00685)

Dear Chief Engineer Adam Mathiowetz,

On behalf of the City of Mitchell, owner of Lake Mitchell Dam, this letter formally petitions the South Dakota Water Management Board for a variance from the minimum spillway design requirements pursuant to SDCL 46-7-5.3.

In response to DANR correspondence dated September 19, 2025, the City commissioned Houston Engineering to complete a comprehensive engineering evaluation of Lake Mitchell Dam performance. The findings of this work are documented in the attached report, *Lake Mitchell Inflow Design Flood Update Study*, which includes updated hydrologic and hydraulic analyses, spillway capacity evaluation, dam breach modeling, and an Incremental Consequence Analysis prepared in accordance with FEMA guidance and current engineering standards. The City has also commissioned Houston Engineering to complete an update to the Emergency Preparedness Plan, and the EPP is presently being updated with the downstream risk information provided in the attached report.

The attached report demonstrates that the existing spillway cannot safely pass the 50 percent Probable Maximum Flood (PMF) without overtopping the dam. However, the analyses also show that the dam can safely pass flood events up to approximately a 23 percent PMF without overtopping. Importantly, the Incremental Consequence Analysis concludes that, for the 23 percent PMF, failure of the dam due to inadequate spillway capacity would not increase the potential for risk to life from flooding to downstream residents or property when compared to the same flood without dam failure.

Consistent with the criteria set forth in SDCL 46-7-5.3, the City respectfully requests that the Chief Engineer investigate the attached analyses and recommend approval of a variance allowing the 23 percent PMF to serve as the Inflow Design Flood for Lake Mitchell Dam. The City understands that this petition is subject to notice and hearing procedures pursuant to Chapter 46-2A and stands ready to participate fully in that process.

Sincerely,

Mayor Jordan Hanson

Under the existing conditions and assuming a no dam failure and dam failure scenario, the 50% PMF places 18 inhabitable structures within "Danger Zones" according to ACER Technical Memorandum No. 11, Downstream Hazard Classification Guidelines (1988) published by the USBR. Structure locations can be viewed from figures in Appendix A. Figure 21 summarizes the structure IDs and their respective Parcel IDs. Parcel IDs and property addresses were obtained from the Davison and Hanson County Web Viewer applications. Figure 22 and Figure 23 detail the structures and their Danger Zones for a no dam failure and dam failure scenario respectively. For the no dam failure scenario, structures 6, 8, 10, and 13 are in the High Danger Zone solely based on the anticipated depths and velocities resulting from flooding. Structures 3, 7, and 18 are in the Judgement Zone solely based on the anticipated depths and velocities resulting from flooding. USBR defines the Judgement Zone as *"Danger level is based upon engineering judgement."* For any structure numbers not shown in the USBR Danger Zone plots, this corresponds to being in the High Danger Zone outside the limits of the USBR plots (V> 25 ft/s and/or D>10 ft).

Structure ID	Parcel ID	Property Address	Danger Zone for 23% PMF Dam Breach	Danger Zone for 50% PMF Dam Breach
1	06145-00100-003-00	1805 SCENIC COURT DR		L
2	06145-00100-002-00	1801 SCENIC COURT DR		J
3	06145-00100-001-00	1725 SCENIC COURT DR	J	H
4	06141-10360-001-22	1902 N FOSTER ST	H	H
5	06141-10360-001-20	1700 N FOSTER ST	H	H
6	06141-10360-001-10	1620 N FOSTER ST	J	H
7	06141-10360-008-00	1509 WESTVIEW DR		J
8	06144-10360-002-00	1021 N GALE RD	L	H
9	06000-10360-134-30	25279 BARBER PL		L
10	103-59-018-002-000-03	25222 CAMPGROUND RD	L	H
11	08000-10460-103-20	40932 246TH ST		L
12	06247-10360-001-10	2761 E 1ST AVE		J
13	06000-10360-244-30	2840 E 1ST AVE	J	H
14	102-59-005-002-000-01	41327 JAMES RIVER RD		L
15	102-59-009-004-000-01	41462 258 ST		L
16	102-59-009-004-000-01	41462 258 ST		L
17	102-59-014-004-000-03	25823 417 AVE		J
18	102-59-014-004-000-03	25823 417 AVE	L	J
L	Low Danger Zone			
J	Judgement Danger Zone			
H	High Danger Zone			

Figure 21 – Structure IDs and Parcel IDs

Report to the Chief Engineer on
Request for a Variance to Spillway Capacity Requirements by
City of Mitchell for Lake Mitchell Dam

On March 1st, 2026, the Water Right Program received a petition to the Water Management Board by the City of Mitchell for a variance from the minimum spillway design requirements for Lake Mitchell Dam pursuant to South Dakota Codified Law (SDCL) 46-7-5.3. The City is seeking to retain the current spillway capacity for the dam. Lake Mitchell Dam is an intermediate sized, category 1 (high hazard) dam which is a dam whose failure may cause loss of life. Lake Mitchell Dam is located on land owned by the City of Mitchell; holder of Vested Water Right No. 426-3 for the reservoir. It has a dam height of 55 feet with an estimated normal storage capacity of 8,960 acre-feet, and an estimated maximum storage capacity of 19,585 acre-feet. This dam was originally constructed in 1928.

High hazard is the standard national terminology for a dam with a hazard potential classification of category 1 under the State's rules so, for the remainder of this report, the term high hazard will be used instead of category 1.

South Dakota Codified Law (SDCL) and Administrative Rule of South Dakota (ARSD)
ARSD 74:02:08:01(3) defines category 1 dam as, "a high hazard dam whose failure may cause loss of life".

Pursuant to ARSD 74:02:08:07, the minimum design flood that an intermediate sized, category 1 dam must have sufficient storage to contain, or spillway capacity to pass through, or over the dam without failure of the dam, is the 0.5 probable maximum flood (PMF) unless a dam is granted a variance pursuant to SDCL 46-7-5.3. An equivalent term for 0.5 PMF is 50% PMF and the terms can be used interchangeably.

SDCL 46-7-5.3 reads as follows:

> SDCL 46-7-5.3. Investigation of dam--Variance relating to minimum spillway design requirements--Hearing. Upon petition to the Board by the owner of a dam, the Chief Engineer may investigate and conduct the necessary analysis to determine the potential damage to downstream residents or property if a dam were to fail due to inadequate spillway capacity. After the investigation and analysis, the Chief Engineer may recommend that a variance to Board rules relating to minimum spillway design requirements for dams be granted or denied. The recommendation, notice, and hearing before the Board shall be conducted pursuant to the procedure contained in chapter 46-2A. Following the hearing, the board may grant a variance upon a finding that failure of the dam due to inadequate

spillway capacity will not increase the potential for damage from flooding to downstream residents or property.

ARSD 74:02:08:01(18) defines PMF as, "the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are possible in the region".

Pursuant to ARSD 74:02:08:09 reconstruction, alteration, or repair that requires plans and specifications, or breaching of an existing dam may not begin until plans and specifications have been approved by the Chief Engineer.

General Background

A brief review of the Water Rights Program's dam records resulted in five past examples of when the Water Management Board heard requests for variances pursuant to SDCL 46-7-5.3. A summary of these requests is provided in Appendix A. Of the five examples, four variances were issued, and one variance request was denied. Two of those variance requests (Redfield and Fourth Street Dams) relied upon the report and analyses prepared by a consulting engineer hired by the dam owner.

These requests occurred primarily in the late 1980's and early 1990's. A review of the variances issued shows little to no consideration of hazard creep occurring, as part of the variance consideration. Hazard creep is the gradual increase in potential consequences of a dam failure—typically due to new development (homes, businesses, campgrounds, etc.) downstream of the dam without any physical change to the dam itself. Hazard creep is an area where dam safety practice and understanding has advanced since South Dakota's laws and rules around dam safety were put into place. Additionally, since these historic requests, significant advancements have occurred in the standard of practice for dam safety, hydrologic modeling, and hydraulic modeling, alongside significant advancements in the quality and quantity of best available information. Combined, all these factors result in modern analysis practices yielding a more accurate representation of watershed behavior and spillway performance during different sized flood events, than what was possible at the time of past variances.

The investigative process generally described in SDCL 46-7-5.3 has also been more formally named and established within the dam safety industry. It can be referred to as either an Incremental Consequence Analysis or an Incremental Damage Analysis, so the use of either of those terms in this report or the supporting material refers to an analysis generally consistent with SDCL 46-7-5.3 and past variance requests. This type of analysis is commonly used in the dam safety industry to evaluate the risk of allowing a dam design with less flood capacity than required by a dam regulatory agency.

Background for this Request

As part of the Lake Mitchell Restoration Project, currently under design, modifications to Lake Mitchell Dam will require review and approval of plans and specifications by the Chief

Engineer prior to the commencement of any construction activities. Two separate approvals will be necessary. First, the plans and specifications for the planned breach of the dam through the spillway must be approved before the breach work may begin. From the information provided to the Water Rights Program, a section of the spillway will be removed as a controlled breach to keep the reservoir mostly drained and allow for sediment removal. Second, following completion of the in-reservoir work, a separate submittal will be required for approval of the plans and specifications for reconstruction of the breached spillway section and installation of the proposed low-level outlet. The consulting engineer has indicated these items should be processed as independent reviews, as information obtained during the spillway breach may directly inform and refine the final reconstruction design.

During a project meeting in August 2025, Water Rights Program staff identified several issues related to the reconstruction phase that may delay or prevent issuance of the required Safety of Dams approval. First, an Emergency Preparedness Plan (EPP) is required for a high hazard dam as part of the Safety of Dams submittal. The EPP currently on file with the Water Rights Program, last updated on June 11, 1987, will require revision prior to consideration of reconstruction approval. Staff also noted that the inundation mapping contained in the existing EPP does not reflect current standards of practice and recommended that updated inundation mapping be prepared. Second, the extent of the proposed modifications to the spillway would, under prevailing best practices for high-hazard dams, necessitate a review of the dam's loading calculations, with updates performed as warranted. Water Rights staff also expressed concern that the design loading proposed for the new low-level control tower—planned for construction adjacent to the spillway within the reservoir—appeared to be lower than the loading required for the dam itself.

In response to these concerns, the City of Mitchell retained Houston Engineering Inc. (hereafter referred to as Houston) to provide technical assistance. Houston's (2026) analysis resulted in the report submitted with the City's variance request, titled Lake Mitchell Inflow Design Floods Update Study. This report serves as supporting technical documentation for the City's variance request.

Past 0.5 PMF Studies of Lake Mitchell Dam and the Updated 0.5 PMF Estimate

There have been two past studies of the 0.5 PMF (also commonly called the 50% PMF) for Lake Mitchell. Lake Mitchell has a concrete horseshoe weir structure serving as the dam's only spillway structure to pass water through the dam. An overview of the dam is provided in Figure 1.

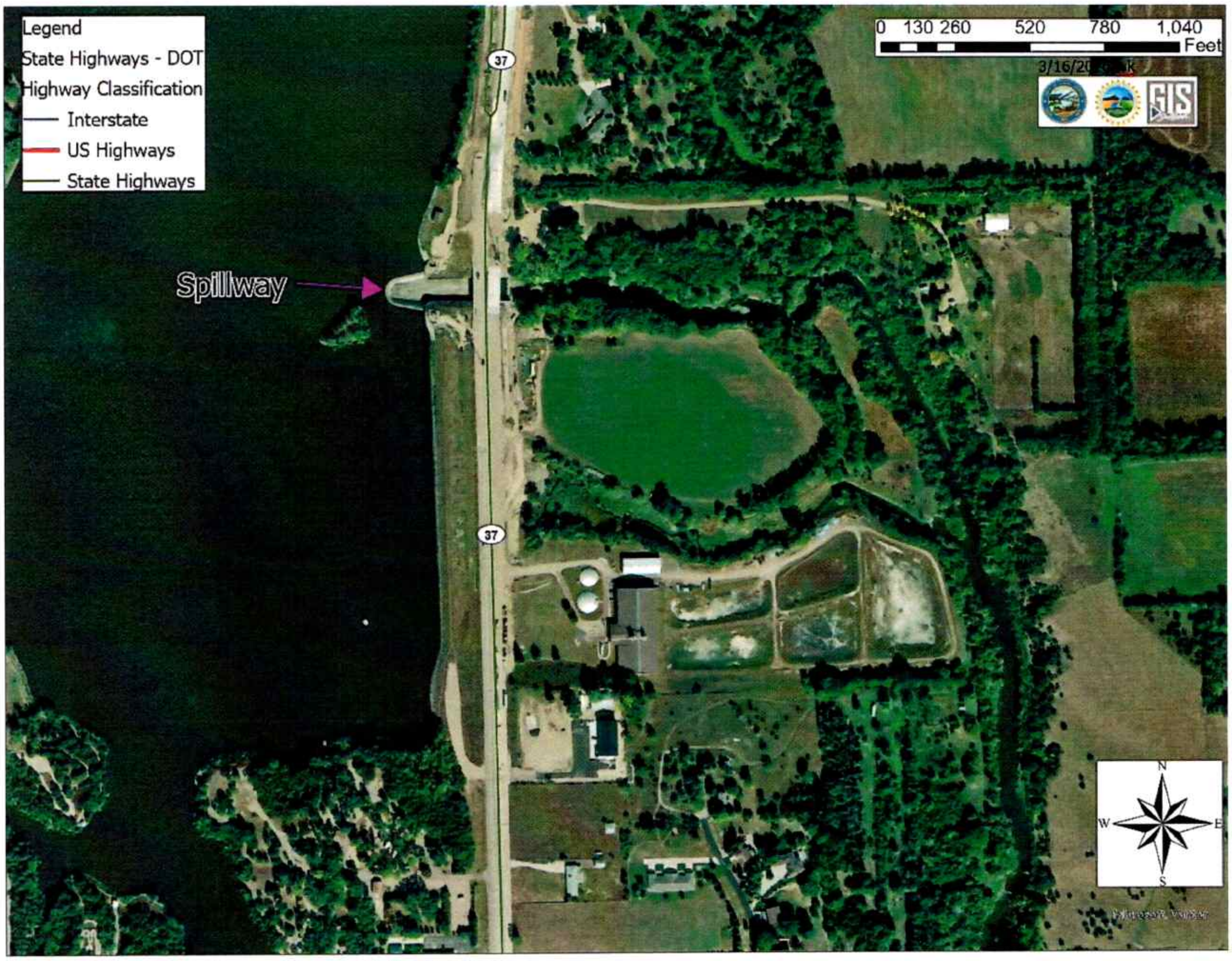

Figure 1: Overview of Lake Mitchell Dam

Two past estimates of the 0.5 PMF event for Lake Mitchell exist. The first was in 1978 as part of the United States Army Corps of Engineers Phase I Inspection Program (USACE, 1978). The second study was completed by Banner Engineering (hereafter refer to as Banner) in 1995 as part of the design work leading up to a major spillway project in 1998 and 1999 (Water Rights, 2026). These studies are summarized in Table 1. A review of the Banner study indicated that since that study, significant updates have occurred in best available information for understanding the hydrology of the watershed for the dam (LiDAR, land use data, soils data, etc.) and significant improvements in modeling capabilities have occurred to inform that understanding. Therefore, dam safety best practice for high hazard dams requires updating the estimate of the 0.5 PMF. For example, the Banner study used Hydrologic Soil Group B for the watershed, but the NRCS SSURGO soils data (provided for GIS as gNATSGO data) indicates the watershed is primarily Hydrologic Soil Group C (NRCS, 2024). Group C soils have a lower infiltration rate than Group B soils, so Group C soils result in higher runoff (NRCS, 2024).

Houston (2026) updated the estimated 0.5 PMF and spillway capacity for Lake Mitchell Dam using the US Army Corps of Engineers HEC-HMS software (version 4.13) along with other data. HEC-HMS is standard software widely used in the dam safety industry for this type of analysis. The methodology and data used for those updates was reviewed and found to be in line with current standard practice for this type of analysis and utilized best available information for the analyses performed. Available stream gage data (approximately 70 years) for Firesteel Creek was utilized to calibrate the model and inform analysis decisions regarding expected watershed behavior during high runoff events.

Early in the study, Houston approached the Water Rights Program regarding the appropriate data source for determining the probable maximum precipitation (PMP). The State's Safety of Dams Rules largely date to 1987, with minor updates in 1989. These Rules reference two PMP data sources: the National Weather Service's Hydrometeorological Report (HMR) No. 51, *Probable Maximum Precipitation Estimates, United States East of the 105th Meridian* (1978), and HMR No. 55, *Probable Maximum Precipitation Estimates, United States Between the Continental Divide and the 103rd Meridian* (1984). In 1988, HMR 55 was superseded by HMR 55A, which has routinely been used in place of the older publication (Water Rights, 2026).

Over the past two decades, the dam safety industry has recognized that the HMR reports are outdated and in need of replacement. Many states have commissioned updated PMP studies, including Nebraska (2008), North Dakota (2021), and Wyoming (2014) (AWA, 2008, 2014, 2021). The Nebraska study boundaries extend north into South Dakota and include the Lake Mitchell watershed. Because the Nebraska PMP study incorporates roughly 30 additional years of extreme precipitation data and reflects improved understanding of precipitation science (AWA, 2008), then-Acting Chief Engineer Mayer approved Houston's use of the Nebraska data so the variance request could rely on the best reasonably available information. This approach is consistent with now-retired Chief Engineer Gronlund's previous allowance of the North Dakota PMP study as part of the Elm Lake Dam rehabilitation project.

Use of the Nebraska PMP values resulted in a slightly lower PMP estimate for the Lake Mitchell watershed (17.25 inches), which aligns with the findings of both the North Dakota and Nebraska PMP studies when compared with HMR 51 (21.9 inches for the watershed).

The updated analysis by Houston ultimately resulted in an updated estimate of the 0.5 PMF for Lake Mitchell Dam of 109,495 cubic feet per second (cfs). Water Right Staff has reviewed the analysis by Houston and concurs with this updated estimate of the 0.5 PMF. Houston also updated the estimated spillway capacity using Computation Fluid Dynamic (CFD) modeling. Widespread CFD modeling is relatively new as best practice for analyzing more complex spillways (ASDSO, 2025). Historically, the main option for complex spillways was to approximate performance (as was done in the Banner report) or invest in expensive and time-consuming physical modeling (Banner, 1995). Given that that the Houston analysis updated the 0.5 PMF, it makes sense that CFD modeling would also be used to obtain a much more accurate picture of spillway hydraulic performance and update the spillway rating curve. The spillway rating curve is a graph of spillway discharge at different reservoir elevations. The updated spillway rating curve shows that the dam's current spillway capacity can only accommodates a 0.23 PMF event (50,368 cfs); therefore, the City is requesting a variance to maintain the current spillway capacity.

Table 1: Comparison of PMF Studies of Lake Mitchell (USACE, 1978; Banner, 1995; modified from Houston, 2026)				
Item	**Value**			**Units**
	USACE (1978)	Banner (1995)	Houston (2026)	
Contributing Drainage Area	496	603	652.76	square miles
Precipitation Data Source and Modeling	Unclear possibly a draft of HMR 51 or HMR 33	HMR 51	Nebraska Statewide PMP, HMR 52, & HEC-HMS	n/a
PMP Duration	Unclear, likely either 24 or 48	48	48	hours
PMP Total	22	21.9	17.25	inches
Hydrograph Development and Modeling	National Inspection of Dams, Hydrologic Analysis Program	National Inspection of Dams, Hydrologic Analysis Program	HEC-RAS 2D	n/a
PMF Peak Reservoir Inflow	77,300	102,800	218,990	cfs
0.5 PMF Peak Reservoir Inflow	37,600	50,100	109,495	cfs
Approximate Water Depth at Dam	2.4 ft below dam crest	0.4 ft below dam crest	Overtops dam by 5.5 ft	feet

Discussion of Request

The discussion of this variance request will focus on review and discussion of the report by Houston. This discussion will also provide some limited background to assist with understanding the Houston report on topics where that background will assist with making a recommendation on this request. The Houston report is attached to the City's variance request.

Houston modeled multiple breach and non-breach scenarios using the US Army Corps of Engineers' HEC-RAS 2D (version 6.7) software and compiled information for the population at risk (PAR) in those scenarios. HEC-RAS 2D is a standard software widely used in the dam safety industry for this type of analysis. PAR is the population present in the area inundated by a dam failure. For defining a dam as high hazard, the State's rules and past practice focus on overnight accommodations (homes, hotels, campgrounds etc.) in the inundation area so, following that and discussion with Water Rights Program staff, the focus of the different modeled scenarios was the impact to habitable structures in the danger zone for a dam breach at the 0.5 PMF event. The locations of those 18 structures are provided in the first several pages of the Appendix in the Houston report. Note that structures 1 though 13 are between the dam and the confluence of Firesteel Creek and the James River. The remaining structures are along the James River, and due to the very flat nature of the James River structures 9, 10, and 11 are upstream of the confluence. Water Rights did ask Houston about the Interstate 90 crossing over the James River downstream of the Firesteel Creek-James River confluence, and it was indicated the bridge didn't overtop (Kelly, 2026).

The two major factors for looking at a flood risk to habitable structures are the depth of flood waters and the velocity of flood waters. USBR (1988) sets danger zones for different depth velocity combinations for houses built on foundations, this is provided in Figure 2. Table 3 provides the danger zone for each structure at the 0.23 PMF event both with and without a dam breach. Table 3 shows the danger zone for each structure if the dam was upgraded to be able to pass the 0.5 PMF event both with and without dam failure. The cost to rehabilitate/modify the dam to pass the 0.5 PMF event without failure would likely be in the millions of dollars, based on the cost of other recent dam rehabilitation projects in SD (Water Rights, 2026). However, in the the Finding of Facts and Conclusions of Law for the denial of the Fourth Street dam variance request by the City of Pierre the Board concluded, "The existence of collateral benefits to residents of the City and the lower costs to residents of the City from the grant of the variance are not factors which may be considered in the grant of the variance." (Water Rights, 2026)

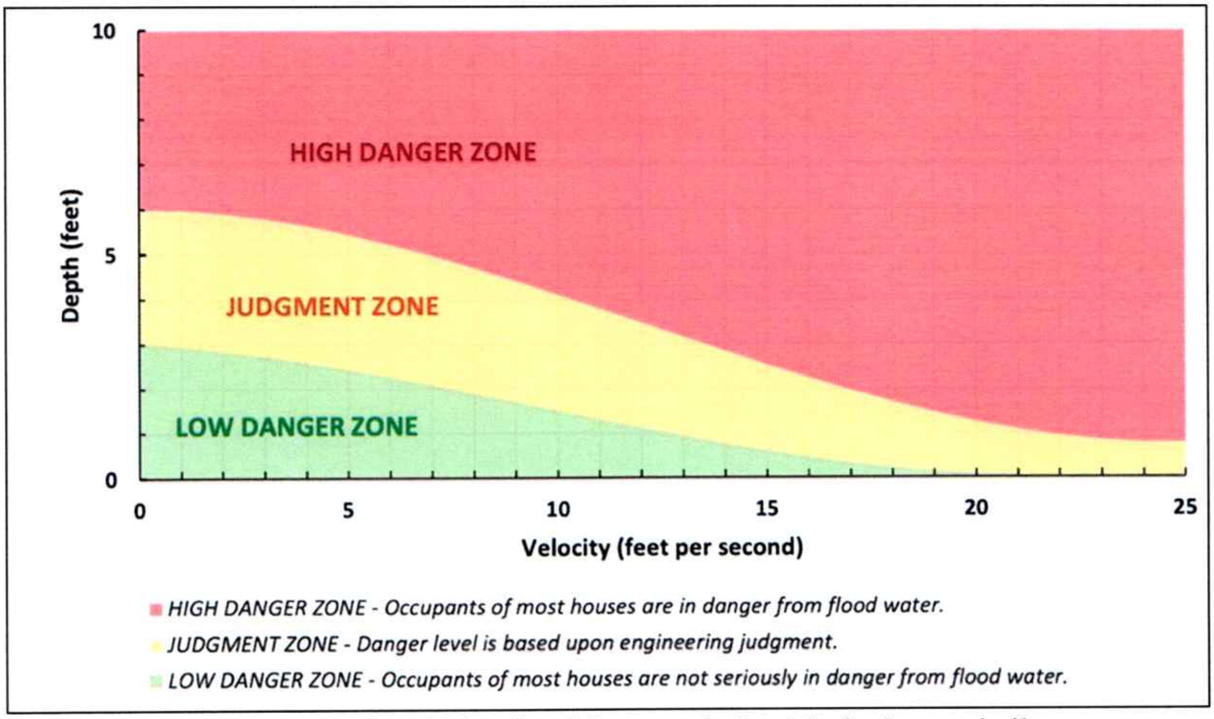

Figure 2: USBR (1988) depth-velocity-flood danger relationship for houses built on foundations

Table 2: Risk to habitable structures (ID Nos. 1 through 18) with and without dam failure at the 23% PMF - ▲denotes increased risk (Houston, 2026)

	23% PMF						
	No Dam Failure			Dam Failure			
	Depth, D	Velocity, V	Hazards	Depth, D	Velocity, V	Hazards	
ID	ft	ft/s	USBR ACER TM No. 11	ft	ft/s	USBR ACER TM No. 11	
1	0.0	0.0		0.0	0.0		
2	0.0	0.0		0.0	0.0		
3	0.0	4.4	L	2.3	6.3	J	▲
4	4.3	2.7	J	6.7	3.8	H	▲
5	4.6	2.8	J	7.0	3.9	H	▲
6	3.0	2.1	J	5.4	2.7	J	
7	0.0	0.0		0.0	0.0		
8	0.0	1.3	L	1.8	1.6	L	
9	0.0	0.0		0.0	0.0		
10	1.5	0.8	L	2.4	0.8	L	
11	0.0	0.0		0.0	0.0		
12	0.0	0.0		0.0	0.0		
13	2.4	4.7	L	3.9	5.3	J	▲
14	0.0	0.0		0.0	0.0		
15	0.0	0.0		0.0	0.0		
16	0.0	0.0		0.0	0.0		
17	0.0	0.0		0.0	0.0		
18	0.0	0.0	L	0.8	0.5	L	

Table 3: Danger zone for downstream structures (ID Nos. 1 through 18) if the dam was upgraded to pass the 0.5 PMF - ▲denotes increased risk (Houston, 2026)

	50% PMF Modified Spillway						
	No Dam Failure			Dam Failure			
	Depth, D	Velocity, V	Hazards	Depth, D	Velocity, V	Hazards	
ID	ft	ft/s	USBR ACER TM No. 11	ft	ft/s	USBR ACER TM No. 11	
1	0.0	0.0		0.0	0.0		
2	2.4	3.3	L	4.1	3.7	J	▲
3	5.9	6.4	H	7.5	6.8	H	
4	12.7	4.6	H	14.4	5.1	H	
5	11.2	4.4	H	12.8	4.7	H	
6	12.3	3.3	H	14.0	3.6	H	
7	3.1	2.7	J	4.8	3.1	J	
8	7.8	1.9	H	9.4	2.1	H	
9	0.6	0.9	L	1.1	0.8	L	
10	7.1	1.3	H	7.5	1.3	H	
11	0.8	0.5	L	1.3	0.6	L	
12	1.9	2.0	L	3.0	2.3	J	▲
13	10.0	6.3	H	10.8	6.6	H	
14	2.9	0.5	L	3.3	0.5	J	▲
15	2.6	0.7	L	3.0	0.7	L	
16	0.4	1.0	L	0.8	1.0	L	
17	3.0	1.3	J	3.4	1.4	J	
18	4.8	1.2	J	5.1	1.3	J	

From Table 2 it can be seen that a dam failure at the 0.23 PMF (current spillway capacity) puts two downstream structures in this high danger zone. Houston (2026) did note that a 0.23 PMF event with no dam present would result in flooding between the 0.23 PMF with no dam failure and the 0.23 PMF with dam failure. From Table 3 it can be seen that if the dam were modified to pass the 0.5 PMF event even without dam failure seven structures would be in the high danger zone. This indicates that at the current level of development in the area downstream of the dam requiring an increase in spillway capacity to the 0.5 PMF as required by rules would increase the danger to downstream residences from flooding. The danger zones for the downstream structures at the 0.23 PMF with dam failure and 0.5 PMF event without dam failure are shown directly adjacent in Table 4. The charge in SDCL 46-7-5.3 is, "the Board may grant a variance upon a finding that failure of the dam due to inadequate spillway capacity will not increase the potential for damage from flooding to downstream residents or property". Given this information at the current level of downstream development, there is a case for a variance to allow the current spillway capacity to be maintained.

Table 4: Comparison of the danger zones for the dam being modified to pass the 50%PMF and the danger zones with a dam failure at the 23%PMF (Houston, 2026)

	Modified 50% PMF			23%PMF Dam Failure		
	No Dam Failure			Dam Failure		
	Depth, D	Velocity, V	Hazards	Depth, D	Velocity, V	Hazards
ID	ft	ft/s	USBR ACER TM No. 11	ft	ft/s	USBR ACER TM No. 11
1	0.0	0.0		0.0	0.0	
2	2.4	3.3	L	0.0	0.0	
3	5.9	6.4	H	2.3	6.3	J
4	12.7	4.6	H	6.7	3.8	H
5	11.2	4.4	H	7.0	3.9	H
6	12.3	3.3	H	5.4	2.7	J
7	3.1	2.7	J	0.0	0.0	
8	7.8	1.9	H	1.8	1.6	L
9	0.6	0.9	L	0.0	0.0	
10	7.1	1.3	H	2.4	0.8	L
11	0.8	0.5	L	0.0	0.0	
12	1.9	2.0	L	0.0	0.0	
13	10.0	6.3	H	3.9	5.3	J
14	2.9	0.5	L	0.0	0.0	
15	2.6	0.7	L	0.0	0.0	
16	0.4	1.0	L	0.0	0.0	
17	3.0	1.3	J	0.0	0.0	
18	4.8	1.2	J	0.8	0.5	L

FEMA (2013a) on selecting inflow design floods (IDFs) for dams contains discussion of using the incremental consequence analysis for selecting the design IDF for a dam. Within this approach, FEMA defines the IDF as, "The IDF selected using incremental consequence analysis is the flood above which there is a negligible increase in downstream water surface elevation, velocity, and/or consequences due to failure of the dam when compared to the same flood without dam failure." FEMA (2013a) goes on to state that, "For a High Hazard Potential dam, the recommended lower limit for an IDF estimated using incremental consequence analysis is the 0.2% annual chance exceedance flood." The 0.2% annual chance exceedance (ACE) flood is also known as the 500-year flood event, which is a flood event with a 1 in 500 chance (0.2%) of occurring or being exceeded in any given year. Houston calculated the peak inflow into the reservoir at 0.2% ACE event to be 29,529 cfs, which is below the 0.23PMF peak inflow of 50,368 cfs (current spillway capacity).

Recommendation

Pursuant to SDCL § 46-7-5.3, the Chief Engineer is recommending the Water Management Board grant the City of Mitchell's variance request for Lake Mitchell Dam. Based on review of information and analysis provided by Houston, submitted with the variance request, a variance from the spillway requirements of the Safety of Dams Rules could be granted since the risk to the public in the inundation area would not be meaningfully decreased by upgrading the dam to pass the 0.5 PMF without failure. However, to provide additional protection of public safety several qualifications for that approval are recommended and discussed below.

1. The EPP be updated and reviewed annually. The EPP is required to include details on how and when to warn the residences and business that are most at risk for loss of life from a dam failure.

   This qualification is recommended because it is imperative that the EPP be periodically reviewed and updated to prevent loss of life, and to provide an accurate and up to date evacuation plan. Widely accepted standard of care for high hazard dams in the United States include having and maintaining an EPP that is periodically reviewed and kept updated (typically annually). State rules only require high hazard dams in South Dakota have an EPP. The existing EPP for the dam on file with the Water Rights Program was last updated June 11, 1987. It has been standard practice for the Water Rights Program to inspect the Lake Mitchell Dam every three years in accordance with ARSD 74:02:08:11 and provide the dam owner with a copy of the Program's inspection report. Program inspection reports from 2010, 2013, 2017, 2019, and 2022 have all recommended the EPP be reviewed and updated.

2. The dam owner is responsible for ensuring an EPP tabletop exercise be held at least every six years.

   This qualification is recommended because familiarity with, and adequacy in executing an EPP, is critical to preventing loss of life. A tabletop exercise helps both staff and participants get familiar with, and maintain familiarity with, the EPP and the emergency response process in a risk-free environment. The most basic goal of a tabletop exercise is to ensure responders know exactly what to do in an emergency. It can also help identify weaknesses in an EPP that need to be reviewed and updated. Tabletop exercises are increasing becoming a requirement by state regulatory agencies nationwide for high hazard dams. FEMA (2013b) recommends a tabletop exercise at least every three to four years for a high hazard dam. Currently, the Water Rights Program aims to inspect high hazard dams every three years. Therefore, six years is recommended to align with a tabletop exercise with every other routine inspection. When possible qualifications were discussed with Houston and the City, the initial suggestion was an exercise at least every five years, but six is recommended to line up with the inspection cycle.

3. The variance is subject to periodic review by the Water Rights Program. Upon review, if it is determined that the risk associated with the variance has increased the potential for damage from flooding to downstream residents or property compared with the risk associated with compliance with the SD Safety of Dam Rules, the Chief Engineer may recommend revocation of the variance to the Board. Any such recommendation is subject to the procedure contained in Chapter 46-2A.

   The case for this qualification is twofold. First, this qualification charges the Water Rights Program with routinely reviewing the area of inundation and assessing changes in risk from a dam failure due to changes in development, known as hazard creep. Since the last variance was recommended for approval, the understanding of how hazard creep affects risk associated with dams has advanced. Routine review of the downstream inundation area for new development helps identify any changes in risk due to hazard creep. The Water Rights Program does not currently have a requirement or procedure to routinely review state regulated dams for changes in the downstream population at risk (PAR). This includes having no requirement or procedure to currently routinely review dams with an approved variance to check if new development (hazard creep) has occurred downstream that increased the potential for damage from flooding to downstream residents or property due to failure of the dam from the approved lower spillway capacity.

   The intent of the dam safety standards is public safety. So second, this qualification accomplishes this intent by encouraging the city to utilize its planning and zoning powers to limit future development in the inundation area that could increase the population at risk in the event of a dam failure. It also encourages the City to work with the County to do the same. The use of a buffer zone outside of the mapped inundation area is encouraged to account for any modeling uncertainties.

   The variance is subject to periodic review. These reviews may be conducted as part of routine inspection of the dam by the Water Rights Program, during any spillway repair, rehabilitation, or replacement project, or any dam rehabilitation project, excluding the water quality project currently under design. Upon review, if it is determined that the risk associated with the variance has increased the potential for damage from flooding to downstream residents or property compared with the risk associated with compliance with the Safety of Dam Rules, the Chief Engineer may recommend revocation of the variance to the Board. Any such recommendation would be subject to the procedure contained in Chapter 46-2A

The Water Rights Program considers dam EPPs to be for official use only, so not open to inspection or copying pursuant to SDCL 1-27-1.5. Therefore, City of Mitchell is also encouraged to make the inundation mapping information for Lake Mitchell publicly available through the National Inventory of Dams or other publicly accessible source.

Conclusions

1. The City of Mitchell has petitioned to the Water Management Board for a variance from the minimum spillway design requirements pursuant to SDCL 46-7-5.3. Lake Mitchell Dam is an intermediate sized, category 1 (high hazard) dam which is a dam whose failure may cause loss of life.

2. A review of the analysis and report by Houston Engineering Inc. provides a case for recommending approval of the variance request with qualifications. Requiring an increase in spillway capacity from the current capacity of 0.23 PMF to the 0.5 PMF, as required by rules, increases the danger to downstream residences from flooding.

3. Advances in dam safety practices since the passage of SDCL 46-7-5.3 and last updates to the State's Safety of Dams Rules, and following the last variance approval, lead to recommending the following qualifications be attached to approval of this variance request to offer additional public safety protections.
   - The EPP be updated and reviewed annually. The EPP is required to include details on how and when to warn the residents and business owners who are most at risk for loss of life from a dam failure.
   - The dam owner is responsible for ensuring an EPP tabletop exercise be held at least every six years.
   - The variance is subject to periodic review by the Water Rights Program. Upon review, if it is determined that the risk associated with the variance has increased the potential for damage from flooding to downstream residents or property compared with the risk associated with compliance with the Safety of Dam Rules, the Chief Engineer may recommend revocation of the variance to the Board. Any such recommendation is subject to the procedure contained in Chapter 46-2A.

Whitney Kilts

Whitney Kilts
Natural Resources Engineer III
SDDANR-Water Rights Program

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Appendix A: Summary of Past Variance requests

Table A1: Summary of past variance Requests

Dam	NID ID	Requested Variance	Decision	Heard	Year of last EPP Update	Reasoning
Redfield	SD00699	30% PMF	Approved	May 1987	2009	Allowing a lower spillway capacity only adds 1.6 to 3 feet on top the 20 to 30 feet inundation depths at the 0.5 PMF without a dam, so it was determined there was no increased risk.
Opal	SD00308	25% PMF	Approved	Dec 1988	2010	Allowing lower would not significantly increase risk, the 1st house downstream had an additional 1 ft of flooding but was outside of critical failure zone.
Lake Farley	SD01030	15% PMF	Approved	Dec 1989	2020	Failure of dam during 50% PMF event would add less than 1 ft of depth to the 18 to 24 ft depths during the 50% PMF with no dam, so it was determined there was no increased risk. Also, the Hwy 15 bridge only being sized for 32 yr flood and creating backwater flooding was considered.
Fourth Street	SD	Not specified	Denied	Mar 1991	1991	Flooding at the DOT building would go from 0.79 ft to 2.47 ft, which would cause significant additional damage to the State's computer system.
Lake Wanalain	SD00716	26% PMF	Approved	May 1993	1992	No increased risk from lower capacity was found. Dam provides some downstream flood reduction befits.

DEPARTMENT of AGRICULTURE
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RECOMMENDATION OF ACTING CHIEF ENGINEER FOR REQUEST FOR A VARIANCE FROM SPILLWAY REQUIREMENTS FOR Lake Mitchell Dam, Davison County

Pursuant to SDCL 46-2A-2, the following is the recommendation of the Acting Chief Engineer, Water Rights Program, Department of Agriculture and Natural Resources concerning the petition submitted by the City of Mitchell, Mayor Jordan Hanson, 612 North Main Street, Mitchell, SD 57301, requesting the Water Management Board to grant a variance from spillway requirements for Lake Mitchell Dam.

The Acting Chief Engineer is recommending that the request for a variance to Water Management Board Rule 74:02:08:17 be GRANTED WITH QUALIFICATIONS since failure of the dam due to inadequate spillway capacity will not increase the potential for damage or loss of life from flooding to the inundation area.

The following qualifications to the variance are recommended:

1. Construction or removal of a dam as defined by Administrative Rules of South Dakota (ARSD) 74:02:08:01(7) will need to comply with ARSD Chapter 74:02:08, Safety of Dams Rules, including approval of plans and specifications by the Chief Engineer prior to any reconstruction, alteration, repair, or breaching of the dam.

2. The Emergency Preparedness Plan (EPP) shall be updated and reviewed annually. The EPP is required to include details on how and when to warn the residences and business that are most at risk for loss of life from a dam failure.

3. The dam owner is responsible for ensuring an EPP tabletop exercise be held at least every six years (see below note).

4. The variance is subject to periodic review. Upon review, if it is determined that the risk associated with the variance has increased the potential for damage from flooding to downstream residents of property compared with the risk associated with compliance with the Safety of Dams Rules, the Chief Engineer may recommend revocation of the variance to the Board. Any such recommendation is subject to the procedure contained in SDCL Chapter 46-2A.

See report on variance request for additional information.

Adam Mathiowetz, PE
Acting Chief Engineer
March 25, 2026

NOTE In regard to an EPP tabletop exercise, ARSD 74:02:08:11 states in part, "The Chief Engineer may inspect all category 1 dams at least once every five years…" Previously, the Water Rights Program has recommended to the City of Mitchell to conduct at tabletop exercise along a five-year schedule as part of discussions regarding this variance petition. However, the Water Rights Program typically inspects category 1 (high hazard) dams every three years. The six-year maximum cycle of tabletop exercise is to align with a two-inspection cycle.

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Lake Mitchell Inflow Design Flood Update Study

City of Mitchell

February 27, 2026

Cover Photo Credit Adam Thury/Mitchell Republic

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a Registered Professional Engineer under the laws of the State of South Dakota.

REGISTERED PROFESSIONAL ENGINEER
REG. NO.
15613
MICHAEL
M. OPAT
SOUTH DAKOTA

Michael M. Opat

Registration No. 15613

2/27/2026

Date

Houston Engineering, Inc.

12702 Westport Parkway, Suite 300
Omaha, NE 68138

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List of Acronyms, Abbreviations, Units

AEP	Annual Exceedance Probability
AMC	Antecedent Moisture Condition
ARF	Areal Reduction Factor
ARSD	Administrative Rules of South Dakota
AS	Auxiliary Spillway
AWA	Applied Weather Associates
CFD	Computational Fluid Dynamics
cfs	Cubic feet per second
CN	Curve Number
DANR	Department of Agriculture and Natural Resources
DEM	Digital Elevation Model
DV	Depth times Velocity
EM	Engineer Manual
EPP	Emergency Preparedness Plan
FBH	Freeboard Hydrograph
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
HMR	Hydrometeorological Report
HMS	Hydrologic Modeling System
HSG	Hydrologic Soil Group
ICA	Incremental Consequence Analysis
IDF	Inflow Design Flood
LiDAR	Light Detection and Ranging
NAVD	North American Vertical Datum
NID	National Inventory of Dams
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWS	National Weather Service
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PSH	Principal Spillway Hydrograph
RAS	River Analysis System
ROG	Rain-on-grid

SSP	Statistical Software Package
TP	Technical Paper
TR	Technical Release
USACE	US Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	United States Geologic Survey
WSE	Water Surface Elevation

1 Executive Summary

The City of Mitchell completed a comprehensive hydrologic and hydraulic evaluation of the Lake Mitchell Dam to meet requirements from the South Dakota Department of Agriculture and Natural Resources (DANR) and to ensure the continued protection of downstream residents, property, and infrastructure. The study was initiated following DANR correspondence dated September 19, 2025, and reflects modern dam safety standards, updated data, and current best practices.

Lake Mitchell Dam, originally constructed in 1928, is classified as a High Hazard dam, meaning that a failure could result in loss of life. As a result, state regulations require the dam to be evaluated against extreme flood events, including the Probable Maximum Flood (PMF) – the largest flood that could reasonably occur based on current scientific understanding.

The assessment included:

- Updated watershed and rainfall analysis using modern precipitation information, LiDAR data, and current land-use information.
- Hydrologic and hydraulic modeling of extreme flood events on Firesteel Creek informed by 70 years of stream gage history
- Computational fluid dynamics modeling of the spillway to determine its true capacity
- Dam breach and downstream flood mapping
- An Incremental Consequence Analysis (ICA) to evaluate public safety impacts under different flood and dam-failure scenarios
- Updates to emergency planning information

Key Findings:

- The updated analysis shows that the existing spillway cannot safely pass the 50% PMF without overtopping the dam, which is a design requirement for reservoirs in South Dakota of the size of Lake Mitchell.
- Upgrading the spillway to pass the full 50% PMF would be costly, invasive, and would not eliminate downstream risk, as higher flows would still move through areas with population at risk.
- Modeling indicates the dam can safely pass floods up to approximately a 23% PMF without overtopping, which is an event that has a very low annual probability of occurrence of roughly 0.1% or that of a 1000-yr event.
- A risk-based evaluation shows that a reduced Inflow Design Flood (IDF) can be justified for this structure

Risk-Based Evaluation

An Incremental Consequence Analysis (ICA) was conducted to assess the impact of downstream flooding both with and without dam failure across various flood magnitudes, with the primary focus on whether a dam failure would significantly increase risks to people and property. The analysis determined that for the 23% PMF event, there is little to no difference in downstream risk between scenarios with and without dam failure. It was also found that several downstream structures are already subject to elevated flood risks due to their proximity to the dam, limited evacuation options, and short warning periods, regardless of dam performance. Furthermore, expanding the spillway to accommodate the 50% PMF would not substantially decrease overall risk and residual hazards would remain.

Recommended Path Forward

1) The City has a strong technical and public-safety basis to request a variance from DANR to allow a 23% PMF to serve as the Inflow Design Flood, consistent with state law and FEMA guidance.
2) Emergency planning materials should be kept current, including annual updates to the Emergency Preparedness Plan (EPP).
3) Periodic emergency response exercises are recommended to ensure coordination and readiness.
4) Long-term land-use planning downstream of the dam should limit future development in flood-prone areas.

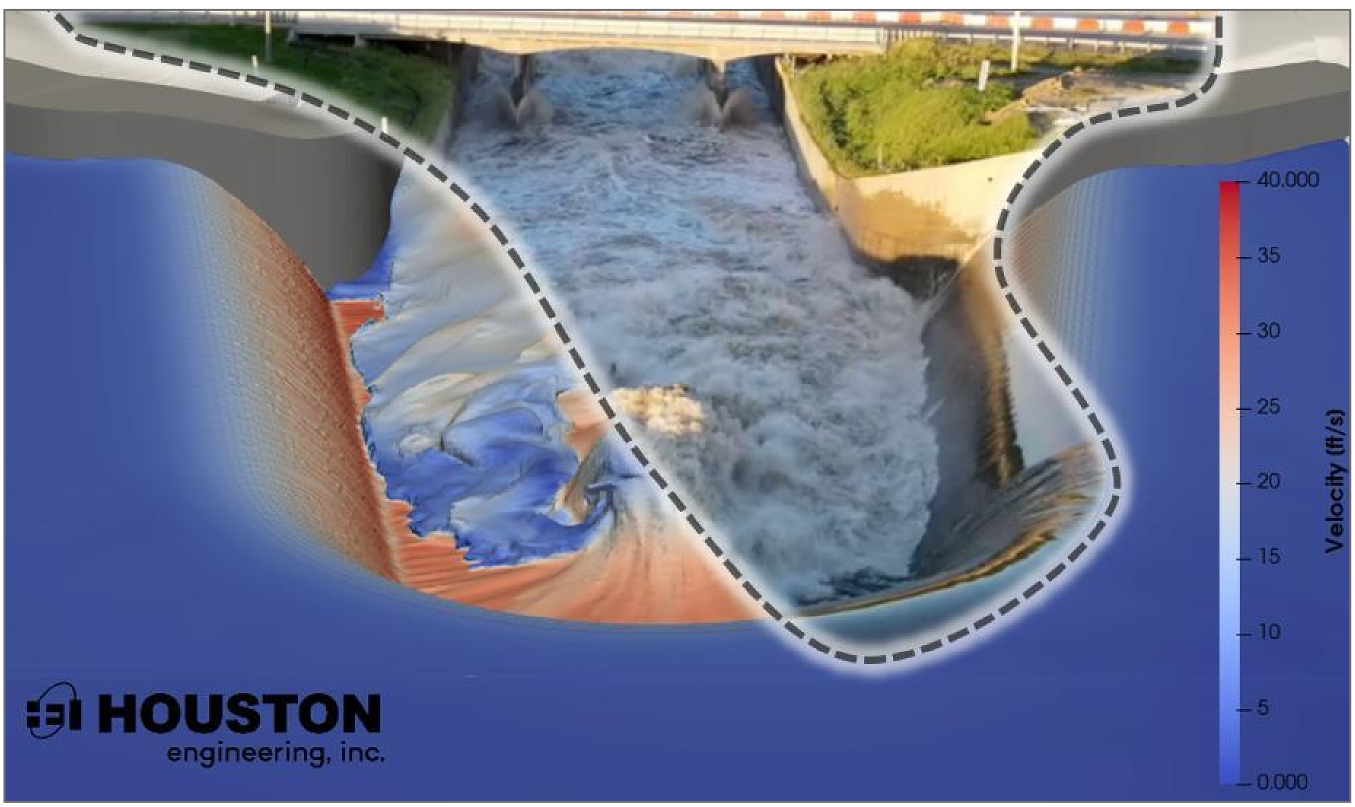

Figure 1 – CFD Modeling matches observed flow patterns within the Lake Mitchell Horseshoe Ogee-weir Spillway

2 Introduction

2.1 Project Background and Objectives

The City of Mitchell is undertaking a comprehensive assessment of the Lake Mitchell Dam in response to requirements set forth by the South Dakota Department of Agriculture and Natural Resources (DANR).This initiative is in direct response to correspondence from DANR dated September 19, 2025, which outlines the studies and documentation necessary to ensure compliance with ARSD 74:02:08 Safety of Dams and current best practices prior to the approval of any dam reconstruction plans.

As a category 1 (potential loss of life) hazard class and intermediate size class dam, Lake Mitchell Dam is subject to state regulations requiring demonstration of safe performance under the 50% Probable Maximum Flood (PMF) event. The following studies and updates are mandated by DANR to confirm compliance:

- **Updated 50% PMF Study:** Incorporate the best available watershed data, including current LiDAR-derived terrain models, updated probable maximum precipitation estimates, and relevant hydrologic information. The objective is to determine whether the existing spillway can safely pass the 50% PMF, or other risk-based inflow design flood, in accordance with state dam safety standards.
- **Spillway Capacity Evaluation:** Review and, if necessary, update the rating curve for the horseshoe weir spillway using modern computational fluid dynamics (CFD) hydraulic modeling tools to ensure accurate performance under revised 50% PMF conditions.
- **Dam Breach Analysis and Inundation Mapping:** Conduct a breach analysis using the updated 50% PMF, or other risk-based inflow design flood, and produce updated inundation maps. These materials are essential for evaluating downstream risk and informing emergency planning.
- **Updated Emergency Preparedness Plan (EPP):** Revise the EPP to reflect the updated breach and inundation scenarios, identify properties and infrastructure potentially impacted by a dam failure, and ensure current contact and emergency response information is included. Guidance from FEMA 64 and the NRCS Form Fillable EAP Template should be referenced.

This engineering study is prepared to address the above requirements. In addition, a variance from the standard 50% PMF requirement is being pursued by means of an incremental damage assessment. This assessment will establish an inflow design flood that the dam can acceptably pass, based on an incremental damage analysis, in accordance with state dam safety regulations and best practices.

2.2 Incremental Consequence Analysis (ICA) and Inflow Design Flood (IDF) Requirements

When results of the study determine that the existing spillway is unable to safely pass the 50% PMF, state regulations allow for the pursuit of a variance to approve a lower percentage of the probable maximum flood event. The process proposed for requesting a variance requires:

1. Completion of an Incremental Consequence Analysis (ICA) to evaluate the incremental increase in downstream consequences resulting from dam failure under various flood scenarios.

2. Identification of an Inflow Design Flood (IDF) that the dam can acceptably pass, based on the results of the ICA. The IDF is selected such that the incremental consequences of dam failure do not result in unacceptable additional risk to public safety.
3. Preparation of adequate documentation and study results to justify the variance request for review and approval by the Chief Engineer. The justification must focus on public safety aspects associated with the proposed IDF.

3 Dam and Reservoir Description

Houston Engineering received historical documents describing the previous inspections and modifications to the dam and reviewed the information contained within them. The following is a summary of Houston Engineering's findings in those documents as well as updated watershed characteristics.

3.1 Lake Mitchell Dam

The dam was constructed in 1928 with projects to modify the dam, spillway, and stilling basin occurring in 1943, 1945, 1960, 1963, 1981, 1993, and 1998. As stated on the USACE National Inventory of Dams (NID) site (National Inventory of Dams), the dam is a 55 ft high earthen embankment dam with an uncontrolled spillway owned by the City of Mitchell, SD. The Dam ID is SD00685 with its location listed as Latitude 43.738117, Longitude -98.025892 in Davison County, South Dakota. The dam is located on Firesteel Creek. The dam is listed as High Hazard.

3.2 Lake Mitchell Reservoir

The current elevation-storage relationship was developed using Light Detection and Ranging (LiDAR) data. An elevation-storage table could not be located from the as-built drawings. Therefore, storage below the spillway crest elevation could not be determined. Figure 2 shows the current capacity curve for the reservoir with the zero (0) value of flood storage set at the spillway crest elevation. Within the analyses explained below, the normal storage below the spillway crest elevation was not required to perform the reservoir routings.

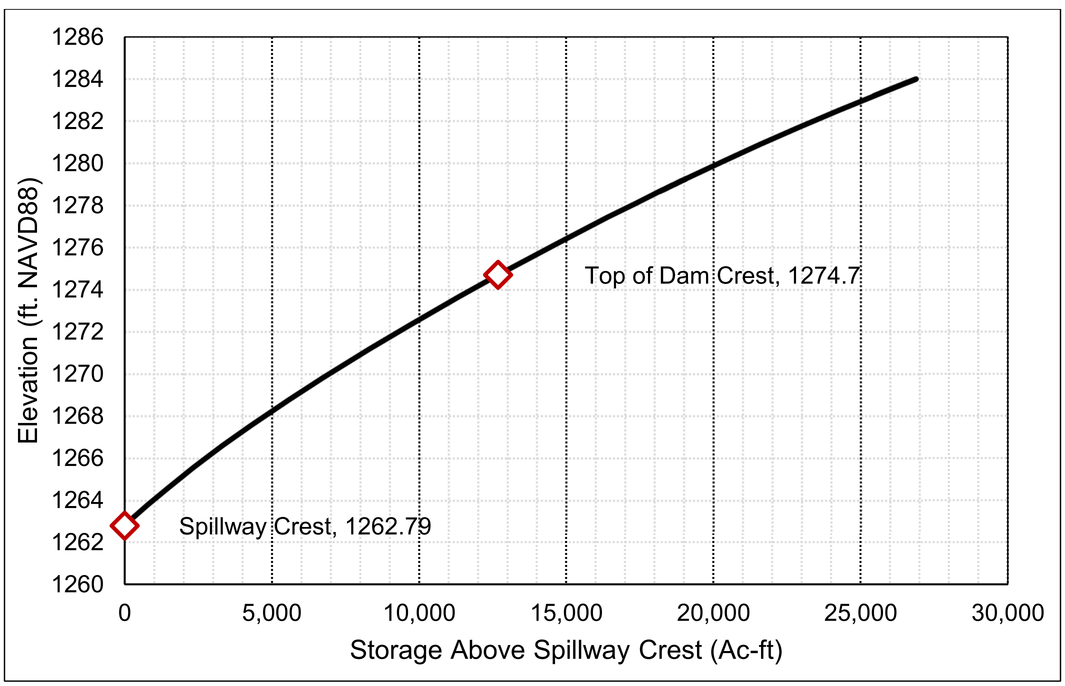

Figure 2 - Lake Mitchell Elevation-Storage Relationship

3.3 Watershed Characteristics

To determine the current drainage area for the watershed, HEC-River Analysis System (HEC-RAS) (version 6.7) was used. Using the rain-on-grid approach, the watershed boundary was carefully delineated based on flow directions from each cell. The total drainage area to Lake Mitchell can be seen in Figure 3 below. A 3-meter Digital Elevation Model (DEM) was used as the underlying terrain, sourced from the SDDANR LiDAR site.

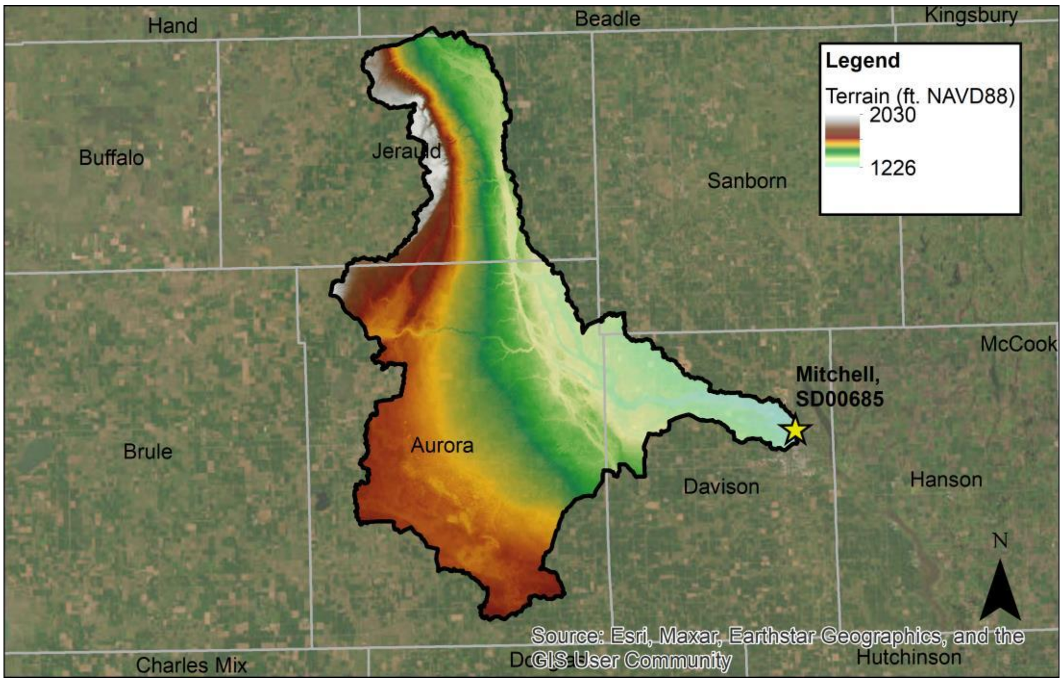

Figure 3 - Lake Mitchell Watershed

Landcover data was obtained from the National Land Cover Database (NLCD). The NLCD shows that much of the watershed is comprised of cultivated crops and pasture/hay. Table 1 below details the watershed composition with respect to landcover using NLCD 2024 data.

Table 1 – Landcover Distribution

NLCD Type	% of Watershed
Open Water	1.07%
Developed, Open Space	3.35%
Developed, Low Intensity	1.00%
Developed, Medium Intensity	0.27%
Developed, High Intensity	0.04%
Deciduous Forest	0.39%
Evergreen Forest	0.01%
Grassland-Herbaceous	5.10%
Pasture-Hay	39.77%
Cultivated Crops	45.10%
Woody Wetlands	0.03%
Emergent Herbaceous Wetlands	3.87%

Landcover within the watershed can be seen in Figure 4 below.

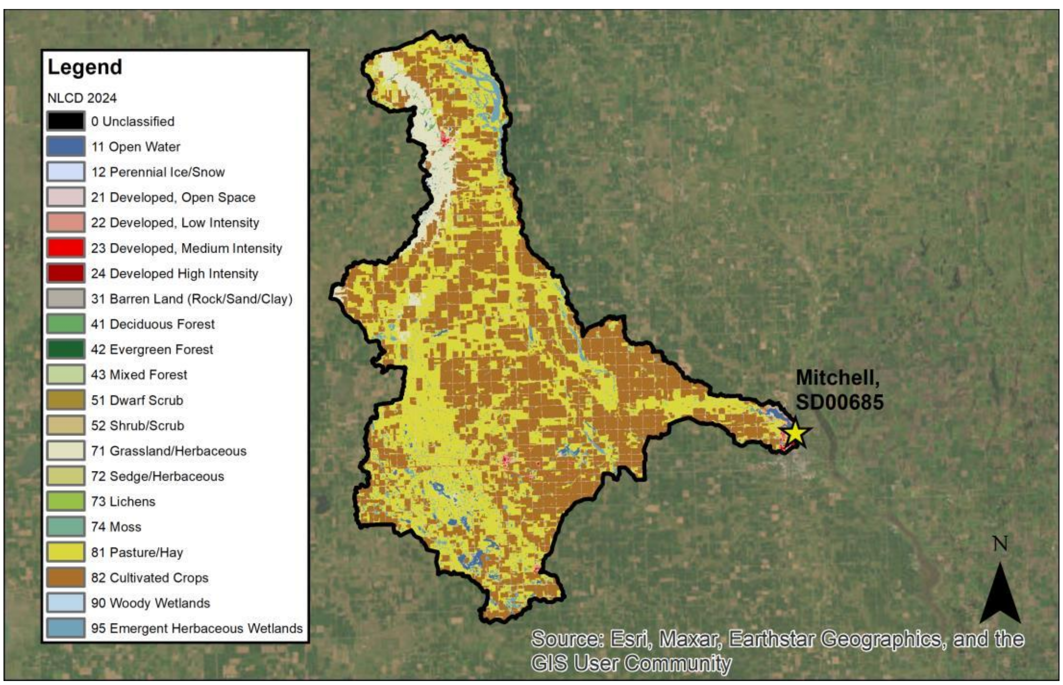

Figure 4 - Watershed Landcover

Hydrologic Soil Group (HSG) information for the watershed is shown in Table 2 below. The data shows that much of the watershed is comprised of HSG C. Certain areas from the USDA's data includes HSG type "None", which accounts for open water areas. For the areas labelled as "None", a HSG of type D was assigned to assume worst case soils.

Table 2 - Hydrologic Soil Group Distribution

HSG	% of Watershed
A	1.22%
B	14.05%
C	63.40%
D	20.87%
None	0.45%

Hydrologic Soil Groups within the watershed can be seen in Figure 5 below.

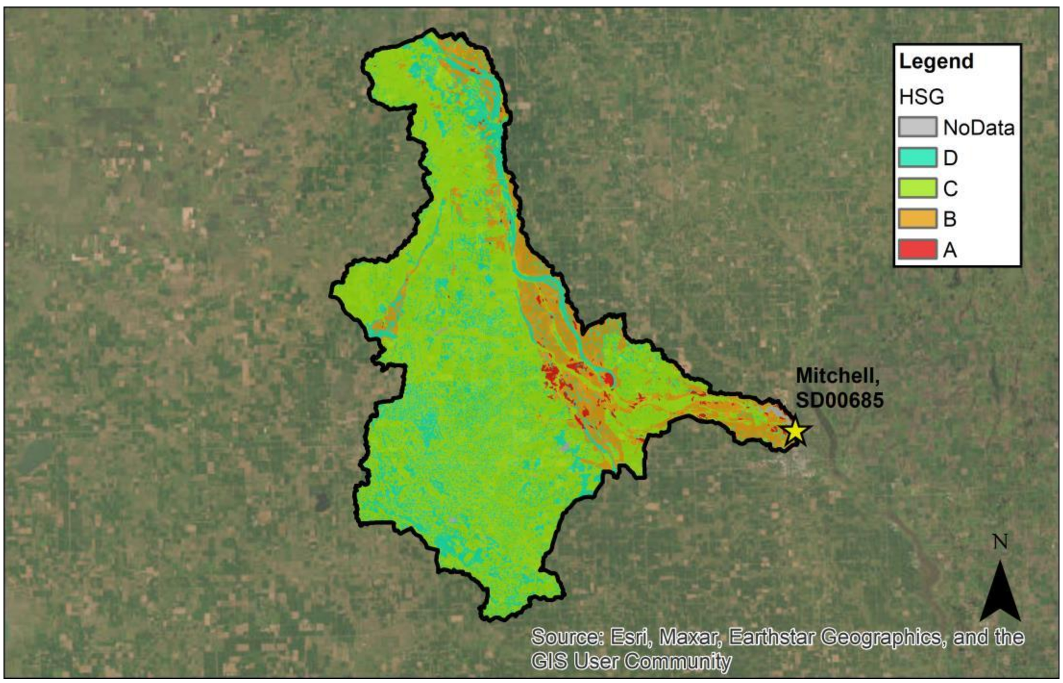

Figure 5 – Watershed HSG

Table 3 provides a location of Lake Mitchell and the total drainage area based on the hydrologic analysis performed.

Table 3 - Watershed Characteristics

Parameter	Value	Unit
Dam Location (Latitude, Longitude)	43.738117, -98.025892	DD
Drainage Area	652.76	sq. mi

4 Hydrologic Analysis

The hydrologic analysis involved using USGS gage data, NOAA Atlas 14 and the Nebraska Statewide PMP Study by AWA for precipitation depths, NLCD, and CN data to assess hydrographs at the USGS gage and Lake Mitchell Dam locations. The overall goal of the rain-on-grid model is to be calibrated to the 1% ACE (100-yr) flow rate at the USGS gage location. Once calibration is complete, the PMP event is analyzed to determine the PMF hydrograph into Lake Mitchell. This allows for determination of the 50% PMF event.

The following steps were taken to perform the hydrologic analysis:

1. Delineate the watershed
2. Determine soil losses
3. Determine precipitation estimates
4. Determine the rainfall-runoff response from precipitation events using a rain-on-grid (ROG) model
5. Calibrate the ROG model to the Firesteel Creek gage analysis
6. Determine the resulting inflow hydrographs to the dam reservoirs for various design flows

Events analyzed include the 100-year, 48-hr event, which allowed for the ROG model calibration the 100-year, 10-day event, and the Probable Maximum Precipitation (PMP) event, which yields the Probable Maximum Flood (PMF) event. The watershed delineation is described in Section 3.3 above. Soil losses, precipitation estimates for the 100-yr events, and the ROG modeling and calibration are discussed in Section 4.1 and 4.2 below. Precipitation estimates for the PMP event and the resulting inflow hydrograph for the PMF event are discussed in Section 4.3 and Section 4.4 below respectively.

4.1 Firesteel Creek Gage Analysis

Data from the USGS National Water Information System was downloaded and analyzed for the 06477500 FIRESTEEL CREEK NEAR MOUNT VERNON, SD gage. The gage has 70 years of recorded data. Figure 6 below shows that peak flows occur during Spring and Summer within the Lake Mitchell Watershed; with a majority of annual peak flows produced during warm season rain event, based on review of the month in which annual peak flows where recorded. Annual peaks recorded in February through April are potentially influenced by snowmelt, however the maximum peak flow rates have been recorded during warm season events. While not directly modeling snowmelt as part of the PMF development – an approach which includes 100-yr rain event antecedent conditions – “primes” the watershed for enhanced runoff similar in manner to antecedent snowpack.

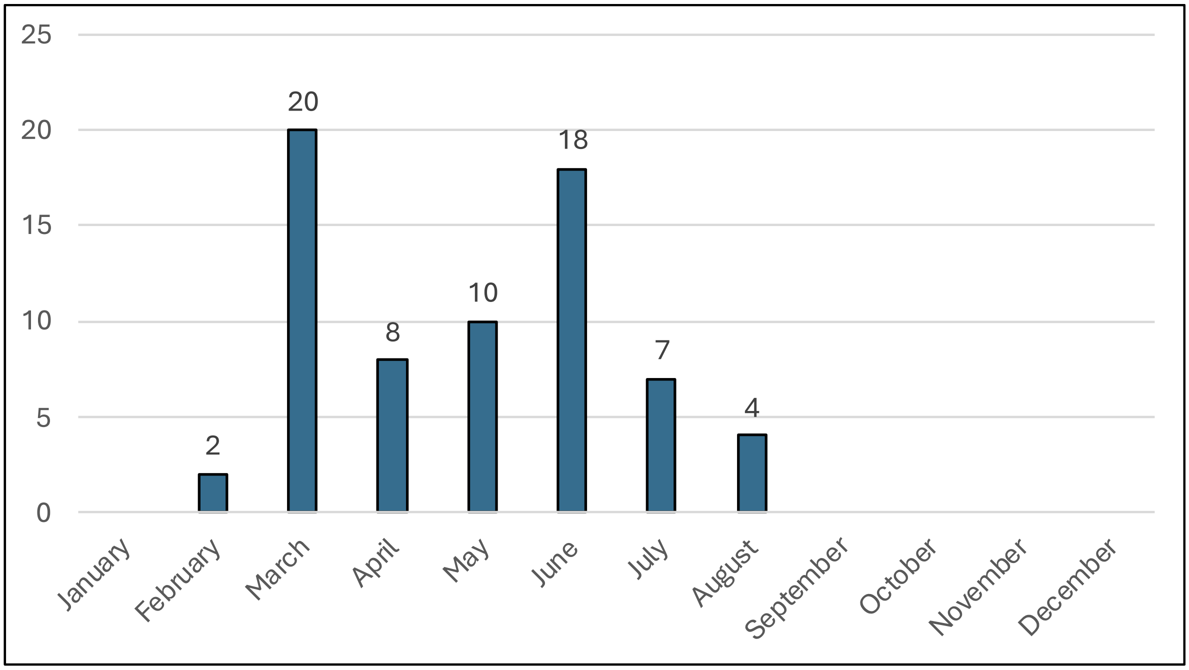

Figure 6 - Peak Flows per Month (1956-2024)

A Bulletin 17C analysis was performed using HEC-SSP to determine the flow-frequency relationship for the USGS gage. Results for the Bulletin 17C analysis are included in Table 4 below.

Table 4 - USGS Gage Flow-Frequency Relationship

Percent Chance Exceedance	Computed Curve Flow (cfs)	Event (year)
1	11,912	100
2	9,666	50
4	7,352	25
5	6,609	20
10	4,375	10
20	2,393	5
50	529	2

Using the flow-frequency relationship, the goal of the rain-on-grid model was to calibrate the model to the 100-year (1% AEP) event. This is discussed in the following section.

4.2 Rain-on-Grid Modeling & Calibration

The HEC-RAS rain-on-grid model was developed using CNs derived from NLCD and HSG data. Textbook CN values were used for the initial model simulation. Rain for the calibration event was derived from NOAA Atlas 14 depths for the 100-year, 48-hr storm. Table 5 contains the NOAA Atlas 14 depths for storm durations of 5-minutes to 10-days for a 100-year storm.

Table 5 - NOAA Atlas 14 Depths for 100-year

Duration	Precipitation Frequency Estimate (in)
5-min:	0.915
10-min:	1.34
15-min:	1.63
30-min:	2.26
60-min:	2.92
2-hr:	3.58
3-hr:	3.97
6-hr:	4.57
12-hr:	5.06
24-hr:	5.55
2-day:	6.14
3-day:	6.45
4-day:	6.70
7-day:	7.39
10-day:	8.09

Precipitation point depth estimates were determined based on the approximate watershed centroid. The National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service (NWS) Precipitation Frequency Data Server, Atlas 14 Point Precipitation Frequency Estimates was used to determine the 100-yr, 48-hr event. The temporal distribution was based on the Frequency Storm meteorologic model within HEC-HMS (version 4.13). Areal Reduction Factors (ARFs) derived from TP40/TP49 were used to reduce the point depths based on the watershed area.

After reviewing the initial model simulation results, the modeled peak discharge at the USGS gage compared to the Bulletin 17C analysis was too great; therefore, CN values were lowered for the modal CN values within the watershed. Calibrated CNs used in the model are shown in Figure 7 below. These values are representative of 1-day, antecedent moisture condition II (AMC II).

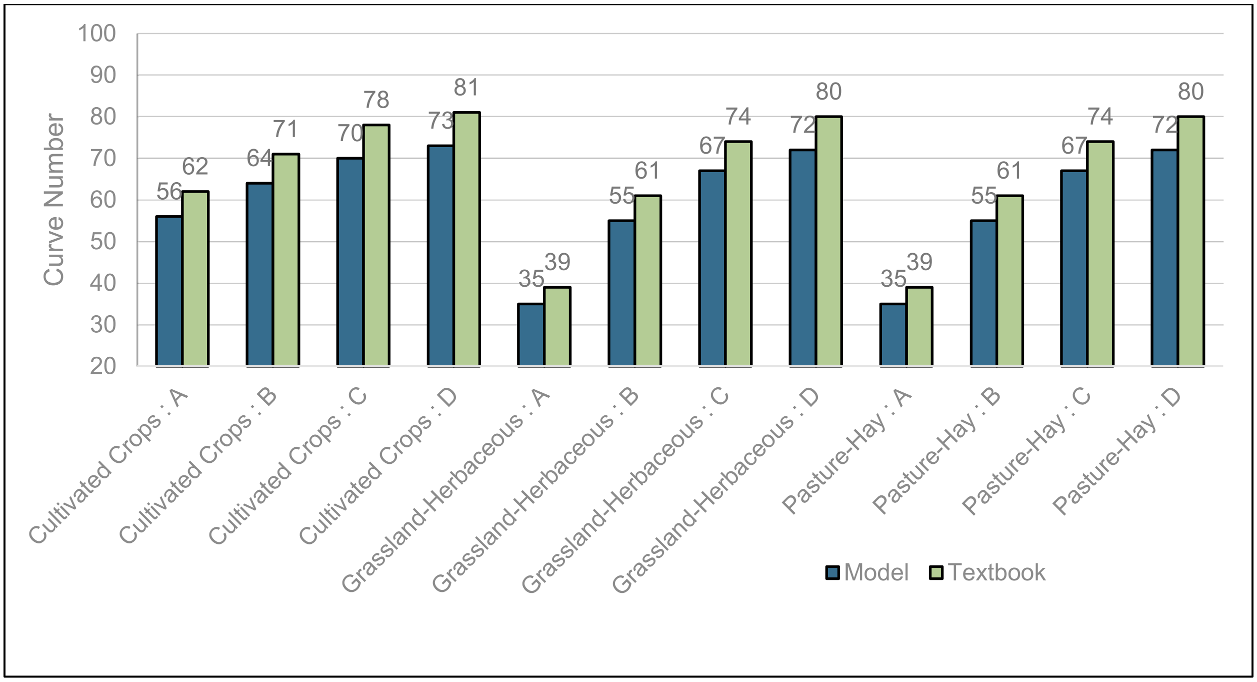

Figure 7 – Calibrated Curve Numbers

Final CN values do not deviate by much compared to standard textbook values based on HSG and land cover types. Calibrated curve numbers for a 1-day, AMC II condition within the watershed can be seen in Figure 8 below.

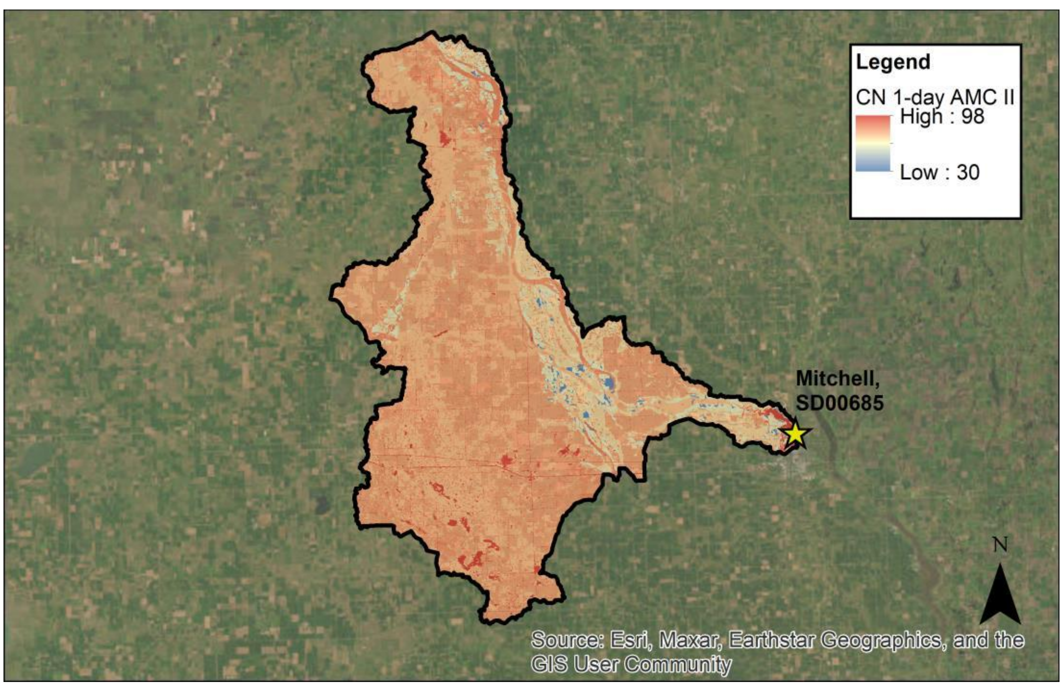

Figure 8 - Watershed Curve Numbers

For the USGS gage Bulletin 17C analysis, the 100-year peak Q was determined to be 11,912 cfs. For the calibrated model, the 100-year peak Q was determined to be 12,388 cfs. Figure 9 shows the flow-frequency relationship for the USGS gage graphically with the calibrated model 100-year result shown.

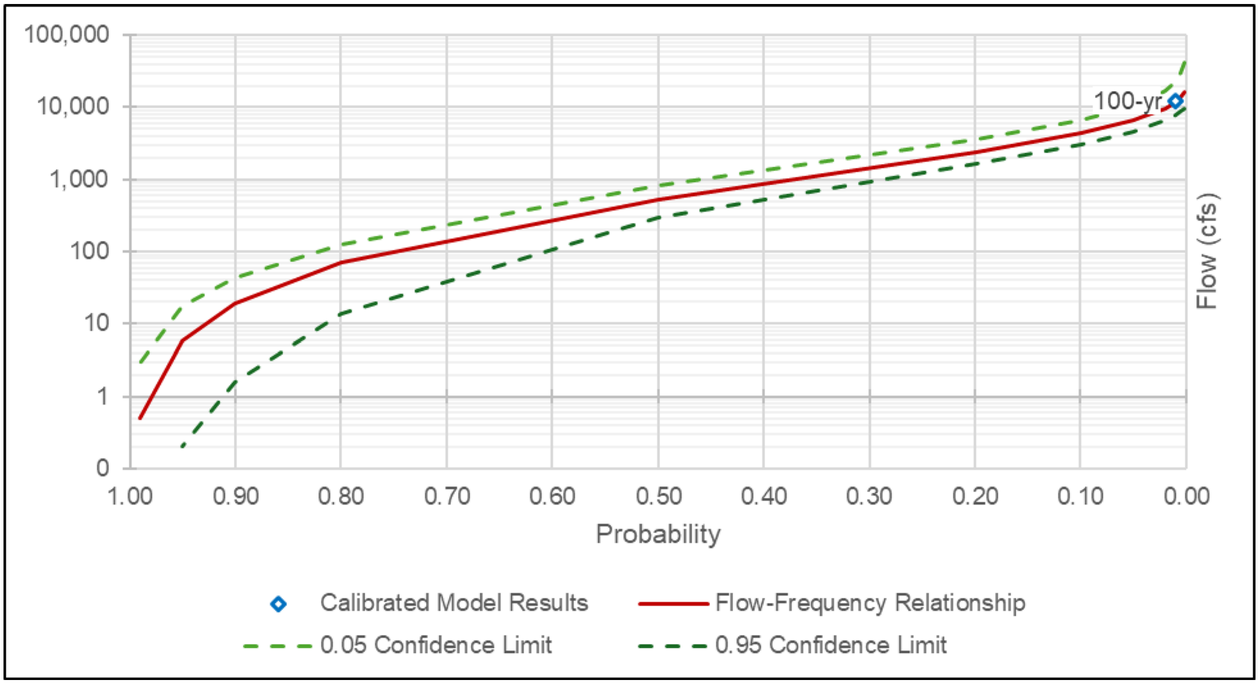

Figure 9 - Bulletin 17C and Calibrated Model Peak Q

The modeled stage and peak flow at the USGS gage location within the rain-on-grid model was plotted against the USGS rating curve. Figure 10 shows this plot.

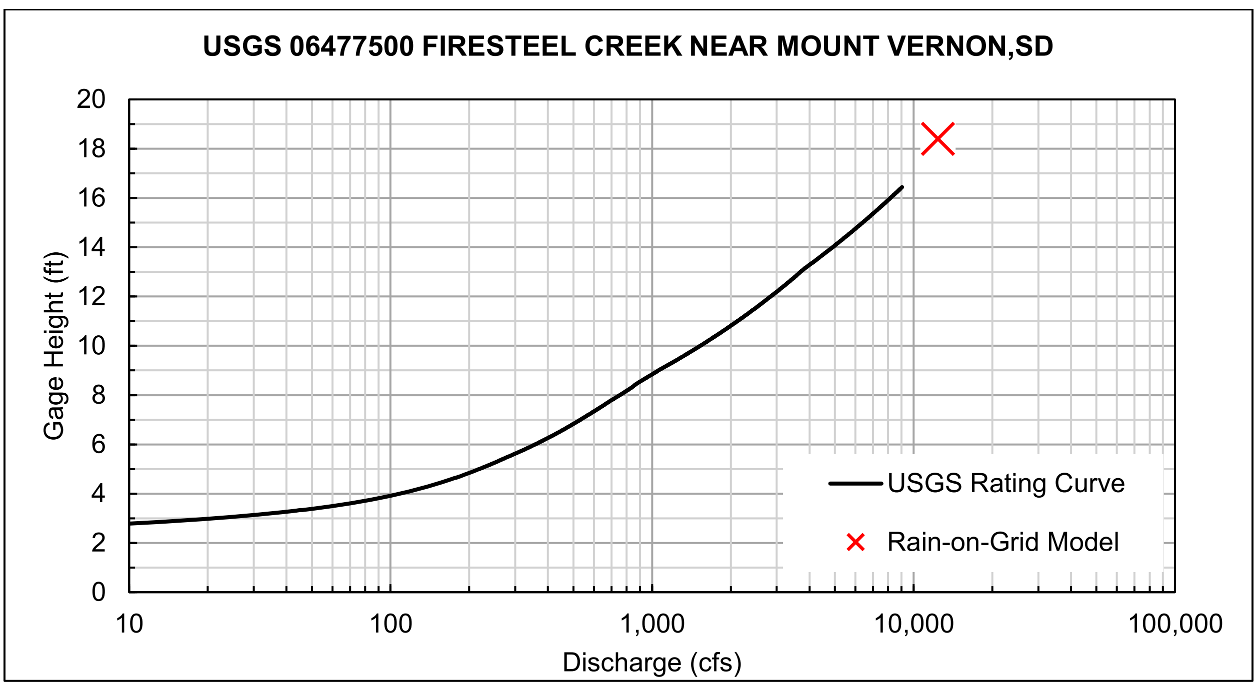

Figure 10 - USGS Rating Curve and Rain-on-Grid Model

At this point, the rain-on-grid model was calibrated and the PMP event was assessed next.

4.3 Probable Maximum Precipitation (PMP)

Precipitation for the PMP event was derived from the Site-Specific Probable Maximum Precipitation (PMP) Study for Nebraska (2008) by Applied Weather Associates (AWA). Discussions with SD DANR were held regarding the use of the Nebraska PMP values in South Dakota and the lack of a state-wide PMP study for South Dakota. Houston Engineering recommended and applied the Nebraska PMP for this study, because it is the accepted standard to supersede HMR 51 for dam design in Nebraska, data from this study extends into South Dakota to cover Lake Mitchell, and a South Dakota specific study is not available. The DANR has accepted the Nebraska Study in other instances and supports their application to the Lake Mitchell PMF Study. Within HEC-HMS, an Optimization Trial was created to determine the maximum precipitation resulting from several adjusted input parameters for an HMR 52 storm, which uses a 72-hour duration. Based on guidance within HMR 52 and the aforementioned PMP study for Nebraska, initial, minimum, and maximum values were specified for the Optimization Trial. The resulting maximum PMP depth from the Optimization Trial was 19.08 inches for a 72-hour storm. The HMR 52 storm hyetograph is created using the critical stacking method where the most intense 6-hr block of rainfall occurs at the middle of the storm duration and then the 2nd and 3rd are placed on either side continuing until the 72-hour duration is met. Since a 48-hour storm duration was used to assess the 100-year event, and reflects the approximate watershed time of concentration, a PMP storm with a 48-hour duration was desired. This yielded a total PMP precipitation depth of 17.25 inches for a 48-hour storm. Figure 11 shows the PMP hyetograph for the 48-hr storm with both precipitation intensity and the respective cumulative precipitation value.

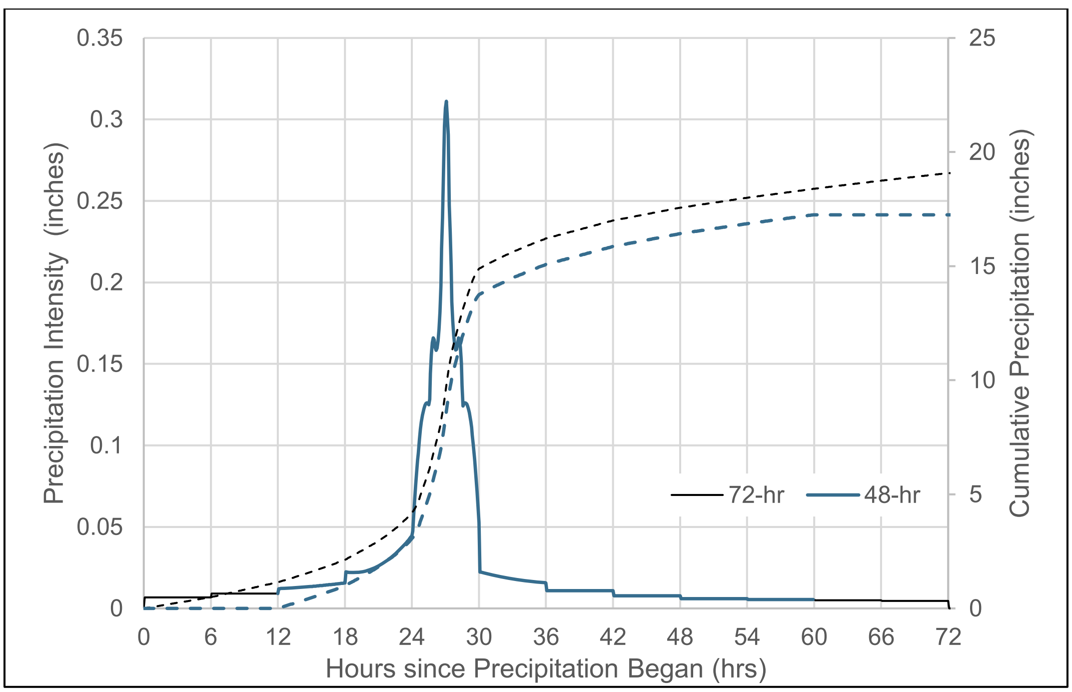

Figure 11 - PMP Hyetograph for 72-hr and 48-hr Storms

The PMP hyetograph for the 48-hr storm was used as an input for the rain-on-grid model to determine the PMF hydrograph inflow to Lake Mitchell.

4.4 Probable Maximum Flood (PMF)

Assessing the PMF for Lake Mitchell involved assessing initial conditions for the watershed prior to a PMP storm occurring. Guidance found in the NRCS's Technical Release 210-60 Earth Dams and Reservoirs (2019) states that the freeboard hydrograph (FBH) should be routed through the reservoir with the starting water surface elevation set to the value corresponding to an elevation 10 days after the maximum stage in the reservoir is attained due to routing of the principal spillway hydrograph (PSH). Typically, the PSH is based on a 10-day duration storm. To represent this within the rain-on-grid model, a 100-year, 10-day storm was simulated in the rain-on-grid model.

To more accurately assess losses in the watershed for a storm duration of 10-days, the NRCS provides guidance on how to transform 1-day CNs to 10-day CNs. This was performed for the 100-year, 10-day storm simulation in the rain-on-grid model to achieve initial conditions prior to a PMP event occurring in the watershed. Initial conditions for the PMP storm in the rain-on-grid model are based on a date and time corresponding to 10 days following the maximum stage in the reservoir resulting from a 100-year, 10-day storm event. This assumption for initial conditions reflects ponding areas within the watershed that may be at or near capacity when a PMP event occurs based on a storm event occurring prior to the PMP event. This is considered a conservative approach in assessing the PMF hydrograph at Lake Mitchell.

Once the PMP simulation was completed, results were extracted from the rain-on-grid model to obtain the PMF hydrograph into Lake Mitchell. From this, a 50% PMF hydrograph was determined by multiplying the PMF flow values by 50%. Hydrographs for the PMF and 50% PMF are shown in Figure 12 below.

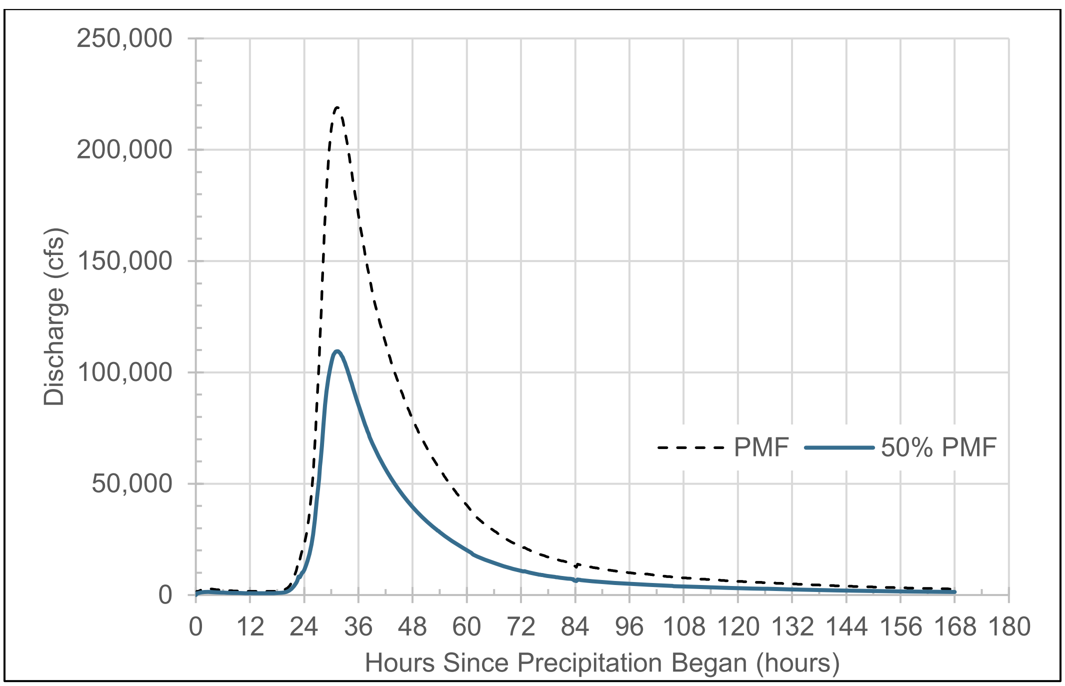

Figure 12 – PMF and 50% PMF Hydrographs into Lake Mitchell

Peak flow values for the PMF and 50% PMF are 218,990 cfs and 109,495 cfs respectively.

4.5 Previous Studies

Houston Engineering reviewed a previous study completed by Banner Associates, Inc. from 1995, titled Lake Mitchell Spillway Inspection Study. Within that study there is a section titled Evaluation of Lake Mitchell Probable Maximum Flood (PMF). Within that section, Banner Associates go on to review a 1978 study from the US Army Corps of Engineers, titled Phase I Inspection Report, that was a part of the National Dam Safety Program and *"presented a hydrologic/hydraulic evaluation of the adequacy of Lake Mitchell Dam, including development of a Probable Maximum Flood (PMF)"* (Banner Associates, 1995). Banner Associates stated that it was unclear which HMR was used to develop the PMF for Lake Mitchell as HMR 51 was released in 1978, the same year as the USACE study, but prior to that HMR 33 was typically used. Based on Banner Associates' review of the USACE study, they found that there was close agreement between the USACE study and HMR 51 PMP values. Banner Associates discussed determining an appropriate contributing drainage area for their analysis and noted discussions with SD DENR. The final value to be used was selected as 603 square miles. Table 6 provides a comparison of the PMF studies for Lake Mitchell.

Table 6 – Comparison of PMF Studies for Lake Mitchell

Item	Value			Units
	USACE (1978)	**Banner Associates (1995)**	**Houston Engineering (2026)**	
Contributing Drainage Area	496	603	652.76	square miles
Precipitation Data Sources and Modeling	Unknown	HMR 51	Nebraska Statewide PMP & HMR 52 and HEC-HMS	
PMP Duration	Unknown	48	48	hours
PMP Total	22.0	21.90	17.25	inches
Hydrograph Development Modeling	National Inspection of Dams, Hydrologic Analysis Program	National Inspection of Dams, Hydrologic Analysis Program	HEC-RAS 2D	
PMF Peak Reservoir Inflow	77,300	102,800	218,990	cfs
50% PMF Peak Reservoir Inflow	37,600	50,100	109,495	cfs

When comparing Banner Associates' 1995 PMF study with this study, there are key assumptions and modeling methods to note. These are listed below.

1. **Storm Area and PMP Total** – It is unclear how Banner Associates arrived at the 21.9 inches; however, it was likely done by performing a linear interpolation at the 48-hour duration between the 200 and 1,000 square mile areas. It is also unclear what type of temporal distribution was used. For the HMR 52 storm used in this study, the area is intended to be the storm area and not necessarily the contributing drainage area. As stated earlier in this study, HEC-HMS was used to develop the PMP hyetograph. HMR 52 was used as the temporal distribution, using the Nebraska Statewide PMP values as the precipitation depths. The HMR 52 storm is 72 hours long. Using the Optimization Trial function within HEC-HMS allows for user selected variables to be optimized. For this study, the total PMP depth was selected to have the goal maximized while allowing the other parameters (storm area, storm orientation, storm peak intensity, and storm centroid location) to be varied. This resulted in the maximum 72-hour storm depth, which was then reduced to the 48-hour depth as stated earlier in the study.
2. **Hydrologic Soil Groups** – Banner Associates stated, *"the soils in this area will generally be in the "B" classification."* Based on recent data from the USDA, the primary HSG observed within the Lake Mitchell Dam's watershed are shown to be "C" followed by "D" and then "B", which resulted in lower infiltration rates being used, thus, increasing runoff.
3. **Inflow Hydrograph and Routing** – It is unclear how the computer program entitled 'National Inspection of Dams, Hydrologic Analysis Program' performed reservoir routing; however, the inflow hydrograph seems to have been developed using Snyder's Unit Hydrograph procedure. Based on the summary table presented in Banner Associates' study, it appears as though the computer program only allows for a single infiltration rate to be used throughout the watershed. As a part of this study by Houston Engineering, the inflow hydrograph was developed using the rain-on-grid (ROG) capabilities within HEC-RAS 2D. HEC-RAS 2D's ROG capabilities allow for spatial infiltration to occur based on gridded datasets as opposed to a single value. The rainfall-runoff calculations occur within the 2D cells, and then flow is routed from one cell to the next until it reaches the outlet. HEC-RAS 2D ROG incorporates both hydrologic and hydraulic modeling methods. The reservoir routing for this study was performed within HEC-HMS and considers the complex spillway hydraulics, which was modeled using CFD software to develop a rating curve.

In summary, the reported PMF peak flow values from the previous studies and this one are different based on the aforementioned modeling methods. This recent study uses the most up-to-date spatial data available and uses modern computer programs and their capabilities to more accurately assess watershed rainfall-runoff responses and spillway hydraulics. Houston Engineering recommends that this study be used to assess the PMF for Lake Mitchell Dam.

5 Hydraulic Analysis

The hydraulic analysis involved using the elevation-storage relationship for the reservoir, CFD modeling of the spillway, and reservoir routing to assess the 50% PMF. The overall goal of the rain-on-grid model is to be calibrated to the 100-year storm at the USGS gage location. Once calibration is complete, the PMP event is analyzed to determine the PMF hydrograph into Lake Mitchell. This allows for determination of the 50% PMF event.

The following steps were taken to perform the hydraulic analysis:

1. Assess the existing spillway capacity
2. Route the dam inflow hydrograph for the 50% PMF through the dam reservoir to assess maximum water surface elevation and overtopping potential
3. Determine the dam outflow hydrograph for the 50% PMF event
4. Assess the performance of the Lake Mitchell Dam
5. Assess downstream hazards for various dam breach events

To assess the existing spillway capacity, a CFD model was developed. This assessment is discussed in Section 5.1 and 5.2 below. Routing of the 50% PMF and the resulting reservoir elevation and outflow is discussed in Section 5.3 below. An evaluation of the performance of the Lake Mitchell Dam is discussed in Section 5.4 below. Dam breach modeling is discussed in Section 5.6 below.

5.1 Spillway Computation Fluid Dynamics (CFD) Analysis

The CFD analysis was configured to resolve crest hydraulics, chute entrance behavior, and tailwater interaction for the existing ogee/elliptical weir. The computational domain extended upstream into the deep portion of the lake so that high approach velocities and any associated energy losses would be captured within the solution rather than prescribed. Boundary conditions and mesh resolution were chosen to resolve the free-surface over the crest, the nappe trajectory, and local features such as the rooster tail, shown in Figure 13 below, that influence nappe aeration and discharge efficiency. Across the scenarios analyzed, the model indicated appreciable approach velocity but negligible energy head loss relative to the design head, meaning upstream losses do not materially affect the head–discharge relationship for the rating curve within the studied range.

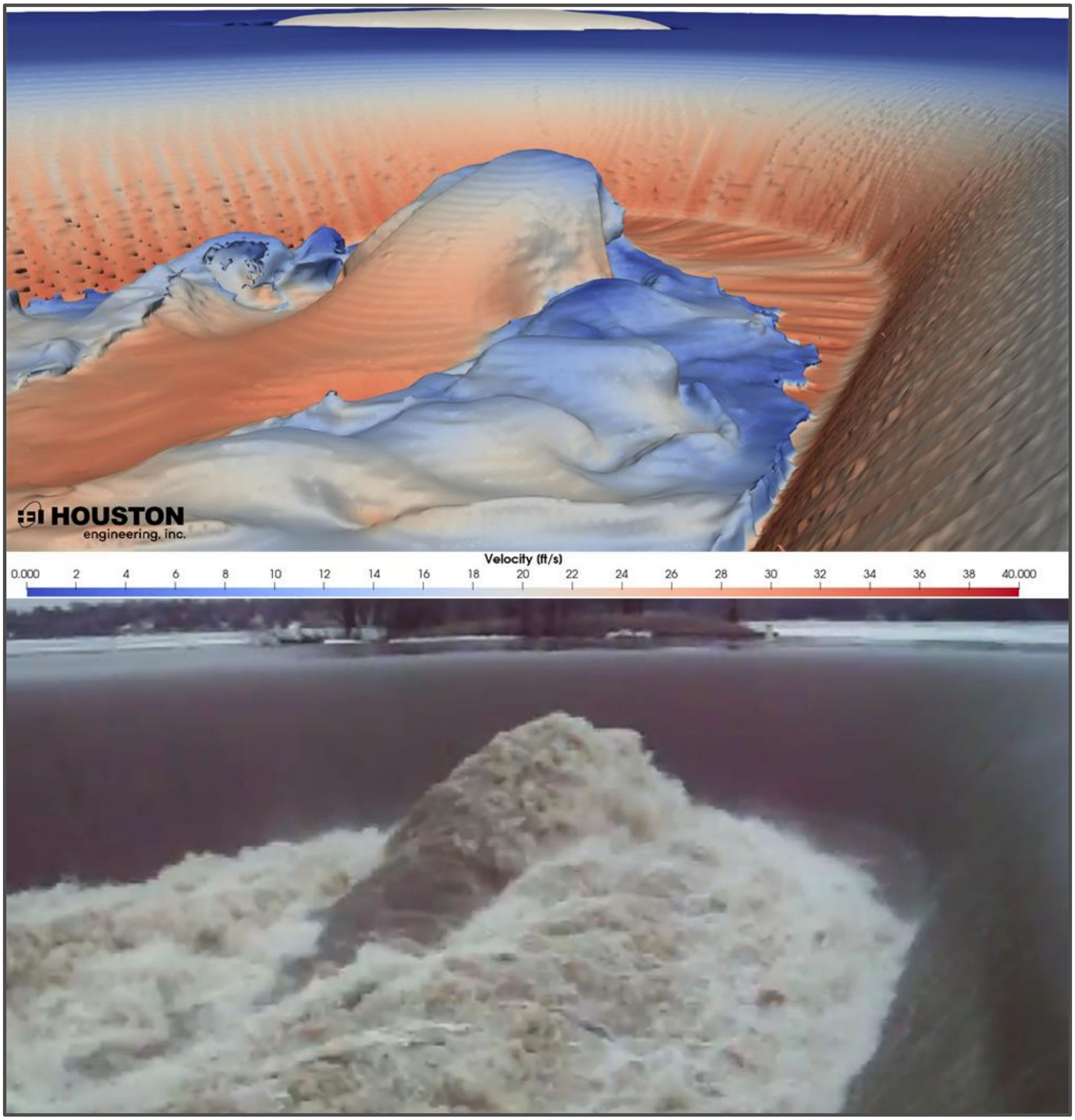

Figure 13 – Observation of "Rooster Tail" within the CFD Model Compared to Photo Evidence

Figure 14 and Figure 15 visually show the effects of the “rooster tail” during operation of low-head and high-head stages.

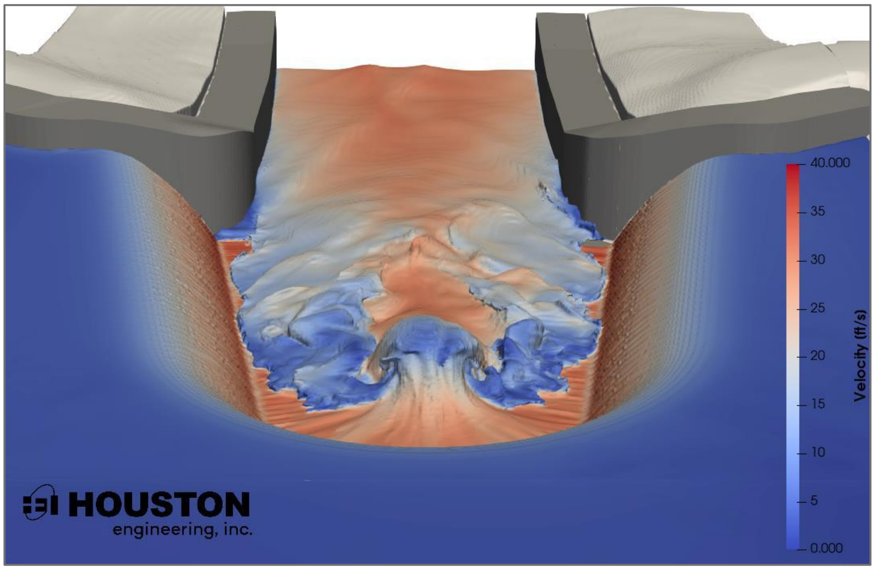

Figure 14 – Low Head Operation in CFD Model

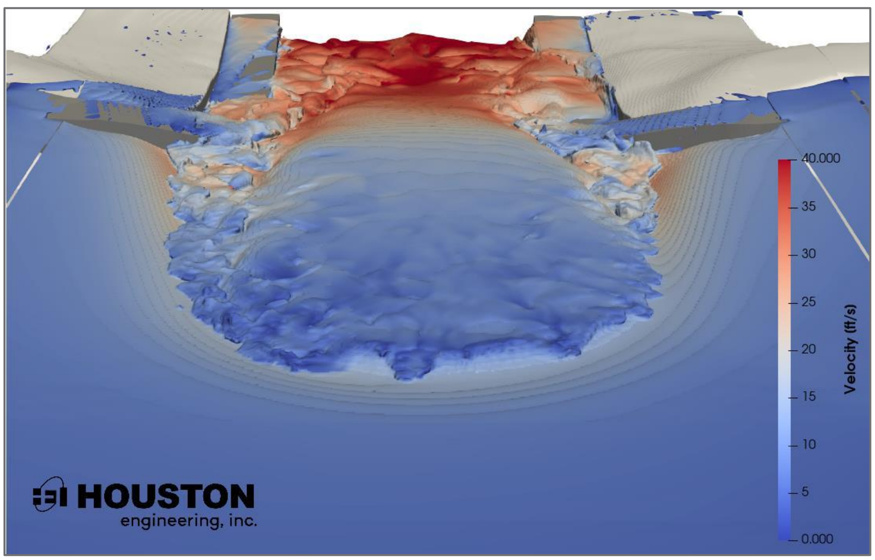

Figure 15 – High Head Operation in CFD Model

5.2 Spillway Rating Curve

To check the CFD results and anchor them to established design guidance, Houston Engineering applied three independent verification steps. First, the derivation of a C_Q–design head relationship in the manner used for USACE EM ogee/elliptical weir design was compared to the CFD-predicted discharge. That C_Q-(H_d) relationship was then applied to the effective weir length to assemble the final rating curve, providing a direct, traceable comparison between classical hydraulics and the numerical simulation. Second, plotting of the downstream elliptical profile of the weir and reverse-engineered the design head that reproduces the intended nappe trajectory. This reconstruction verified that the existing weir was designed for approximately 11.6 feet of overtopping; the same head appears in the Banner plan set at the design flow condition. Using the "Ogee Design" C_Q, the resulting discharge matched the flow rate list on the plans within 1%, which corroborates both the CFD solution and the C_Q-based check. Third, Houston Engineering evaluated submergence onset by extracting the Froude number across the crest and relating it to stage. The CFD indicates the transition to submerged behavior occurs between Elevations 1272 and 1274. When USACE submergence guidance is applied at this threshold, the expected reduction in discharge capacity is on the order of ten percent, which matches the break in the C_Q curve observed directly from the CFD outputs. The consistency between these checks—C_Q vs. CFD, nappe reconstruction at 11.6 feet, and submergence penalty vs. C_Q inflection—provides a coherent validation of the model's predictive behavior around both free-flow and transition regimes. Figure 16 shows the C_Q – H_d relationship.

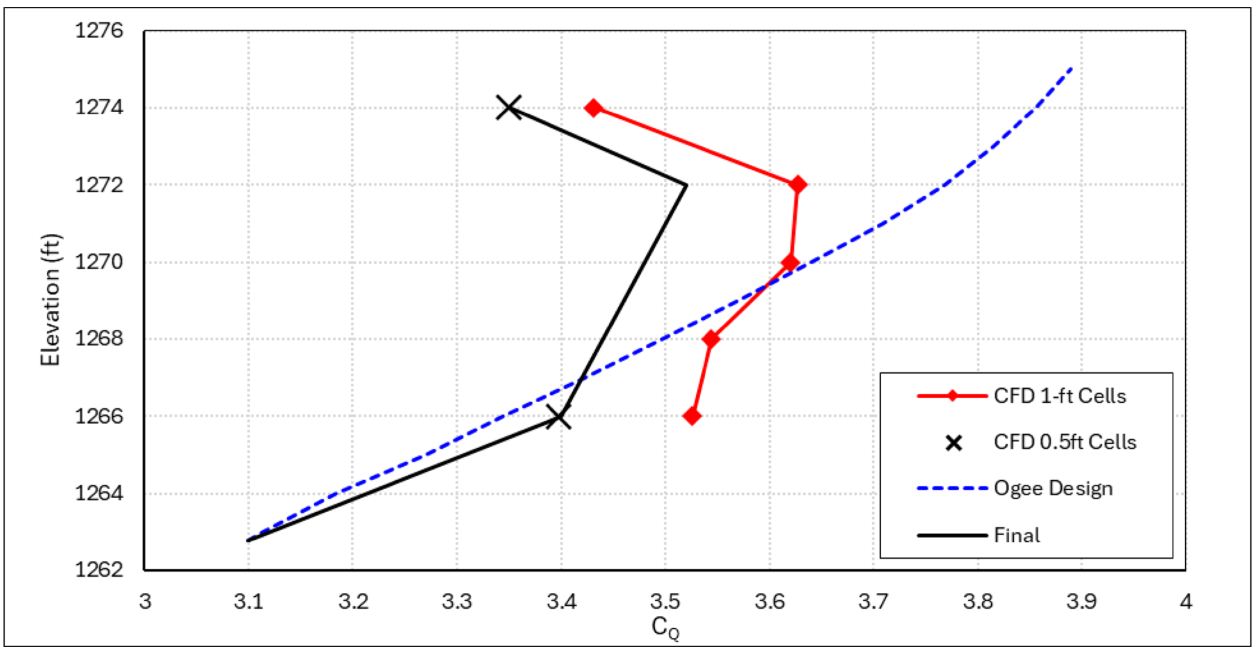

Figure 16 – C_Q – H_d Relationship from CFD Model

The spillway is confirmed to be designed for a head of approximately 11.6 feet, and the CFD-based rating curve reproduces this design point within engineering tolerance when expressed through the C_Q–H_d framework and effective weir length. The weir underperforms the unsubmerged design curve at higher stages due to early submergence caused by backwater forming as flow enters the chute and by the rooster tail that disrupts free discharge conditions; the onset occurs between Elevations 1272 and 1274 and produces about a ten percent reduction in discharge at the transition, consistent with both empirical guidance and the C_Q break in the CFD results.

Upstream energy losses, while present due to high approach velocities, are insignificant relative to the head governing discharge and therefore do not materially alter the final rating curve within the analyzed range. Together, these results indicate that the governing performance limitation is the early submergence and associated nappe behavior rather than upstream energy loss, and they support using the CFD-derived, submergence-adjusted rating curve for routing and operations near and above the 1272–1274 elevation band. Figure 17 shows various rating curves assessed using the CFD model.

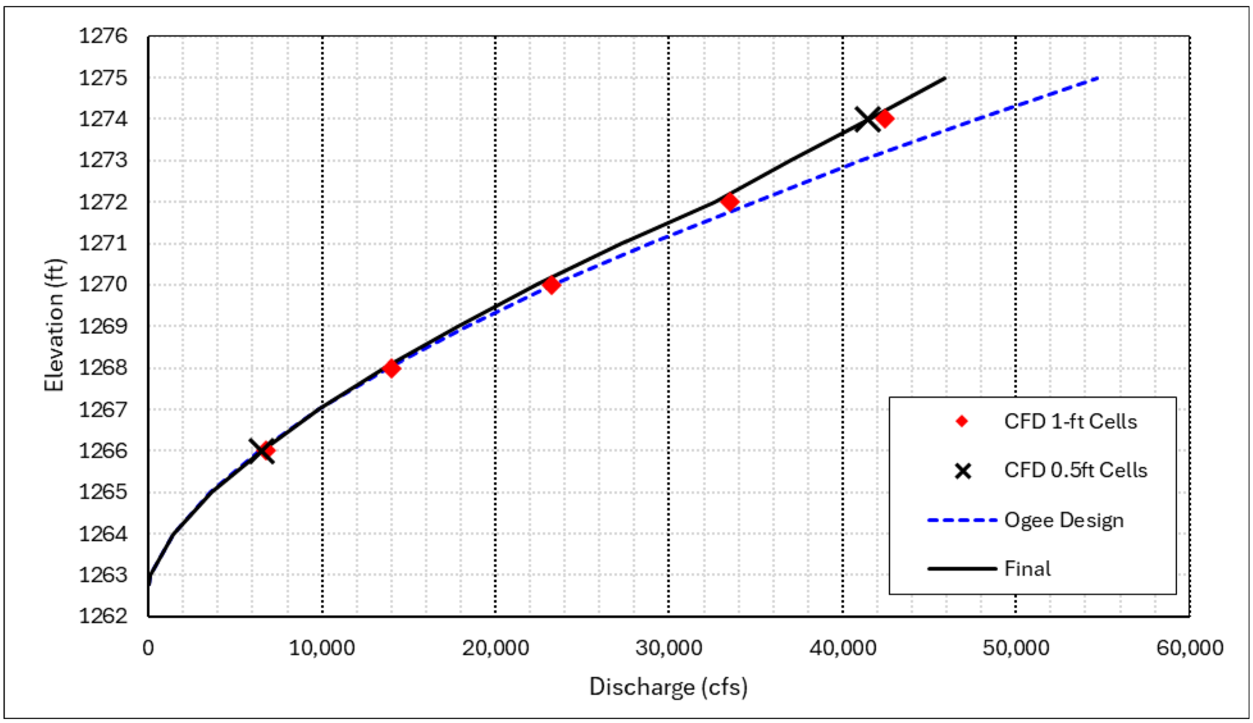

Figure 17 – CFD Model Rating Curves

Discharge through the spillway increases as reservoir elevation increases; however, the elevation-discharge relationship is affected by the capacity of the spillway exit channel. Figure 18 shows the effect that the exit channel has on the spillway’s discharge. As elevation increases, the spillway’s weir control transitions to exit channel control. The exit channel begins to govern as water surface elevation in the reservoir approaches the top of dam crest elevation.

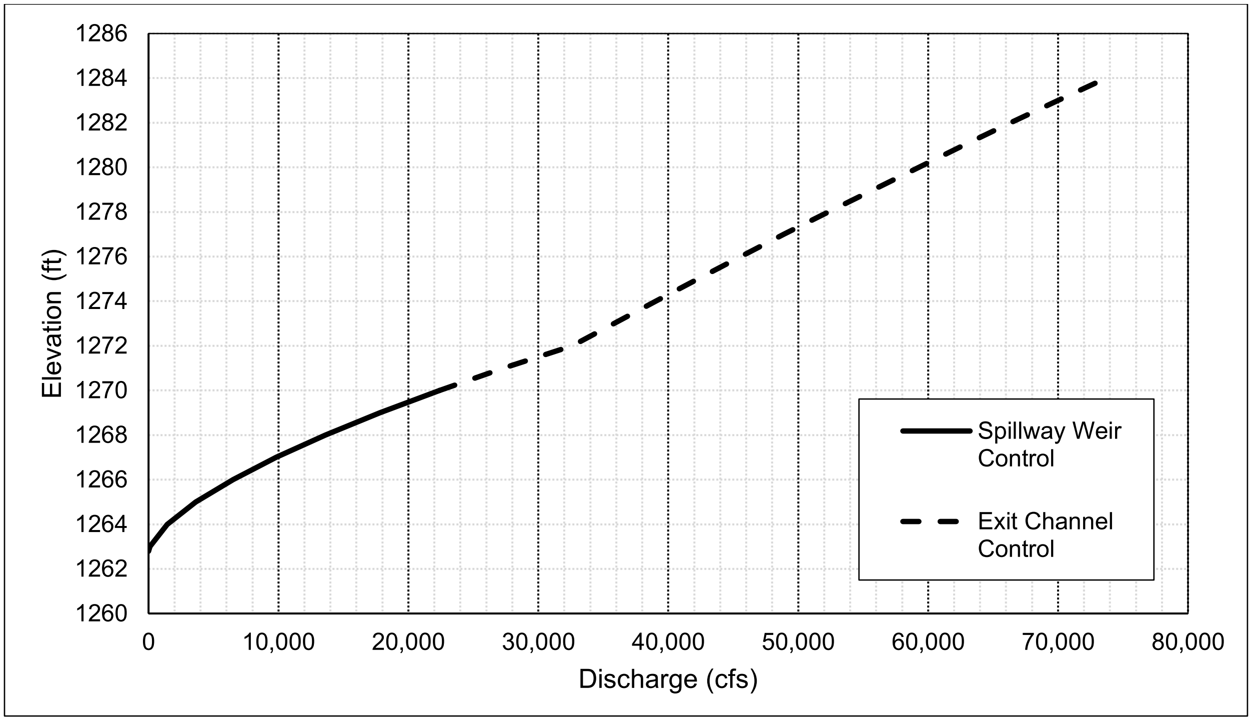

Figure 18 - Lake Mitchell Spillway Rating Curve

5.3 Reservoir Routing

Reservoir routing for Lake Mitchell involved using HEC-HMS (version 4.13). The 50% PMF hydrograph was routed through the reservoir with the spillway rating curve from the CFD model being used. If the reservoir was overtopped, the dam crest was set up as a broad crested weir to account for overtopping flows. Table 7 summarizes the 50% PMF routing results.

Table 7 - 50% PMF Reservoir Routing

Variable	Value	Unit
Spillway Crest Elevation	1262.79	Ft NAVD88
Top of Dam Elevation	1274.70	Ft NAVD88
Maximum Routed Elevation	1280.15	Ft NAVD88
Peak Inflow Q	109,495	cfs
Peak Outflow Q Spillway	59,803	cfs
Peak Outflow Q Dam Crest	43,631	cfs

Based on the HEC-HMS results, during a 50% PMF event, the Lake Mitchell Dam would overtop by approximately 5.5 feet and pass approximately 100,000 cfs downstream.

5.4 Lake Mitchell Performance Evaluation

After the hydrologic and hydraulic analyses were completed, the Lake Mitchell Dam was assessed based on the mandates set forth by DANR. **With respect to the 50% PMF event, the Lake Mitchell Dam is not in compliance with being able to pass the 50% PMF dam inflow hydrograph without overtopping of the dam**. Houston Engineering determined, based on the existing data and analyses performed, that the Lake Mitchell Dam can handle up to and including a 23% PMF event without overtopping. Results for the 23% PMF routing are included in Table 8 below.

Table 8 - 23% PMF Reservoir Routing

Variable	Value	Unit
Spillway Crest Elevation	1262.79	Ft NAVD88
Top of Dam Elevation	1274.70	Ft NAVD88
Maximum Routed Elevation	1274.61	Ft NAVD88
Peak Inflow Q	50,368	cfs
Peak Outflow Q Spillway	41,031	cfs

5.5 Lake Mitchell Dam "Removed"

Assuming the Lake Mitchell Dam was "removed" or not in place, for the 23% PMF event, the inflow hydrograph would not be attenuated and the peak flow passing downstream would be equal to the inflow of 50,368 cfs. The flooding extents for this scenario would be worse compared to the 23% PMF no dam failure scenario, which has a peak outflow of 41,031 cfs. The mapped inundation extents would fall somewhere between the extents of the 23% PMF no dam failure and the extents of the 23% dam failure scenario.

5.6 Downstream Breach Modeling

To summarize the analyses performed prior to performing the breach modeling, Figure 19 shows this visually below. A HEC-RAS 2D unsteady state model was developed to assess breach hazards downstream of the Lake Mitchell Dam. The 2D model was set up using the same approach as the ROG watershed model; however, no losses were computed in the model. Flow was introduced into the model using a boundary condition line at the downstream toe of the dam representing the breach hydrographs.

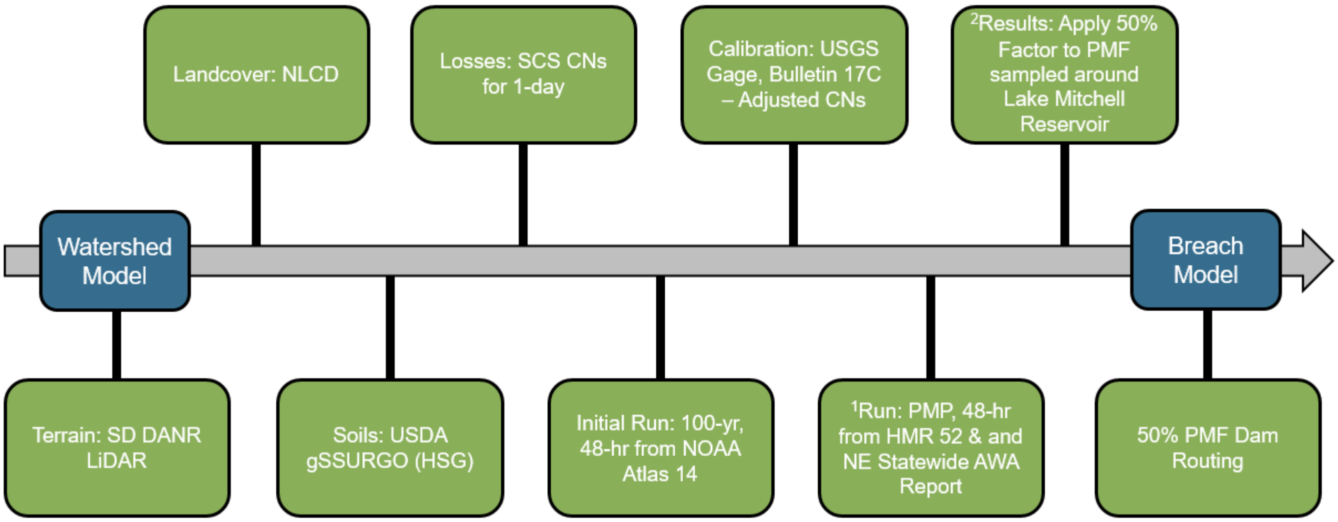

Figure 19 – Summary of Watershed Model prior to Breach Model

The breach procedure involved using the results from the hydrologic and hydraulic analyses for the watershed and dam. The NRCS states that the peak breach discharge needs to be developed using criteria detailed in the Technical Release 210-60 Earth Dams and Reservoirs (2019). Within that document, the NRCS also states the following: *"Evaluate dam failure with the water surface elevation of the reservoir at the dam crest or the peak reservoir stage resulting from the probable maximum flood (PMF)."* Various breach and non-breach scenarios were assessed as part of the breach modeling. The scenarios are listed below.

- Sunny Day, Breach – The reservoir is at normal operating elevation, which corresponds to the spillway crest elevation. The only volume of water included in this scenario is based on the volume in the reservoir at the spillway crest elevation.
- Rainy Day, 50% PMF, Breach – A storm event occurs which produces a runoff event equal to the 50% PMF. The reservoir elevation at the time of breach is set to either the Dam Crest or maximum routed 50% PMF elevation in the reservoir, whichever is lower. The volume of water included in this scenario is the summation of the volume in the reservoir prior to the storm event, which is equal to the Sunny Day volume, and the total runoff volume from the 50% PMF event. This scenario assumes the dam is breached when the elevation as stated earlier is reached. After the dam breach occurs, the remaining inflow hydrograph flowing into the reservoir is assumed to have no attenuation and is routed directly downstream of the dam.
- Rainy Day, 50% PMF, No Breach – A storm event occurs which produces a runoff event equal to the 50% PMF. The 50% PMF hydrograph is routed through the reservoir, but no breach is assumed. If overtopping occurs, the overtopping is modeled within the reservoir routing model. The volume of water included in this scenario is the summation of the volume in the reservoir prior to the storm event, which is equal to the Sunny Day volume, and the total runoff volume from the 50% PMF event. This scenario assumes the dam is not breached.

- Rainy Day, 23% PMF, Breach – A storm event occurs which produces a runoff event equal to the 23% PMF. The reservoir elevation at the time of breach is set to either the Dam Crest or maximum routed 23% PMF elevation in the reservoir, whichever is lower. The volume of water included in this scenario is the summation of the volume in the reservoir prior to the storm event, which is equal to the Sunny Day volume, and the total runoff volume from the 23% PMF event. This scenario assumes the dam is breached when the elevation as stated earlier is reached. After the dam breach occurs, the remaining inflow hydrograph flowing into the reservoir is assumed to have no attenuation and is routed directly downstream of the dam.
- Rainy Day, 23% PMF, No Breach – A storm event occurs which produces a runoff event equal to the 23% PMF. The 23% PMF hydrograph is routed through the reservoir, but no breach is assumed. If overtopping occurs, the overtopping is modeled within the reservoir routing model. The volume of water included in this scenario is the summation of the volume in the reservoir prior to the storm event, which is equal to the Sunny Day volume, and the total runoff volume from the 23% PMF event. This scenario assumes the dam is not breached.
- Rainy Day, 50% PMF with Modified Spillway, Breach – The existing spillway rating curve was adjusted to provide enough capacity so that the dam would not overtop during a 50% PMF. A storm event occurs which produces a runoff event equal to the 50% PMF. The reservoir elevation at the time of breach is set to either the Dam Crest or maximum routed 50% PMF elevation in the reservoir, whichever is lower. The volume of water included in this scenario is the summation of the volume in the reservoir prior to the storm event, which is equal to the Sunny Day volume, and the total runoff volume from the 50% PMF event. This scenario assumes the dam is breached when the elevation as stated earlier is reached. After the dam breach occurs, the remaining inflow hydrograph flowing into the reservoir is assumed to have no attenuation and is routed directly downstream of the dam.
- Rainy Day, 50% PMF with Modified Spillway, No Breach – The existing spillway rating curve was adjusted to provide enough capacity so that the dam would not overtop during a 50% PMF. A storm event occurs which produces a runoff event equal to the 50% PMF. The 50% PMF hydrograph is routed through the reservoir, but no breach is assumed. The volume of water included in this scenario is the summation of the volume in the reservoir prior to the storm event, which is equal to the Sunny Day volume, and the total runoff volume from the 50% PMF event. This scenario assumes the dam is not breached.

The peak breach discharge for all the Rainy Day Breach scenarios was determined using the criteria set forth in the NRCS's TR 210-60 and TR-66 documents. The input data that was used can be seen in Table 9 below. This data was obtained from As-built drawings, LiDAR, and HEC-HMS routings. In lieu of bathymetry below the LiDAR elevation in the reservoir, the reservoir volume at time of breach is based on the NID Max Storage (acre-ft) value (National Inventory of Dams) for the Rainy Day breaches.

Table 9 – Rainy Day Reservoir Breach Parameters

Parameter	Value	Unit
Dam Crest Elevation	1274.7	ft. NAVD88
Water Surface Elevation at Time of Breach	1274.7	ft. NAVD88
Dam Top Width	12	ft.
Upstream Dam Side Slope	2.3	ft. (H:1)
Downstream Dam Side Slope	2.8	ft. (H:1)
Valley Floor Elevation	1248	ft. NAVD88
Reservoir Volume at Time of Breach	19,585	ac.-ft.
Valley Width at Dam Axis and WSE	1100	ft.
Top of Wave Berm Elevation	N/A	ft. NAVD88
Width of Top of Wave Berm	N/A	ft.
Wave Berm Side Slope	N/A	ft. (H:1)
Top of Stability Berm Elevation	N/A	ft. NAVD88
Width of Top of Stability Berm	N/A	ft.
Stability Berm Side Slope	N/A	ft. (H:1)
Timestep for Breach Hydrograph	5	minutes

The breach inundation zones are shown in Appendix A. Rasters were calculated in RAS Mapper and ArcGIS software. The maps are results of unsteady state routing within HEC-RAS. The following maps are included:

1. Breach inundation extents – This represents the maximum inundation extents due to the breach/non-breach hydrograph, along with Flood Insurance Rate Map floodplain limits for reference.
2. Depths prior to breach – This represents maximum depths due to spillway flows prior to the breach/non-breach hydrograph.
3. Breach depths – This represents maximum depths due to the breach/non-breach hydrograph.
4. Breach velocities - This represents maximum velocities due to the breach/non-breach hydrograph.
5. D x V assuming people are caught outdoors during the dam failure – This represents the product of the maximum depths and maximum velocities and corresponds to DV values associated with hazards to people outdoors during the breach/non-breach hydrograph.
6. WSEs – This represents maximum water surface elevations due to the breach/non-breach hydrograph, along with Flood Insurance Rate Map Base Flood Elevations for reference.
7. Arrival Times – This represents arrival time based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage or when the breach occurs.

Coincidental downstream flooding was not taken into consideration during the breach analysis. Flow into the outlet channel prior to the breach occurring only consists of spillway outflow. Figure 20 includes peak flow values for each breach scenario modeled.

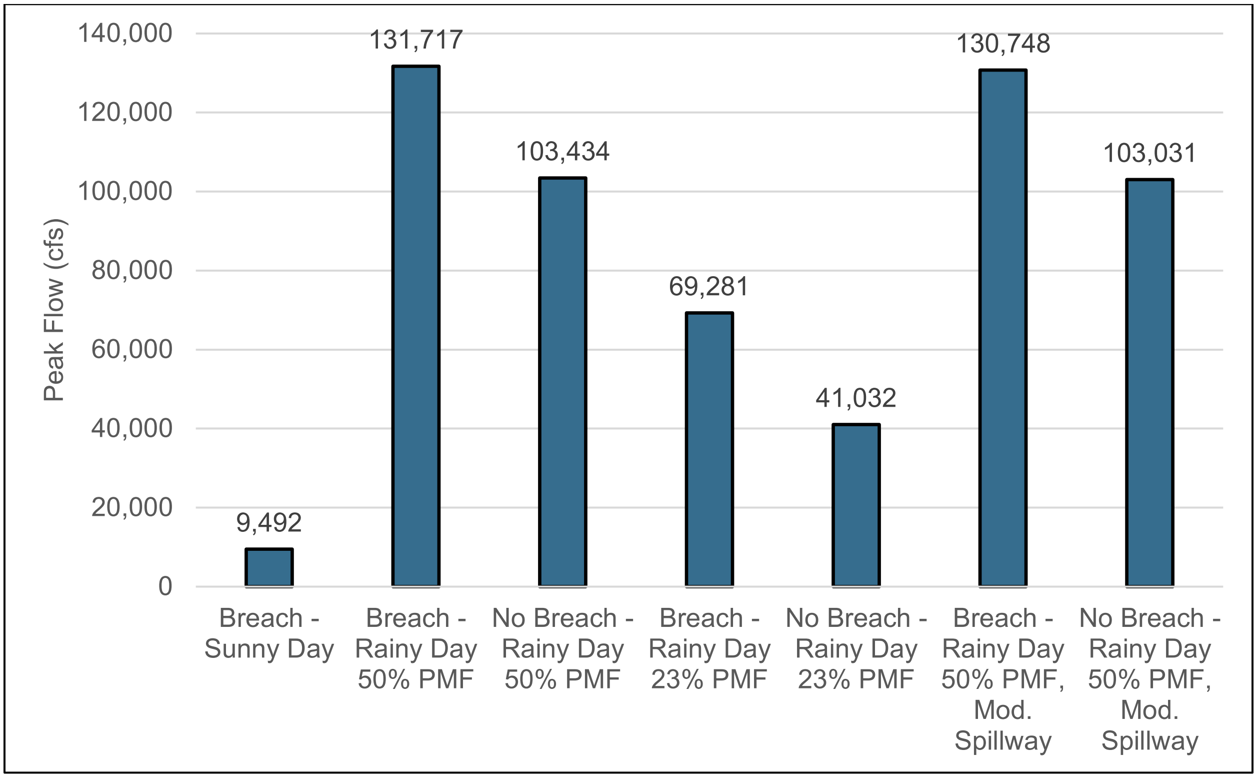

Figure 20 – Peak Breach Discharges

5.7 Incremental Consequence Analysis (ICA)

Within the document Selecting and Accommodating Inflow Design Floods for Dams, FEMA P-94 (2013), FEMA discusses an approach described as the "Incremental Consequence Analysis". Within this approach, FEMA defines the IDF as *"The IDF selected using incremental consequence analysis is the flood above which there is a negligible increase in downstream water surface elevation, velocity, and/or consequences due to failure of the dam when compared to the same flood without dam failure."* The document goes on to state that, *"For a High Hazard Potential dam, the recommended lower limit for an IDF estimated using incremental consequence analysis is the 0.2% annual chance exceedance flood."* A comparison of the flood magnitudes for various events is shown in Table 10 below. The 23% PMF is above the lower limit, as recommended by FEMA.

Table 10 – Peak Inflow Magnitudes by Event

Event	Peak Inflow	Unit
PMF	218,990	cfs
50% PMF	109,495	cfs
23% PMF	50,368	cfs
500-yr (0.2% ACE)	29,529	cfs

According to SDCL 46-7-5.3, *"Following the hearing, the board may grant a variance upon a finding that failure of the dam due to inadequate spillway capacity will not increase the potential for damage from flooding to downstream residents or property."* Based on the analyses performed as a part of this study, Houston Engineering believes that a variance in the spillway design flood could be justified. The variance request is supported by the results of an Incremental Consequence Analysis and finds that risk to the public is not meaningfully increased between scenarios with Lake Mitchell modified to pass the 50% PMF or in a condition that the Lake Mitchell Dam have an inflow design flood equal to the 23% PMF.

Under the existing conditions and assuming a no dam failure and dam failure scenario, the 50% PMF places 18 inhabitable structures within "Danger Zones" according to ACER Technical Memorandum No. 11, Downstream Hazard Classification Guidelines (1988) published by the USBR. Structure locations can be viewed from figures in Appendix A. Figure 21 summarizes the structure IDs and their respective Parcel IDs. Parcel IDs and property addresses were obtained from the Davison and Hanson County Web Viewer applications. Figure 22 and Figure 23 detail the structures and their Danger Zones for a no dam failure and dam failure scenario respectively. For the no dam failure scenario, structures 6, 8, 10, and 13 are in the High Danger Zone solely based on the anticipated depths and velocities resulting from flooding. Structures 3, 7, and 18 are in the Judgement Zone solely based on the anticipated depths and velocities resulting from flooding. USBR defines the Judgement Zone as *"Danger level is based upon engineering judgement."* For any structure numbers not shown in the USBR Danger Zone plots, this corresponds to being in the High Danger Zone outside the limits of the USBR plots (V> 25 ft/s and/or D>10 ft).

Structure ID	Parcel ID	Property Address	Danger Zone for 23% PMF Dam Breach	Danger Zone for 50% PMF Dam Breach
1	06145-00100-003-00	1805 SCENIC COURT DR		L
2	06145-00100-002-00	1801 SCENIC COURT DR		J
3	06145-00100-001-00	1725 SCENIC COURT DR	J	H
4	06141-10360-001-22	1902 N FOSTER ST	H	H
5	06141-10360-001-20	1700 N FOSTER ST	H	H
6	06141-10360-001-10	1620 N FOSTER ST	J	H
7	06141-10360-008-00	1509 WESTVIEW DR		J
8	06144-10360-002-00	1021 N GALE RD	L	H
9	06000-10360-134-30	25279 BARBER PL		L
10	103-59-018-002-000-03	25222 CAMPGROUND RD	L	H
11	08000-10460-103-20	40932 246TH ST		L
12	06247-10360-001-10	2761 E 1ST AVE		J
13	06000-10360-244-30	2840 E 1ST AVE	J	H
14	102-59-005-002-000-01	41327 JAMES RIVER RD		L
15	102-59-009-004-000-01	41462 258 ST		L
16	102-59-009-004-000-01	41462 258 ST		L
17	102-59-014-004-000-03	25823 417 AVE		J
18	102-59-014-004-000-03	25823 417 AVE	L	J
L	Low Danger Zone			
J	Judgement Danger Zone			
H	High Danger Zone			

Figure 21 – Structure IDs and Parcel IDs

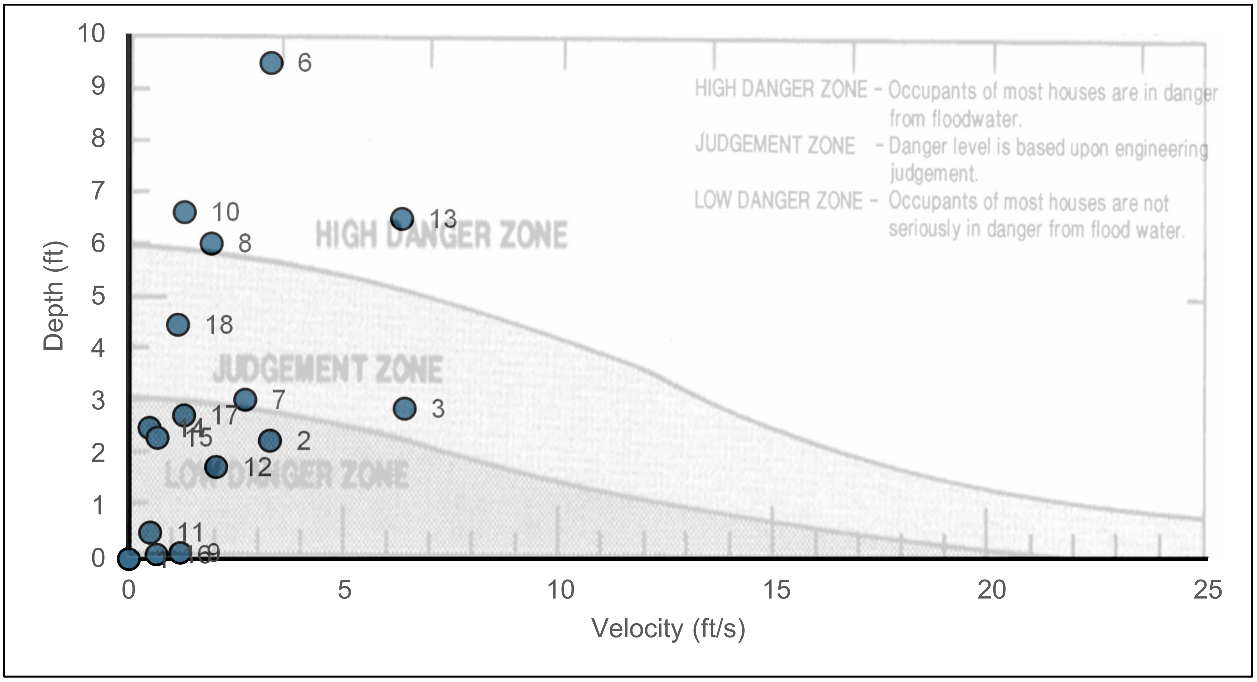

Figure 22 - 50% PMF No Dam Failure Dangers

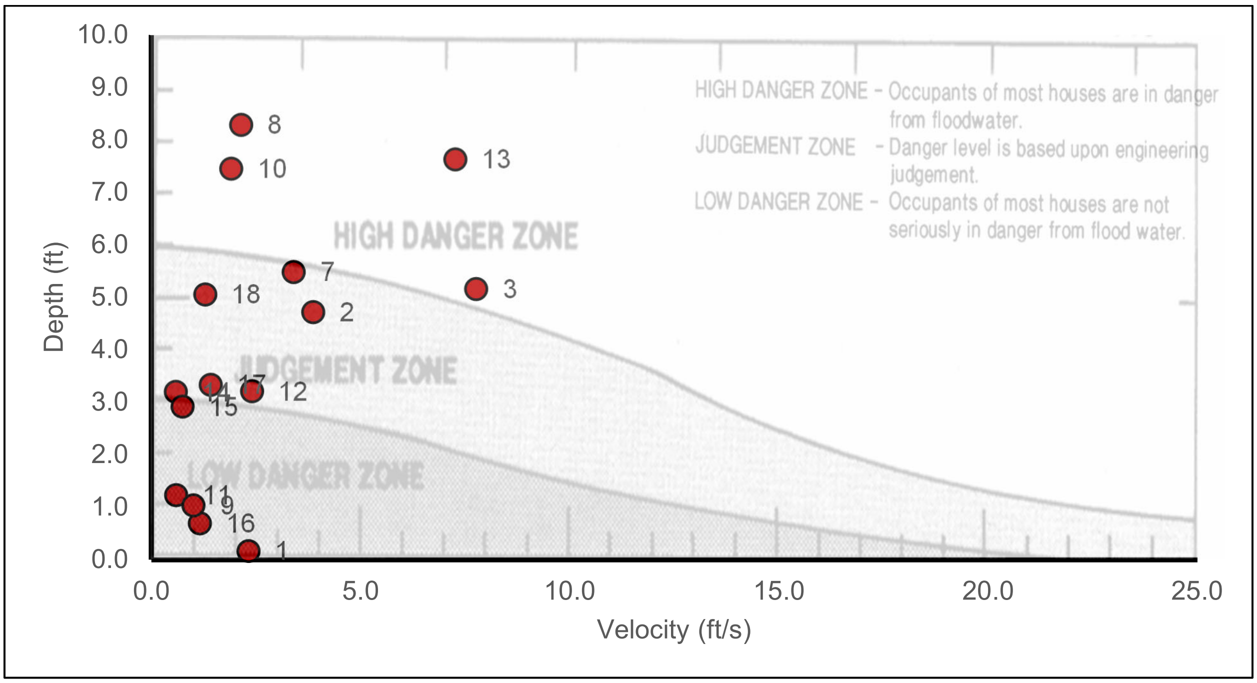

Figure 23 – 50% PMF Dam Failure Dangers

From the no dam failure to dam failure scenario under the 50% PMF event, structures 2, 3, 12, and 17 are elevated in Danger Zone when comparing the no dam failure and dam failure scenarios. Figure 24 lists each structure and the corresponding Danger Zone for the no dam failure and dam failure scenarios.

	50% PMF						
	No Dam Failure			Dam Failure			
	Depth, D	Velocity, V	Hazards	Depth, D	Velocity, V	Hazards	
ID	ft	ft/s	USBR ACER TM No. 11	ft	ft/s	USBR ACER TM No. 11	
1	0.0	0.0	L	0.2	2.3	L	
2	2.3	3.3	L	4.7	3.9	J	▲
3	2.9	6.4	J	5.2	7.8	H	▲
4	10.6	4.6	H	13.0	5.5	H	
5	11.1	4.4	H	13.5	5.5	H	
6	9.5	3.3	H	12.6	4.0	H	
7	3.0	2.7	J	5.5	3.4	J	
8	6.0	1.9	H	8.3	2.1	H	
9	0.1	1.2	L	1.1	1.0	L	
10	6.6	1.3	H	7.5	1.9	H	
11	0.5	0.5	L	1.2	0.6	L	
12	1.8	2.0	L	3.2	2.4	J	▲
13	6.5	6.3	H	7.6	7.3	H	
14	2.5	0.5	L	3.2	0.6	L	
15	2.3	0.7	L	2.9	0.7	L	
16	0.1	0.6	L	0.7	1.2	L	
17	2.7	1.3	L	3.3	1.4	J	▲
18	4.5	1.1	J	5.1	1.3	J	

Figure 24 – USBR Danger Zone Comparisons for 50% PMF

Danger Zones and comparisons for the 23% PMF are shown in Figure 25, Figure 26, and Figure 27 below.

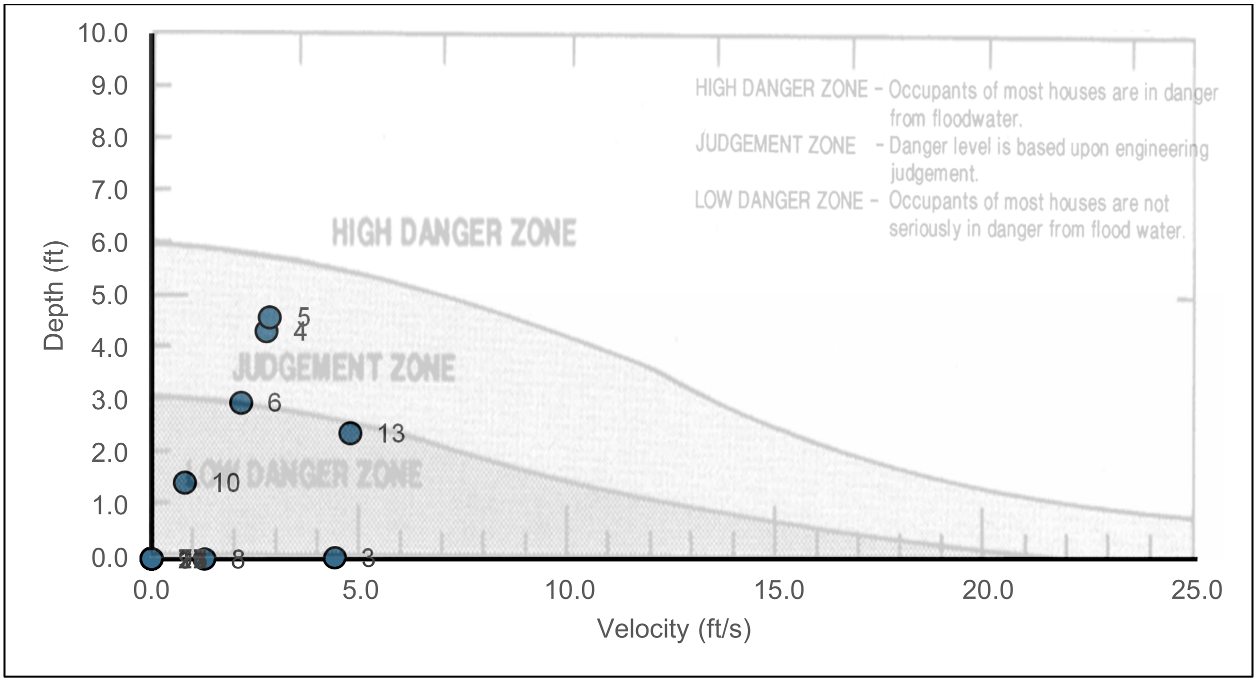

Figure 25 – 23% PMF No Dam Failure Dangers

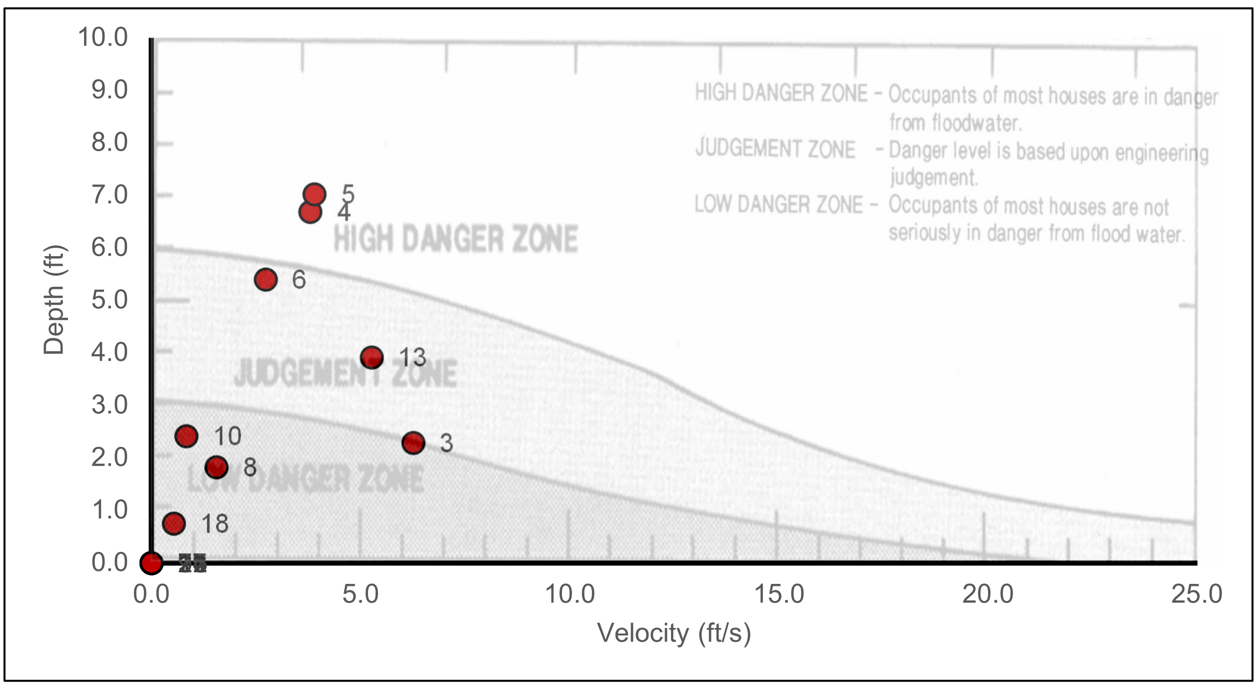

Figure 26 - 23% PMF Dam Failure Dangers

	23% PMF						
	No Dam Failure			Dam Failure			
	Depth, D	Velocity, V	Hazards	Depth, D	Velocity, V	Hazards	
ID	ft	ft/s	USBR ACER TM No. 11	ft	ft/s	USBR ACER TM No. 11	
1	0.0	0.0		0.0	0.0		
2	0.0	0.0		0.0	0.0		
3	0.0	4.4	L	2.3	6.3	J	▲
4	4.3	2.7	J	6.7	3.8	H	▲
5	4.6	2.8	J	7.0	3.9	H	▲
6	3.0	2.1	J	5.4	2.7	J	
7	0.0	0.0		0.0	0.0		
8	0.0	1.3	L	1.8	1.6	L	
9	0.0	0.0		0.0	0.0		
10	1.5	0.8	L	2.4	0.8	L	
11	0.0	0.0		0.0	0.0		
12	0.0	0.0		0.0	0.0		
13	2.4	4.7	L	3.9	5.3	J	▲
14	0.0	0.0		0.0	0.0		
15	0.0	0.0		0.0	0.0		
16	0.0	0.0		0.0	0.0		
17	0.0	0.0		0.0	0.0		
18	0.0	0.0	L	0.8	0.5	L	

Figure 27 - USBR Danger Zone Comparisons for 23% PMF

Structures 1 through 7 are located approximately 1.5 miles downstream of the Lake Mitchell Dam and structure 13 is approximately 3.0 miles downstream from the dam. Egress from the structures involves heading towards streets that are shown to be inundated and hazardous as well. In addition to the lack of safe egress, with the proximity to the dam, the time required to act may be limited. To take protective action, a warning must be issued; however, upon receiving a warning, the threat of flooding must be detected first. Thus, before being able to act and get to safety and out of the flood extents, the threat must be detected, a warning must be issued, the warning must be received, and then the necessary steps taken to find safety must be enacted. Figure 28 displays a visual representation of this process (USBR, 2019).

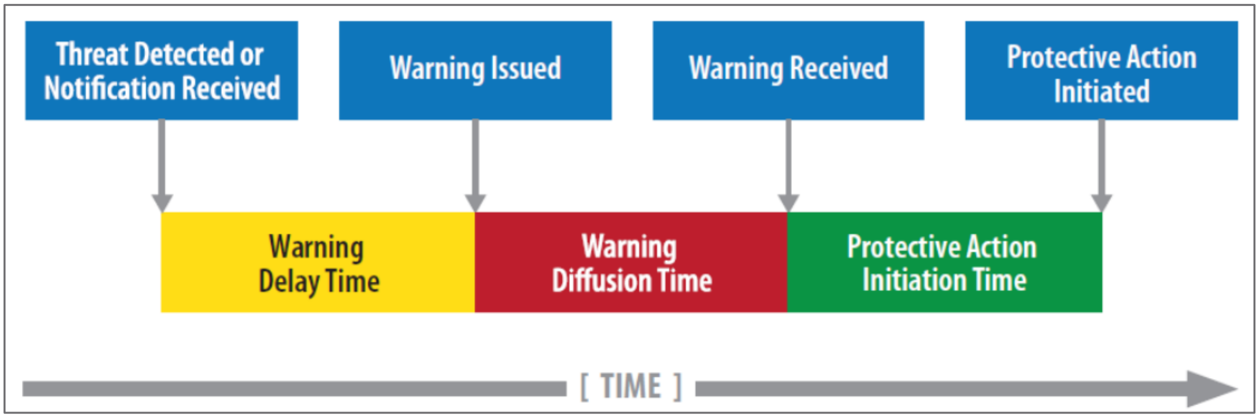

Figure 28 - Warning and Action Process

For the 23% PMF dam failure scenario, structures 3, 4, 5, and 13 are elevated in Danger Zones with respect to depths and velocities; however, as discussed above, these structures are already at a high risk based on warning times, delay times, and egress routes. Therefore, the risk to these structures for a no dam failure scenario at the 23% PMF is inherently high due to their proximity to the dam and egress routes. Based upon this, there is a negligible increase in consequences due to failure of the dam when compared to the same flood (23% PMF) without dam failure.

If the Lake Mitchell Dam were to require the IDF to be equal to the 50% PMF, one alternative would be to modify the spillway to increase its capacity to safely pass the 50% PMF. The estimated construction costs would likely be in the millions of dollars. If a modified spillway to pass the 50% PMF was desired, comparing the same water surface elevation in the reservoir to present conditions, a higher discharge would pass downstream. Danger Zones and comparisons for the 50% PMF with a modified spillway are shown in Figure 29, Figure 30, and Figure 31 below.

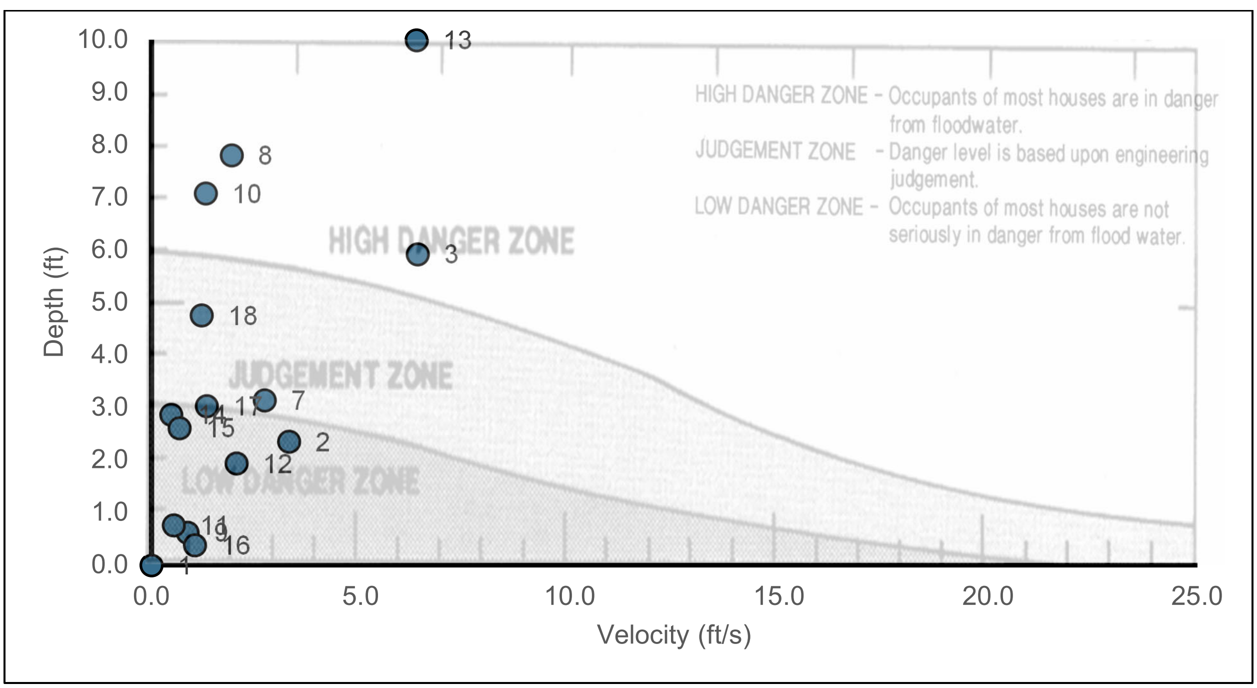

Figure 29 – 50% PMF Modified Spillway No Dam Failure Dangers

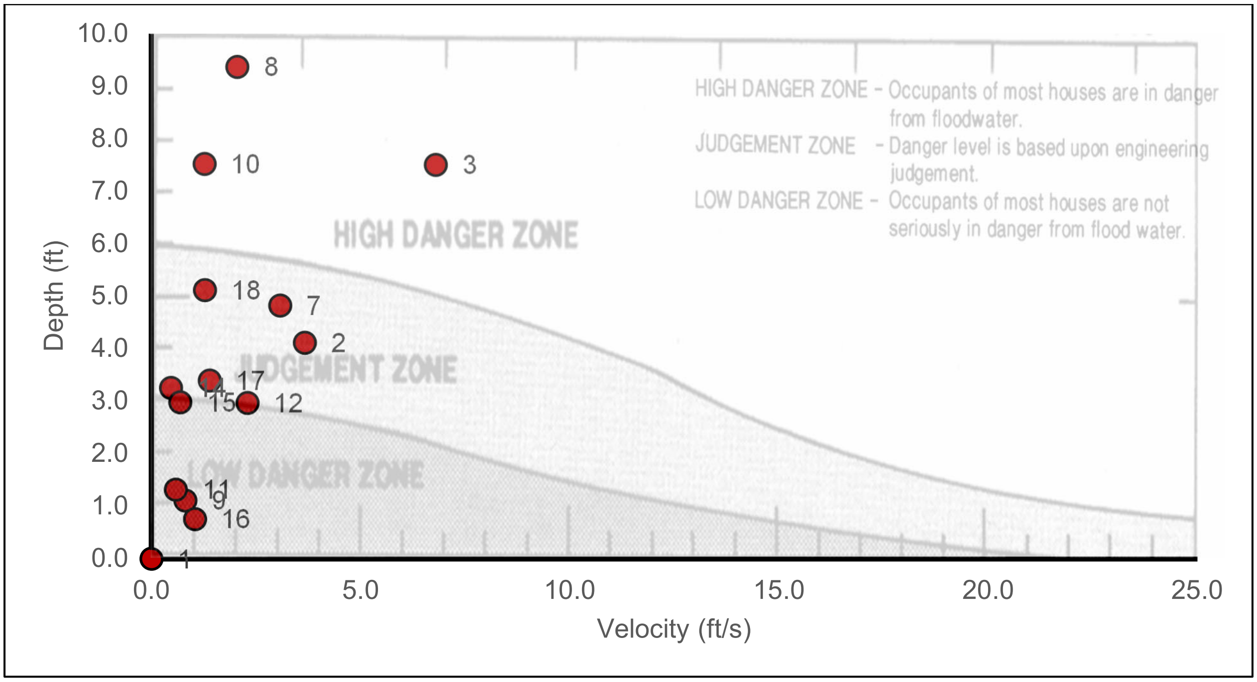

Figure 30 – 50% PMF Modified Spillway Dam Failure Dangers

	50% PMF Modified Spillway						
	No Dam Failure			Dam Failure			
	Depth, D	Velocity, V	Hazards	Depth, D	Velocity, V	Hazards	
ID	ft	ft/s	USBR ACER TM No. 11	ft	ft/s	USBR ACER TM No. 11	
1	0.0	0.0		0.0	0.0		
2	2.4	3.3	L	4.1	3.7	J	▲
3	5.9	6.4	H	7.5	6.8	H	
4	12.7	4.6	H	14.4	5.1	H	
5	11.2	4.4	H	12.8	4.7	H	
6	12.3	3.3	H	14.0	3.6	H	
7	3.1	2.7	J	4.8	3.1	J	
8	7.8	1.9	H	9.4	2.1	H	
9	0.6	0.9	L	1.1	0.8	L	
10	7.1	1.3	H	7.5	1.3	H	
11	0.8	0.5	L	1.3	0.6	L	
12	1.9	2.0	L	3.0	2.3	J	▲
13	10.0	6.3	H	10.8	6.6	H	
14	2.9	0.5	L	3.3	0.5	J	▲
15	2.6	0.7	L	3.0	0.7	L	
16	0.4	1.0	L	0.8	1.0	L	
17	3.0	1.3	J	3.4	1.4	J	
18	4.8	1.2	J	5.1	1.3	J	

Figure 31 - USBR Danger Zone Comparisons for 50% PMF with a Modified Spillway

For the 50% PMF with a modified spillway, three (3) structures are shown to be elevated in Danger Zone when comparing the no dam failure and dam failure scenarios. Therefore, if the 50% PMF were to remain as the IDF for the Lake Mitchell Dam and a modification to the spillway was required, there would still be residual risk comparable to the 23% PMF.

6 Other Recommendations

6.1 Downstream Zoning Control

Often when a dam has a hazard class lower than high hazard, downstream zoning control is considered. Proper zoning control and coordination is required to ensure that if future downstream development occurs, it does not cause the hazard class of the dam to increase. This is known as “hazard creep” for a dam. The Lake Mitchell Dam is already listed as high hazard; however, proper planning should be considered. Houston Engineering recommends planning for any future development downstream of the dam and to limit any development to be outside of the breach extents. It may be practical to consider not just the breach extents but to apply a buffer zone from the extents to set zoning or development restrictions. Dam safety regulators typically do not have control over zoning laws or ordinances so this must be planned for and coordinated with local officials.

6.2 EPP Updates

Houston Engineering recommends updating the EPP annually. Continual reviews and updates are standard practices for high hazard dams within the United States. Updates may include but are not limited to the following:

- Address changes
- Contact information
- Facility changes
- Emergency procedures
- Downstream developments
- Inundation areas

Within the attached EPP in Appendix B, there is a section titled ‘Maintenance—EAP Review and Revision’, which contains items to cover during the review and how to handle revisions to the EPP.

6.3 EPP Tabletop Exercise

Houston Engineering recommends holding a tabletop exercise to ensure all parties involved in the emergency response know their roles and responsibilities. A tabletop drill or exercise helps participants get familiar with the emergency response process and allows safety leaders to assess the organizations’ emergency preparedness in a risk-free environment. The most basic goal of a tabletop exercise is to ensure your team members know exactly what to do in an emergency. FEMA recommends holding a tabletop exercise at least every 3 to 4 years while the State of South Dakota recommends holding one at least once every 5 years. Items to cover during the tabletop exercise may include but are not limited to the following:

- Agencies involved and their roles and responsibilities
- Potential Failure Modes (PFMs) of dams
- Operation and Maintenance

- Unique features at dam
- Warning times
- Evacuation routes
- Exercise simulating real world dam failure scenario

Within the attached EPP in Appendix B, there is a section titled 'Maintenance—EAP Review and Revision', which contains items to cover during the tabletop exercise.

7 Appendices

Appendix A - Dam Failure and No Dam Failure Flood Maps

Appendix B – Emergency Preparedness Plan (EPP)

8 References

Applied Weather Associates (AWA). Site-Specific Probable Maximum Precipitation (PMP) Study for Nebraska. 2008

Federal Emergency Management Agency (FEMA). Selecting and Accommodating Inflow Design Floods for Dams, FEMA P-94. 2013

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Appendices

Appendix A – Dam Failure and No Dam Failure Flood Maps

Homes

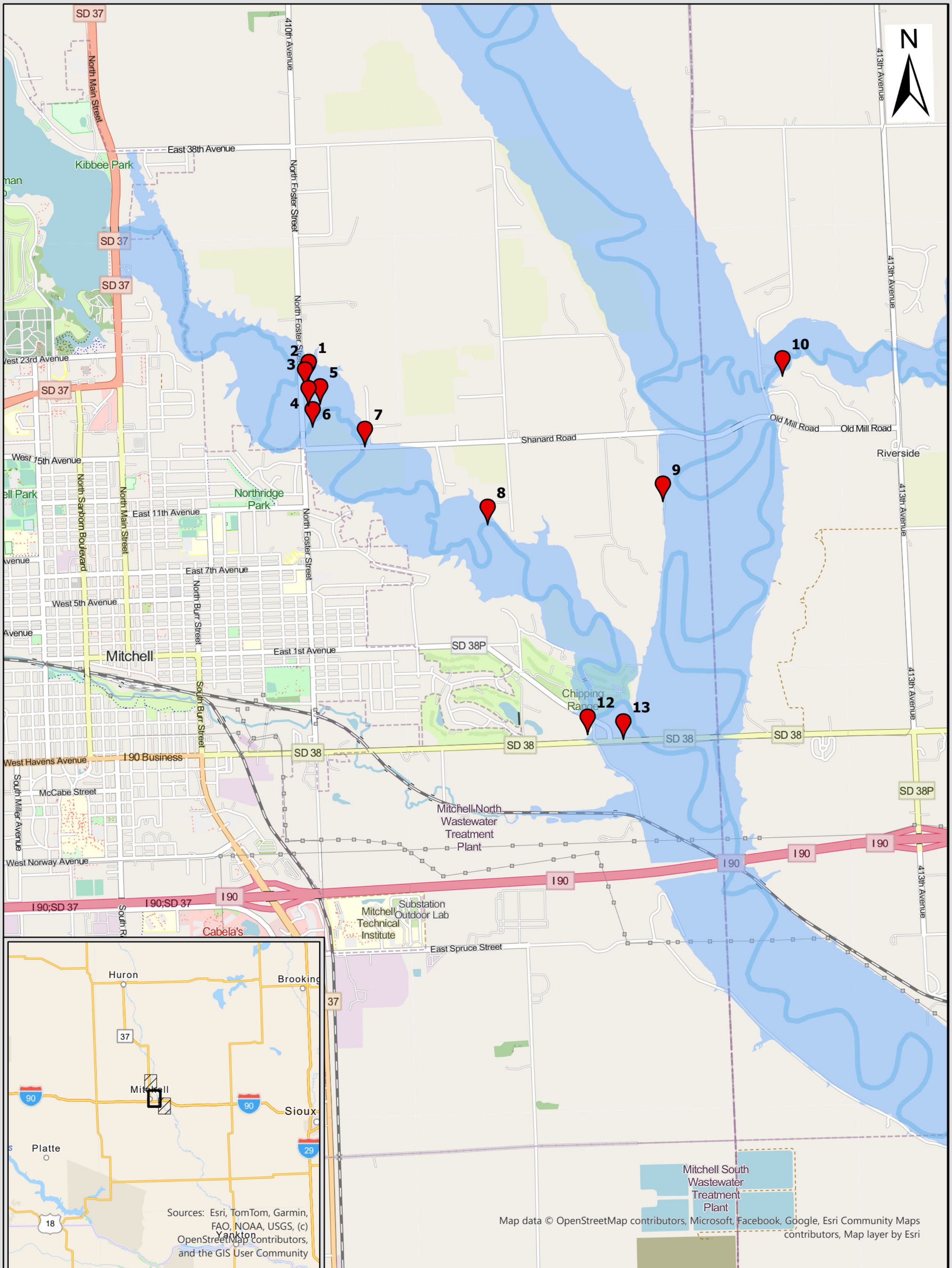
50% PMF Breach Inundation

0 0.5 1 Miles

Homes Affected by IDFs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	RR	CK	11351-0002	1/26/2026	

HOUSTON engineering, inc.



Homes

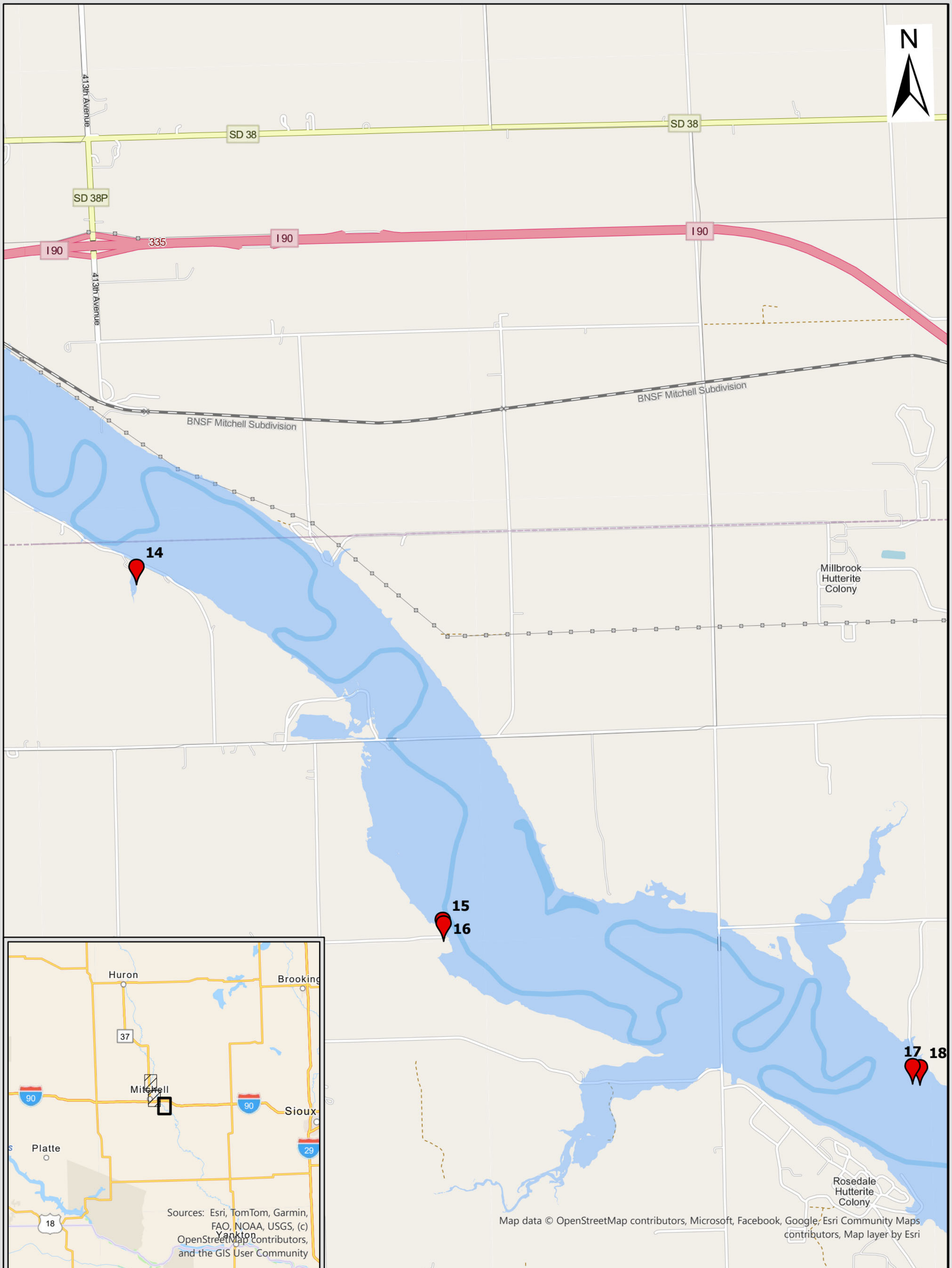
50% PMF Breach Inundation

0 0.5 1 Miles

Homes Affected by IDFs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	RR	CK	11351-0002	1/26/2026	

HOUSTON engineering, inc.



Homes

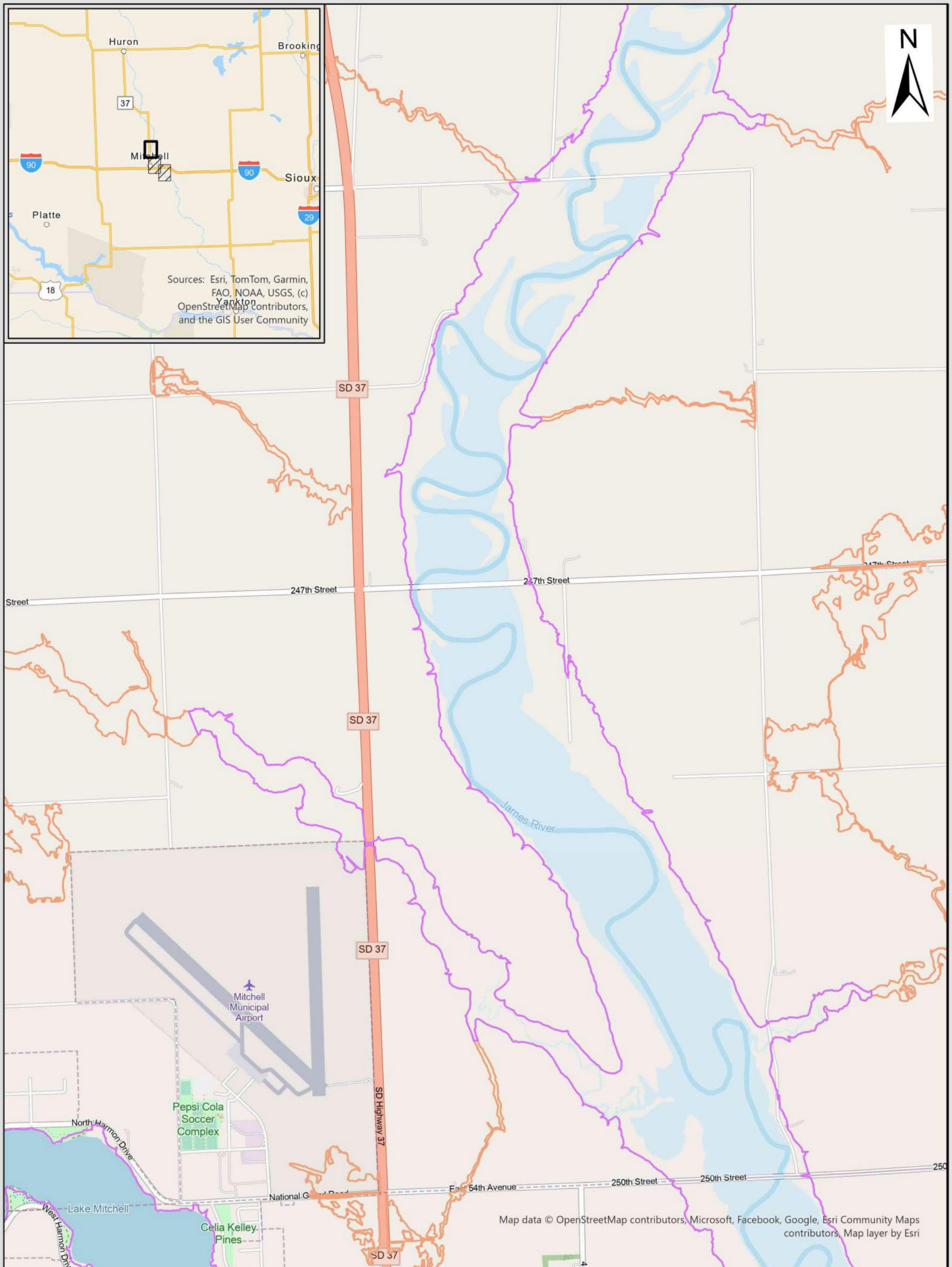
50% PMF Breach Inundation

0 0.5 1 Miles

Homes Affected by IDFs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	RR	CK	11351-0002	1/26/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

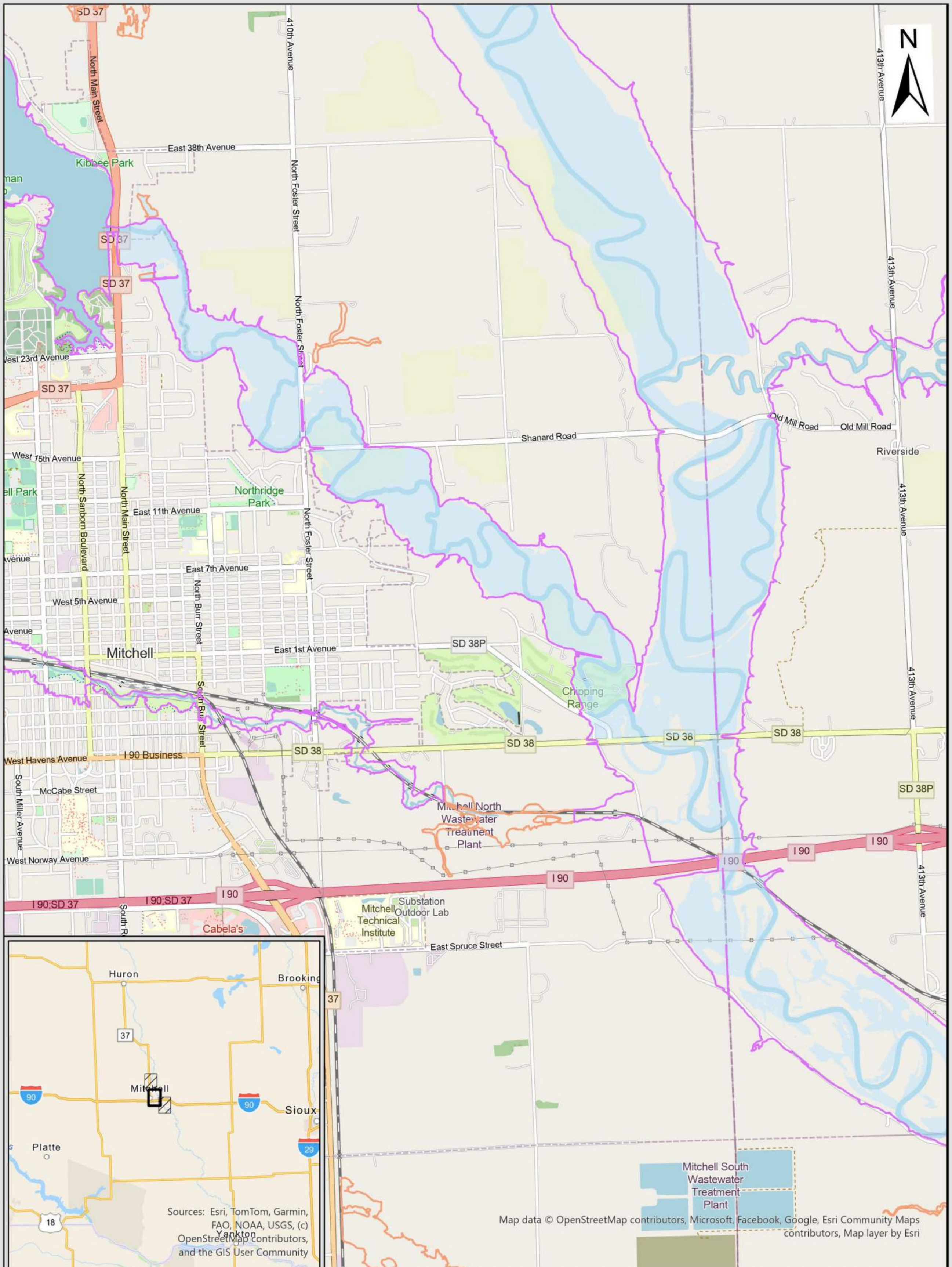
FEMA Flood Zone AE

0 0.5 1 Miles

Sunny Day Breach Inundation Extents

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

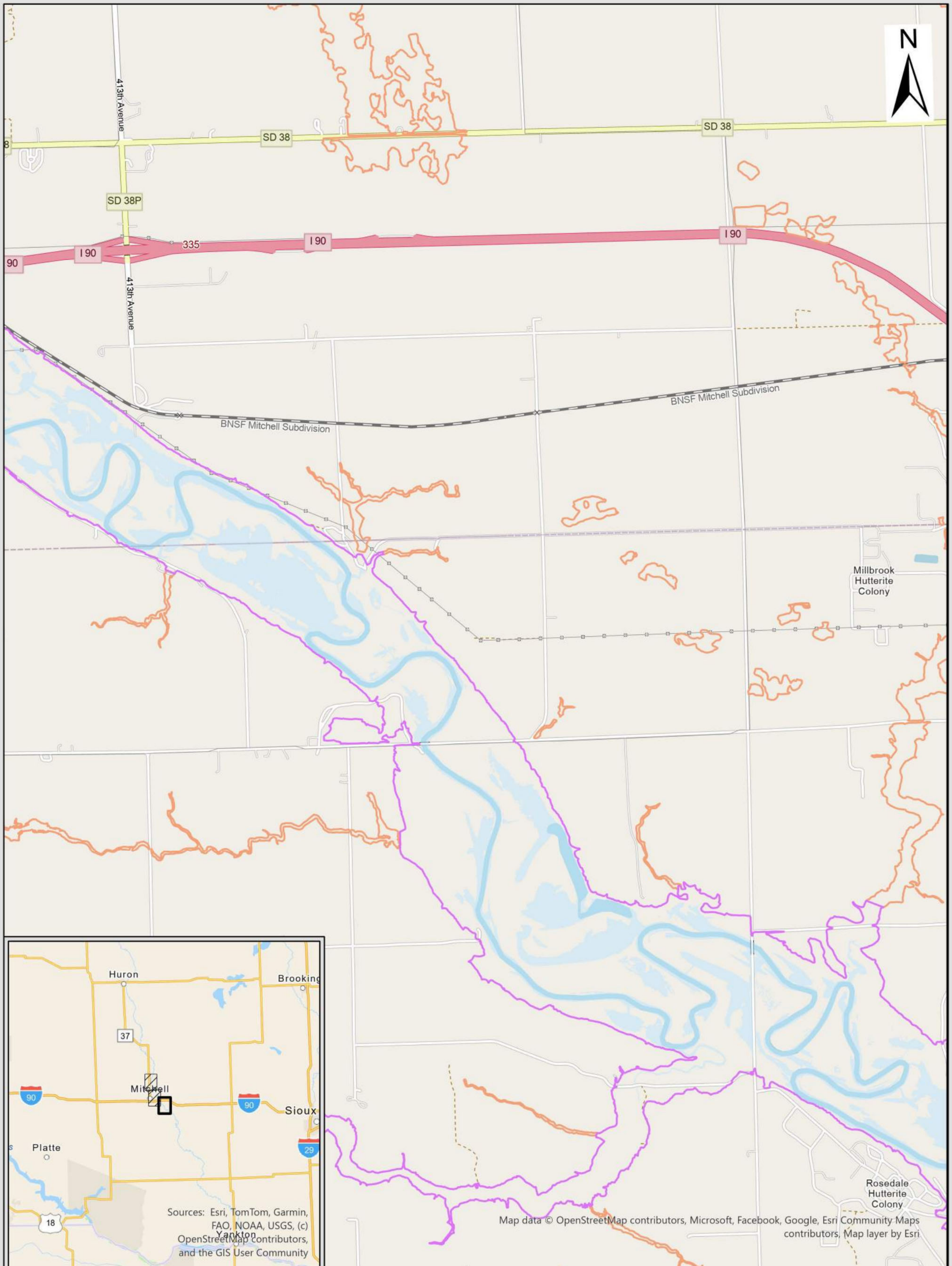
FEMA Flood Zone AE

0 0.5 1 Miles

Sunny Day Breach Inundation Extents

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

FEMA Flood Zone AE

0 0.5 1 Miles

Sunny Day Breach Inundation Extents

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

Depth Before Breach (ft)

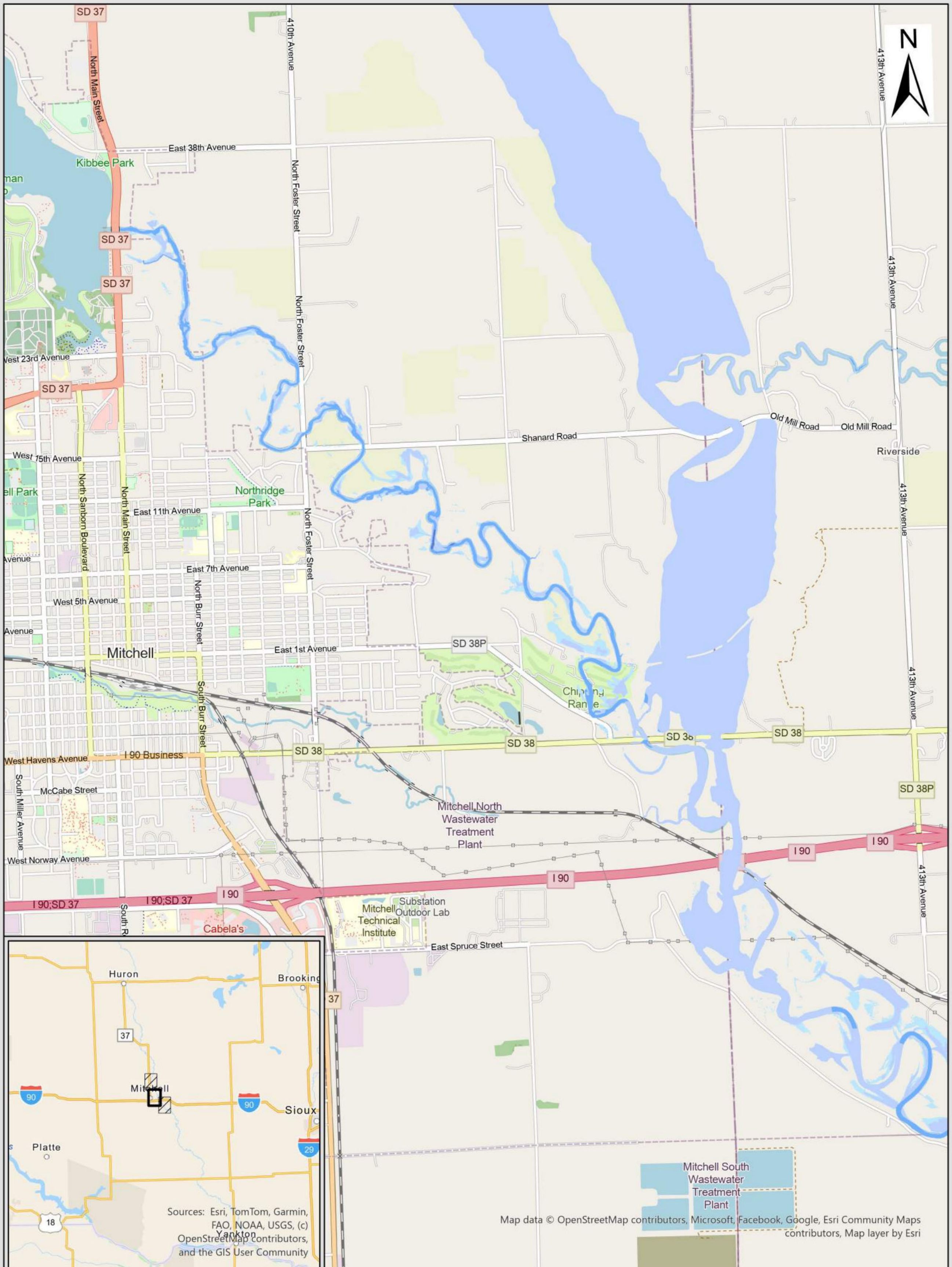
Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Sunny Day Depths Prior to Breach					
Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 1/13/2026	Sheet:

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Sunny Day Depths Prior to Breach

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Sunny Day Depths Prior to Breach

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

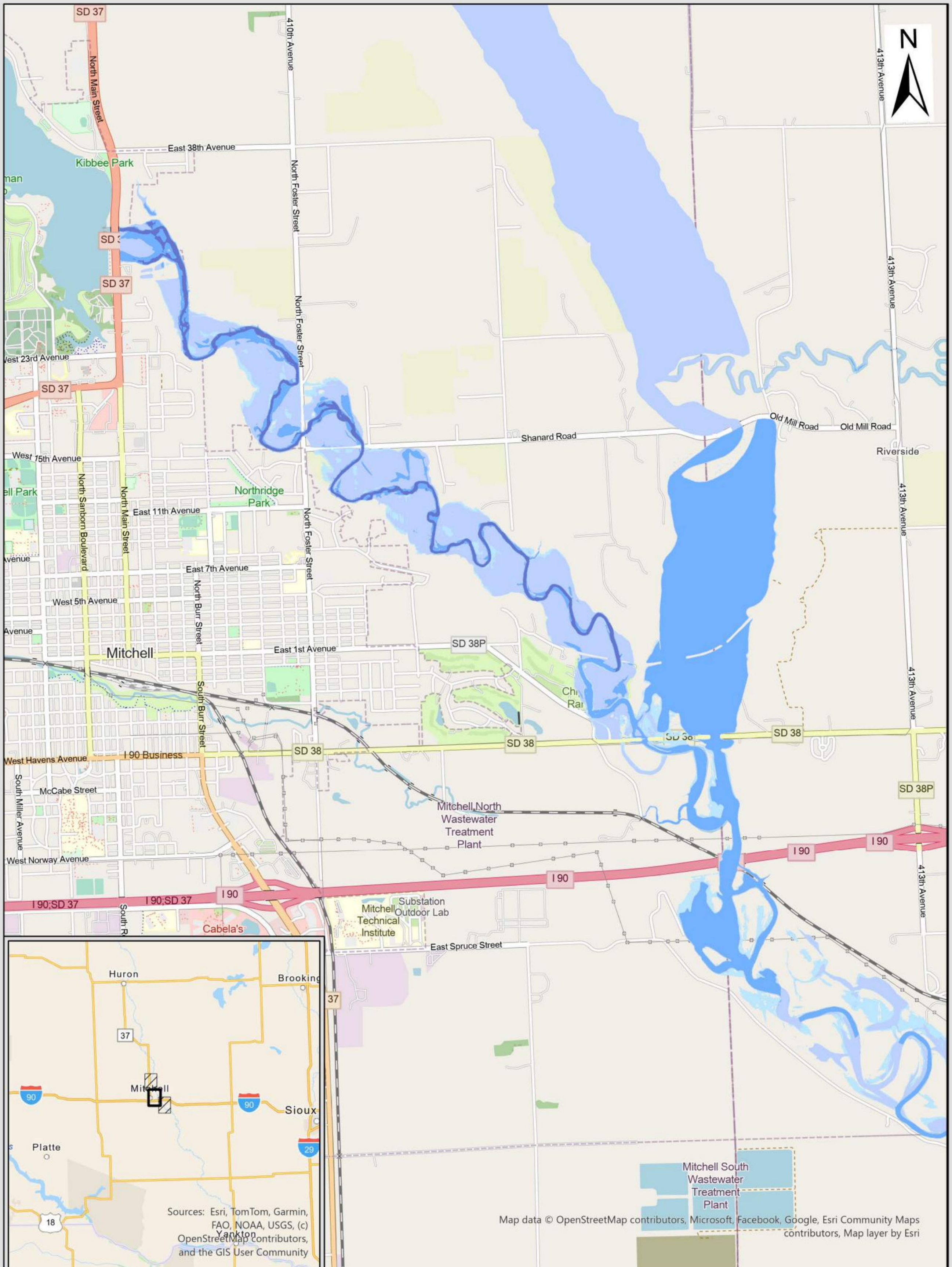
- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Sunny Day Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.



Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Sunny Day Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Sunny Day Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

Breach Velocities (ft/s)

Value

- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Sunny Day Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

Breach Velocities (ft/s)

Value

- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Sunny Day Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

Breach Velocities (ft/s)

Value

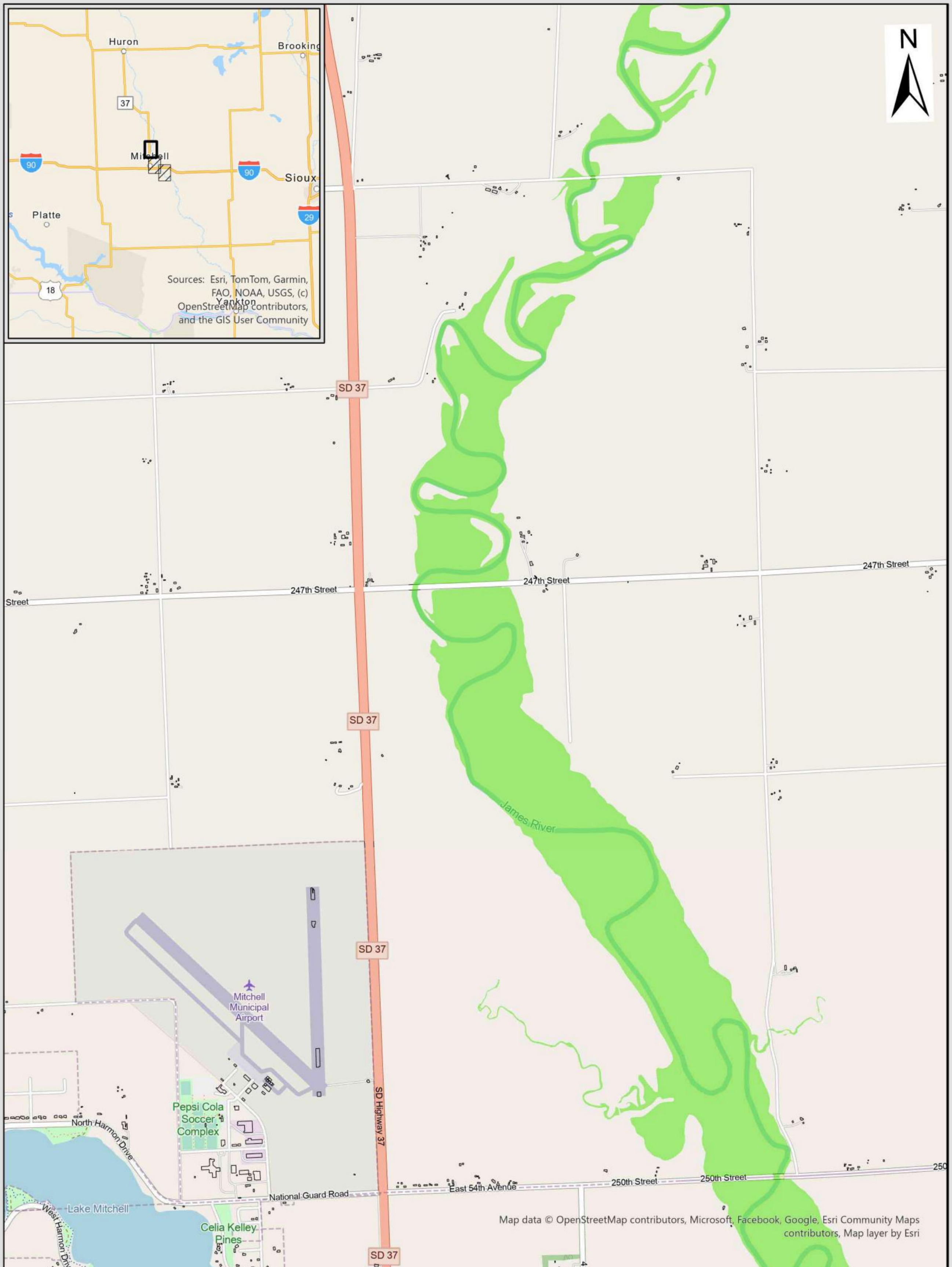
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Sunny Day Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

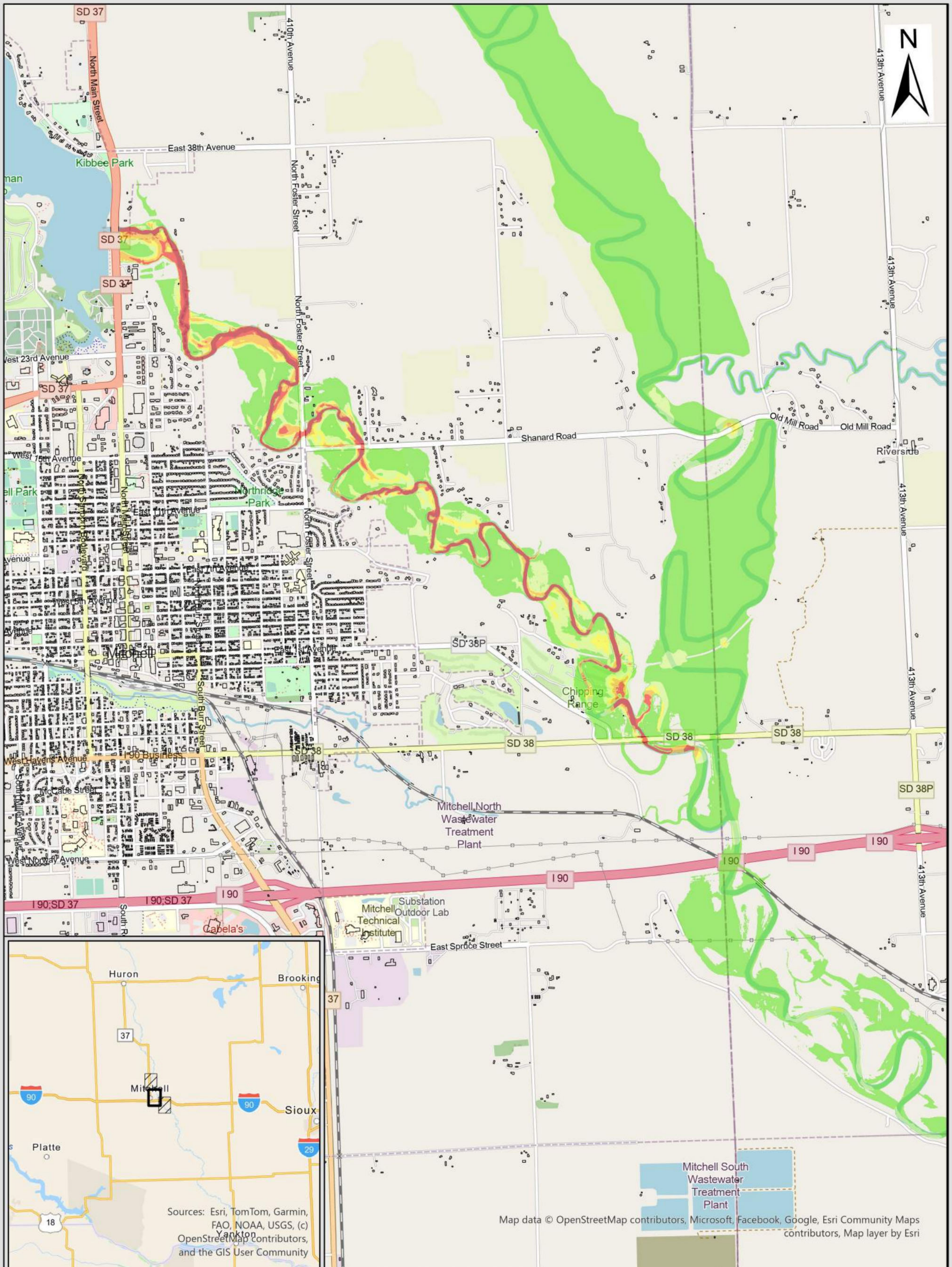
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Sunny Day Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

Sunny Day Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

Buildings

Depth x Velocity (ft*ft/s)

Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Sunny Day Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/12/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

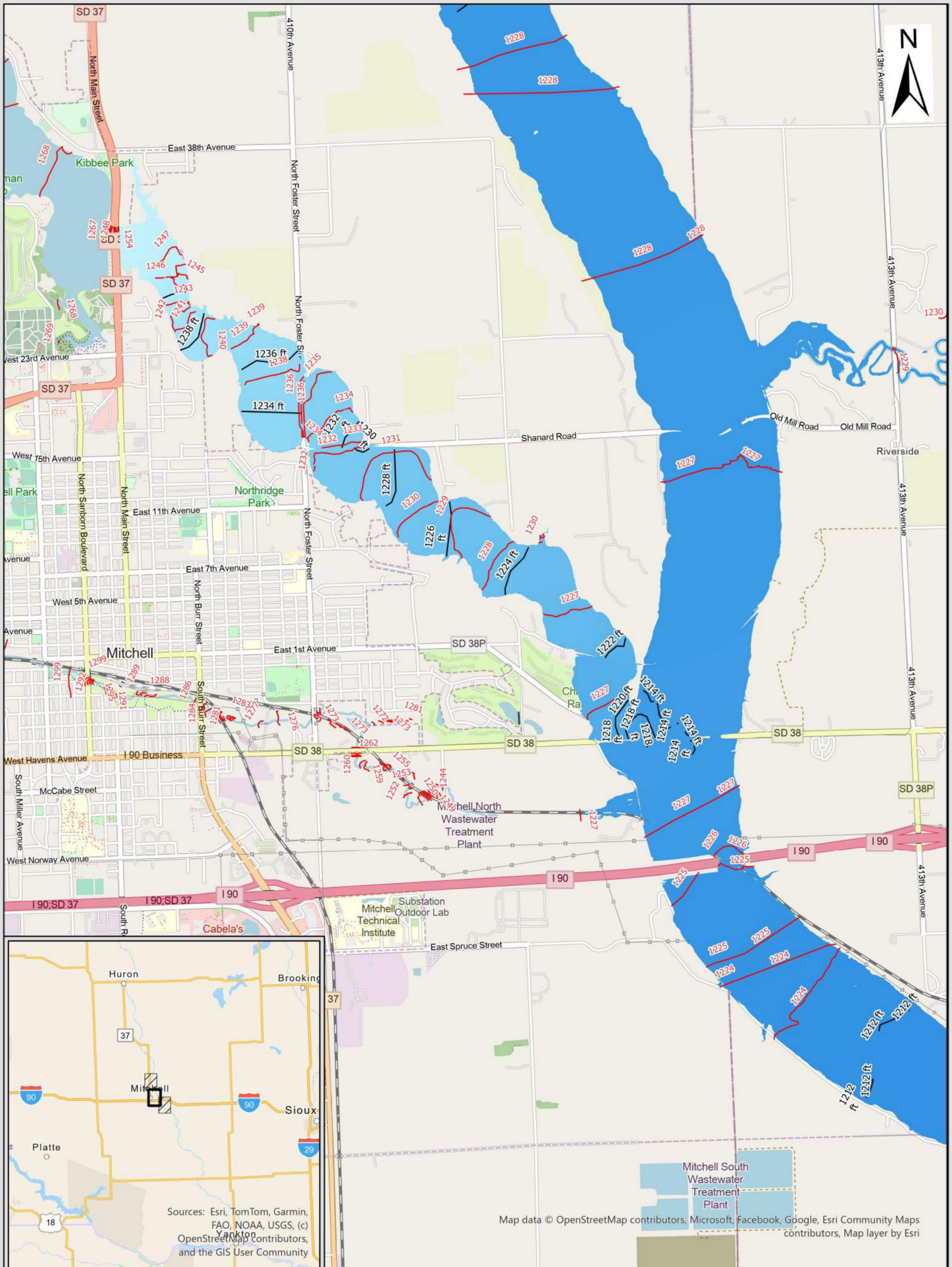
— Base Flood Elevations

0 0.5 1 Miles

Sunny Day WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

— Base Flood Elevations

0 0.5 1 Miles

Sunny Day WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

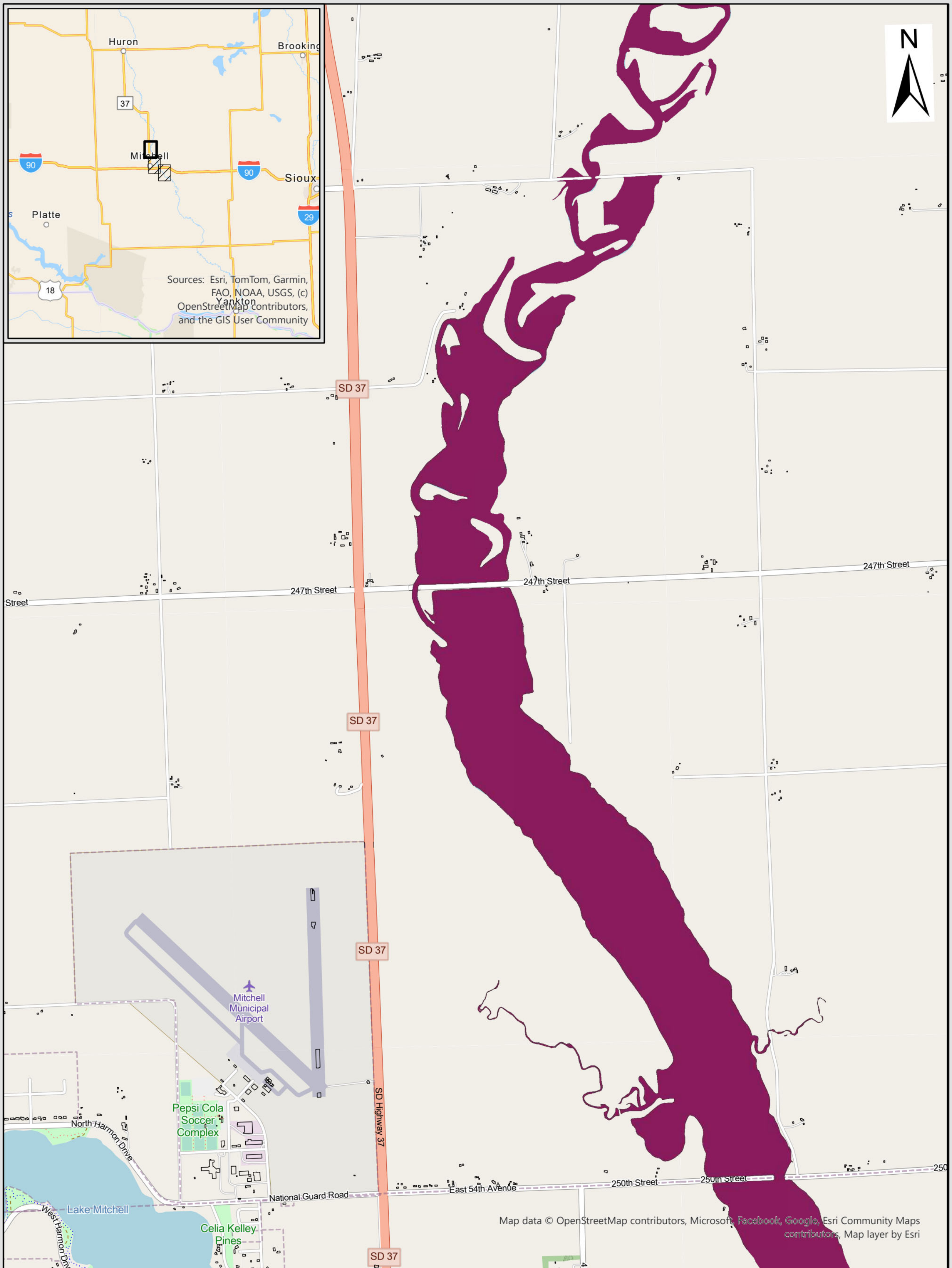
— Base Flood Elevations

0 0.5 1 Miles

Sunny Day WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

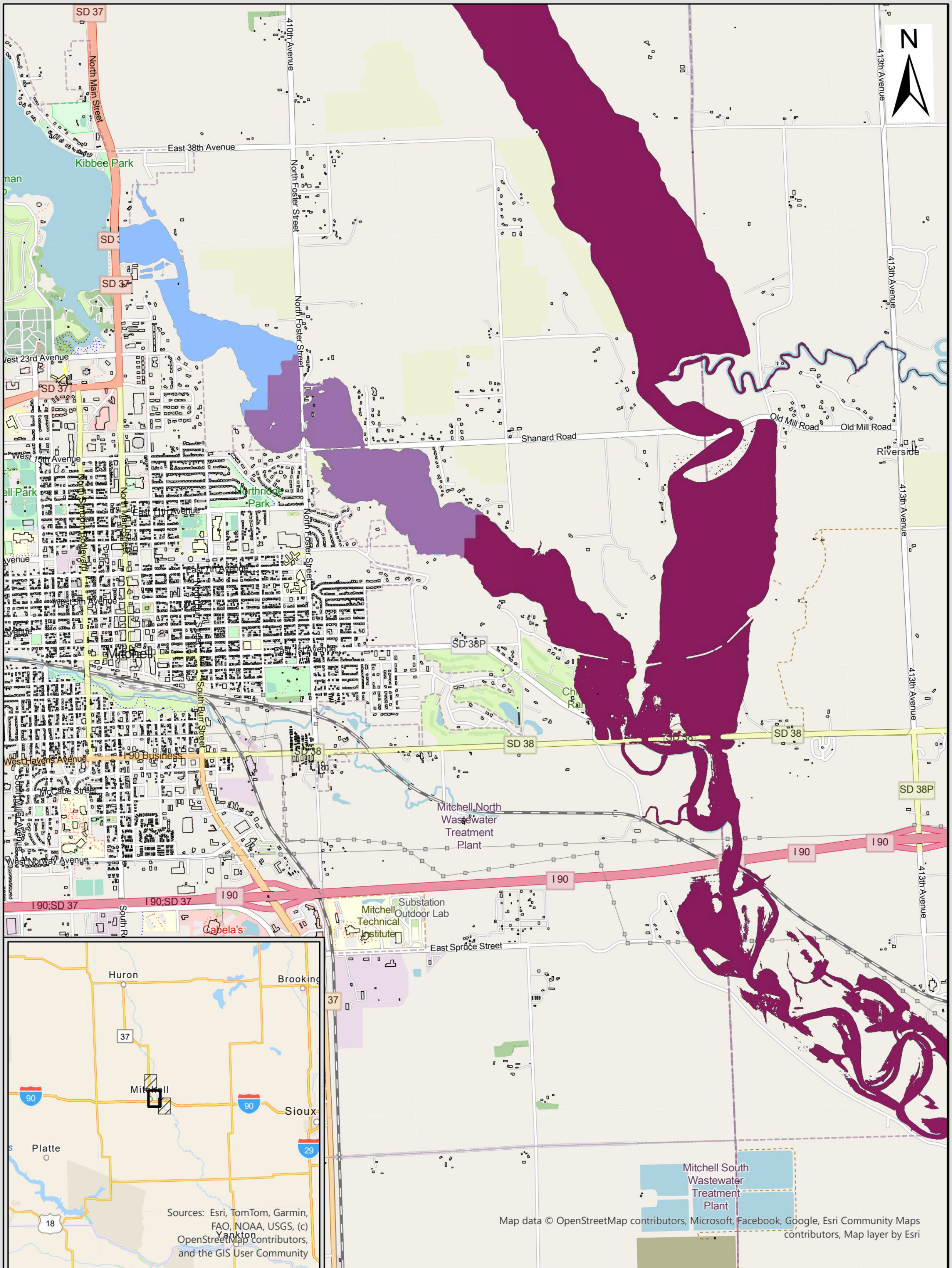
0 0.5 1 Miles

Sunny Day Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

0 0.5 1 Miles

Sunny Day Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.

Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

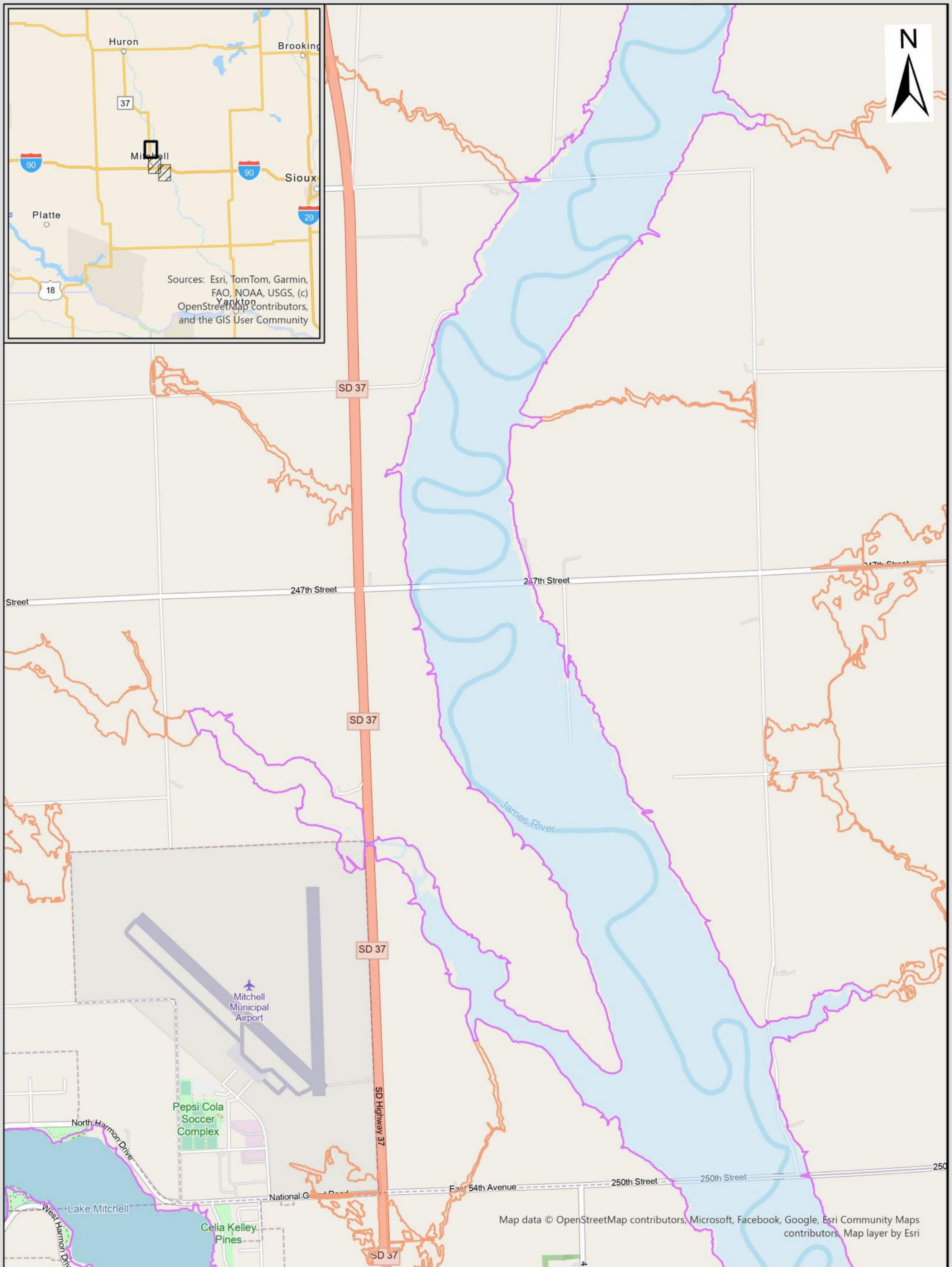
0 0.5 1 Miles

Sunny Day Breach Arrival Time

Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 2/27/2026	Sheet:

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Breach Inundation Extents

FEMA Flood Zone A

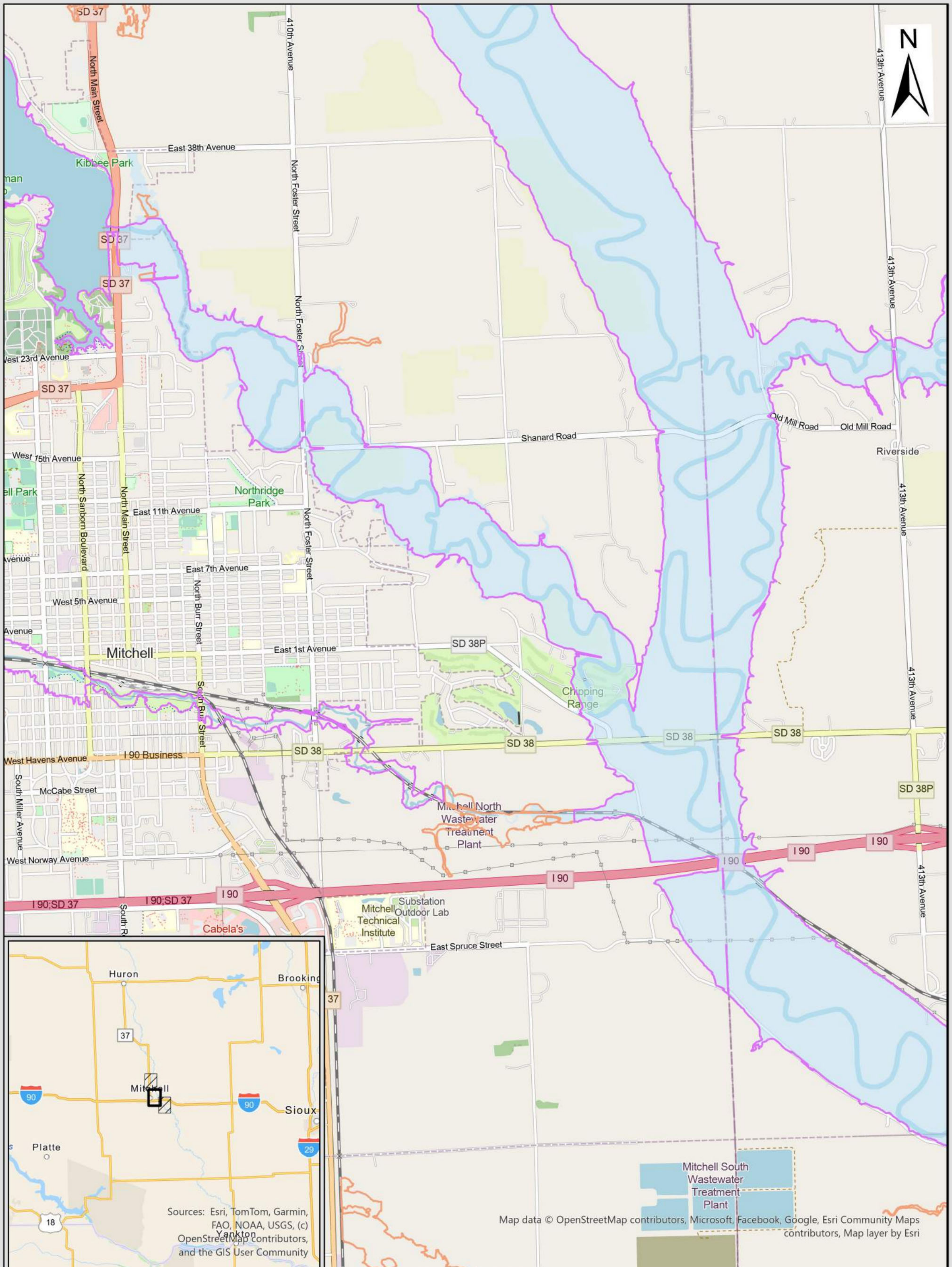
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 50% PMF Breach Inundation Extents

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

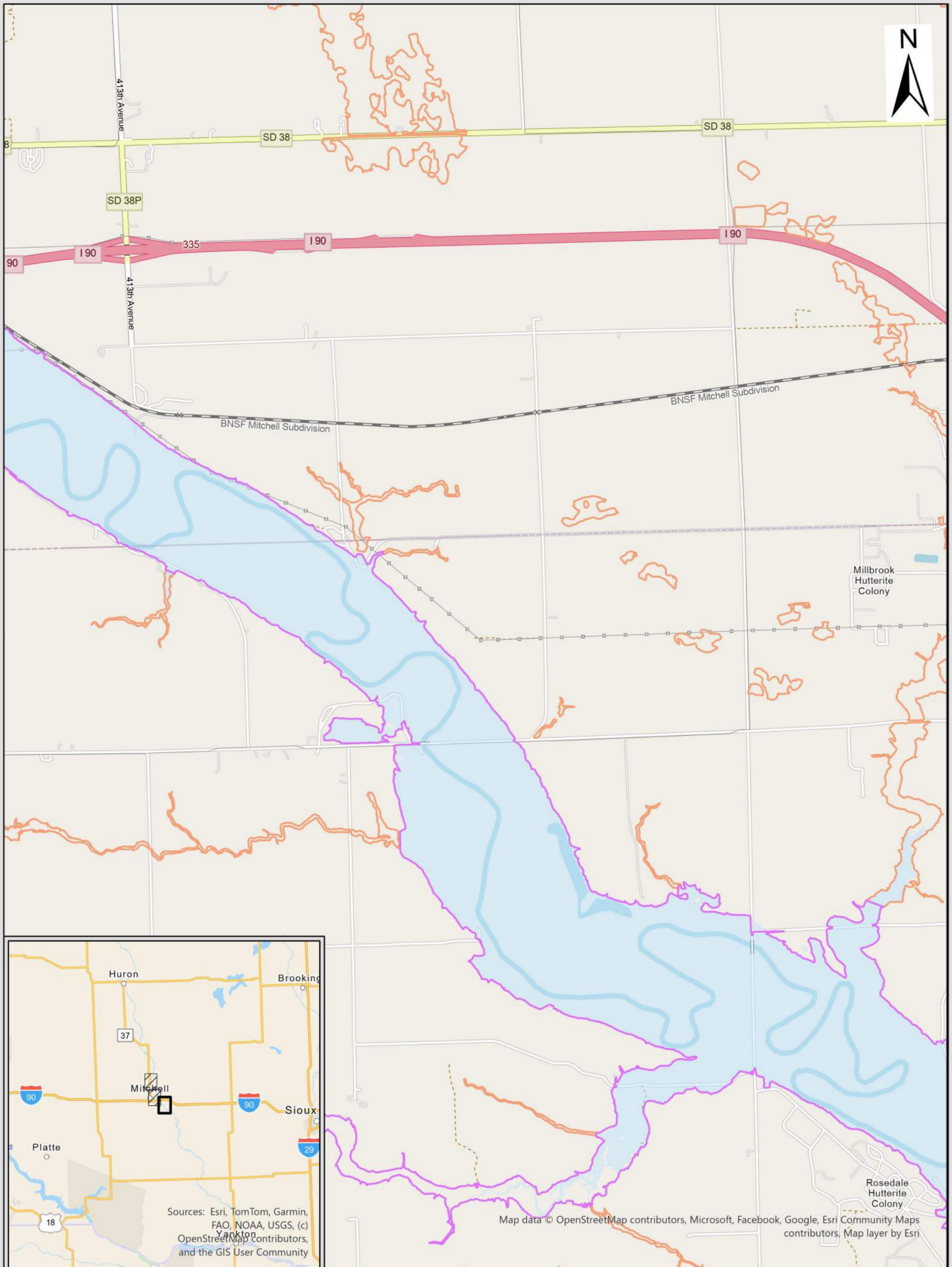
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 50% PMF Breach Inundation Extents

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

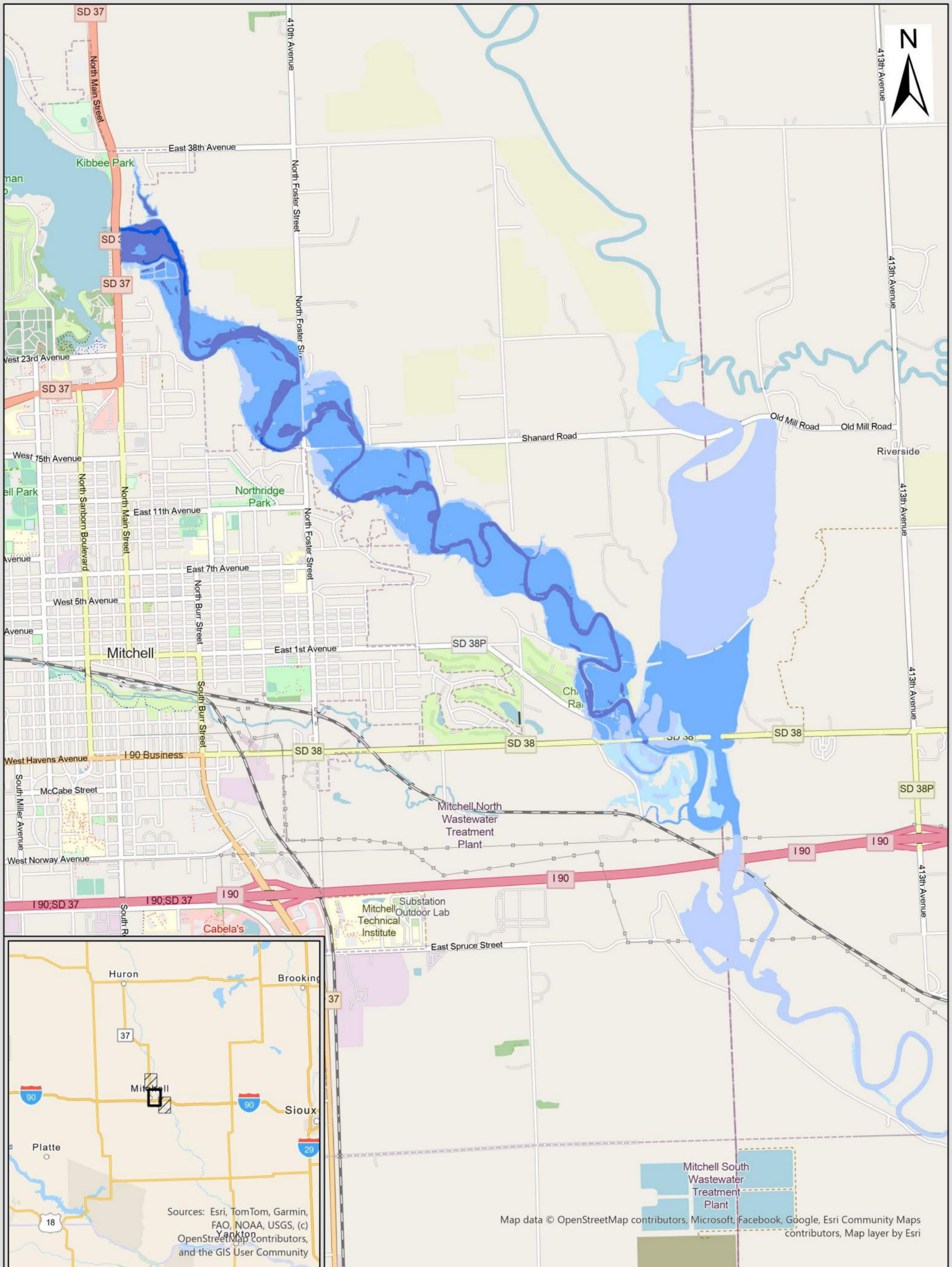
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 50% PMF Breach Inundation Extents

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

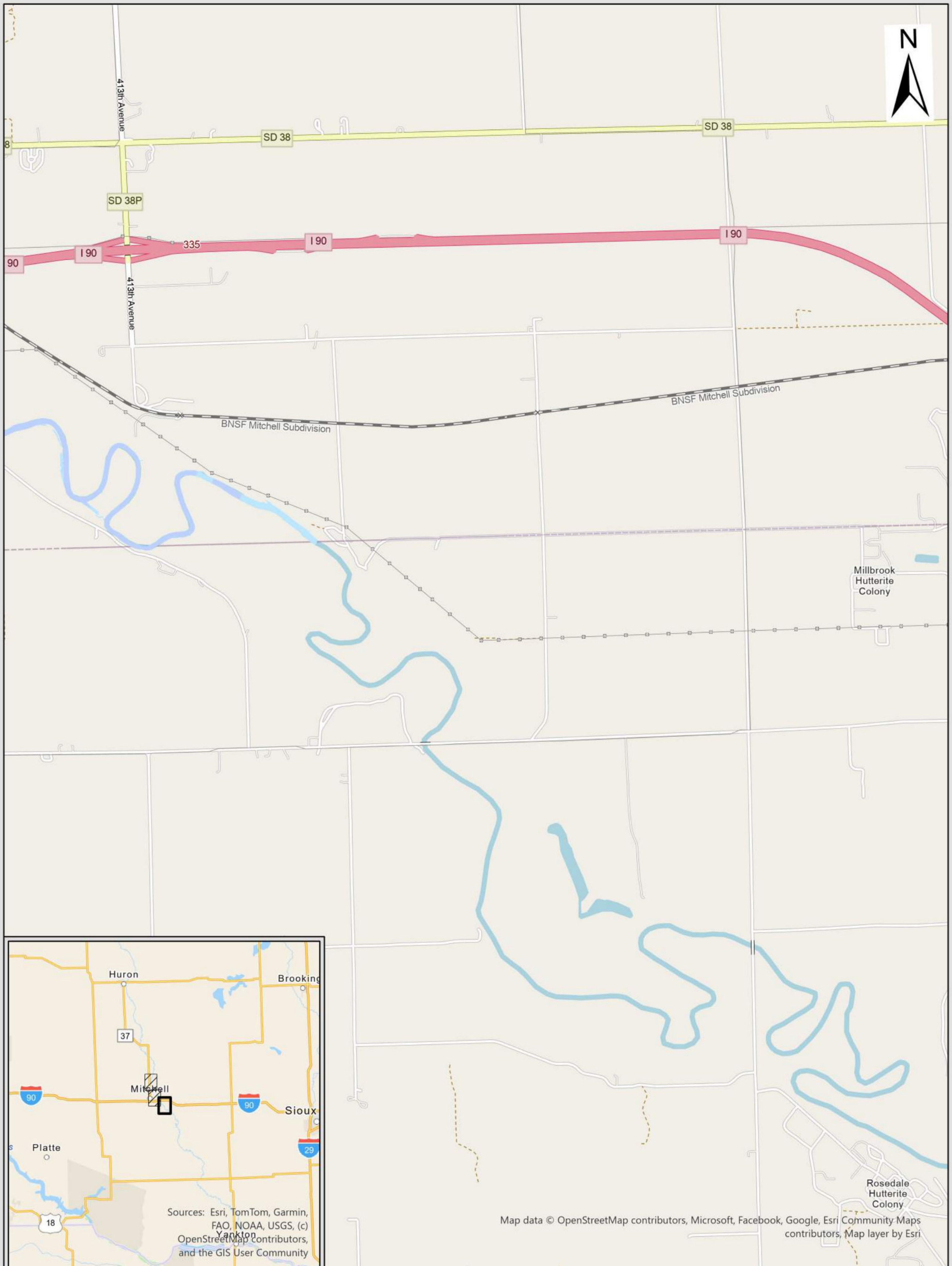
- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% Depths Prior to Breach

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF Depths Prior to Breach

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

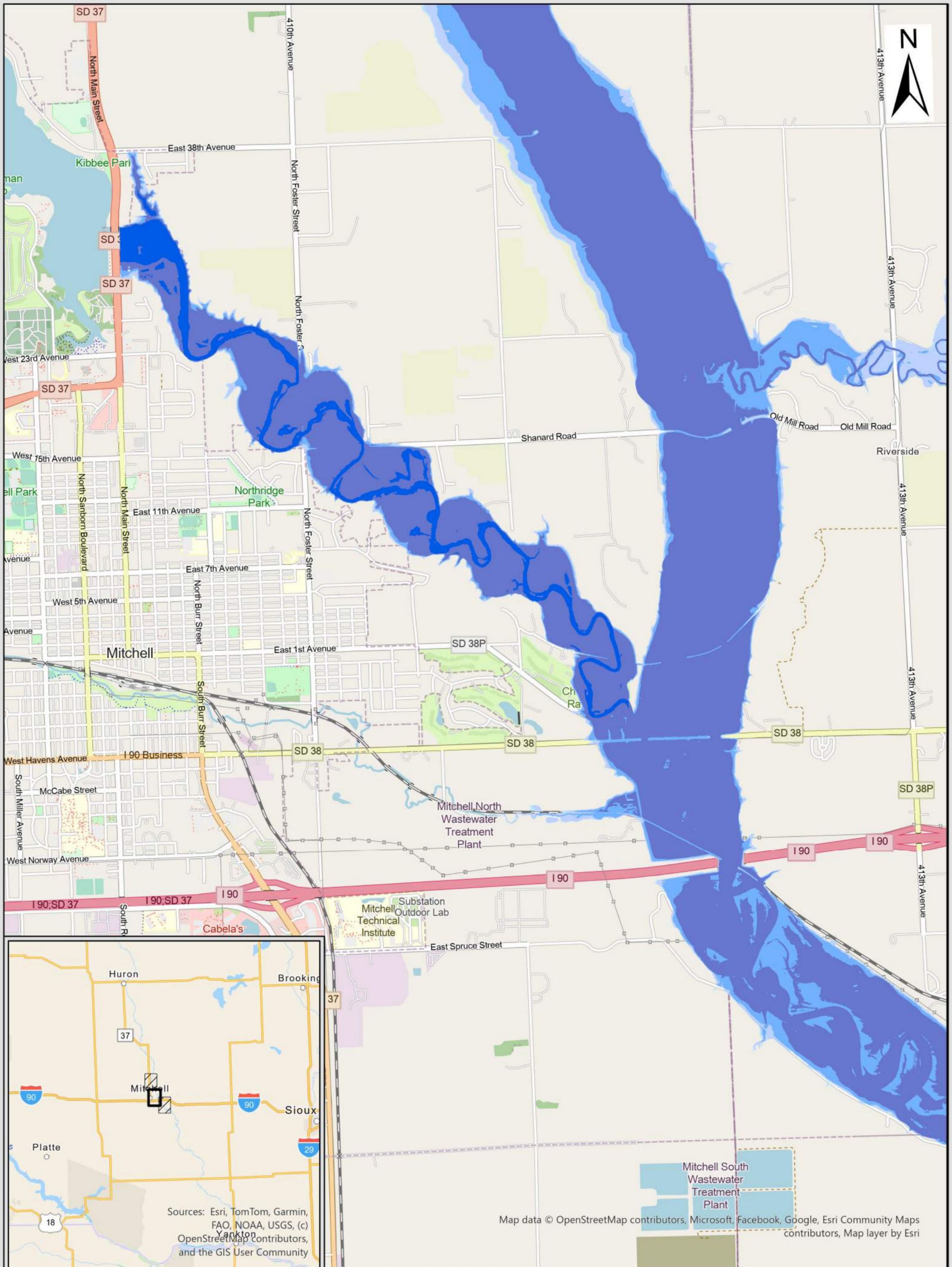
- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depths (ft)

Value

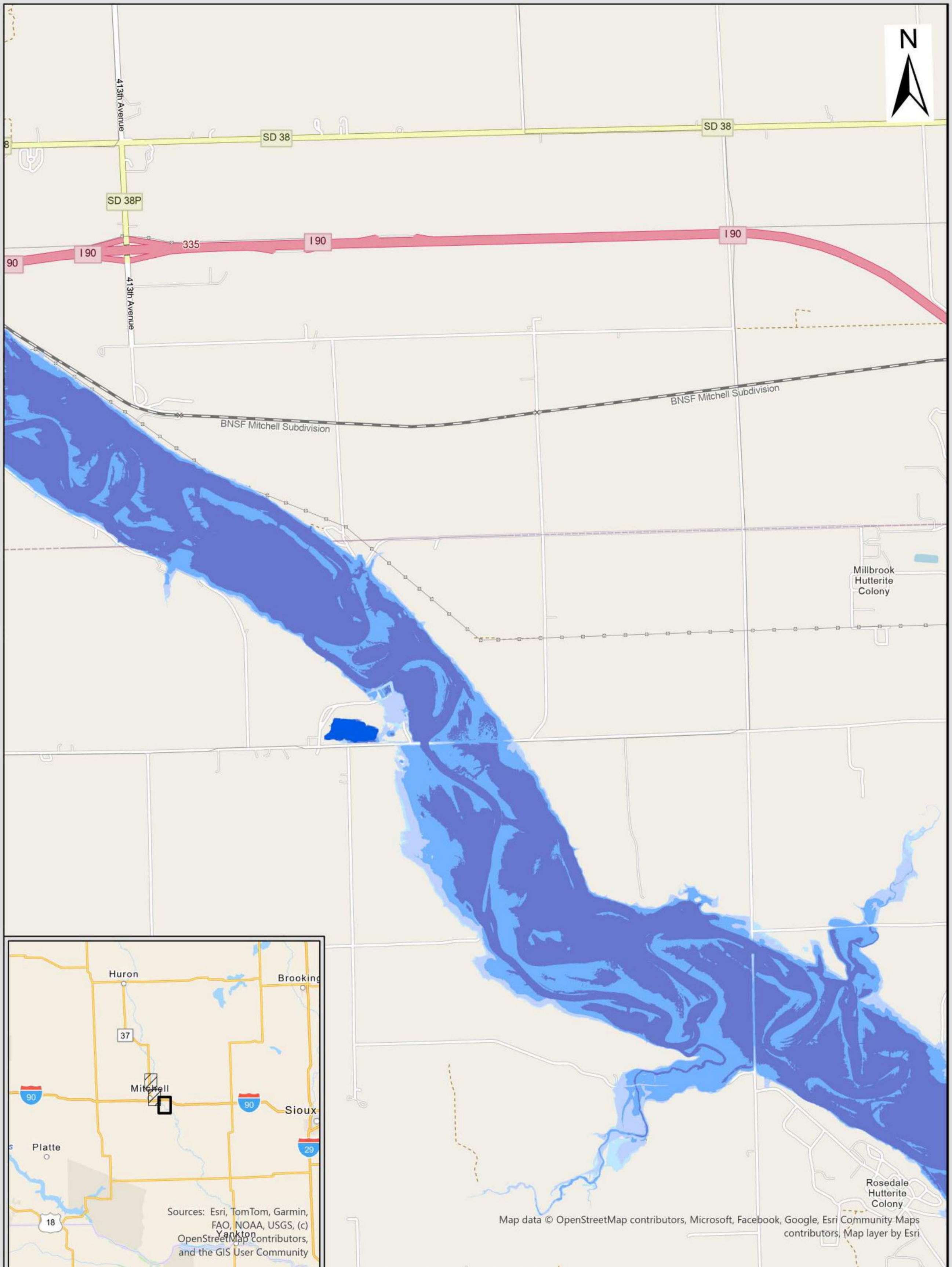
- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depths (ft)

Value

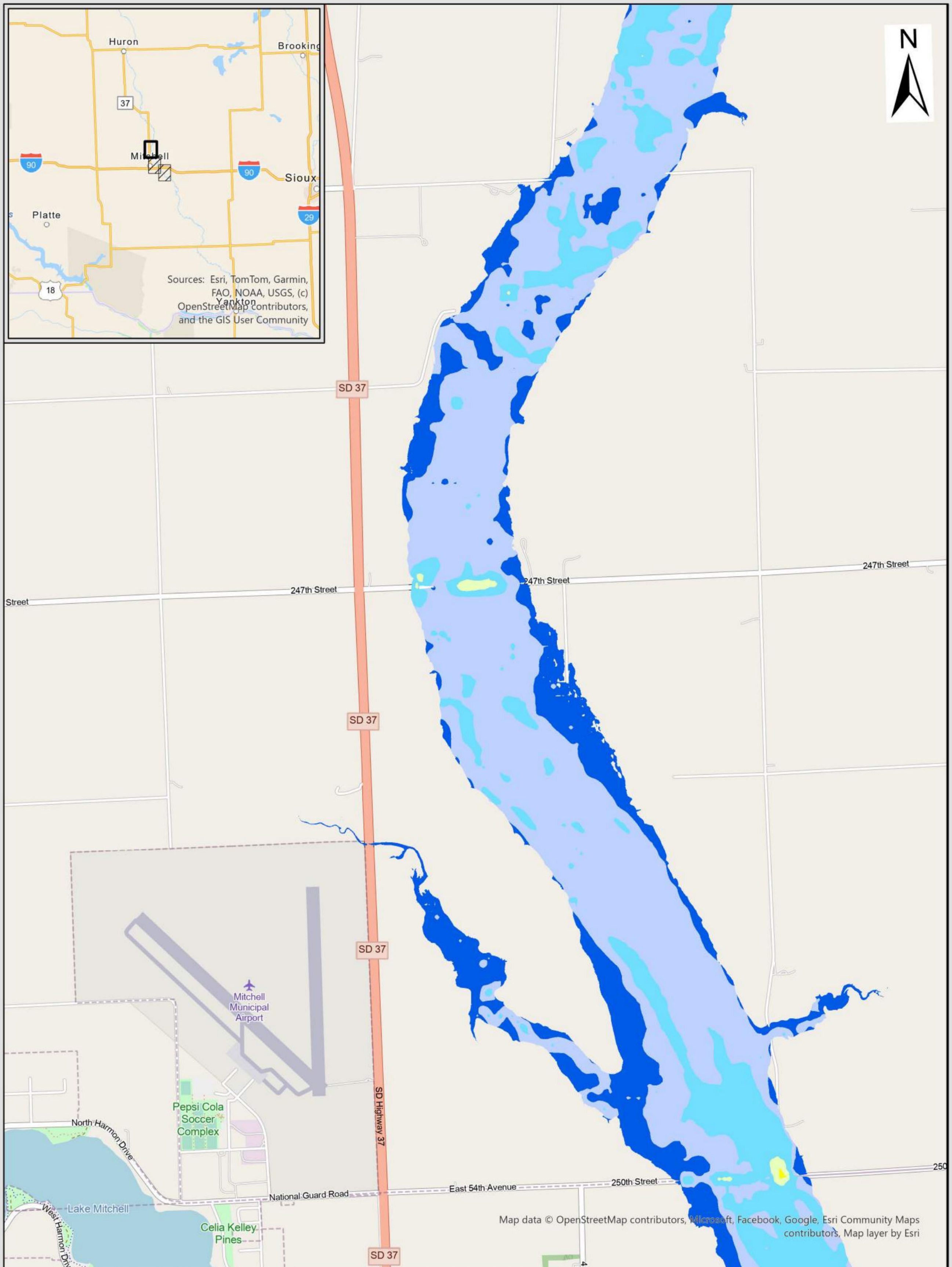
- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

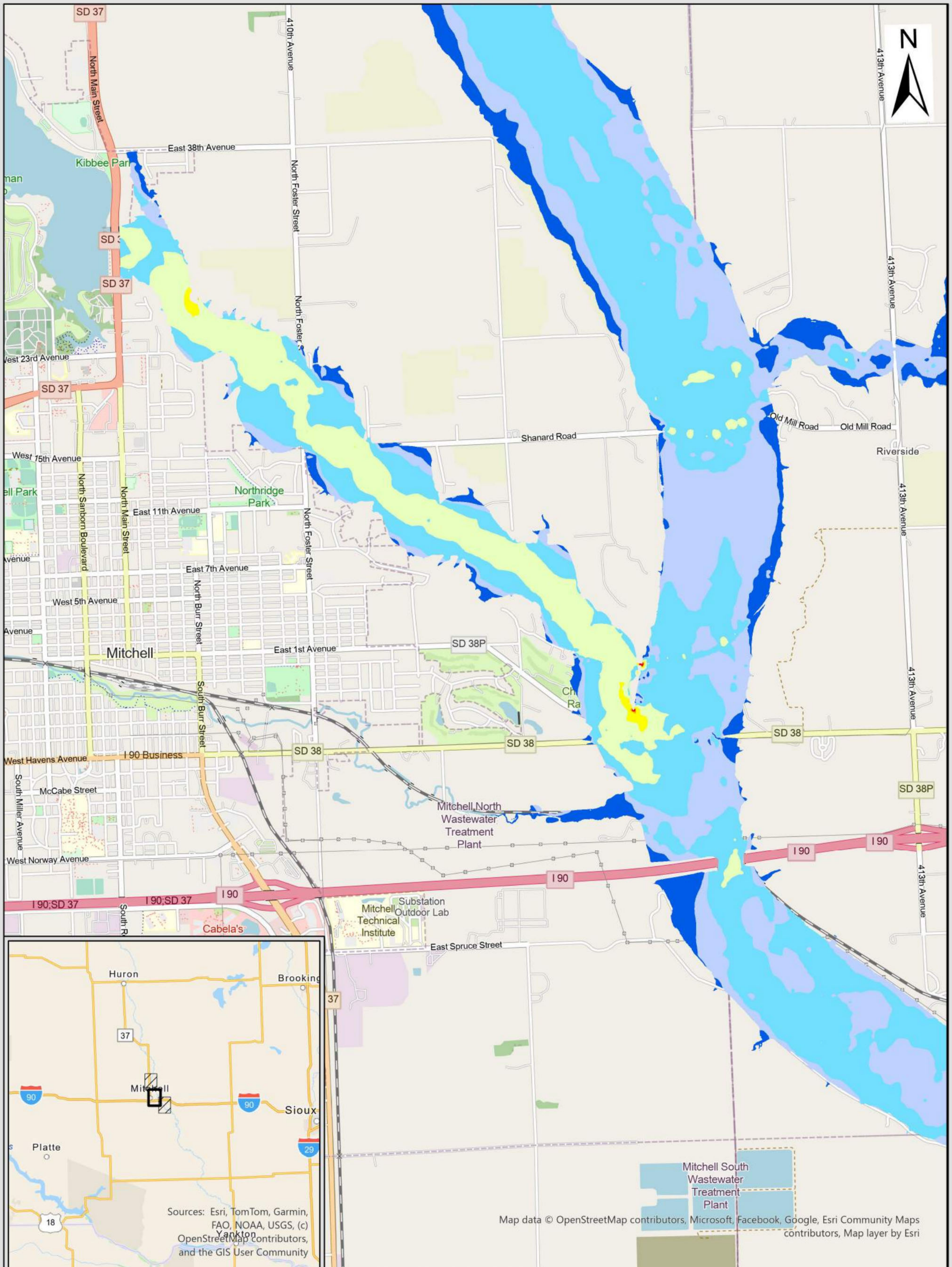
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 50% PMF Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

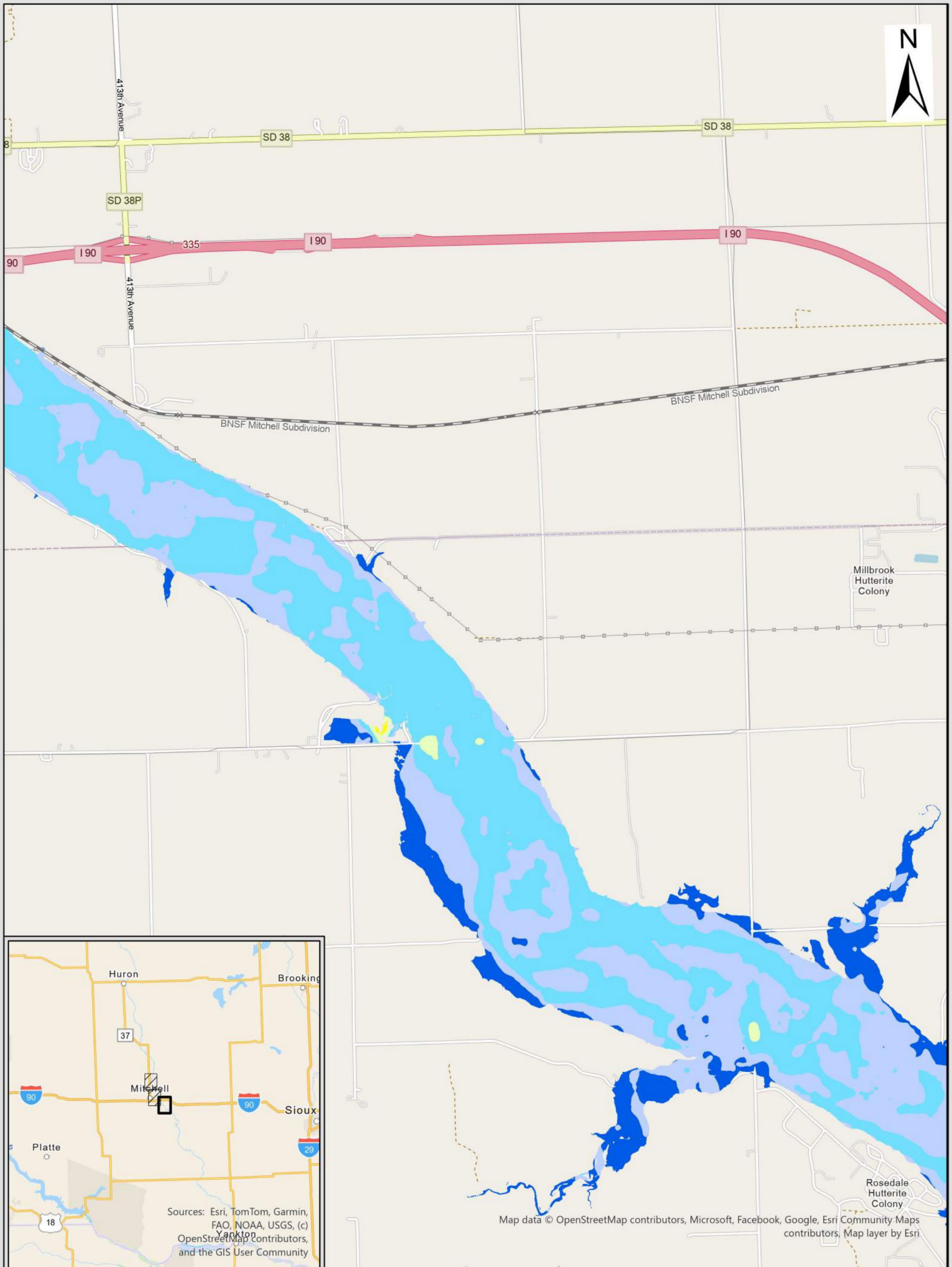
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 50% PMF Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

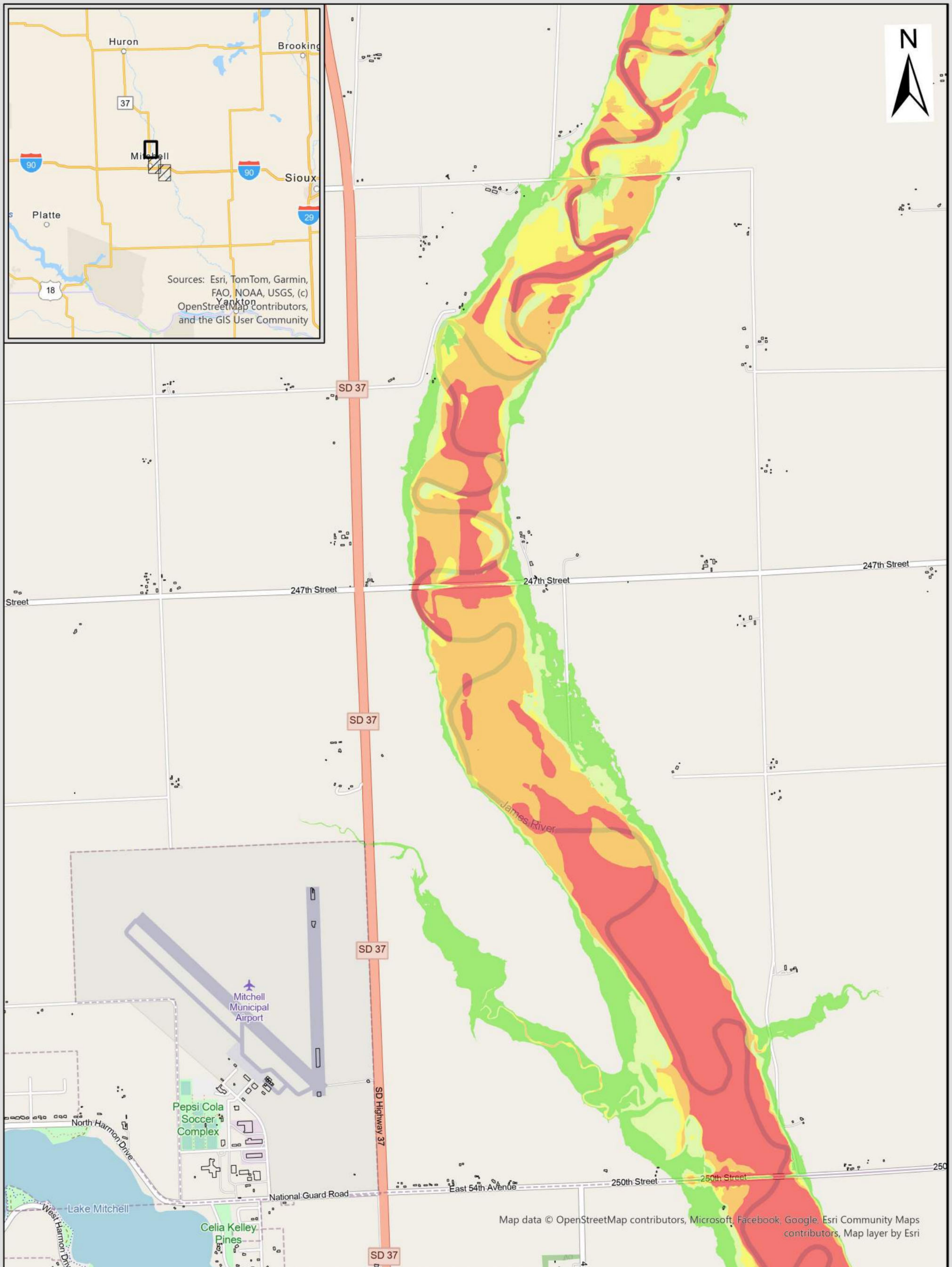
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 50% PMF Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

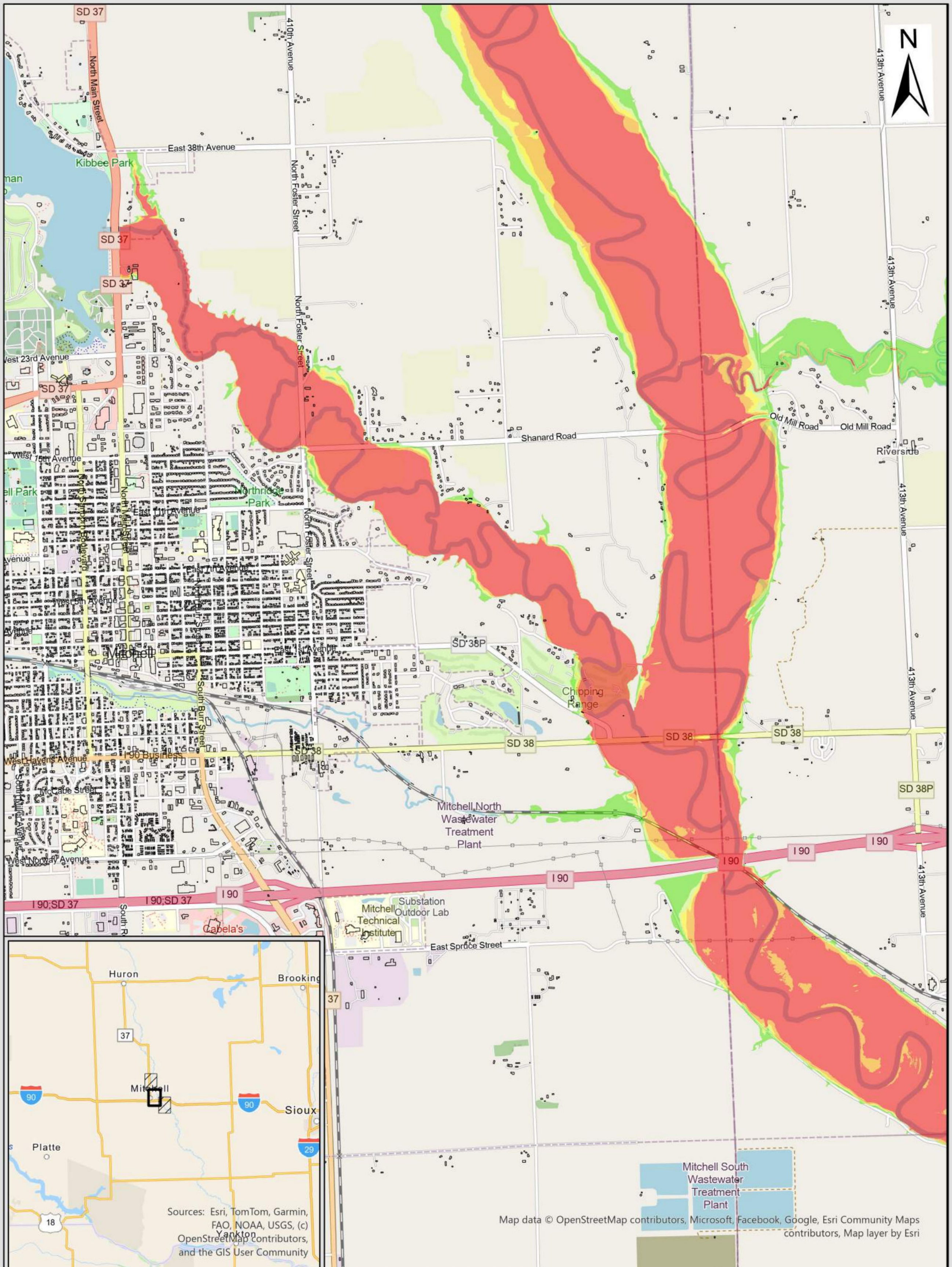
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 50% PMF Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

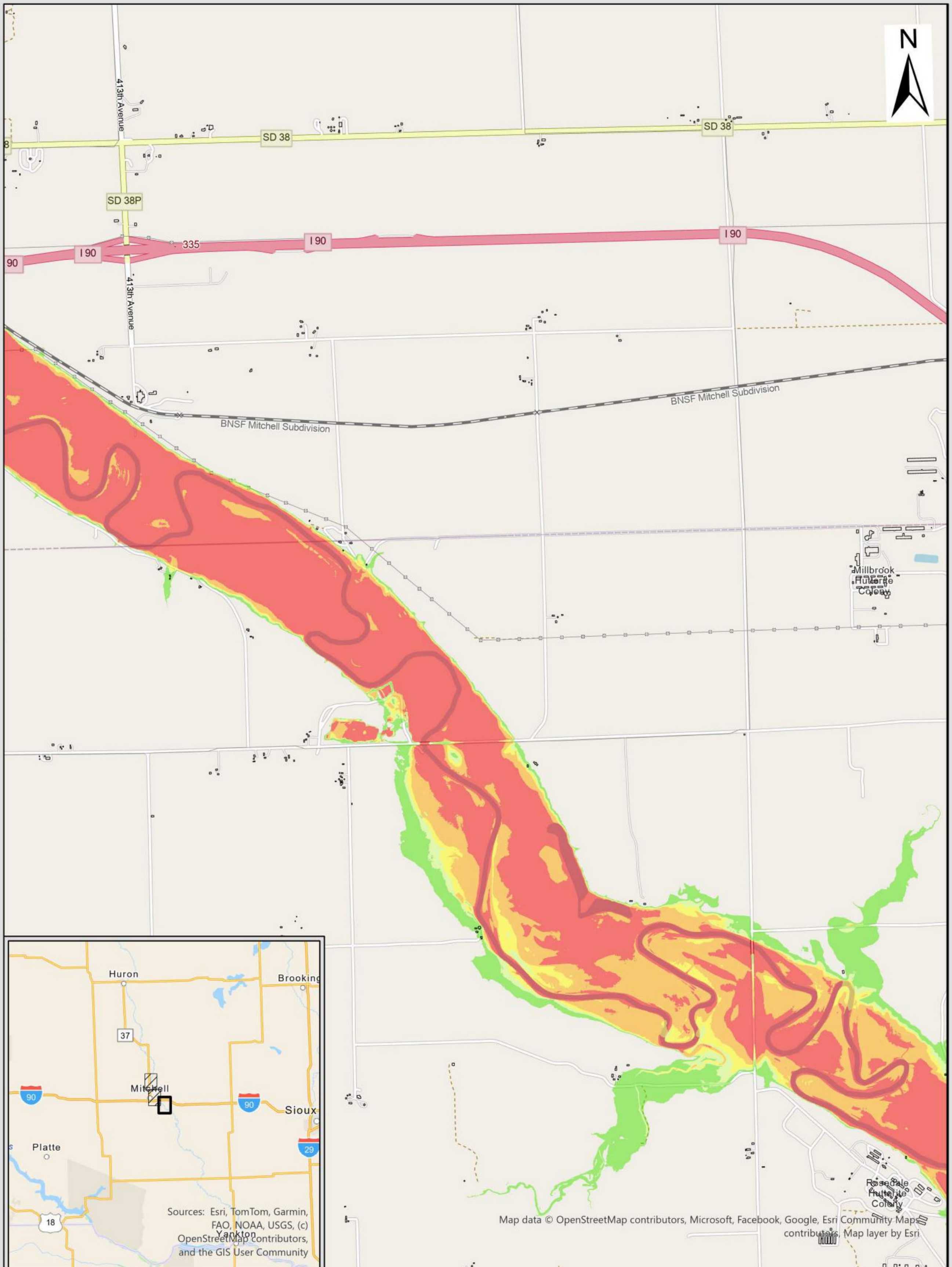
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 50% PMF Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 50% PMF Depth x Velocity

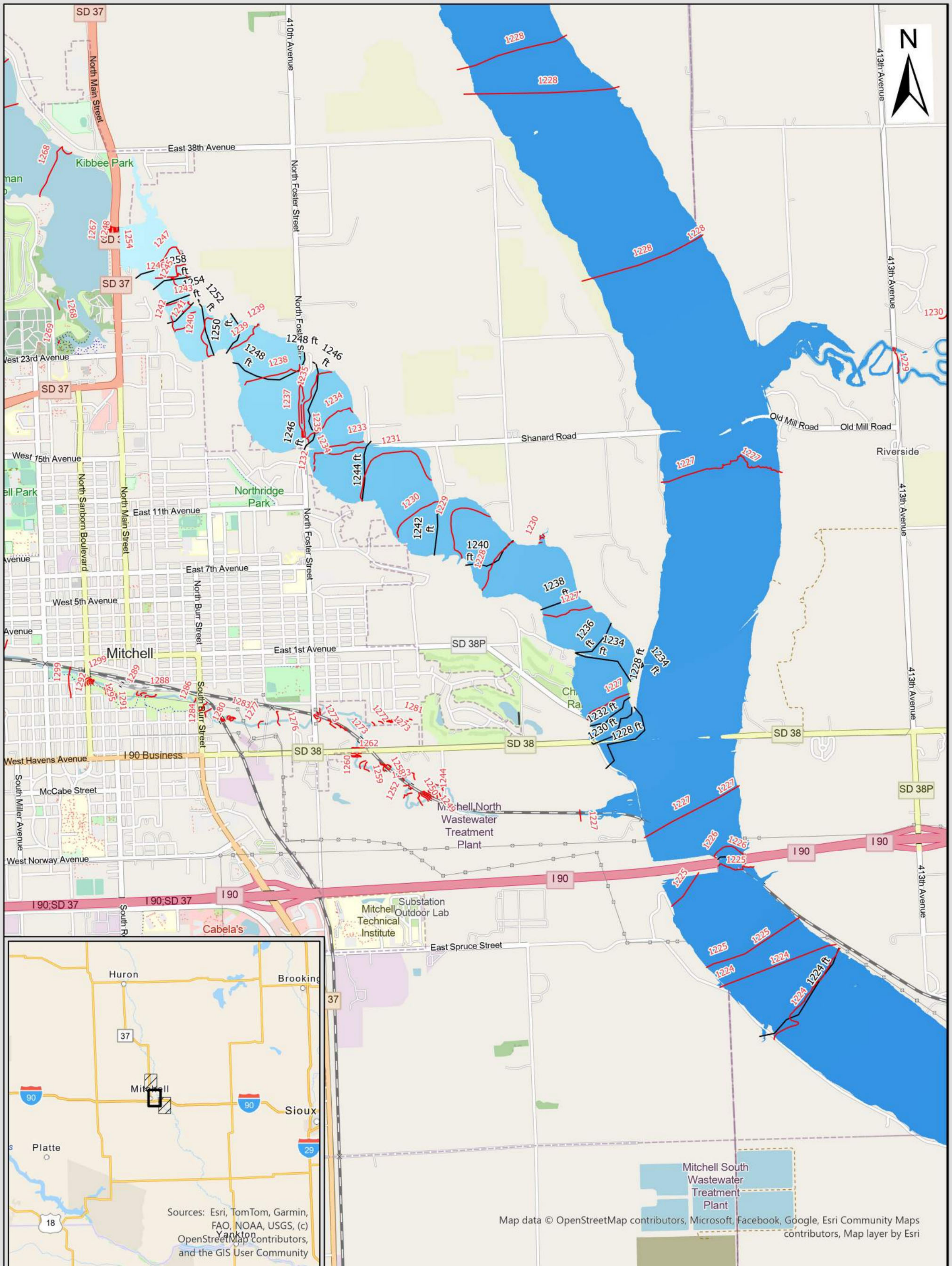
Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Rainy Day 50% PMF WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 50% PMF WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

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1204.33

— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 50% PMF WSEs

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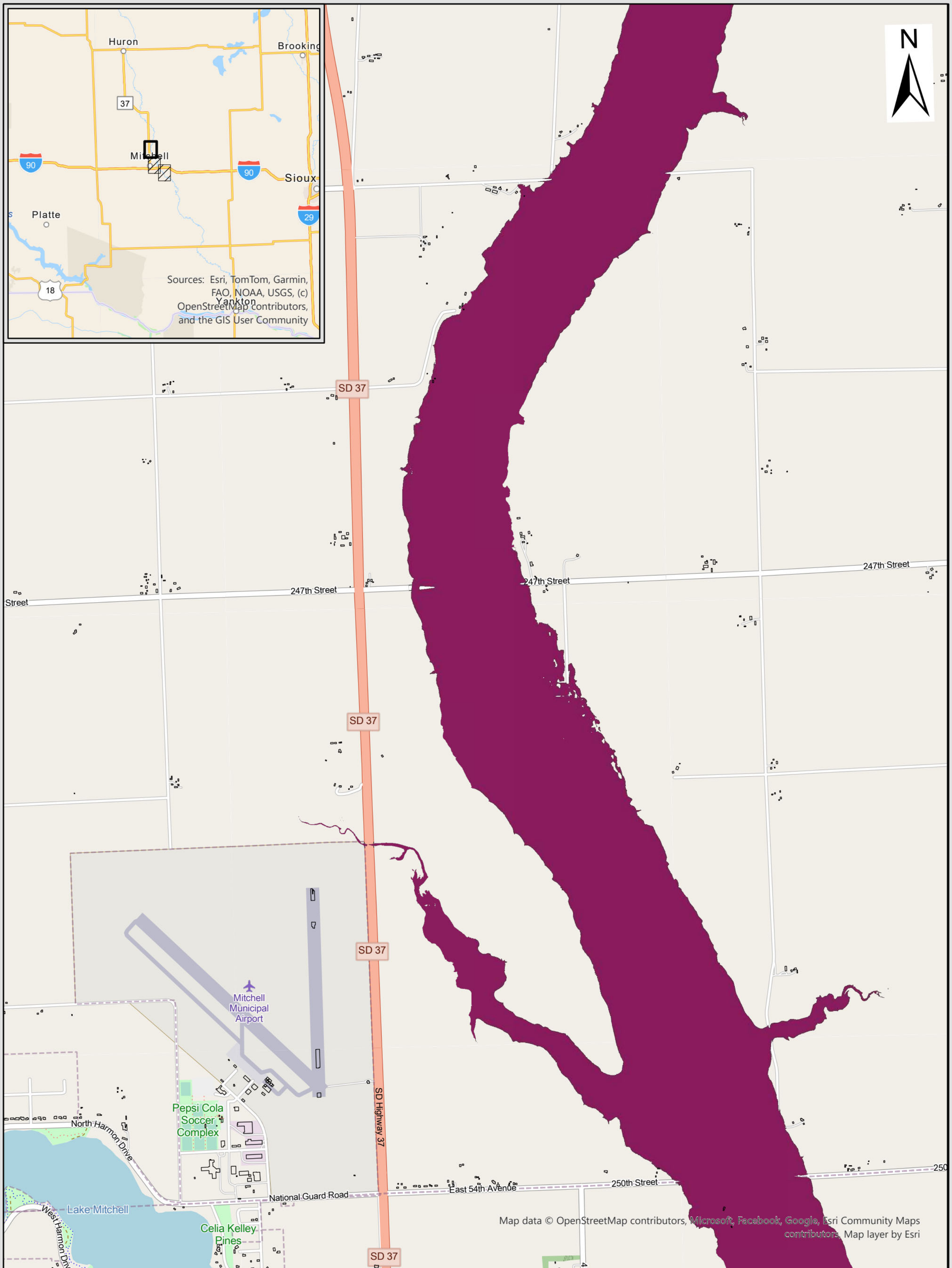
HOUSTON engineering, inc.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

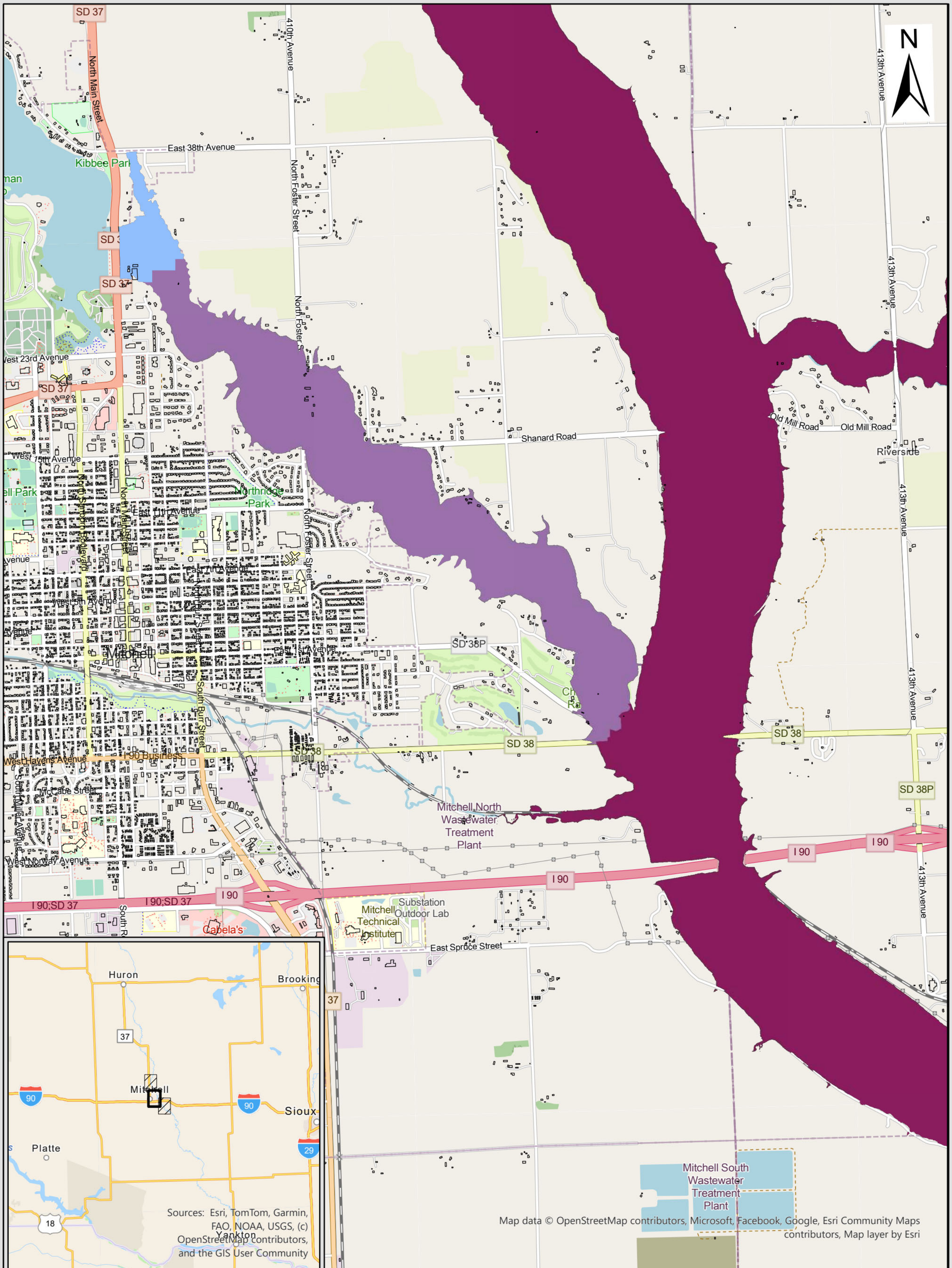
0 0.5 1 Miles

Rainy Day 50% PMF Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

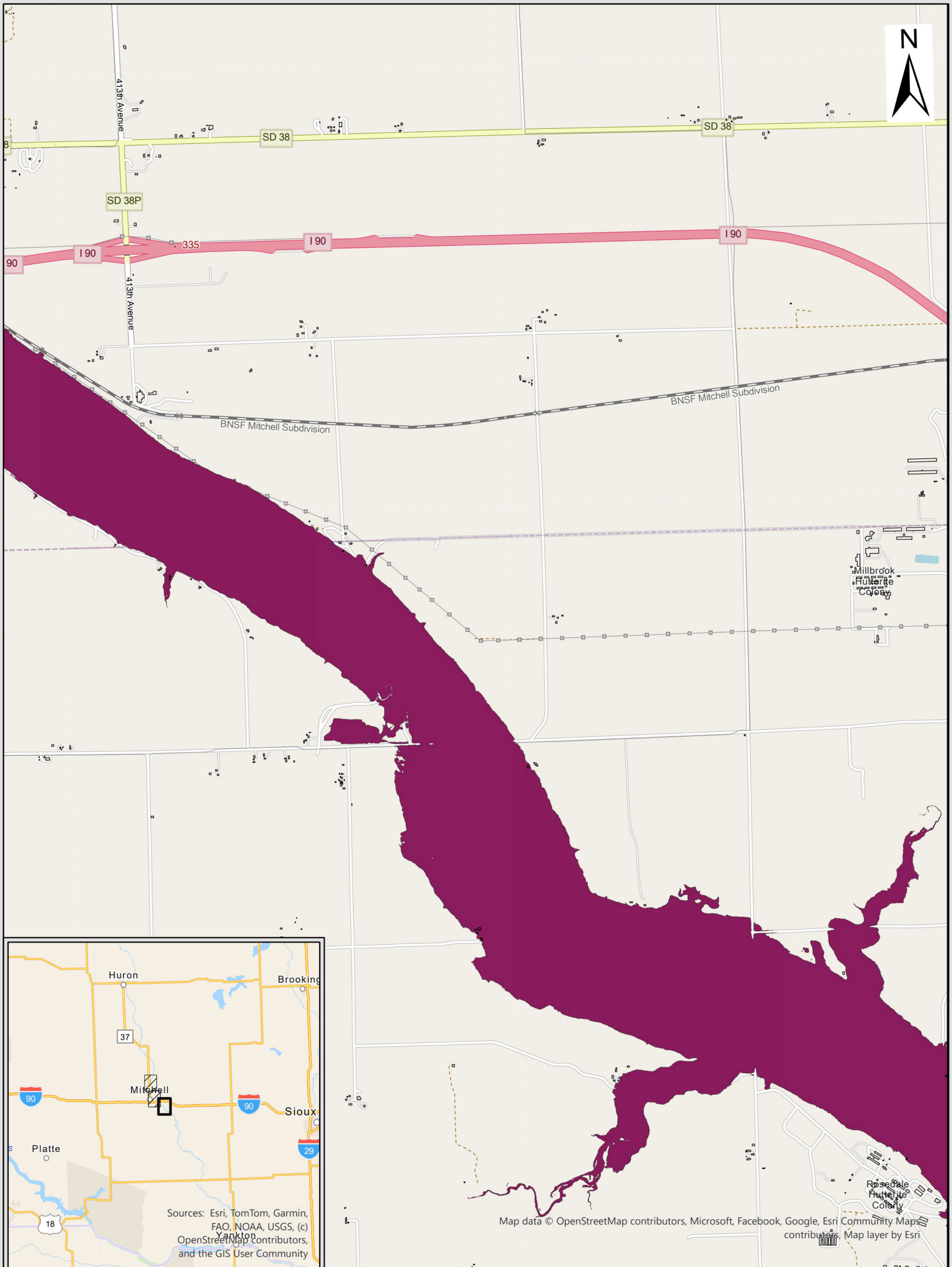
0 0.5 1 Miles

Rainy Day 50% PMF Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

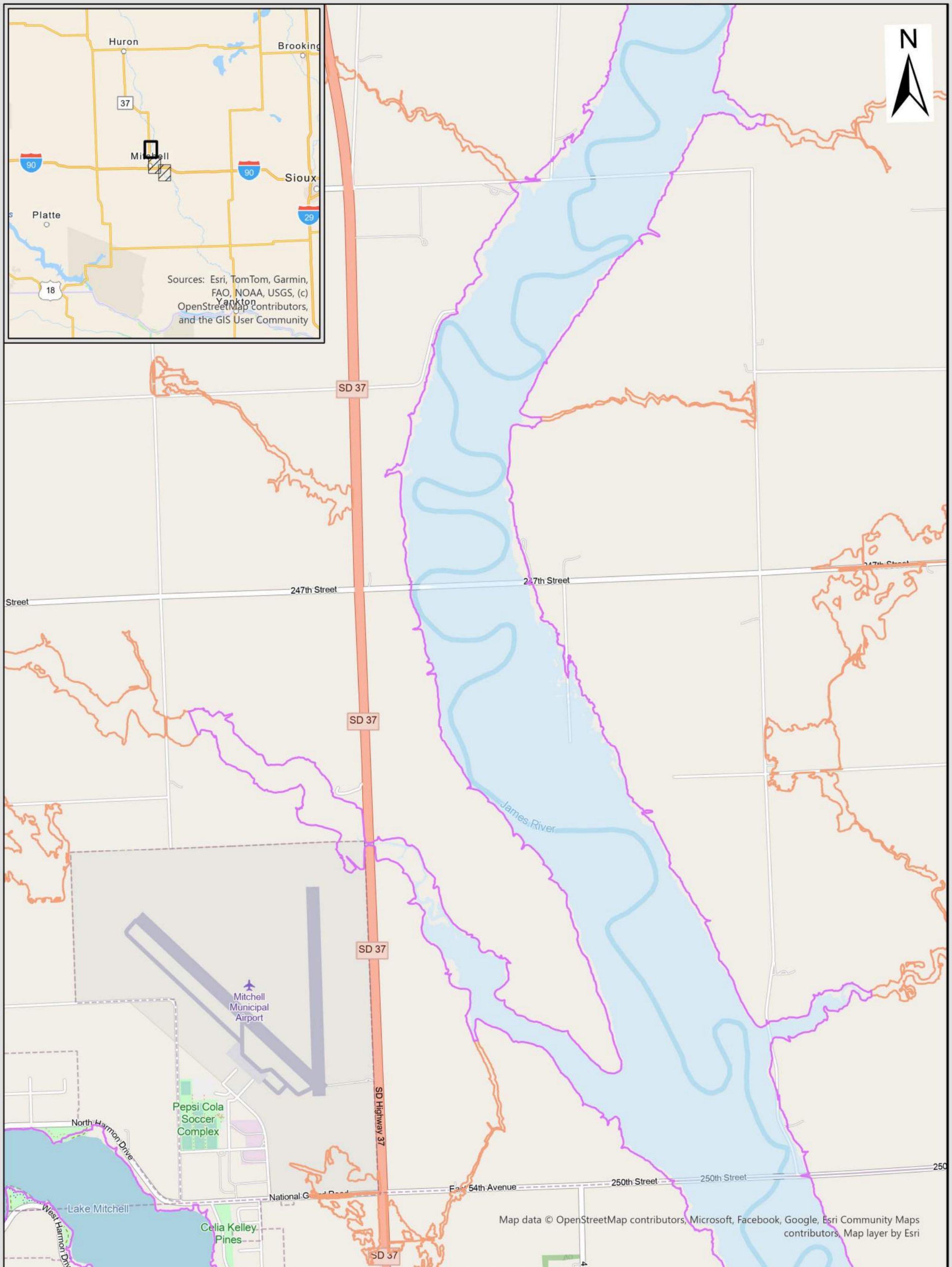
0 0.5 1 Miles

Rainy Day 50% PMF Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Breach Inundation Extents

FEMA Flood Zone A

FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Breach Inundation Extents

FEMA Flood Zone A

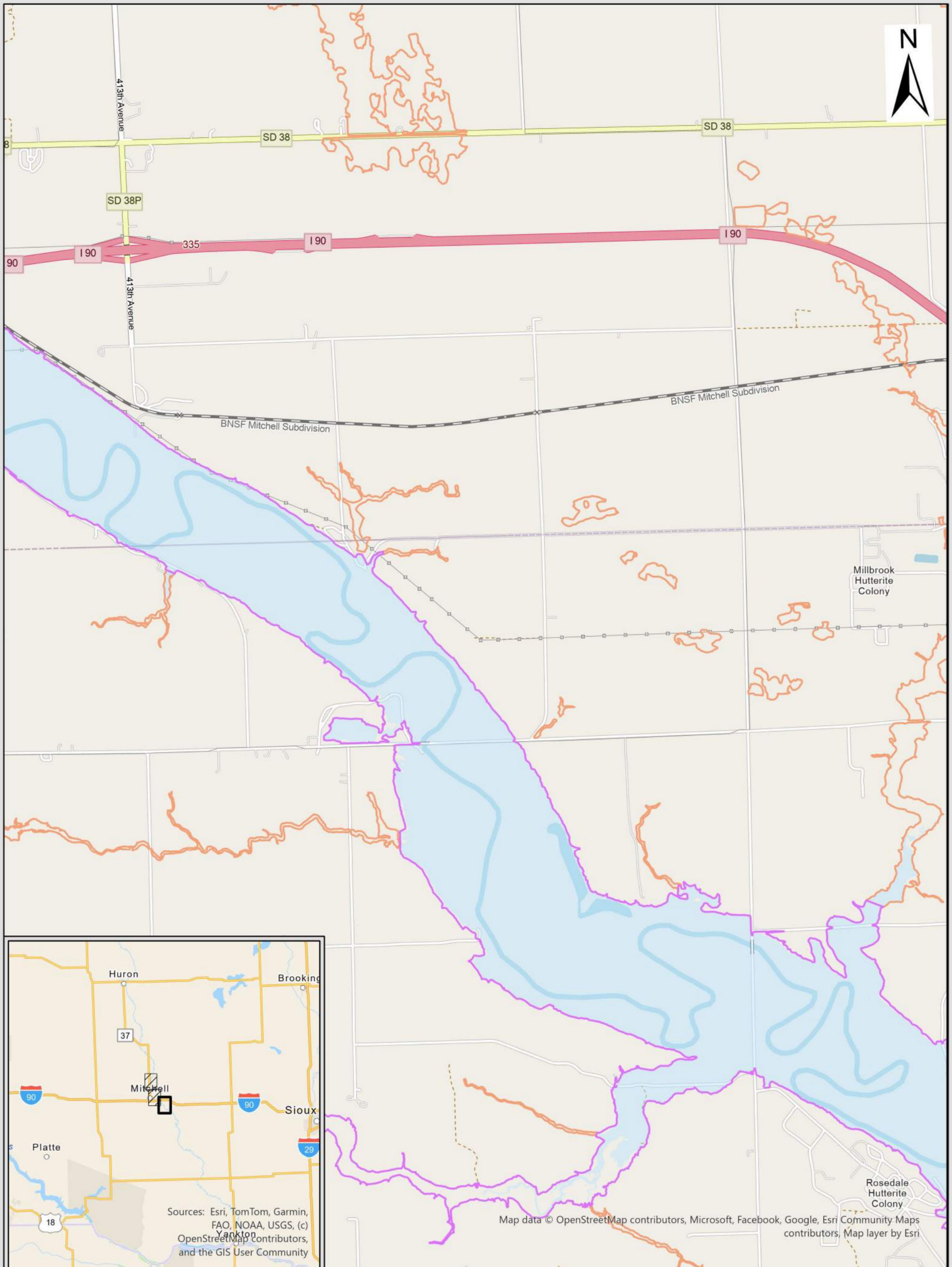
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

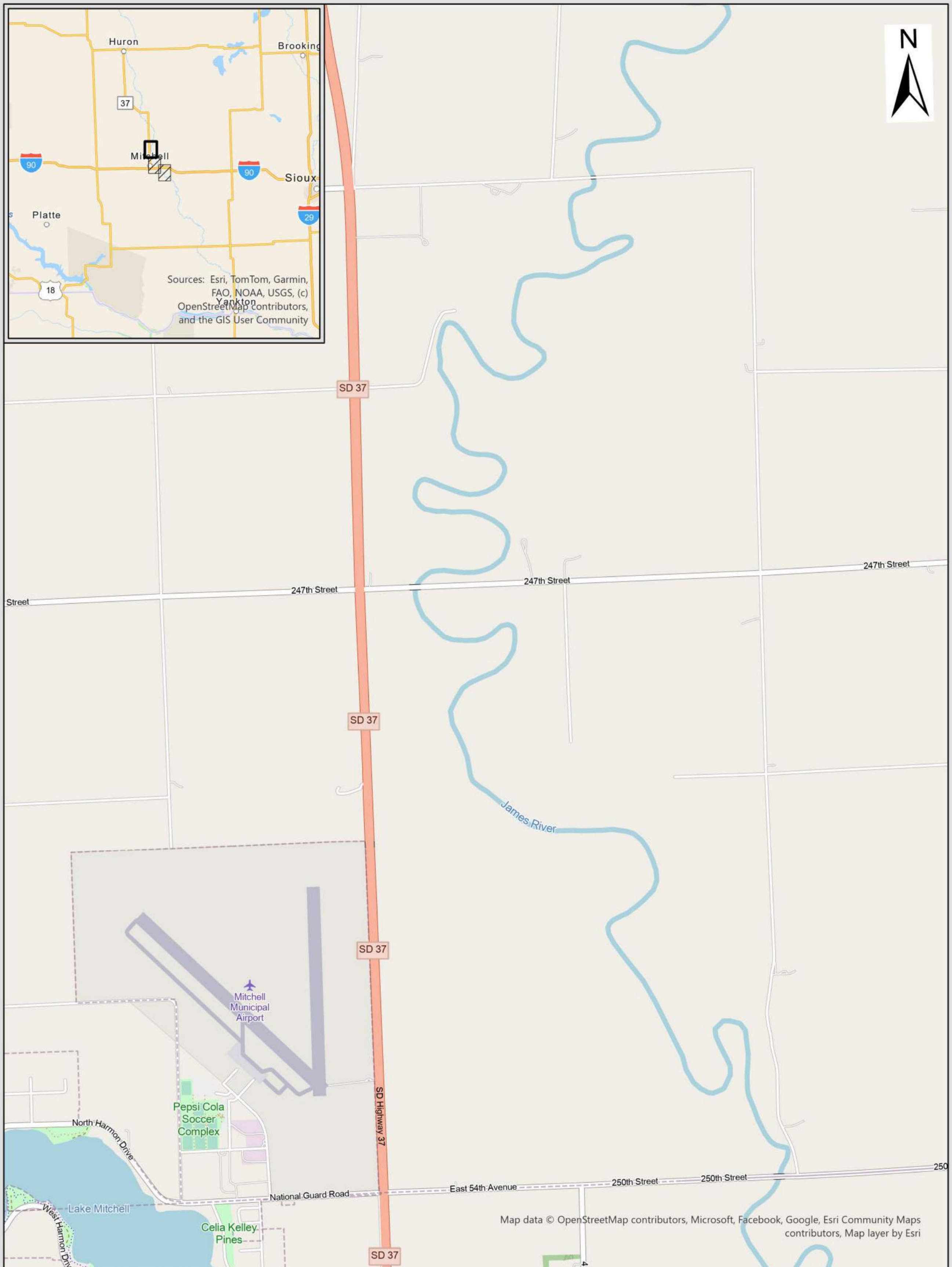
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

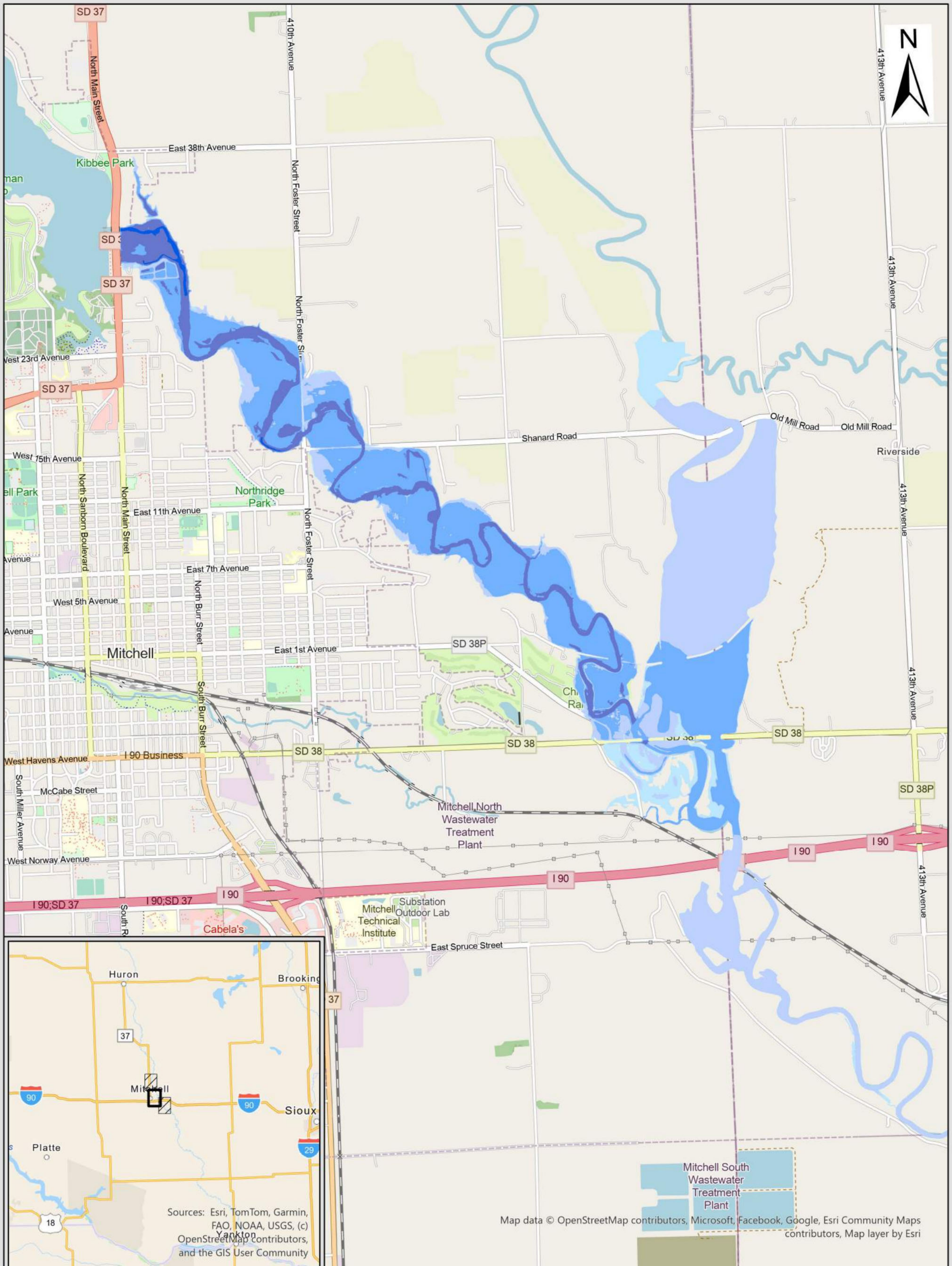
- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depths Prior

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depths Prior

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depths Prior

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

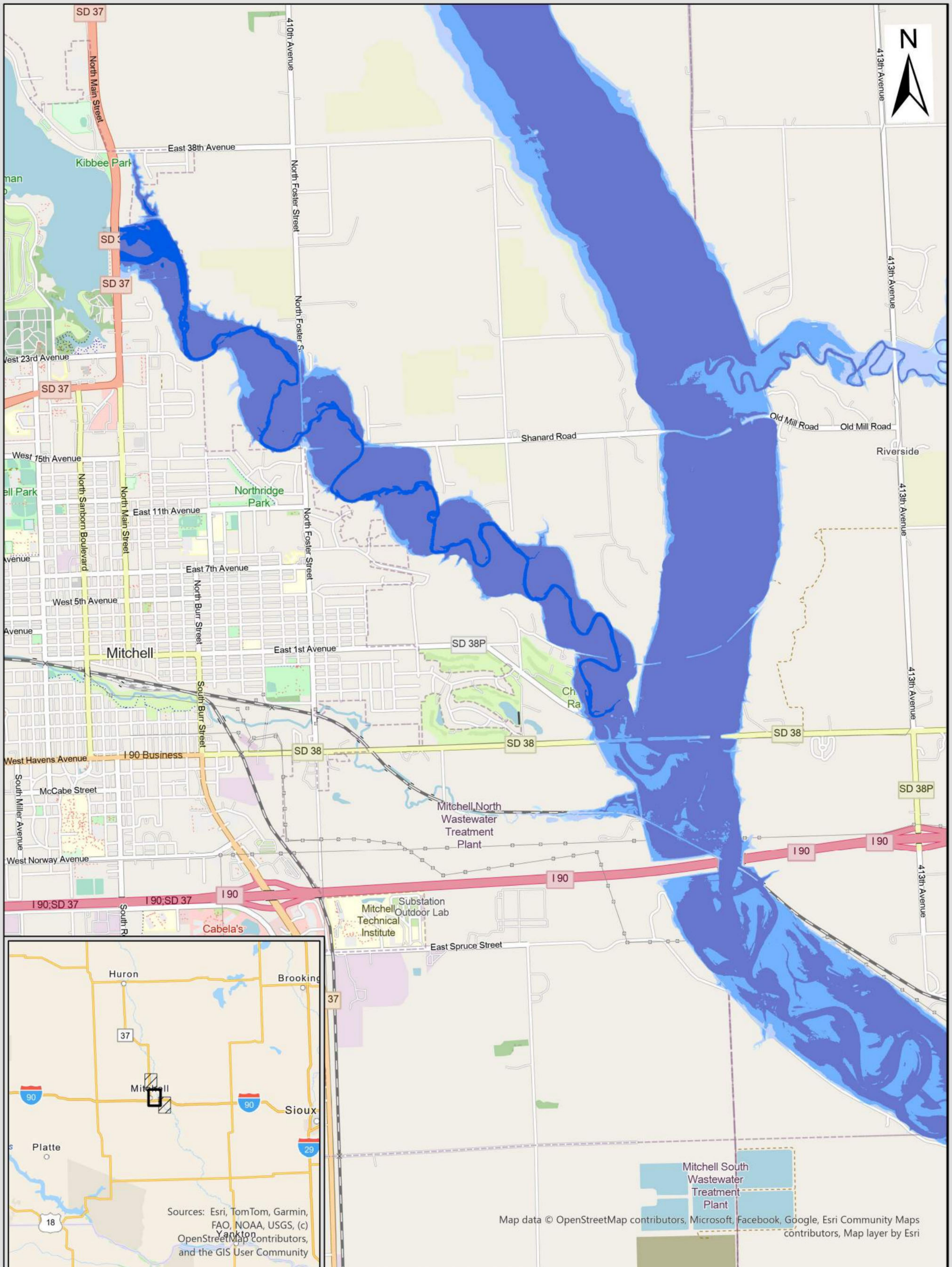
- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

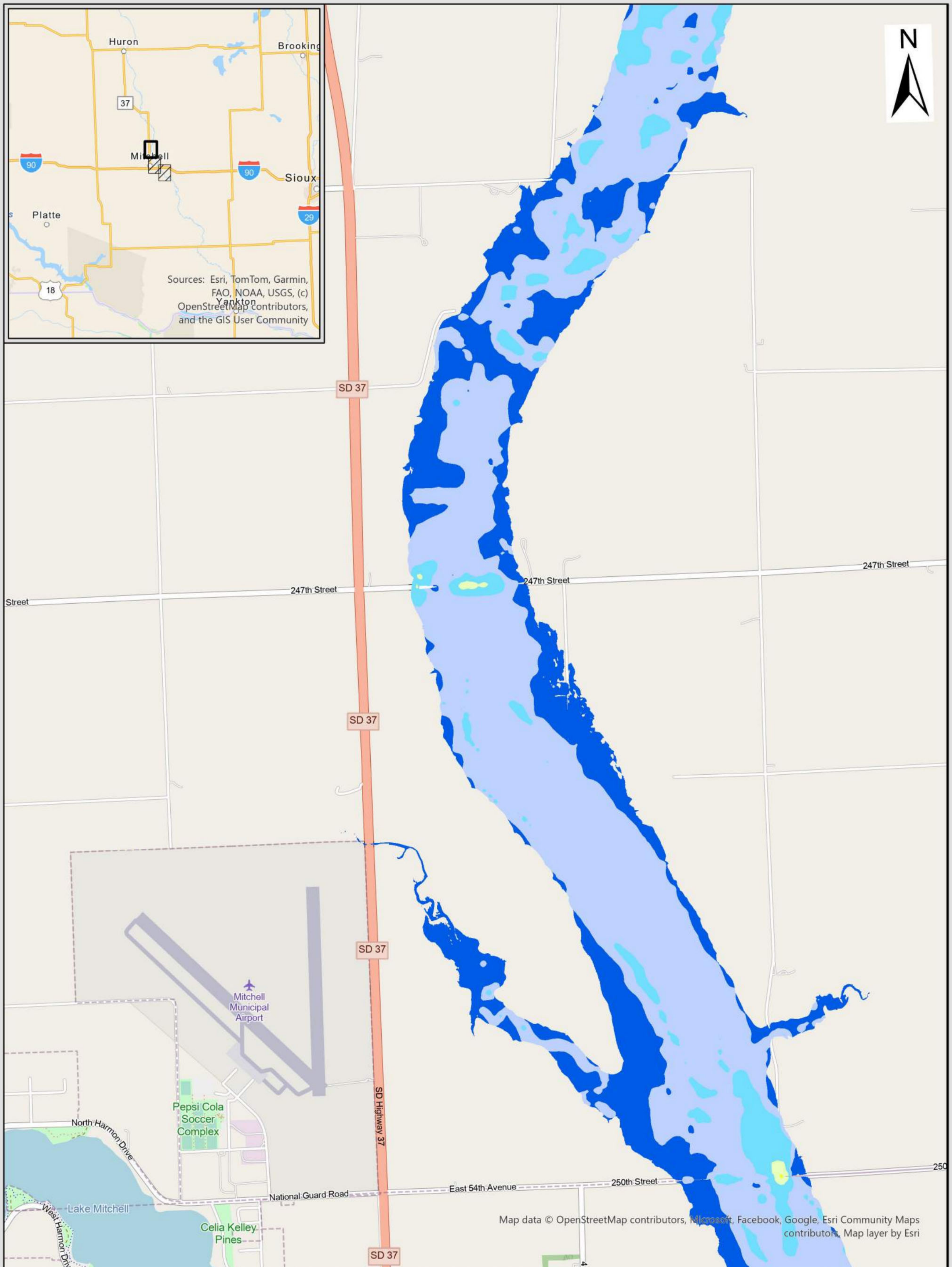
- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

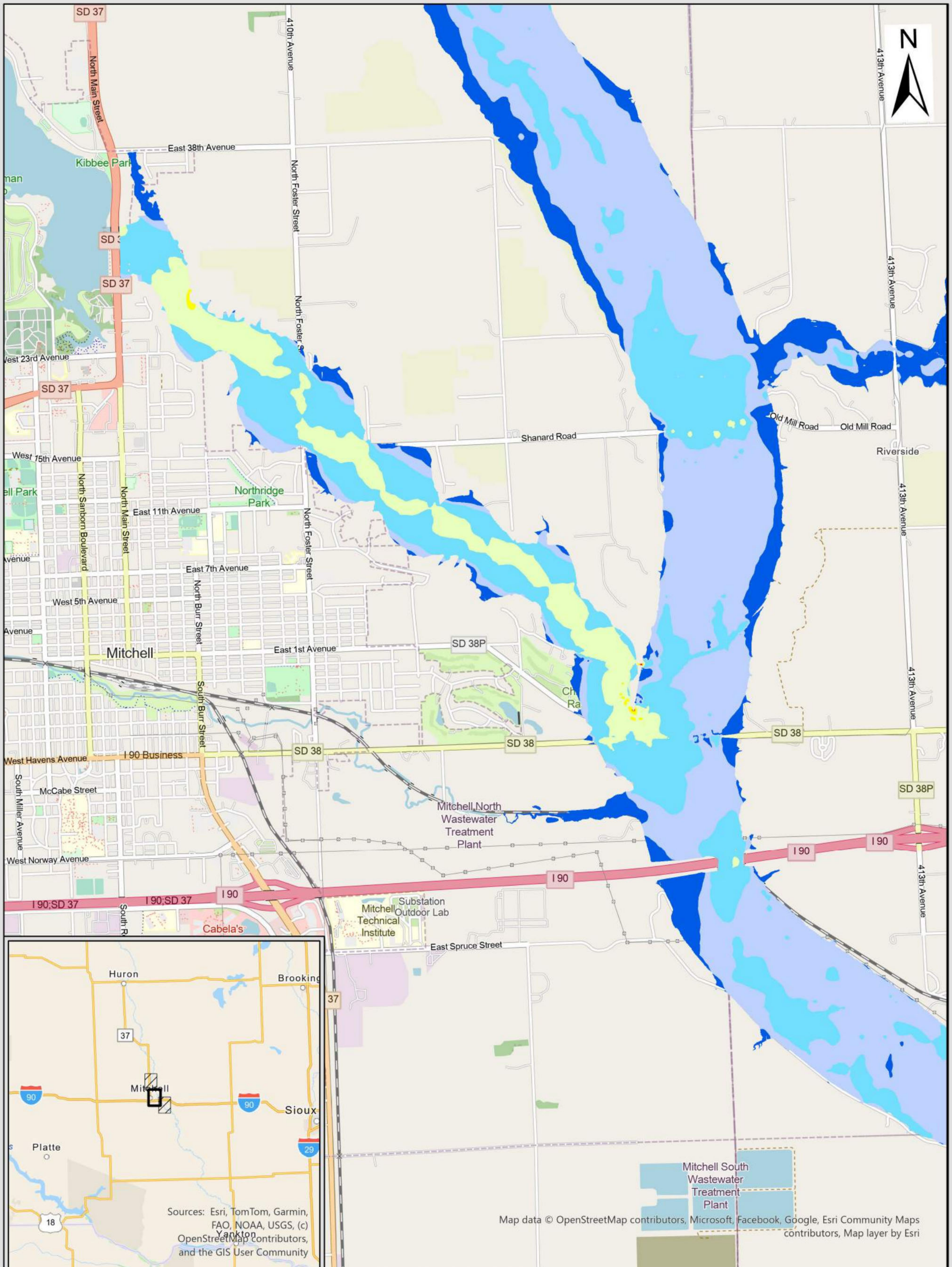
Value

- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

Rainy Day 50% PMF No Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

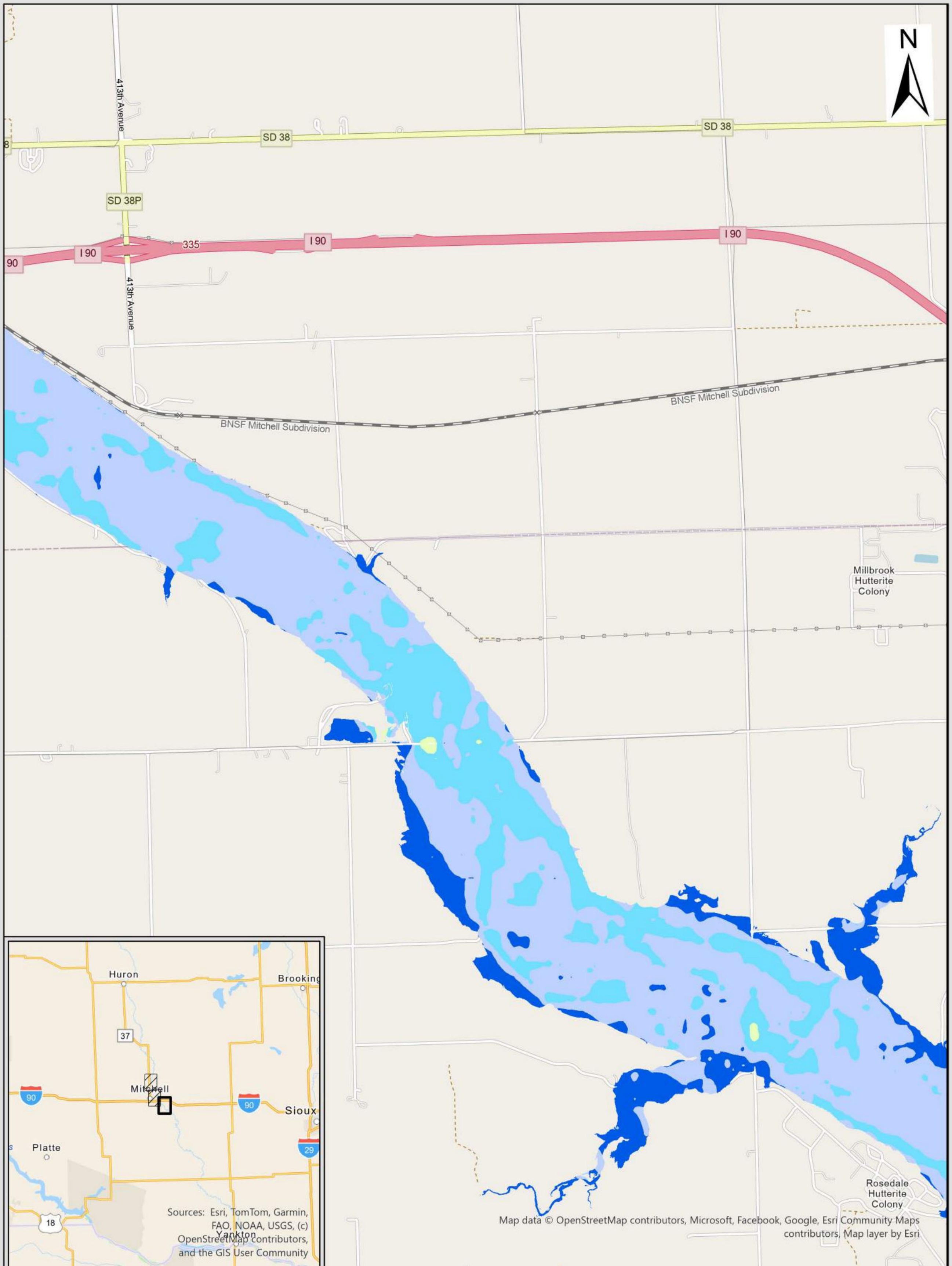
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

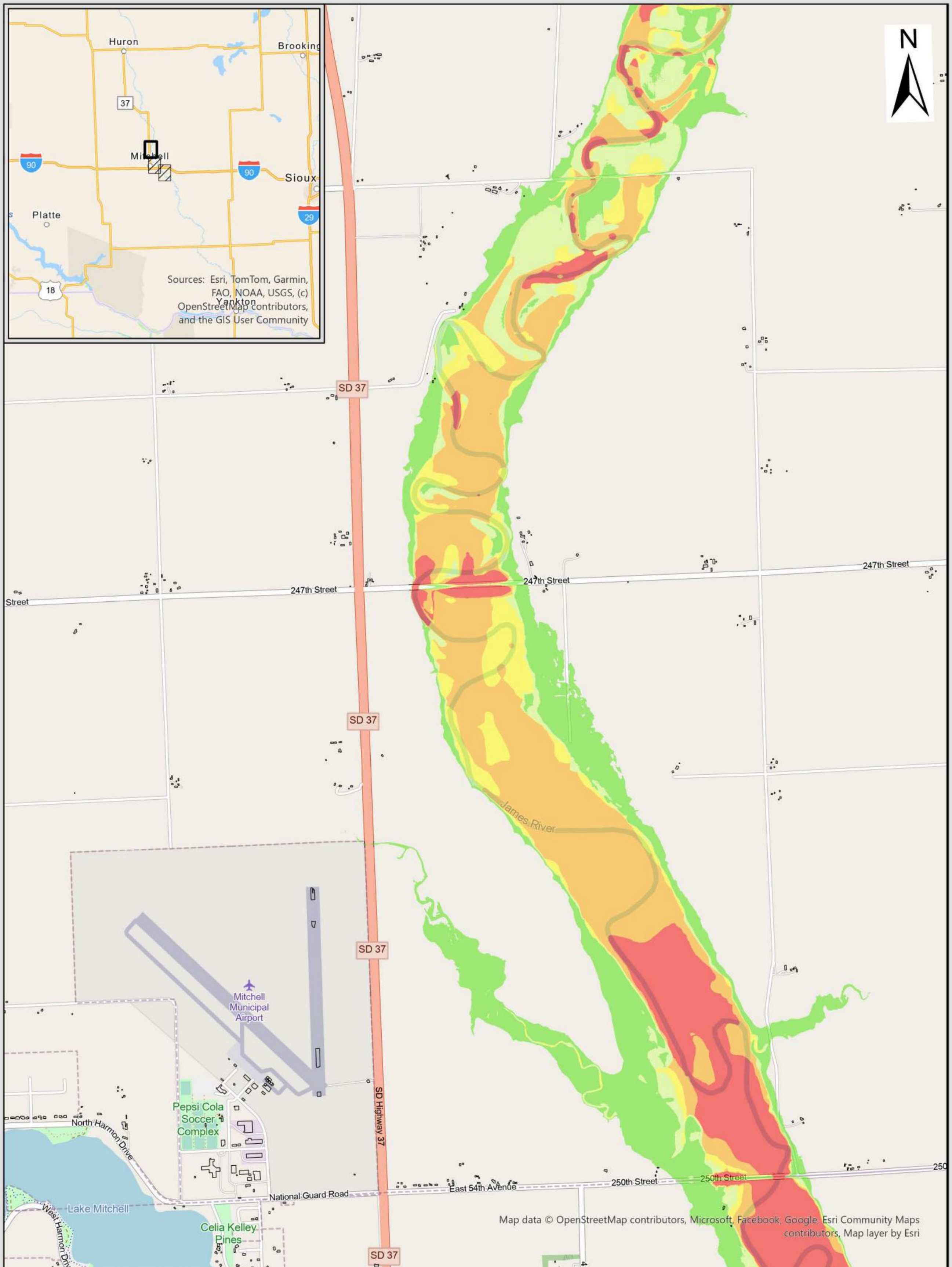
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

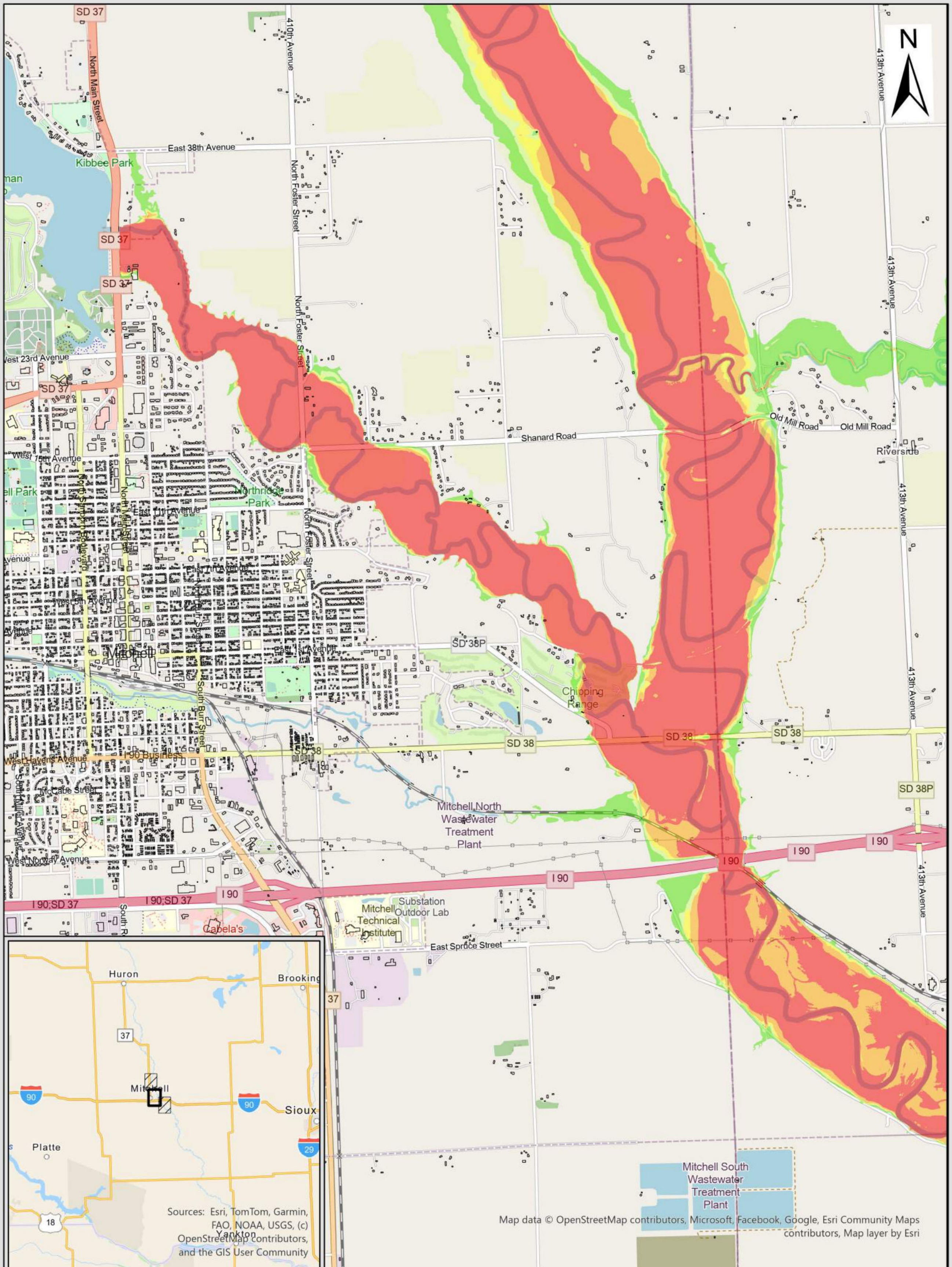
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

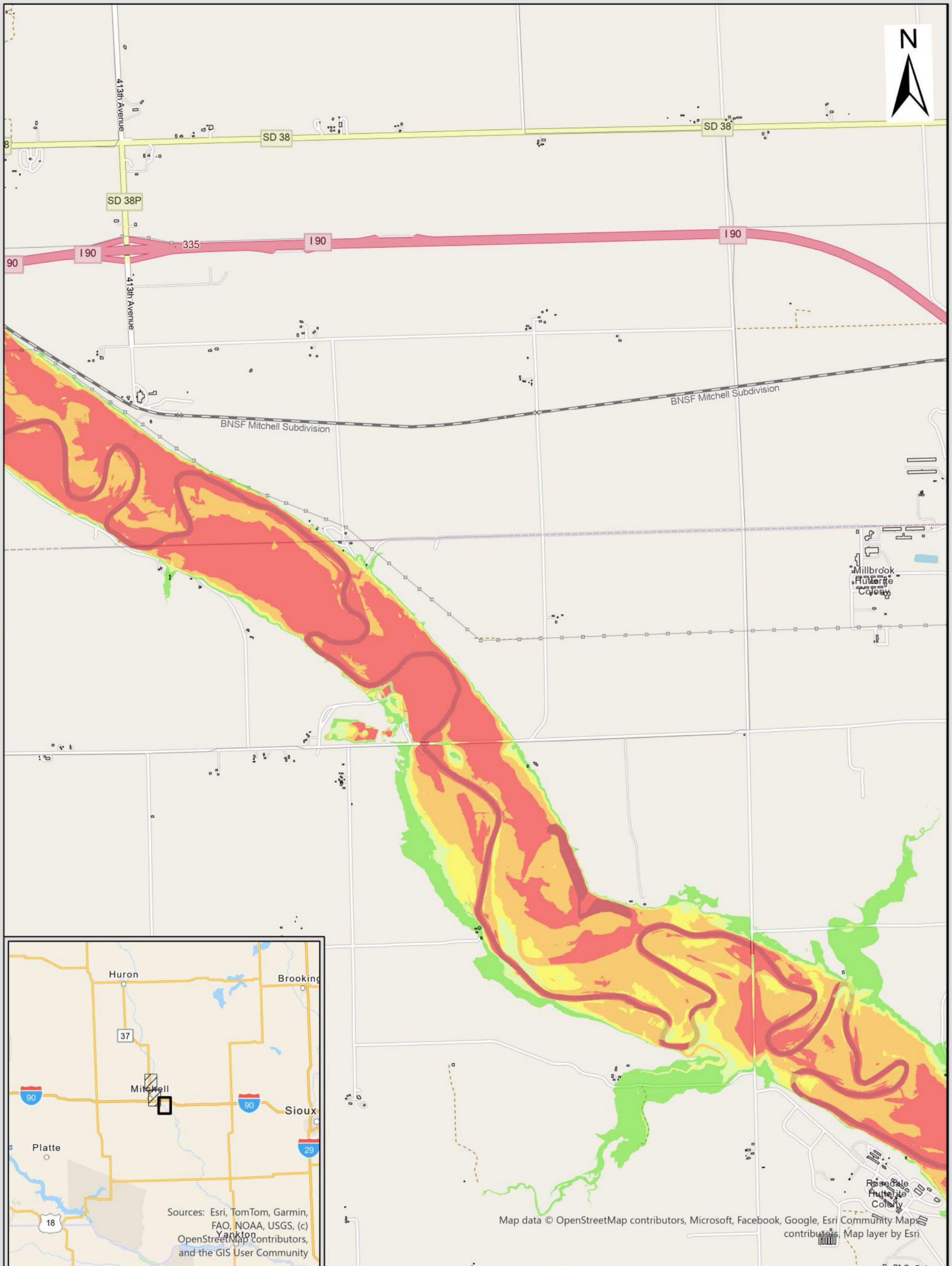
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 50% PMF No Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 50% PMF No Depth Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

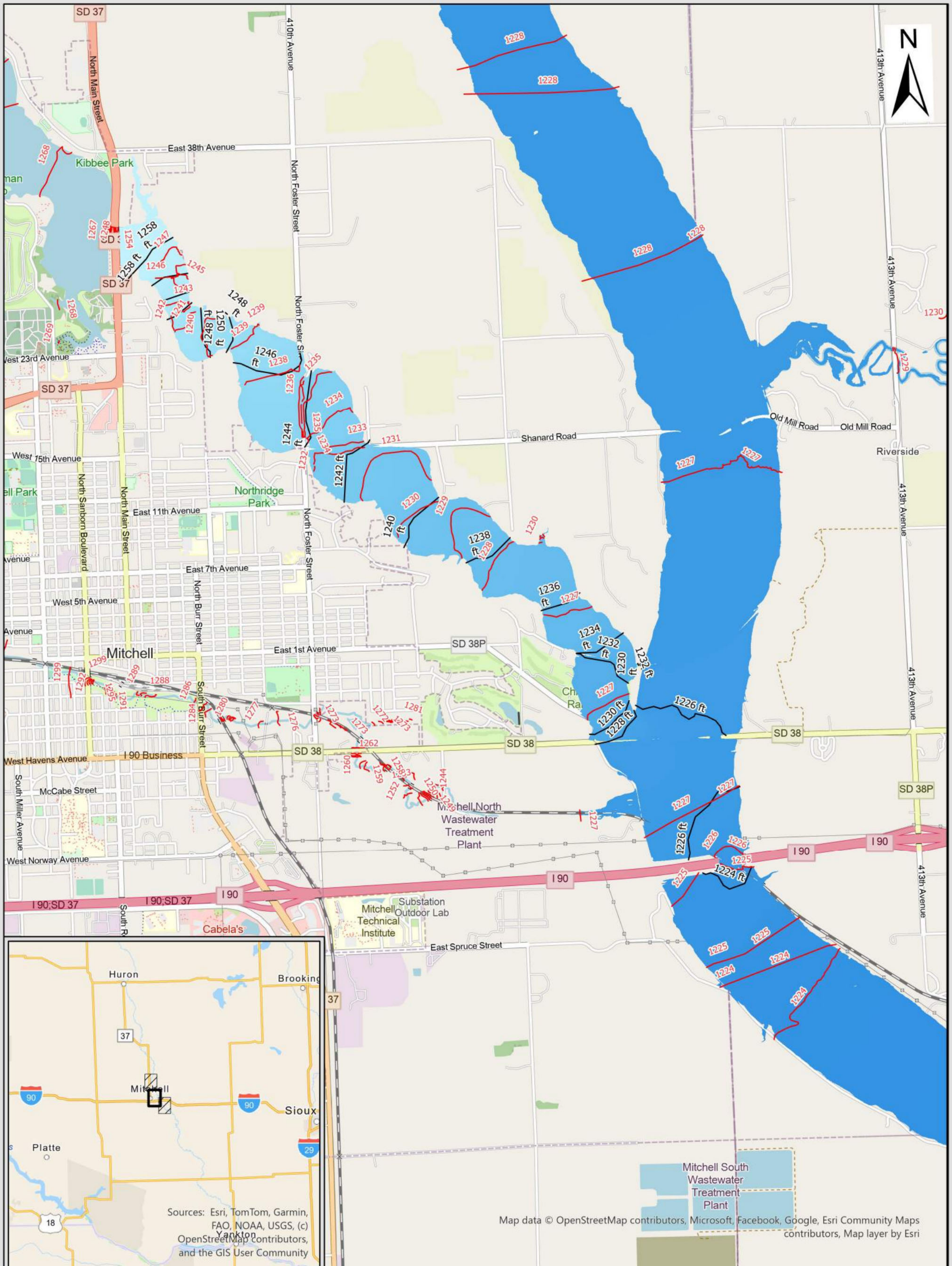
1204.33

— Base Flood Elevations

Rainy Day 50% PMF No Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 50% PMF No Breach WSEs					
Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 1/13/2026	Sheet:

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

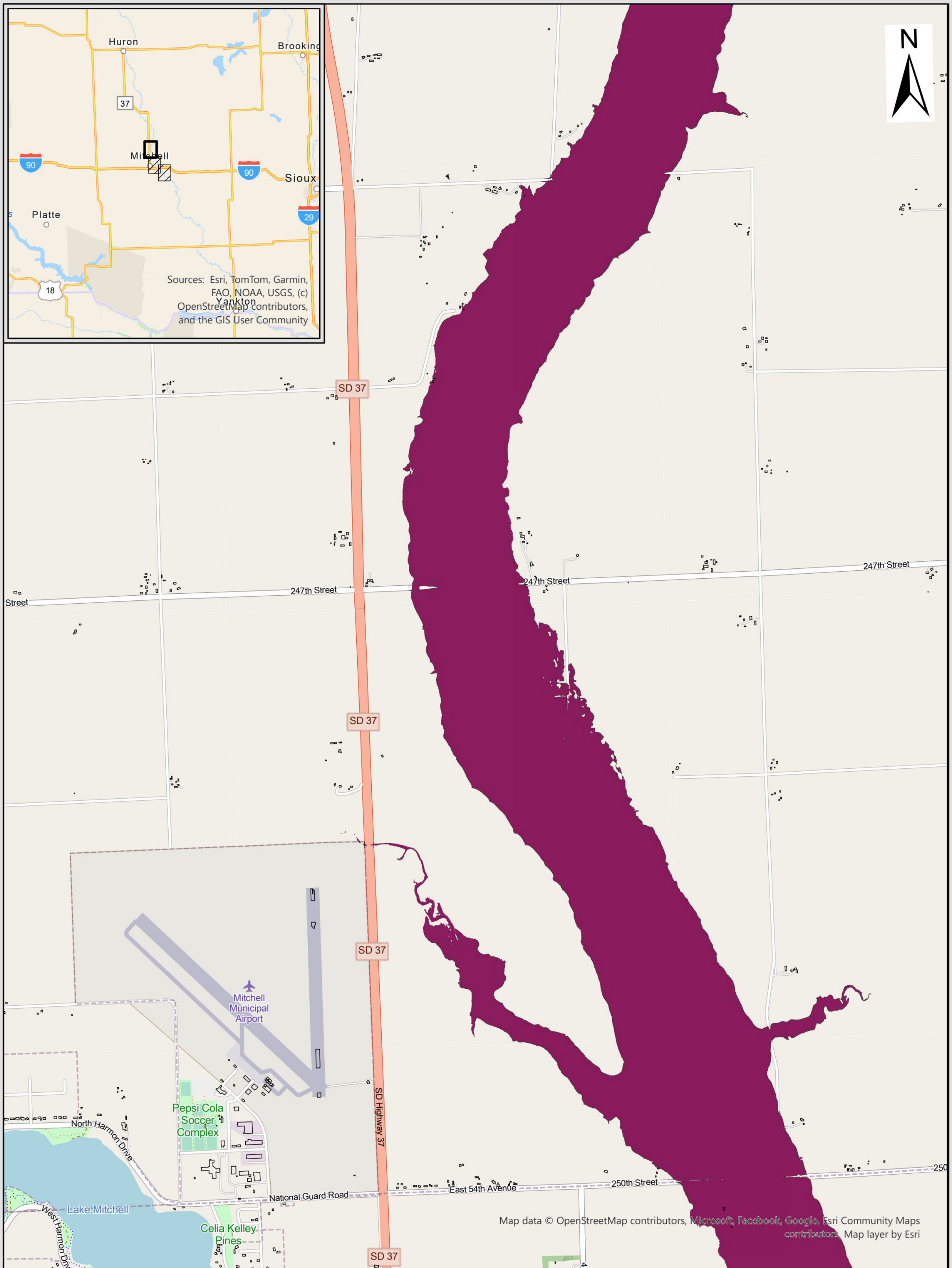
— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 50% PMF No Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

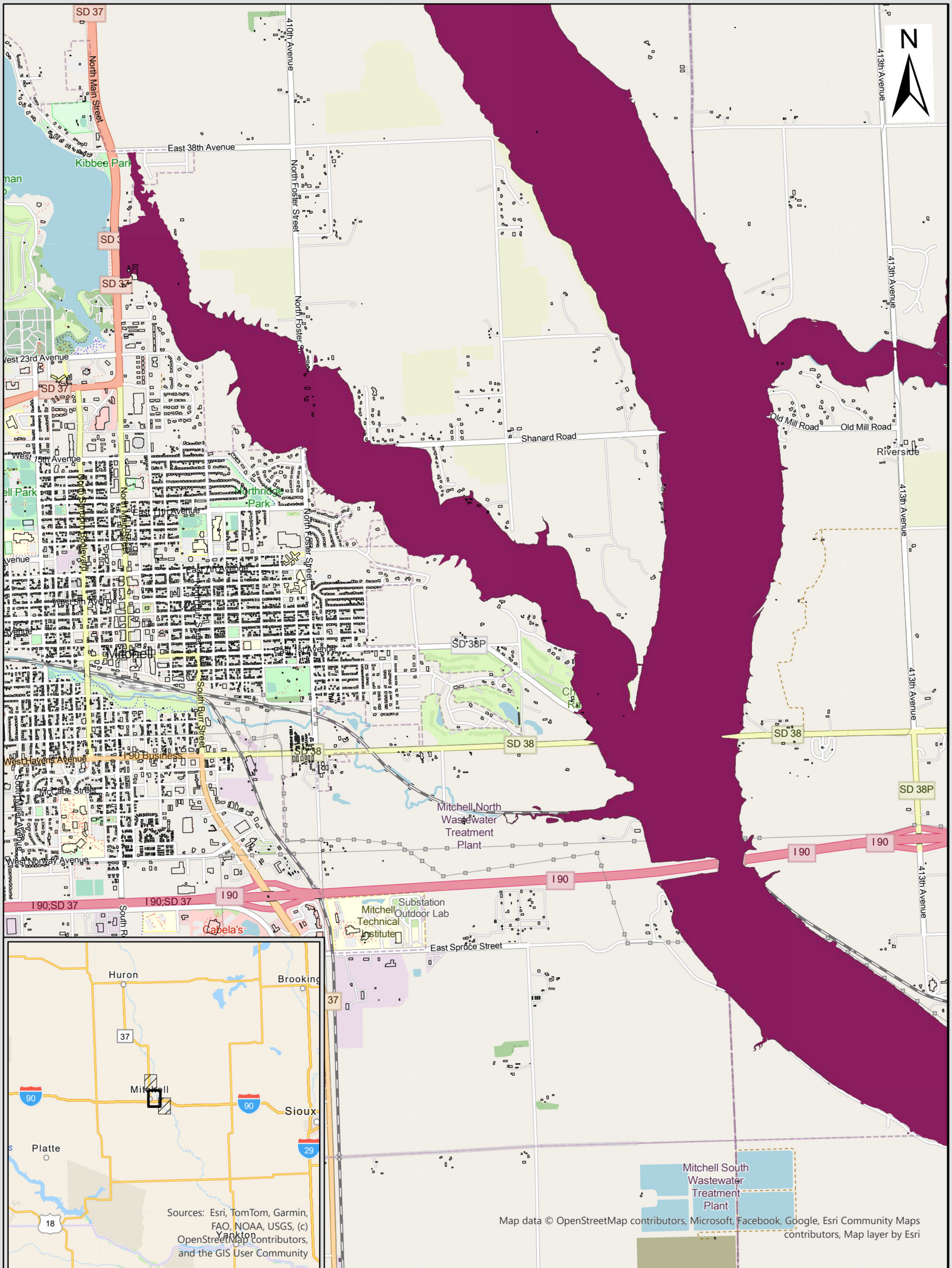
0 0.5 1 Miles

Rainy Day 50% PMF No Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
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0 0.5 1 Miles

Rainy Day 50% PMF No Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

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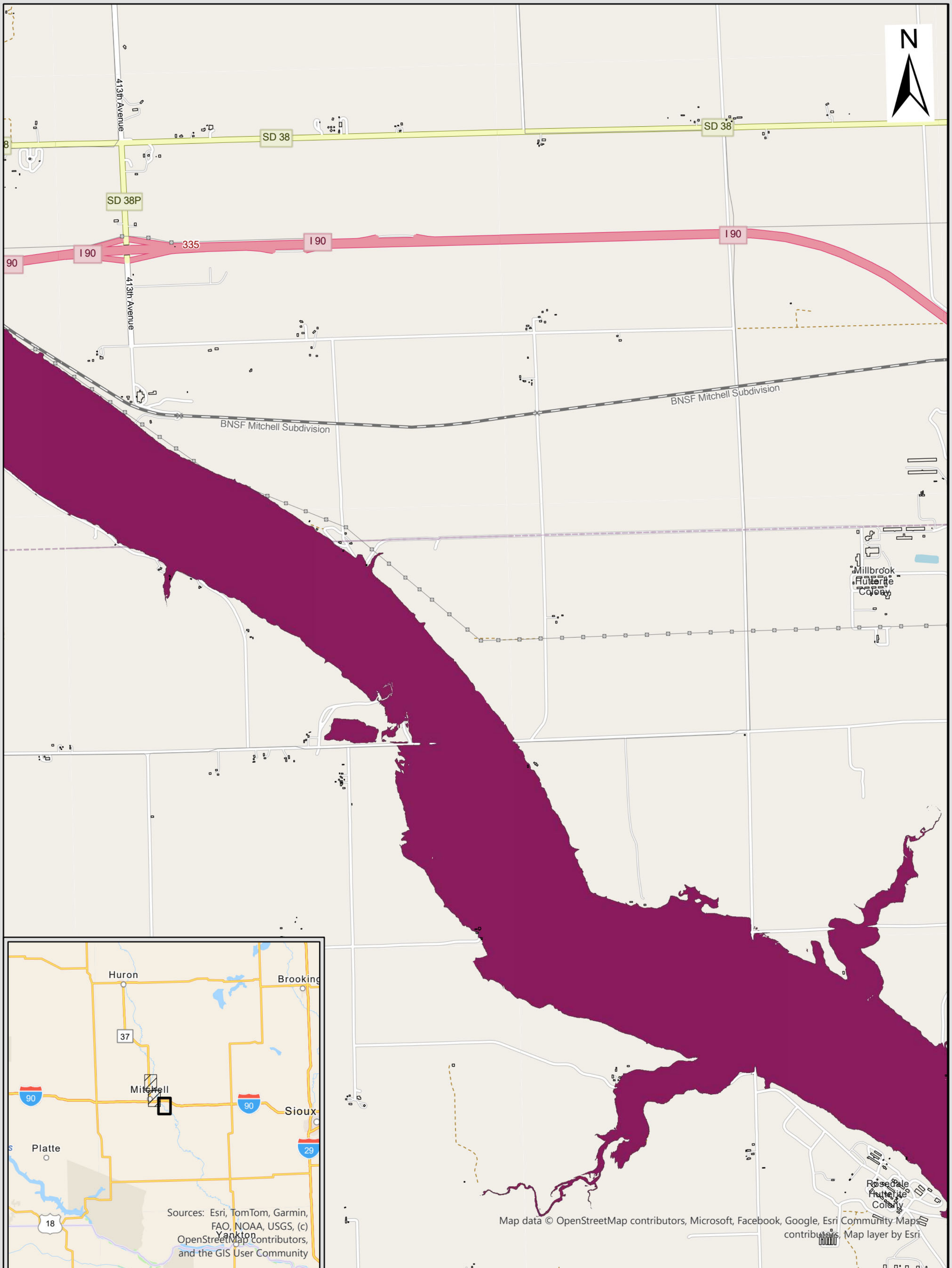


Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

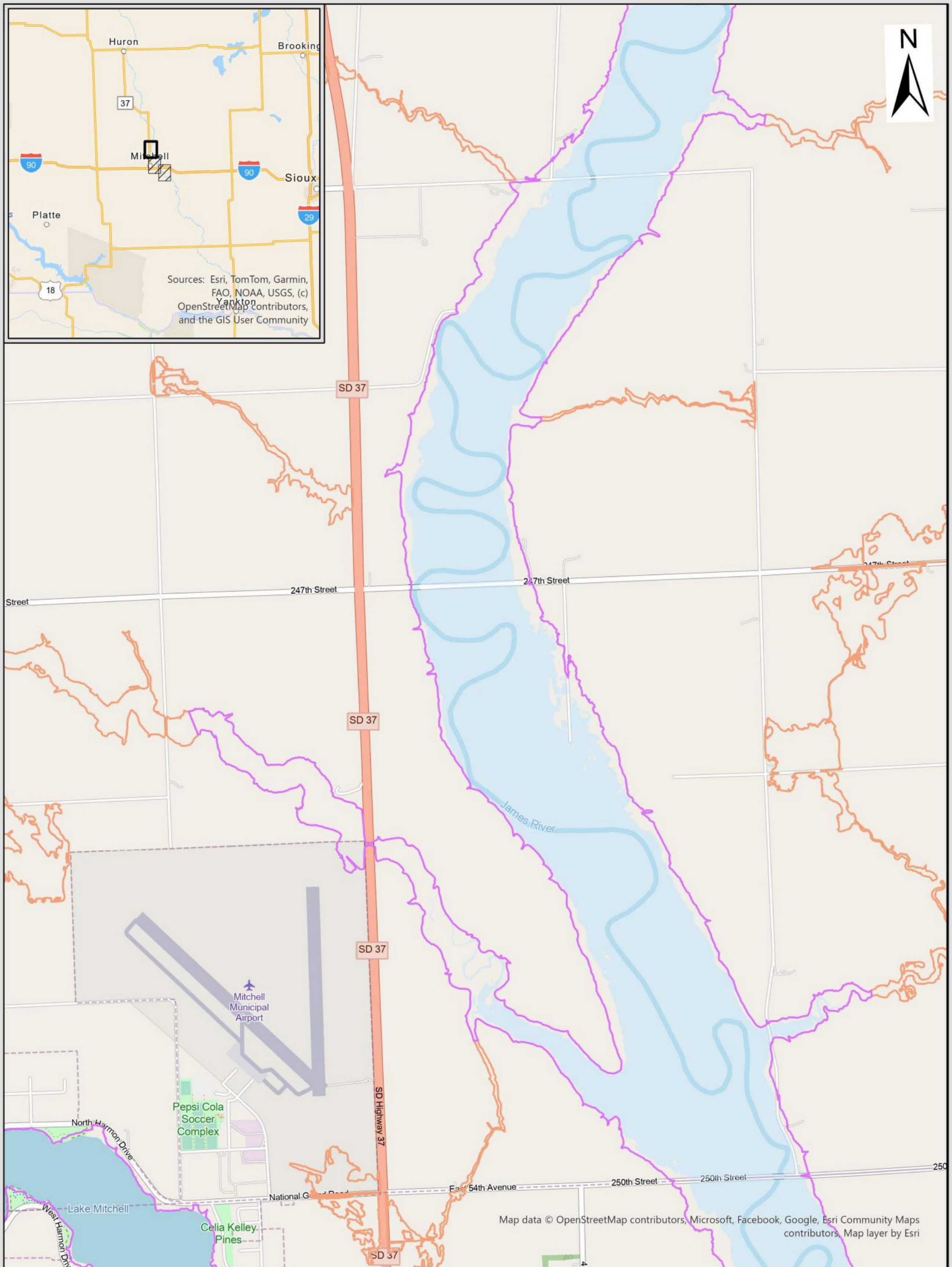
0 0.5 1 Miles

Rainy Day 50% PMF No Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Breach Inundation Extents

FEMA Flood Zone A

FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 23% PMF Breach Inundation Extent					
Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 1/13/2026	Sheet:

HOUSTON engineering, inc.

Breach Inundation Extents

FEMA Flood Zone A

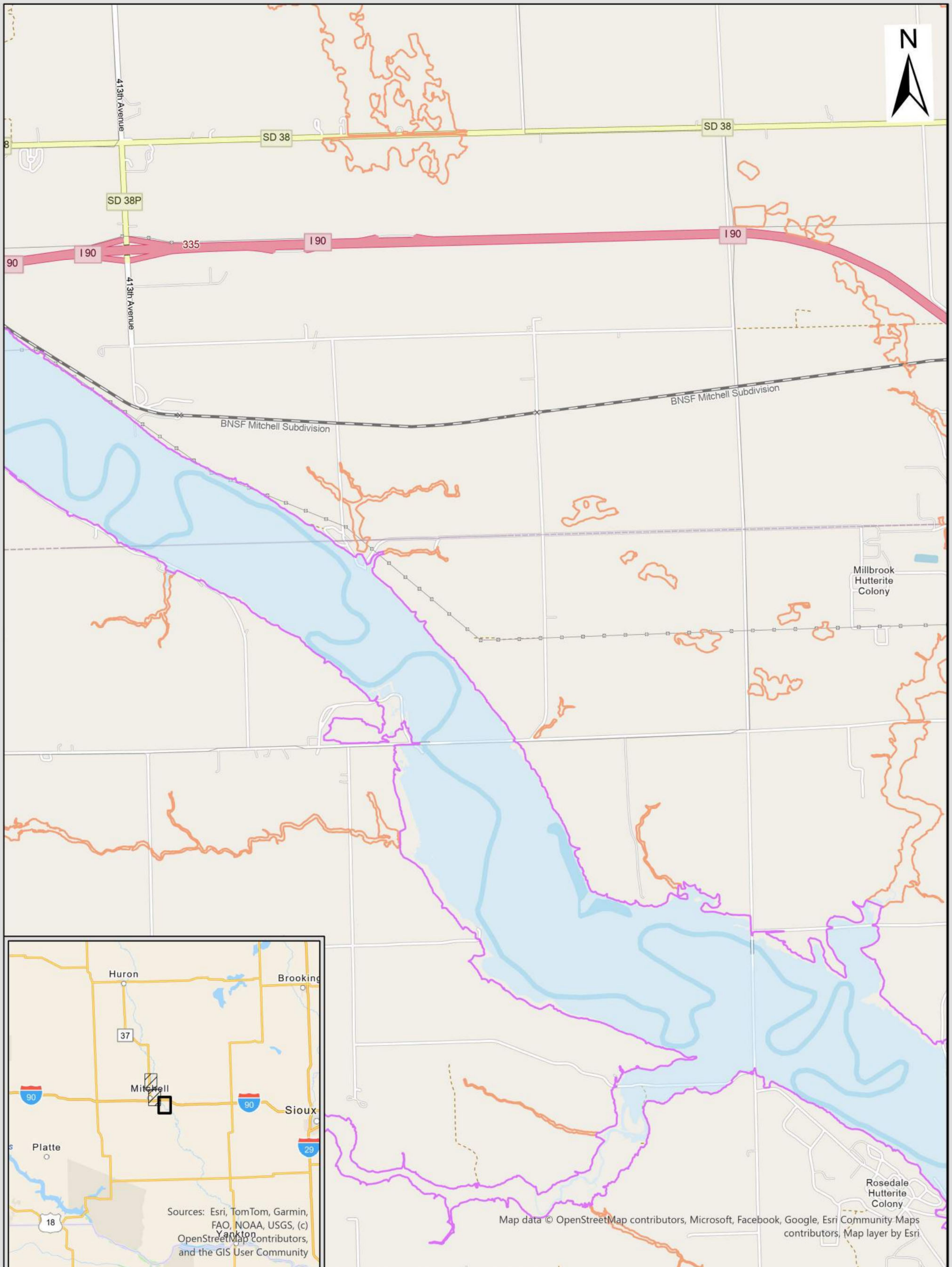
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 23% PMF Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

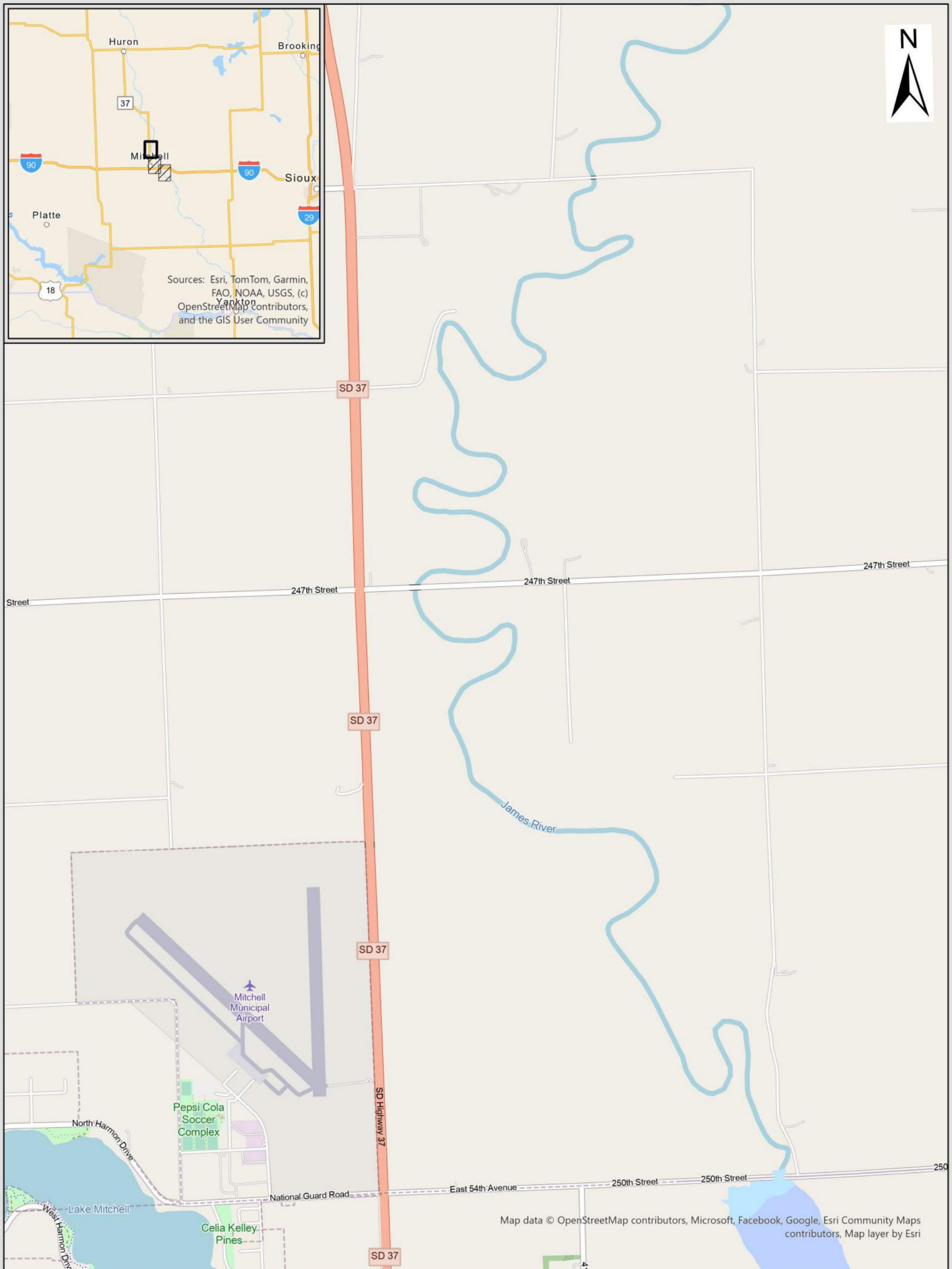
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 23% PMF Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

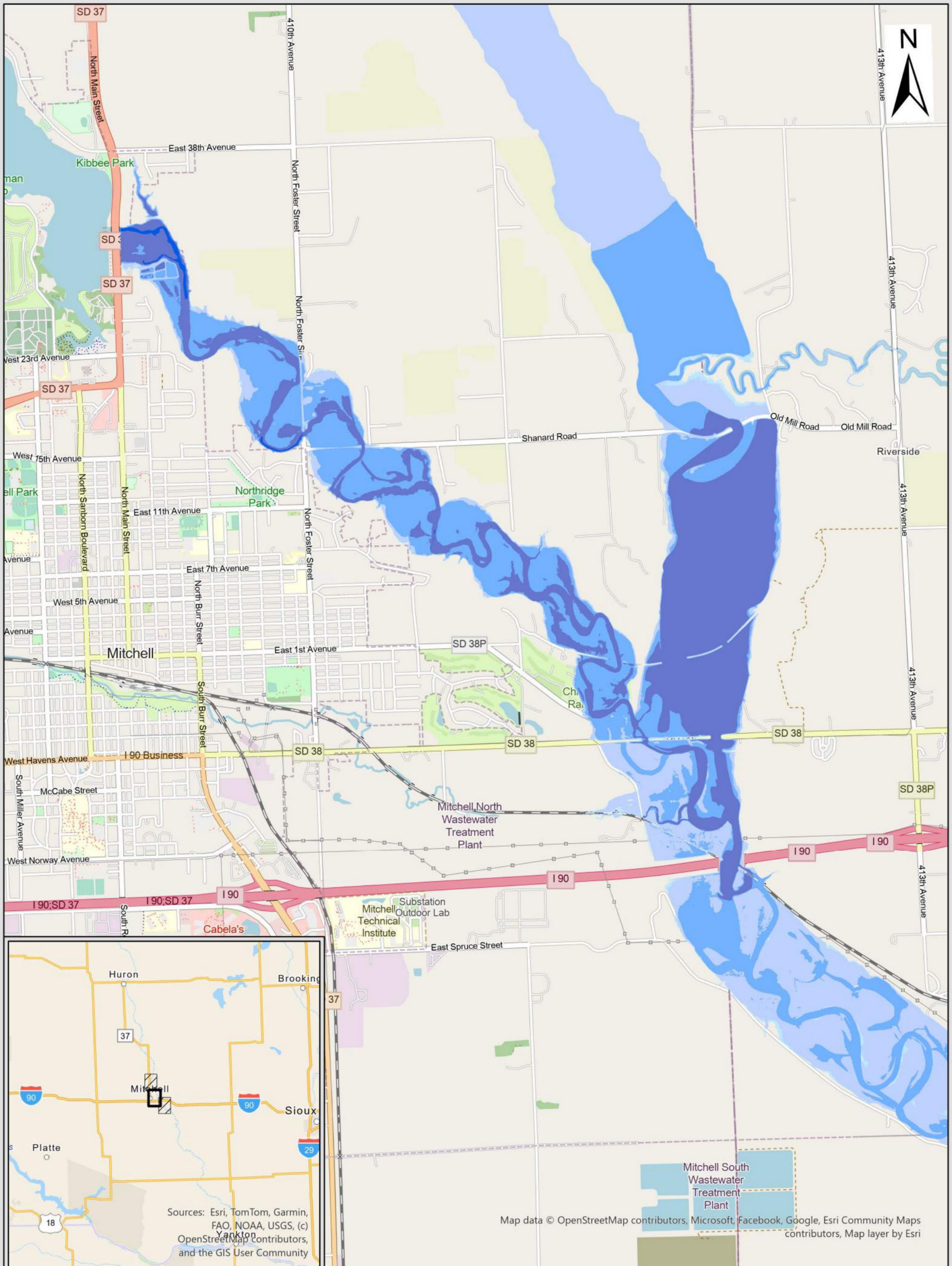
Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

Rainy Day 23% PMF Depths Prior to Breach

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF Depths Prior to Breach					
Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 1/13/2026	Sheet:

HOUSTON engineering, inc.

Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF Depths Prior to Breach

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
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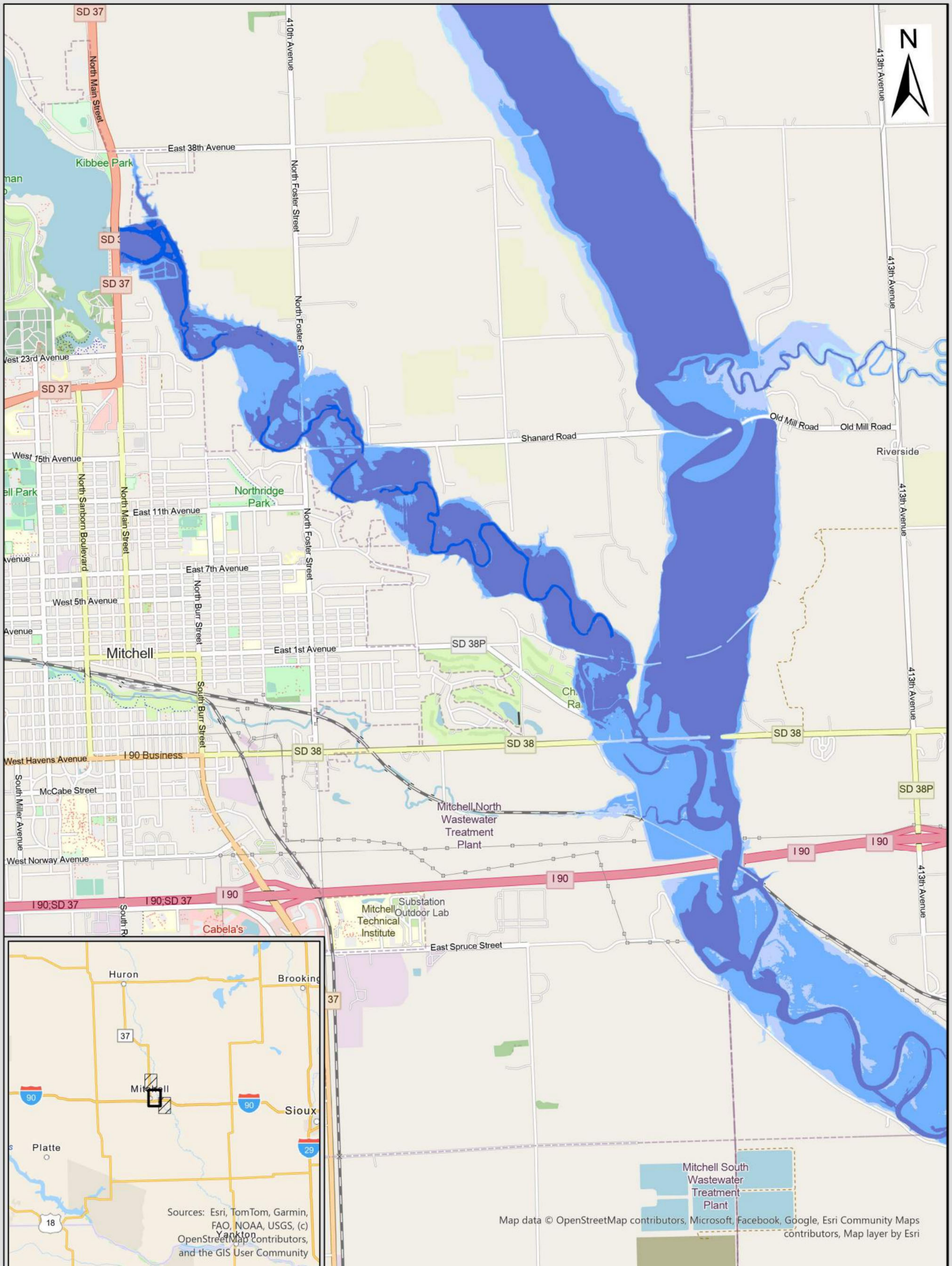
0 0.5 1 Miles

Rainy Day 23% PMF Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Breach Velocities (ft/s)

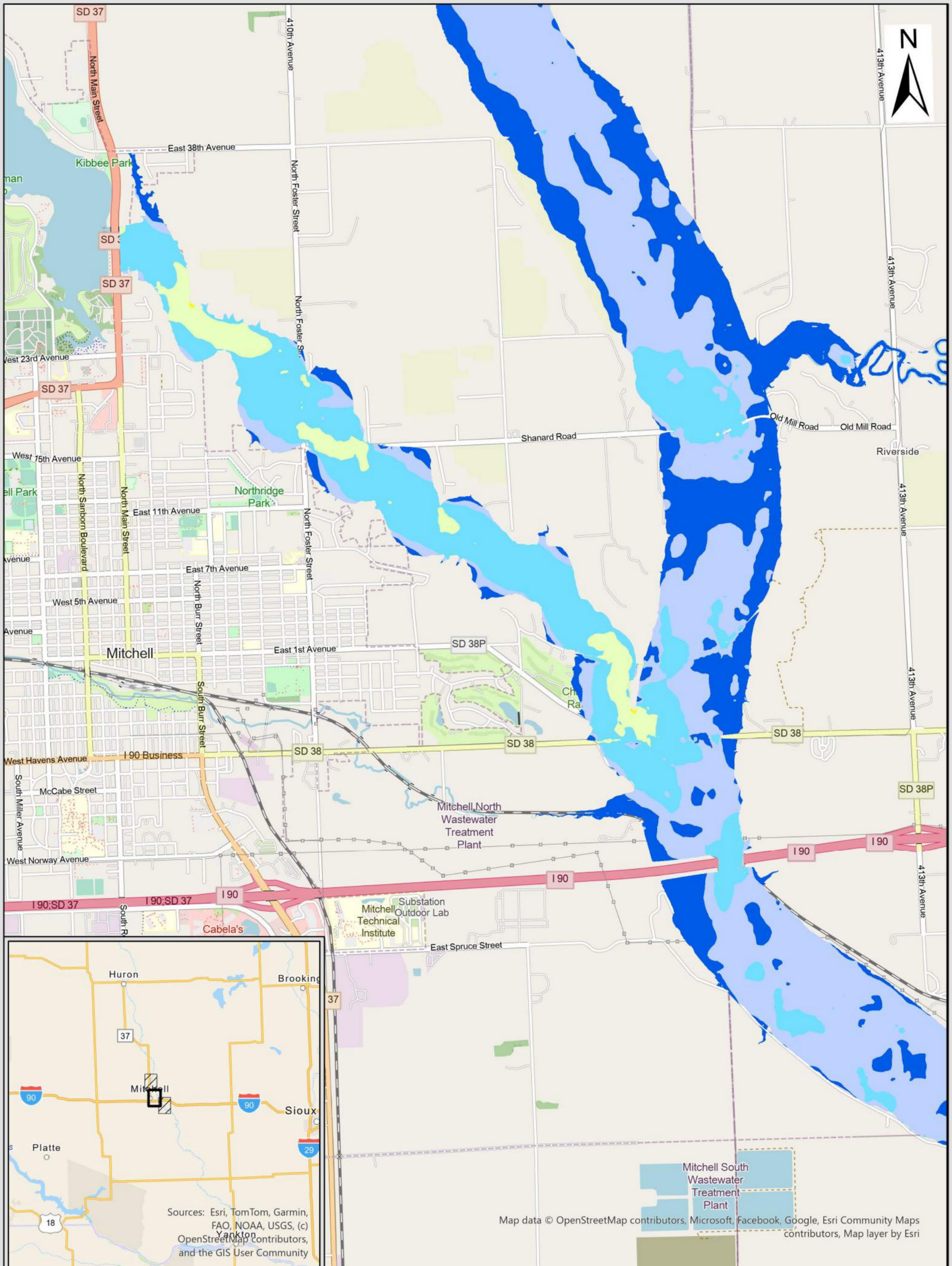
Value

- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Velocities					
Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 1/13/2026	Sheet:

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
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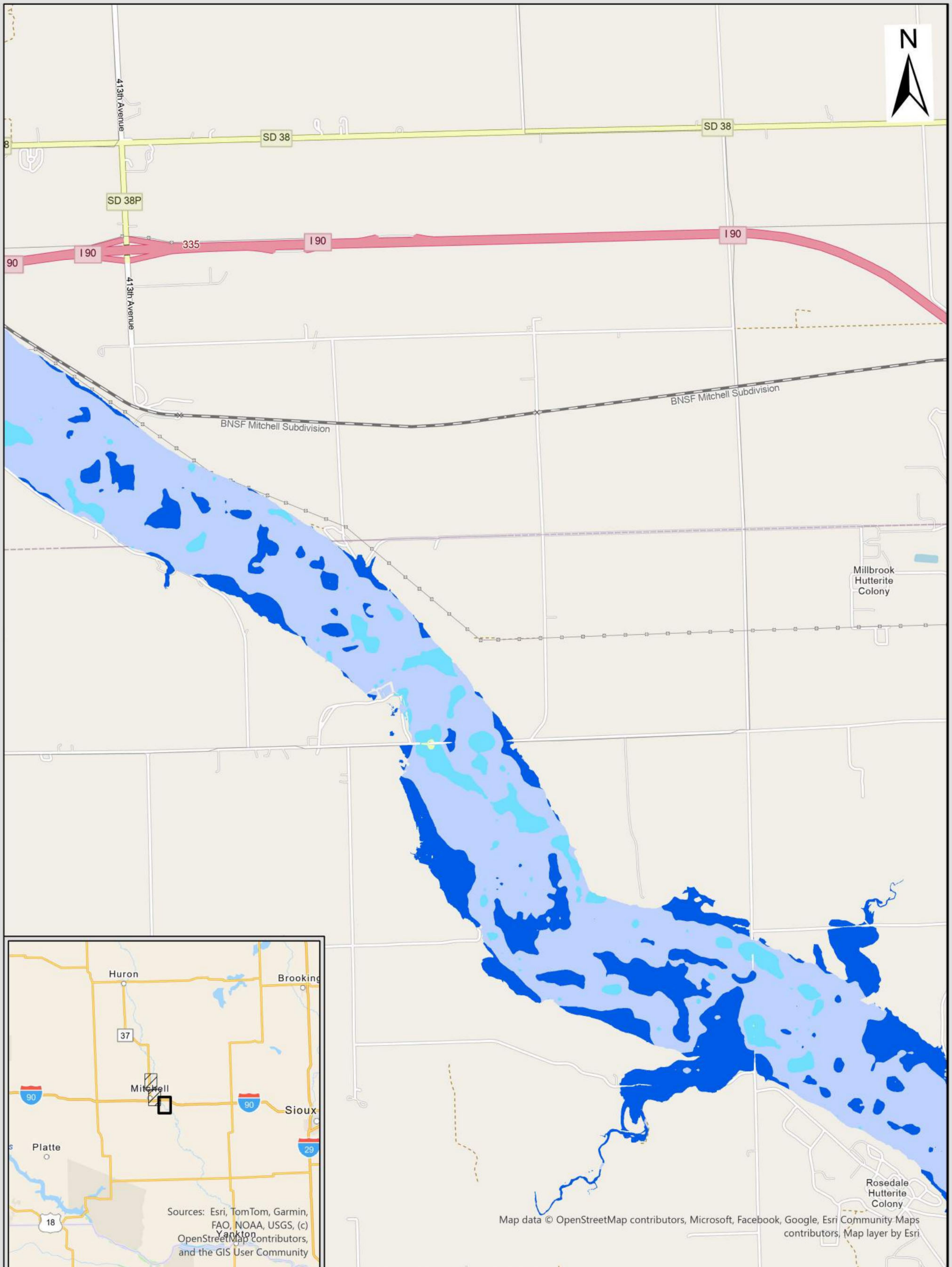
0 0.5 1 Miles

Rainy Day 23% PMF Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

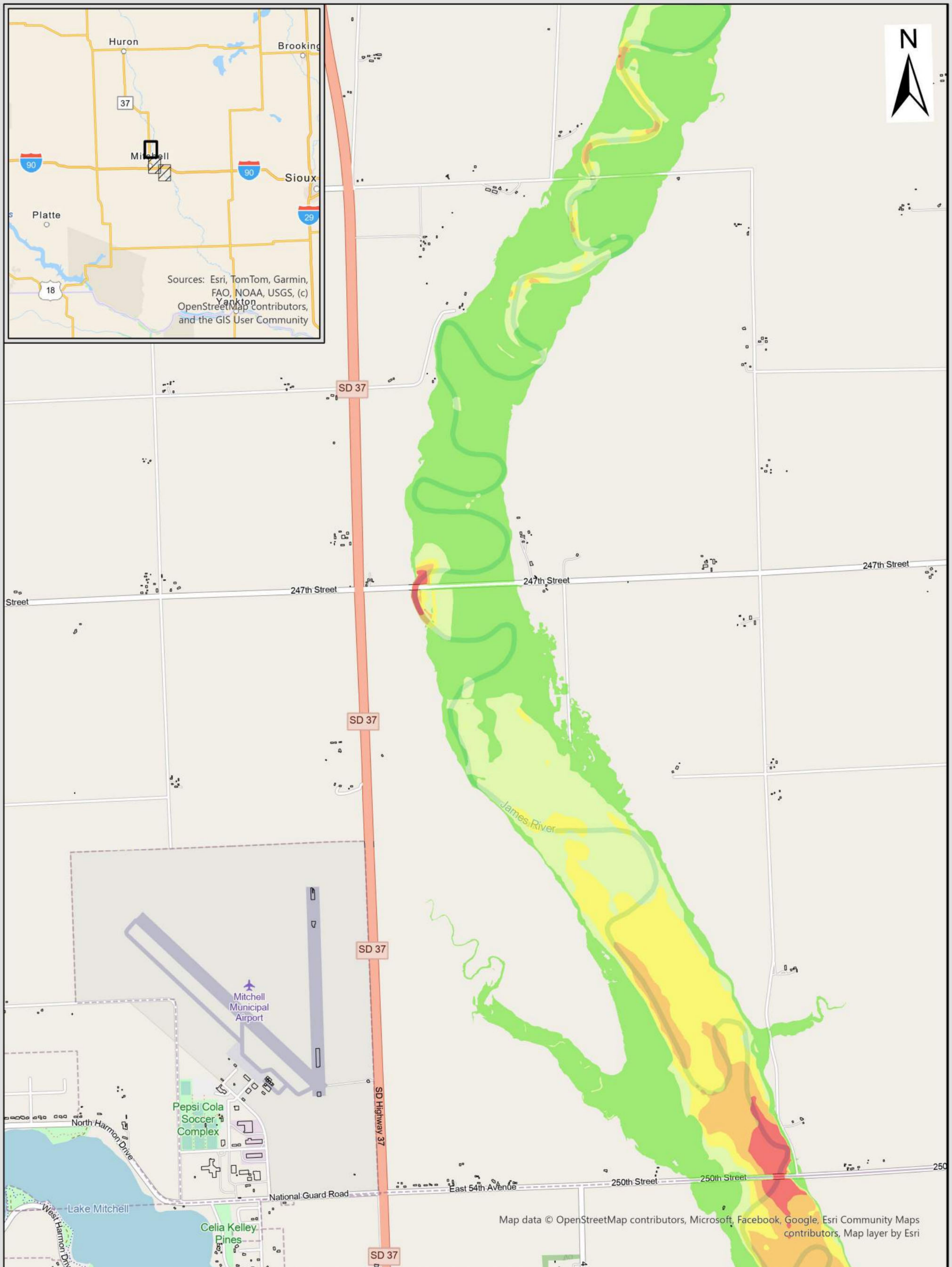
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

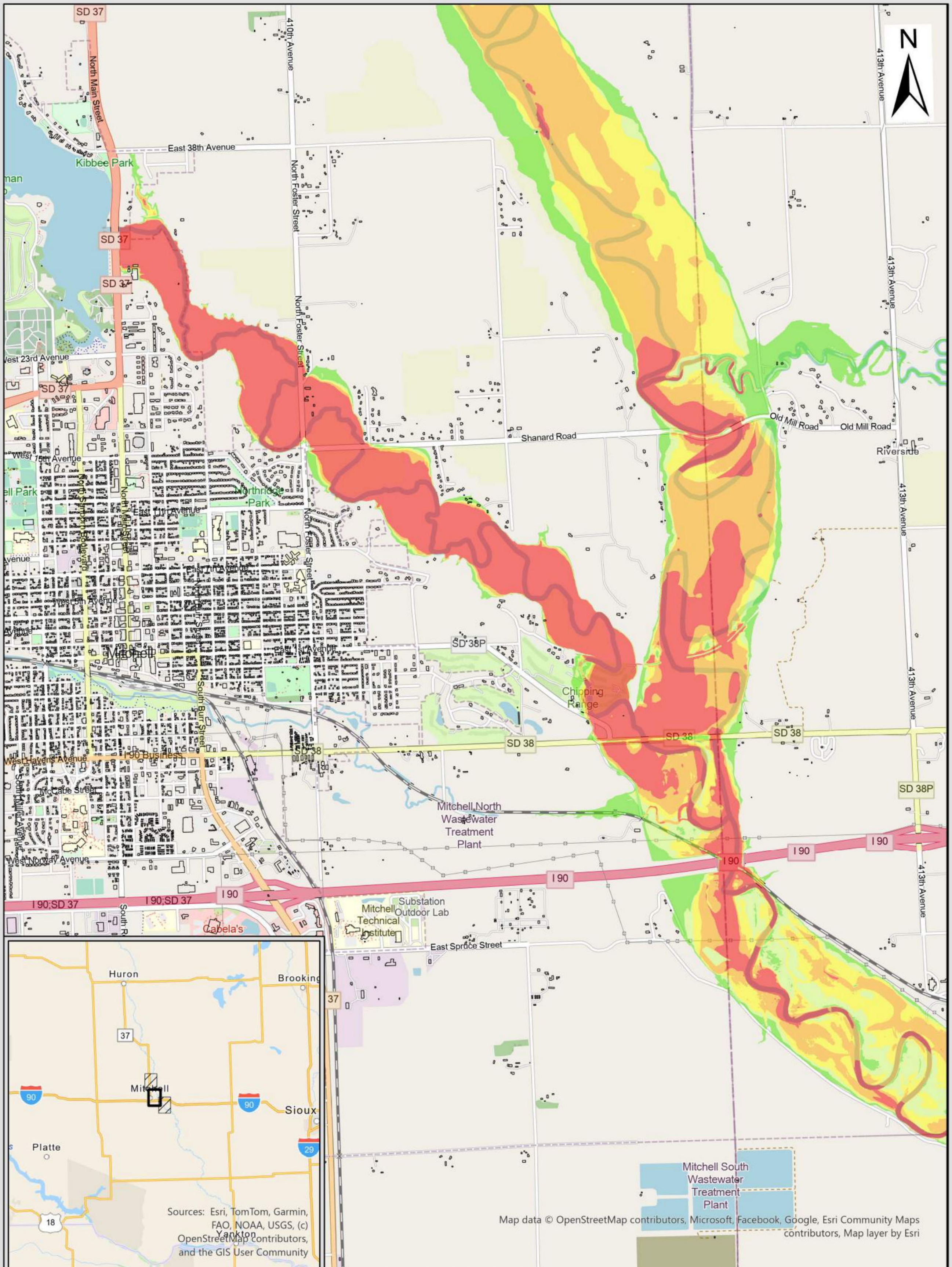
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/14/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

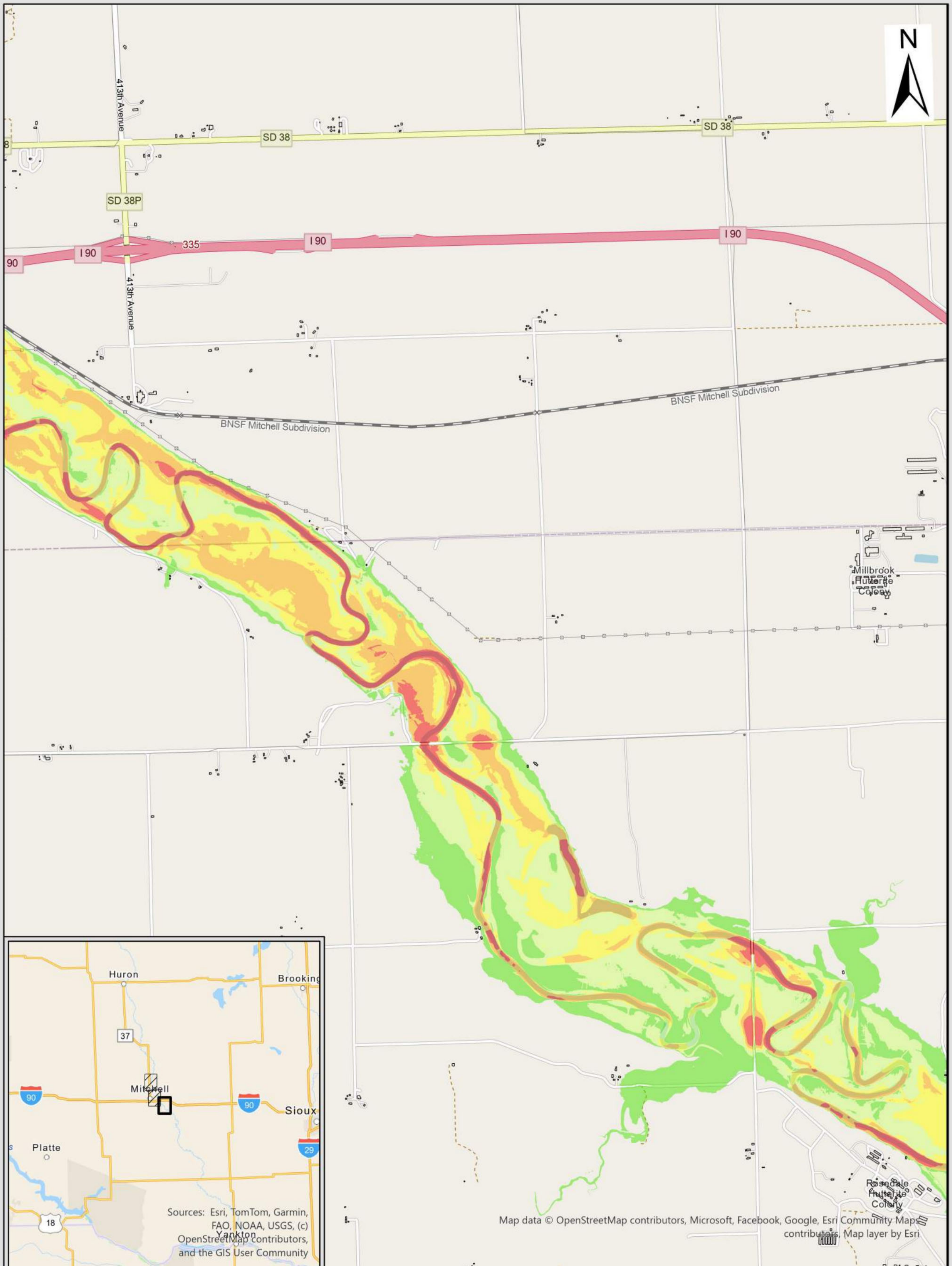
Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Depth x Velocity					
Scale: AS SHOWN	Drawn by: JH	Checked by: CK	Project No.: 11351-0002	Date: 1/14/2026	Sheet:

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/14/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

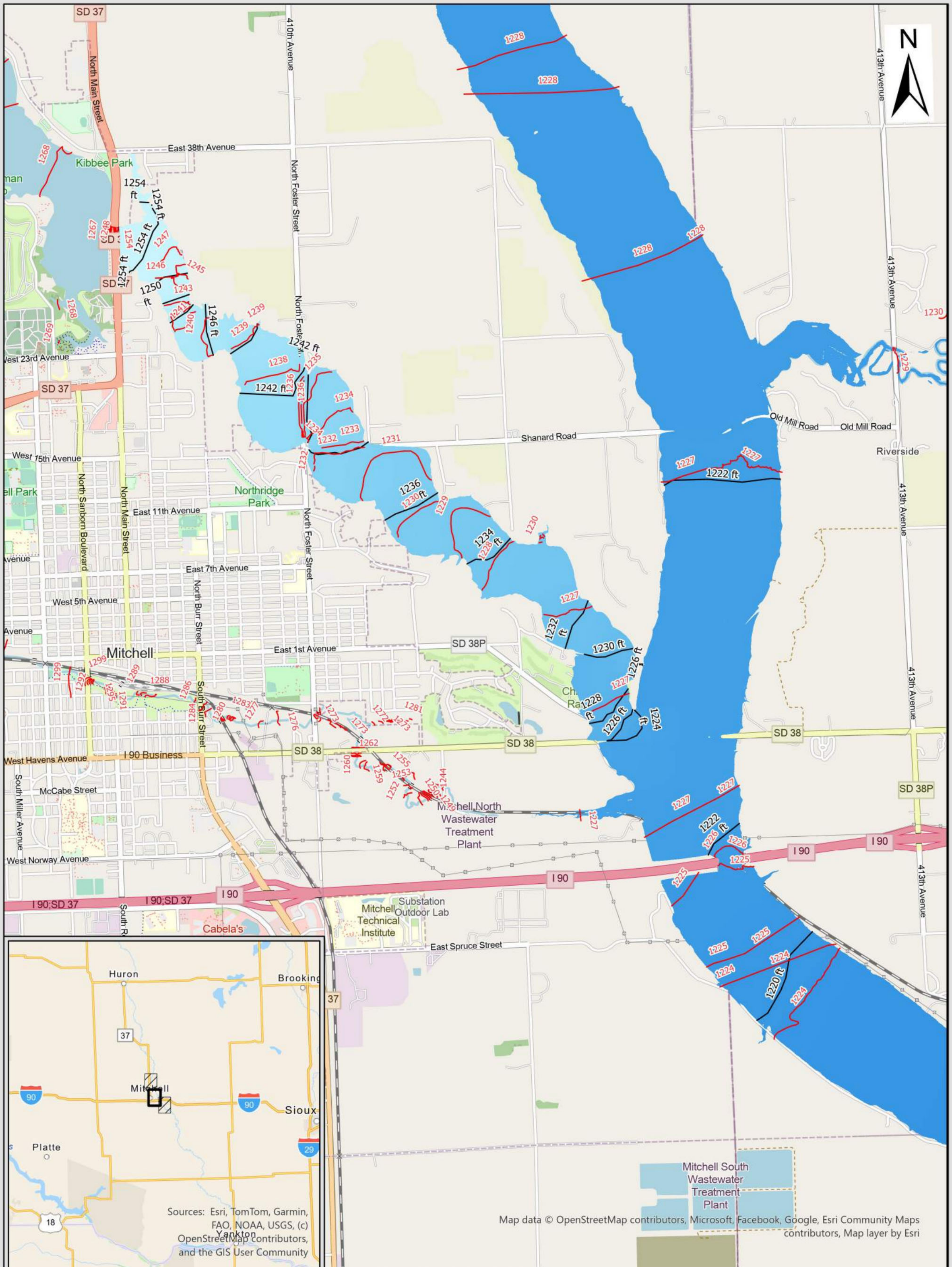
— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 23% PMF Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

Base Flood Elevations

0 0.5 1 Miles

Rainy Day 23% PMF Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

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1204.33

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0 0.5 1 Miles

Rainy Day 23% PMF Breach WSEs

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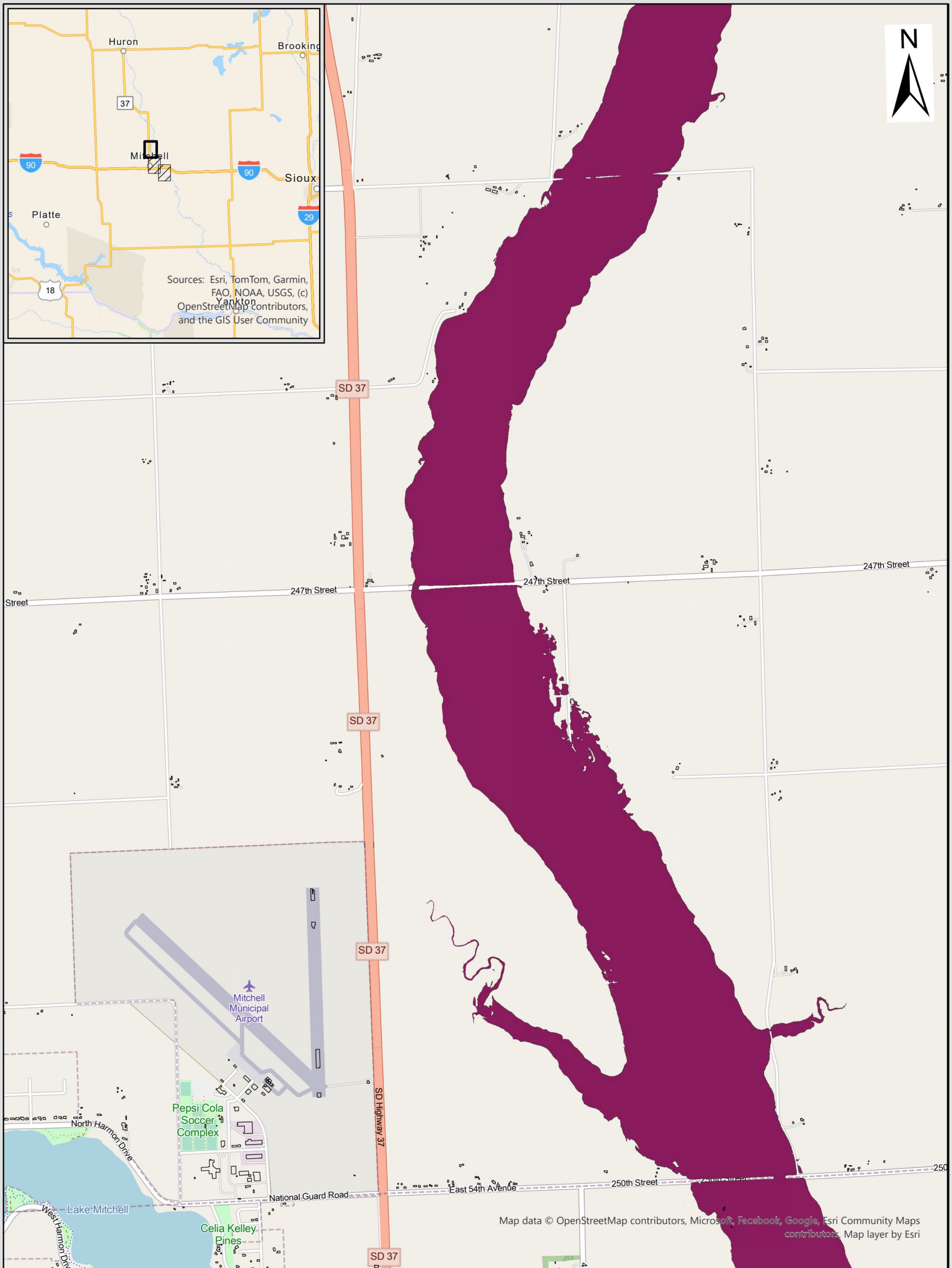
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Rainy Day 23% PMF Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

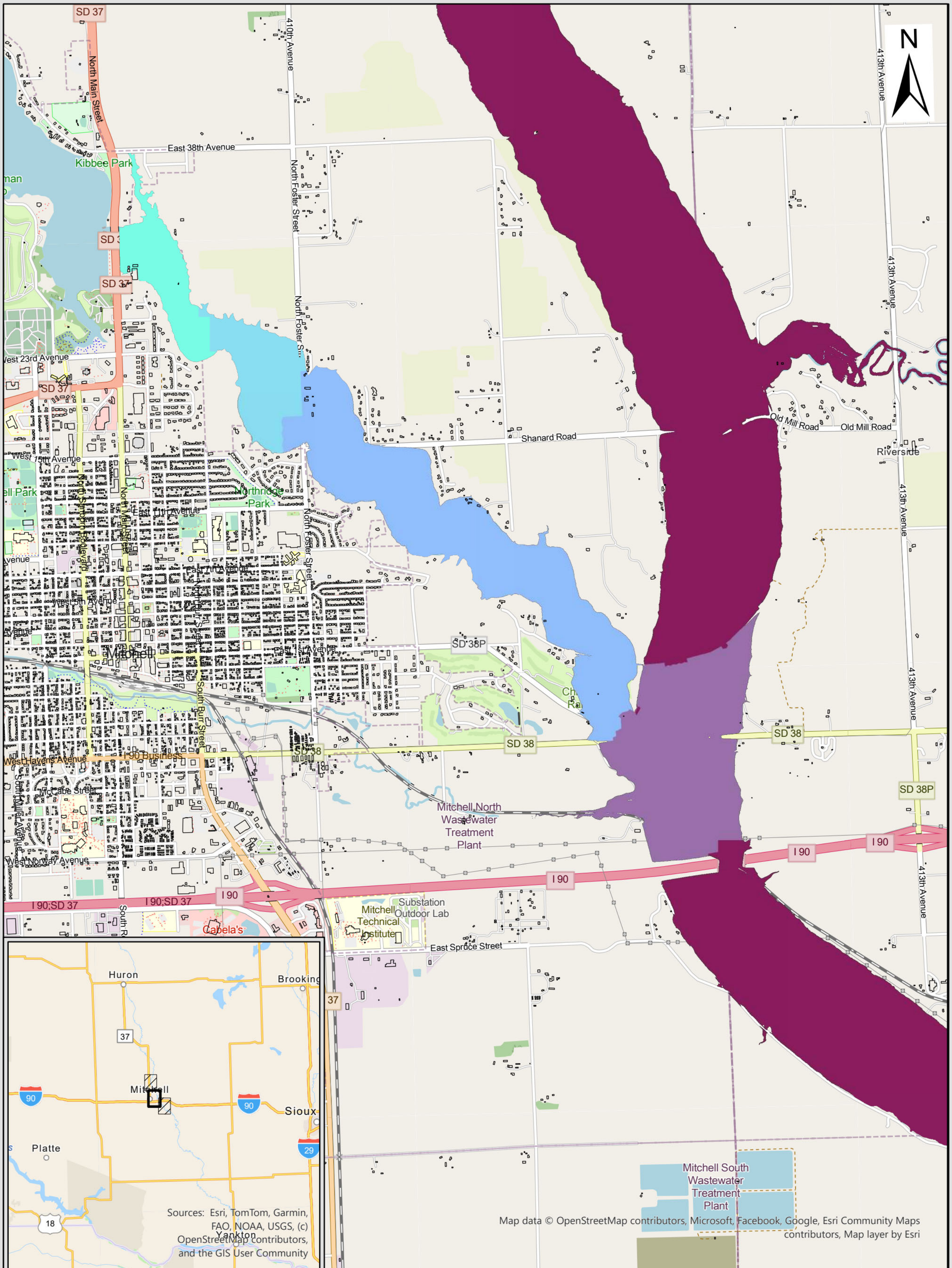
Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

0 0.5 1 Miles

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

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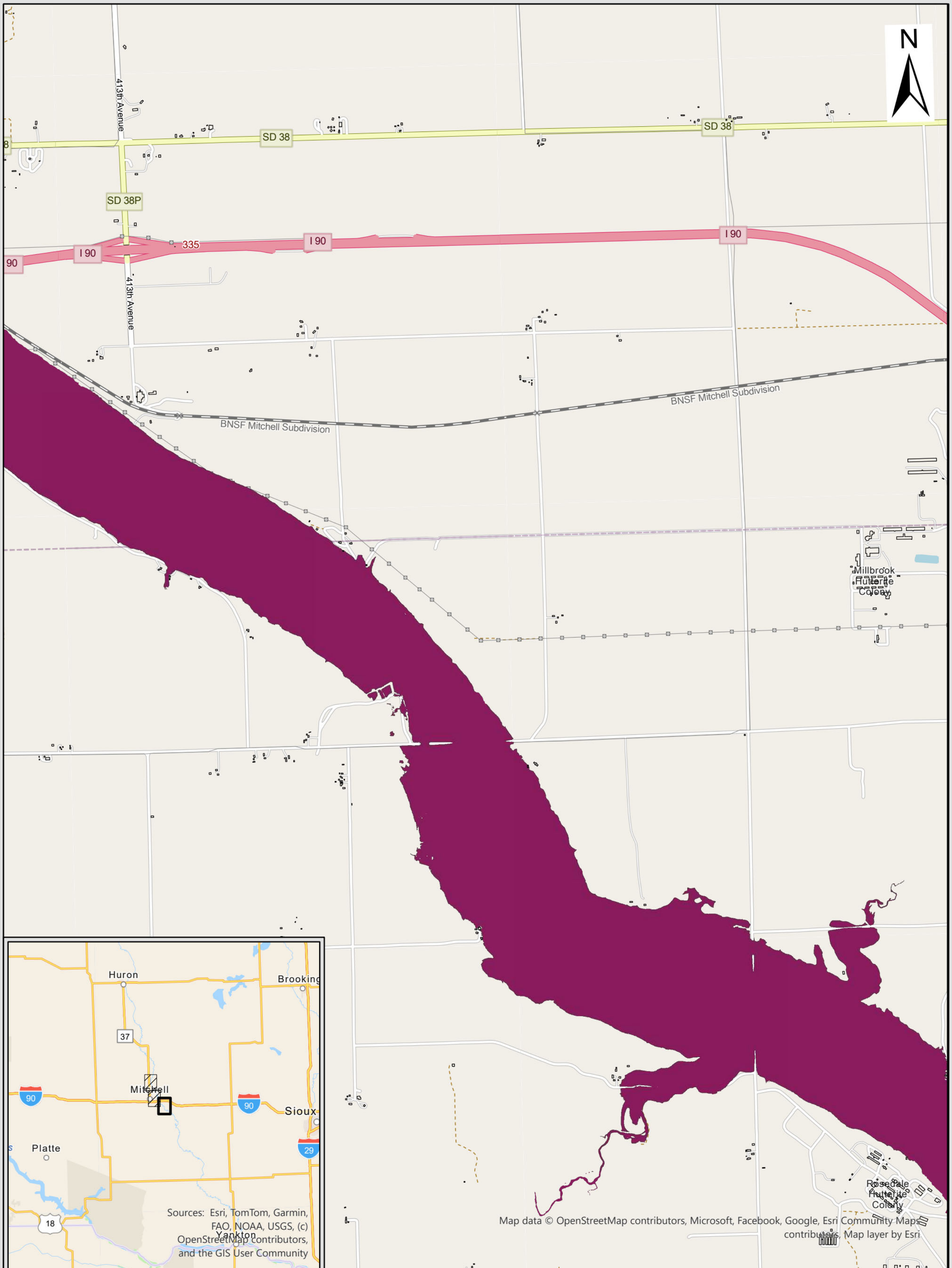

Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
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- 120 - 240
- 240+

0 0.5 1 Miles

Rainy Day 23% PMF Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

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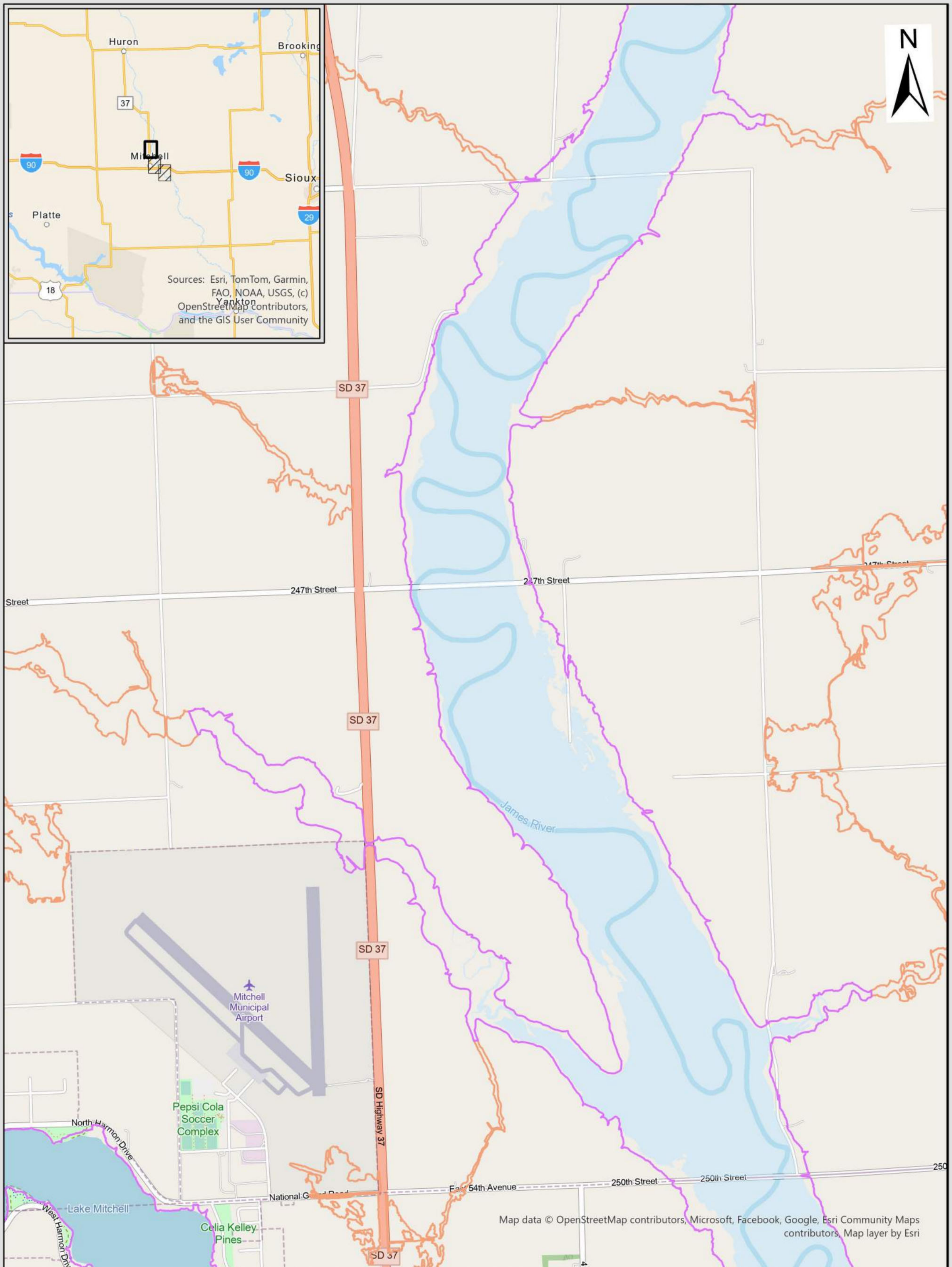


Breach Inundation Extents

FEMA Flood Zone A

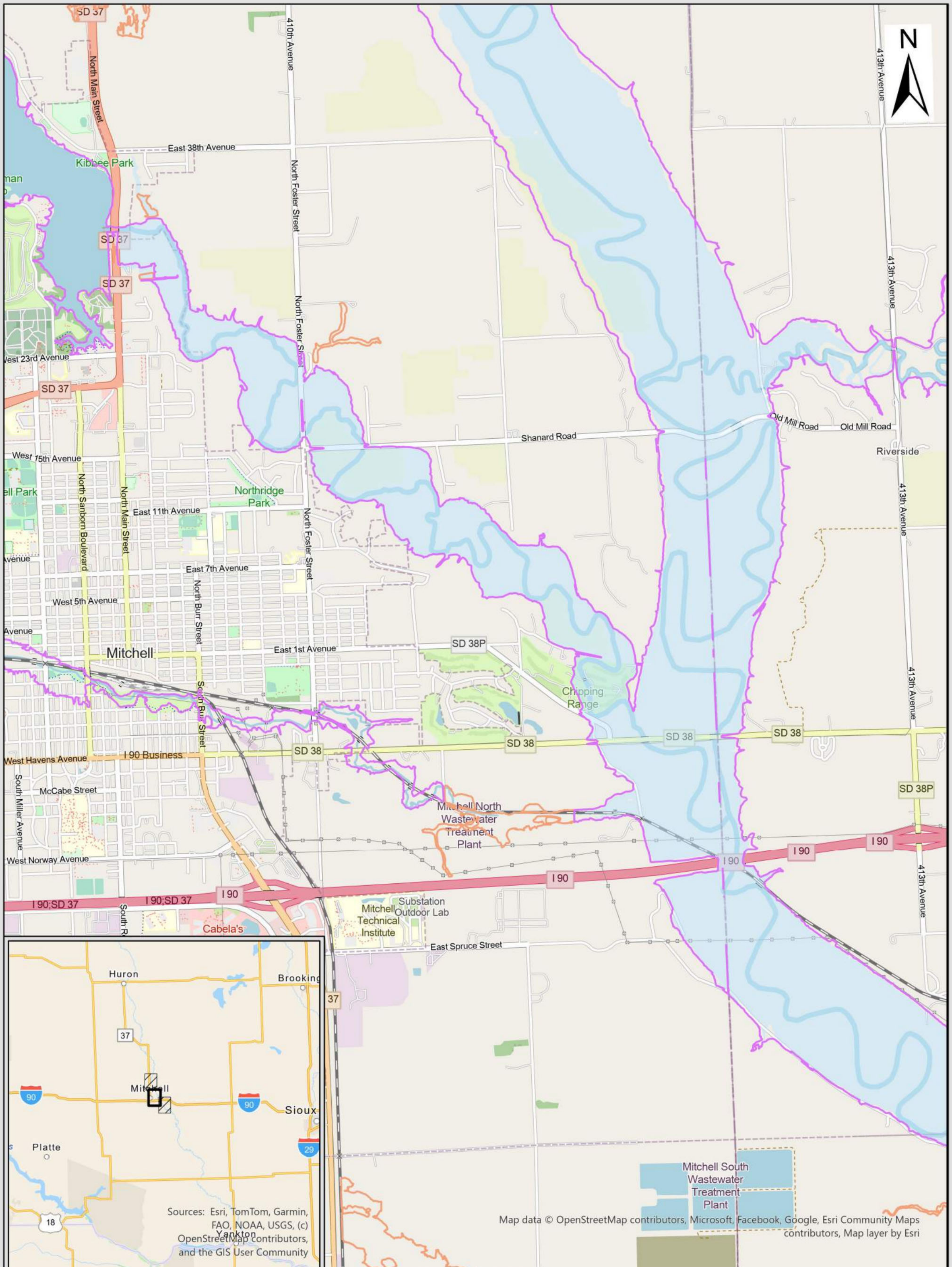
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

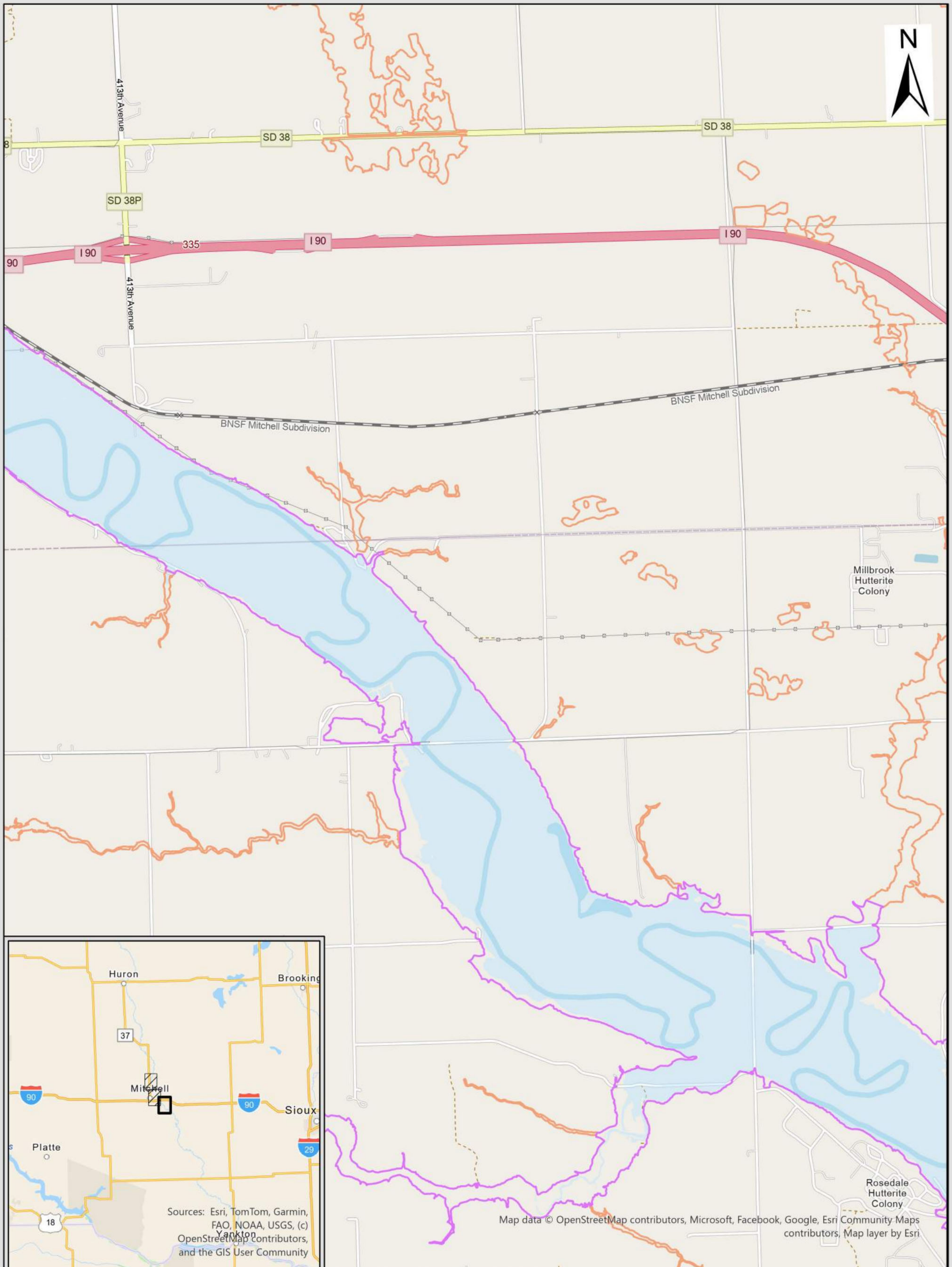
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Inundation Extents

FEMA Flood Zone A

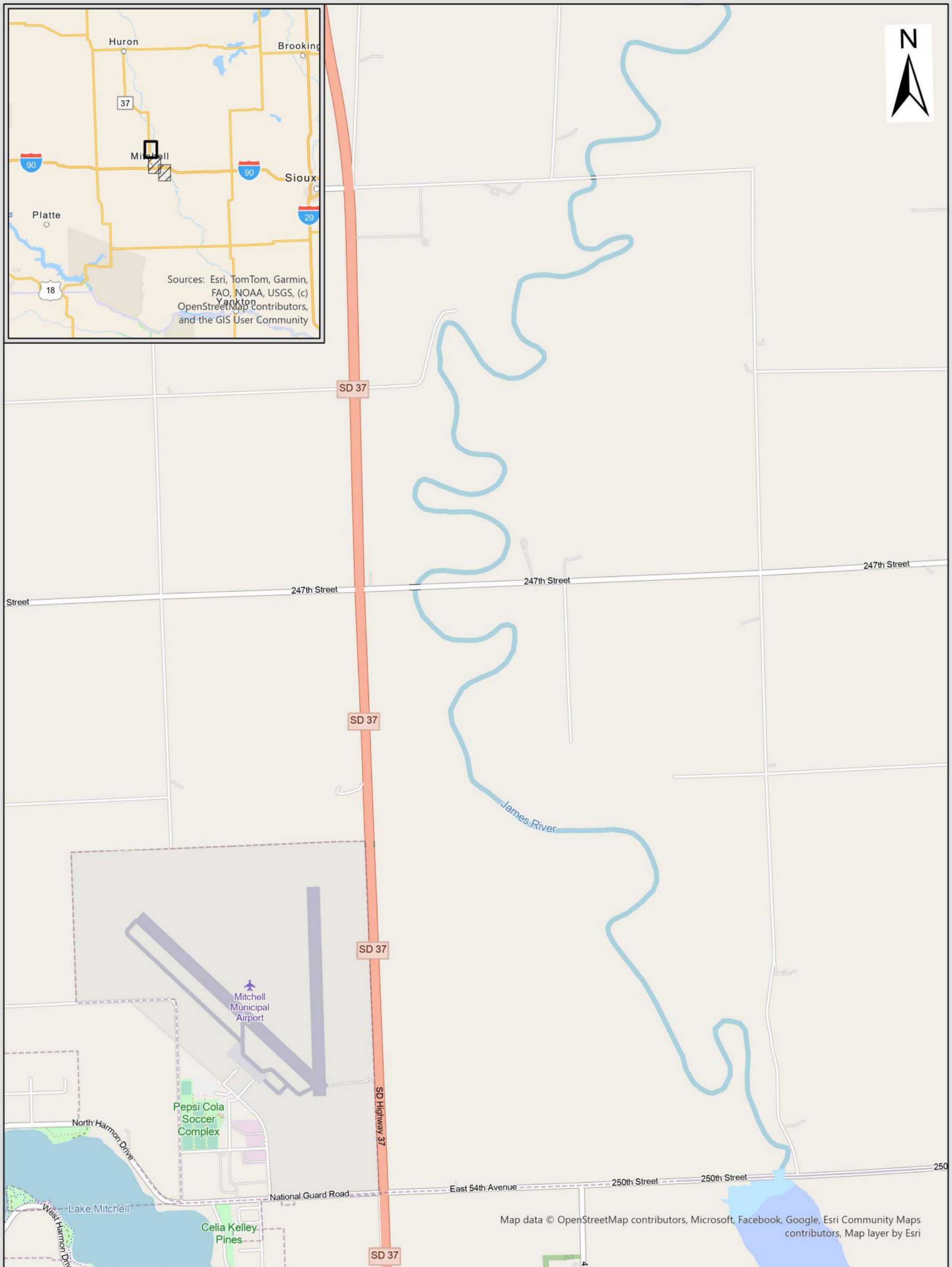
FEMA Flood Zone AE

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Inundation Extent

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

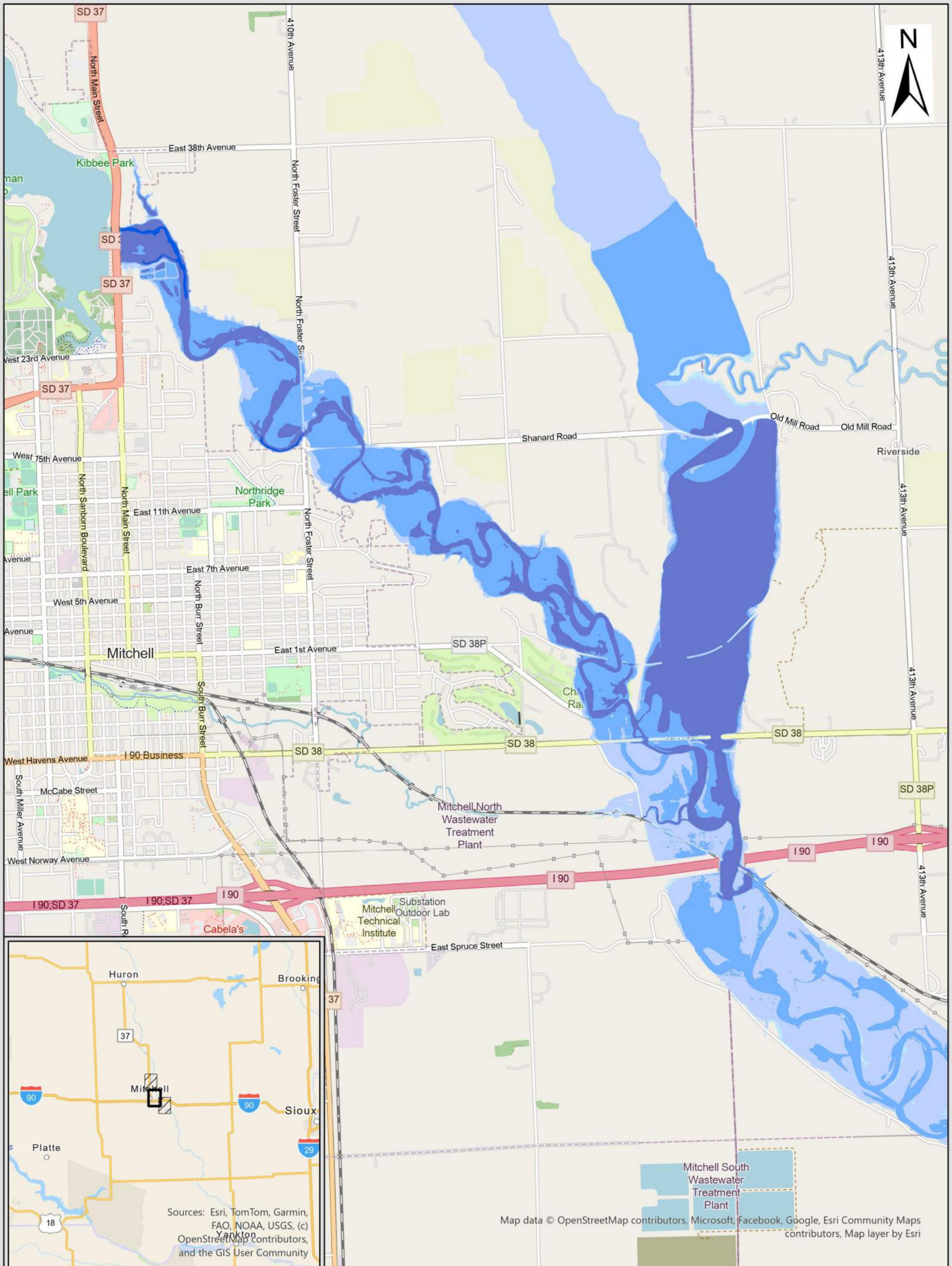
- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depths Prior

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depths Prior

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depth Before Breach (ft)

Value

- 0.00 - 1.00
- 1.00 - 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depths Prior

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Rainy Day 23% PMF No Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

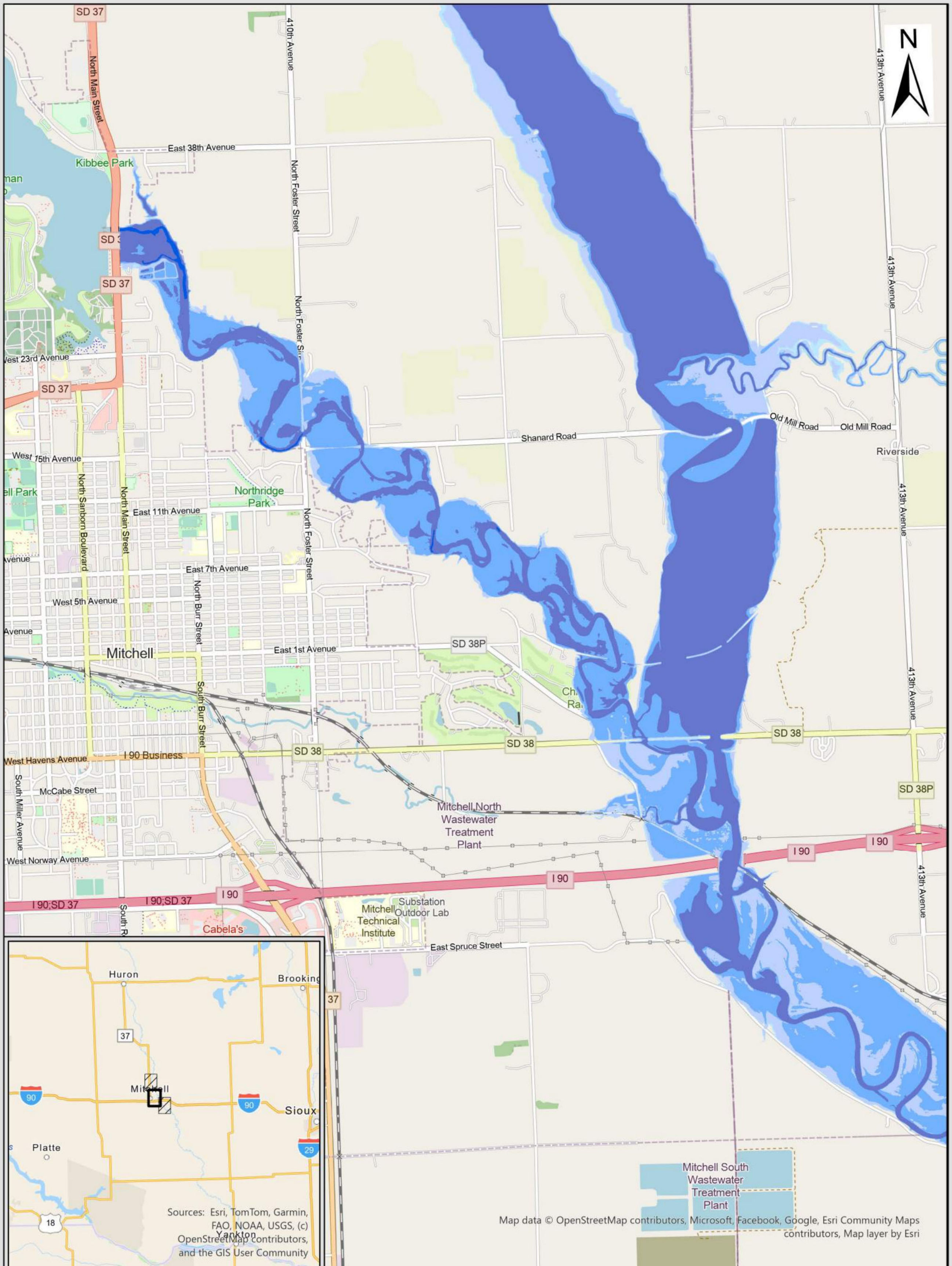
HOUSTON engineering, inc.

Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles



Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

Depths (ft)

Value

- 0.00 - 1.00
- 1.00- 5.00
- 5.00 - 10.00
- 10.00 - 20.00
- 20.00+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depths

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
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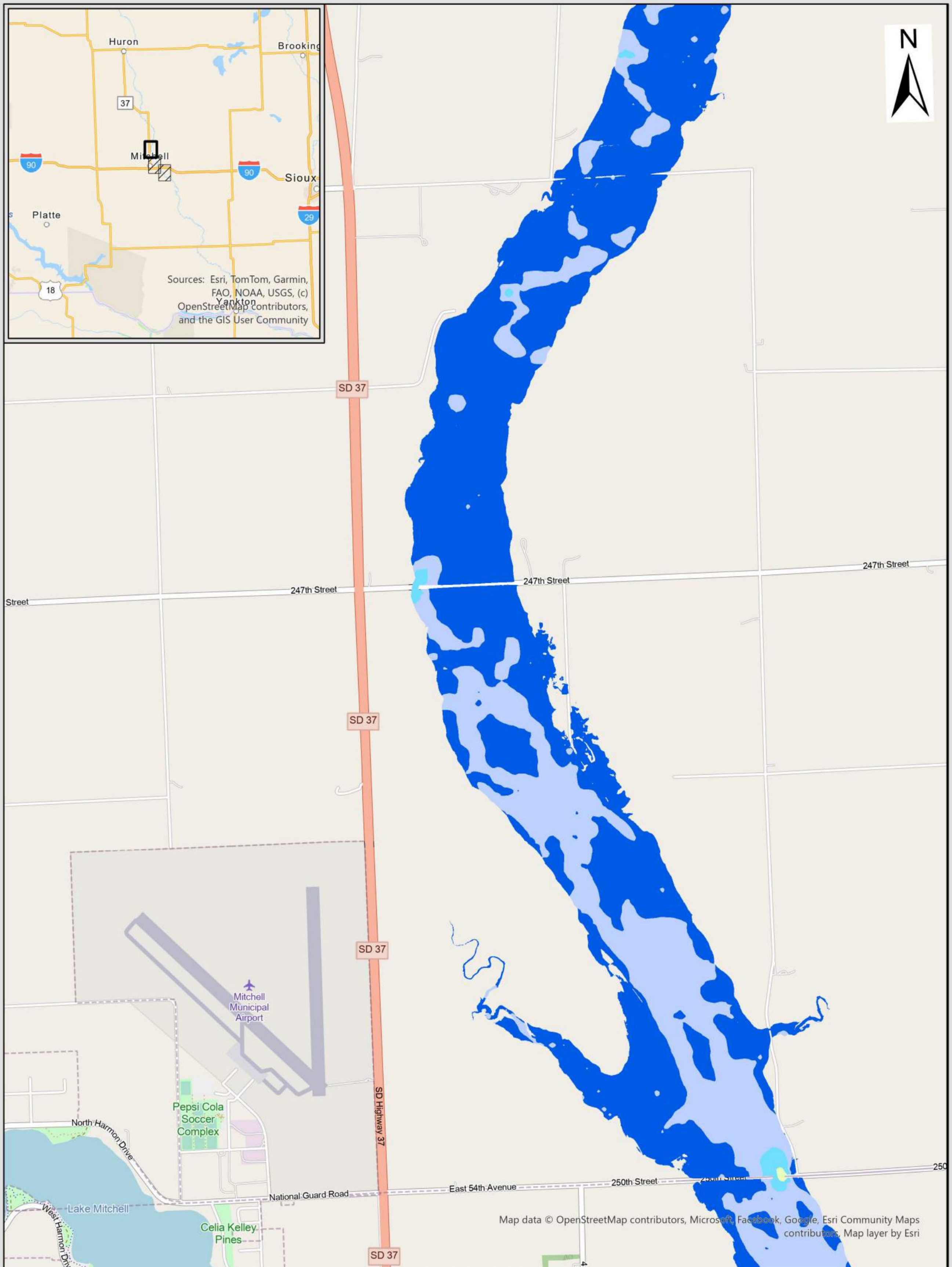
HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

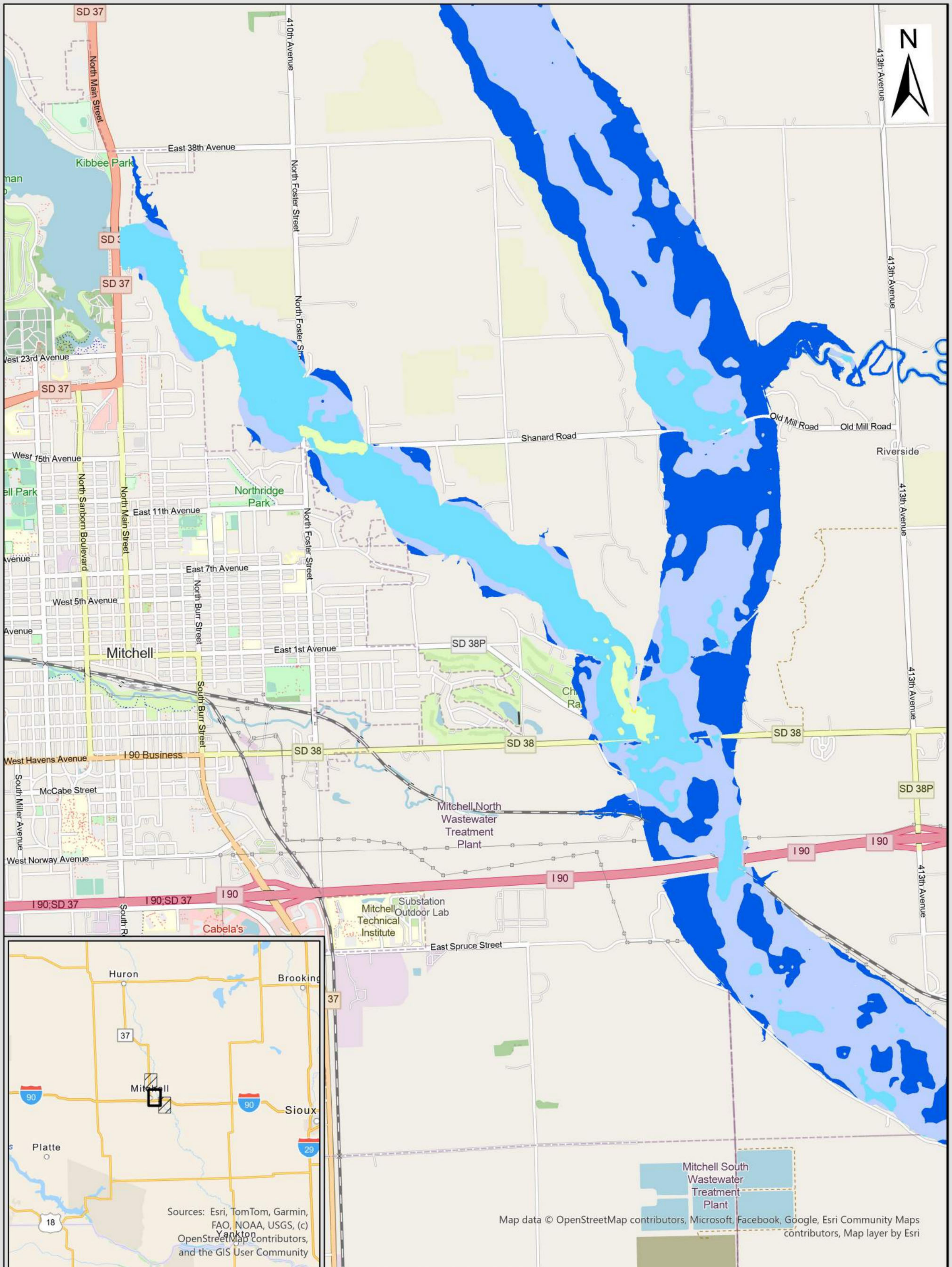
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

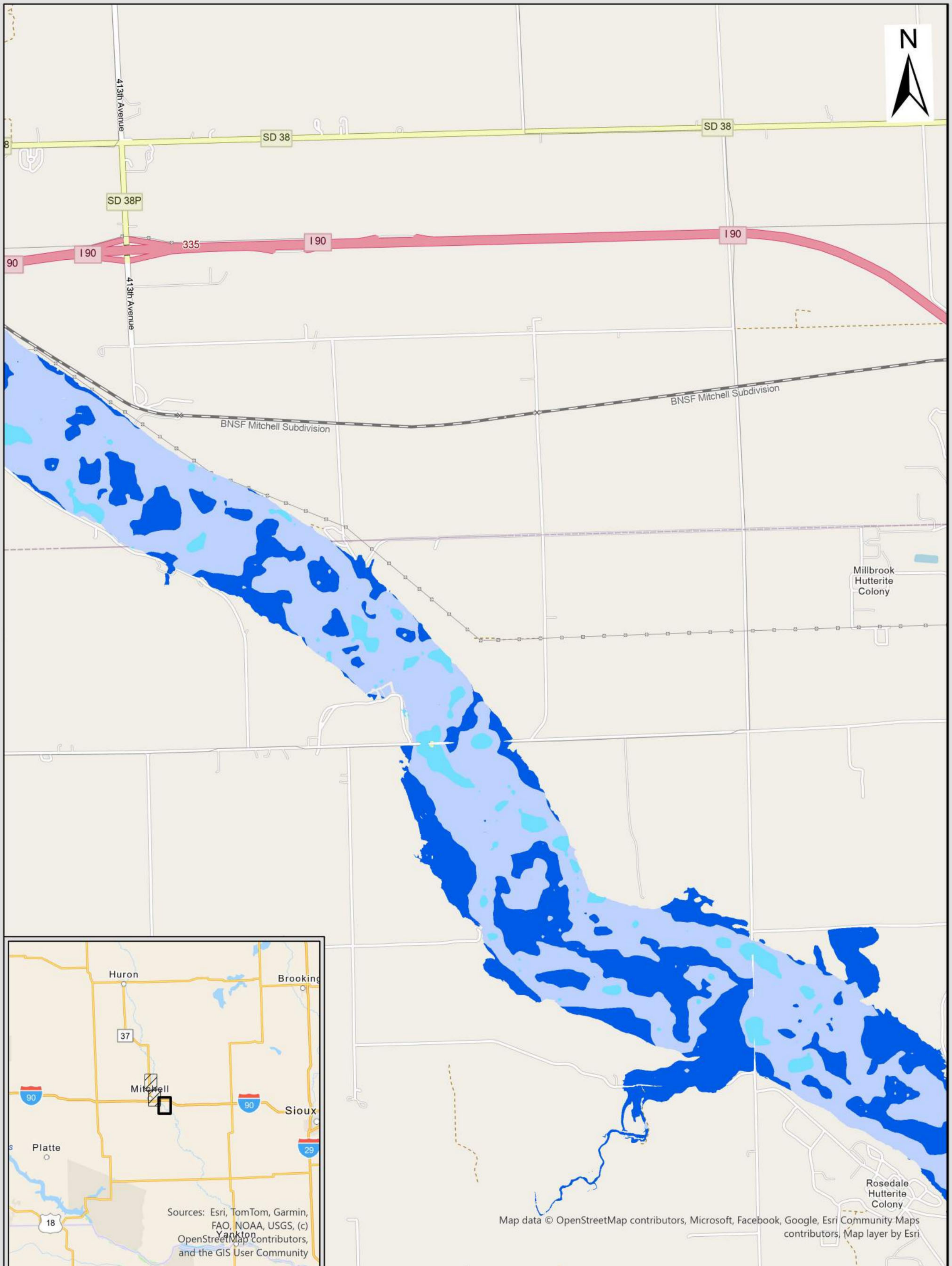
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Breach Velocities (ft/s)

Value

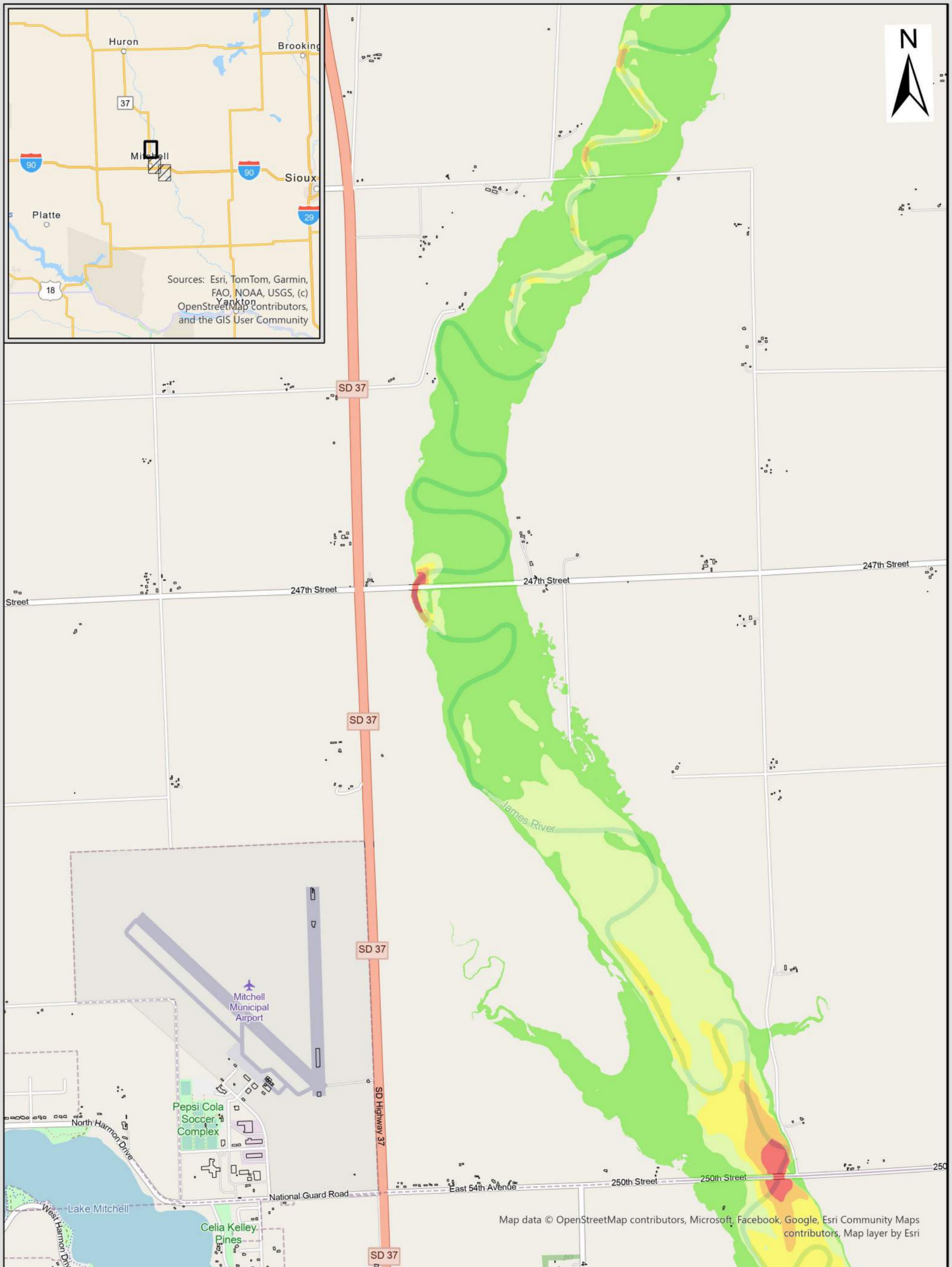
- 0.1 - 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 18.0
- 18.0+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Velocities

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

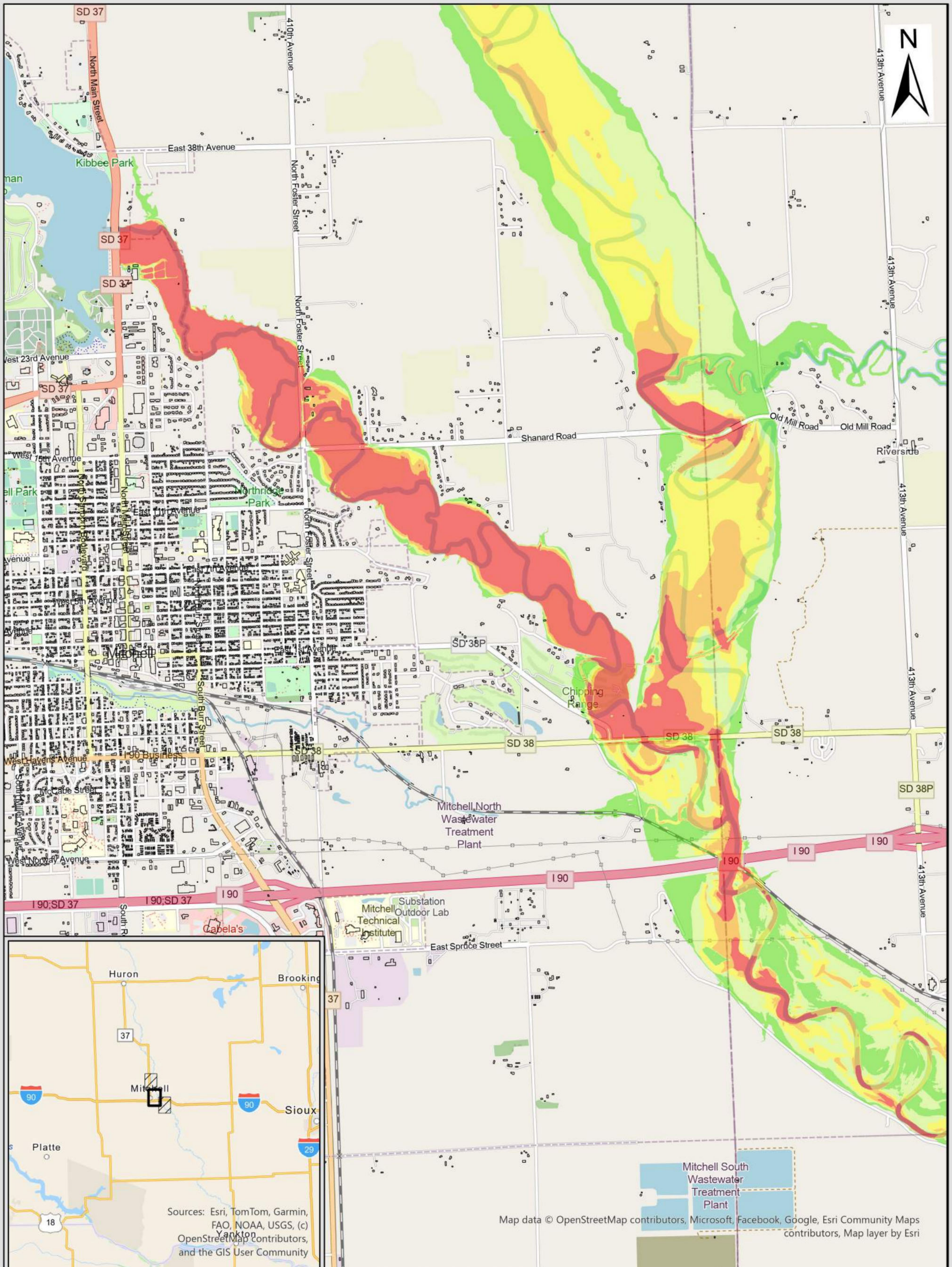
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

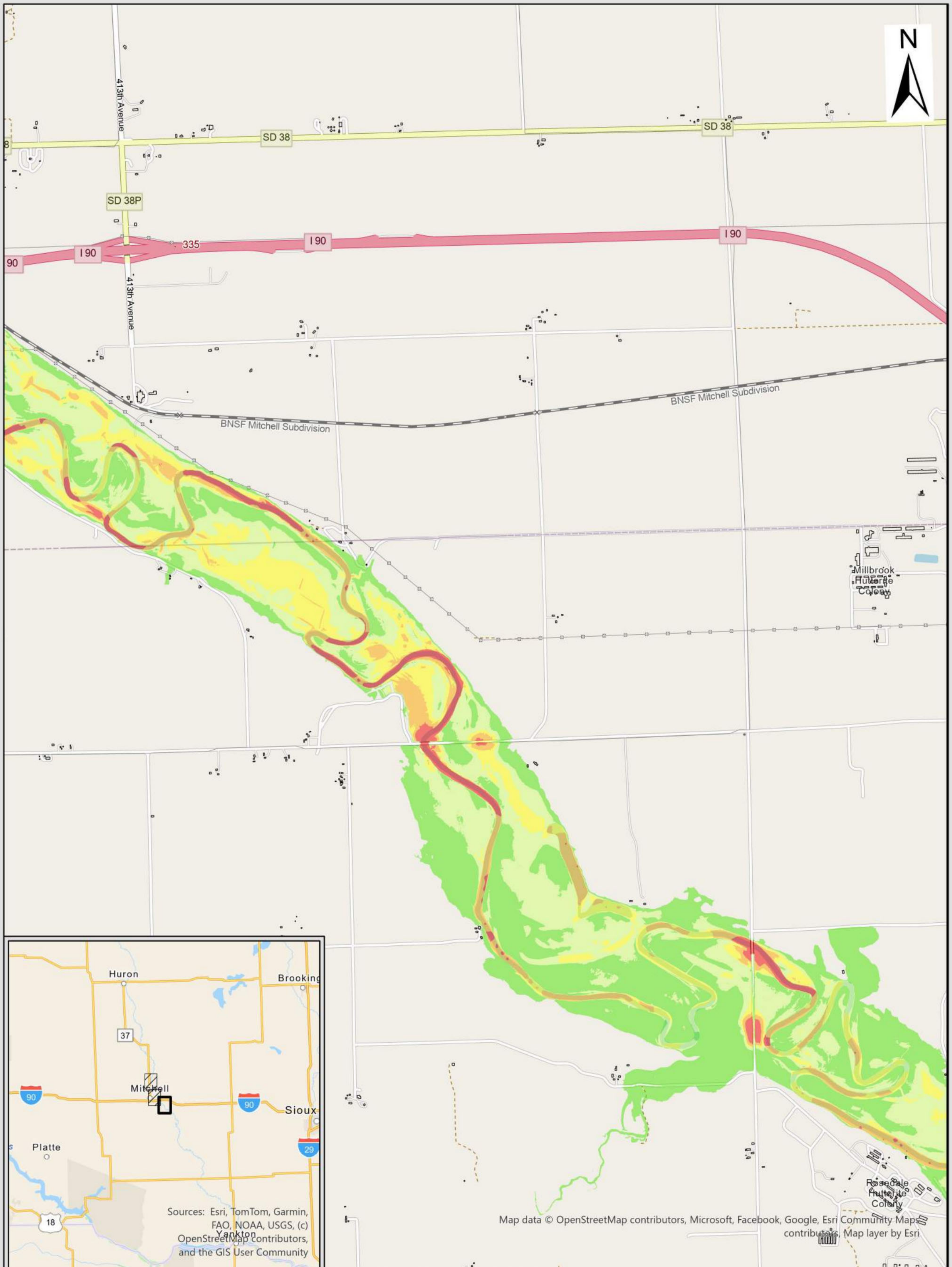
- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Buildings

Depth x Velocity (ft*ft/s)

Value

- 0.1 - 4.3
- 4.3 - 6.5
- 6.5 - 8.7
- 8.7 - 13
- 13+

0 0.5 1 Miles

Rainy Day 23% PMF No Breach Depth x Velocity

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

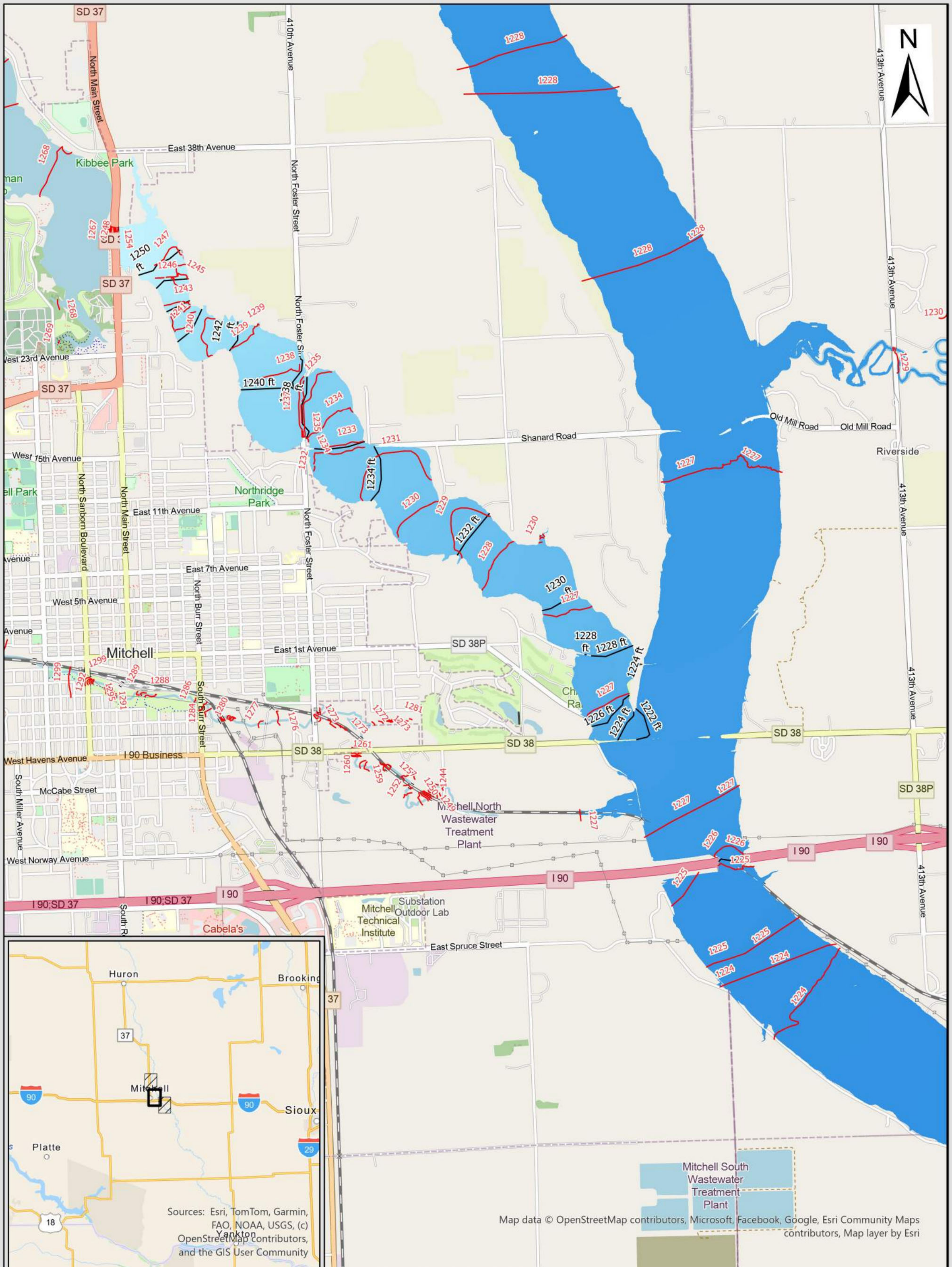
— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 23% PMF No Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 23% PMF No Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.

— WSE Contours (2-ft)

Water Surface Elevations (ft NAVD 88)

Value

1260.85

1204.33

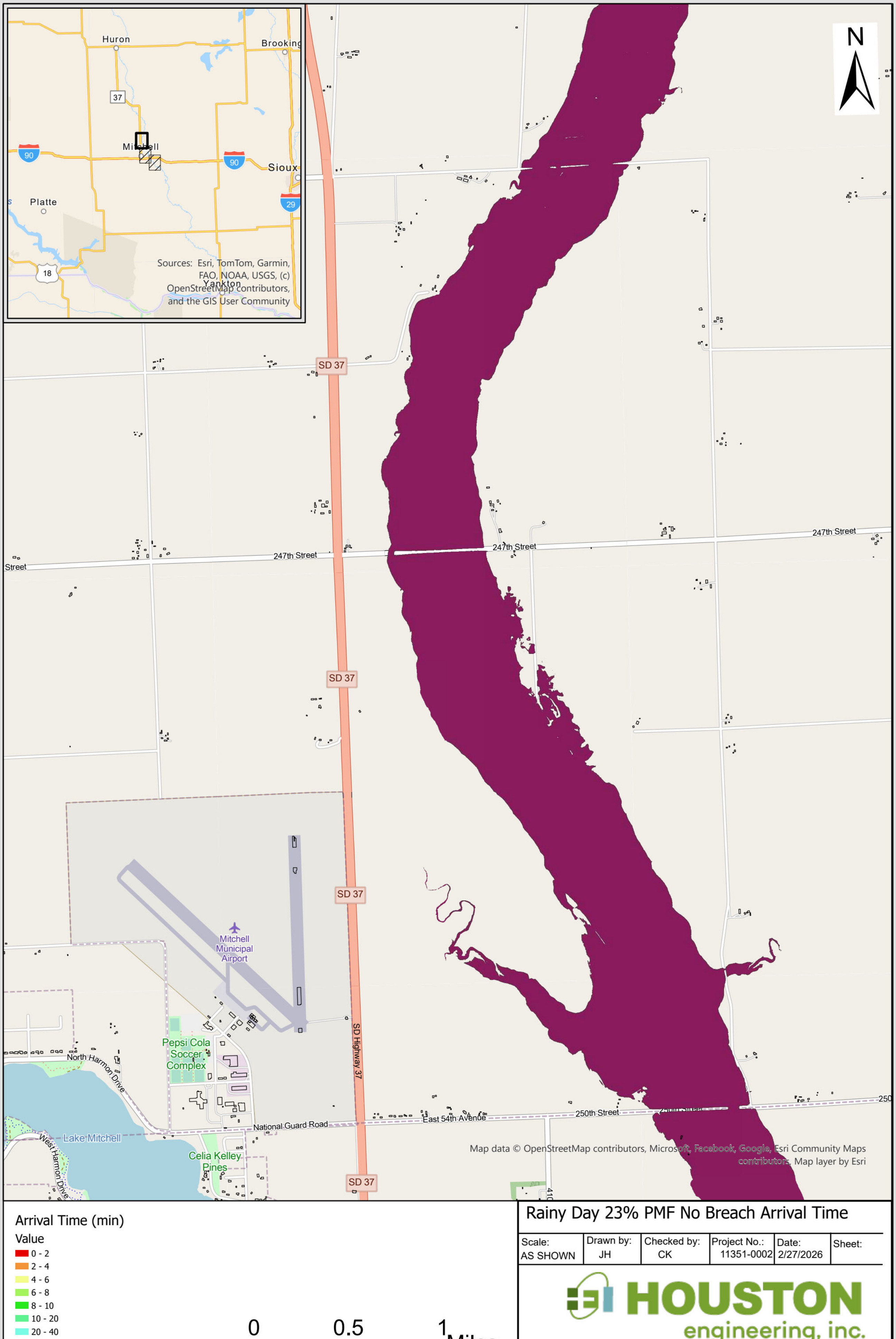
— Base Flood Elevations

0 0.5 1 Miles

Rainy Day 23% PMF No Breach WSEs

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	1/13/2026	

HOUSTON engineering, inc.



Arrival Time (min)

Value

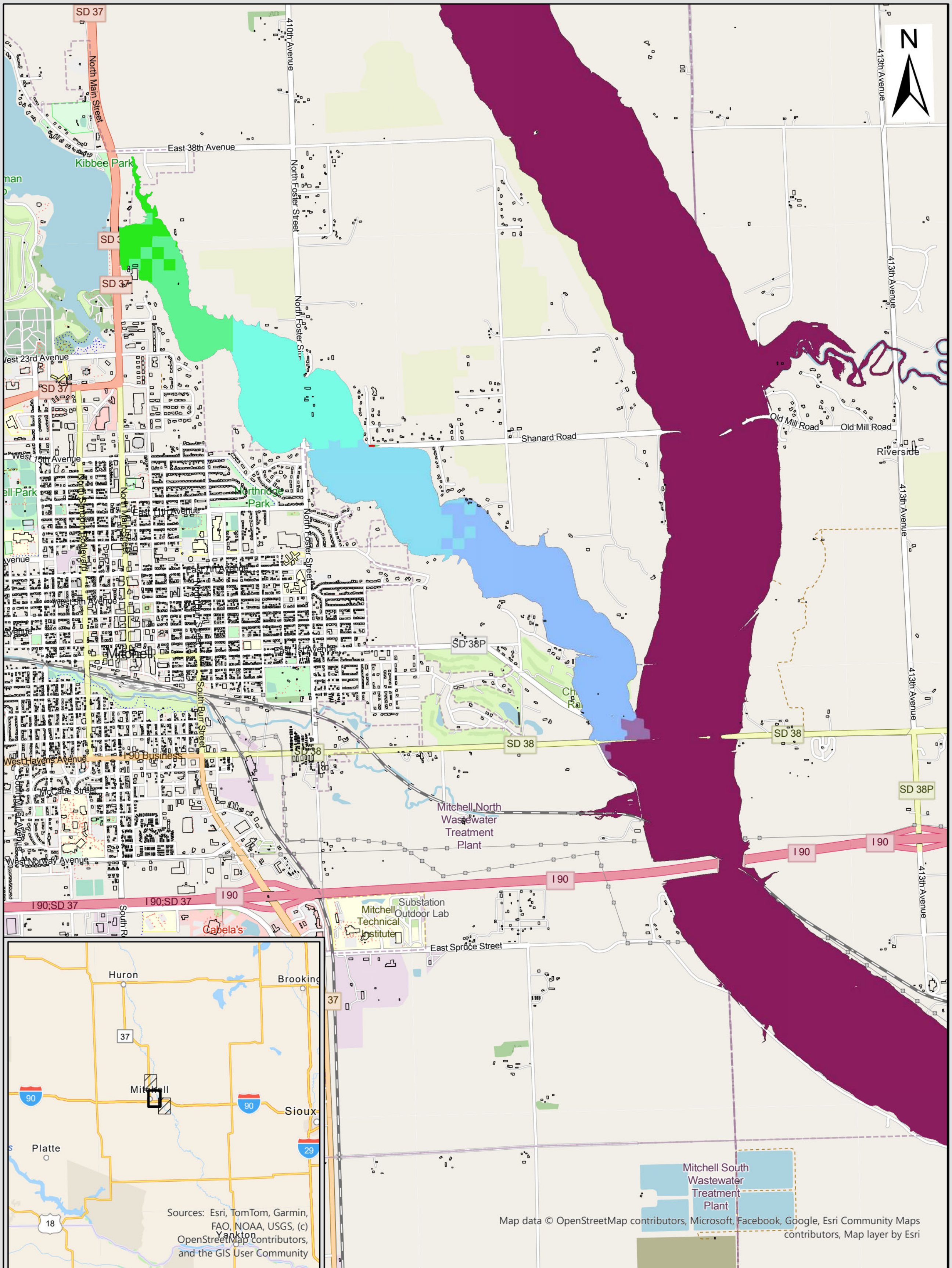
- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

Rainy Day 23% PMF No Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
- 120 - 240
- 240+

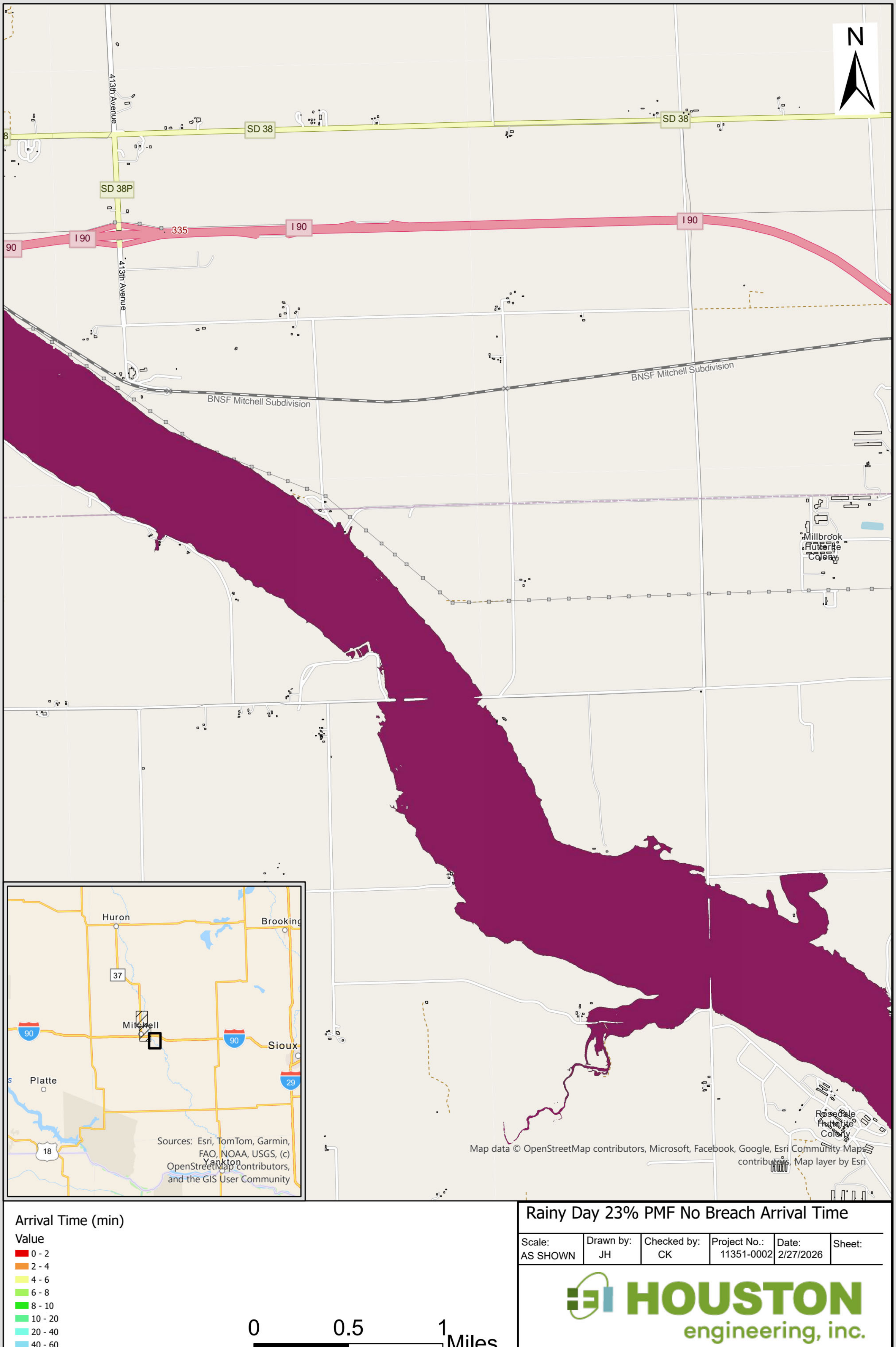
0 0.5 1 Miles

Rainy Day 23% PMF No Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	JH	CK	11351-0002	2/27/2026	

HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.



Arrival Time (min)

Value

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 120
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- 240+

Rainy Day 23% PMF No Breach Arrival Time

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
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HOUSTON engineering, inc.

*The times shown are based on how long it takes downstream areas to reach maximum water surface elevation after the reservoir reaches its maximum stage.

Appendix B – Emergency Preparedness Plan (EPP)

DRAFT FORM – IN PROGRESS

Emergency Action Plan (EAP)

Mitchell Dam

(Lake Mitchell)

National Inventory of Dams (NID) No. SD00685

Davison County, South Dakota

City of Mitchell

With assistance from the
U.S. Department of Agriculture
Natural Resources Conservation Service

Insert local area map showing specific location of dam

Insert state map showing location of dam

Reviewed and Updated:

____

Chair, City of Mitchell

____

Sheriff, Davison County, SD

____

Date

____

Date

Copy ___ of___

Contents

Basic EAP Data

Purpose

The purpose of this EAP is to reduce the risk of human life loss and injury and minimize property damage during an unusual or emergency event at Mitchell Dam.

Potential Impacted Area

See *Evacuation Map* tab (Appendix B–4) and *People at Risk* tab (Appendix B–5) for the locations and contact information of the following residents and businesses that may be flooded if the dam should fail and the estimated time for the flood wave to travel from the dam to these locations:

(Describe homes, businesses, and roads in downstream evacuation area)

Dam Description

Height: 55 ft	Drainage Area: mi
Built: 1928	Hazard Classification: High
Legal Description: Sects. 14 and 23, T13N, R21W	Dam Operator: Coal County Conservation District
Latitude: Longitude:	Major Property Owner:
National Inventory of Dams No.:	Dam Designer: NRCS

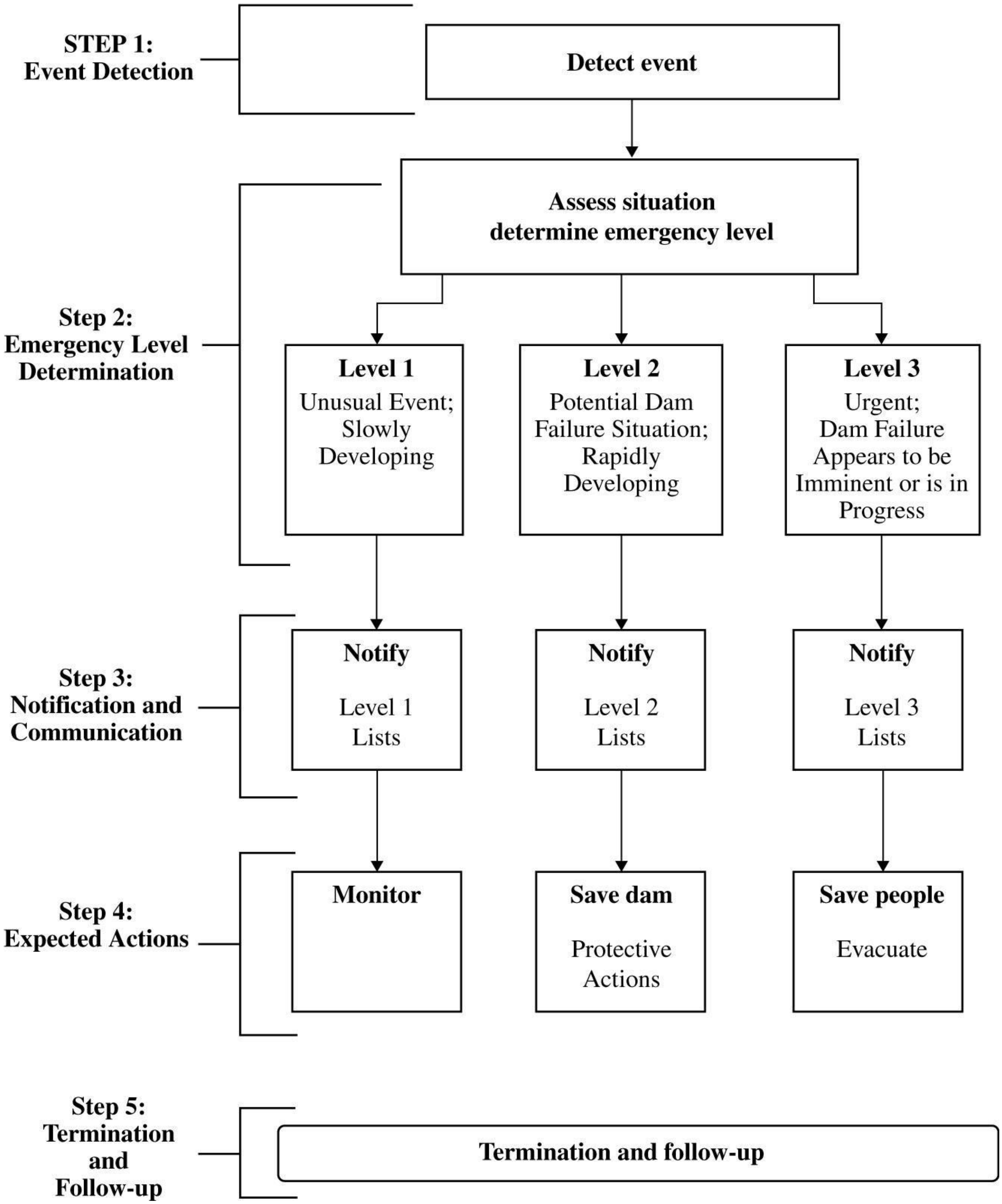
See detailed design data in *Appendix B* tab.

Directions to dam (See *Location and Vicinity Map*; Appendix B–2.)

Rock Creek Watershed, Dam No. 23, can be accessed by traveling south 1.2 miles on OK Highway 44 from the Interstate 40 interchange south of Rock City; turn right (west) on a gated dirt road that goes directly to the left abutment of the dam. Keys for the lock on the gate are available from the Conservation District Manager at 523 Second Street, Rock City, OK. Note that a portion of this road is within the dam breach inundation area, and the valley below the dam may be flooded.

An alternate route to the dam is available approximately 0.5 miles south of Rock Creek on Highway 44; turn right on an ungated dirt road that goes to the right abutment of the dam. Note that Highway 44 may be inundated or the bridge may be damaged, so access to this alternate route may have to be gained from Highway 44 south of the dam.

EAP Overview



Roles and Responsibilities

Dam Operator's Representative (Conservation District Manager)

- As soon as an emergency event is observed or reported, immediately determine the emergency level (see *Emergency Levels* tab).
  - Level 1: unusual event, slowly developing
  - Level 2: potential dam failure situation, rapidly developing
  - Level 3: dam failure appears imminent or is in progress
- Immediately notify the personnel in the order shown on the notification chart for the appropriate level (see *Notification Charts* tab).
- Provide updates of the situation to the police/sheriff dispatcher to assist them in making timely and accurate decisions regarding warnings and evacuations.
- Provide leadership to assure the EAP is reviewed and updated annually and copies of the revised EAP are distributed to all who received copies of the original EAP.

Incident Commander (County Sheriff)

- Serve as the primary contact person responsible for coordination of all emergency actions.
- When a Level 2 situation occurs: Prepare emergency management personnel for possible evacuations that may be needed if a Level 3 situation occurs.
- When a Level 3 situation occurs:
  - Initiate warnings and order evacuation of people at risk downstream of the dam.
  - Notify local emergency management services to carry out the evacuation of people and close roads within the evacuation area (see *Evacuation Map* tab).
- Decide when to terminate the emergency.
- Participate in an annual review and update of the EAP.

Emergency Management Services (Rock City)

- Maintain communication with media.
- When a Level 2 situation occurs:
  - Prepare emergency management personnel for possible evacuations that may be needed if a Level 3 situation occurs.
  - Alert the public as appropriate.
- When a Level 3 situation occurs:
  - Alert the public.
  - Immediately close roads and evacuate people within the evacuation area (see *Evacuation Map* tab).
- Participate in an annual review and update of the EAP.

Dam Operator's Technical Representatives (NRCS)

- Advise the dam operator of the emergency level determination, if time permits.
- Advise the dam operator of remedial actions to take if Level 2 event occurs, if time permits.

State Dam Safety Agency (Oklahoma Water Resources Board)

- Advise the dam operator of the emergency level determination, if time permits.
- Advise the dam operator of remedial actions to take if Level 2 event occurs, if time permits.

The Five-step EAP Process

Step 1 Event Detection

This step describes the detection of an unusual or emergency event and provides information to assist the dam operator in determining the appropriate emergency level for the event.

Unusual or emergency events may be detected by:

- Observations at or near the dam by government personnel (local, state, or Federal), landowners, visitors to the dam, or the public
- Evaluation of instrumentation data
- Earthquakes felt or reported in the vicinity of the dam
- Forewarning of conditions that may cause an unusual event or emergency event at the dam (for example, a severe weather or flash flood forecast)

See *Guidance for Determining the Emergency Level* table for assistance in evaluating specific events to determine if they are unusual or potential emergency situations.

Step 2 Emergency Level Determination

After an unusual or emergency event is detected or reported, the Conservation District Manager or his alternate is responsible for classifying the event into one of the following three emergency levels:

Emergency Level 1—Nonemergency, unusual event, slowly developing:
This situation is not normal but has not yet threatened the operation or structural integrity of the dam, but possibly could if it continues to develop. NRCS technical representatives or state dam safety officials should be contacted to investigate the situation and recommend actions to take. The condition of the dam should be closely monitored, especially during storm events, to detect any development of a potential or imminent dam failure situation. The Sheriff should be informed if it is determined that the conditions may possibly develop into a worse condition that may require emergency actions.

Emergency Level 2—Potential dam failure situation, rapidly developing:
This situation may eventually lead to dam failure and flash flooding downstream, but there is not an immediate threat of dam failure. The Sheriff should be notified of this emergency situation and placed on alert. The dam operator should closely monitor the condition of the dam and periodically report the status of the situation to the Sheriff. If the dam condition worsens and failure becomes imminent, the Sheriff must be notified immediately of the change in the emergency level to evacuate the people at risk downstream.

If time permits, NRCS and state dam safety officials should be contacted to evaluate the situation and recommend remedial actions to prevent failure of the dam. The dam operator should initiate remedial repairs (note local resources that may be available—see Appendix B–1). Time available to employ remedial actions may be hours or days.

This emergency level is also applicable when flow through the earth spillway has or is expected to result in flooding of downstream areas and people near the channel could be endangered. Emergency services should be on alert to initiate evacuations or road closures if the flooding increases.

Emergency Level 3—Urgent; dam failure appears imminent or is in progress:
This is an extremely urgent situation when a dam failure is occurring or obviously is about to occur and cannot be prevented. Flash flooding will occur downstream of the dam. This situation is also applicable when flow through the earth spillway is causing downstream flooding of people and roads. The Sheriff should be contacted immediately so emergency services can begin evacuations of all at-risk people and close roads as needed (see *Evacuation Map* tab).

See the following pages for guidance in determining the proper emergency level for various situations.

Guidance for Determining the Emergency Level

Event	Situation	Emergency level*
Earth spillway flow	Reservoir water surface elevation at auxiliary spillway crest or spillway is flowing with no active erosion	1
	Spillway flowing with active gully erosion	2
	Spillway flow that could result in flooding of people downstream if the reservoir level continues to rise	2
	Spillway flowing with an advancing headcut that is threatening the control section	3
	Spillway flow that is flooding people downstream	3
Embankment overtopping	Reservoir level is 1 foot below the top of the dam	2
	Water from the reservoir is flowing over the top of the dam	3
Seepage	New seepage areas in or near the dam	1
	New seepage areas with cloudy discharge or increasing flow rate	2
	Seepage with discharge greater than 10 gallons per minute	3
Sinkholes	Observation of new sinkhole in reservoir area or on embankment	2
	Rapidly enlarging sinkhole	3
Embankment cracking	New cracks in the embankment greater than ¼-inch wide without seepage	1
	Cracks in the embankment with seepage	2
Embankment movement	Visual movement/slippage of the embankment slope	1
	Sudden or rapidly proceeding slides of the embankment slopes	3
Instruments	Instrumentation readings beyond predetermined values	1
Earthquake	Measurable earthquake felt or reported on or within 50 miles of the dam	1
	Earthquake resulting in visible damage to the dam or appurtenances	2
	Earthquake resulting in uncontrolled release of water from the dam	3
Security threat	Verified bomb threat that, if carried out, could result in damage to the dam	2
	Detonated bomb that has resulted in damage to the dam or appurtenances	3
Sabotage/ vandalism	Damage to dam or appurtenance with no impacts to the functioning of the dam	1
	Modification to the dam or appurtenances that could adversely impact the functioning of the dam	1
	Damage to dam or appurtenances that has resulted in seepage flow	2
	Damage to dam or appurtenances that has resulted in uncontrolled water release	3

* Emergency Level 1: Nonemergency unusual event, slowly developing
* Emergency Level 2: Potential dam failure situation, rapidly developing
* Emergency Level 3: Urgent; dam failure appears imminent or is in progress

Examples of Emergency Situations

The following are examples of conditions that usually constitute an emergency situation that may occur at a dam. Adverse or unusual conditions that can cause the failure of a dam are typically related to aging or design and construction oversights. Extreme weather events that exceed the original designed conditions can cause significant flow through the auxiliary spillway or overtopping of the embankment. However, accidental or intentional damage to the dam may also result in emergency conditions. The conditions have been grouped to identify the most likely emergency-level condition. The groupings are provided as guidance only. Not all emergency conditions may be listed, and the dam operator is urged to use conservative judgment in determining whether a specific condition should be defined as an emergency situation at the dam.

Pre-existing conditions on this dam: There has been a small seepage area near the downstream toe on the north side of the release channel. This was first noticed in the 1990s, but has not changed since that time.

Earth Spillway Flows

Emergency Level 2—Potential dam failure situation; rapidly developing:

1. Significant erosion or headcutting of the spillway is occurring, but the rate does not appear to threaten an imminent breach of the spillway crest that would result in an uncontrolled release of the reservoir.
2. Flow through the earth auxiliary spillway is or is expected to cause flooding that could threaten people, homes, and/or roads downstream from the dam.

Emergency Level 3—Urgent; dam failure appears imminent or is in progress:

1. Significant erosion or headcutting of the spillway is occurring at a rapid rate, and a breach of the control section appears imminent.
2. Flow through the earth auxiliary spillway is causing flooding that is threatening people, homes, and/or roads downstream from the dam.

Embankment Overtopping

Emergency Level 2—Potential dam failure situation; rapidly developing:

1. The reservoir level is within 1 foot from the top of the dam.

Emergency Level 3—Urgent; dam failure appears imminent or is in progress:

1. The reservoir level has exceeded the top of the dam, and flow is occurring over the embankment.

Seepage and Sinkholes

Emergency Level 2—Potential dam failure situation; rapidly developing:

1. Cloudy seepage or soil deposits are observed at seepage exit points or from internal drain outlet pipes.
2. New or increased areas of wet or muddy soils are present on the downstream slope, abutment, and/or foundation of the dam, and there is an easily detectable and unusual increase in volume of downstream seepage.
3. Significant new or enlarging sinkhole(s) near the dam or settlement of the dam is observed.
4. Reservoir level is falling without apparent cause.
5. The following known dam defects are or will soon be inundated by a rise in the reservoir:
    - Sinkhole(s) located on the upstream slope, crest, abutment, and/or foundation of the dam; or
    - Transverse cracks extending through the dam, abutments, or foundation.

Emergency Level 3—Urgent; dam failure appears imminent or is in progress:

1. Rapidly increasing cloudy seepage or soil deposits at seepage exit points to the extent that failure appears imminent or is in progress.
2. Rapid increase in volume of downstream seepage to the extent that failure appears imminent or is in progress.
3. Water flowing out of holes in the downstream slope, abutment, and/or foundation of the dam to the extent that failure appears imminent or is in progress.
4. Whirlpools or other evidence exists indicating that the reservoir is draining rapidly through the dam or foundation.
5. Rapidly enlarging sinkhole(s) are forming on the dam or abutments to the extent that failure appears imminent or is in progress.
6. Rapidly increasing flow through crack(s) eroding materials to the extent that failure appears imminent or is in progress.

Embankment Movement and Cracking

Emergency Level 2—Potential dam failure situation; rapidly developing:

1. Settlement of the crest, slopes, abutments and/or foundation of the dam that may eventually result in breaching of the dam.
2. Significant increase in length, width, or offset of cracks in the crest, slopes, abutments, and/or foundation of the dam that may eventually result in breaching of the dam.

Emergency Level 3—Urgent; dam failure appears imminent or is in progress:

1. Sudden or rapidly proceeding slides, settlement, or cracking of the embankment crest, slopes, abutments, and/or foundation, and breaching of the dam appears imminent or is in progress.

Step 3 Notification and Communication

Notification

After the emergency level has been determined, the people on the following notification charts for the appropriate emergency level shall be notified immediately.

Communication

Emergency Level 1—Nonemergency, unusual event; slowly developing:
The Conservation District Manager and NRCS District Conservationist should contact the NRCS State Conservation Engineer and Oklahoma Water Resources Board. Describe the situation, and request technical assistance on next steps to take.

Emergency Level 2—Emergency event, potential dam failure situation; rapidly developing:
The following message may be used to help describe the emergency situation to the Sheriff or Rock City emergency management personnel:

"This is _____Identify yourself; name, position)_________.

We have an emergency condition at Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City.

We have activated the Emergency Action Plan for this dam and are currently under Emergency Level 2.

We are implementing predetermined actions to respond to a rapidly developing situation that could result in dam failure.

Please prepare to evacuate the area along low-lying portions of Rock Creek.

Reference the evacuation map in your copy of the Emergency Action Plan.

We will advise you when the situation is resolved or if the situation gets worse.

I can be contacted at the following number ___________________. If you cannot reach me, please call the following alternative number ___________________."

Emergency Level 3—Urgent event; dam failure appears imminent or is in progress:
The Sheriff should be contacted immediately and the area evacuated (see *Evacuation Map* tab). The following actions should be taken:

1. Call the Sheriff's dispatch center. Be sure to say, "This is an emergency." They will call other authorities and the media and begin the evacuation. The following message may be used to help describe the emergency situation to the Sheriff or Rock City emergency management personnel:

   "This is an emergency. This is _____Identify yourself; name, position)_________.

   Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City, is failing. The downstream area must be evacuated immediately. Repeat, Rock Creek Watershed, Dam No. 23, is failing; evacuate the area along low-lying portions of Rock Creek.

   We have activated the Emergency Action Plan for this dam and are currently under Emergency Level 3. Reference the evacuation map in your copy of the Emergency Action Plan.

   I can be contacted at the following number ___________________. If you cannot reach me, please call the following alternative number___________________."

2. Do whatever is necessary to bring people in immediate danger (anyone on the dam, downstream from the dam, boating on the reservoir, or evacuees) to safety if directed by the Sheriff.
3. Keep in frequent contact with the Sheriff and emergency services to keep them up-to-date on the condition of the dam. They will tell you how you can help handle the emergency.
4. If all means of communication are lost: (1) try to find out why, (2) try to get to another radio or telephone that works, or (3) get someone else to try to re-establish communications. If these means fail, handle the immediate problems as well as you can, and periodically try to re-establish contact with the Sheriff and emergency services.

The following prescripted message may be used as a guide for the Sheriff or Rock City emergency services personnel to communicate the status of the emergency with the public:

Attention: This is an emergency message from the Sheriff. Listen carefully. Your life may depend on immediate action.

Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City, is failing. Repeat. Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City, is failing.

If you are in or near this area, proceed immediately to high ground away from the valley. Do not travel on Highway 44 south of Rock City or return to your home to recover your possessions. You cannot outrun or drive away from the flood wave. Proceed immediately to high ground away from the valley.

Repeat message.

Emergency Level 1 Notifications

Nonemergency
unusual event; slowly developing

Dam Operator's Rep.
Conservation District Manager
John Jordan
407–555–XXXX(Office)
407–555–XXXX(Home)
407–555–XXXX (Cell)

(1)

Dam Operator's Technical Reps.
NRCS District Conservationist
Shelly Winters
407–555–XXXX (Office)
407–555–XXXX (Home)
407–555–XXXX (Cell)

(2)

State Dam Safety Official
Oklahoma Water Resources Board
Joe Griswold
618–555–XXXX (Office)
618–555–XXXX (Home)
618–555–XXXX (Cell)

NRCS State Engineer
Robert Redford
917–555–XXXX (Office)
917–555–XXXX (Home)
917–555–XXXX (Cell)

Note:
1, 2, etc., denotes call sequence

Legend:
Calls by operator ______
Second level calls - - - - -

See *Emer. Services Contacts* tab for contact information for back-ups to the persons shown above and other emergency personnel.

Emergency Level 2 Notifications

Emergency event, potential dam failure situation; rapidly developing

Dam Operator's Rep.
Coal County Conservation District Manager
John Jordan
407-555-XXXX (Office)
407-555-XXXX (Home)
407-555-XXXX (Cell)

(1) **Dam Operator's Technical Reps.**
NRCS District Conservationist
Shelly Winters
407–555–XXXX (Office)
407–555–XXXX (Home)
407–555–XXXX (Cell)

(2) **Incident Commander**
Sheriff
Henry Martin
407–555–XXXX (Office)
407–555–XXXX (Home)

(3) **State Dam Safety Official**
Oklahoma Water Resources Board
Joe Griswold
618–555–XXXX (Office)
618–555–XXXX (Home)
618–555–XXXX (Cell)

NRCS State Engineer
Robert Redford
917–555–XXXX (Office)
917–555–XXXX (Home)
917–555–XXXX (Cell)

Rock City Emergency Management Dispatcher

OK Highway Patrol Dispatcher

Rock City Police Dispatcher

Coal County Amateur Radio Association:
John Turney
KE5GBD
407–555–XXXX

National Weather Service
618–555–XXXX

Note:
1, 2, etc., denotes call sequence

Legend:
Calls by operator ________
Second level calls - - - - - -

See *Communications* tab for prescripted messages.

See *Emer. Services Contacts* tab for contact information for back-ups to the persons shown above and other emergency personnel.

Emergency Level 3 Notifications

Urgent event, dam failure appears imminent or is in progress

Dam Operator's Rep.
Coal County Conservation District Manager
John Jordan
407–555–XXXX (Office)
407–555–XXXX (Home)
407–555–XXXX (Cell)

(1)
Incident Commander
Sheriff
Henry Martin
407–555–XXXX (Office)
407–555–XXXX (Home)
407–555–XXXX (Cell)
or
24-Hour 911

(2)
State Dam Safety Official
Oklahoma Water Resources Board
Joe Griswold
618–555–XXXX (Office)
618–555–XXXX (Home)
618–555–XXXX (Cell)

(3)
Dam Operator's Technical Reps.
NRCS District Conservationist
Shelly Winters
407–555–XXXX (Office)
407–555–XXXX (Home)
407–555–XXXX (Cell)

Rock City Emergency Management Dispatcher

National Weather Service
618–555–XXXX

NRCS State Engineer
Robert Redford
917–555–XXXX (Office)
917–555–XXXX (Home)
917–555–XXXX (Cell)

OK Highway Patrol Dispatcher

Coal County Amateur Radio Association:
John Turney
KE5GBD
407–555–XXXX

Rock City Police Dispatcher

Note:
1, 2, etc., denotes call sequence

Legend
Calls by operator ________
Second level calls - - - - -

See *Communications* tab for prescripted messages.

See *Emer. Services Contacts* tab for contact information for back-ups to the persons shown above and other emergency personnel.

Emergency Services Contacts

Agency / Organization	Principal contact	Address	Office telephone number	Alternate telephone numbers
Coal County Board of Supervisors	Gloria Brown, Chair	336 Highway 66 Rock City, OK	407–555–XXXX	407–555–XXXX
Coal County Road Department	Max Gray, Supervisor	973 Ninth Street Rock City, OK	407–555–XXXX	407–555–XXXX
Coal County Conservation District	John Jordon * District Manager	523 Second Street Rock City, OK	407–555–XXXX	407–555–XXXX (H) 407–555–XXXX (C)
Coal County Conservation District	Mary James * District Secretary	523 Second Street Rock City, OK	407–555–XXXX	407–555–XXXX (H) 407–555–XXXX (C)
Coal County Conservation District	Mike Blain * Board Chair	523 Second Street Rock City, OK	407–555–XXXX	407–555–XXXX (H) 407–555–XXXX (C)
Coal County Sheriff	Henry Martin	336 Highway 66 Rock City, OK	407–555–XXXX	407–555–XXXX (H) 407–555–XXXX (C)
Dry Gulch Television Station KJMT	Chris Klinger Manager	5632 Main Street Dry Gulch, OK	407–555–XXXX	407–555–XXXX
Landowner of Dam No. 23	Bryon Babcock	R.R. #2 Rock City, OK		407–555–XXXX (H) 407–555–XXXX (C)
National Weather Service	Danny Lee Climatologist	66374 Elm Street Norman, OK	618–555–XXXX	407–555–XXXX
Natural Resources Conservation Service	Shelly Winters District Conservationist	523 Second Street Rock City, OK	407–555–XXXX	407–555–XXXX (H) 405–555–XXXX (C)
Natural Resources Conservation Service	John Blake * Technician	523 Second Street Rock City, OK	407–555–XXXX	407–555–XXXX (H)
Natural Resources Conservation Service	Robert Redford State Engineer	3458 Farm Road Strong City, OK	917–555–XXXX	917–555–XXXX (H) 917–555–XXXX (C)
Oklahoma Department of Transportation	Bill Dobson District Engineer	539 Center Street Dry Gulch, OK	407–555–XXXX	
Oklahoma Highway Patrol	Richard Barnell	299 First Avenue Dry Gulch, OK	407–555–XXXX	
Oklahoma Water Resources Board	Joe Griswold Dam Safety Officer	1522 Maple Avenue Strong City, OK	618–555–XXXX	618–555–XXXX (H) 618–555–XXXX (C)
Rock City Emergency Management Coordinator	Jeff Powers	121 Main Street Rock City, OK	407–555–XXXX	
Rock City Fire Department	Harry James	336 Maple Street Rock City, OK	407–555–XXXX	
Rock City Police	Red Jones	336 Maple Street Rock City, OK	407–555–XXXX	
Rock City Radio Station 1040 AM	Scott Fagen Manager	667 Eighth Street Rock City, OK	407–555–XXXX	

* Back-up to primary contact

Step 4 Expected Actions

If the police or Sheriff receives a 911 call regarding observations of an unusual or emergency event at the dam, they should immediately contact the Conservation District office. After the Conservation District Manager determines the emergency level, the following actions should be taken. If time permits, NRCS and the Oklahoma Water Resources Board should be contacted for technical consultation.

Emergency Level 1—Nonemergency, unusual event; slowly developing:

A. The Conservation District Manager should inspect the dam. At a minimum, inspect the full length of the upstream slope, crest, downstream toe, and downstream slope. Also, check the reservoir area, abutments, and downstream channel for signs of changing conditions. **If increased seepage, erosion, cracking, or settlement are observed, immediately report the observed conditions to the NRCS or the Oklahoma Water Resources Board; refer to the emergency level table for guidance in determining the appropriate event level for the new condition and recommended actions.**

B. Record all contacts that were made on the *Contact Checklist* (Appendix A–1). Record all information, observations, and actions taken on the *Event Log Form* (Appendix A–2). Note the time of changing conditions. Document the situation with photographs and video, if possible.

C. The Conservation District Manager should contact NRCS and request technical staff to investigate the situation and recommend corrective actions.

Emergency Level 2—Potential dam failure situation; rapidly developing:

A. The Conservation District Manager should contact the NRCS and the Oklahoma Water Resources Board to report the situation and, if time permits, request technical staff to investigate the situation and recommend corrective actions.

B. The Conservation District Manager should contact the sheriff to inform him/her that the EAP has been activated and if current conditions get worse, an emergency situation may require evacuation. Preparations should be made for possible road closures and evacuations.

C. Provide updates to the Sheriff and emergency services personnel to assist them in making timely decisions concerning the need for warnings, road closures, and evacuations.

D. If time permits, the Conservation District Manager should inspect the dam. At a minimum, inspect the full length of the upstream slope, crest, downstream toe, and downstream slope. Also, check the reservoir area, abutments, and downstream channel for signs of changing conditions. **If piping, increased seepage, erosion, cracking, or settlement are observed, immediately report the observed conditions to the NRCS and the Oklahoma Water Resources Board; refer to the emergency level table for guidance in determining the appropriate event level for the new condition and recommended actions.**

E. Record all contacts that were made on the *Contact Checklist* (Appendix A–1). Record all information, observations, and actions taken on the *Event Log Form* (Appendix A–2). Note the time of changing conditions. Document the situation with photographs and video, if possible.

F. If time permits, the following emergency remedial actions should be taken as appropriate.

Emergency Level 2—Potential dam failure situation; rapidly developing—continued:

Emergency remedial actions

If time permits, the following emergency remedial actions should be considered for Emergency Level 2 conditions. Immediate implementation of these remedial actions may delay, moderate, or prevent the failure of the dam. Several of the listed adverse or unusual conditions may be apparent at the dam at the same time, requiring implementation of several modes of remedial actions. Close monitoring of the dam must be maintained to confirm the success of any remedial action taken at the dam. Time permitting, any remedial action should be developed through consultation with NRCS and the Oklahoma Water Resources Board. See *Resources Available* (Appendix B–1) for sources of equipment and materials to assist with remedial actions.

Embankment overtopping

1. If the water level in the reservoir is no longer rising, place sandbags along the low areas of the top of the dam to control wave action, reduce the likelihood of flow concentration during minor overtopping, and to safely direct more water through the spillway.
2. Cover the weak areas of the top of the dam and downstream slope with riprap, sandbags, plastic sheets, or other materials to provide erosion-resistant protection.

Seepage and sinkholes

1. Open the principal spillway gate to lower the reservoir level as rapidly as possible to a level that stops or decreases the seepage to a nonerosive velocity. If the gate is damaged or blocked, pumping or siphoning may be required.

   Continue lowering the water level until the seepage stops.
2. If the entrance to the seepage origination point is observed in the reservoir (possible whirlpool) and is accessible, attempt to reduce the flow by plugging the entrance with readily available materials such as hay bales, bentonite, soil or rockfill, or plastic sheeting.
3. Cover the seepage exit area(s) with several feet of sand/gravel to hold fine-grained embankment or foundation materials in place. Alternatively, construct sandbag or other types of ring dikes around seepage exit areas to retain a pool of water, providing backpressure and reducing the erosive nature of the seepage.
4. Prevent vehicles and equipment from driving between the seepage exit points and the embankment to avoid potential loss from the collapse of an underground void.

Embankment movement

1. Open outlet(s) and lower the reservoir to a safe level at a rate commensurate with the urgency and severity of the condition of the slide or slump. If the gate is damaged or blocked, pumping or siphoning may be required.
2. Repair settlement of the crest by placing sandbags or earth and rockfill materials in the damaged area to restore freeboard.
3. Stabilize slides by placing a soil or rockfill buttress against the toe of the slide.

Earthquake

1. Immediately conduct a general overall visual inspection of the dam.
2. Perform a field survey to determine if there has been any settlement and movement of the dam embankment, spillway, and low-level outlet works.
3. Drain the reservoir, if required.

Emergency Level 3—Urgent; dam failure appears imminent or is in progress:

A. The Conservation District Manager shall immediately contact the Sheriff and others shown on the notification chart.

B. The Sheriff shall lead the efforts to carry out warnings, close roads, and evacuate people at risk downstream from the dam (see *Evacuation Map* tab).

C. Emergency management services personnel shall alert the public and immediately evacuate at-risk people and close roads as necessary.

D. The Conservation District Manager shall maintain continuous communication and provide the Sheriff with updates of the situation to assist him/her in making timely decisions concerning warnings and evacuations.

E. The Conservation District Manager should record all contacts that were made on the *Contact Checklist* (Appendix A–1). Record all information, observations, and actions taken on the *Event Log Form* (Appendix A–2). Note the time of changing conditions. Document the situation with photographs and video, if possible.

F. Advise people monitoring the dam to follow safe procedures. Everyone should stay away from any of the failing structures or slopes and out of the potential breach inundation areas.

Step 5 Termination

Whenever the EAP has been activated, an emergency level has been declared, all EAP actions have been completed, and the emergency is over, the EAP operations must eventually be terminated and follow-up procedures completed.

Termination responsibilities

The Sheriff is responsible for terminating EAP operations and relaying this decision to the Conservation District Manager. It is then the responsibility of each person to notify the same group of contacts that were notified during the original event notification process to inform those people that the event has been terminated.

Prior to termination of an Emergency Level 3 event that has not caused actual dam failure, the NRCS technical representative or the State Dam Safety Officer will inspect the dam or require the inspection of the dam to determine whether any damage has occurred that could potentially result in loss of life, injury, or property damage. If it is determined that conditions do not pose a threat to people or property, the Sheriff will be advised to terminate EAP operations as described above.

The Conservation District Manager shall assure that the *Dam Safety Emergency Situation Report* (Appendix A–3) is completed to document the emergency event and all actions that were taken. The Conservation District shall distribute copies of the completed report to the Oklahoma Water Resources Board and the NRCS State Conservation Engineer.

Maintenance—EAP Review and Revision

EAP annual review

The Conservation District Manager will review and, if needed, update the EAP at least once each year. The EAP annual review will include the following:

- Calling all contacts on the three notification charts in the EAP to verify that the phone numbers and persons in the specified positions are current. The EAP will be revised if any of the contacts have changed.
- Contacting the local law enforcement agency to verify the phone numbers and persons in the specified positions. In addition, the Conservation District Manager will ask if the person contacted knows where the EAP is kept and if responsibilities described in the EAP are understood.
- Calling the locally available resources to verify that the phone numbers, addresses, and services are current.

Revisions

The Conservation District is responsible for updating the EAP document. The EAP document held by the Conservation District is the master document. When revisions occur, the Conservation District will provide the revised pages and a revised revision summary page to all the EAP document holders. The document holders are responsible for revising outdated copy of the respective document(s) whenever revisions are received. Outdated pages shall be immediately discarded to avoid any confusion with the revisions.

EAP periodic test

The Conservation District will host and facilitate a periodic test of the EAP at least once every 5 years.

The periodic test will consist of a meeting, including a tabletop exercise, conducted at the Coal County Conservation District office. Attendance should include the Conservation District Manager, key conservation district staff members, NRCS staff, at least one representative of the local law enforcement agency, and others with key responsibilities listed in the EAP. At the discretion of the Conservation District, other organizations that may be involved with an unusual or emergency event at the dam are encouraged to participate. Before the tabletop exercise begins, meeting participants will visit the dam during the periodic test to familiarize themselves with the dam site.

The tabletop exercise will begin with the facilitator presenting a scenario of an unusual or emergency event at the dam. The scenario will be developed prior to the exercise. Once the scenario has been presented, the participants will discuss the responses and actions that they would take to address and resolve the scenario. The narrator will control the discussion, ensuring realistic responses and developing the scenario throughout the exercise. The Conservation District Manager should complete an event log as they would during an actual event.

After the tabletop exercise, the five sections of the EAP will be reviewed and discussed. Mutual aid agreements and other emergency procedures can be discussed. The Conservation District will prepare a written summary of the periodic test and revise the EAP, as necessary.

Record of Holders of Control Copies of this EAP

Copy Number	Organization	Person receiving copy
1	Coal County Conservation District 523 Second Street Rock City, OK 50010	John Jordan
2	Coal County Conservation District 523 Second Street Rock City, OK 50010	Mike Blain
3	NRCS Field Office 523 Second Street Rock City, OK 50010	Shelly Winters
4	NRCS State Office 3458 Farm Road Strong City, OK 51020	Robert Redford
5	Coal County Sheriff's Department 336 Highway 66 Rock City, OK 50010	Henry Martin
6	Rock City Emergency Management 121 Main Street Rock City, OK 50010	Jeff Powers
7	Rock City Police Department 336 Maple Street Rock City, OK 50010	Red Jones
8	Oklahoma Water Resources Board 1522 Maple Street Strong, OK 50010	Joe Griswold

Record of Revisions and Updates Made to EAP

Revision Number	Date	Revisions made	By whom
1	6–25–07	Updated 6–25–07 EAP with current contact information for Conservation District personnel and names of new residents in evacuation area	John Jordon

Concurrences

By my signature, I acknowledge that I, or my representative, have reviewed this plan and concur with the tasks and responsibilities assigned herein for me and my organization.

1.____

Signature *Organization* *Date*

Printed name and title: Mike Blain, Chair, Coal County Conservation District

2. ____

Signature *Organization* *Date*

Printed name and title: Henry Martin, Sheriff, Coal County

3.____

Signature *Organization* *Date*

Printed name and title: Jeff Powers, Emergency Management Coordinator, Rock City

4.____

Signature *Organization* *Date*

Printed name and title: Red Jones, Chief of Police, Rock City

5.____

Signature *Organization* *Date*

Printed name and title: Shelley Winters, District Conservationist, NRCS, Rock City

6.____

Signature *Organization* *Date*

Printed name and title:____

7.____

Signature *Organization* *Date*

Printed name and title: ____

Appendices—Forms, Glossary, Maps, and Supporting Data

Appendix A

A–1 Contact Checklist

A–2 Unusual or Emergency Event Log Form

A–3 Dam Emergency Situation Report Form

A–4 Glossary of Terms

Appendix B

B–1 Resources Available

B–2 Location and Vicinity Maps

B–3 Watershed Project Map

B–4 Evacuation Map

B–5 Residents/Businesses/Highways at Risk

B–6 Plan View of Dam

B–7 Profile of Principal Spillway

B–8 Reservoir Elevation-Area-Volume and Spillway Capacity Data

B–9 National Inventory of Dams (NID) Data

Appendix A–1

Contact Checklist

Rock Creek Watershed, Dam No. 23

Coal County, Oklahoma Date ______________

The following contacts should be made immediately after the emergency level is determined (see pages 7–10 for guidance to determine the appropriate emergency level for a specific situation). The person making the contacts should initial and record the time of the call and who was notified for each contact made. See the *Notification Charts* tab for critical contact information and *Emer. Services Contacts* tab for contact information for other possible emergency services.

Emergency Level 1 (see page 12)	Person Contacted	Time Contacted	Contacted by
___ NRCS District Conservationist	______________	______________	______________
___ NRCS State Conservation Engineer	______________	______________	______________
___ Oklahoma Water Resources Board	______________	______________	______________

Emergency Level 2 (see page 13)	Person Contacted	Time Contacted	Contacted by
____ NRCS District Conservationist	______________	______________	______________
____ NRCS State Conservation Engineer	______________	______________	______________
____ Oklahoma Water Resources Board	______________	______________	______________
____ Sheriff	______________	______________	______________

Emergency Level 3 (see page 14)	Person Contacted	Time Contacted	Contacted by
____ Sheriff	______________	______________	______________
____ Oklahoma Water Resources Board	______________	______________	______________
____ NRCS District Conservationist	______________	______________	______________
____ NRCS State Conservation Engineer	______________	______________	______________

Appendix A–2

Unusual or Emergency Event Log

(to be completed during the emergency)

Dam name: Rock Creek Watershed, Dam No. 23 County: Coal County

When and how was the event detected?

____

____

Weather conditions: ____

____

General description of the emergency situation:

____

____

____

Emergency level determination: _______________ Made by: ______________________________

Actions and Event Progression

Date	Time	Action/event progression	Taken by

Report prepared by: ____ Date: ________________

Appendix A–3

Dam Emergency Situation Report

(to be completed following the termination of the emergency)

Dam name: Rock Creek Watershed, Dam No. 23

National Inventory of Dams (NID) No.: OK11111

Dam location: 2 miles south of Rock City Coal County Rock Creek

(City) *(County)* *(Stream/River)*

Date: Time:

Weather conditions: ____

General description of emergency situation:

____

____

Area(s) of dam affected:

____

____

Extent of dam damage: ____

Possible cause(s): ____

Effect on dam's operation:____

Initial reservoir elevation: _______________________ Time: ______________

Maximum reservoir elevation: _____________________ Time: ______________

Final reservoir elevation: _________________________ Time: ______________

Description of area flooded downstream/damages/injuries/loss of life: ____________________

____

____

Other data and comments:

____

Observer's name and telephone number:____

Report prepared by: ____ Date: ______________

Appendix A–4
Glossary of Terms

Abutment That part of the valleyside against which the dam is constructed. The left and right abutments of dams are defined with the observer looking downstream from the dam.

Acre-foot A unit of volumetric measure that would cover 1 acre to a depth of 1 foot. One acre-foot is equal to 43,560 cubic feet or 325,850 gallons.

Berm A nearly horizontal step (bench) in the upstream or downstream sloping face of the dam.

Boil A disruption of the soil surface due to water discharging from below the surface. Eroded soil may be deposited in the form of a ring (miniature volcano) around the disruption.

Breach An opening through the dam that allows draining of the reservoir. A controlled breach is an intentionally constructed opening. An uncontrolled breach is an unintended failure of the dam.

Conduit A closed channel (round pipe or rectangular box) that conveys water through, around, or under the dam.

Control section A usually level segment in the profile of an open channel spillway above which water in the reservoir discharges through the spillway.

Cross section A slice through the dam showing elevation vertically and direction of natural water flow horizontally from left to right. Also, a slice through a spillway showing elevation vertically and left and right sides of the spillway looking downstream.

Dam An artificial barrier generally constructed across a watercourse for the purpose of impounding or diverting water.

Dam failure The uncontrolled release of a dam's impounded water.

Dam Operator The person(s) or unit(s) of government with responsibility for the operation and maintenance of dam.

Drain, toe or foundation, or blanket A water collection system of sand and gravel and typically pipes along the downstream portion of the dam to collect seepage and convey it to a safe outlet.

Drainage area (watershed) The geographic area on which rainfall flows into the dam.

Drawdown The lowering or releasing of the water level in a reservoir over time or the volume lowered or released over a particular period of time.

Emergency A condition that develops unexpectedly, endangers the structural integrity of the dam and/or downstream human life and property, and requires immediate action.

Emergency Action Plan (EAP) A formal document identifying potential emergency conditions that may occur at the dam and specifying preplanned actions to minimize potential failure of the dam or minimize failure consequences including loss of life, property damage, and environmental impacts.

Evacuation map A map showing the geographic area downstream of a dam that should be evacuated if it is threatened to be flooded by a breach of the dam or other large discharge.

Filter The layers of sand and gravel in a drain that allow seepage through an embankment to discharge into the drain without eroding the embankment soil.

Freeboard Vertical distance between a stated water level in the reservoir and the top of dam.

Gate, slide or sluice, or regulating An operable, watertight valve to manage the discharge of water from the dam.

Groin The area along the intersection of the face of a dam and the abutment.

Hazard classification A system that categorizes dams (high, significant, or low) according to the degree of their potential to create adverse incremental consequences such as loss of life, property damage, or environmental impacts of a failure or misoperation of a dam.

Height, dam The vertical distance between the lowest point along the top of the dam and the lowest point at the downstream toe, which usually occurs in the bed of the outlet channel.

Hydrograph, inflow or outflow, or breach A graphical representation of either the flow rate or flow depth at a specific point above or below the dam over time for a specific flood occurrence.

Incident Commander The highest predetermined official available at the scene of an emergency situation.

Instrumentation An arrangement of devices installed into or near dams that provide measurements to evaluate the structural behavior and other performance parameters of the dam and appurtenant structures.

Inundation area or map The geographic area downstream of the dam that would be flooded by a breach of the dam or other large discharge.

Notification To immediately inform appropriate individuals, organizations, or agencies about a potentially emergency situation so they can initiate appropriate actions.

Outlet works (principal spillway) An appurtenant structure that provides for controlled passage of normal water flows through the dam.

Piping The progressive destruction of an embankment or embankment foundation by internal erosion of the soil by seepage flows.

Probable Maximum Precipitation (PMP) or Flood (PMF) The theoretically greatest precipitation or resulting flood that is meteorologically feasible for a given duration over a specific drainage area at a particular geographical location.

Reservoir The body of water impounded or potentially impounded by the dam.

Riprap A layer of large rock, precast blocks, bags of cement, or other suitable material, generally placed on an embankment or along a watercourse as protection against wave action, erosion, or scour.

Risk A measure of the likelihood and severity of an adverse consequence.

Seepage The natural movement of water through the embankment, foundation, or abutments of the dam.

Slide The movement of a mass of earth down a slope on the embankment or abutment of the dam.

Spillway (auxiliary or emergency) The appurtenant structure that provides the controlled conveyance of excess water through, over, or around the dam.

Spillway capacity The maximum discharge the spillway can safely convey with the reservoir at the maximum design elevation.

Spillway crest The lowest level at which reservoir water can flow into the spillway.

Tailwater The body of water immediately downstream of the embankment at a specific point in time.

Toe of dam The junction of the upstream or downstream face of an embankment with the ground surface.

Top of dam (crest of dam) The elevation of the uppermost surface of an embankment which can safely impound water behind the dam.

Appendix B–1
Resources Available

Locally available equipment, labor, and materials:
The County Commissioners have the following resources that can be utilized in the event of an emergency:

- two front-end loaders
- two backhoes
- one track hoe
- two graders
- two dump trucks
- a sand borrow pit
- a clay borrow pit

Contact the Coal County Road Department—see *Emer. Services Contacts* tab.

Other locally available resources include:

Heavy equipment service and rental	**Sand and gravel supply**	**Ready-mix concrete supply**
Bob's Dozer Service 134 Elm Street Rock City, OK 407–555–XXXX	Kern's Sand and Gravel R.R. 2 Rock City, OK 407–555–XXXX	Burnett Concrete Co. 231 Sixth Street Dry Gulch, OK 407–555–XXXX
Tiller Construction Co. 405 Second Street Dry Gulch, OK 407–555–XXXX	Renfro Sand Products 334 Aston Avenue Spring Lake, OK 407–555–XXXX	
Pumps	**Diving contractor**	**Sand bags**
A to Z Rental 569 Seventh Street Rock City, OK 407–555–XXXX	Steve White 2201 56th Street Johnstown, OK 917–555–XXXX	A to Z Rental 5643 Water Street Johnstown, OK 917–555–XXXX

Appendix B–2
Location and Vicinity Maps

(Insert map)

Appendix B–3
Watershed Project Map

(Insert map)

Appendix B–4
Evacuation Map

(Insert map)

Appendix B–5
Residents/Businesses/Highways at Risk

A major flood caused by a sudden breach of the dam is estimated to inundate six homes, three businesses, and three highways. These homes and businesses (marked on the evacuation map) are located east of OK Highway 44 and south of Chestnut Street in Rock City.

House/ business no.*	Resident/business	Address	Phone no.	Distance downstream from dam (ft)	Travel time** (hr)	Max water depth above first floor (ft)
1	Fred and Ethel James	10300 132nd Street	555–XXXX	5,000	0.3	5.4
B-2	Larry's Hardware	3214 Chestnut Street	555–XXXX	11,400	0.9	0.8
B-3	Lori's Music Shop	2288 Farm Road	555–XXXX	11,600	0.9	2.6
B-4	Bill's Coffee Shop	1455 Sugar Street	555–XXXX	11,800	1.0	4.8
5	Terry and Ann Smith	4812 Chestnut Street	555–XXXX	13,600	1.1	3.0
6	Amos Hill	5500 Apple Road	555–XXXX	14,000	1.1	3.2
7	Allen and Ruth Jones	4814 Chestnut Street	555–XXXX	13,800	1.1	1.2
8	Mike and Carol Green	4902 Chestnut Street	555–XXXX	14,000	1.1	2.4
9	Stephanie Evans	4910 Chestnut Street	555–XXXX	14,200	1.1	0.5
	OK Highway 44			2,000	0.2	7.9
	Interstate 40			10,000	0.8	3.4
	OK Route 66			11,200	0.9	3.4

* See Appendix B–4.
** Estimated time for breach wave (peak) to travel from dam to downstream locations

Basis for computation of evacuation area and flooding depths
Breach inundation study completed by NRCS–August 2004
Hydraulic model used: NRCS TR–20 (routing); TR–60 (peak discharge); TR–66 (hydrograph)
Model assumptions:

- "Sunny Day" Breach (no inflow into the reservoir)
- Water surface elevation in reservoir prior to breach = _______ (top of dam)
- Total volume of breach hydrograph = ______ acre-ft
- Height of water at time of breach = ______ ft
- Peak breach discharge = _______ ft^3/s

- Downstream area defined by field surveys consisting of 10 cross sections and 3 bridge openings

Appendix B–6
Plan View of Dam

(Insert map)

Appendix B–7
Profile of Principal Spillway

(Insert map)

Appendix B–8
Reservoir Elevation-area-volume and Spillway Capacity Data

ROCK CREEK WATERSHED
DAM NO. 23

Elevation	Reservoir Surface acres	Reservoir Storage acre ft	Spillway Discharge ft^3/s
1682.0	0.0	0.0	0
1684.0	0.3	0.3	0
1686.0	2.0	2.5	0
1688.0	3.7	8.2	0
1690.0	8.6	20.5	0
1692.0	15.9	45.0	0
1694.0	18.7	79.6	9
1696.0	23.5	121.8	0
Principal Spillway Crest			
1697.0	26.2	146.7	0
1698.0	31.1	175.4	45
1700.0	40.8	247.3	76
1702.0	49.3	337.4	82
1704.0	62.0	448.7	87
1706.0	71.4	582.1	92
1708.0	86.7	740.2	97
1710.0	98.6	925.5	102
Auxiliary Spillway Crest			
1712.0	115.0	1139.1	108
1714.0	129.9	1384.0	516
1716.0	145.3	1659.2	2090
1718.0	160.7	1965.2	4437
1720.0	178.8	2304.7	7763
1720.2	180.6	2340.6	7937

Henry Martin

407-555-XXXX

Appendix B–9

National Inventory of Dams (NID) Data

Dam name: ________

State: ________

NID ID: ________

Longitude:– ________

Latitude: ________

Geodetic location: ________

County: ________

Stream: ________

Nearest town: ________

Distance to nearest town: ___ **mi**

Operator: ________ **Cons. District**

Year constructed: ________

Max. discharge: ____ **ft^3/s**

Max. storage: _____**acre-ft**

Normal storage: _____ **acre-ft**

Surface area: ___ **acre**

Drainage area: ___ **mi^2**

Inspection frequency: **1 yr**

State regulated?: **Yes**

State reg. agency: ________

Federal funding: **USDA NRCS**

Federal design: **USDA NRCS**

Federal constructed: **USDA NRCS**

Program authority: **Flood prevention**

Watershed No.: _____

Watershed name: ________

Service life: ___ **yr**

O&M insp. resp.: ________ **Cons. District**

O&M insp. current?: _____

Population at risk: __

Dam height: ____ **ft**

Dam length: _____ **ft**

Dam volume: _____ **yd^3**

Design hazard potential: ____

Current hazard potential: _____

Hazard potential class. year: ____

Sediment storage: ____ **acre-ft**

Flood storage: _____ **acre-ft**

Surcharge storage: ____ **acre-ft**

Other storage: ____ **acre-ft**

Principal spillway type: **Concrete pipe**

Principal spillway conduit diameter: ___ **in**

Auxiliary spillway type: **Vegetated earth**

Auxiliary spillway width: _____ **ft**