



**US Army Corps  
of Engineers®**

St. Paul District

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# **Alternative C Analysis Appendix C**

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Fargo Moorhead Metropolitan Area  
Flood Risk Management Project

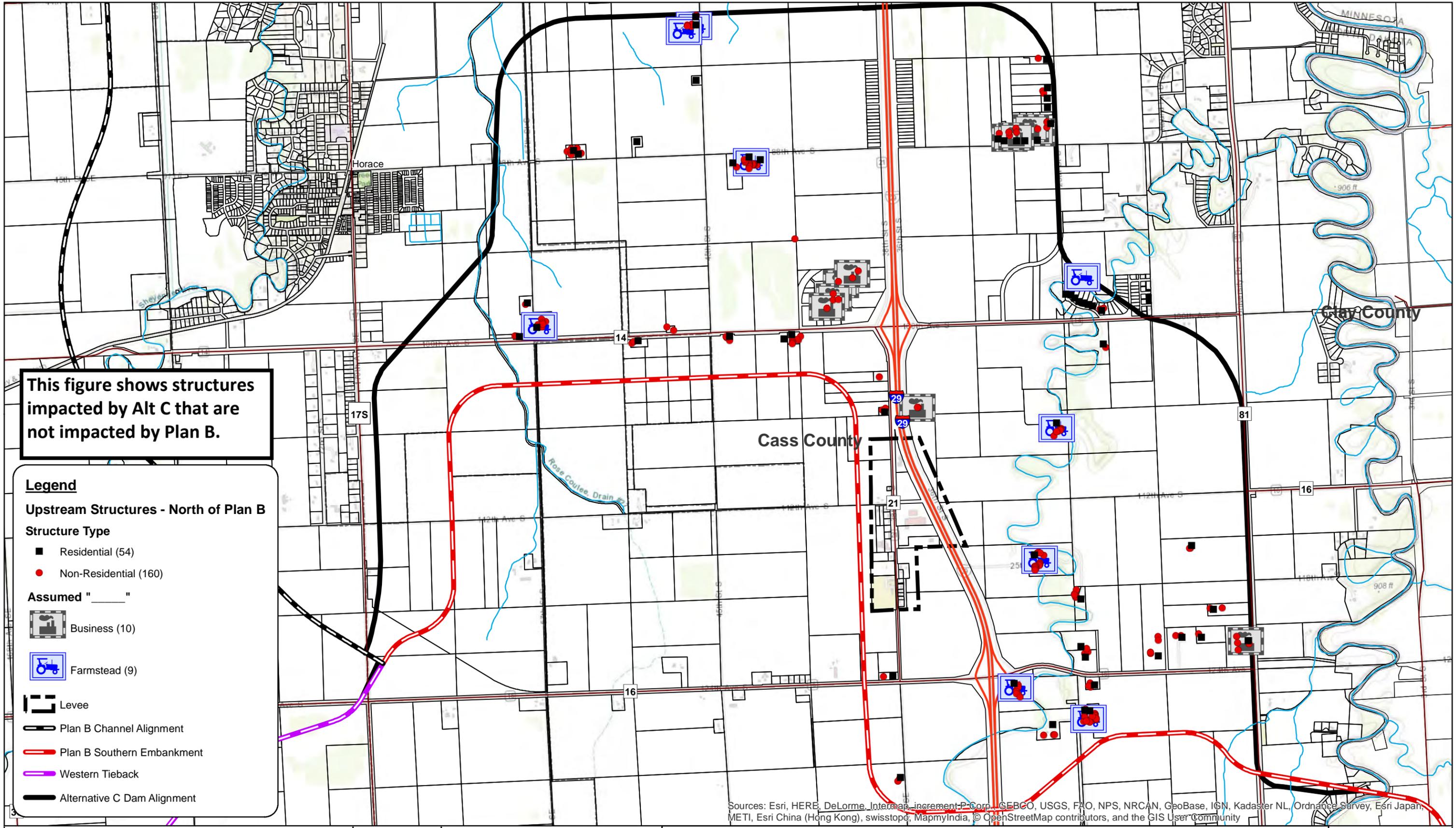
Supplemental Environmental  
Assessment Document

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## Comparison of Alternative C (JPA Southern Alignment Revised) with Plan B

1. Non-Federal Sponsors’ Property Rights Area will be approximately 8,000 acres larger with Alternative C (Alt C).
  - a. Size is driven by the PMF (Probable Maximum Flood) event, which has an approximate 0.1-foot difference between Alt C and Plan B (assumes gate sizing consistent with Plan B).
  - b. Additional 8,000 acres is the area between Alt C and Plan B alignments as shown on attached map “FM Area Diversion Project Upstream Mitigation Area” that is labeled “Upstream Structures - North of Plan B” in the legend..
  - c. Alt C still impacts Richland and Wilkin Counties (1% ACE event) and would have the same acreage in the non-Federal Sponsors’ Property Rights Area in those counties as Plan B.
2. Overall acres removed from the 1% ACE event floodplain decrease by 6,000 acres with Alt C.
3. The Alt C embankment/dam is 2.9 miles longer than the Plan B embankment/dam and taller in the more northerly locations.
  - a. Increase in permanent project footprint for Alt C is approximately 800 acres
  - b. It is estimated that Alt C would result in an impact to 100 additional acres of wetlands
  - c. Results in increased impacts to agriculture and tax base
  - d. Greater risk associated with longer dam, located closer to the population at risk.
4. Alt C would cost a minimum of \$280M more than Plan B.
5. Thirty-seven additional residential structures and 7 additional businesses would be impacted with Alt C vs. Plan B (assumes a ring levee would be included for the St. Benedict Area with Alt C). Plan B would impact 3 additional farmsteads. See attached maps “FM Area Diversion Project Upstream Mitigation Area.”
6. Overall dam height at the northern end will be approximately 23-feet for Alt C vs. 20-feet for Plan B, not including the additional freeboard that may be required due to increased wind-wave effects.
7. The OHB ring levee is required for both Plan B and Alt C
8. An additional ring levee or buyout/relocation of the St. Benedict Area would be required under Alt C.
9. Transportation Impacts
  - a. Alt C requires reconstruction of Interstate 29 interchanges at CR 14 and CR 16.
  - b. Alt C requires 3 additional miles of Interstate 29 be raised when compared to Plan B.
  - c. With Alt C, Cass County would no longer have any key east/west corridors south of Fargo during a flood event over 37’. CR 14 currently serves as one of two key routes east/west routes out of the City of Horace.
10. Drainage Impacts: Alt C requires longer local drainage system improvements (approx. 5.8 miles)
11. The Alt C southern embankment location results in a longer drawdown of the staging area pool after a flood (7 additional days for 2% ACE event and 6 additional days for 1% ACE event). Longer duration of water on agricultural land could delay planting.
12. Environmental/Cultural: Increased potential for impacts with Alt C due to longer and wider dam; a St. Benedicts ring levee; and affecting corridor of Wild Rice River north of CR 16.
13. Governors’ Task Force Goal: Strive for equity of impacts and benefits between North Dakota and Minnesota. Plan B meets this goal. Alt C shifts burden to North Dakota beyond what is equitable.

		Pre-Task Force	Plan B	Alt C
Total Staging Area	North Dakota	58%	<b>80%</b>	86%
	Minnesota	42%	<b>20%</b>	14%
Additional Area (newly flooded)	North Dakota	38%	70%	69%
	Minnesota	62%	30%	31%
Protected Area	North Dakota	81%	<b>79%</b>	76%
Protected Area	Minnesota	19%	<b>21%</b>	24%



**This figure shows structures impacted by Alt C that are not impacted by Plan B.**

**Legend**

**Upstream Structures - North of Plan B**

**Structure Type**

- Residential (54)
- Non-Residential (160)

**Assumed " " "**

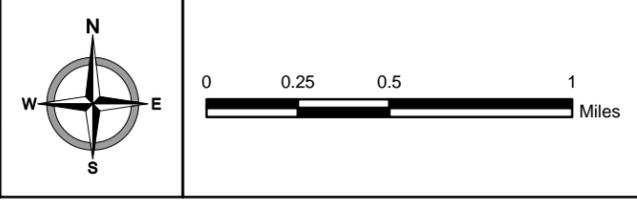
- Business (10)
- Farmstead (9)

**Other Features**

- ▬ Levee
- ▬ Plan B Channel Alignment
- ▬ Plan B Southern Embankment
- ▬ Western Tieback
- ▬ Alternative C Dam Alignment

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

**FM AREA DIVERSION PROJECT  
UPSTREAM MITIGATION AREA**



Created By: KMV Date Created: 07/20/18 Date Saved: 08/07/18 Date Exported: 08/07/18  
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**This figure shows structures impacted by Plan B that are not impacted by Alt C.**

**Legend**

**Upstream Structures - Plan B Fringe**

**Structure Type**

- Residential (17)
- Non-Residential (146)

**Assumed " " "**

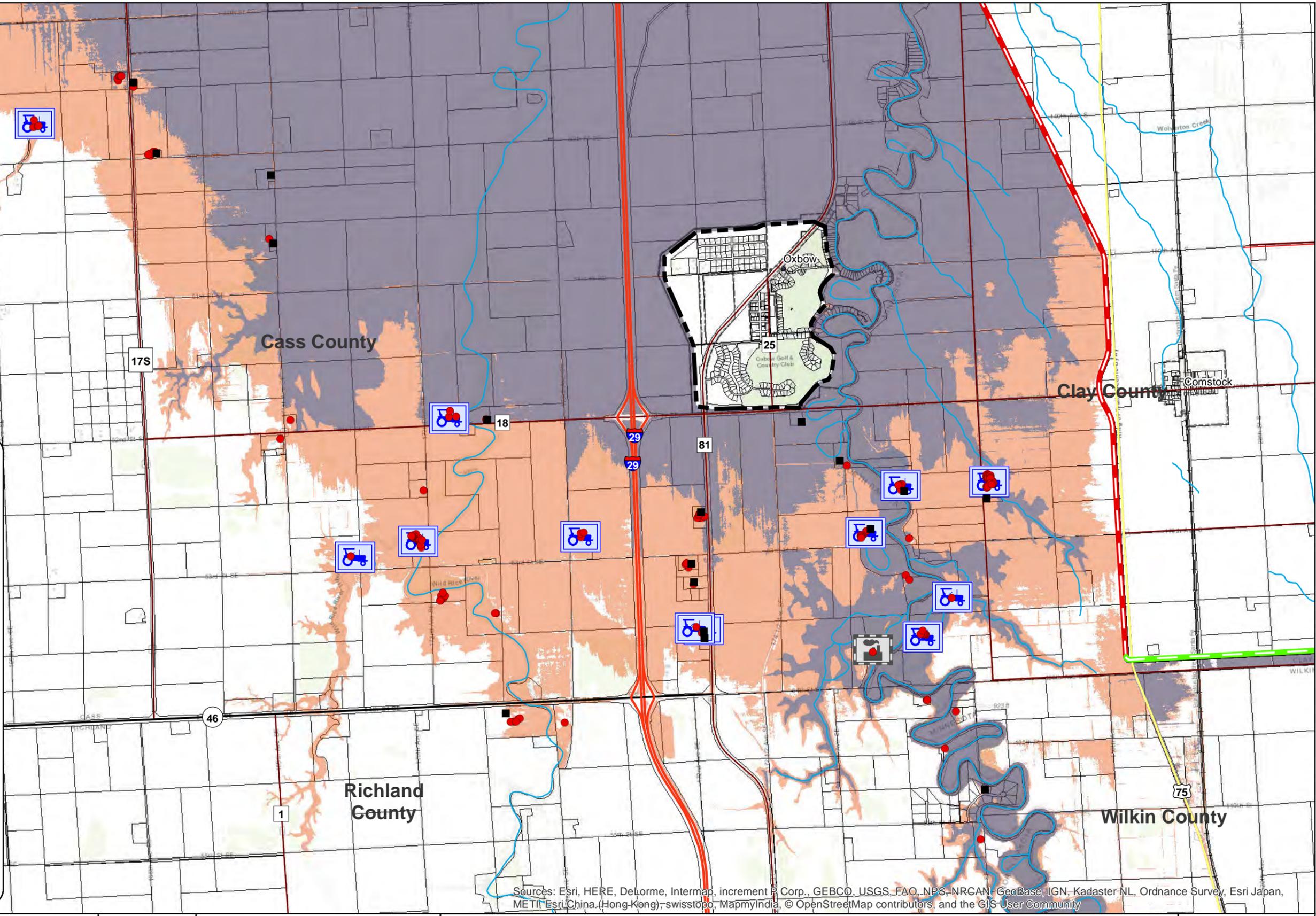
- Business (1)
- Farmstead (12)

**Levee**

- ▬ Plan B Channel Alignment
- ▬ Plan B Southern Embankment
- ▬ Eastern Tieback
- ▬ Western Tieback
- ▬ Alternative C Dam Alignment

**Alt. C Project Conditions - 100 Year**

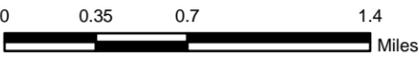
- Alt. C Project Conditions - 100 Year
- Plan B Project Conditions - 100 Year



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong-Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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# Alternative C Hydraulic Modeling Summary

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**To:** Minnesota Department of Natural Resources  
**From:** Houston-Moore Group  
**Subject:** Alternative C Hydraulic Modeling Summary  
**Date:** July 31, 2018  
**Project:** Fargo-Moorhead Metropolitan Area Flood Risk Management Project

## 1. INTRODUCTION

The Minnesota Department of Natural Resources (DNR), as part of their alternative screening for the Supplemental Environmental Impact Statement (SEIS) and their permit review of the FM Diversion Plan B Project, requested Houston-Moore Group (HMG) and the U.S. Army Corps of Engineers (USACE) to model the proposed JPA Alignment (without the NW Diversion). This option is also referred to as Alternative C by DNR. The requested modeling includes the 1% Annual Chance Exceedance (ACE), 0.2% ACE, and PMF flood events as well as additional analysis for the dam breach analysis. The DNR also requested that a ring levee be included around the St. Benedict area (businesses, church, etc.) as part of the analysis for Alternative C. The memorandum summarizes the 1% ACE, 0.2% ACE, and PMF flood event modeling performed by HMG for Alternative C.

## 2. HYDRAULIC MODELING SUMMARY

The modeled alignment for Alternative C is shown in the attached Figure 1 and is based on the original alignment developed by representatives of the Richland-Wilkin Joint Powers Authority (JPA) with refinements developed by the Technical Advisory Group (TAG) that was established to support the Governor's Task Force. The modeled Alternative C alignment includes the Western and Eastern Tieback embankments and was analyzed using a RS37' through town for the 1% ACE event. The alignment of a ring levee around St. Benedict is also shown on Figure 1. The Phase 9 unsteady HEC-RAS model, which utilizes the full Period of Record (POR) hydrology, was used for the analysis.

## 3. RESULTS

The results for Alternative C are summarized in the attached table for the 1% ACE, 0.2% ACE, and PMF flood events. A comparison of results to Plan B is summarized below:



Phase 9 HEC-RAS Model Location	1% ACE Existing	1% ACE Plan B	1% ACE Alt. C	0.2% ACE Existing	0.2% ACE Plan B	0.2% ACE Alt. C	PMF Existing	PMF Plan B	PMF Alt. C
Red River Upstream from Dam (XS 2531315)	914.12	921.02	917.93	915.74	922.73	919.83	917.83	923.65	923.53
Red River at Cass/Richland County Line (XS 2578502)	918.28	921.92	919.77	922.34	923.83	922.73	924.90	926.32	926.19

The hydraulic modeling performed for Alternative C shows the Eastern Tieback embankment and crossing of Wolverton Creek will be required with Alternative C. Additionally, the Western Tieback will be required and will not change. Other considerations with the Alternative C alignment compared to Plan B include:

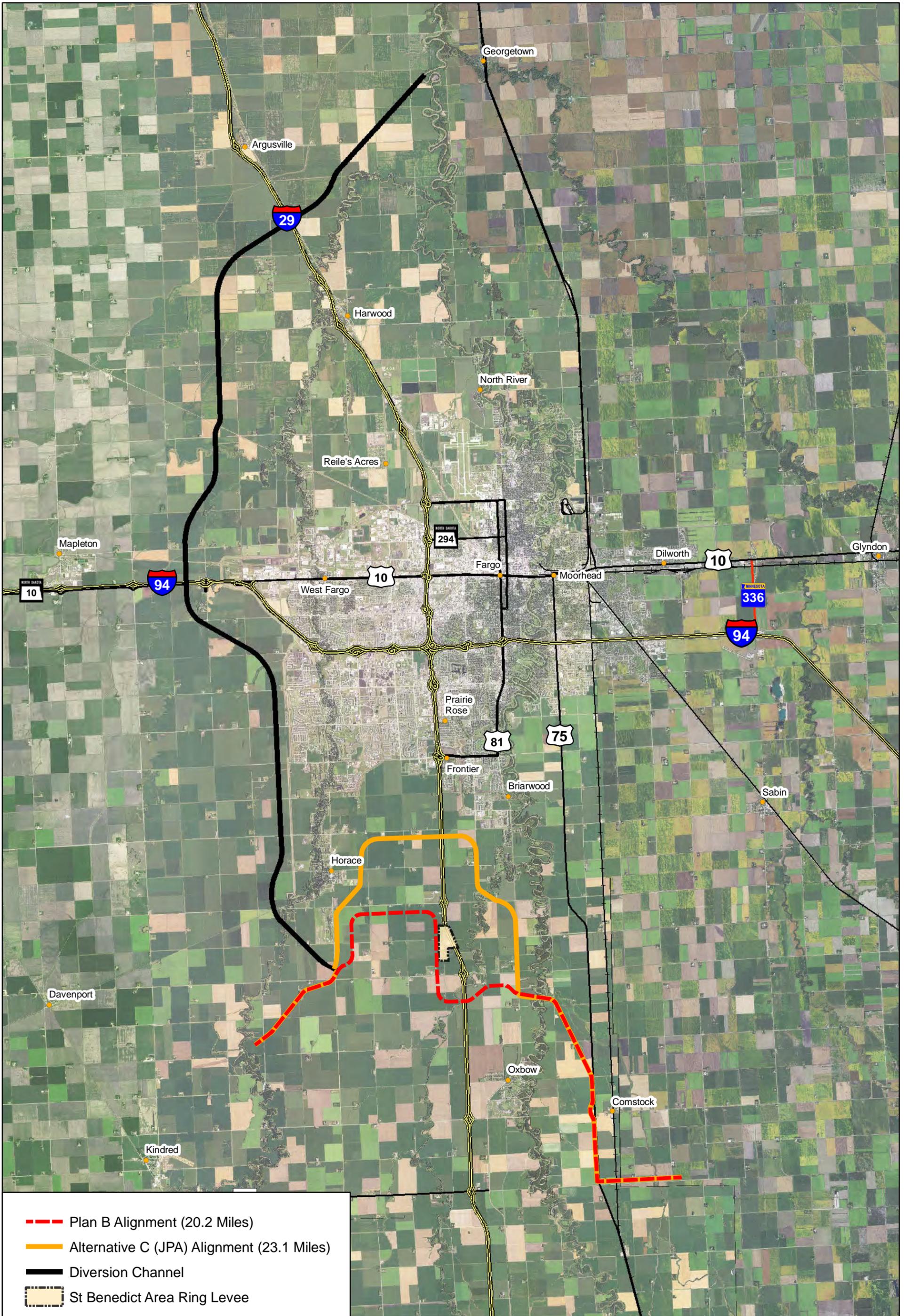
- Alternative C Alignment for the dam is approximately 23.1 miles long. The length of dam is approximately 2.9 miles longer than the Plan B alignment (20.2 miles long).
- For the 1% ACE, 107 Residential and 547 non-residential structures will be impacted by Alternative C. For comparison, Plan B has 72 Residential and 550 non-residential structures impacted. Additional commercial structures are impacted with Alternative C compared to Plan B due to the dam's proximity to the metropolitan area. The exact number has not been quantified.
- 28,690 acres will be impacted by Alternative C. For comparison, Plan B has 28,633 acres impacted.
- For the 1% ACE, Plan B retains 26,122 acres of existing floodplain within the protected area, and Alternative C retains 24,711 acres of existing floodplain within the protected area.
- For the 0.2% ACE, Plan B retains 43,073 acres of existing floodplain for the within the protected area, and Alternative C retains 39,471 acres of existing floodplain within the protected area.
- Requires the reconstruction of the I-29 interchanges at CH14 and CH16. This will also require an interstate grade raise over the proposed St. Benedict ring levee.
- Will require reconstruction of a portion of Cass County Drain 27 as part of the local drainage plan.
- With Alternative C dam location further to the north, local drainage of the inundation area will need to be to the east and into the Wild Rice River, unless an additional penetration through the dam is constructed. Alternative C will require 5.8 miles additional of local drainage systems because of the increased length of dam.
- Using consistent gate sizing as Plan B, the Alternative C maximum pool elevation during the Probable Maximum Flood (PMF) event still drives the top of dam elevation and the mitigation pool.
- North-South section of dam to the west of the Red River increases the tailwater on the Red River Control Structure. This results in higher peak WSELs in the inundation area during project operation during the PMF event or may require additional gates be added to the RRN or WRR control structures.
- Increased Forested Wetland Impacts due to the Alternative C Wild Rice River crossing location.
- Assume increased impacts to seasonally flooded wetlands due to longer project footprint and a St. Benedicts ring levee



- Cultural: Increased potential for impacts due to longer dam. Direct and indirect effects to historic St. Benedicts church and cemetery due to ring levee and associated road raises. Adversely impacts 3 sites eligible for listing on the NRHP (Section 26, 35 and Section 2 (Freeman Farm which contains 7 contributing/eligible structures)). High probability for archaeological sites along forested Wild Rice River meanders north of CH16. CH16 bridge over the Wild Rice is a National Register Eligible Historic property.
- Greater risk associated with longer dam, located closer to the population at risk
- Longer fetch length will increase wind wave effects which may result in increased dam freeboard requirements.
- OHB ring levee would still be necessary.
- Pool drawdown challenges since it will be more difficult to make use of the DIS for pool drawdown.
- Unknown communication tower impacts?

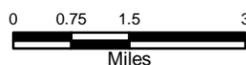
# Figures and Tables





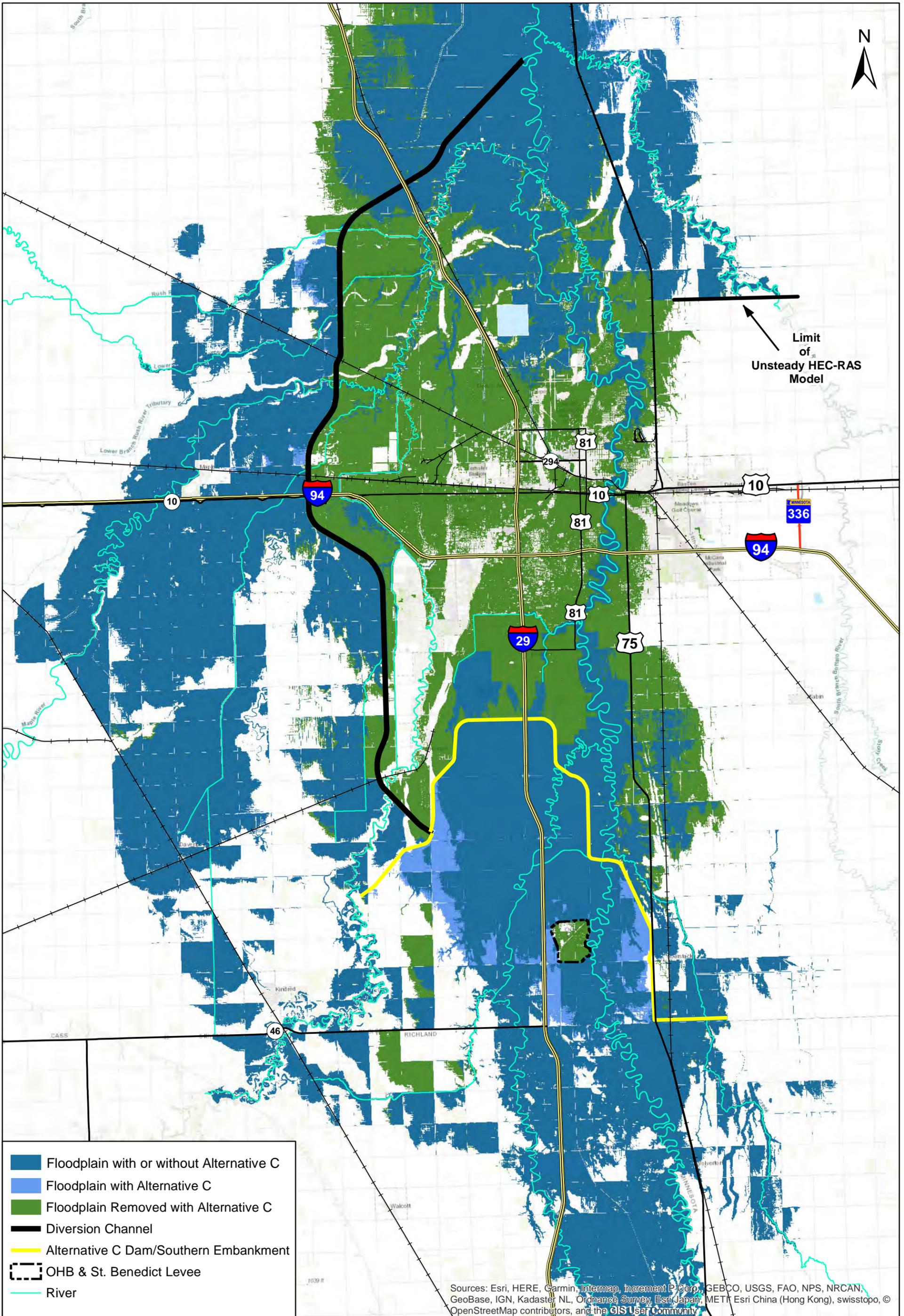
- - - Plan B Alignment (20.2 Miles)
- Alternative C (JPA) Alignment (23.1 Miles)
- Diversion Channel
- St Benedict Area Ring Levee

**Figure 1 - Alternative C Hydraulic Modeling Summary**



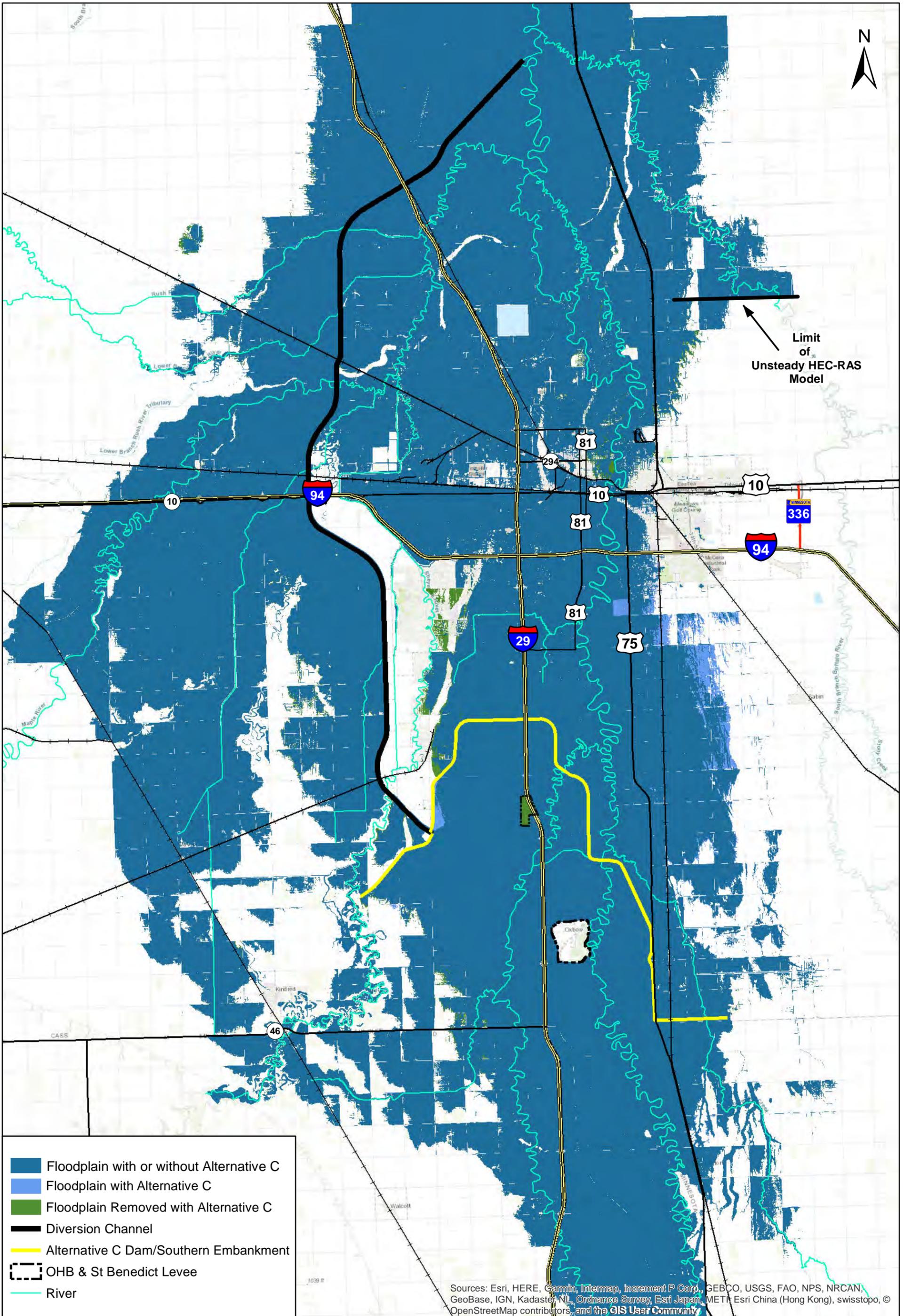
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**Figure 3 - Alternative C - 0.2% Chance Event With Emergency Measures**





**Figure 4 - Alternative C - PMF With Emergency Measures**



**Table 1 Alternative C Staging Area Water Surface Elevation and Downstream Impacts**

Locaitons		100-yr			500-yr			PMF		
Location Name	Cross Section/ Storage Area	EXwithEM	WPwithEM	ΔWP-EX	EXwithEM	WPwithEM	ΔWP-EX	EXnoEM	WPnoEM	ΔWP-EX
Red River @ Drayton, ND (30 mi. to Border)	1062362	802.33	802.37	0.04	803.87	804.02	0.15			
Red River @ Oslo, MN	1416287	813.52	813.53	0.01	814.21	814.33	0.12			
Red River @ Grand Forks, ND	1558518	832.72	832.80	0.08	836.40	836.95	0.55			
Red River @ Thompson, ND	1667877	846.78	846.77	-0.01	849.73	849.96	0.23			
Red River @ Climax, MN	1763746	856.88	856.84	-0.04	862.06	862.53	0.47			
Red River @ Nielsville, MN	1829877	860.92	860.88	-0.04	865.93	866.39	0.46			
Red River @ Shelly, MN	1891054	864.99	864.95	-0.04	868.00	868.32	0.32			
Red River @ Halstad, MN	1981580	868.22	868.15	-0.07	870.27	870.46	0.19			
Red River @ Hendrum, MN	2038409	872.57	872.43	-0.14	874.36	874.54	0.18			
Red River @ Perley, MN	2129181	877.26	877.22	-0.04	878.08	878.09	0.01			
Red River @ Georgetown, MN	2194021	881.79	881.93	0.14	882.58	882.75	0.17	888.06	887.31	-0.75
Red River @ Fargo/Moorhead (Fargo Gage)	2388223	904.16	899.71	-4.45	907.32	902.69	-4.63	908.27	907.66	-0.61
Western Tieback	WRS313	913.87	917.81	3.94	914.49	919.39	4.90	918.13	923.36	5.23
Wild Rice River Upstream of Dam	69855	916.18	917.96	1.78	916.66	919.60	2.94	917.82	923.54	5.72
Red River Upstream of Dam	2531315	914.12	<b>917.93</b>	3.81	915.74	<b>919.83</b>	4.09	917.83	<b>923.53</b>	5.70
Red River @ Cass/Richland County Line	2578502	918.28	919.77	1.49	922.34	922.73	0.39	924.90	926.19	1.29
Wild Rice River @ Cass/Richland Co. Line	109018	922.27	922.28	0.01	923.86	923.87	0.01	926.35	926.39	0.04

**Table 2 Plan B Staging Area Water Surface Elevation and Downstream Impacts**

Locaitons		100-yr			500yr			PMF		
Location Name	Cross Section/ Storage Area	EXwithEM	WPwithEM	ΔWP-EX	EXwithEM	WPwithEM	ΔWP-EX	EXnoEM	WPnoEM	ΔWP-EX
Red River @ Drayton, ND (30 mi. to Border)	1062362	802.33	802.37	0.04	803.87	804.04	0.17			
Red River @ Oslo, MN	1416287	813.52	813.53	0.01	814.21	814.33	0.12			
Red River @ Grand Forks, ND	1558518	832.72	832.79	0.07	836.40	836.98	0.58			
Red River @ Thompson, ND	1667877	846.78	846.76	-0.02	849.73	849.98	0.25			
Red River @ Climax, MN	1763746	856.88	856.83	-0.05	862.06	862.56	0.50			
Red River @ Nielsville, MN	1829877	860.92	860.86	-0.06	865.93	866.43	0.50			
Red River @ Shelly, MN	1891054	864.99	864.94	-0.05	868.00	868.35	0.35			
Red River @ Halstad, MN	1981580	868.22	868.15	-0.07	870.27	870.48	0.21			
Red River @ Hendrum, MN	2038409	872.57	872.42	-0.15	874.36	874.56	0.20			
Red River @ Perley, MN	2129181	877.26	877.22	-0.04	878.08	878.09	0.01			
Red River @ Georgetown, MN	2194021	881.79	881.93	0.14	882.58	882.75	0.17			
Red River @ Fargo/Moorhead (Fargo Gage)	2388223	904.16	899.73	-4.43	907.32	902.70	-4.62	908.27	907.52	-0.75
Western Tieback	WRSA313	913.87	920.85	6.98	914.49	922.42	7.93	918.13	923.38	5.25
Wild Rice River Upstream of Dam	69855	916.18	920.92	4.74	916.66	922.54	5.88	917.82	923.53	5.71
Red River Upstream of Dam	2531315	914.12	<b>921.02</b>	6.90	915.74	<b>922.73</b>	6.99	917.83	<b>923.65</b>	5.82
Red River @ Cass/Richland County Line	2578502	918.28	921.92	3.64	922.34	923.83	1.49	924.90	926.32	1.42
Wild Rice River @ Cass/Richland Co. Line	109018	922.27	922.43	0.16	923.86	923.96	0.10	926.35	926.41	0.06

			Pre-Task Force (Phase 8.1)		Plan B (Phase 9 - DNR)		Alternative C (Phase 9 - DNR)	
Criteria			Current Project 35 ft Through Town (baseline)		100 Year MDNR A19-A14 RPWFP100POR RPEXP100POR		100 Year POR Full Protection	
Upstream Floodplain Impacts			EX	WP	EX	WP	EX	WP
	Cass County	Total Area (ac)	10,326	16,290	12,675	19,955	18,871	22,706
		Add'l Area (ac)		5,964		7,280		3,835
	Richland County	Total Area (ac)	3,263	4,387	2,347	2,961	1,864	2,003
		Add'l Area (ac)		1,124		614		139
North Dakota		Total Area (ac)	13,589	20,676	15,022	22,916	20,735	24,709
		Add'l Area (ac)		7,088		7,894		3,973
	Clay County	Total Area (ac)	1,989	12,229	1,124	4,206	1,122	2,821
		Add'l Area (ac)		10,240		3,082		1,699
	Wilkin County	Total Area (ac)	1,160	2,551	1,139	1,511	1,091	1,160
		Add'l Area (ac)		1,391		372		69
Minnesota		Total Area (ac)	3,149	14,780	2,263	5,717	2,213	3,981
		Add'l Area (ac)		11,631		3,454		1,768
Total (ND/MN)		Total Area (ac)	16,738	35,456	17,285	28,633	22,948	28,690
		Add'l Area (ac)		18,720		11,348		5,742
Percentage (ND)		Total Area (%)		58.3%		80.0%		86.1%
		Add'l Area (%)		37.9%		69.6%		69.2%
Percentage (MN)		Total Area (%)		41.7%		20.0%		13.9%
		Add'l Area (%)		62.1%		30.4%		30.8%
Areas Removed with Emergency Measures			EX	WP	EX	WP	EX	WP
North Dakota		Total Area (ac)		---		35,045		28,909
		Add'l Area (%)		---		79.3%		76.0%
Minnesota		Total Area (ac)		---		9,145		9,125
		Add'l Area (%)		---		20.7%		24.0%
Total (ND/MN)				---		44,190		38,034
Upstream Impacted Structures			EX	WP	EX	WP	EX	WP
	Cass County	# of Res Structures	9	41	15	57	27	98
		# of Non-Res Structures	130	258	210	380	346	455
		Total # of Structures	139	299	225	437	373	553
		# of Additional Structures		160		212		180
	Richland County	# of Res Structures	0	3	0	3	0	0
		# of Non-Res Structures	32	61	21	39	12	15
		Total # of Structures	32	64	21	42	12	15
		# of Additional Structures		32		21		3
North Dakota		# of Res Structures	9	44	15	60	27	98
		# of Non-Res Structures	162	319	231	419	358	470
		Total # of Structures	171	363	246	479	385	568
		# of Additional Structures		192		233		183
	Clay County	# of Res Structures	1	20	1	10	1	8
		# of Non-Res Structures	29	211	14	104	14	56
		Total # of Structures	30	231	15	114	15	64
		# of Additional Structures		201		99		49
	Wilkin County	# of Res Structures	2	5	1	2	1	1
		# of Non-Res Structures	21	37	17	27	17	21
		Total # of Structures	23	42	18	29	18	22
		# of Additional Structures		19		11		4
Minnesota		# of Res Structures	3	25	2	12	2	9
		# of Non-Res Structures	50	248	31	131	31	77
		Total # of Structures	53	273	33	143	33	86
		# of Additional Structures		220		110		53
Total (ND/MN)		# of Res Structures	12	69	17	72	29	107
		# of Non-Res Structures	212	567	262	550	389	547
		Total # of Structures	224	636	279	622	418	654
		# of Additional Structures		412		343		236