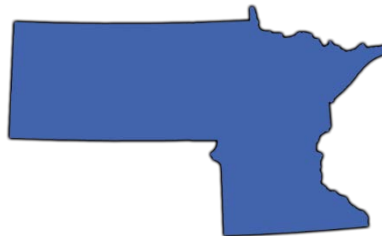


# **Option Analysis**

**Presentation by:  
Technical Advisory Group**

**Presentation to:  
Fargo-Moorhead Area Flood Diversion Task Force**

**December 11, 2017**



# Task Force Charter

- “Develop design principles and concept-level engineering to achieve balanced flood risk management”
- Find solutions that satisfy state and local laws, rules, and ordinances
- Provide 100-year FEMA certifiable flood protection
- Maintain federal authorization

# **TAG Direction from Task Force**

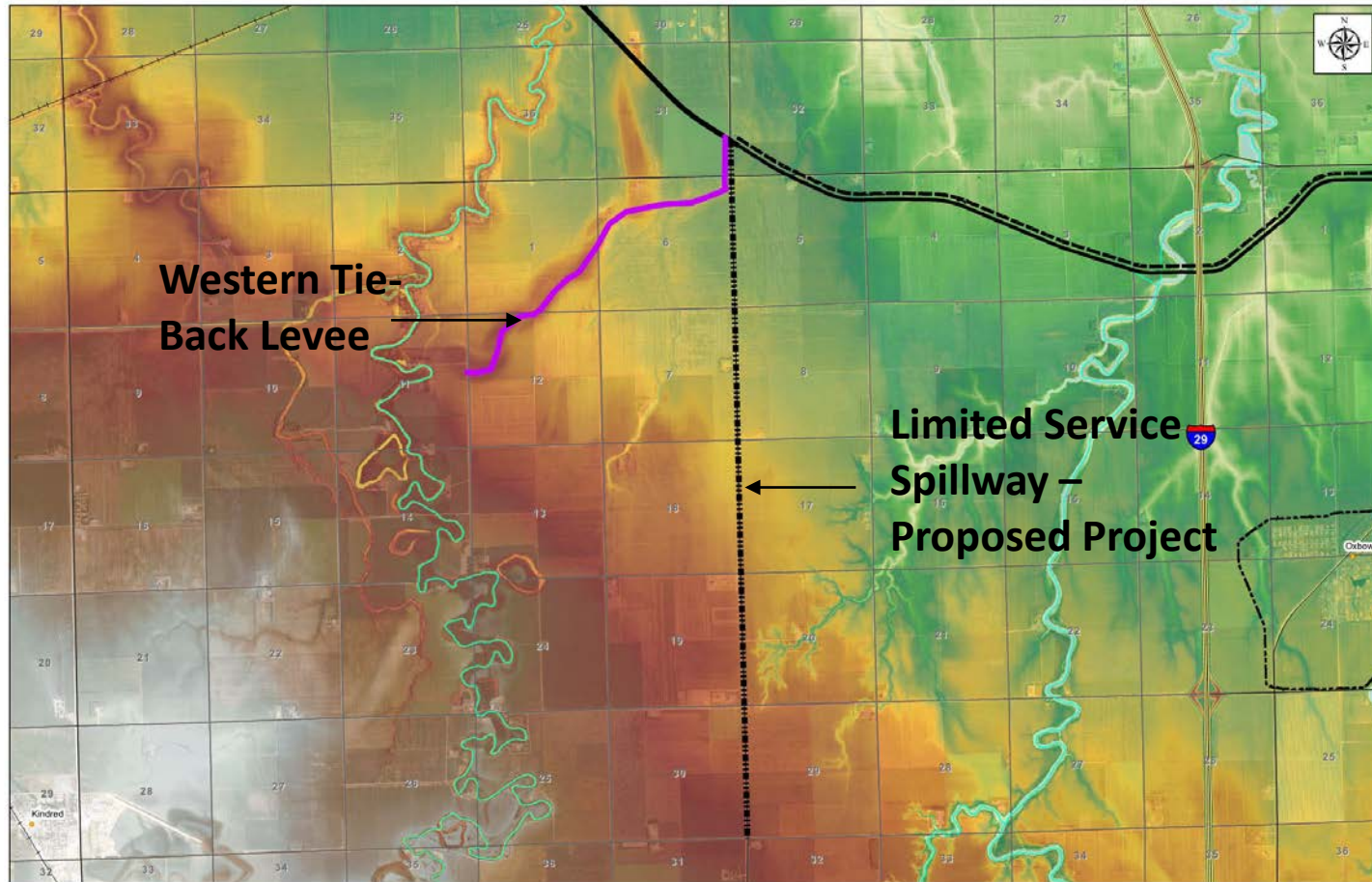
- Use full period of record hydrology (33,000 cfs – 100-year)
- Include Western Tie-back levee in all options
- Distributed Storage is part of a long-term strategy and doesn't impact current analysis
- Develop 3 options for consideration
  - Include results for RS37, RS38, and RS39
  - Include option that allows up to 6 inches of downstream impacts
- Strive for equity in impacts – ND/MN
- Minimize acres removed from the floodplain
- Minimize newly impacted acreage and structures
- Consider economics – cost increases and reductions

# Components/Options

- Western Tie Back Levee
- Eastern Tie Back
- Northern Storage/Diversion Channel Alignment
- Additional Flows Through Town
  - RS 35 feet
  - RS 37 feet
  - RS 38 feet
  - RS 39 feet
- Change Location of Dam/Southern Embankment
  - Option 7A
  - Option 7B
  - Option 7C
- Allow Downstream Impacts up to 6 inches

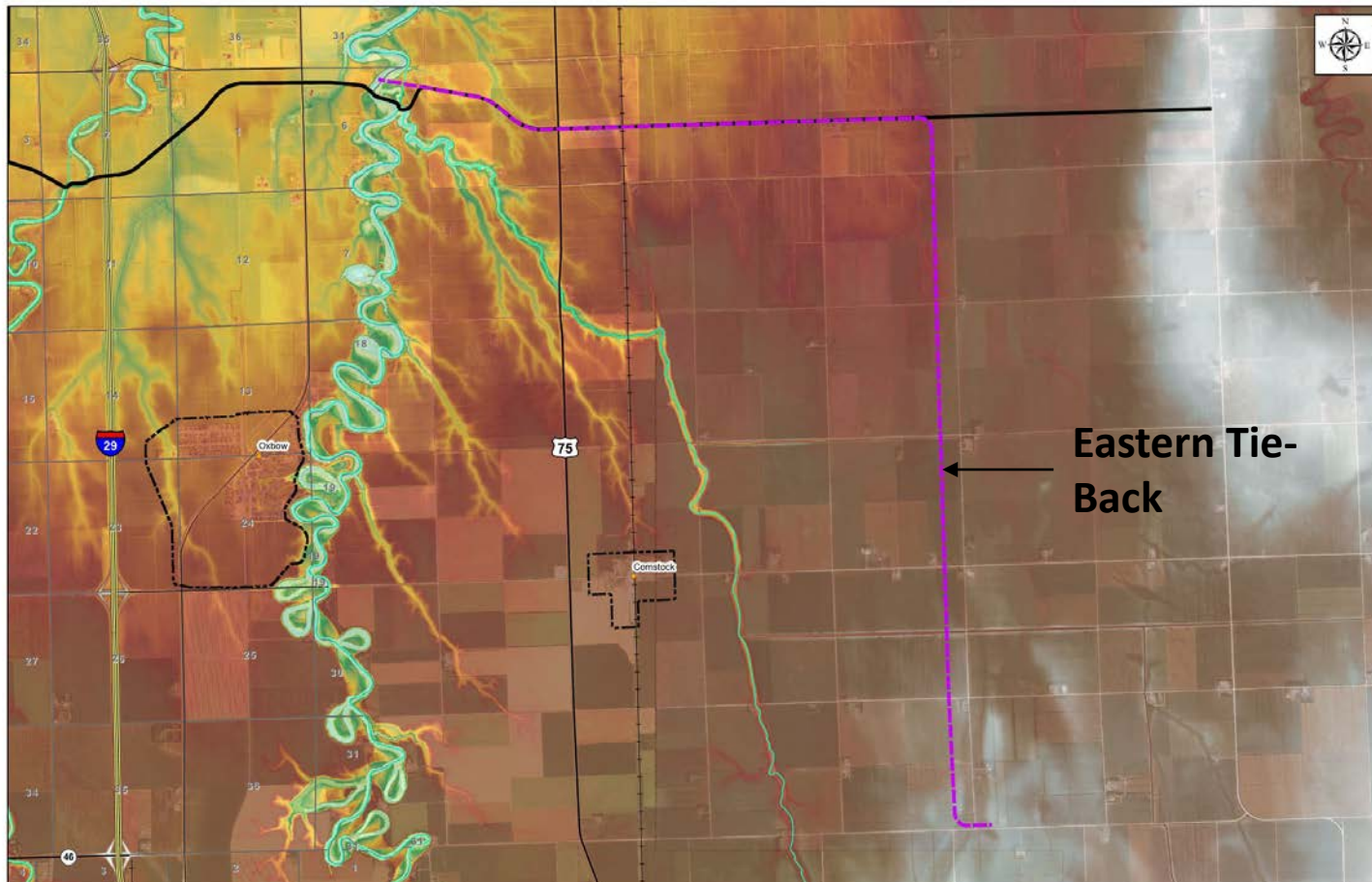
# Western Tie Back Levee as a Component

- Included for Options 7A, 7B, and 7C
- Increases floodplain in ND



# Eastern Tie Back as a Component (new)

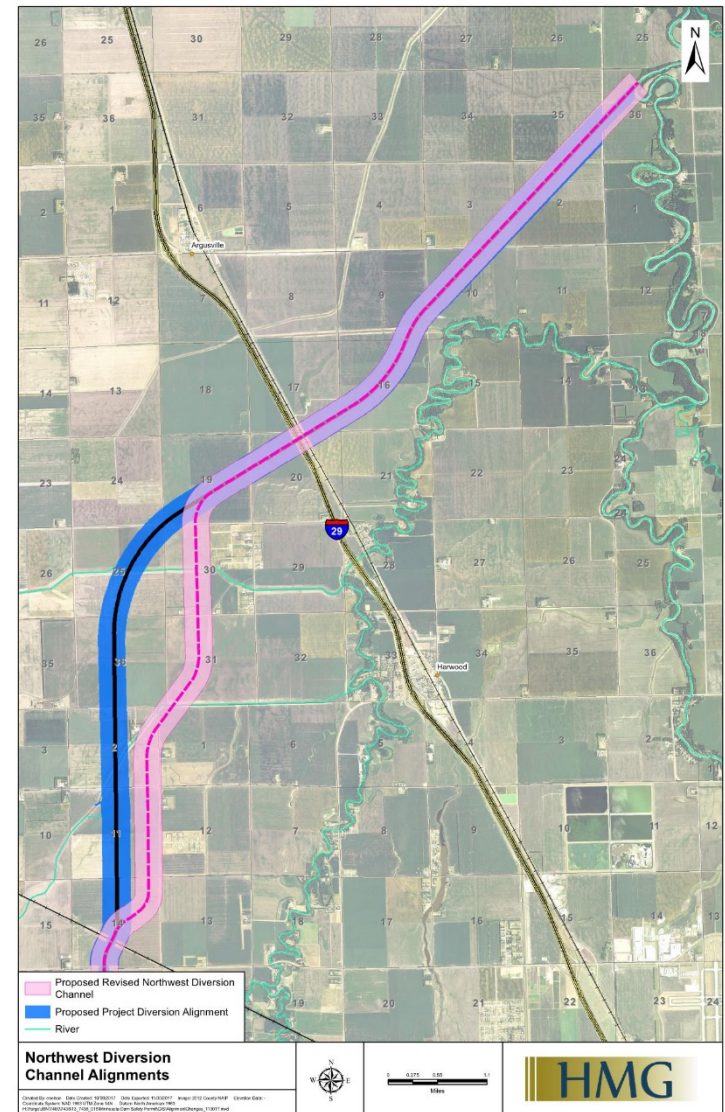
- Included for Options 7A, 7B, and 7C
- Reduces newly inundated floodplain in MN





# Northern Storage/Diversion Channel Alignment Option

- Evaluated diversion channel alignment change in northwest project area
- Preserves more existing floodplain (potentially 1800 acres)
- Not included in current analysis due to minimal staging area reduction



# Additional Flows Through Town

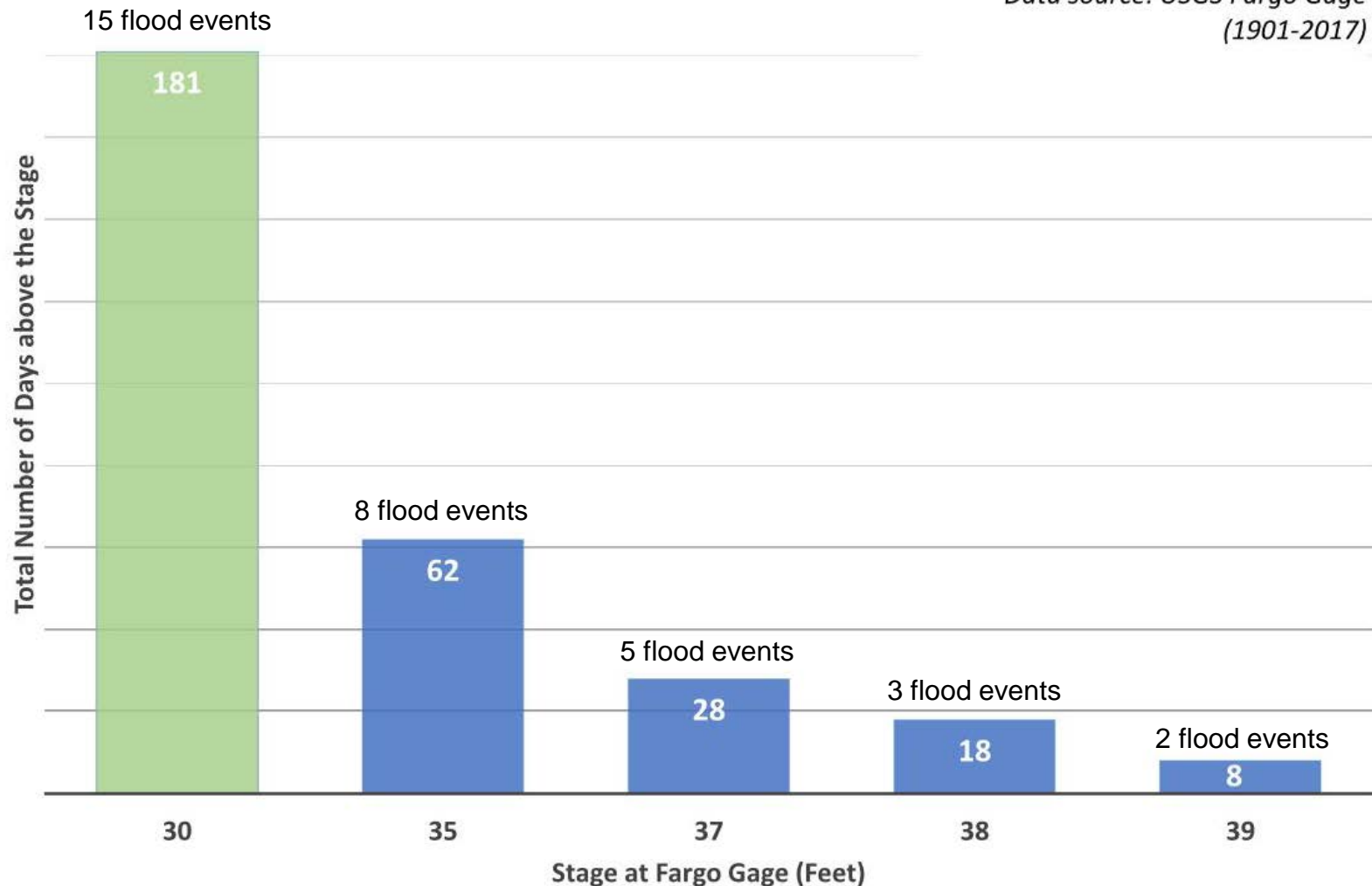
- Additional flows through town reduces the frequency of staging area operation and size of the inundation area
- Additional flows through town requires additional In Town measures be implemented
- Proposed project design (2013) has RS 35' through town in a 100-year flood
- Additional analysis includes RS37', RS38', and RS39'



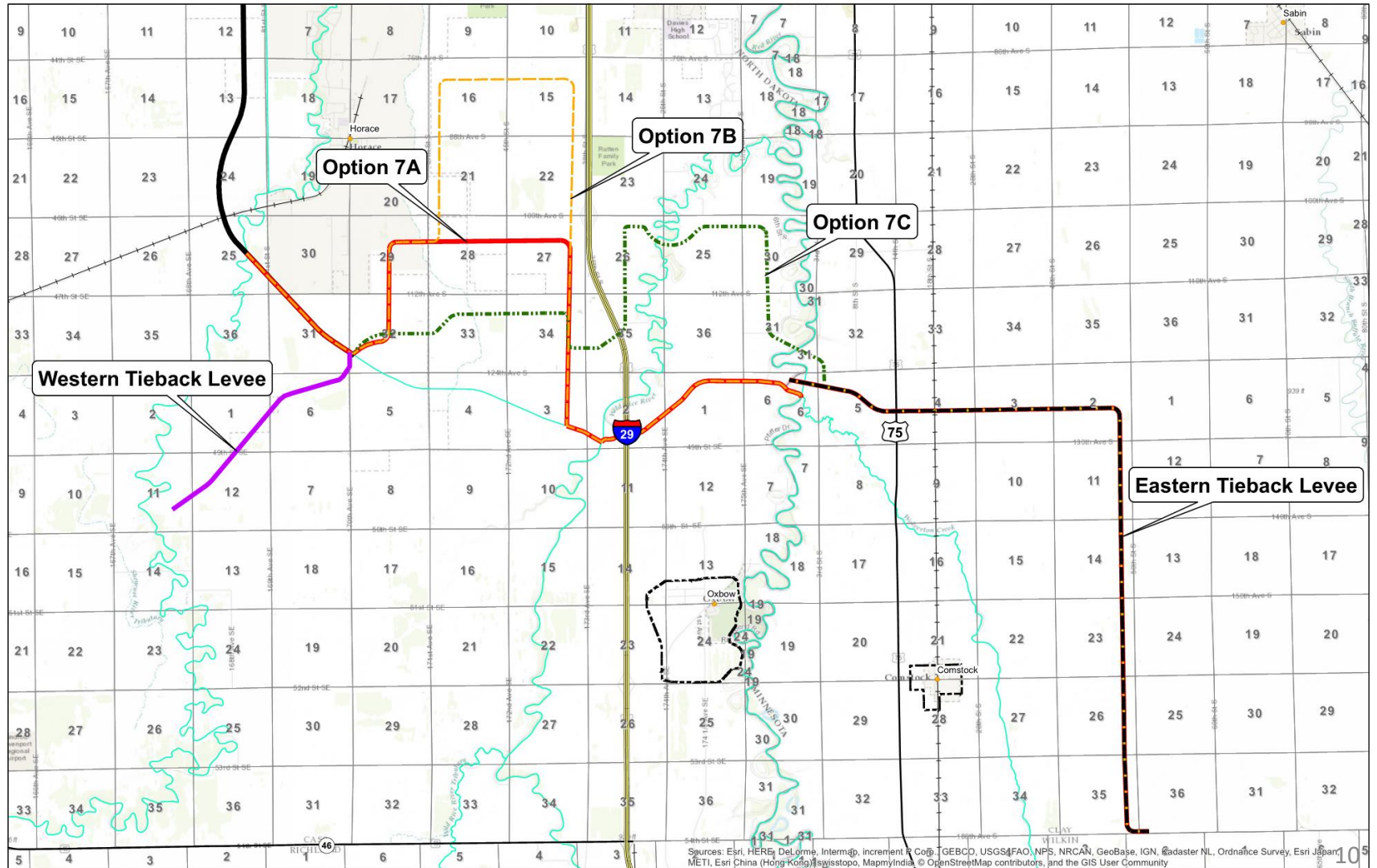
# Additional Flows Through Town Histogram and Frequency Curve

Number of Days in Historical Operation

Data source: USGS Fargo Gage  
(1901-2017)

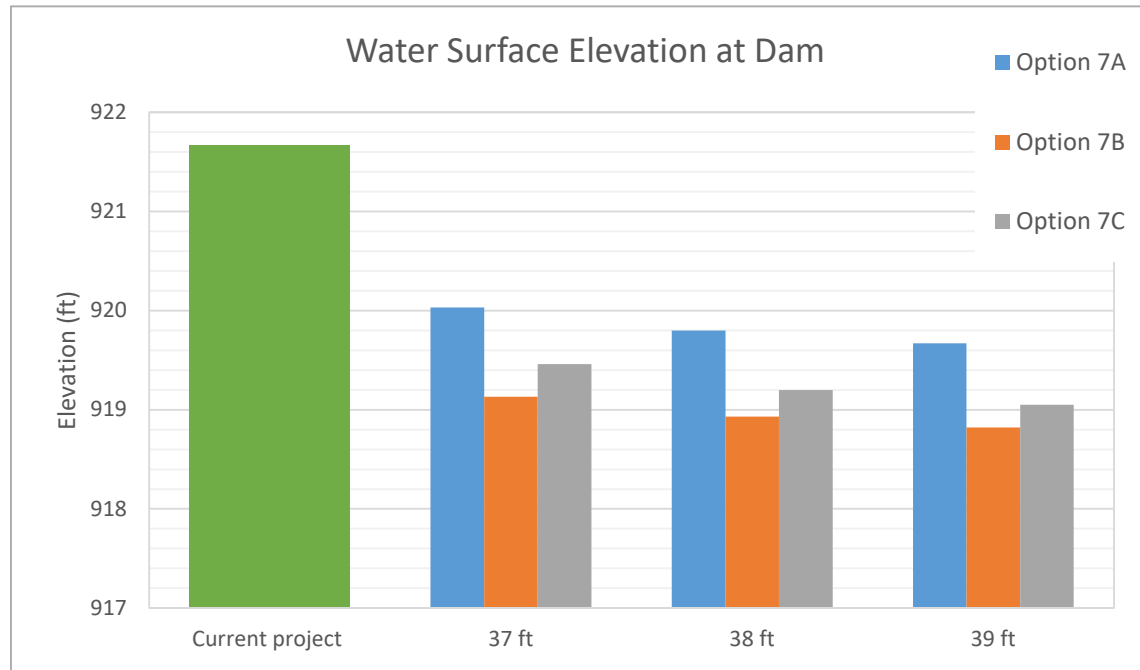


# Options 7A, 7B, 7C: Dam Alignments will be discussed in detail later in presentation

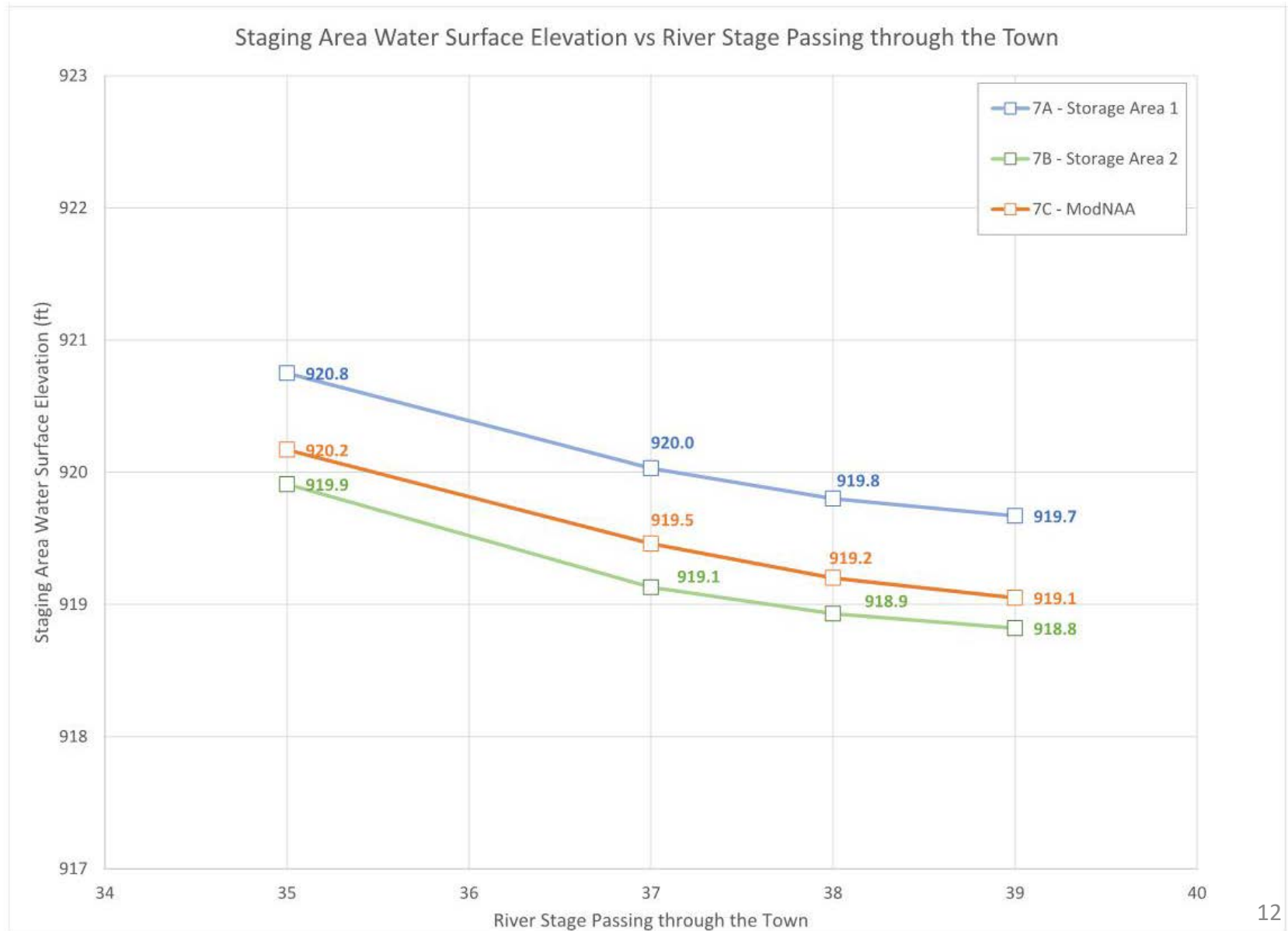


# Additional Flows Through Town Summary

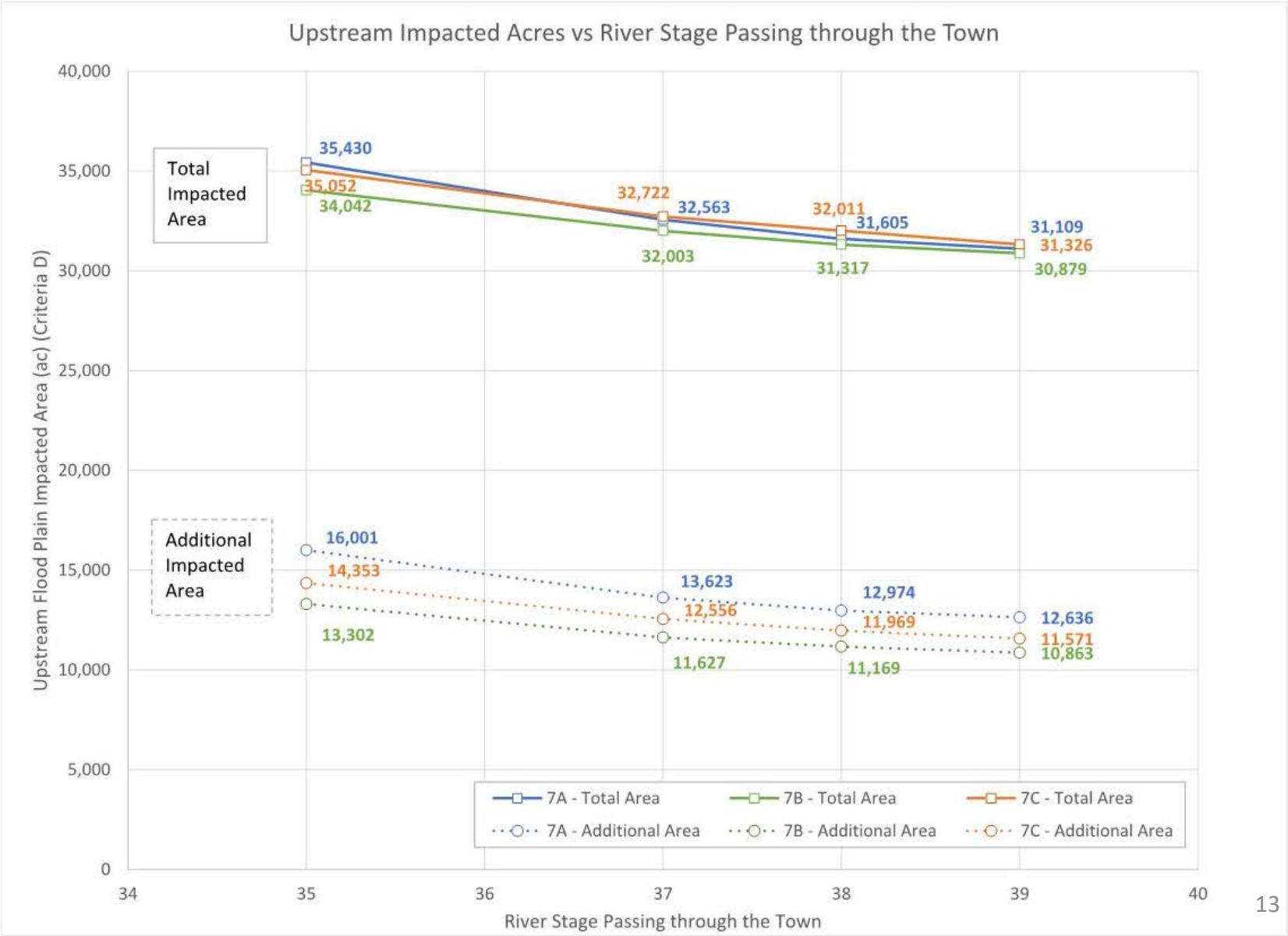
	Proposed 35' (baseline)	37'	38'	39'
Return Frequency /Discharge (cfs)	13 year / 16,400 cfs	21 year / 20,200 cfs	28 year / 22,200 cfs	39 year / 24,500 cfs
Cost (Construction and Acquisitions – FM Only)	Ongoing	\$150M / 82 Additional Homes	\$330M / 168 Additional Homes	\$420M / 314 Additional Homes



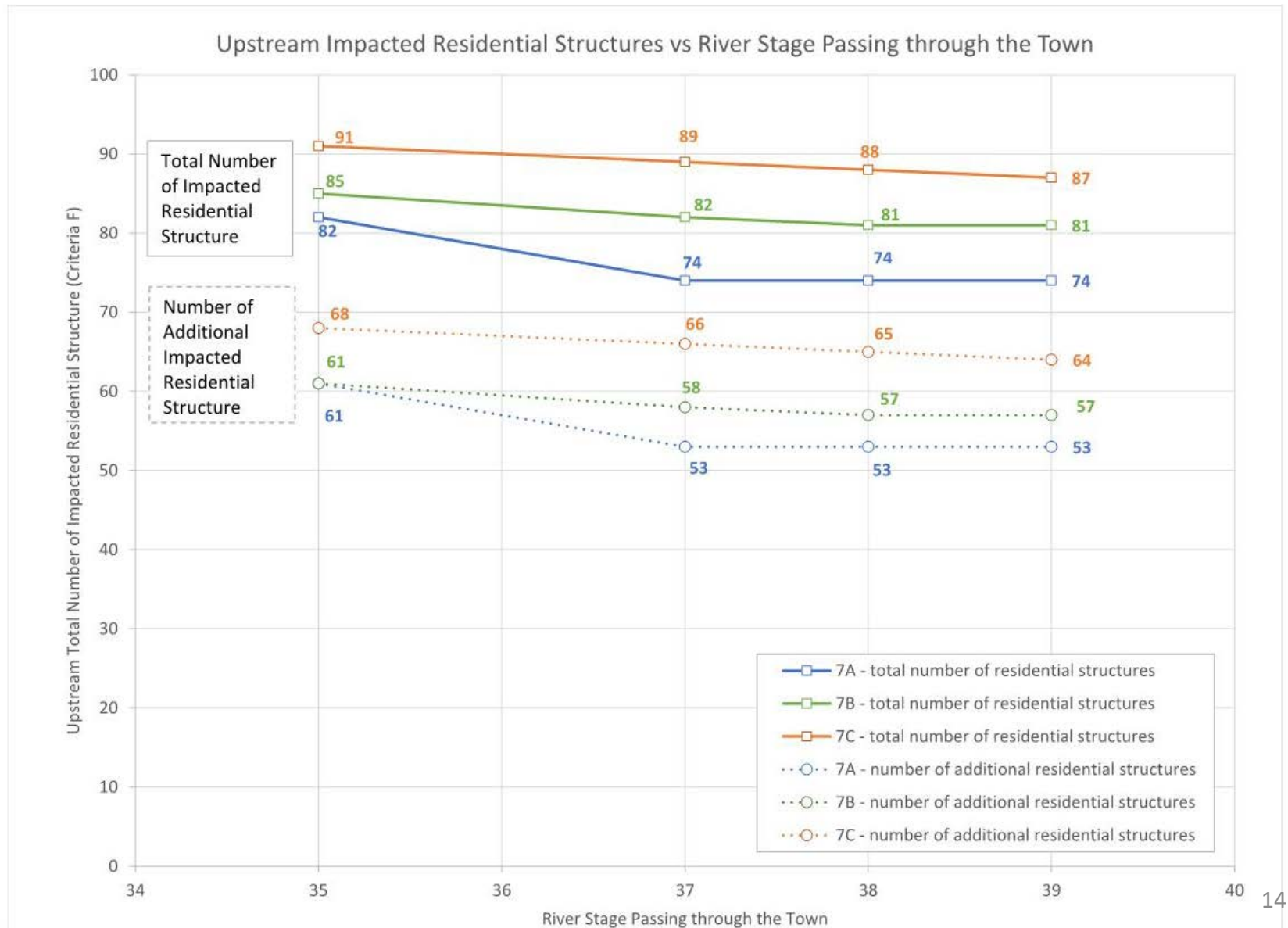
# Additional Flows Through Town Summary



# Additional Flows Through Town Summary



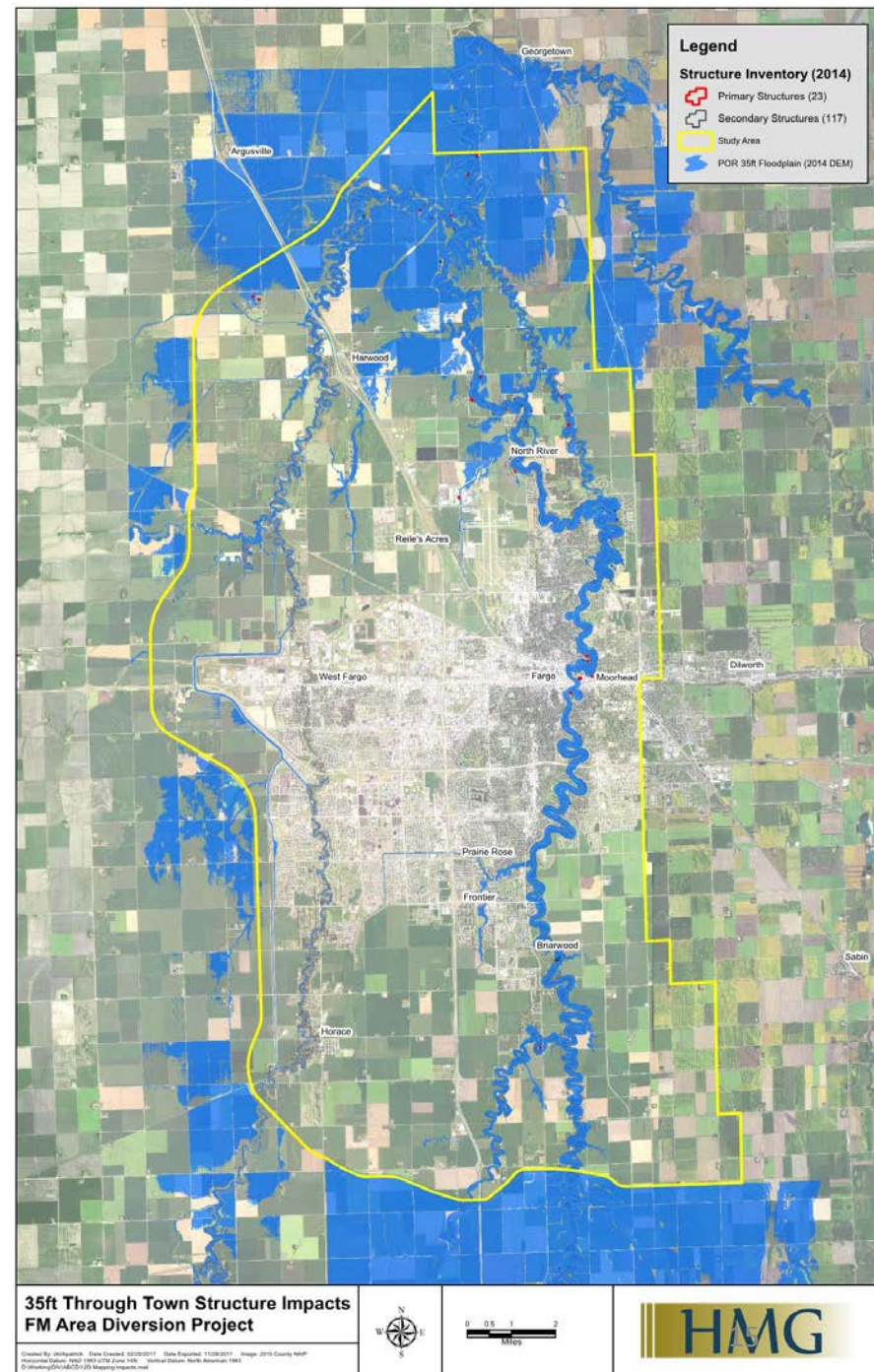
# Additional Flows Through Town Summary





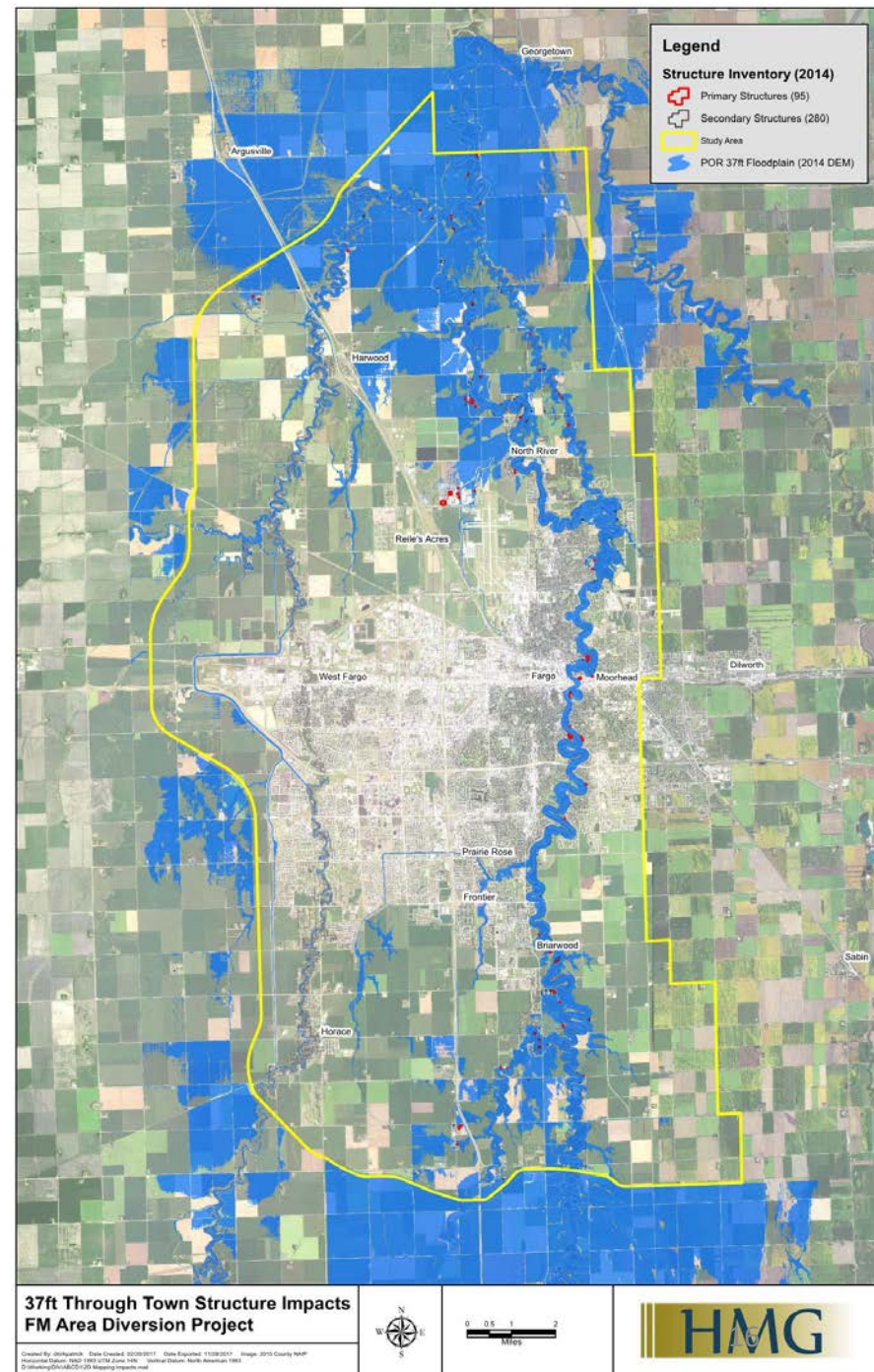
# Additional Flows Through Town (RS 35')

## 23 Unprotected Primary Structures



# Additional Flows Through Town (RS 37')

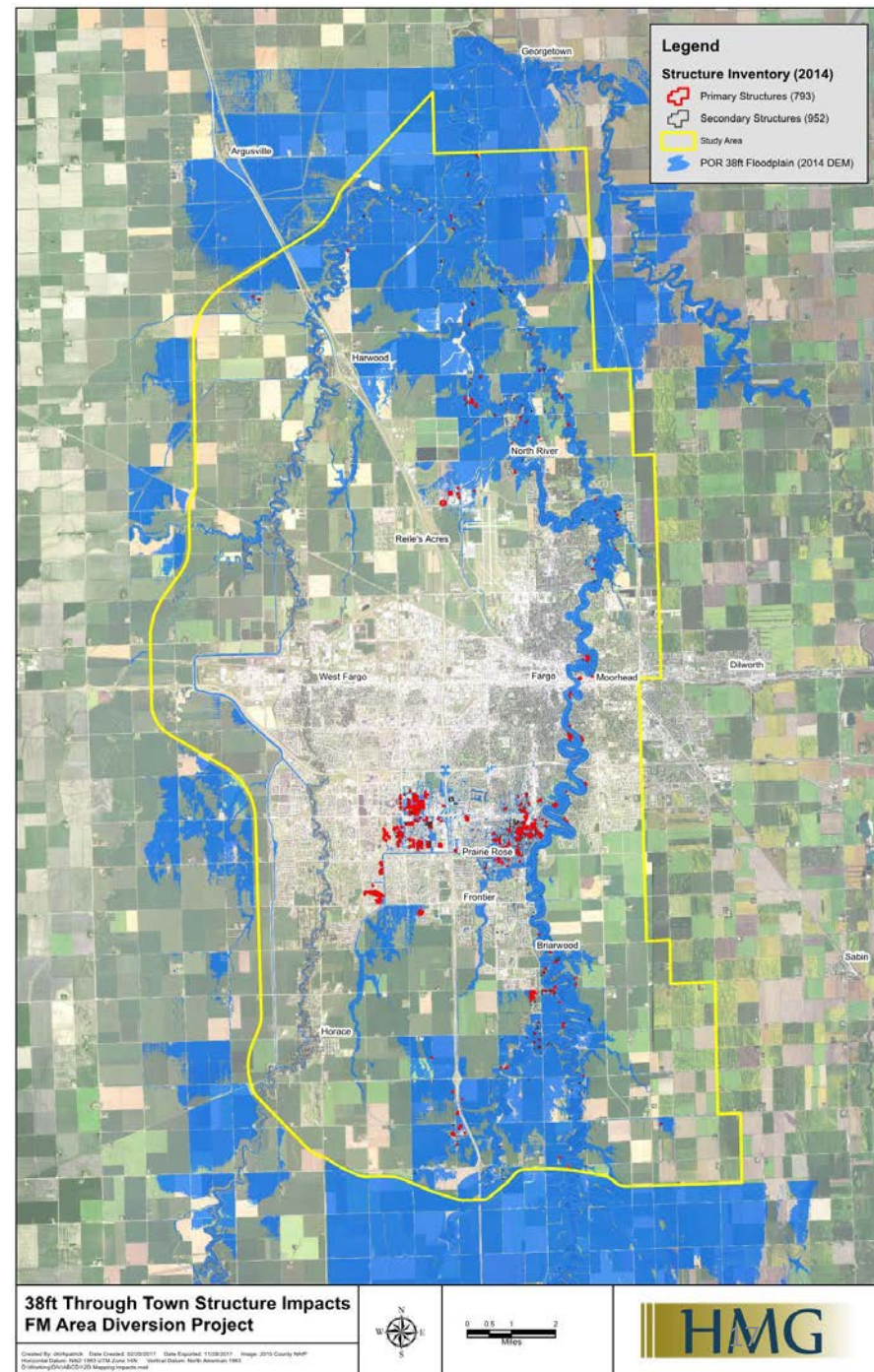
## 95 Unprotected Primary Structures





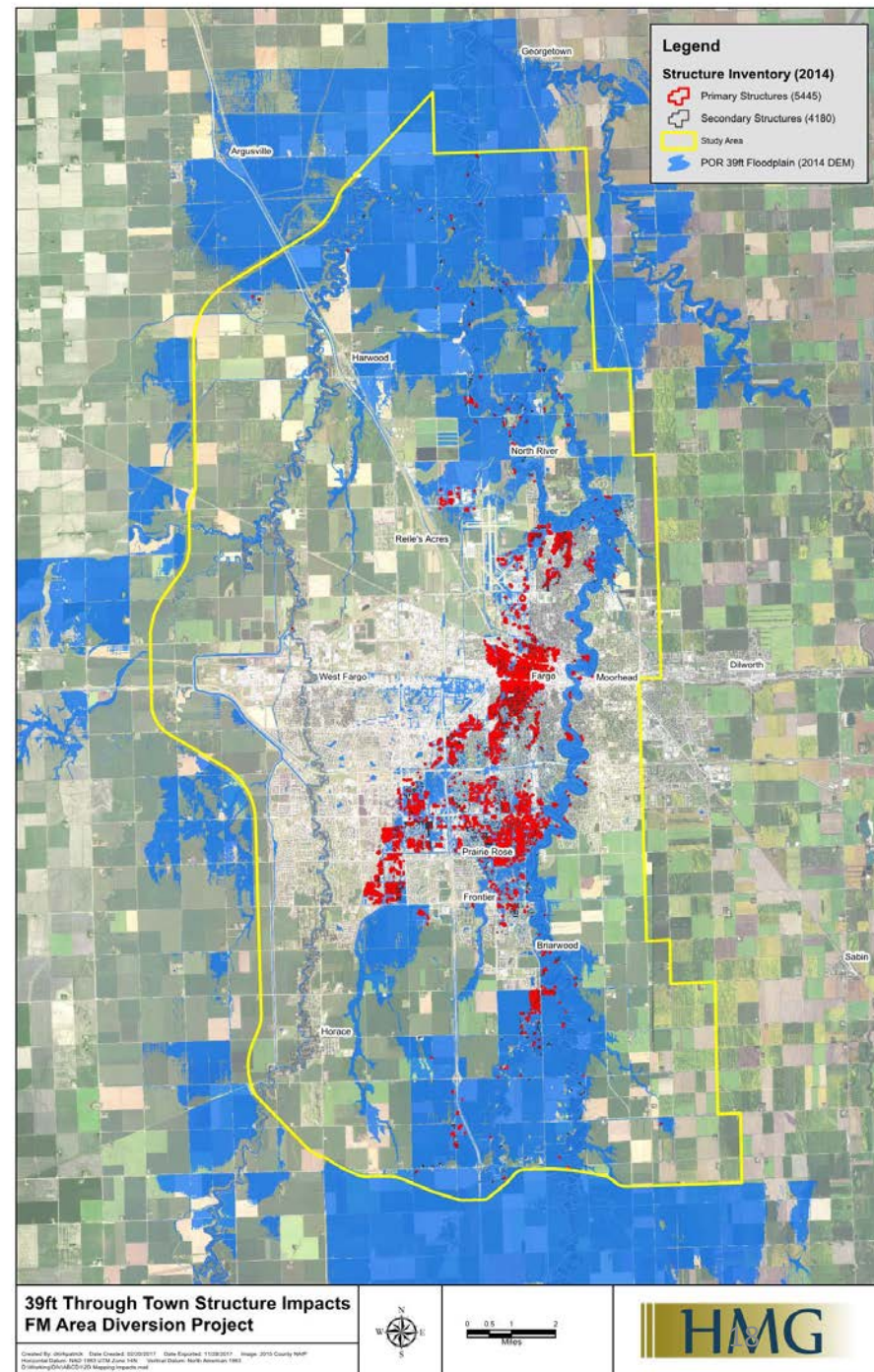
# Additional Flows Through Town (RS 38')

## 793 Unprotected Primary Structures



# Additional Flows Through Town (RS 39')

## 5,445 Unprotected Primary Structures



# Summary

- Western Tie Back Levee – Yes
- Eastern Tie Back – Yes
- Northern Storage/Diversion Channel Alignment – Neutral
- Additional Flows Through Town
  - RS 35 feet
  - RS 37 feet - Yes
  - RS 38 feet
  - RS 39 feet

# Change Operation Plan to Allow up to 6 inches of Downstream Impacts (RS 37)

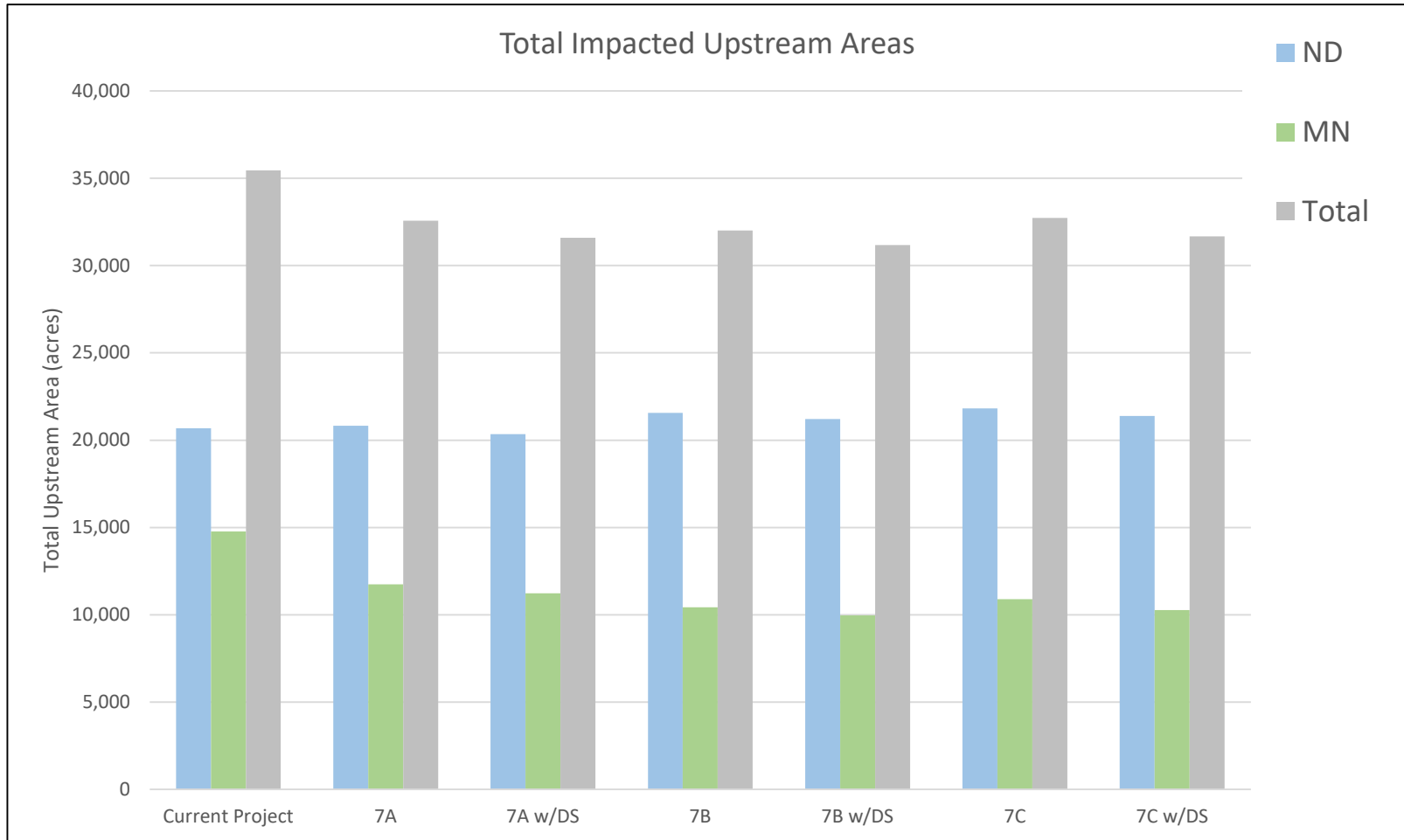
Reference Point	7A	7A w/ DS	7B	7B w/DS	7C	7C w/DS
Drayton, ND Impact	+0.03'	<b>+0.10'</b>	+0.03'	<b>+0.10'</b>	+0.03'	<b>+0.10'</b>
Grand Forks, ND Gage Impact	+0.05'	<b>+0.23'</b>	+0.05'	<b>+0.23'</b>	+0.03'	<b>+0.22'</b>
Climax, MN Impact	-0.05'	<b>+0.49'</b>	-0.05'	<b>+0.49'</b>	-0.10'	<b>+0.47'</b>
Halstad, MN Impact	-0.06'	<b>+0.18'</b>	-0.06'	<b>+0.18'</b>	-0.08'	<b>+0.17'</b>
Hendrum, MN Impact	-0.14'	<b>+0.21'</b>	-0.14'	<b>+0.21'</b>	-0.16'	<b>+0.20'</b>
Perley, MN Impact	-0.06'	<b>+0.11'</b>	-0.06'	<b>+0.11'</b>	-0.07'	<b>+0.11'</b>
Staging Area Elevation at Dam (Base/Change)	920.03 / N/A	<b>919.65 / -0.38'</b>	919.13 / N/A	<b>918.80 / -0.33'</b>	919.46 / N/A	<b>919.02 / -0.44'</b>



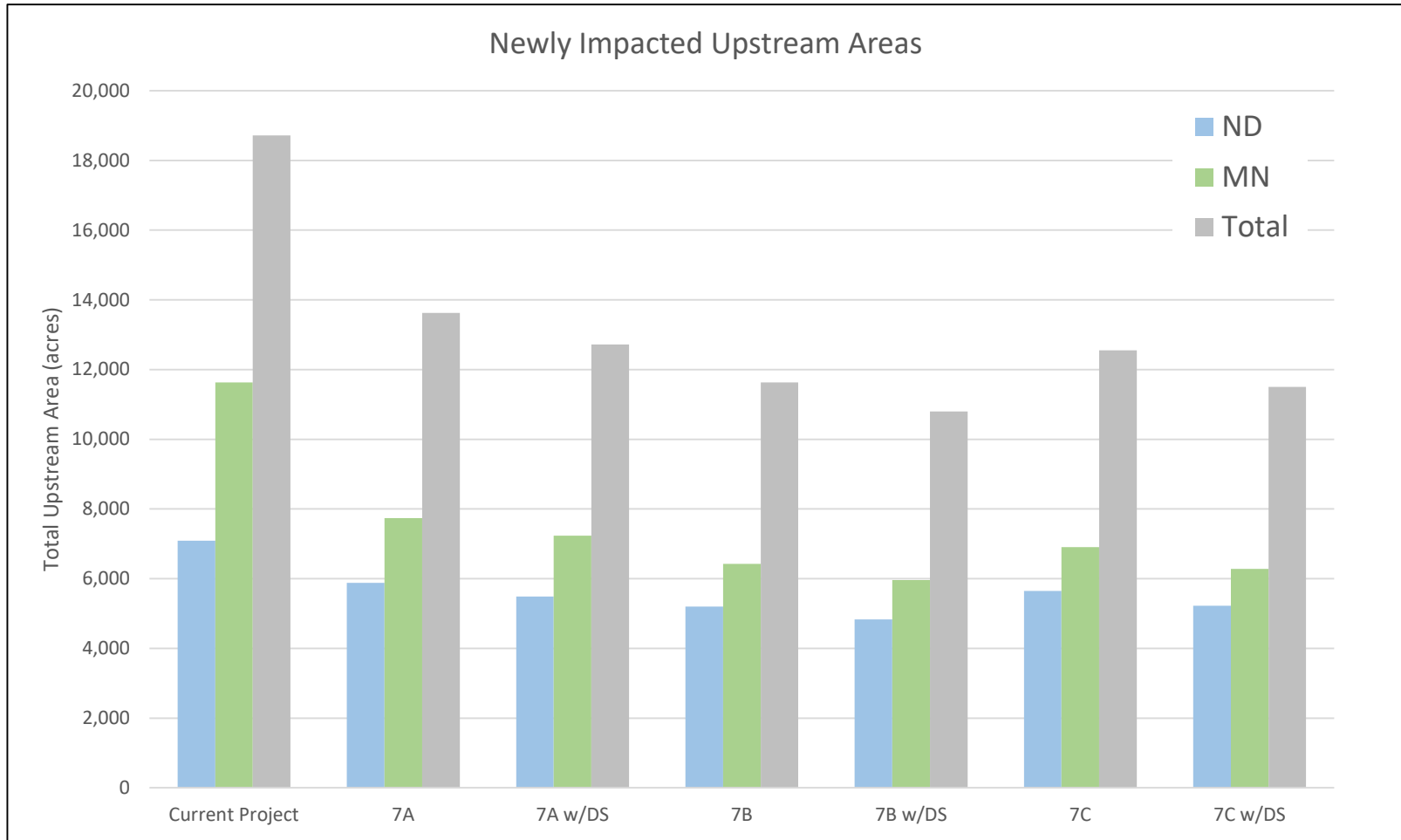
# Change Operation Plan to Allow up to 6 inches of Downstream Impacts (RS 37)

	7A	7A w/ DS	7B	7B w/ DS	7C	7C w/ DS
Total Impacted Upstream Area (acres)	32,563	<b>31,590</b>	32,003	<b>31,173</b>	32,722	<b>31,671</b>
Total Impacted Upstream Area – ND/MN (acres)	20,821 (64%) / 11,742 (36%)	<b>20,354</b> <b>(64%) /</b> <b>11,236</b> <b>(36%)</b>	21,572 (67%) / 10,430 (33%)	<b>21,206</b> <b>(68%) /</b> <b>9,968</b> <b>(32%)</b>	21,816 (67%) / 10,905 (33%)	<b>21,392</b> <b>(68%) /</b> <b>10,278</b> <b>(32%)</b>
Total Newly Impacted Upstream Area (acres)	13,623	<b>12,720</b>	11,627	<b>10,798</b>	12,556	<b>11,505</b>
Newly Impacted Upstream Area – ND/MN (acres)	5,885 (43%) / 7,739 (57%)	<b>5,487</b> <b>(43%) /</b> <b>7,233</b> <b>(57%)</b>	5,200 (45%) / 6,427 (55%)	<b>4,834</b> <b>(45%) /</b> <b>5,964</b> <b>(55%)</b>	5,651 (45%) / 6,904 (55%)	<b>5,227</b> <b>(45%) /</b> <b>6,278</b> <b>(55%)</b>
Newly Impacted Upstream Area – Richland/Wilkin (acres)	442 / 418	<b>416 /</b> <b>357</b>	299 / 200	<b>283 /</b> <b>191</b>	337 / 239	<b>310 /</b> <b>216</b>
Total Area Protected (acres)	50,491	<b>50,401</b>	48,562	<b>48,471</b>	50,810	<b>50,715</b>
Protected Area (acres - ND/MN)	41,005 (81%) / 9,486 (19%)	<b>40,921</b> <b>(81%) /</b> <b>9,480</b> <b>(19%)</b>	39,074 (80%) / 9,488 (20%)	<b>38,990</b> <b>(80%) /</b> <b>9,481</b> <b>(20%)</b>	41,313 (81%) / 9,498 (19%)	<b>41,222</b> <b>(81%) /</b> <b>9,493</b> <b>(19%)</b>

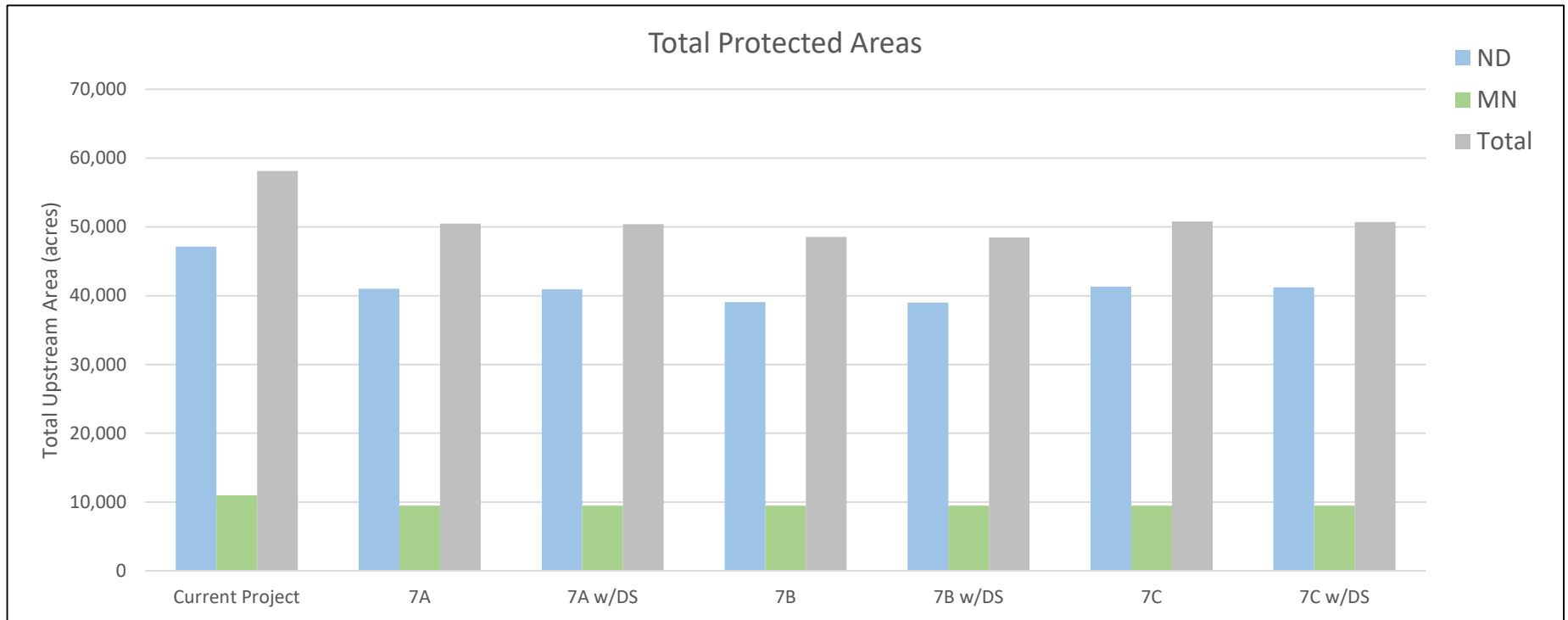
# Change Operation Plan to Allow up to 6 inches of Downstream Impacts (RS 37)



# Change Operation Plan to Allow up to 6 inches of Downstream Impacts (RS 37)



# Change Operation Plan to Allow up to 6 inches of Downstream Impacts (RS 37)



# Change Operation Plan to Allow up to 6 inches of Downstream Impacts (RS 37)

	7A	7A w/ DS	7B	7B w/ DS	7C	7C w/ DS
Total Upstream Residential Structures Impacted (Existing/with-Project)	21 / 74	21 / 74	24 / 82	24 / 80	23 / 89	23 / 87
Upstream Residential Structures Impacted – Richland (Existing/with-Project)	0 / 2	0 / 2	0 / 1	0 / 1	0 / 2	0 / 1
Upstream Residential Structures Impacted – Wilkin (Existing/with-Project)	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2
Upstream Residential Structures Impacted - Cass (Existing/with-Project)	17 / 53	17 / 53	20 / 63	20 / 62	19 / 67	19 / 66
Upstream Residential Structures Impacted – Clay (Existing/with-Project)	2 / 17	2 / 17	2 / 16	2 / 15	2 / 18	2 / 18

# **Change Operation Plan to Allow up to 6 inches of Downstream Impacts**

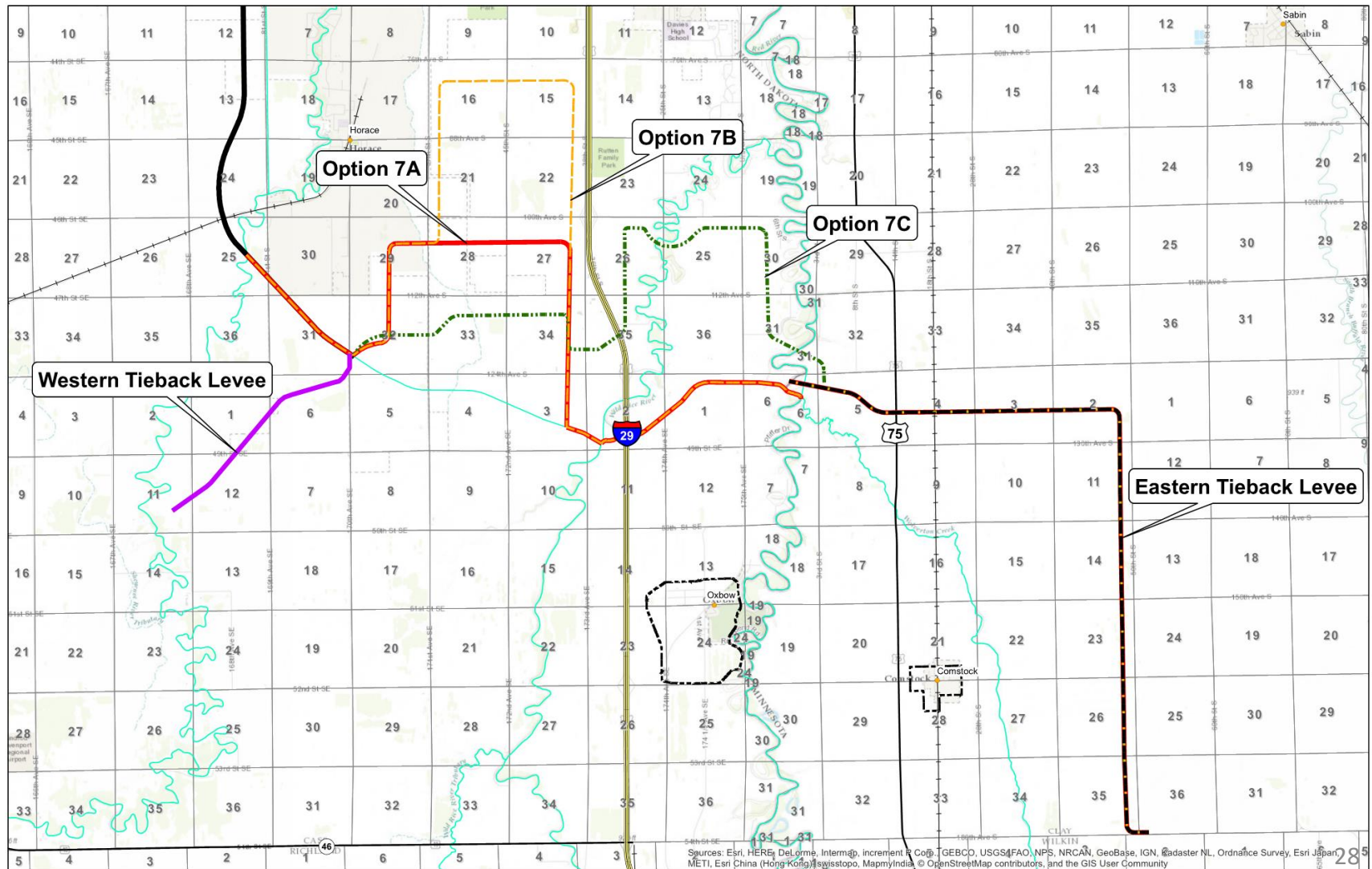
- Operational Component that could be applied to Alternatives 7A, 7B, and 7C
- Some impact may extend beyond the U.S./Canadian border
- Generally reduces maximum staging elevation by 0.3 to 0.4 feet
- Cost depends on level of downstream mitigation required



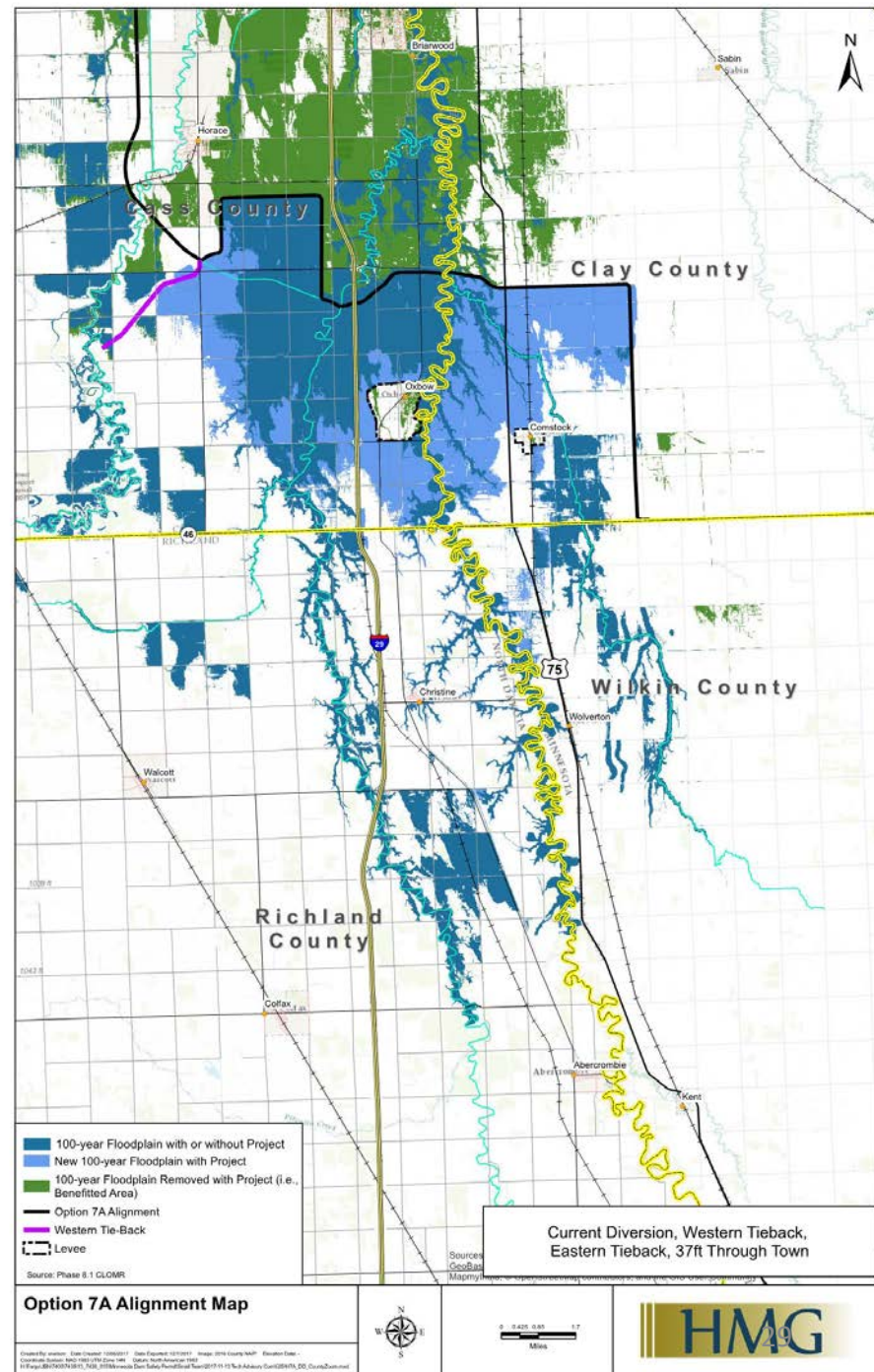
# Summary

- **Western Tie Back Levee – Yes**
- **Eastern Tie Back – Yes**
- **Northern Storage/Diversion Channel Alignment – Neutral**
- **Additional Flows Through Town**
  - RS 35 feet
  - RS 37 feet - Yes
  - RS 38 feet
  - RS 39 feet
- **Allow Downstream Impacts up to 6 inches – Policy/Permit Decision**
- **Change Location of Dam/Southern Embankment**
  - Option 7A
  - Option 7B
  - Option 7C

# Options 7A, 7B, 7C: Dam Alignments

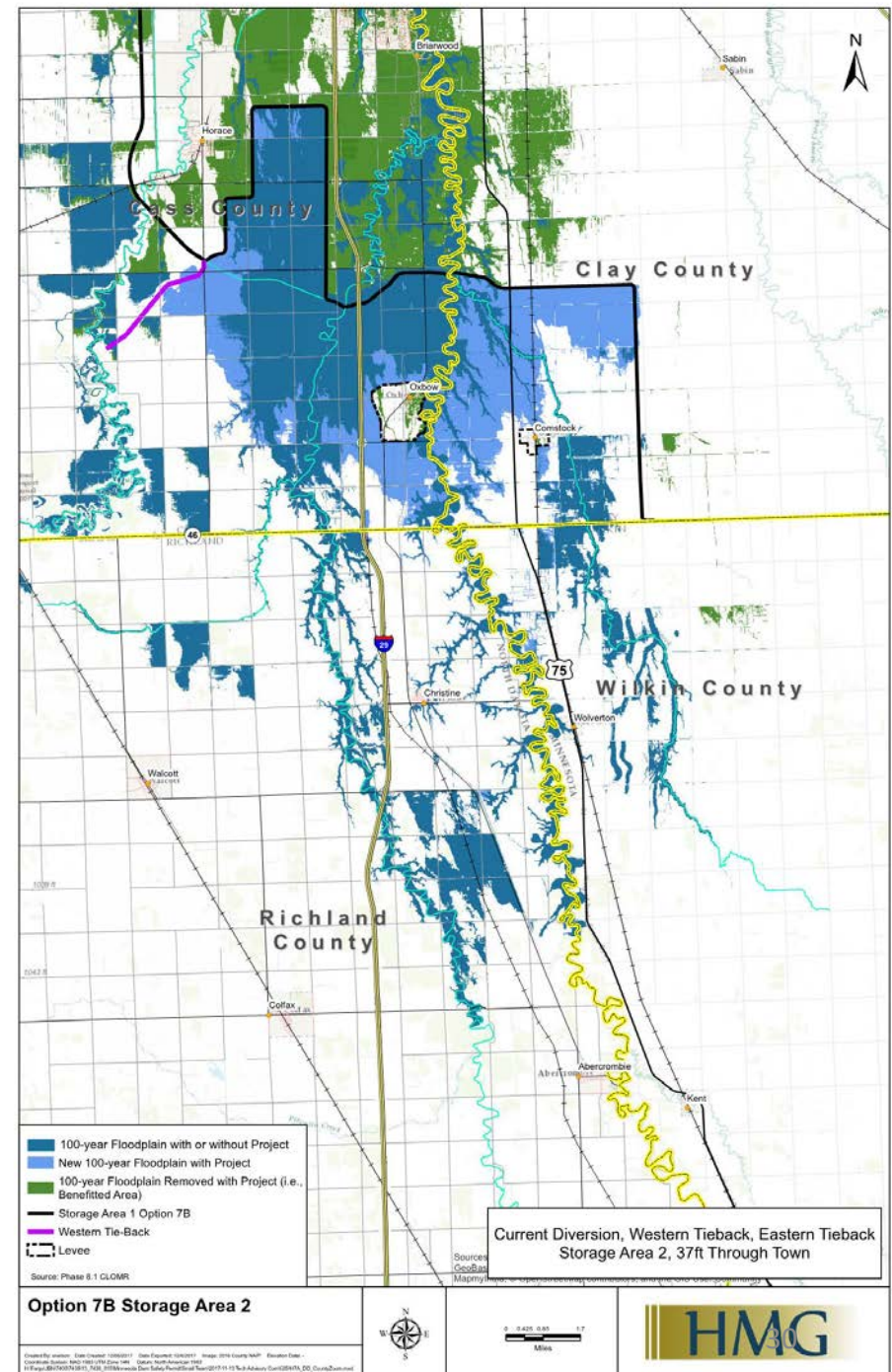


# Option 7A

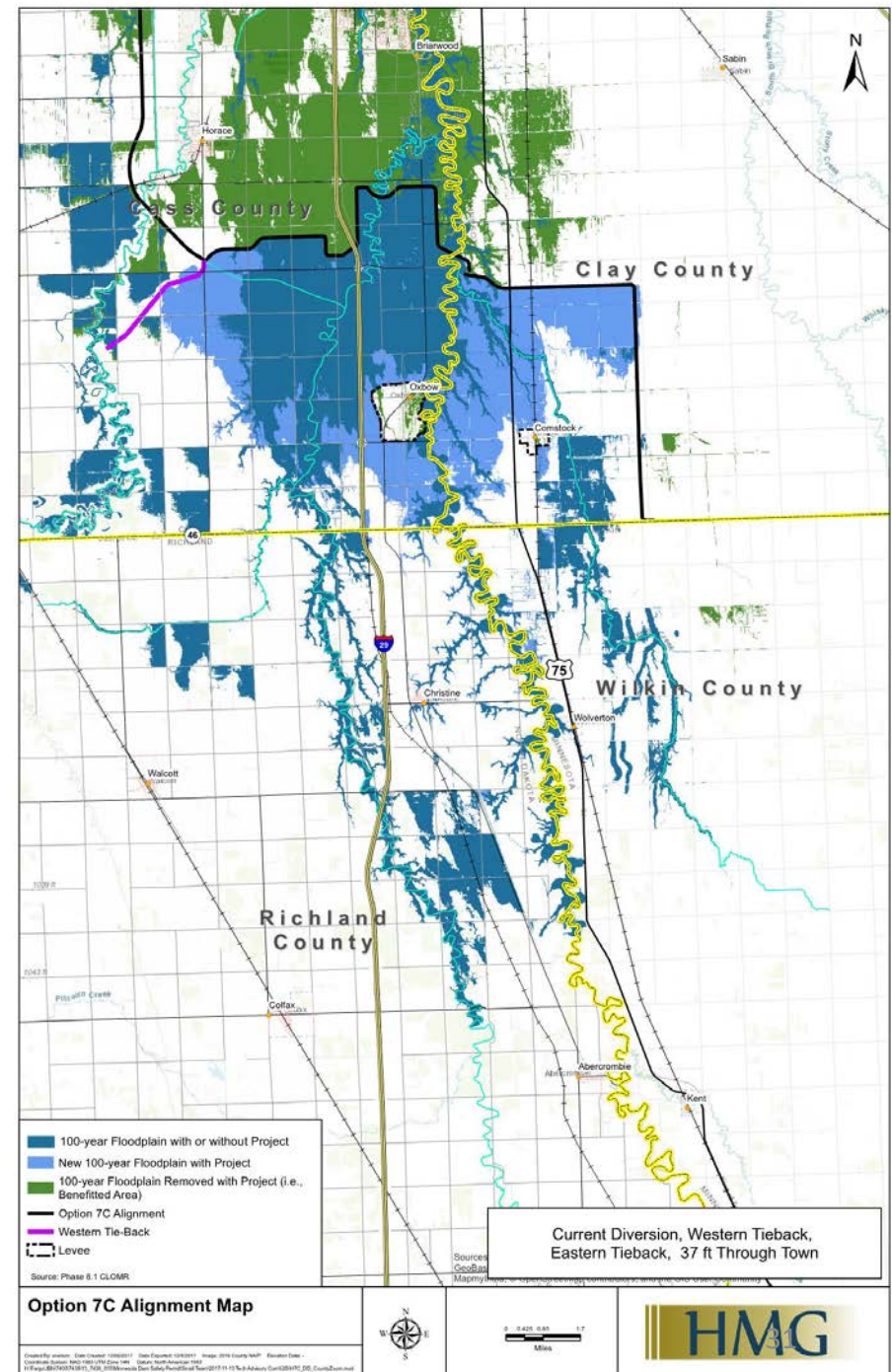




# Option 7B



# Option 7C

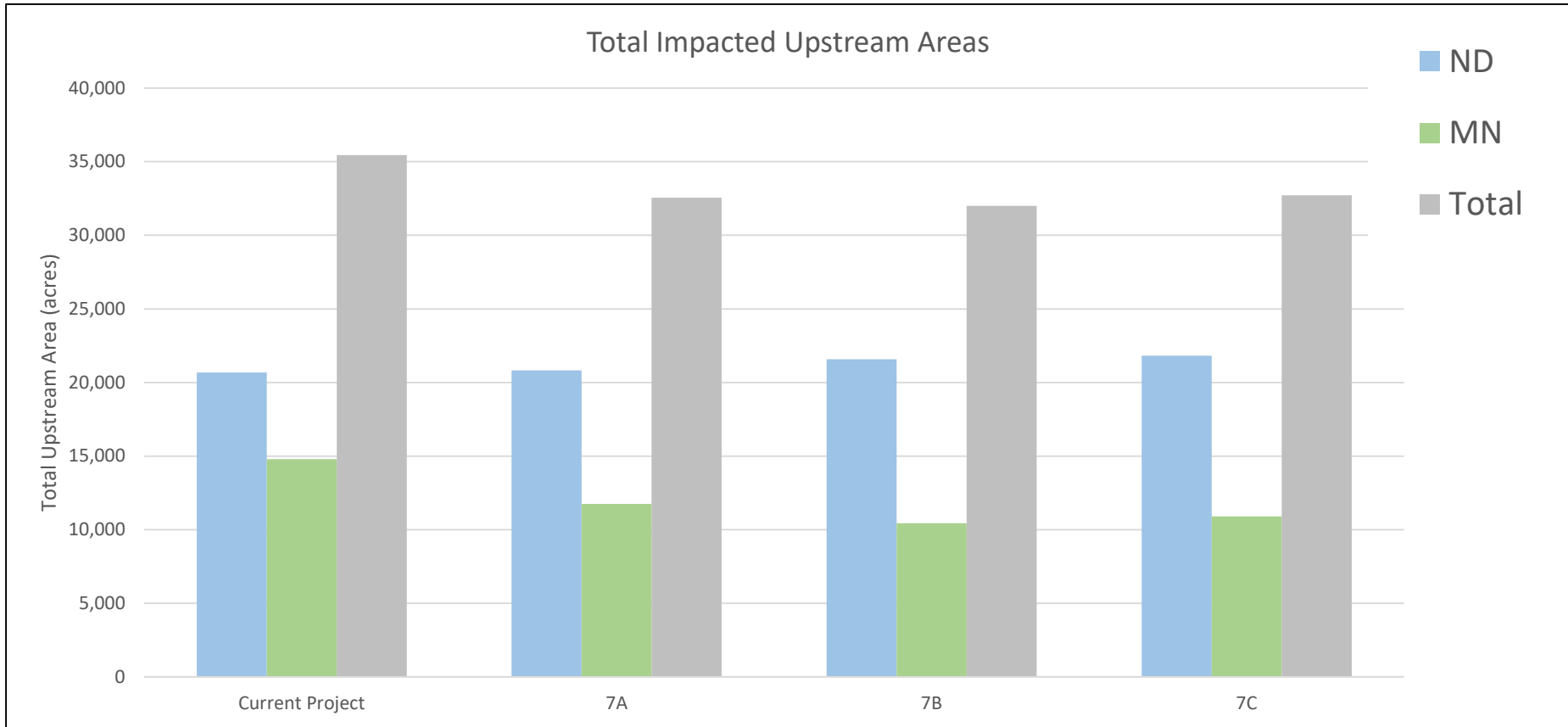


# Options 7A, 7B, 7C (RS37)

	Proposed (Baseline)	7A	7B	7C
Total Impacted Upstream Area (acres)	35,456	32,563	32,003	32,722
Total Impacted Upstream Area – ND/MN (acres)	20,676 (58%) / 14,780 (42%)	20,821 (64%) / 11,742 (36%)	21,572 (67%) / 10,430 (33%)	21,816 (67%) / 10,905 (33%)
Total Newly Impacted Upstream Area (acres)	18,720	13,623	11,627	12,556
Newly Impacted Upstream Area – ND/MN (acres)	7,088 (37%) / 11,631 (63%)	5,885 (43%) / 7,739 (57%)	5,200 (45%) / 6,427 (55%)	5,651 (45%) / 6,904 (55%)
Newly Impacted Upstream Area – Richland/Wilkin (acres)	1,124 / 1,391	442 / 418	299 / 200	337 / 239
Total Area Protected (acres)	58,137	50,491	48,562	50,810
Protected Area (acres - ND/MN)	47,145 (81%) / 10,992 (19%)	41,005 (81%) / 9,486 (19%)	39,074 (80%) / 9,488 (20%)	41,313 (81%) / 9,498 (19%)

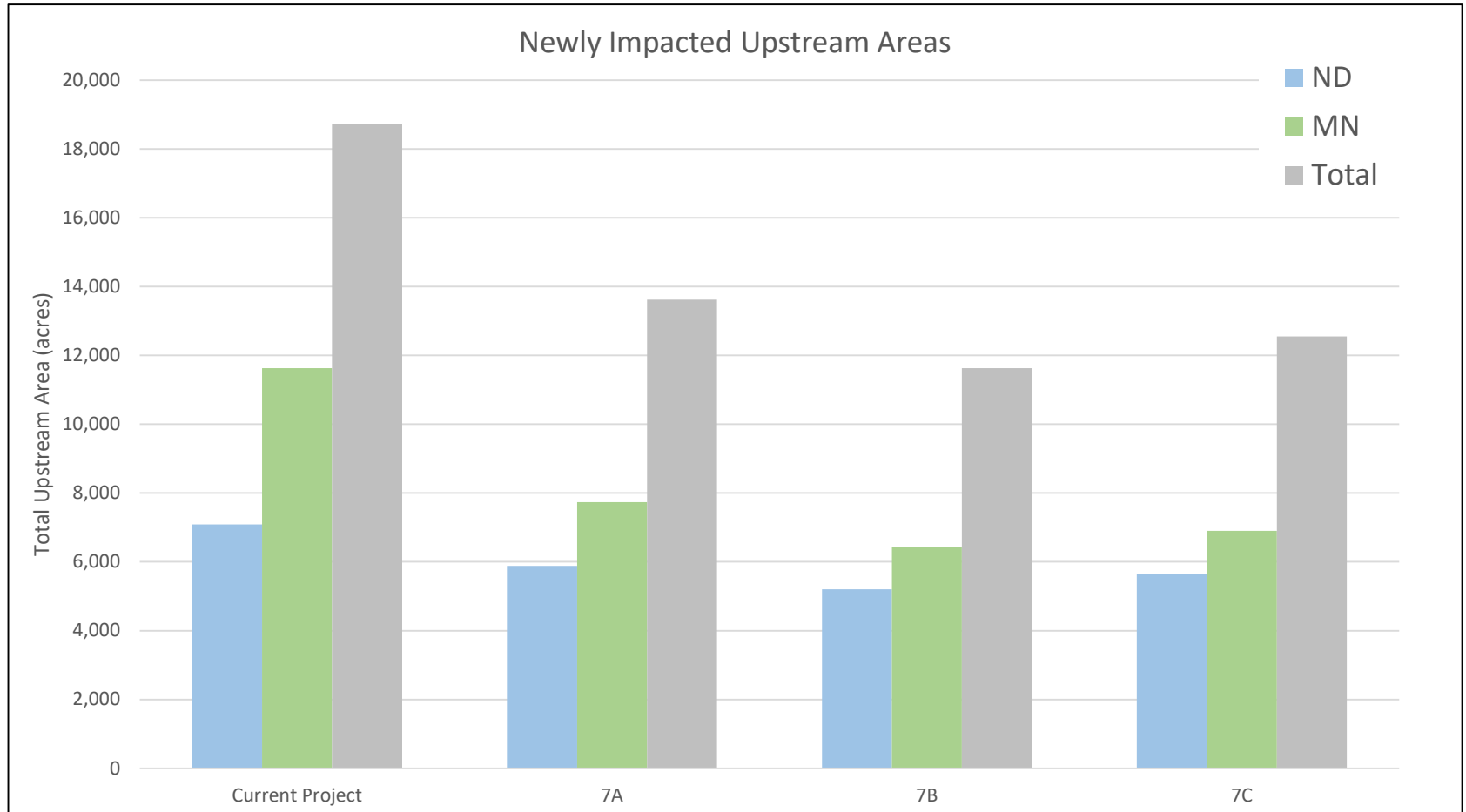


# Options 7A, 7B, 7C (RS37)

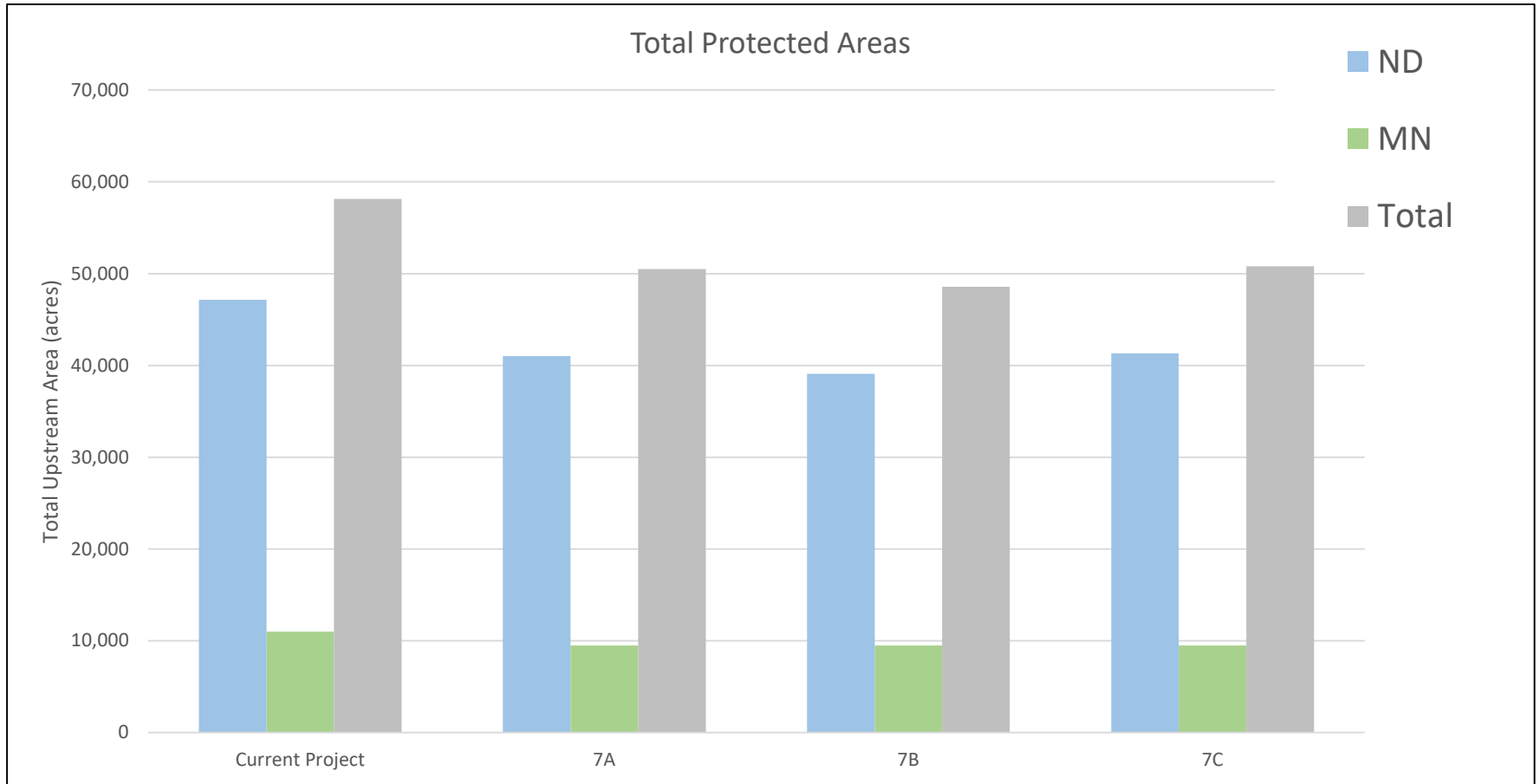


\* In addition to acreages shown, there are approximately 8,000 acres in North Dakota and 500 acres in Minnesota that are located under the footprint of the diversion channel and dam and would be impacted by the Project.

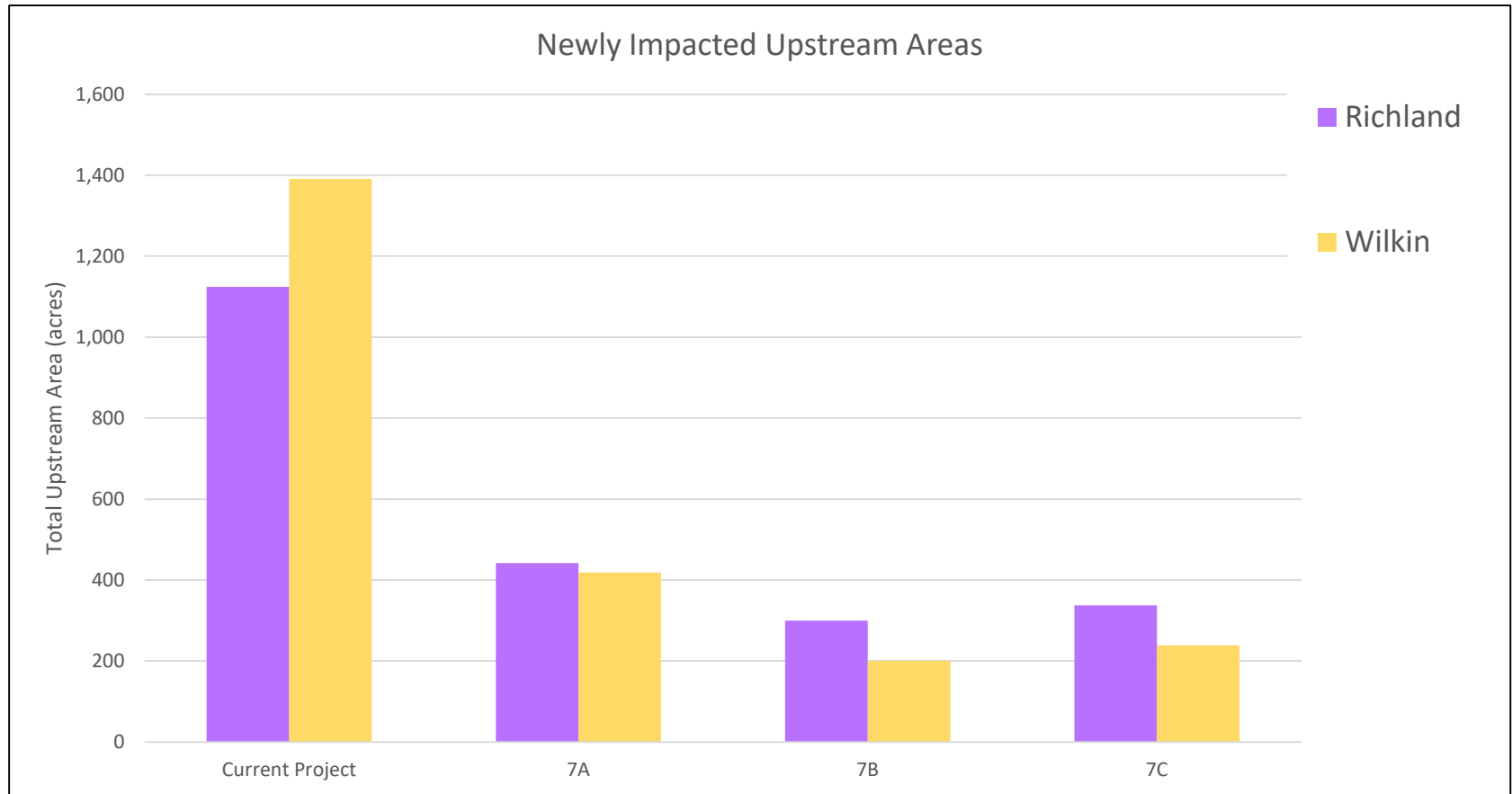
# Options 7A, 7B, 7C (RS37)



# Options 7A, 7B, 7C (RS37)



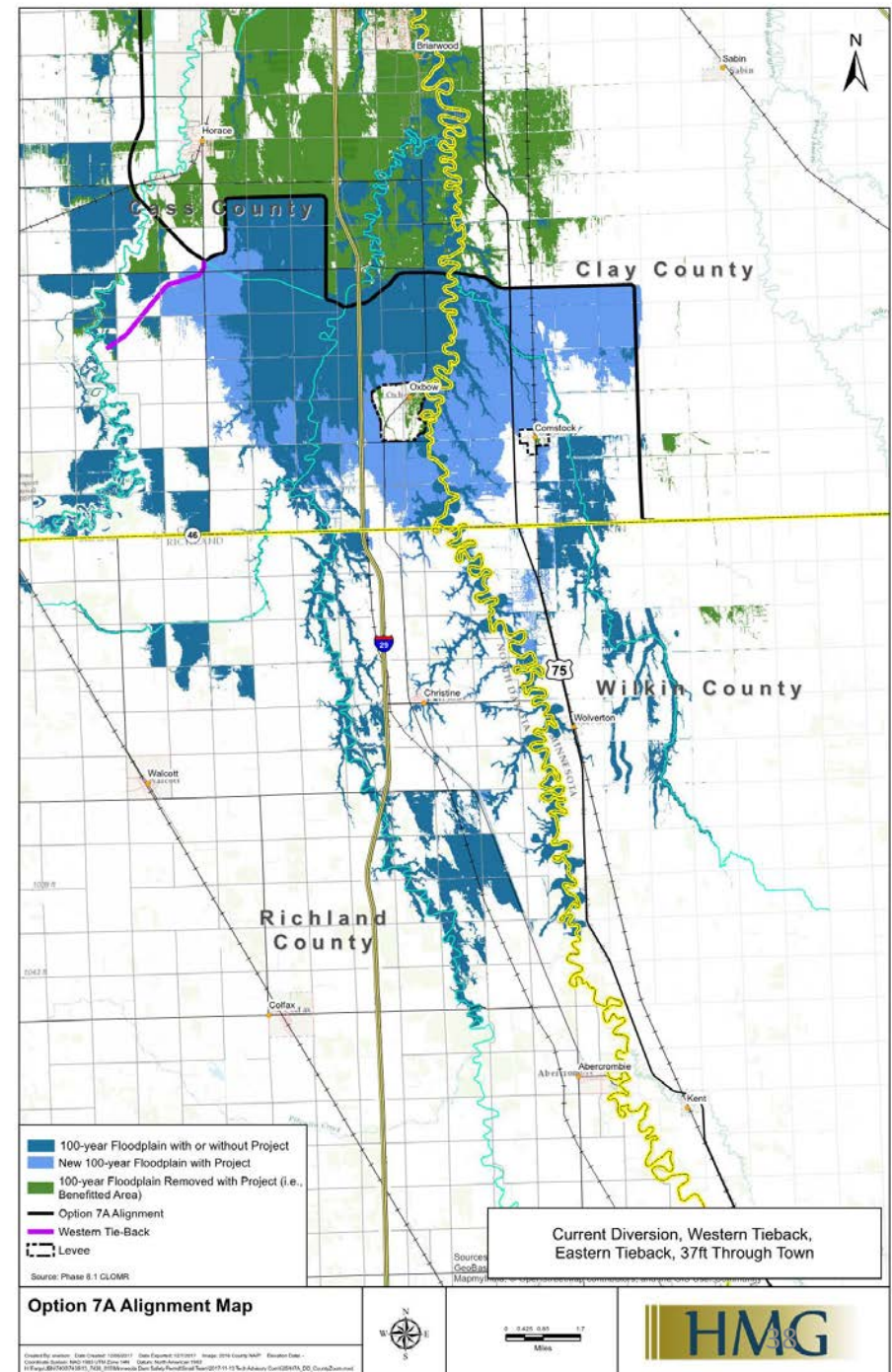
# Options 7A, 7B, 7C (RS37)



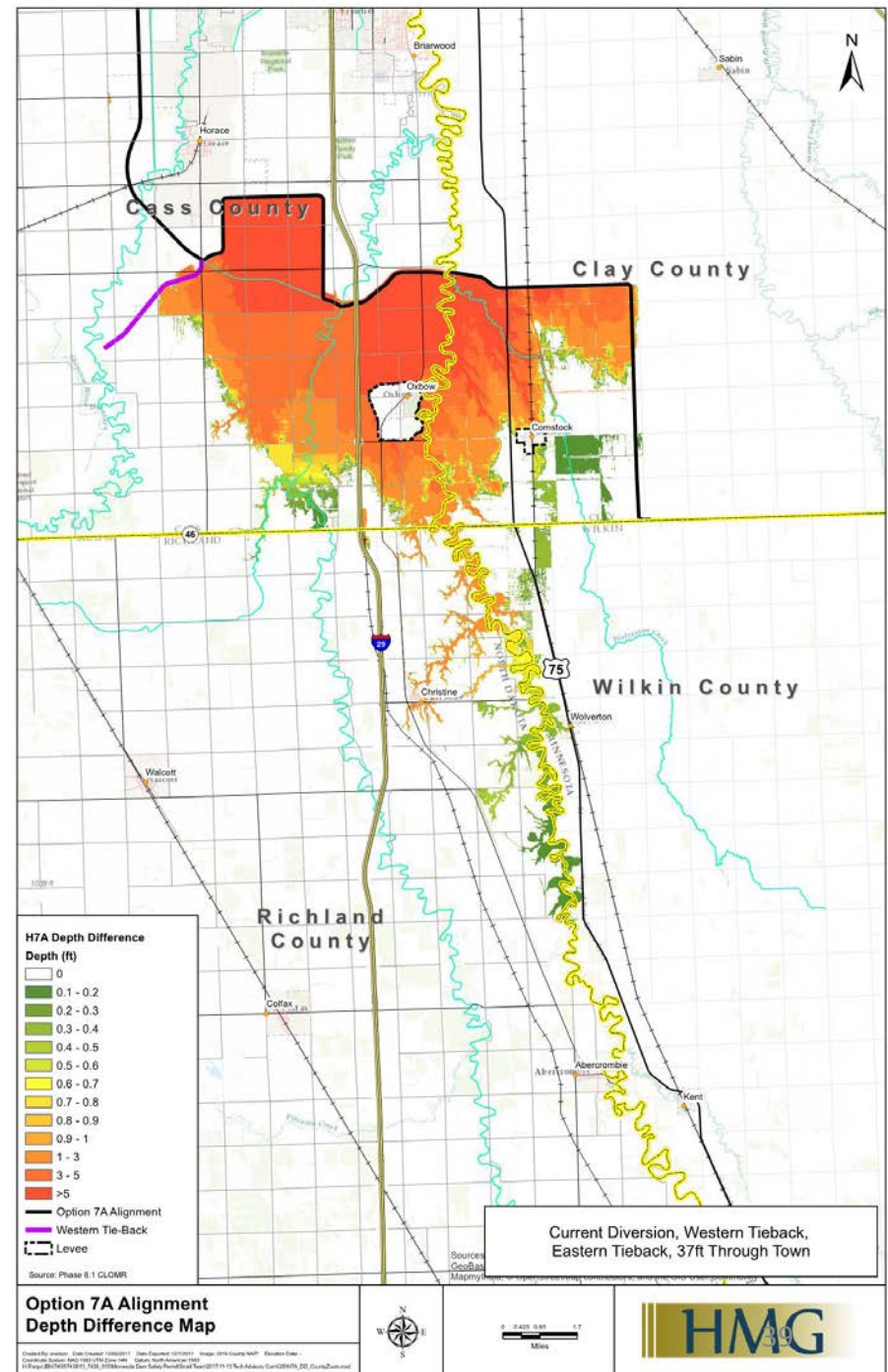
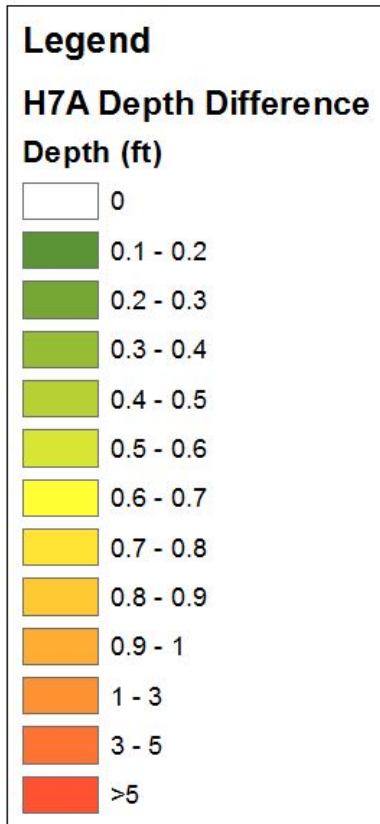
# Options 7A, 7B, 7C (RS37)

	Proposed (Baseline)	7A	7B	7C
Total Upstream Residential Structures Impacted (Existing/with-Project)	12 / 69	21 / 74	24 / 82	23 / 89
Upstream Residential Structures Impacted – Richland (Existing/with-Project)	0 / 3	0 / 2	0 / 1	0 / 2
Upstream Residential Structures Impacted – Wilkin (Existing/with-Project)	2 / 5	2 / 2	2 / 2	2 / 2
Upstream Residential Structures Impacted - Cass (Existing/with-Project)	9 / 41	17 / 53	20 / 63	19 / 67
Upstream Residential Structures Impacted – Clay (Existing/with-Project)	1 / 20	2 / 17	2 / 16	2 / 18
Length of Dam (miles)	12.8	19.6	23.7	19.6

# Option 7A

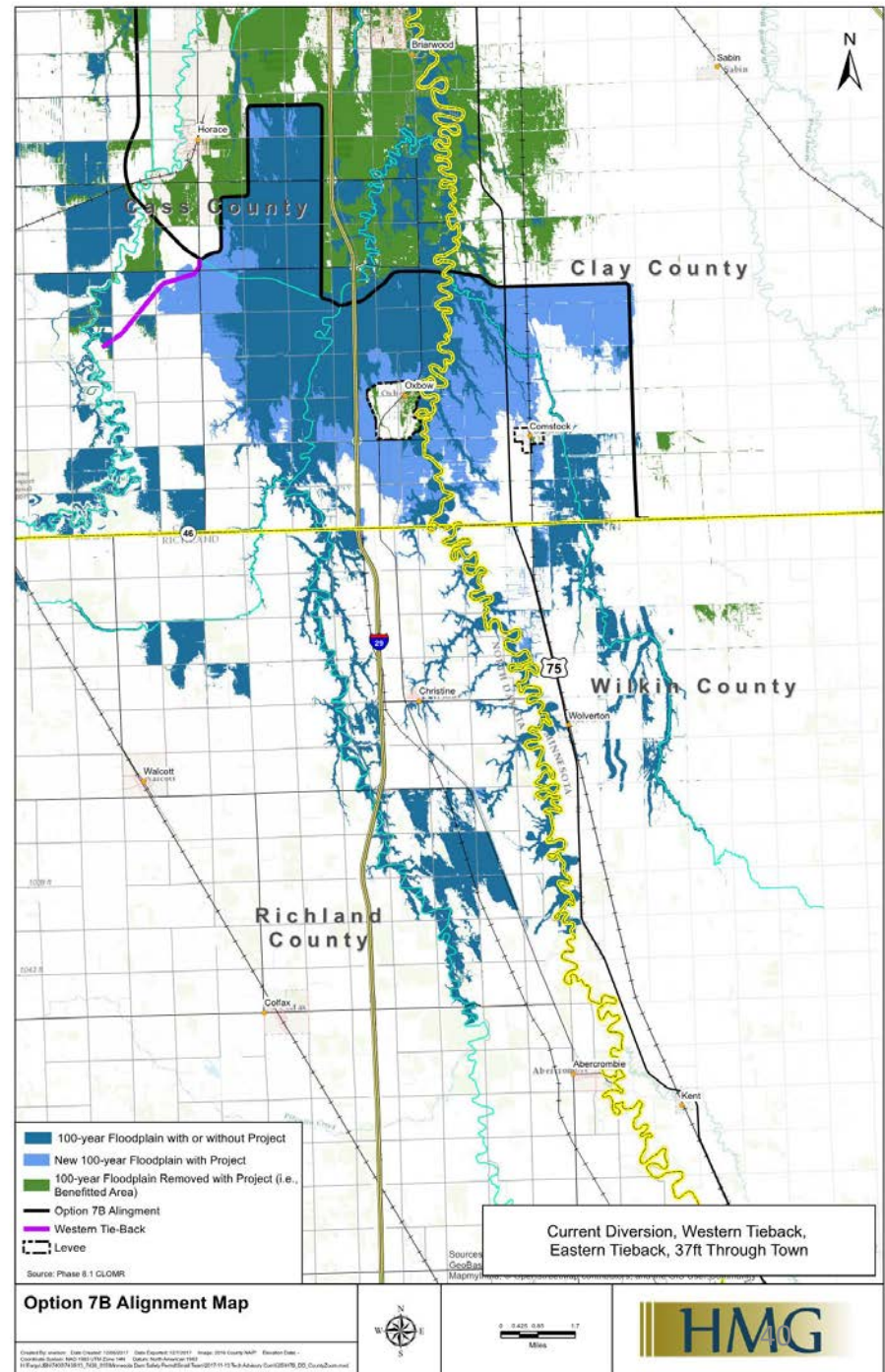


# Option 7A – Additional Depth





# Option 7B

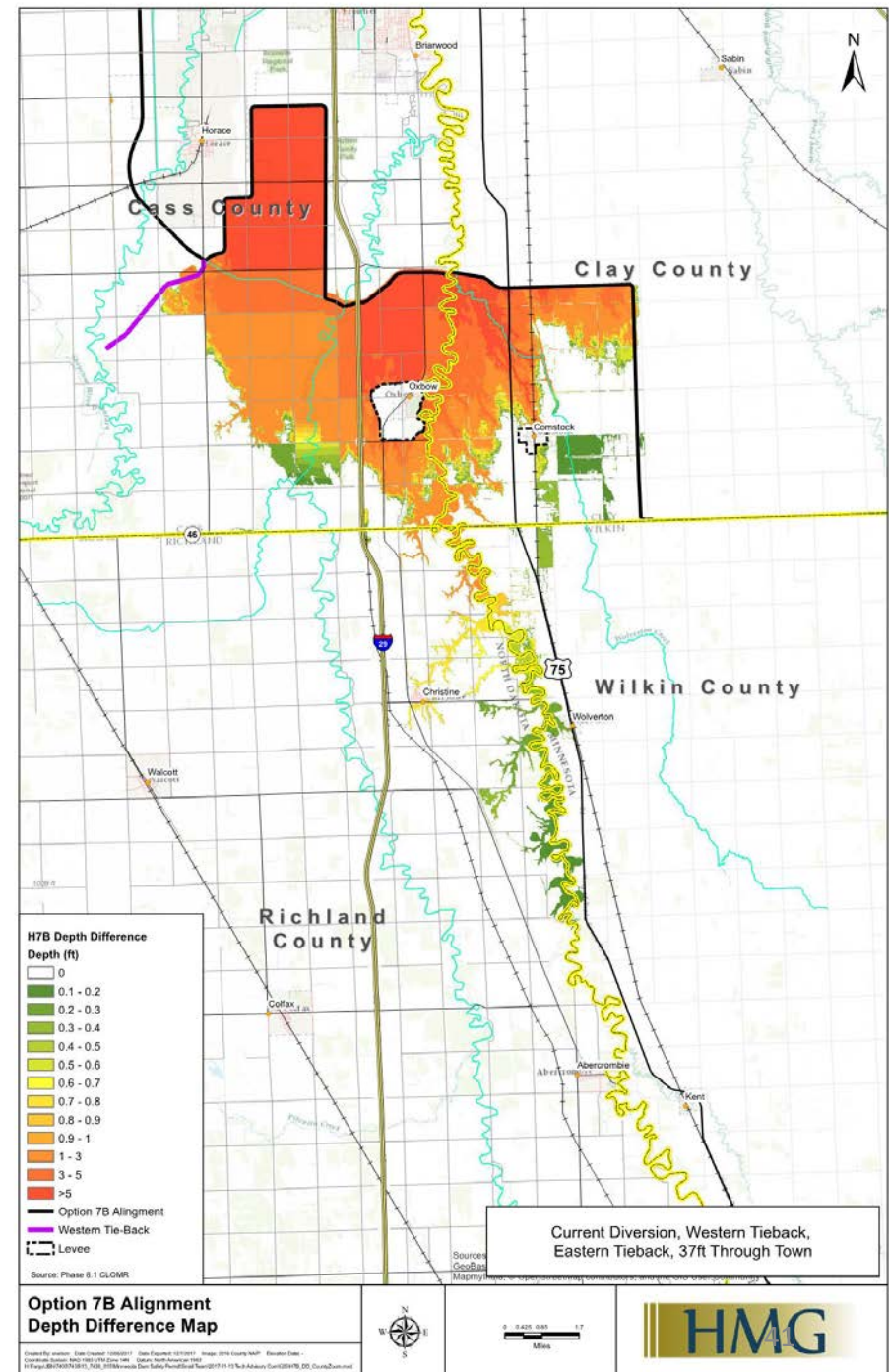
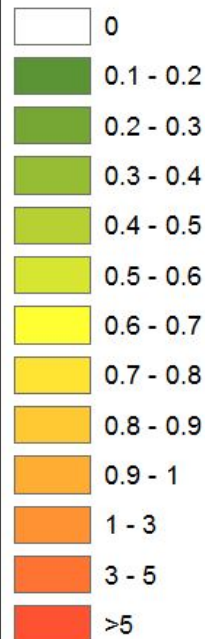




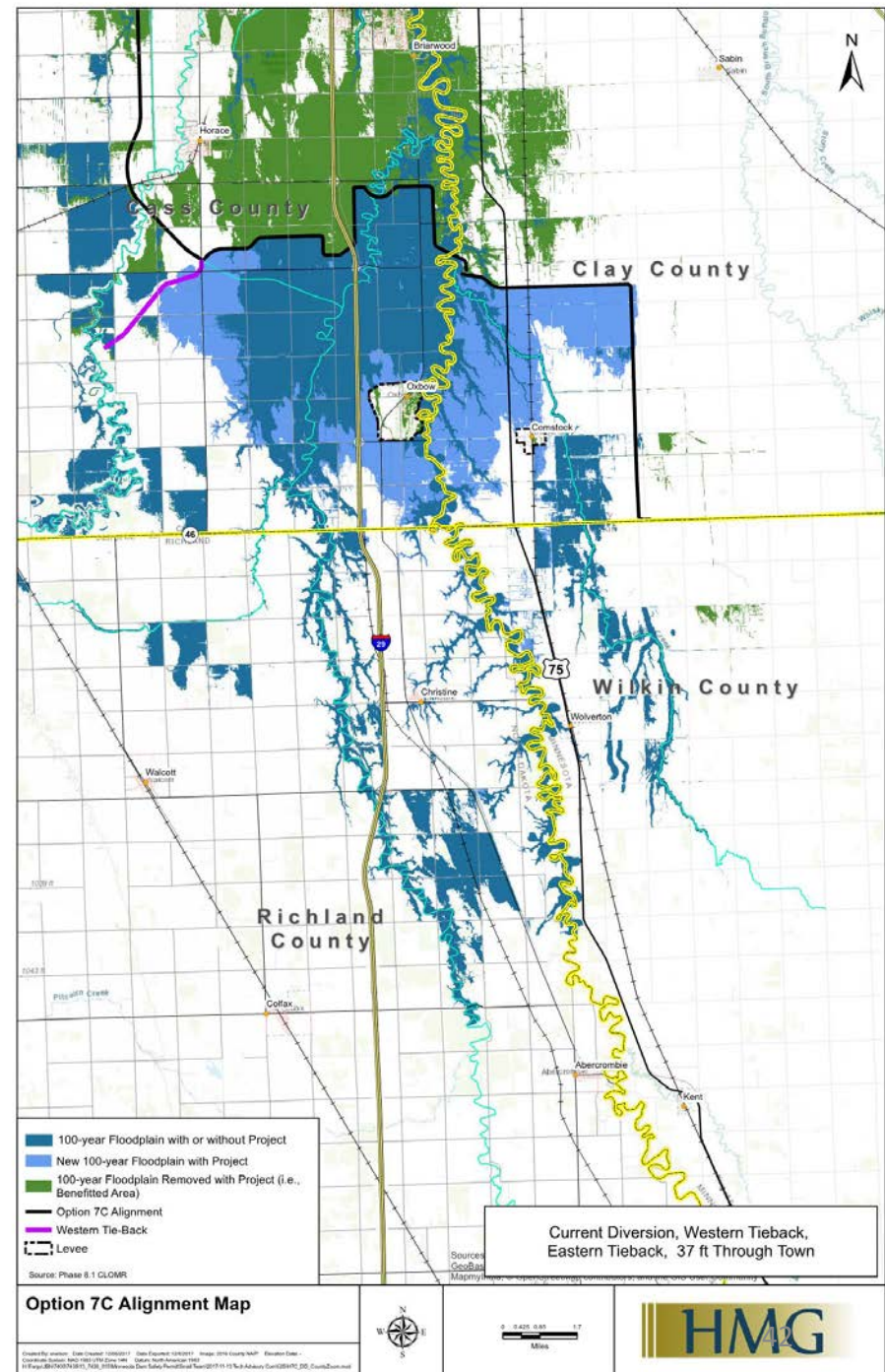
# Option 7B – Additional Depth

## Legend

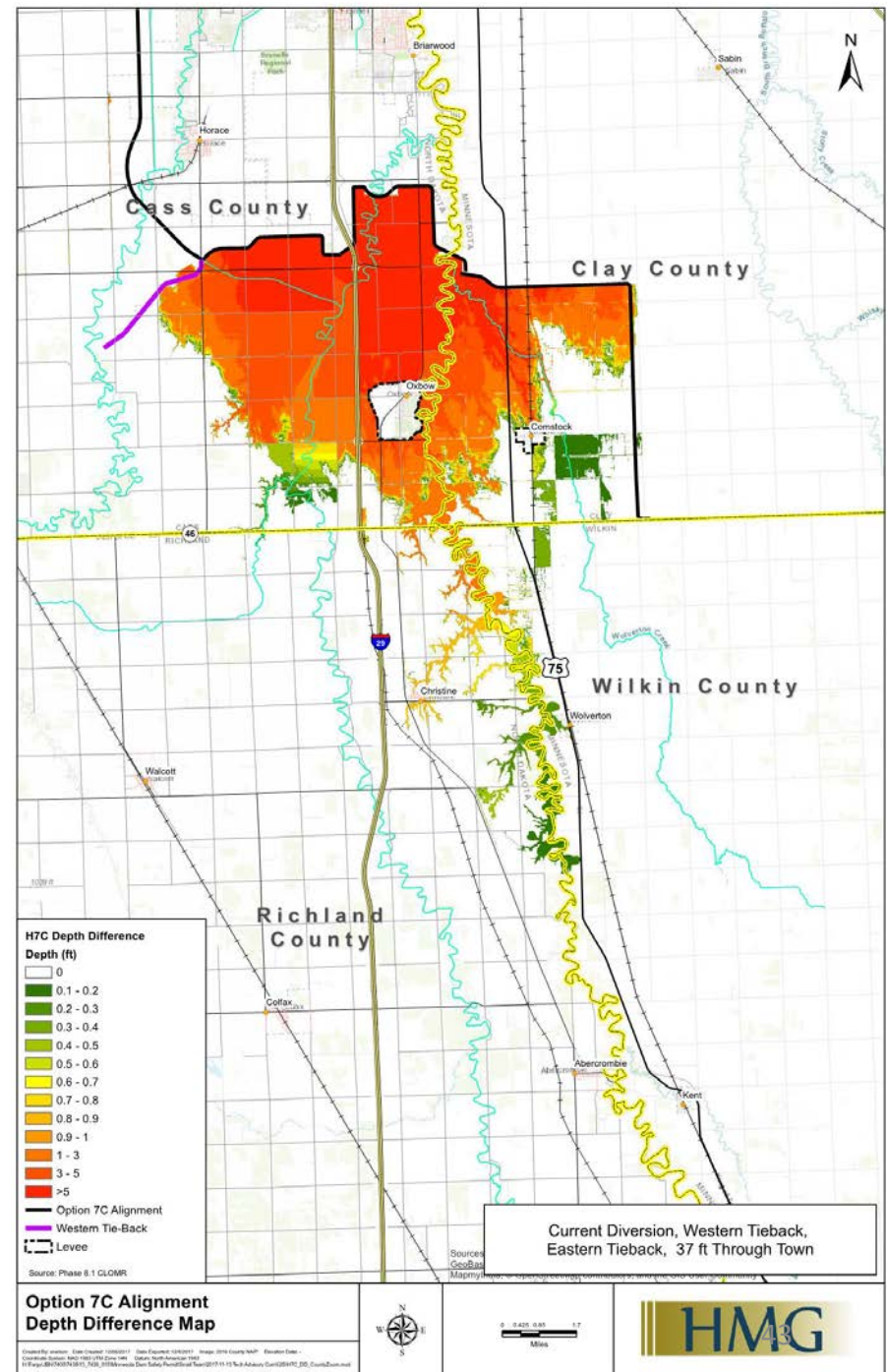
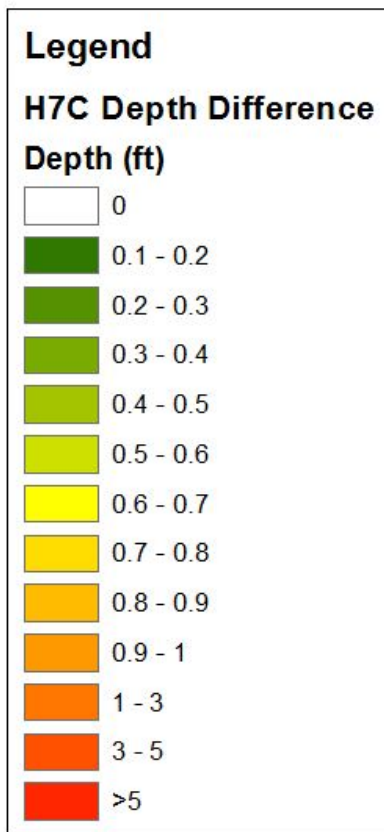
### H7B Depth Difference Depth (ft)



# Option 7C



# Option 7C – Additional Depth



# Options 7A, 7B, 7C (RS37) – Estimated Additional Cost Summary (\$ millions)

	7A	7B	7C
Western Tie-Back Levee	4	4	4
Eastern Tie-Back	15	15	15
Additional Flows Through Town (RS37')	150	150	150
Change Location of Dam	135	270	180
Total	304	439	349
Potential Cost Reductions (Lower grade raises, Comstock Ring Levee, etc.)	TBD	TBD	TBD

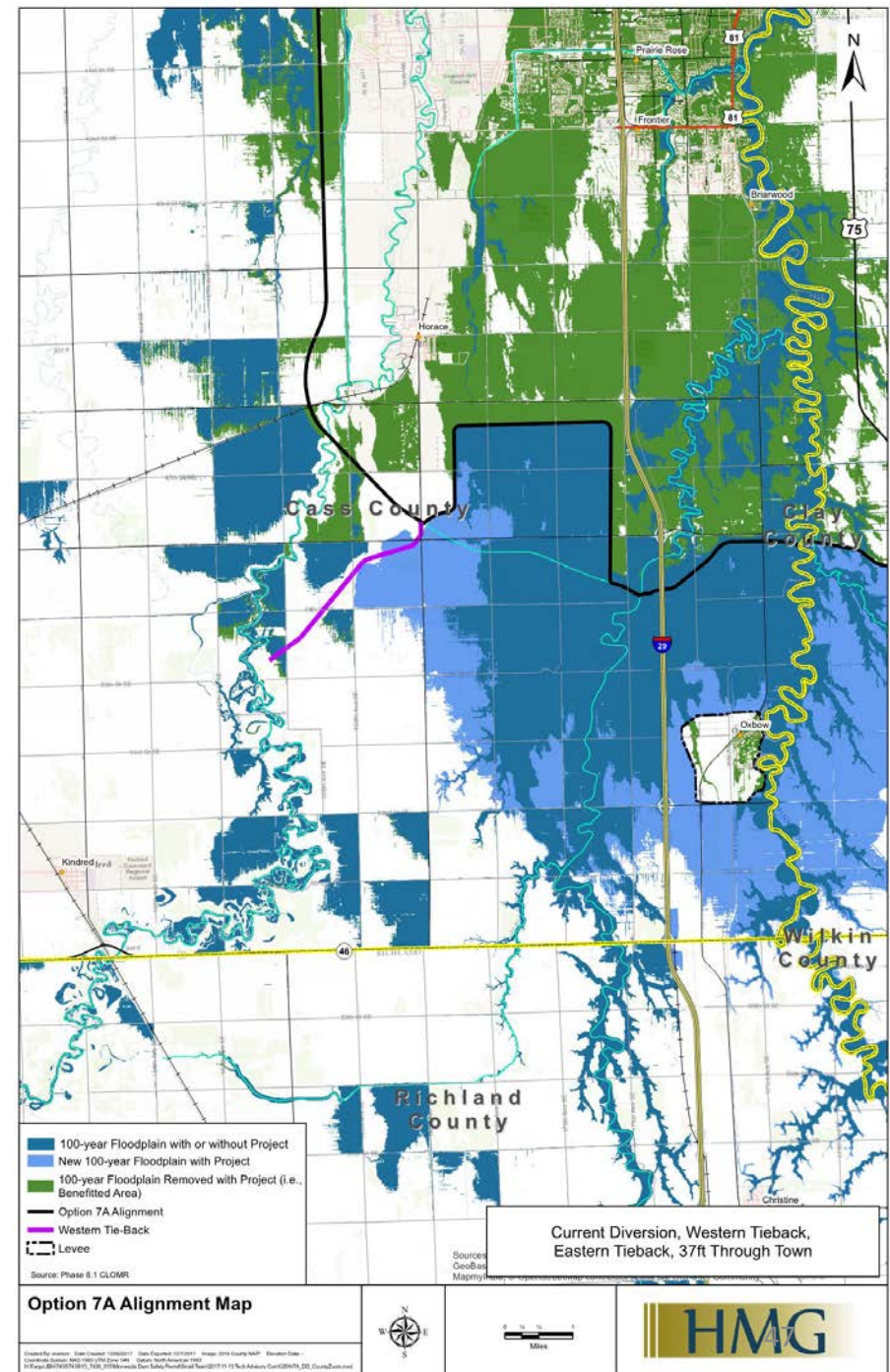


# Summary

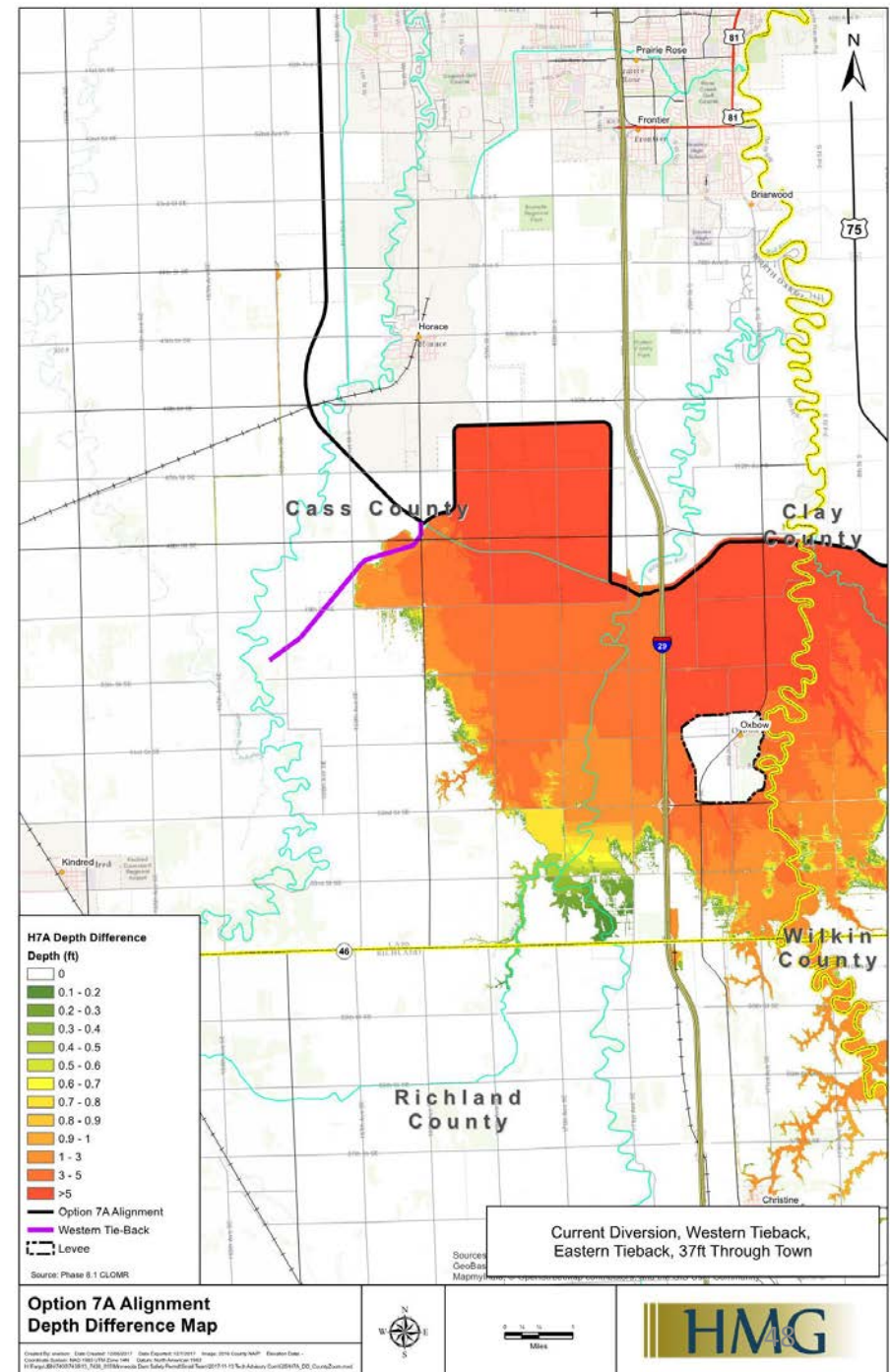
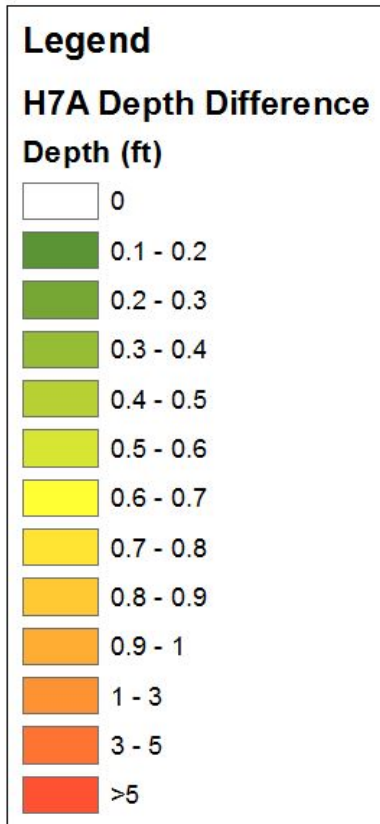
- Western Tie Back Levee – Yes
- Eastern Tie Back – Yes
- Northern Storage/Diversion Channel Alignment – Neutral
- Additional Flows Through Town
  - RS 35 feet
  - RS 37 feet - Yes
  - RS 38 feet
  - RS 39 feet
- Allow Downstream Impacts up to 6 inches – Policy/Permit Decision
- **Change Location of Dam/Southern Embankment**
  - **Option 7A**
  - **Option 7B**
  - **Option 7C**

# Discussion

# Option 7A – Cass County



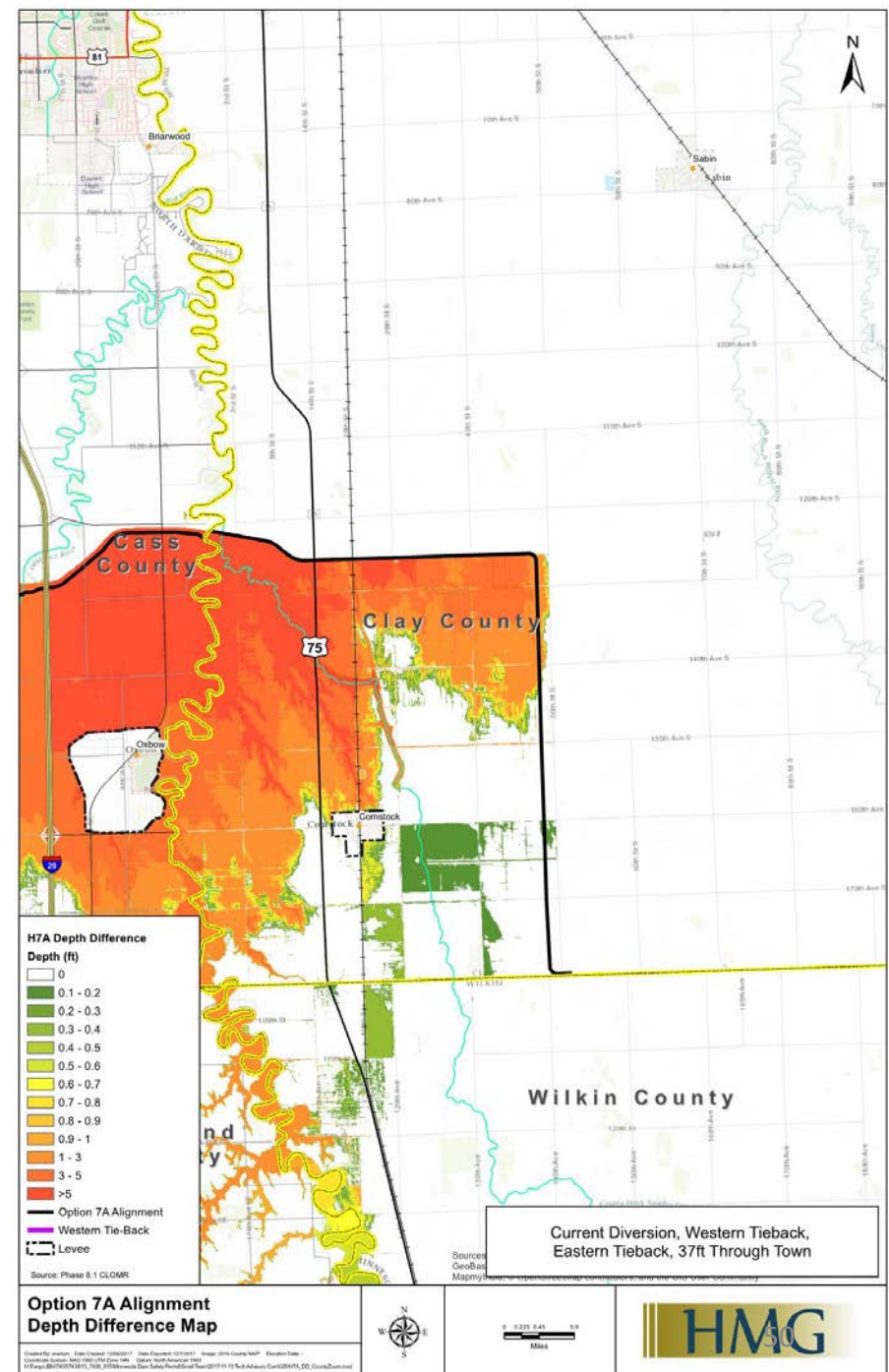
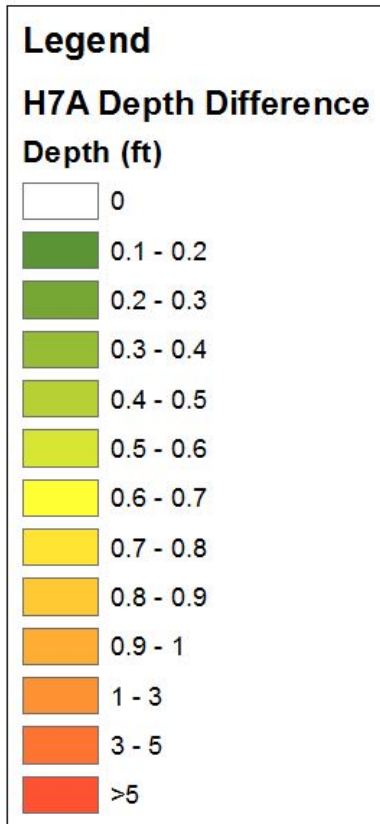
# Option 7A – Cass County Additional Depth



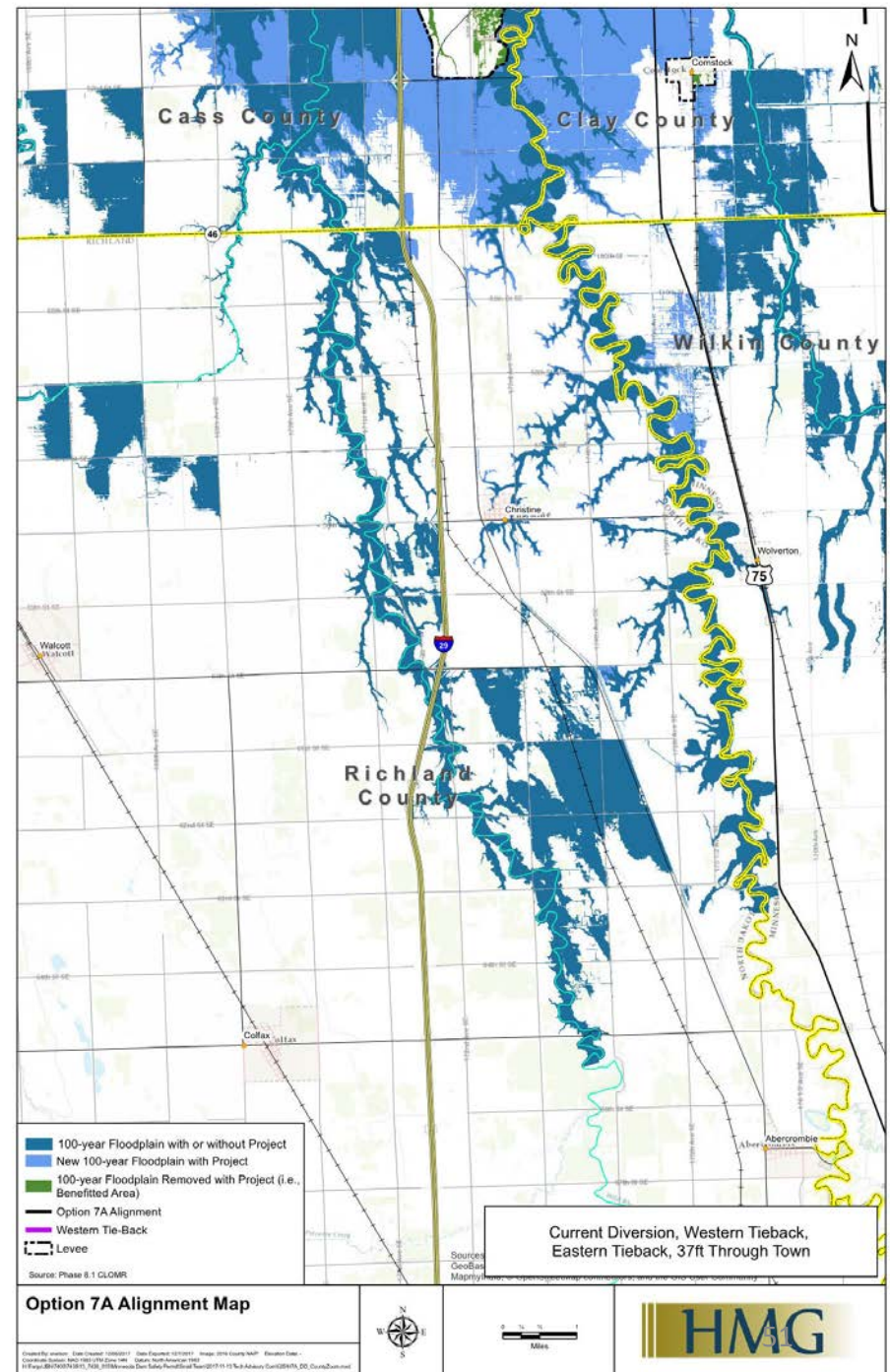


[illegible]

# Option 7A – Clay County Additional Depth

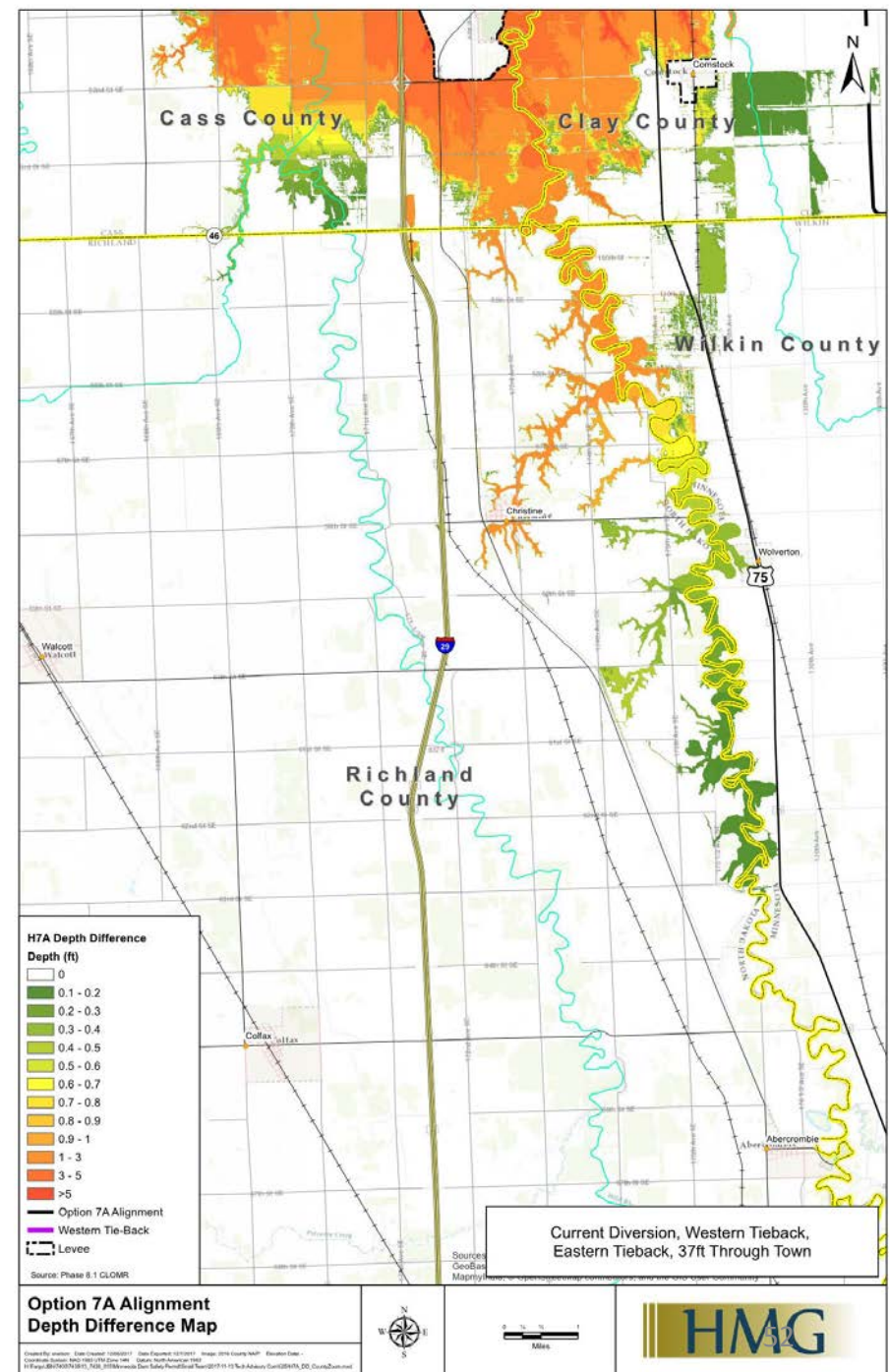
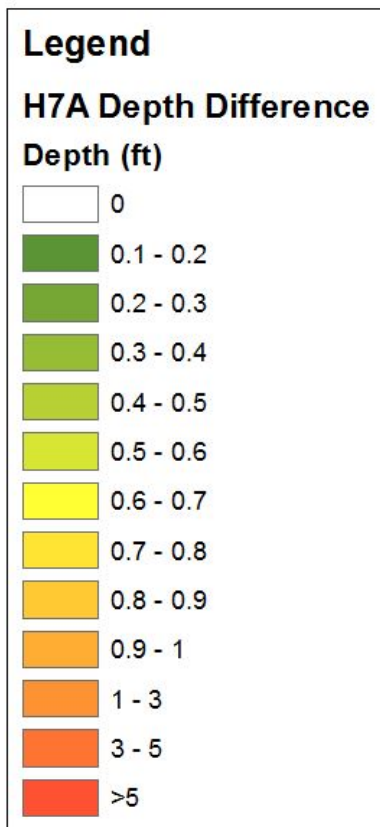


# Option 7A – Richland County

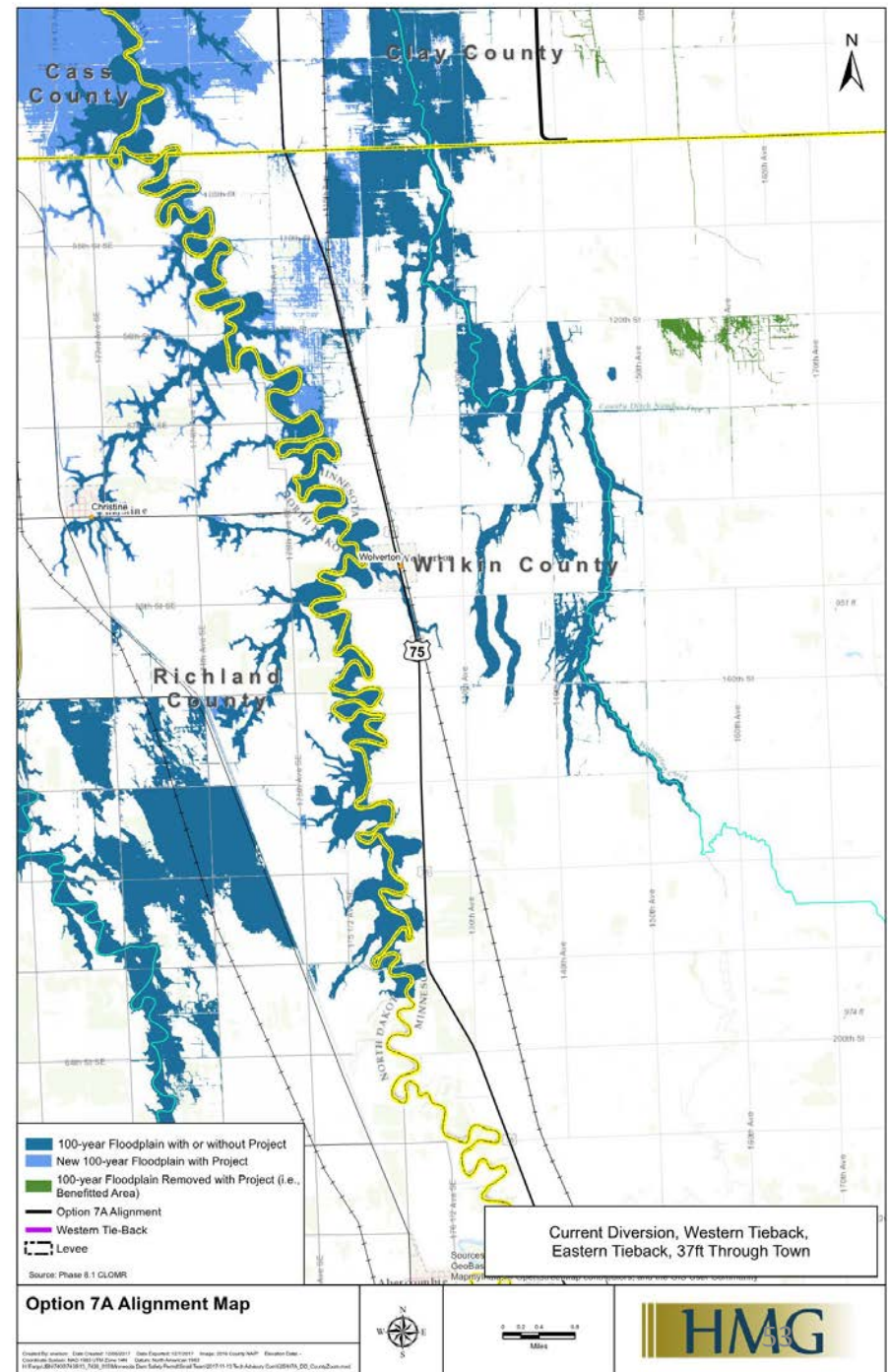




# Option 7A – Richland County Additional Depth

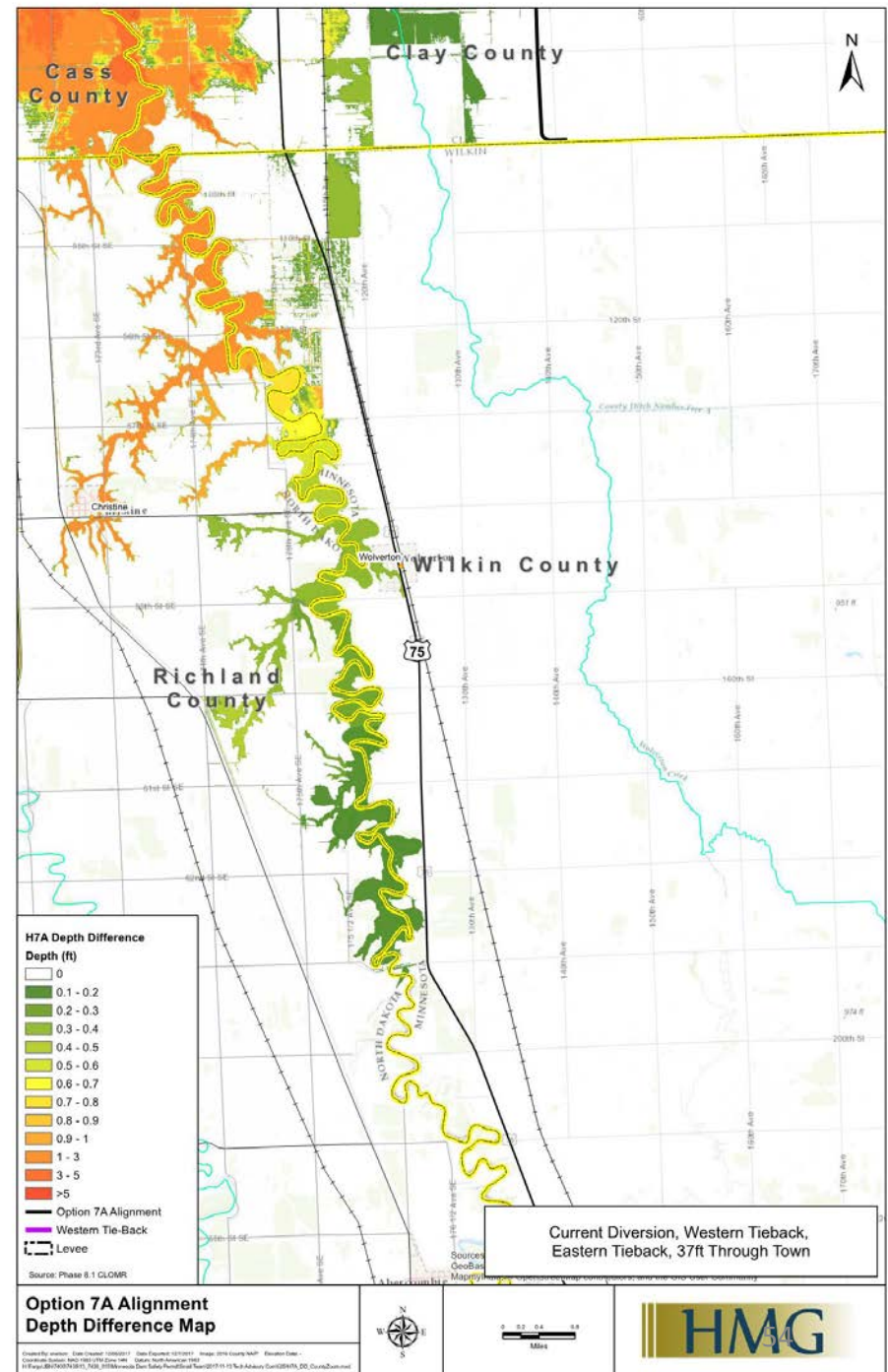
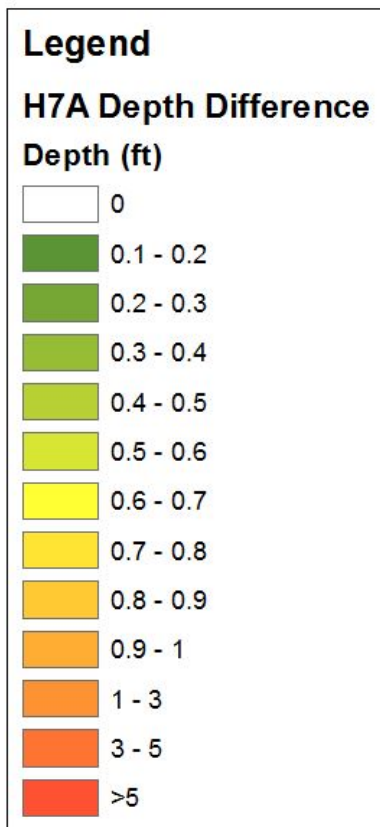


# Option 7A – Wilkin County

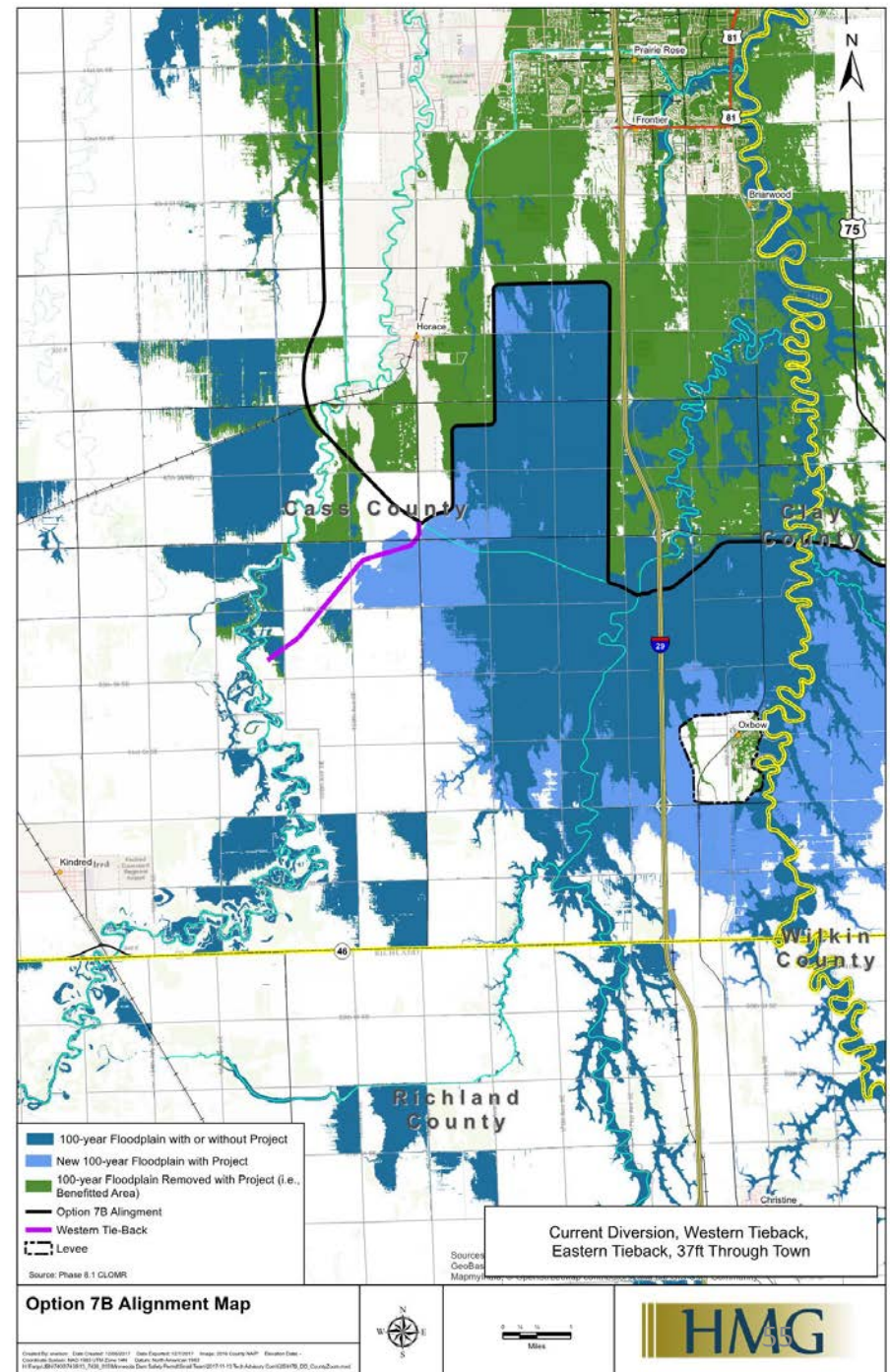




# Option 7A – Wilkin County Additional Depth



# Option 7B – Cass County

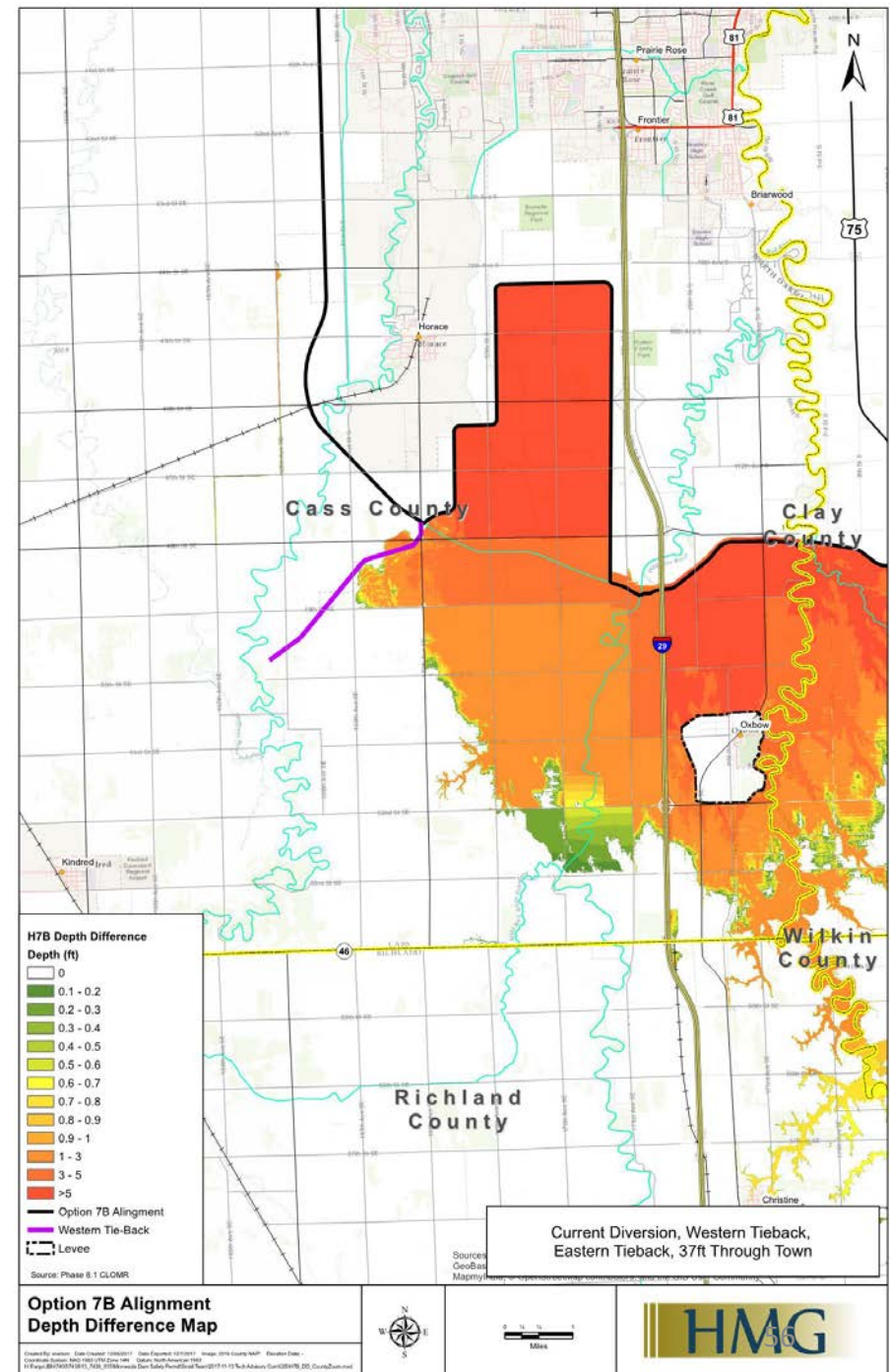
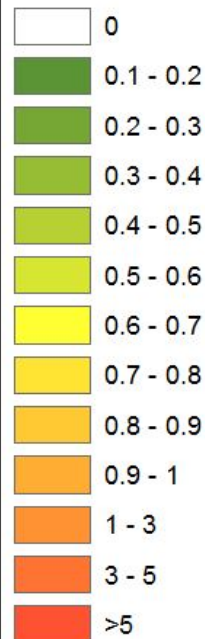


# Option 7B – Cass County Additional Depth

## Legend

### H7B Depth Difference

#### Depth (ft)



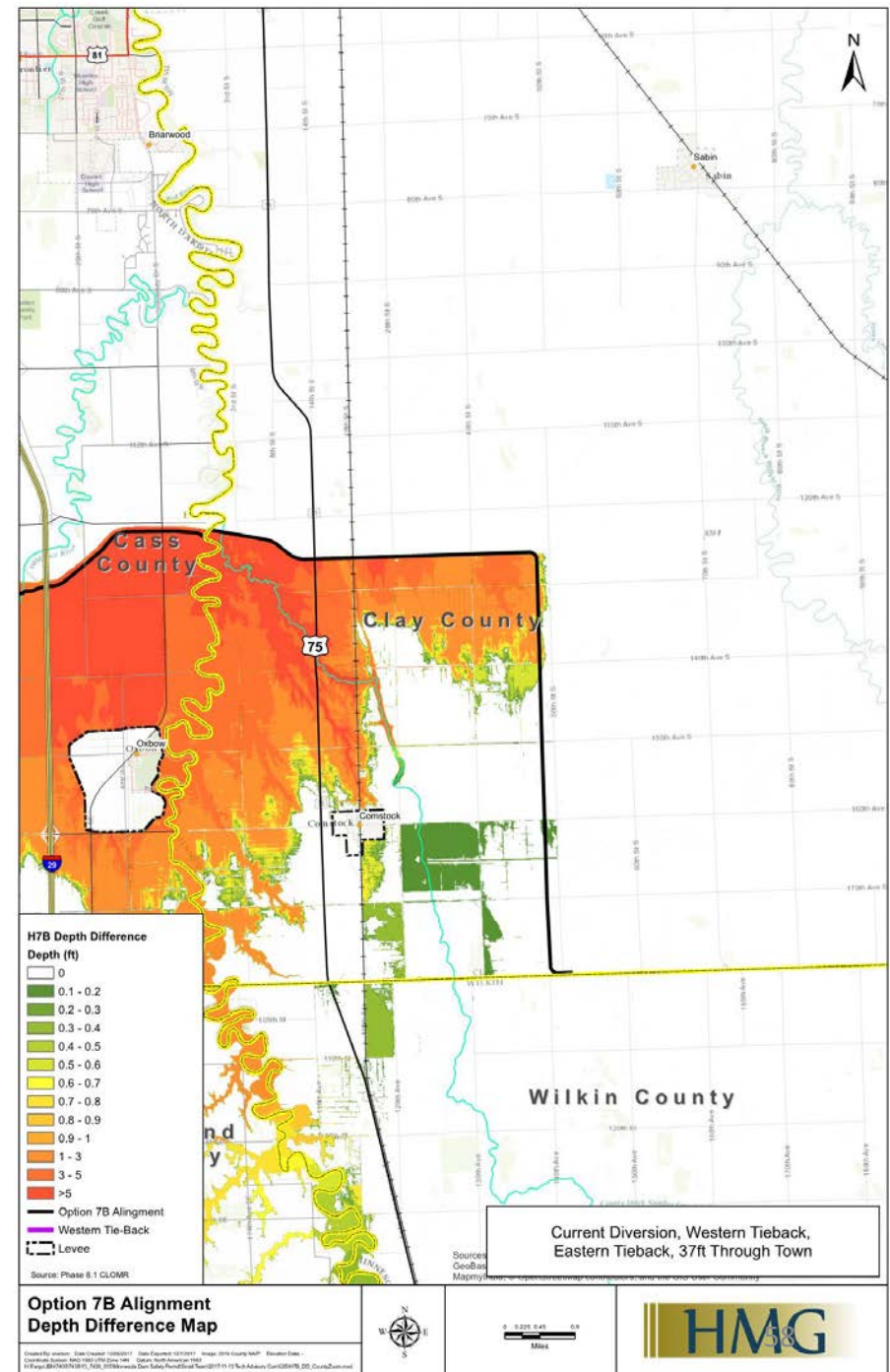
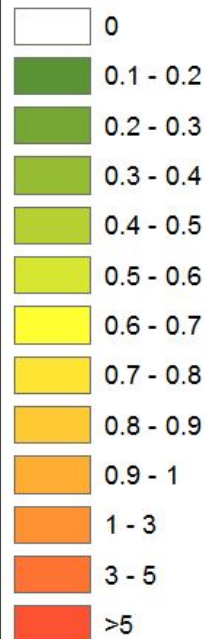


[illegible]

# Option 7B – Clay County Additional Depth

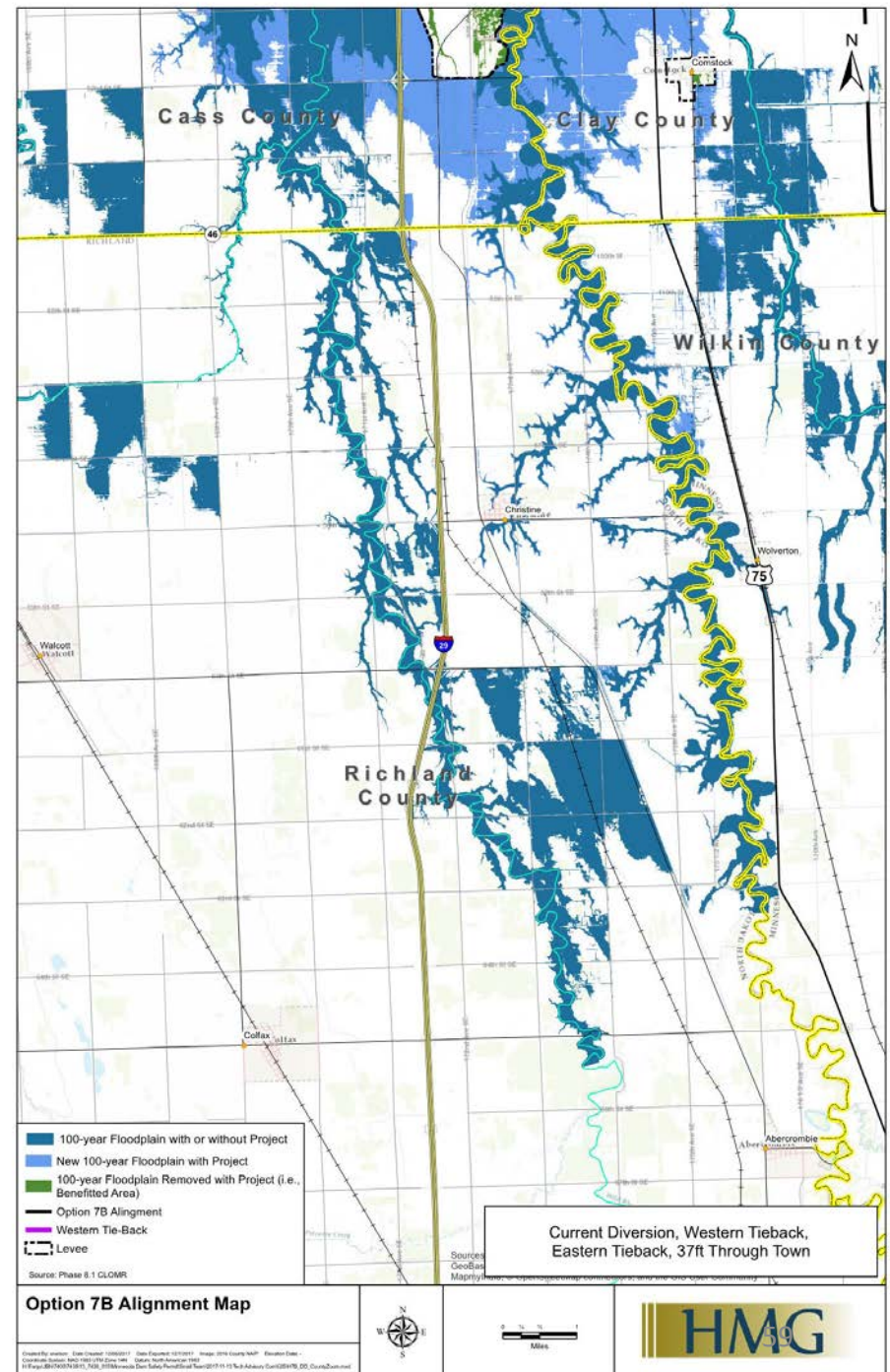
## Legend

### H7B Depth Difference Depth (ft)





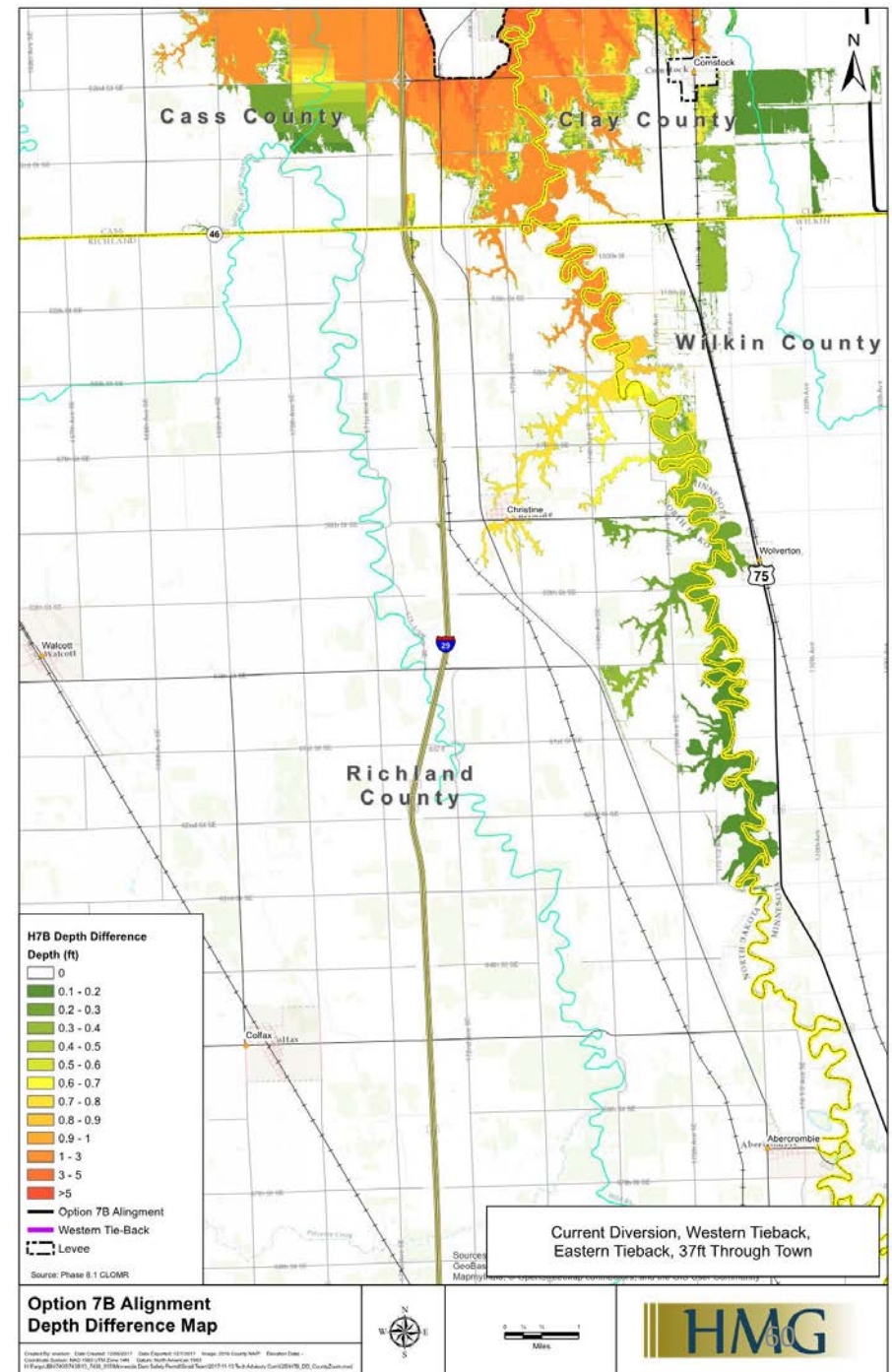
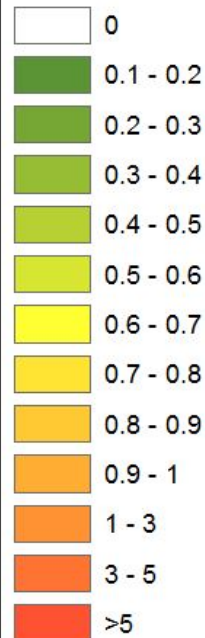
# Option 7B – Richland County



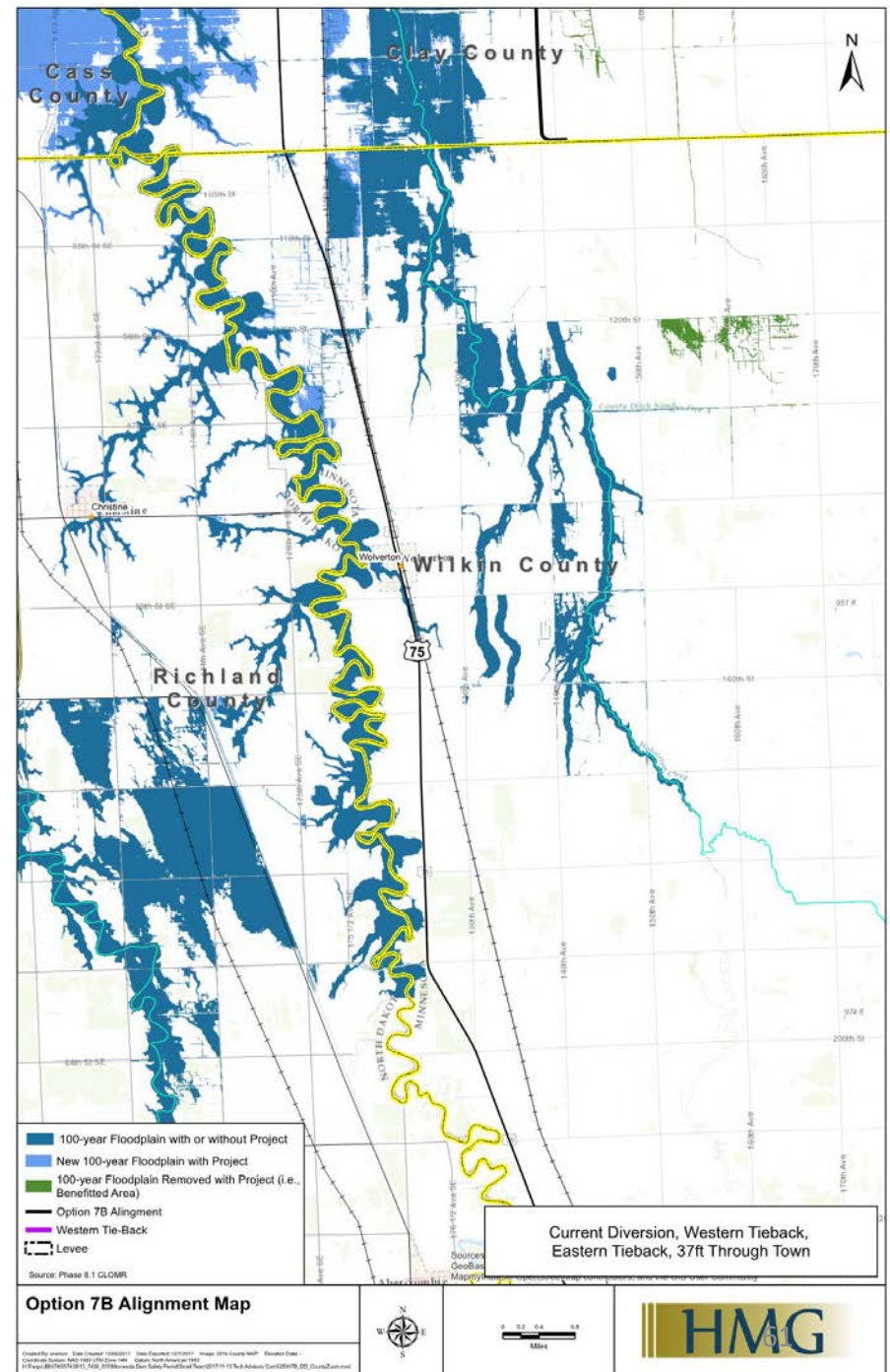
# Option 7B – Richland County Additional Depth

## Legend

### H7B Depth Difference Depth (ft)



# Option 7B – Wilkin County

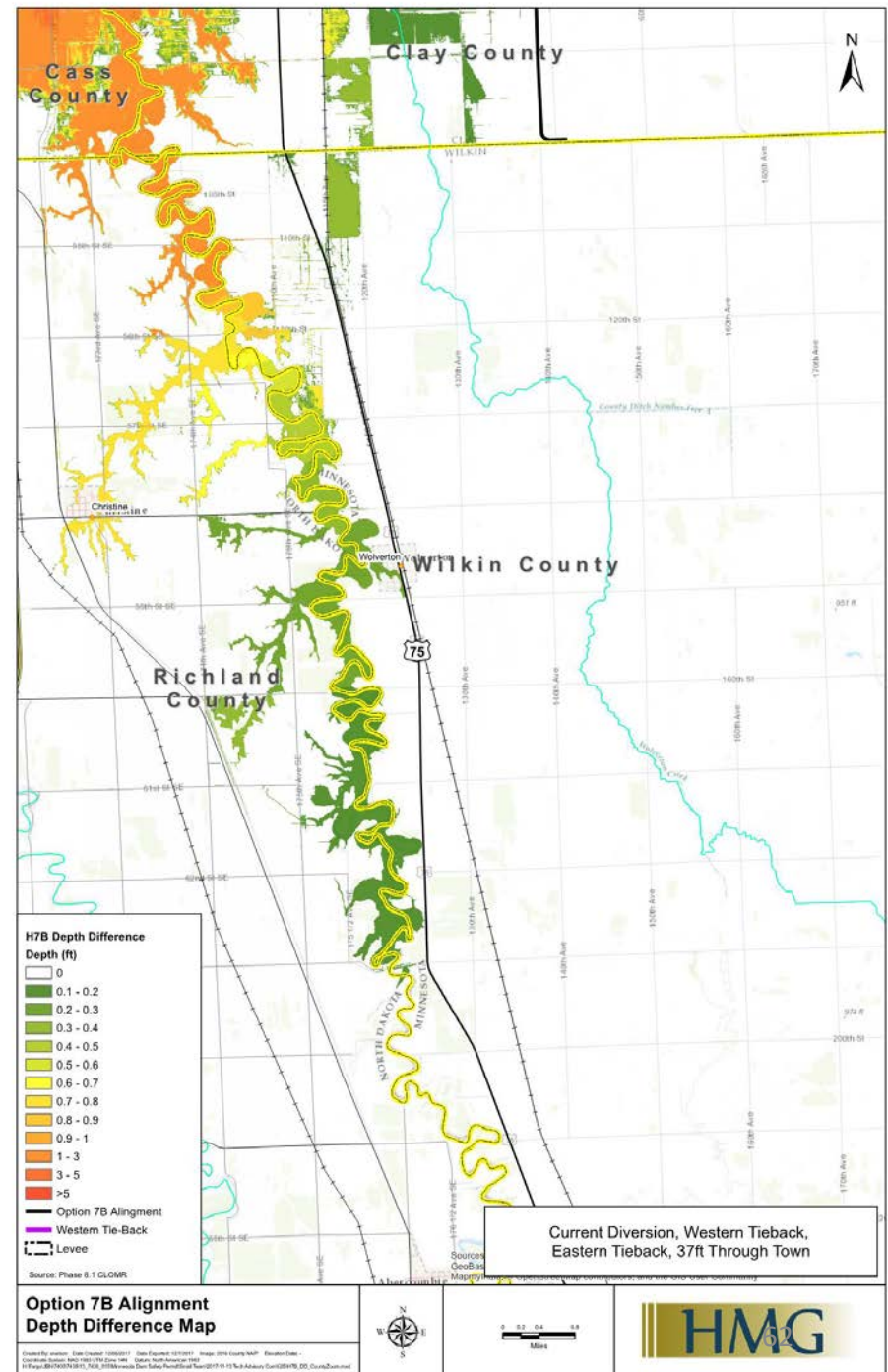
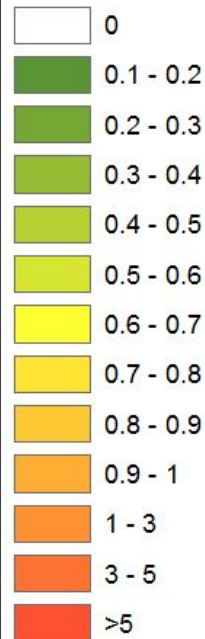




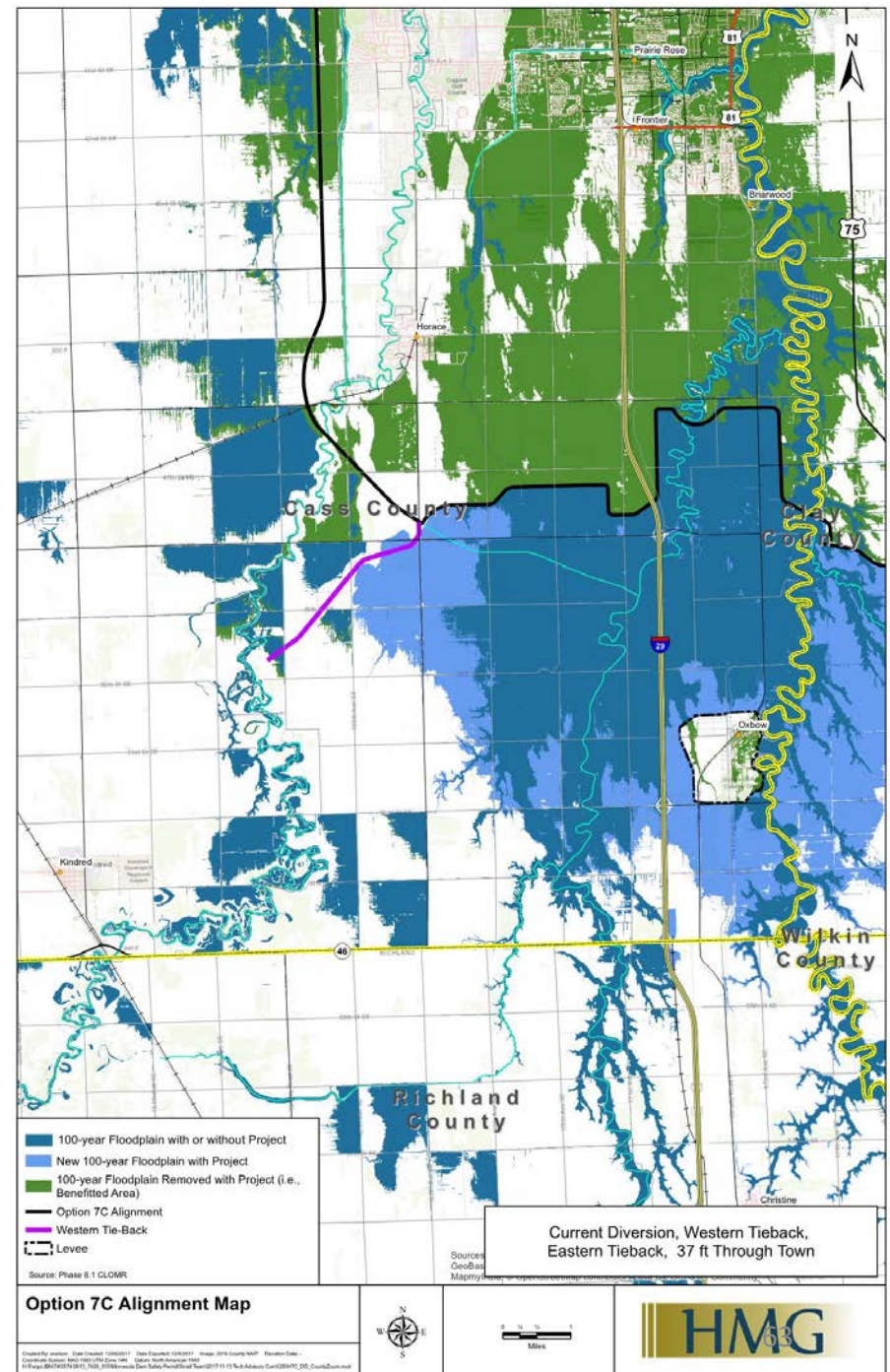
# Option 7B – Wilkin County Additional Depth

## Legend

### H7B Depth Difference Depth (ft)

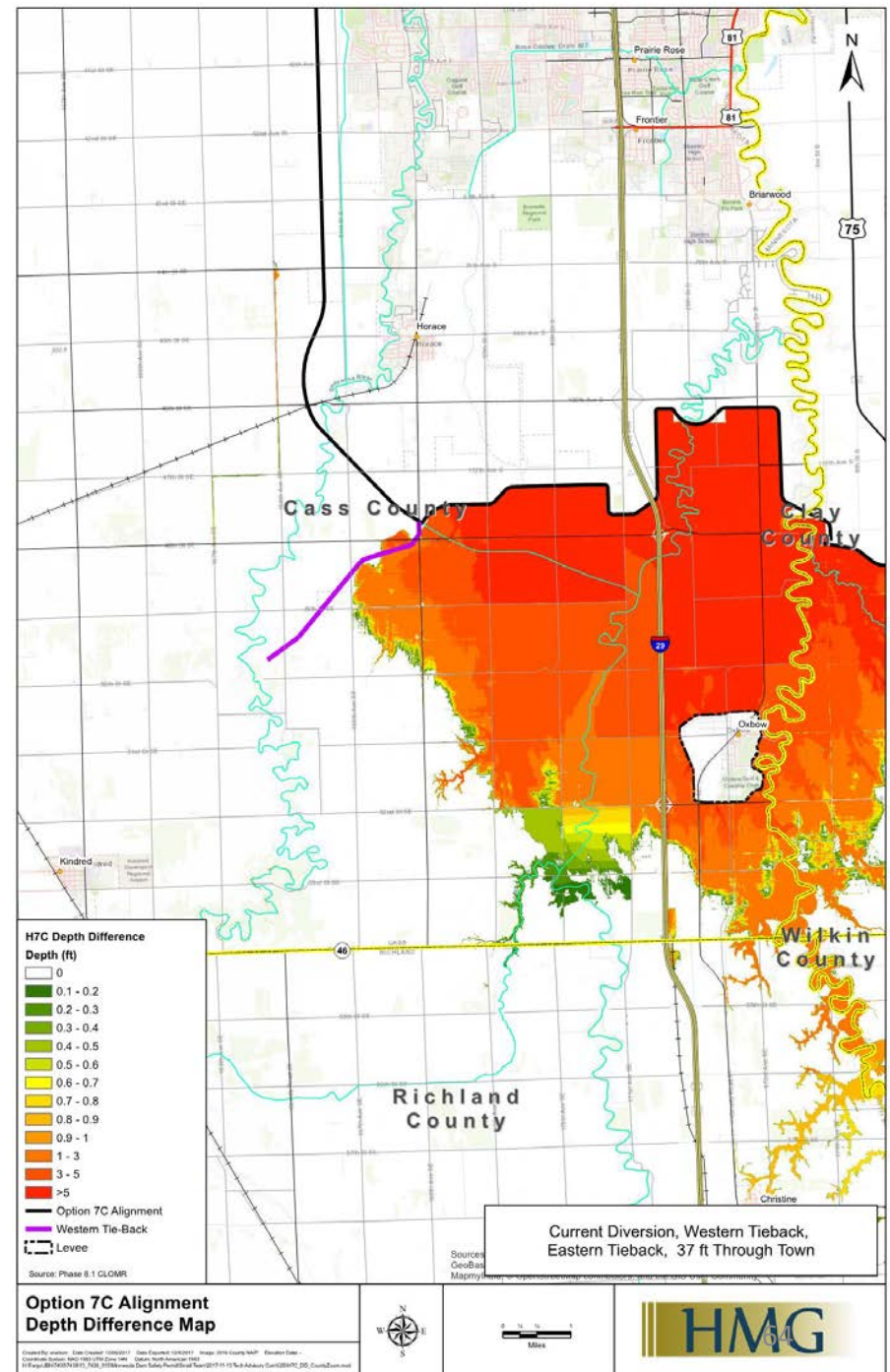
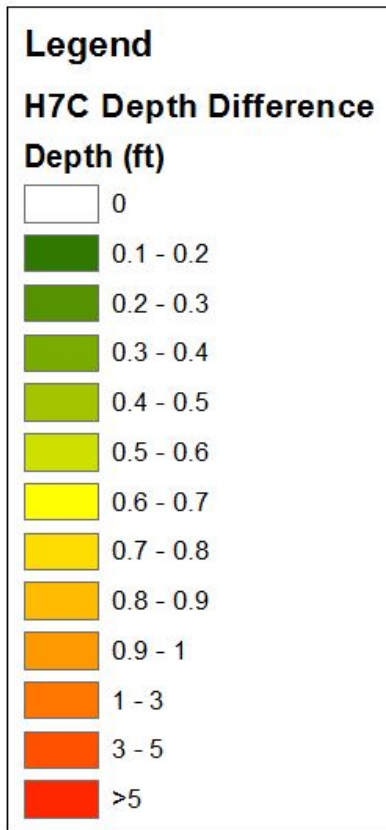


# Option 7C – Cass County

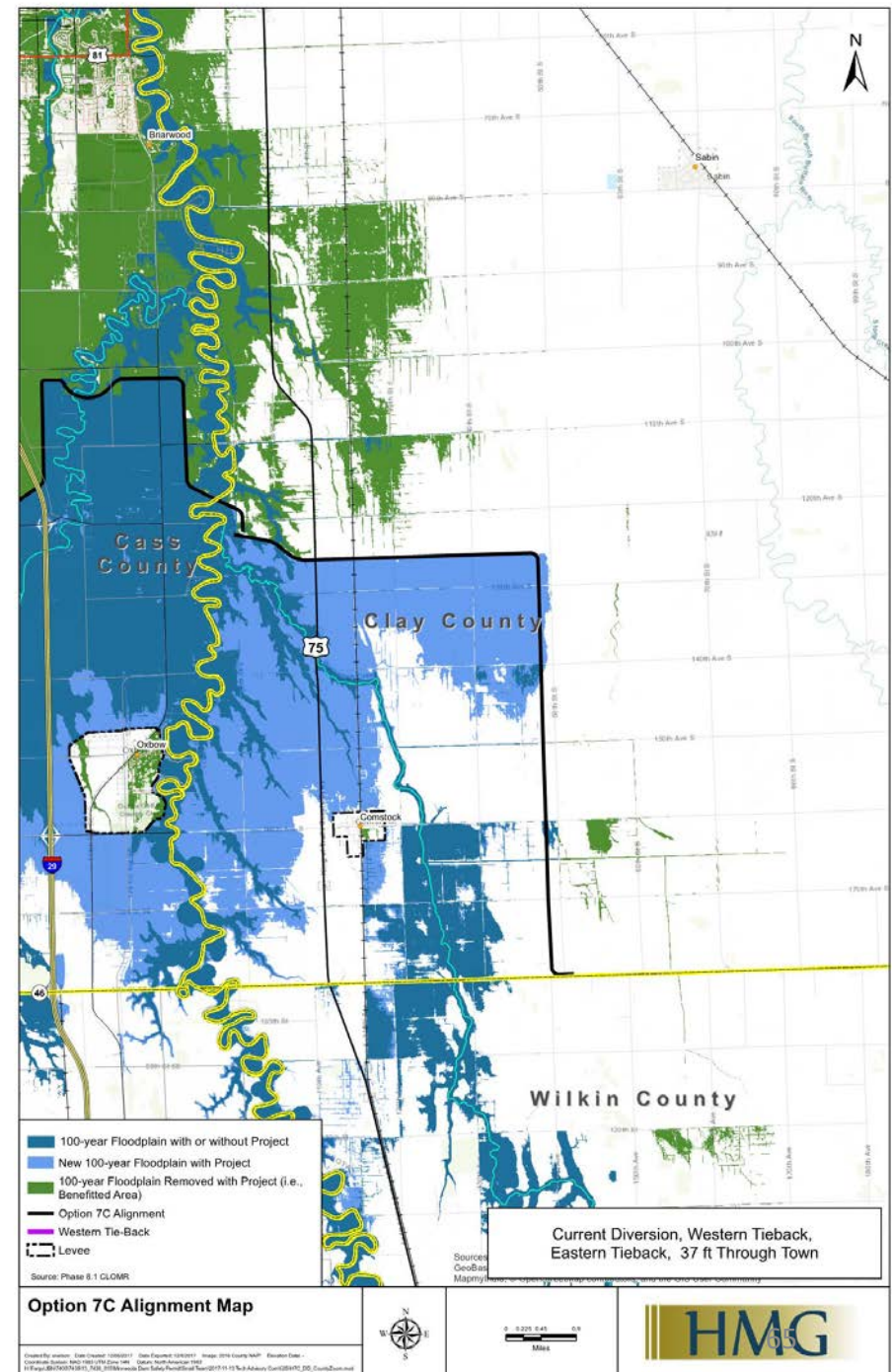




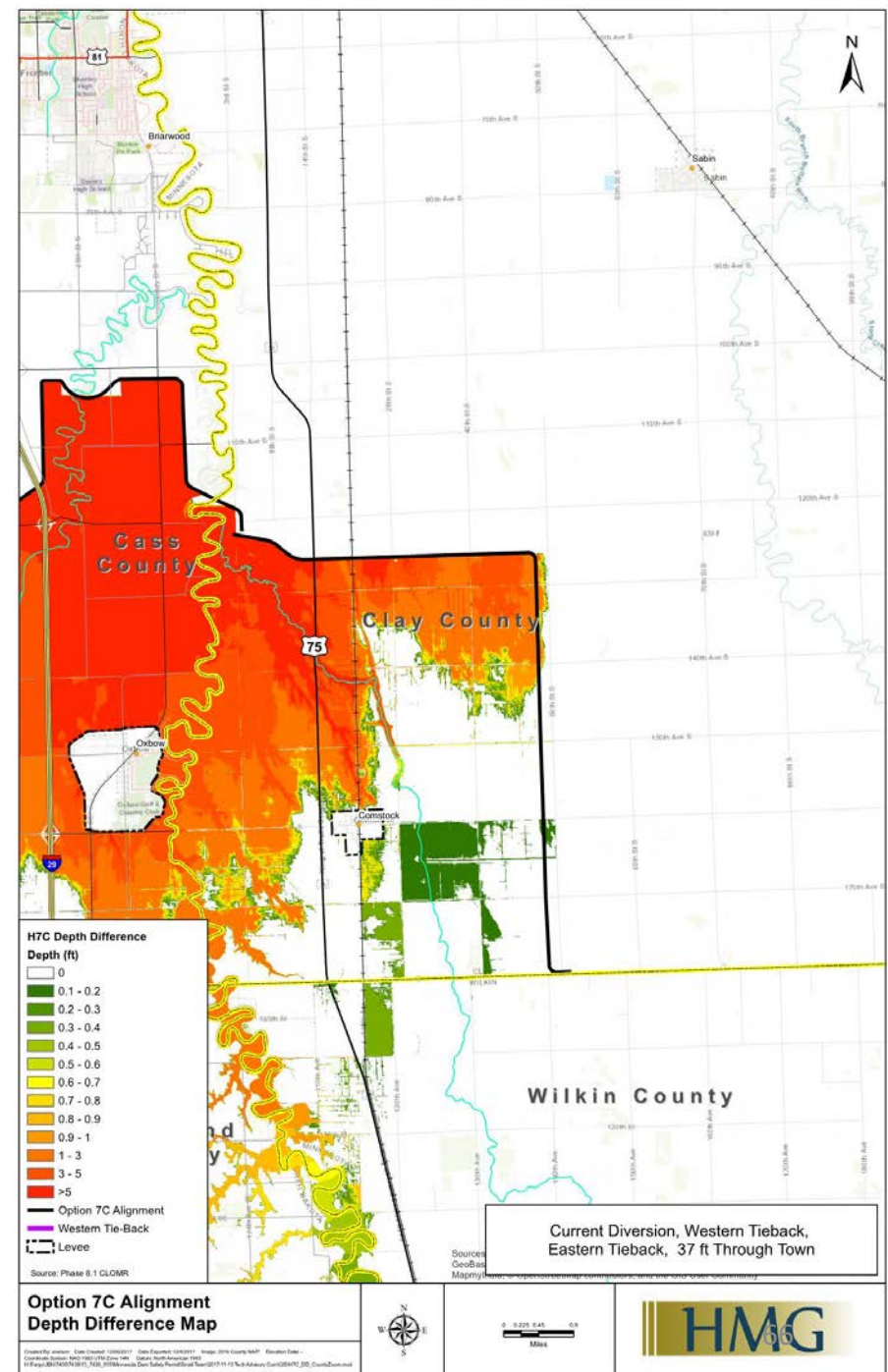
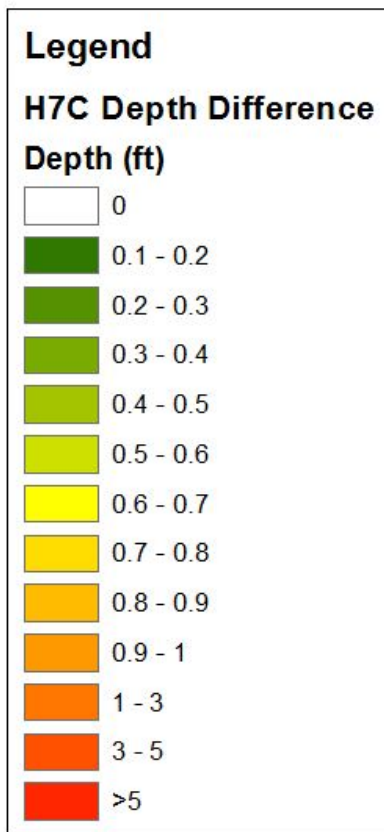
# Option 7C – Cass County Additional Depth



# Option 7C – Clay County

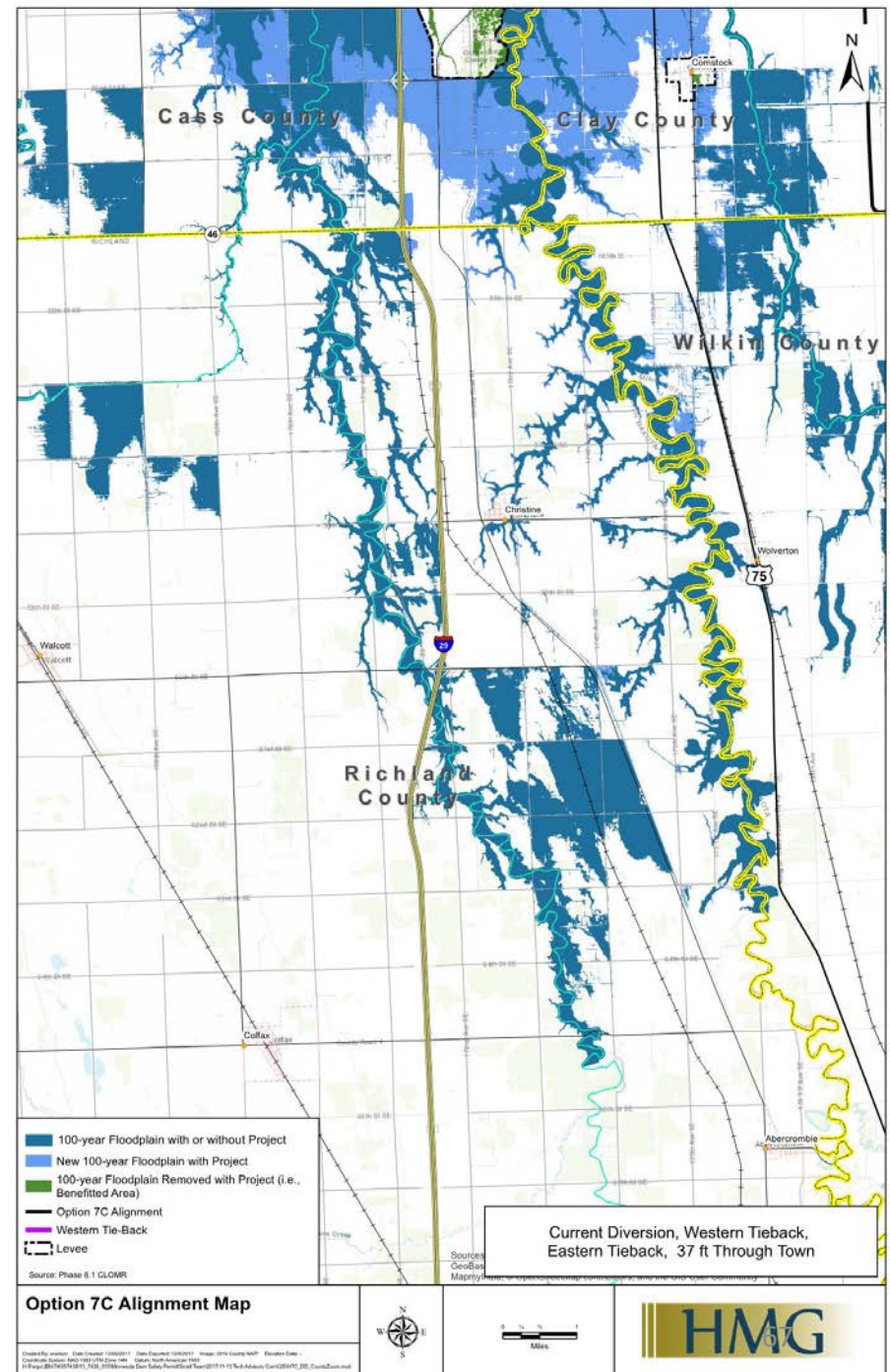


# Option 7C – Clay County Additional Depth

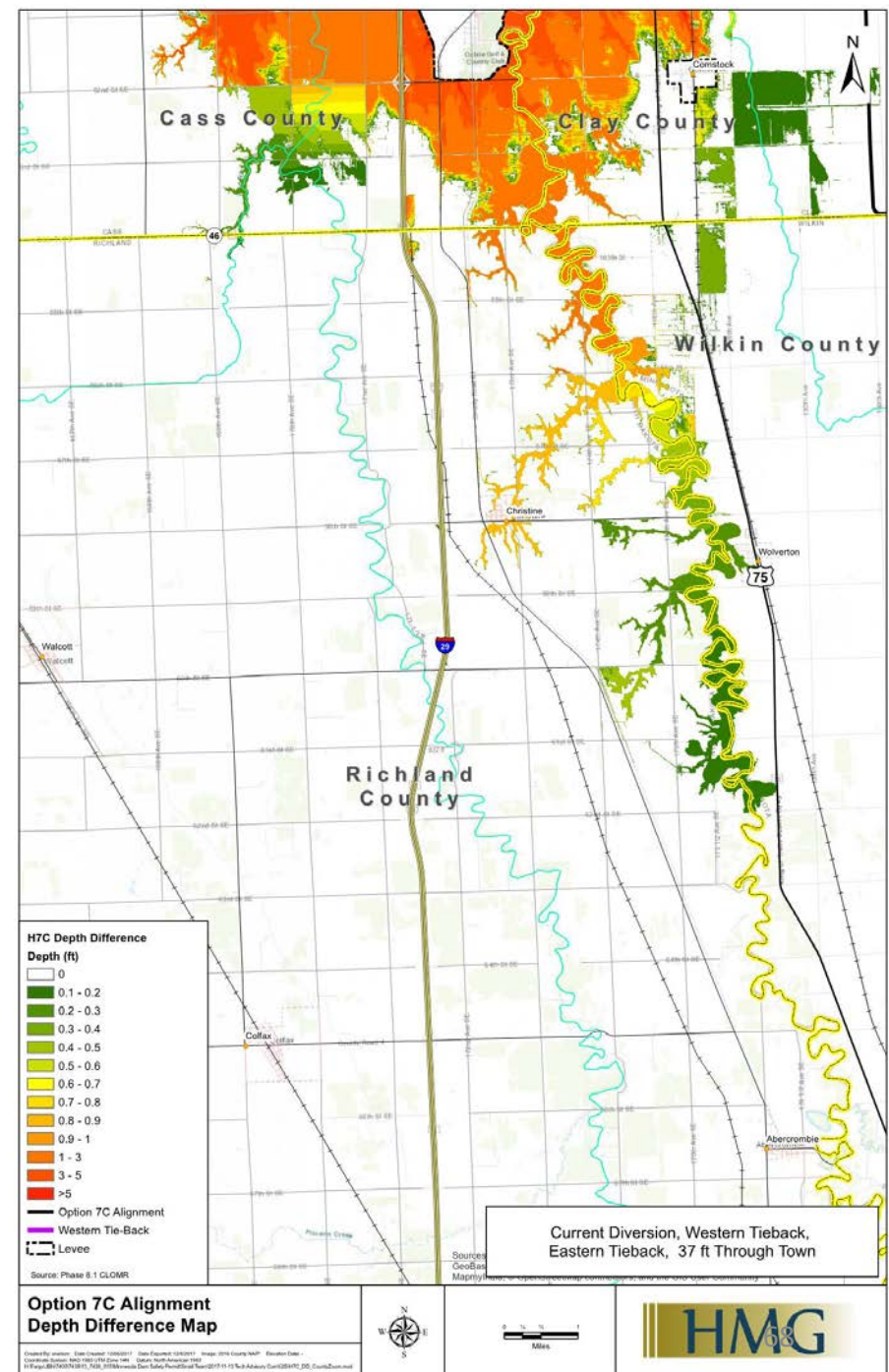
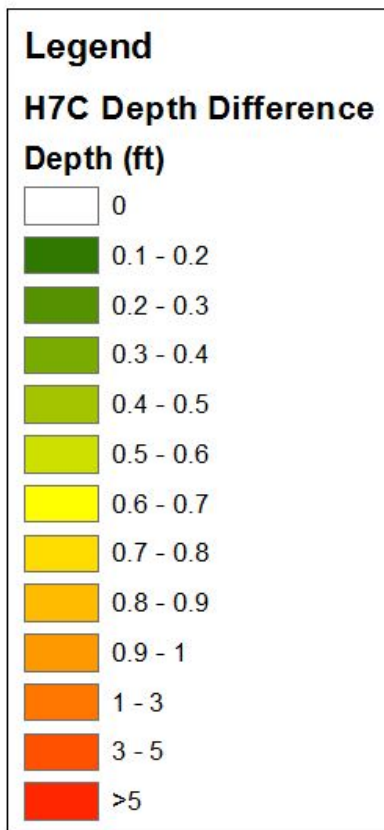




# Option 7C – Richland County

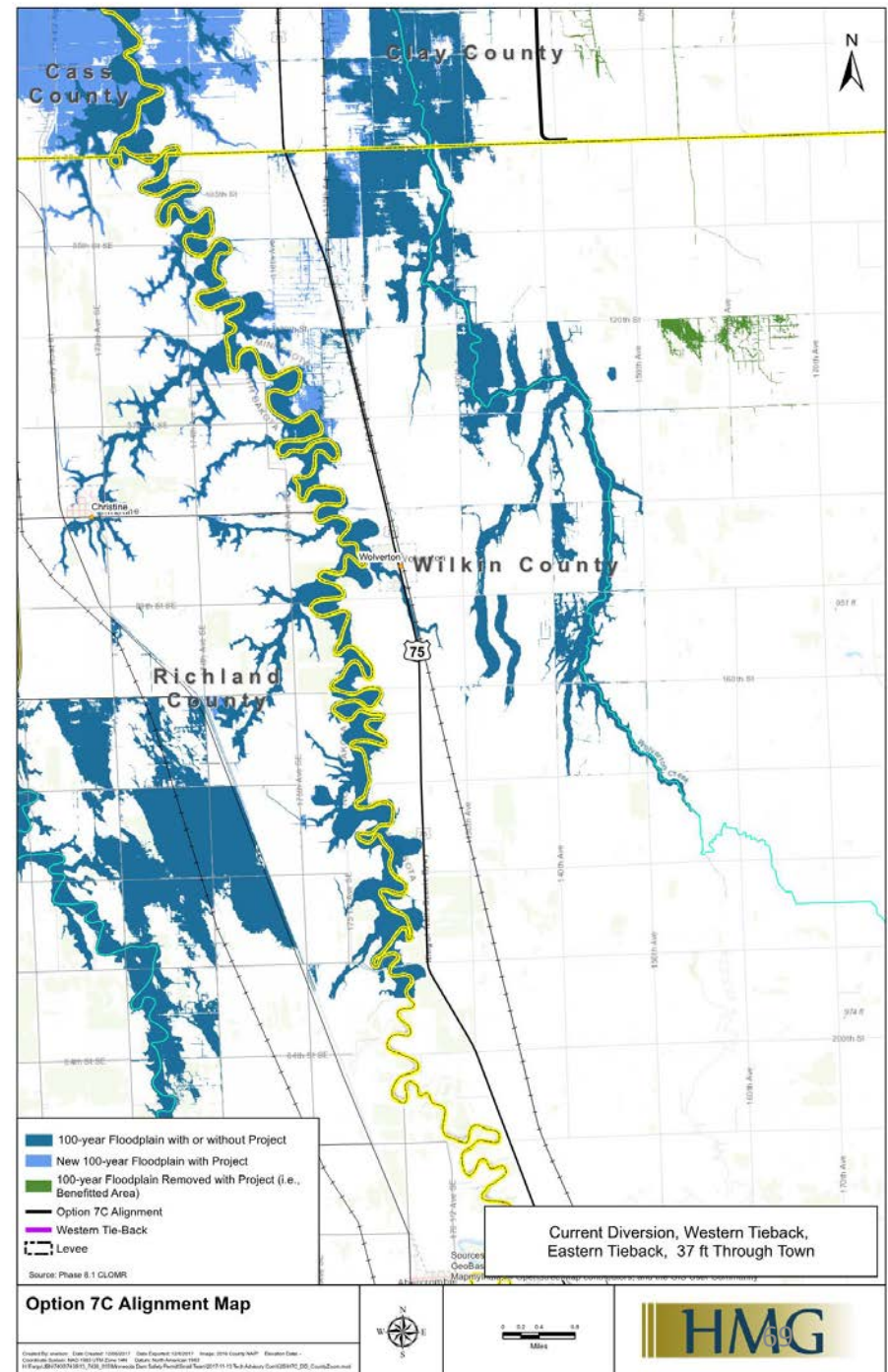


# Option 7C – Richland County Additional Depth

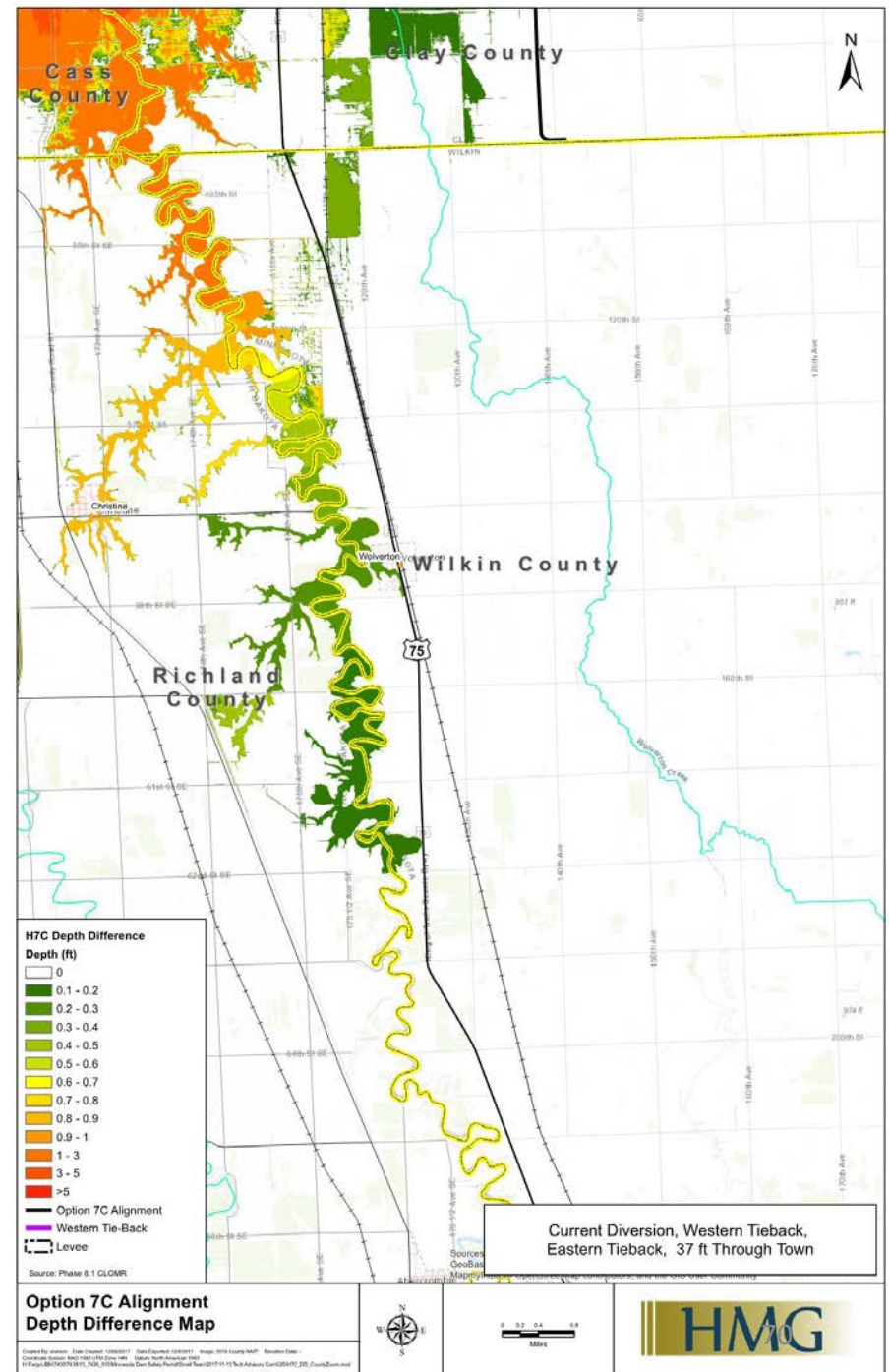
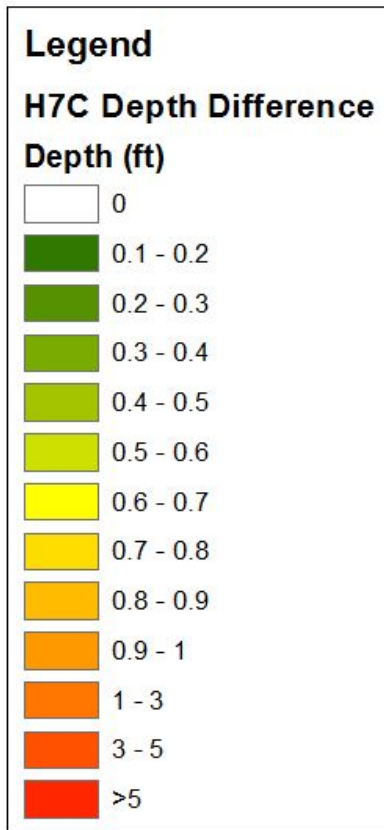




# Option 7C – Wilkin County



# Option 7C – Wilkin County Additional Depth



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# Additional Flows Through Town Summary

	<b>Proposed 35' (baseline)</b>	<b>37'</b>	<b>38'</b>	<b>39'</b>
Return Frequency / Discharge (cfs)	13 year / 16,400 cfs	21 year / 20,200 cfs	28 year / 22,200 cfs	39 year / 24,500 cfs
Staging Area Elevation at Dam – Option 7A (WSEL/Change)	921.66 / N/A	920.03 / -1.63'	919.80 / -1.86'	919.67 / -1.99'
Staging Area Elevation at Dam – Option 7B (WSEL/Change)	921.66 / N/A	919.13 / -2.53'	918.93 / -2.73'	918.82 / -2.84'
Staging Area Elevation at Dam – Option 7C (WSEL/Change)	921.66 / N/A	919.46 / -2.20'	919.20 / -2.46'	919.05 / -2.61'
Cost (Construction and Acquisitions – FM Only)	Ongoing	\$150M / 82 Additional Homes	\$330M / 168 Additional Homes	\$420M / 314 Additional Homes

# Technical Advisory Group (TAG)

- Held two public meetings on Nov. 14 & Nov. 28
  - Meetings were well attended by Task Force members
- Defined criteria to evaluate alternatives and components
- Screened alternatives and components for further evaluation
- **Developed and evaluated options for Task Force Consideration**
- All information shown is for the 1-percent annual chance (100-year flood event)



# **TAG Key Criteria (not in particular order)**

- Satisfy Task Force Charter
- Meet Laws and Ordinances
- Minimize Residual Risk
- Reduce Floodplain Impacts
- Reduce Environmental Effects
- Limit Impacts to Structures
- Resilience/Robustness of Design
- Cost and Engineering Feasibility
- Upstream and Downstream Impacts
- Impacts at the U.S./Canadian Border

# Consensus Items

