2018 OHIO STORMWATER CONFERENCE
11th Annual

Stantec

Maumee Watershed Conservancy District

2018 Ohio Stormwater Conference
Sandusky, OH – May 11, 2018

Hancock County Flood Risk Reduction Program

Watershed Planning Case Study

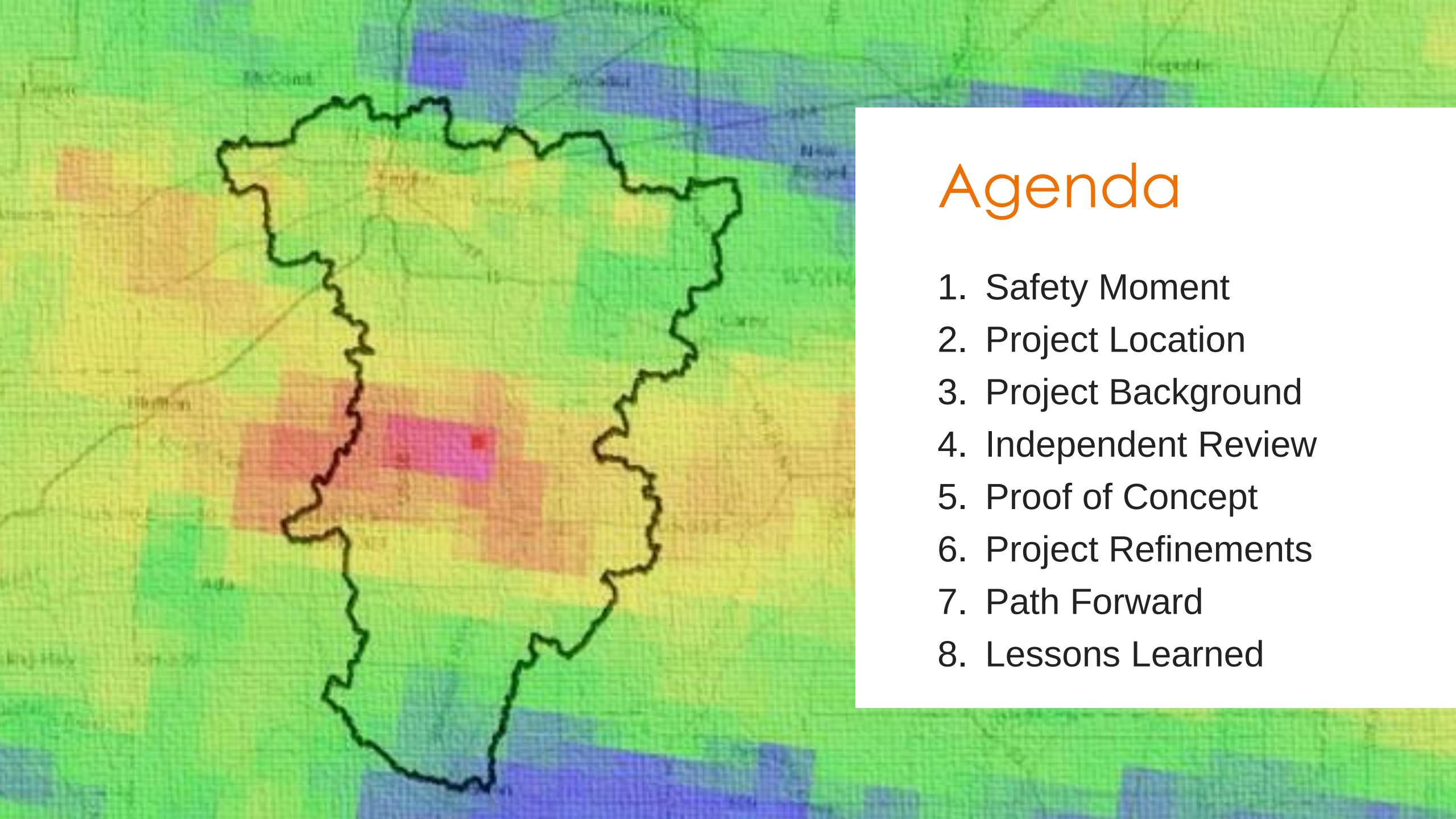
David Hayson, PE, SI

Senior Project Engineer

BS Civil Engineering – University of Dayton
Land Surveying Certificate – Cincinnati State

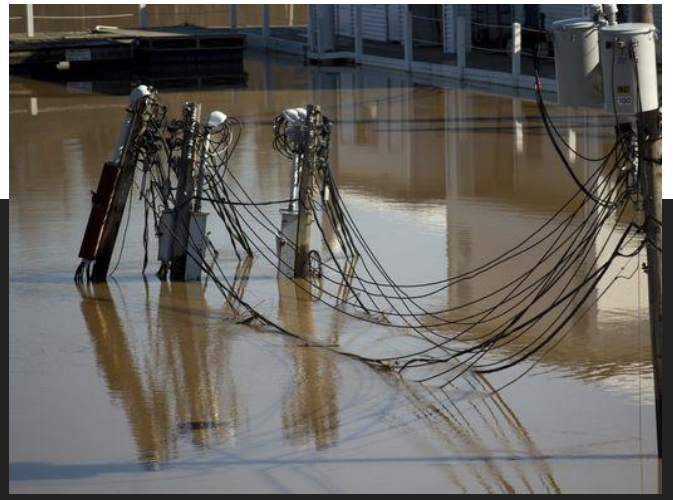
Cincinnati - Water Resources Group

- Hydrologic and Hydraulic Assessment
  - Planning and Site/Civil Design
  - Modeling
  - Benefit-Cost Analyses



Agenda

1. Safety Moment
2. Project Location
3. Project Background
4. Independent Review
5. Proof of Concept
6. Project Refinements
7. Path Forward
8. Lessons Learned



Safety Moment

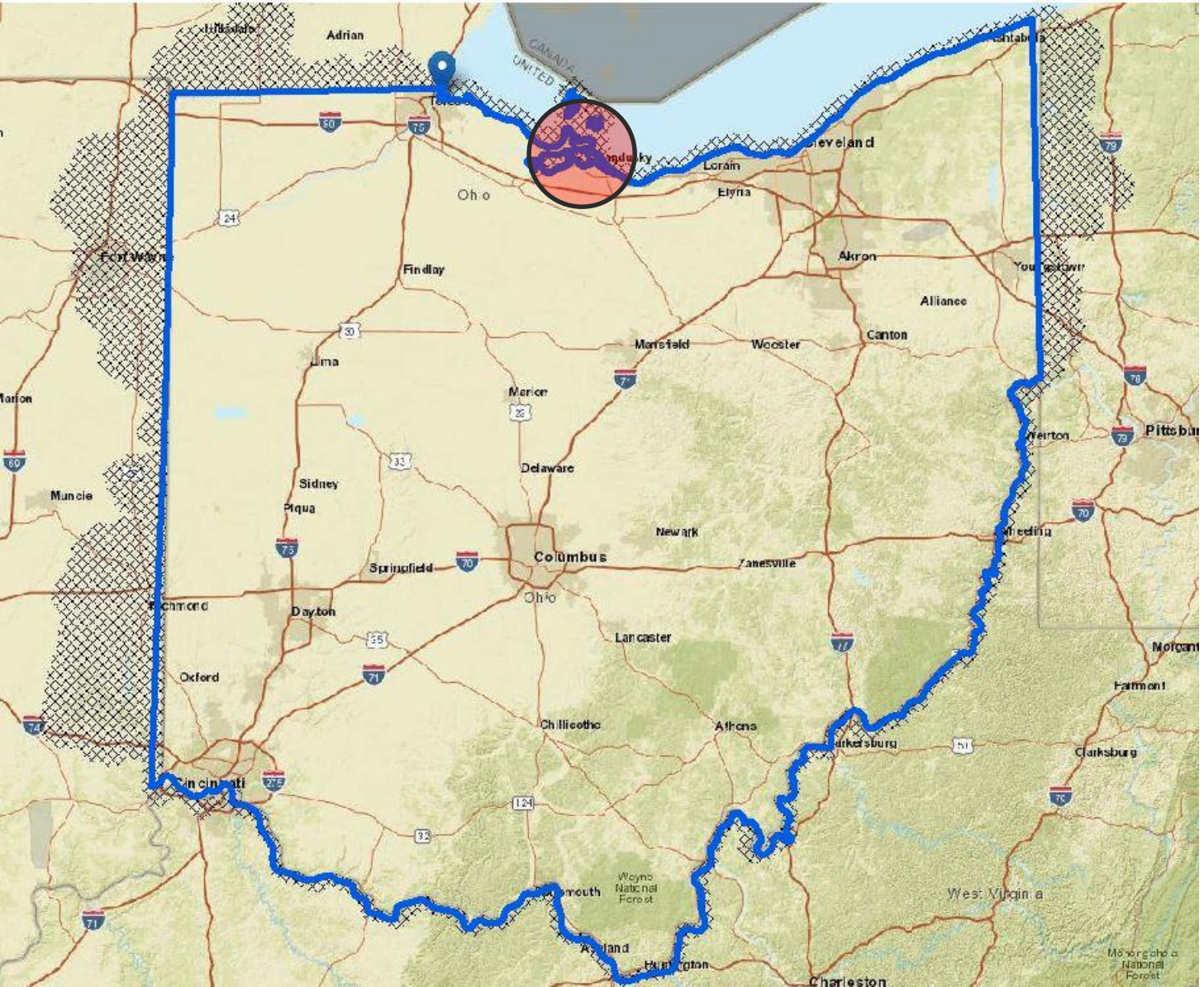
Don’t Play, Swim, or Drive through Flooding Rivers.

Watershed / Client

Project Location

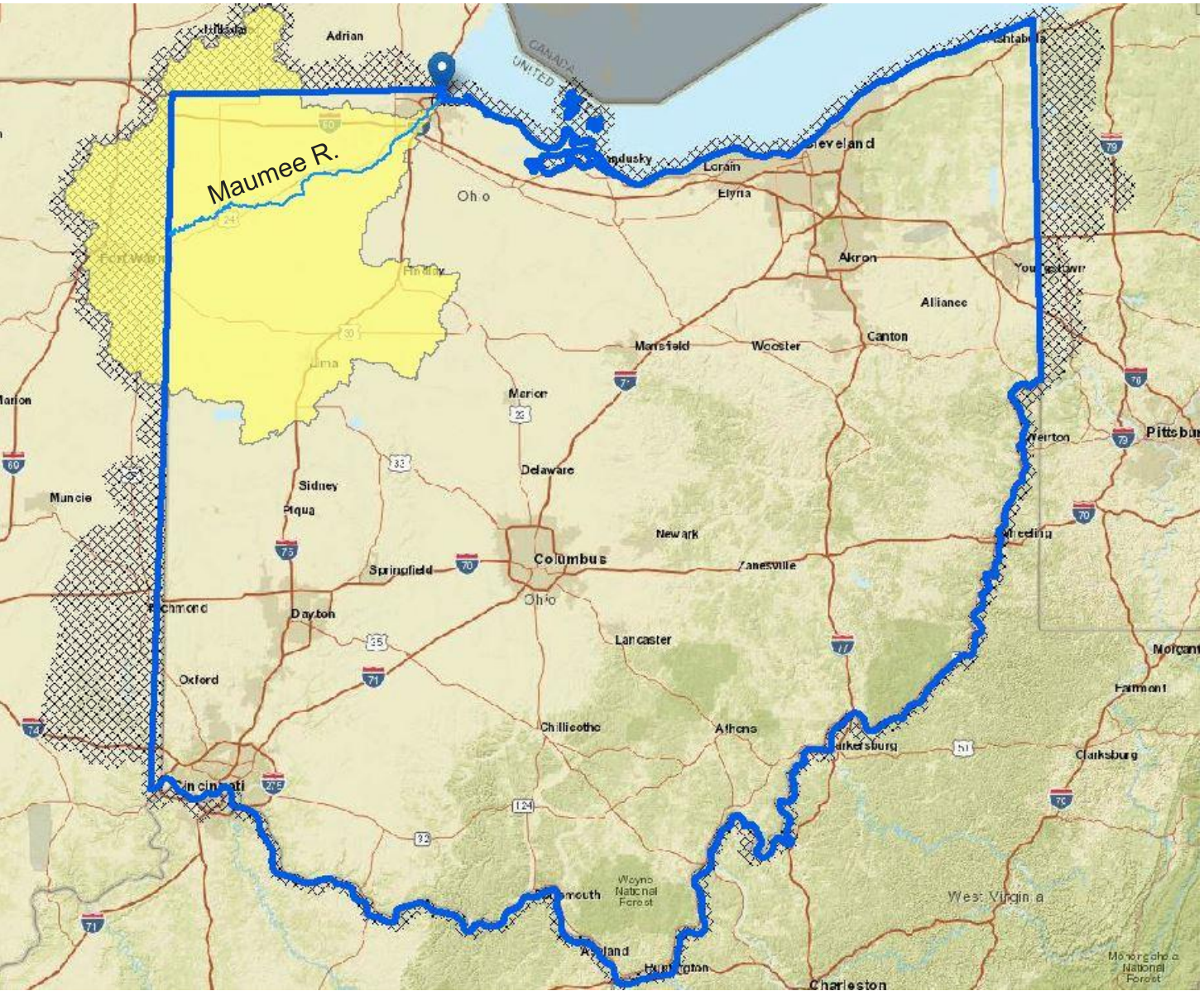
2018 Ohio SW Conference

You Are Here!



Project Location

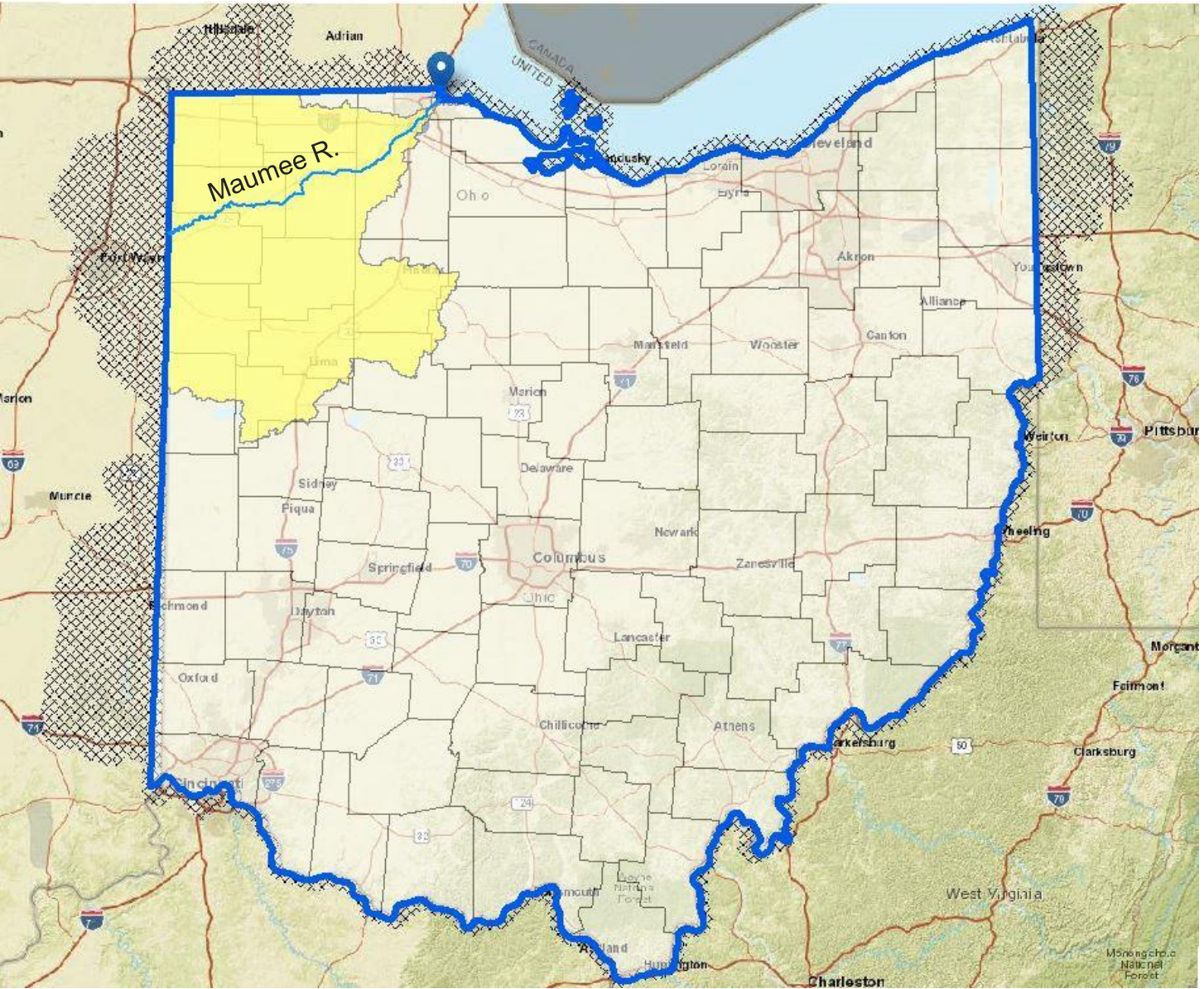
Maumee River Watershed



~6,575 sq. miles

Project Client

Maumee River Watershed

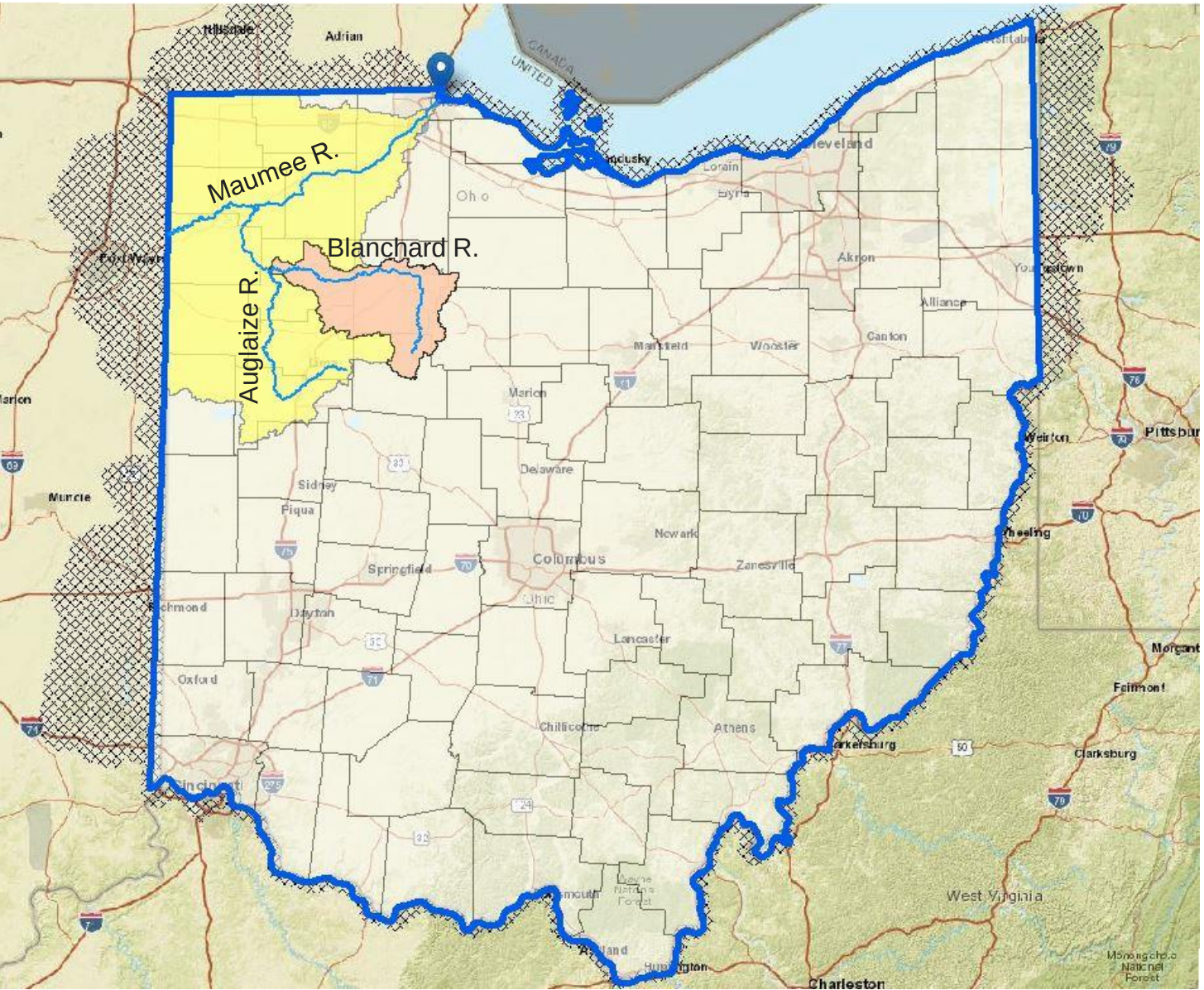


Maumee Watershed Conservancy District

- Represents 15 Counties in NW Ohio
- Established under Ohio Revised Code Chapter 6101 (December 1948)

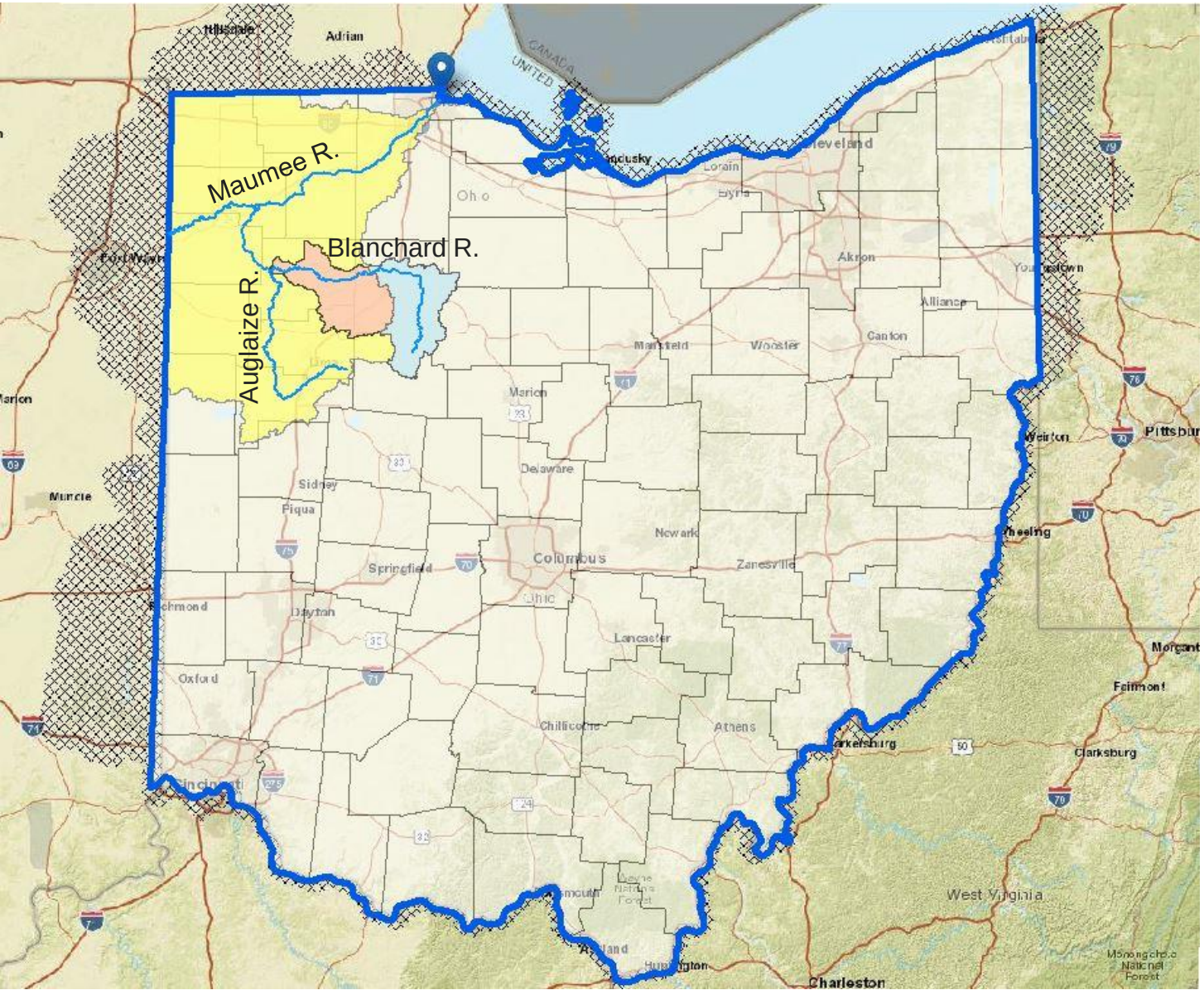
Project Location

Blanchard River Watershed



~770 sq. miles

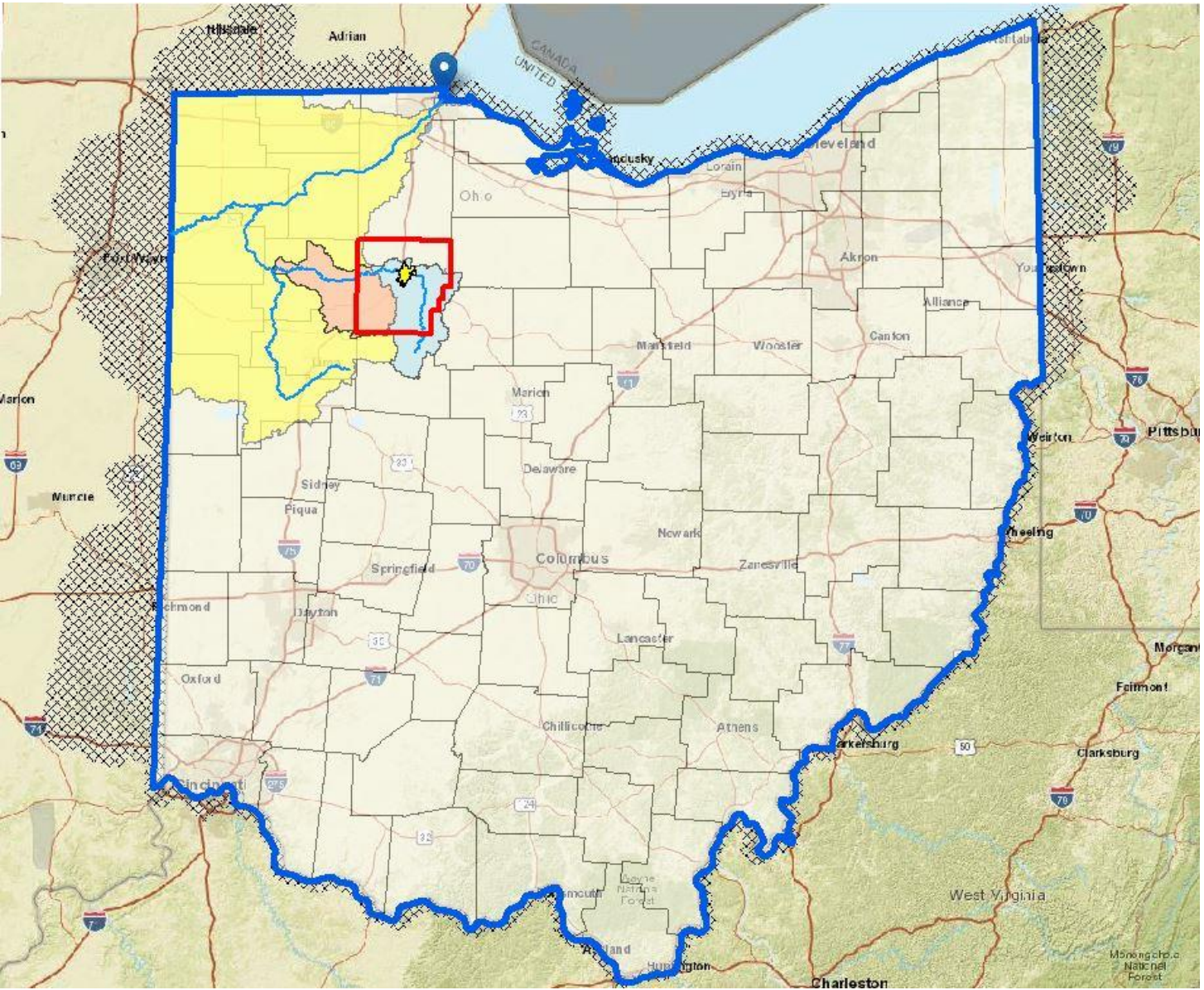
Project Location



Upper Blanchard River Watershed

~350 sq. miles

Project Location



Upper Blanchard River Watershed

Key Project Stakeholders:

MWCD

Hancock County

City of Findlay

Why are we studying the watershed?

Project Background

July 2017 Findlay Blanchard river flood drone footage time-lapse (bgdrone419) https://www.youtube.com/watch?v=LNHug0fvx7k

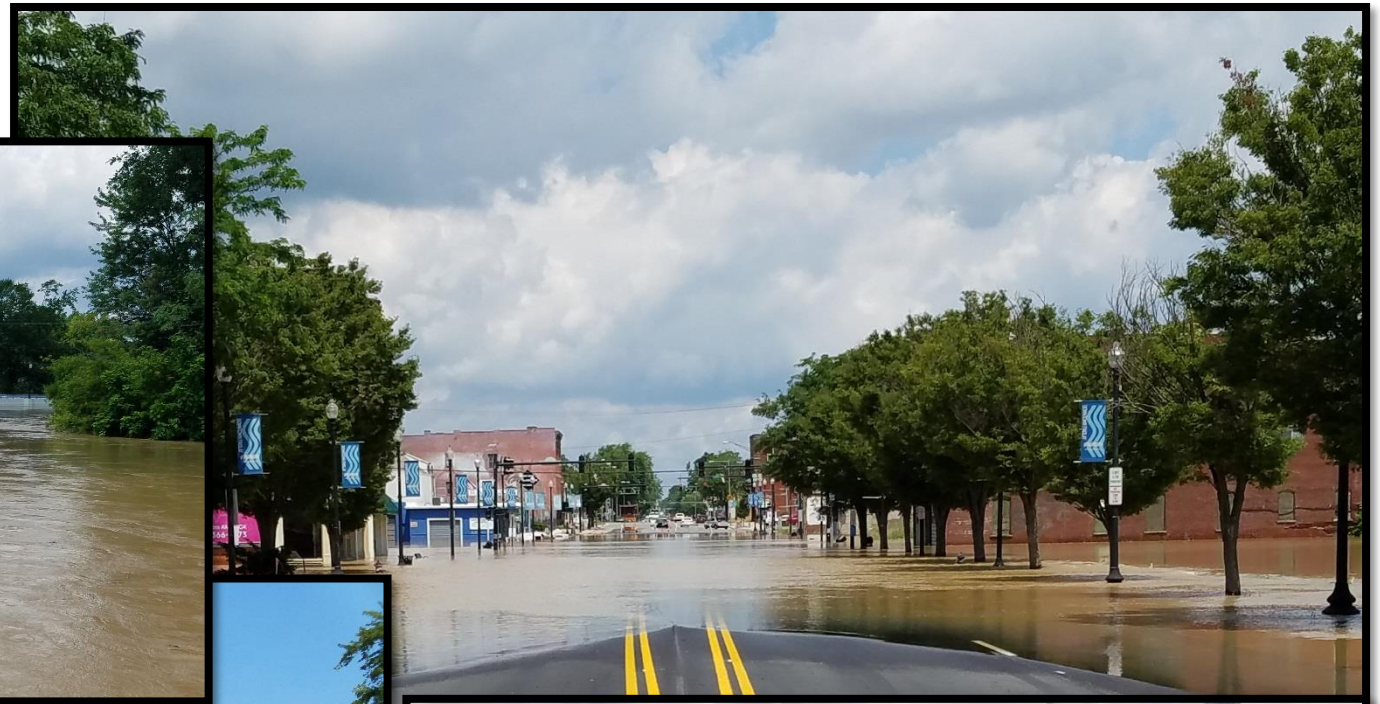
July 2017

Flood Categories (in feet)

Major Flood Stage:	13.5
Moderate Flood Stage:	12
Flood Stage:	11
Action Stage:	8

Historic Crests

(1) 18.50 ft on 03/25/1913
(2) 18.46 ft on 08/22/2007
(3) 17.43 ft on 06/14/1981
(4) 16.76 ft on 02/11/1959
(5) 16.53 ft on 07/14/2017
(6) 16.50 ft on 02/07/2008
(7) 16.42 ft on 03/01/2011
(8) 16.10 ft on 01/22/1959
(9) 15.58 ft on 12/22/2013
(10) 15.42 ft on 06/02/1997



https://water.weather.gov

August 2007

Flood Categories (in feet)

Major Flood Stage:	13.5
Moderate Flood Stage:	12
Flood Stage:	11
Action Stage:	8

Historic Crests

(1) 18.50 ft on 03/25/1913
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Source:
Google Image Search
May be subject to copyright.

https://water.weather.gov

USGS Gage 04189000 – Annual Peak Streamflow

Flood Categories (in feet)

Major Flood Stage:	13.5
Moderate Flood Stage:	12
Flood Stage:	11
Action Stage:	8

Historic Crests

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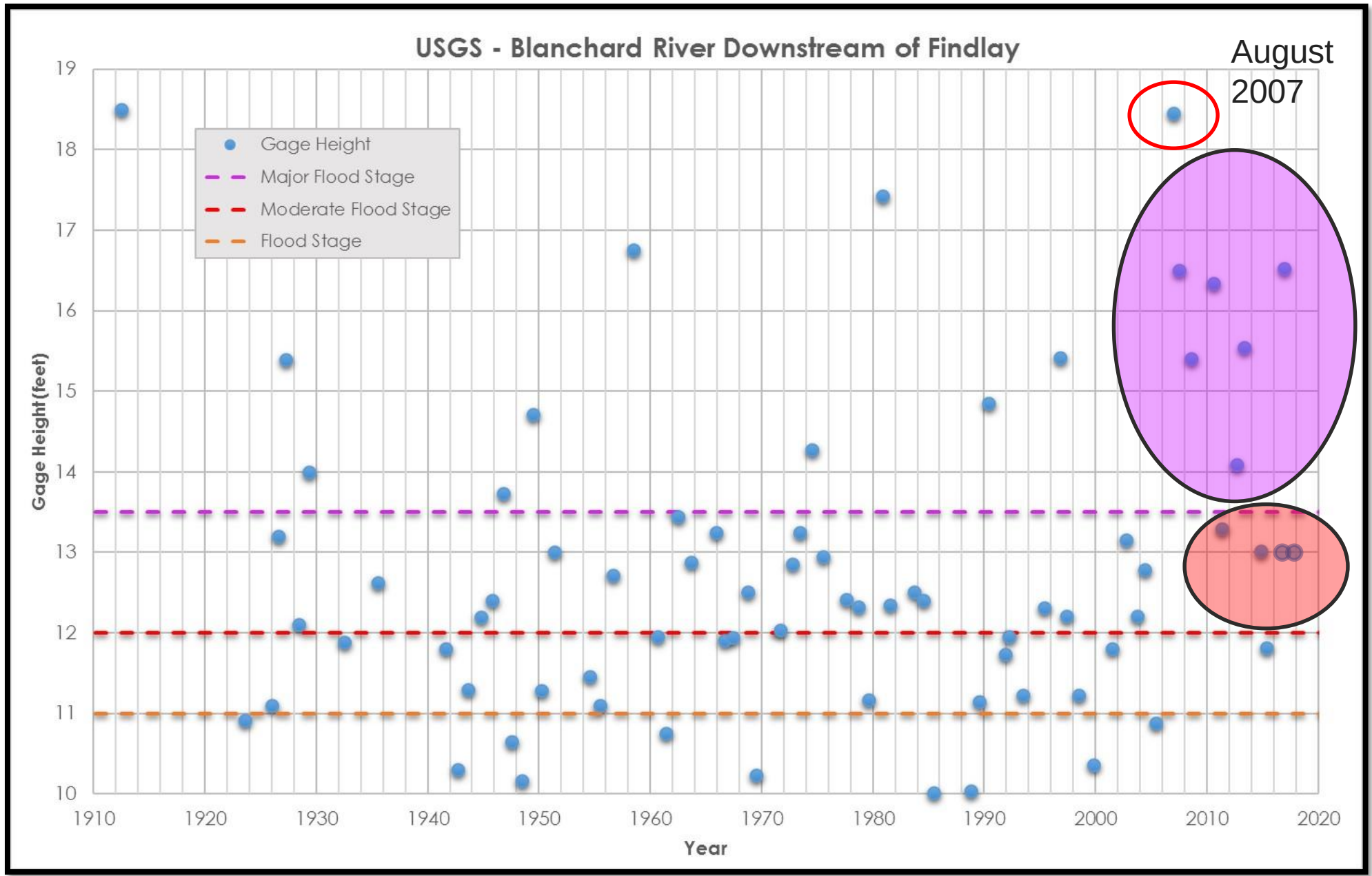
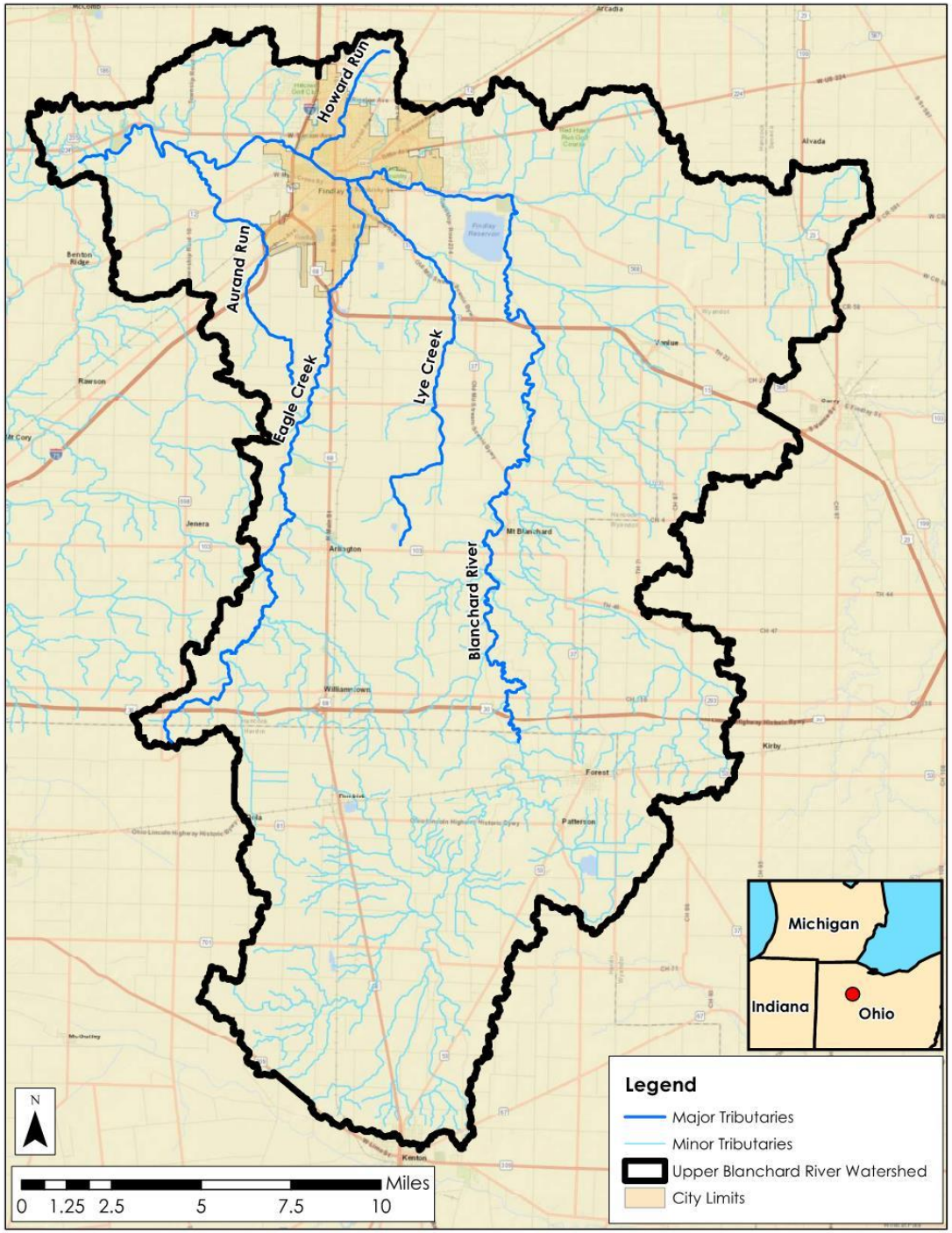


https://water.weather.gov

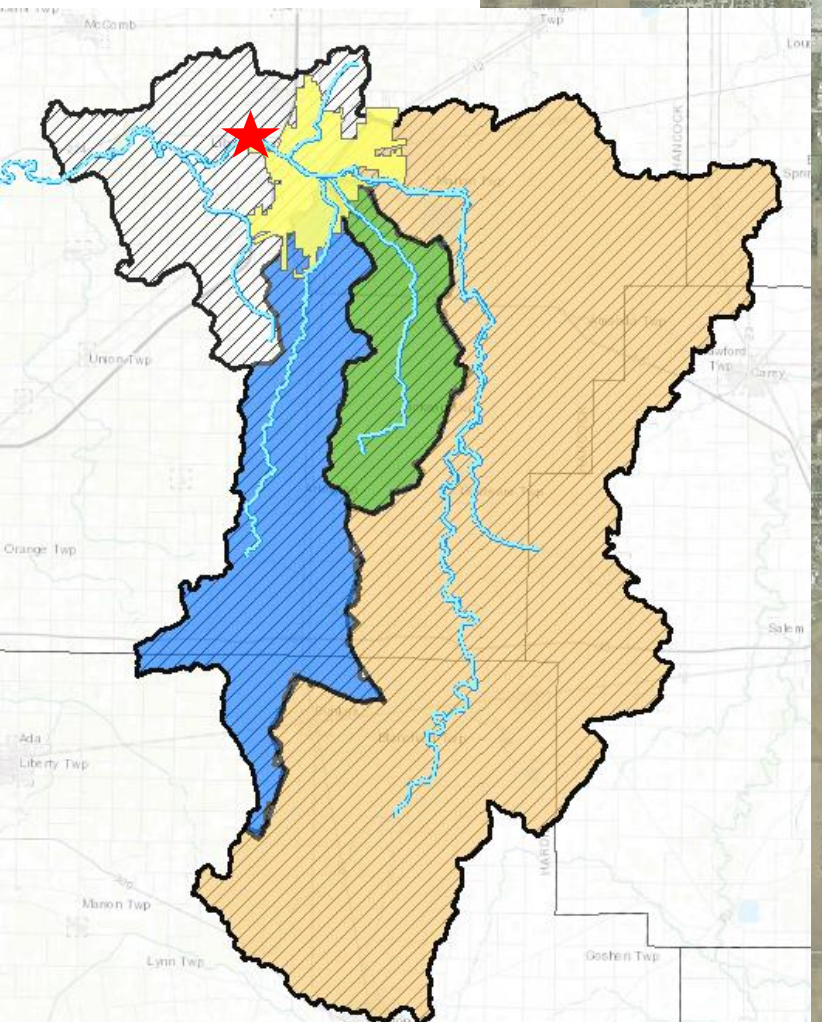
Project Background

Where Does the Water Come From?



Project Background

Where Does the Water Come From?



USGS Gage #04189000 (~346 mi.^{2})

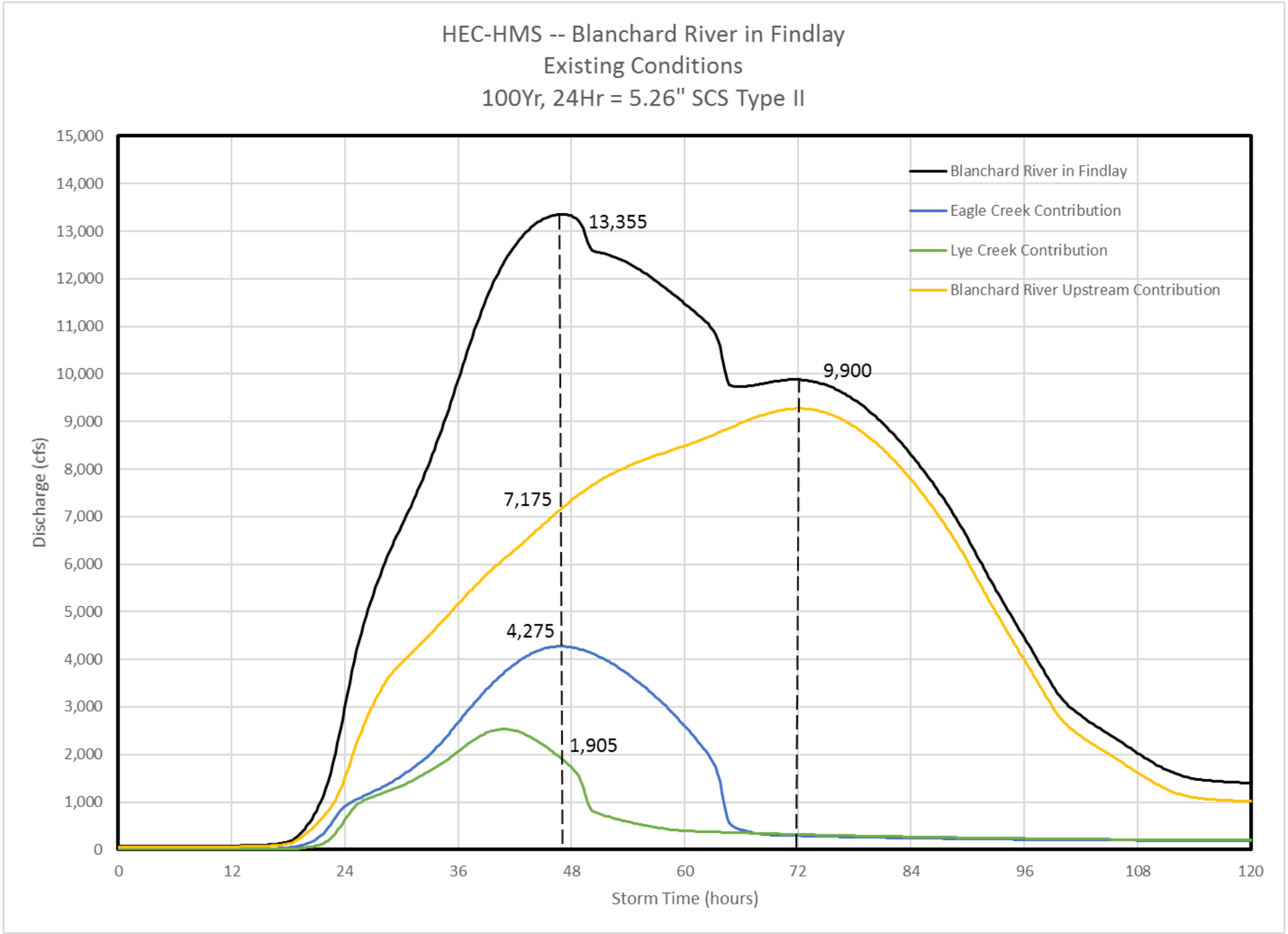
Blanchard River (~242 mi.^{2})

Lye Creek (~28 mi.^{2})

Eagle Creek (~63 mi.^{2})

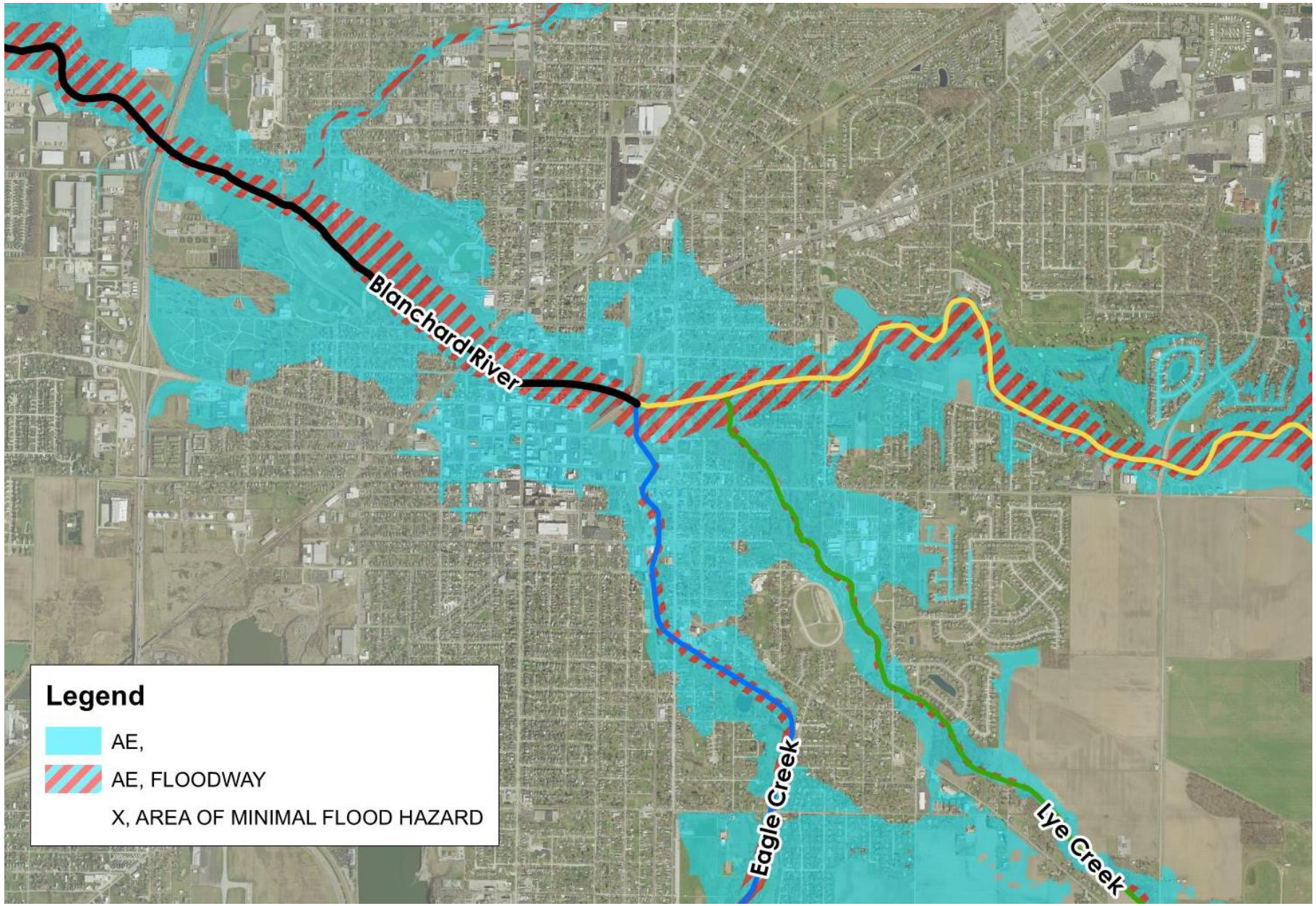
HEC-HMS

SCS Type II Storm Used For Conceptual Planning



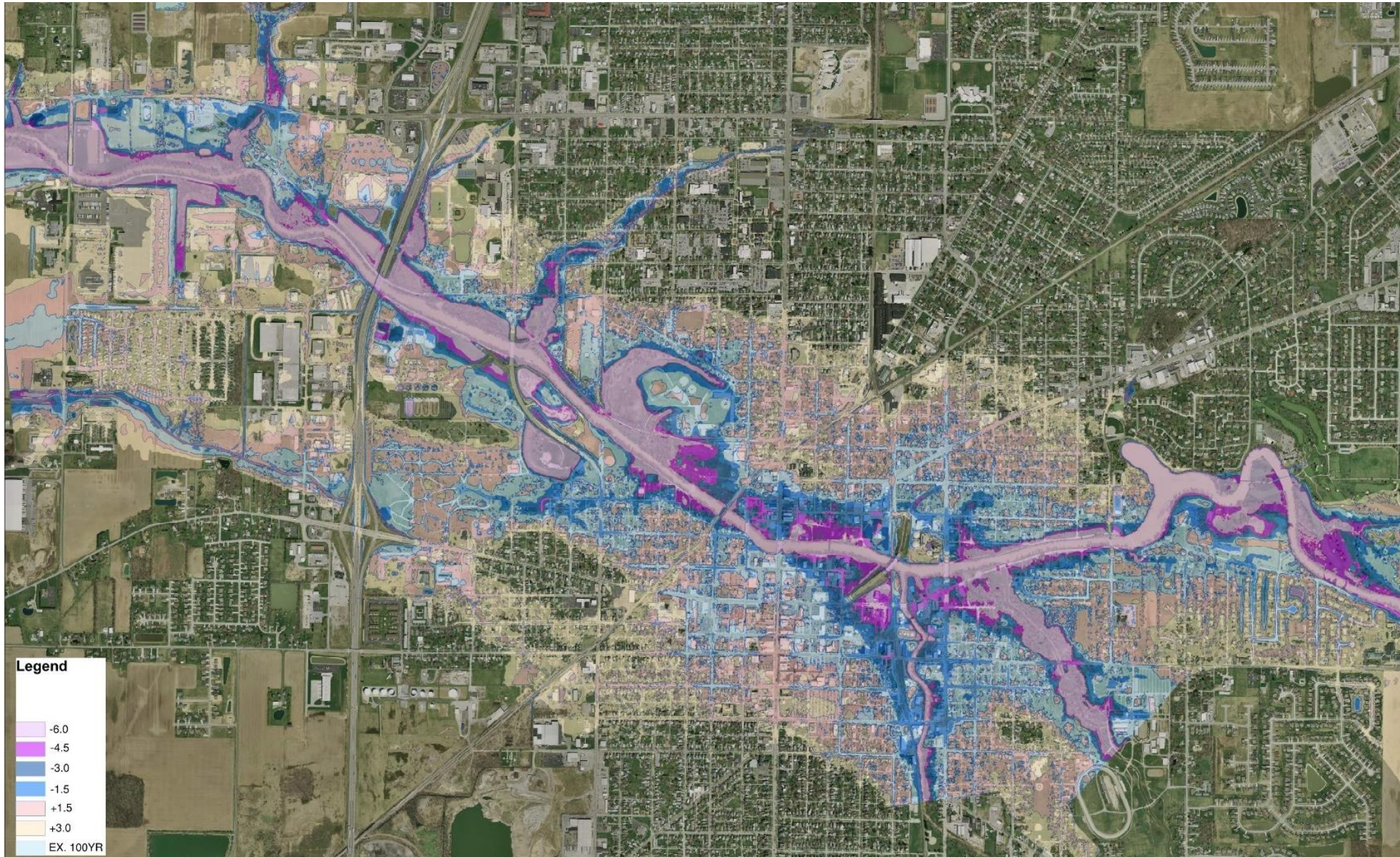
Project Background

Existing 1% Annual-Chance Flood Extents



Project Background

Floodplain Extents - Depths



Past Studies

Project Background

Past Studies

Vogt, Ivers, Seaman and Associates (1950s)

- "Findlay Flood Problem" – Interim Report on the Upper Blanchard River Basin

"No simple plan for minor channel improvements will effectively eliminate flood damages."

Levees/floodwalls and Retention reservoirs were considered

Unfavorable Cost-Benefit Ratio

Past Studies

Vogt, Ivers, Seaman and Associates (1950s)

- “Findlay Flood Problem” – Interim Report on the Upper Blanchard River Basin

USACE (1963)

- Survey Report of Flood Control at the City of Findlay

Corps of Engineers’ Reports

“Since 1871, ***16*** preliminary reports have been written on the subject of improvement of the Maumee River and its tributaries.

Past Studies

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Solutions Considered

Reservoirs – *3 sites considered*

Floodplain Evacuation – *Impractical*

Channel Improvement – *Not feasible*

High Velocity Channel – *Not feasible*

Diversion – *Reviewed in further detail*

Levees & Floodwalls – *Feasible*

August 2007

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URS (2008)

- Draft Alternatives Assessment for Findlay and Ottawa, Ohio Flood Damage Reduction Project

Prepared for NWOFMP

“…memorandum assessed the continued viability of previously considered or recommended alternatives”

Past Studies

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USACE (**2011**, 2015, 2016)

- **Interim Feasibility Study**
- Draft Environmental Impact Statement
- Draft Final EIS

FEASIBILITY SCOPING REPORT
BLANCHARD RIVER WATERSHED, OHIO

Interim Feasibility Study
for
Flood Risk Management
in
Findlay and Ottawa, Ohio

December 2011

Past Studies

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- **Final Array of Plans**
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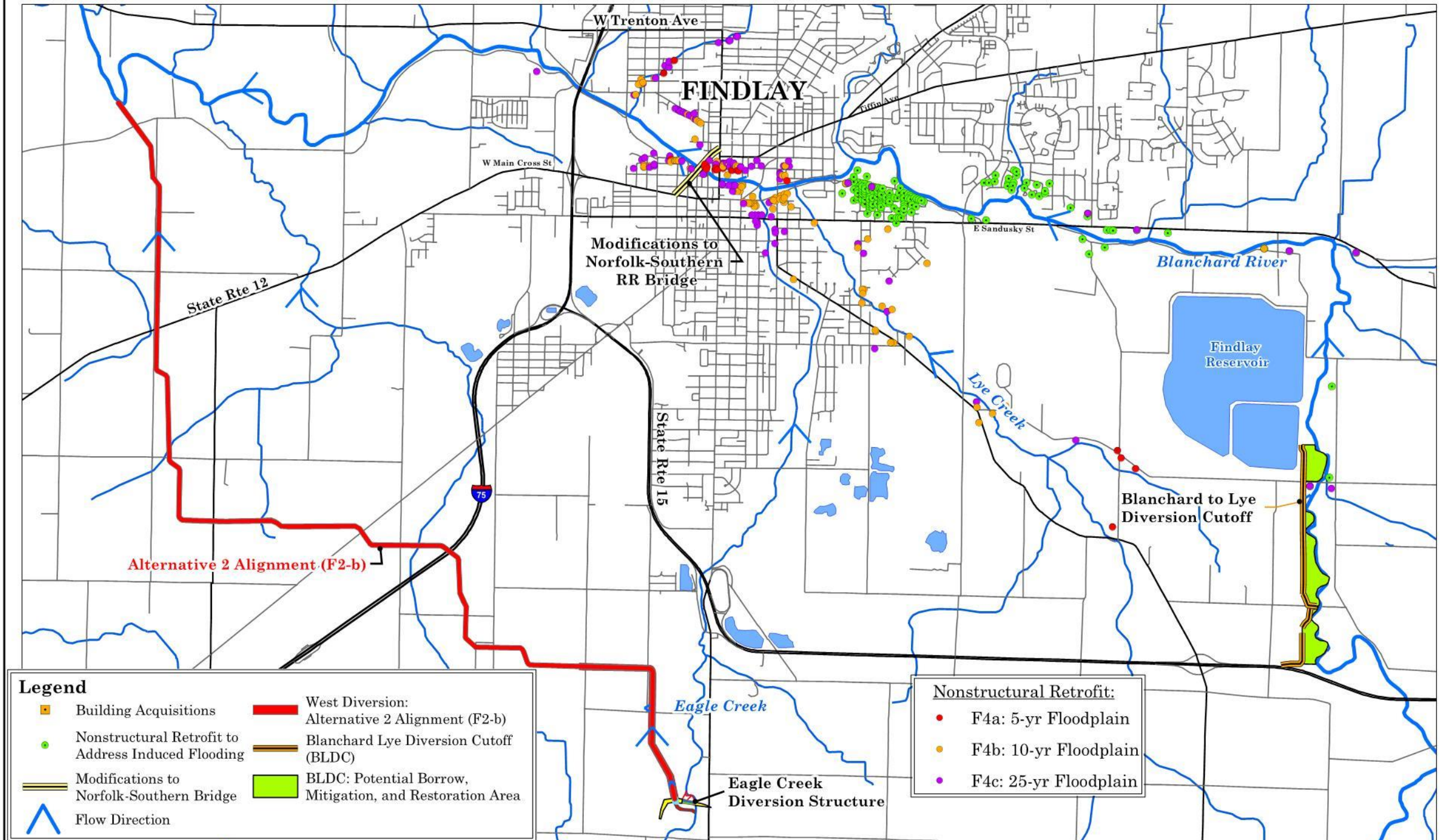
REPORT SYNOPSIS
FINAL ARRAY OF PLANS
BLANCHARD RIVER WATERSHED, OHIO

Interim Feasibility Study
for
Flood Risk Management
in
Findlay and Ottawa, Ohio

March 2013

US Army Corps of Engineers
Buffalo District
BUILDING STRONG


W Trenton Ave
FINDLAY
W Main Cross St
E Sandusky St
Modifications to Norfolk-Southern RR Bridge
State Rte 12
State Rte 15
75
Blanchard River
Findlay Reservoir
Lye Creek
Blanchard to Lye Diversion Cutoff
Alternative 2 Alignment (F2-b)
Eagle Creek
Eagle Creek Diversion Structure
Legend
Building Acquisitions
Nonstructural Retrofit to Address Induced Flooding
Modifications to Norfolk-Southern Bridge
Flow Direction
West Diversion: Alternative 2 Alignment (F2-b)
Blanchard Lye Diversion Cutoff (BLDC)
BLDC: Potential Borrow, Mitigation, and Restoration Area
Nonstructural Retrofit:
F4a: 5-yr Floodplain
F4b: 10-yr Floodplain
F4c: 25-yr Floodplain

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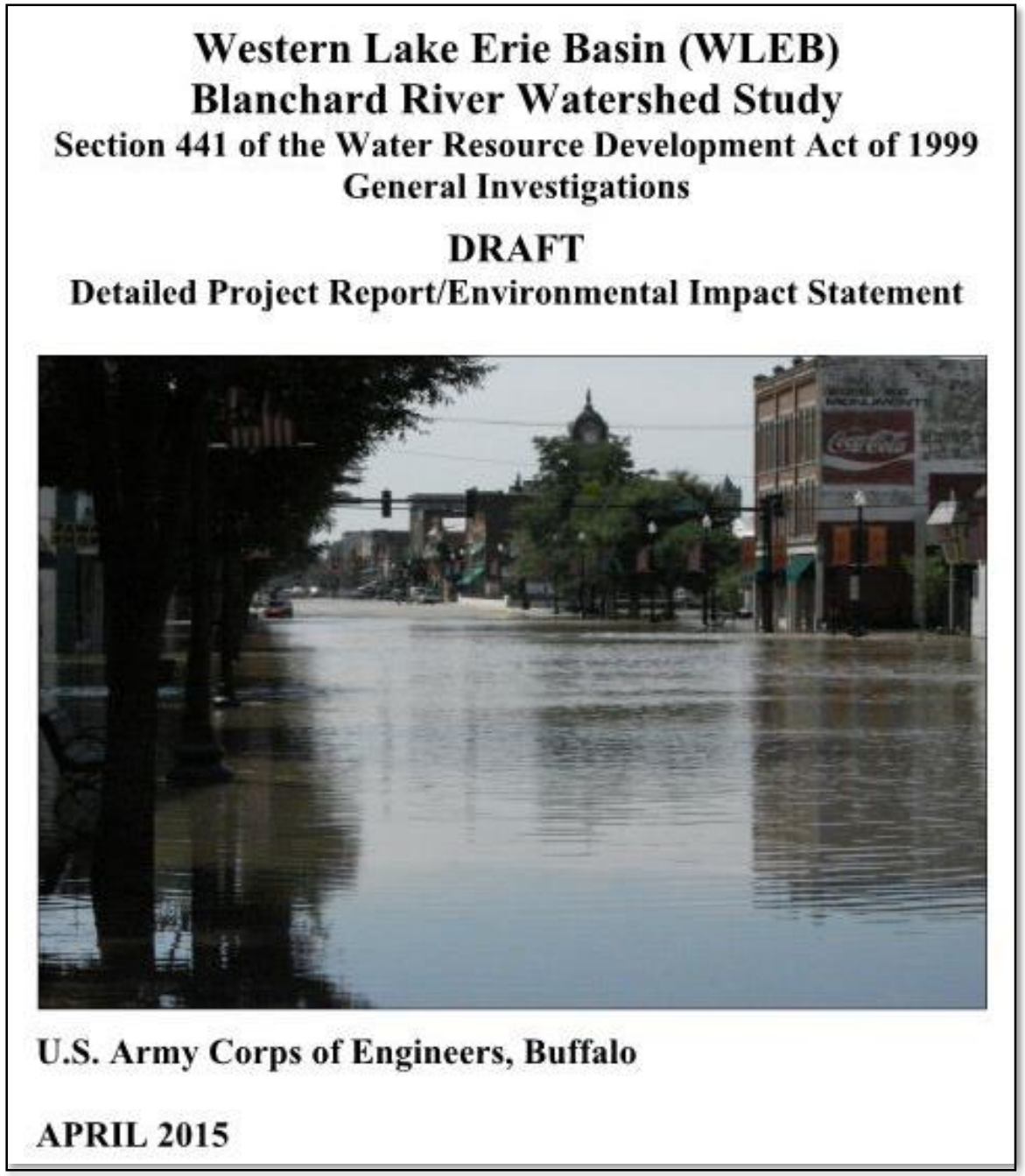

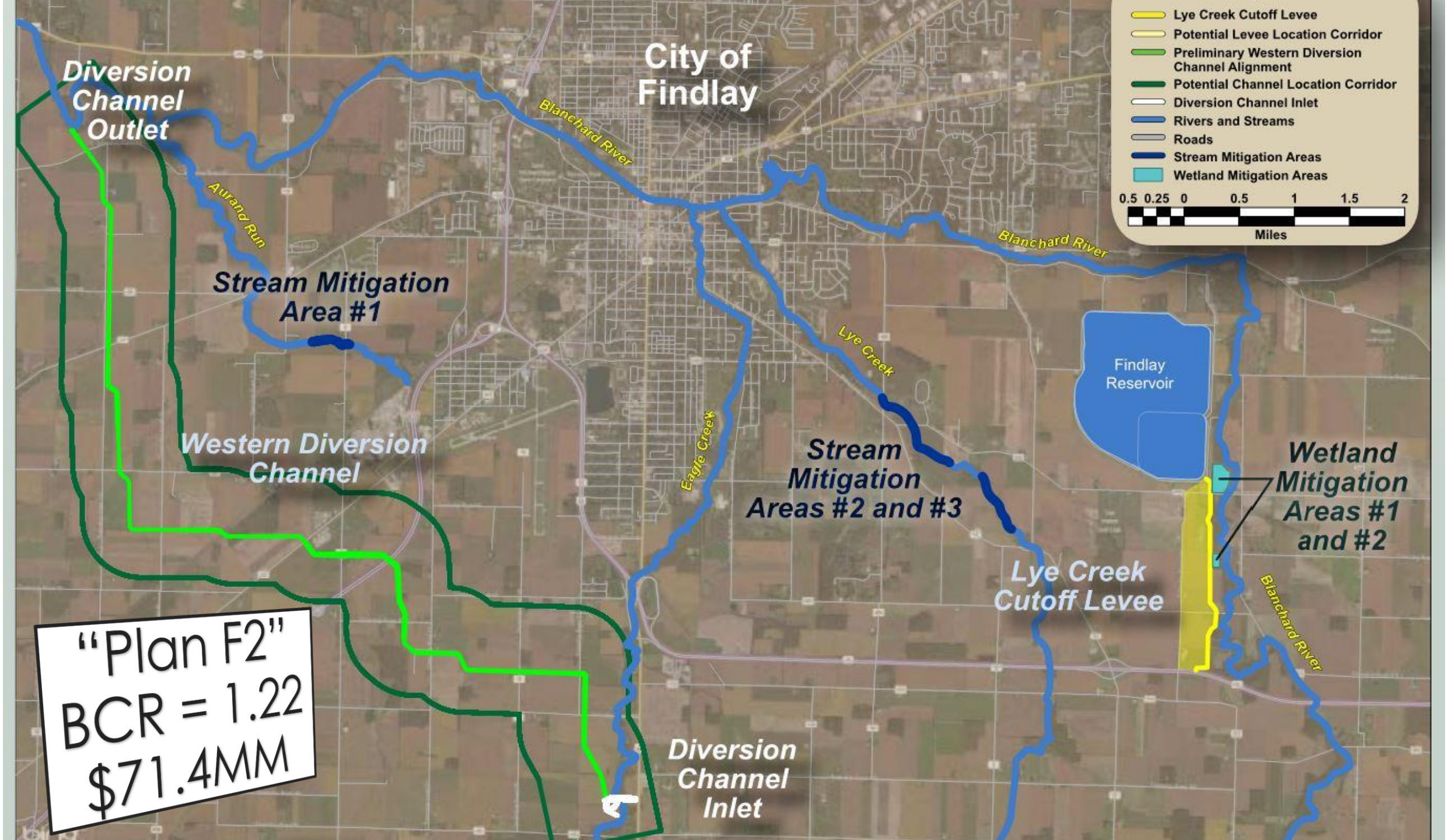
Diversion Channel Outlet
City of Findlay
Blanchard River
Aurand Run
Stream Mitigation Area #1
Western Diversion Channel
Eagle Creek
Lye Creek
Blanchard River
Findlay Reservoir
Stream Mitigation Areas #2 and #3
Wetland Mitigation Areas #1 and #2
Lye Creek Cutoff Levee
Blanchard River
Diversion Channel Inlet
"Plan F2"
BCR = 1.22
$71.4MM
Lye Creek Cutoff Levee
Potential Levee Location Corridor
Preliminary Western Diversion Channel Alignment
Potential Channel Location Corridor
Diversion Channel Inlet
Rivers and Streams
Roads
Stream Mitigation Areas
Wetland Mitigation Areas
0.5 0.25 0 0.5 1 1.5 2
Miles

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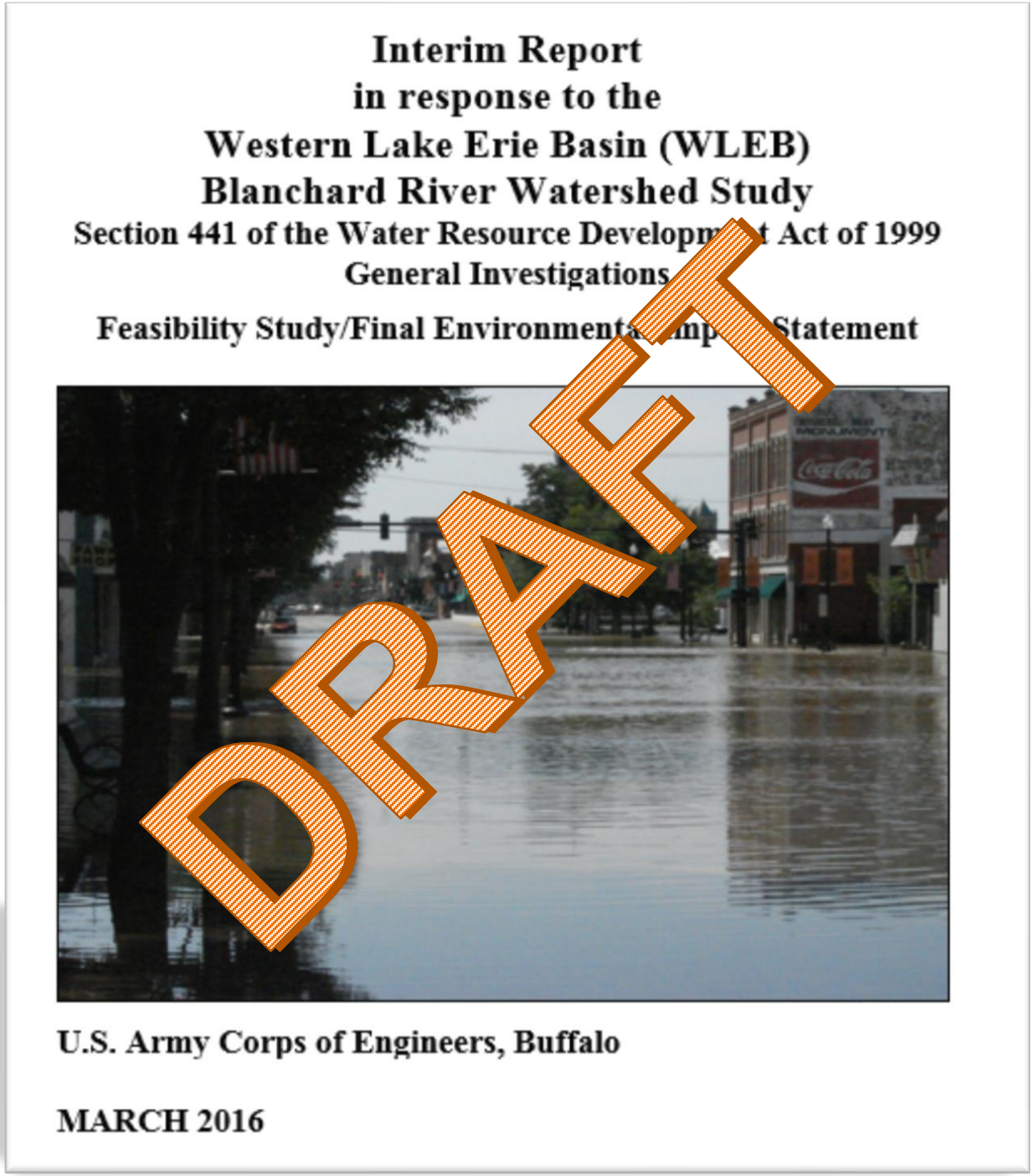

Western Diversion of Eagle Creek

25-Year (4% ACE) Capacity

Opinion of Probable Cost

25-Year Channel Sizing Estimates		
01	Lands & Damages	$ 6,580,000
02	Relocations	$ 14,590,000
06	Fish & Wildlife	$ 1,758,000
08	Roads, Railroads Bridges	$ 2,657,000
09	Channels and Canals	$ 34,587,000
15	Floodway Control & Diversion Structure	$ 8,708,000
18	Cultural Resource Preservation	$ 692,000
30	Planning, Engineering & Design	$ 8,182,000
31	Construction Management	$ 3,149,000
	First Costs	$ 80,903,000
	Interest during construction	$ 5,671,000
	Total Cost	**$ 86,574,000**

About $18 million allocated for new bridges and roads

Includes 27.5% Contingency

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*Source: USACE Buffalo District Website: http://www.lrb.usace.army.mil/Portals/45/docs/Blanchard/August2015/August-2015-Recommended-Plan.pdf

Original Scope of Work

Project Transition

Enter Stantec

Scope

- Analyze the USACE Feasibility Report
- Perform field surveys and geotechnical investigations
- Determine preferred channel alignment

Not authorized

- *Prepare property acquisition plan and legal descriptions*
- *Prepare final design and construction plans.*
- *Prepare necessary documents to secure regulatory permits*

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“Phase 1” – Gap Analysis

Independent Review

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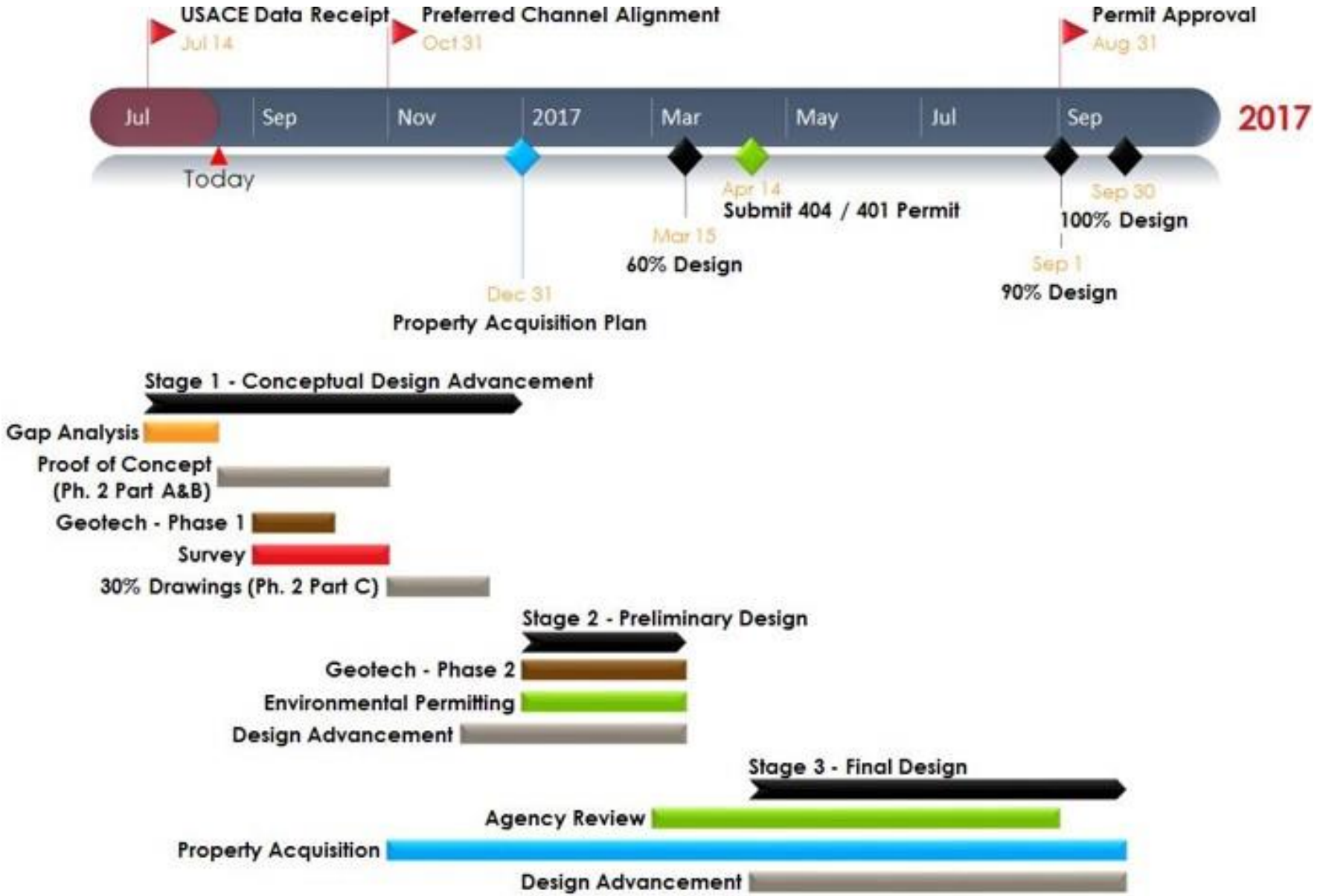
Original Proposed Schedule

Schedule



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Data We Reviewed

Field Reconnaissance

- Preliminary Reconnaissance
  - Observed topography, landuses & infrastructure
  - Gained context for project scale

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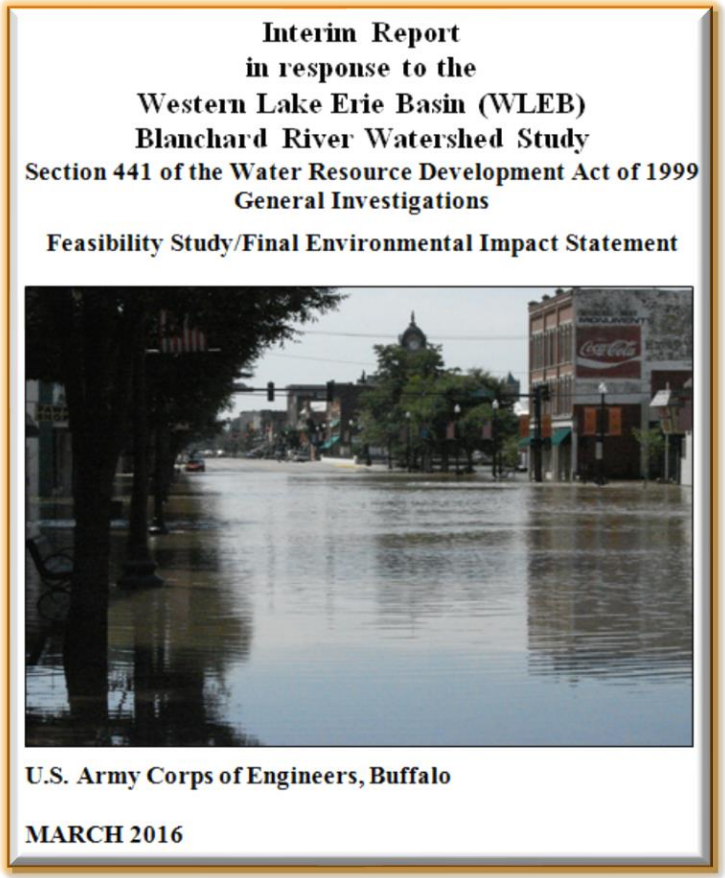
Data We Reviewed

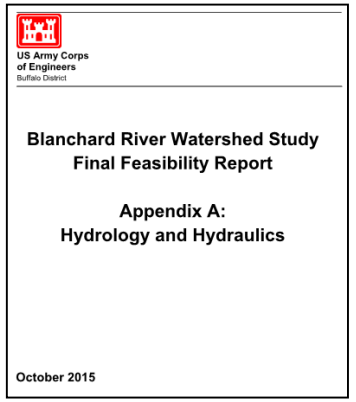
Data Reviewed

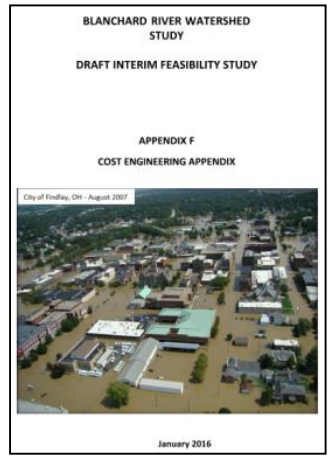
- **Reports**
- Files on USACE External Hard Drive
- Public Data (USGS, ODOT, etc.)

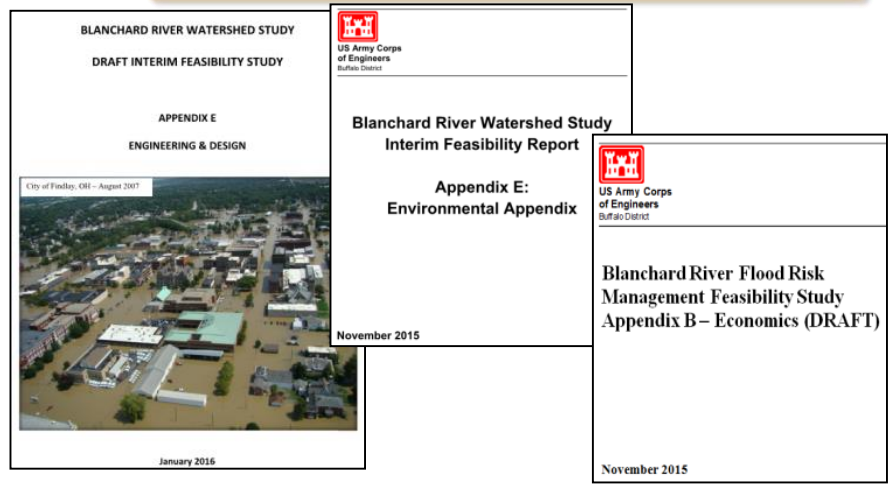
Project Components

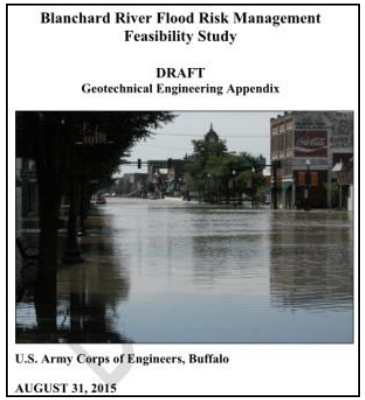
- H&H
- Base Map Data
- Geotechnical
- Transportation
- Cost
- Economics
- Design
- Environmental











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Data We Reviewed

Data Reviewed

- Reports
- **Files on USACE External Hard Drive**
- Public Data (USGS, ODOT, etc.)

Project Components

- H&H
- Base Map Data
- Geotechnical
- Transportation
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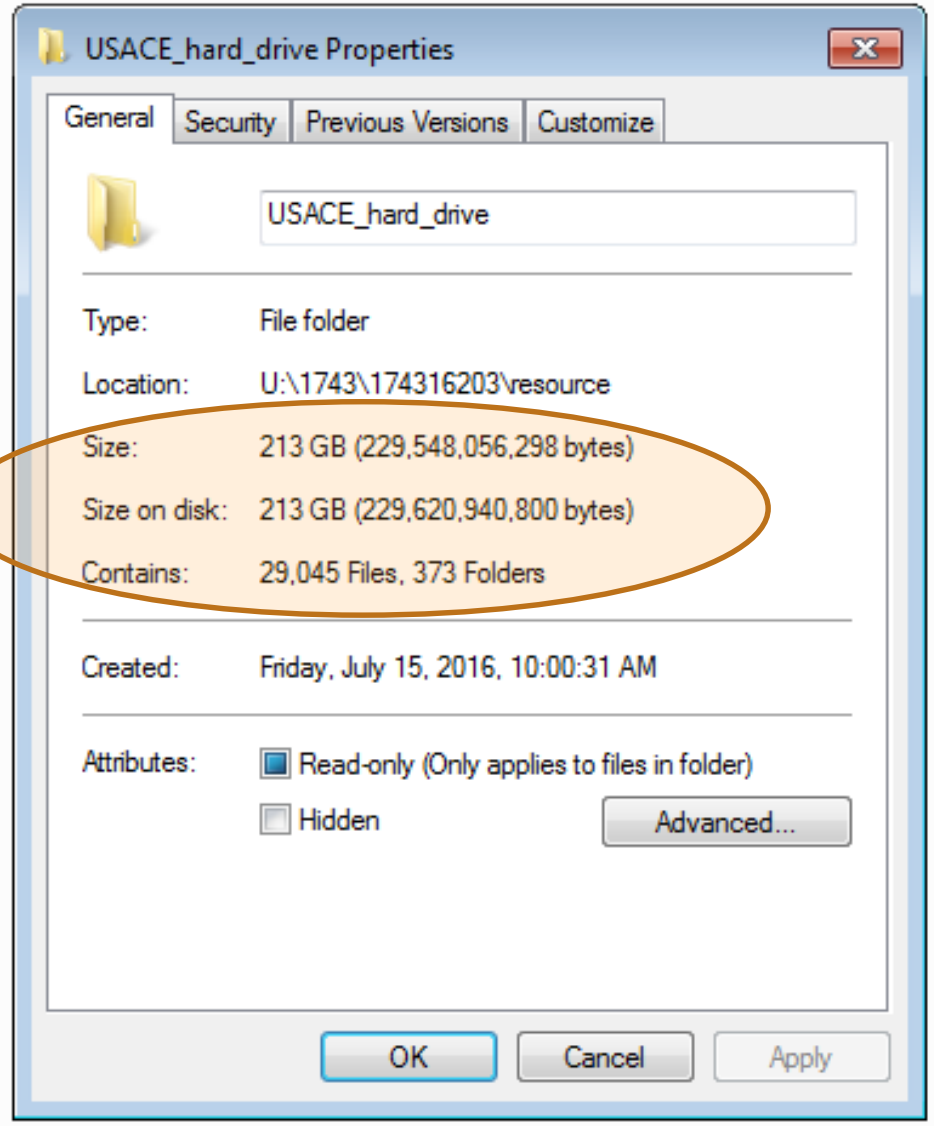

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Data We Reviewed

15 Alternatives

Hydrologic and Hydraulic model methodology

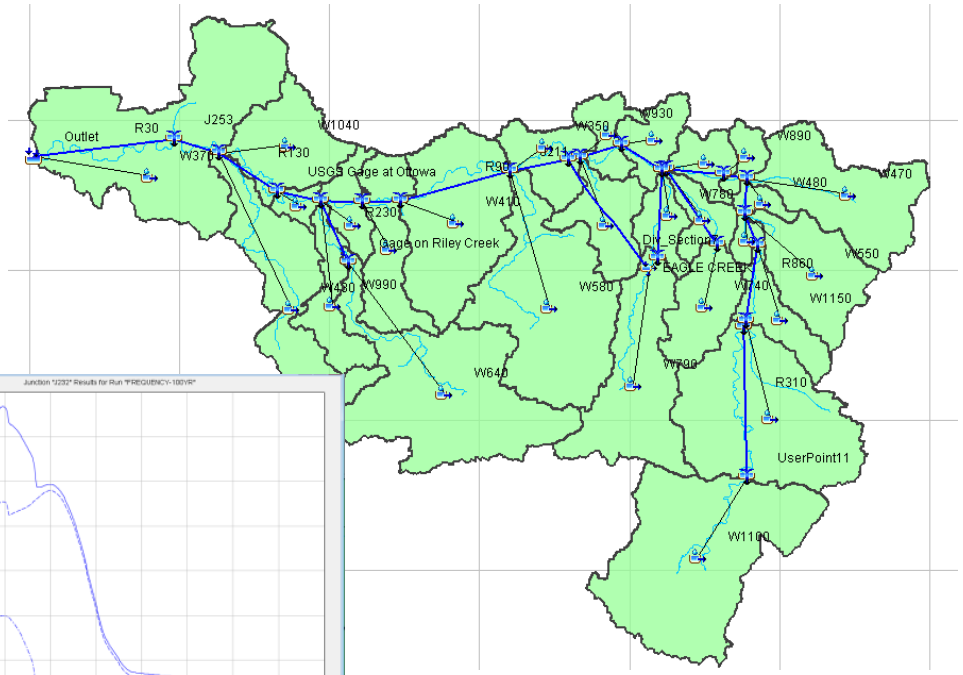
Model Results

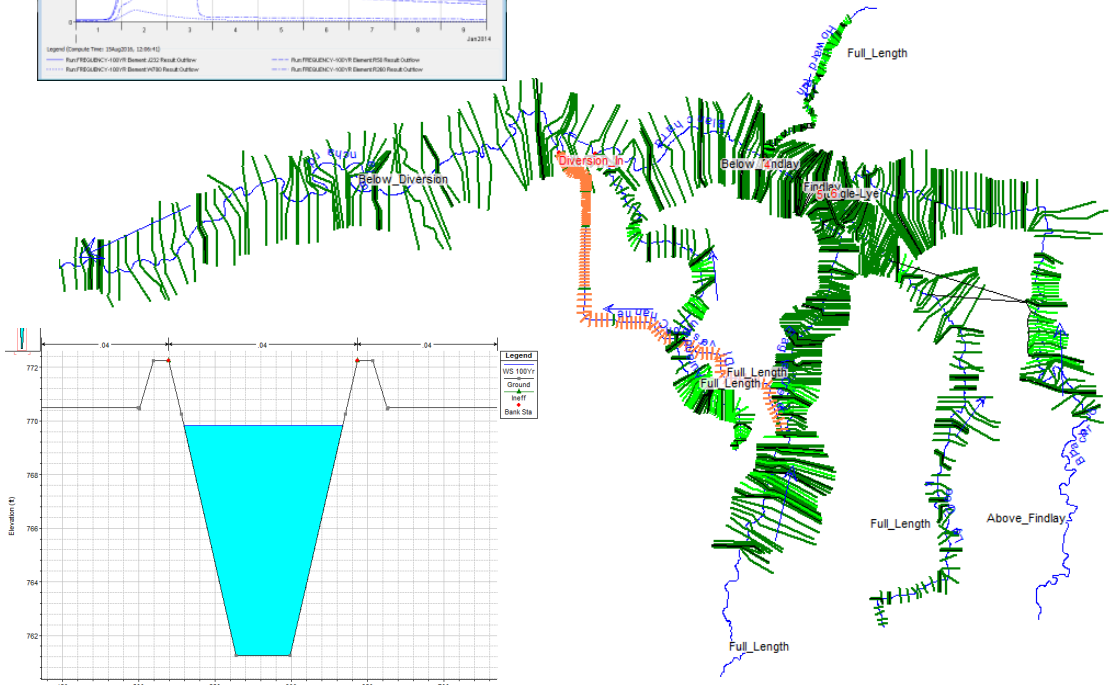
Data Reviewed

- Reports
- Files on USACE External Hard Drive
- Public Data (USGS, ODOT, etc.)

Project Components

- **H&H**
- Base Map Data
- Geotechnical
- Transportation
- Cost
- Economics
- Design
- Environmental





Data We Reviewed

Historical project borings

ODOT TIMS data

Data Reviewed

- Reports
- Files on USACE External Hard Drive
- Public Data (USGS, ODOT, etc.)

Project Components

- H&H
- Base Map Data
- **Geotechnical**
- Transportation
- Cost
- Economics
- Design
- Environmental

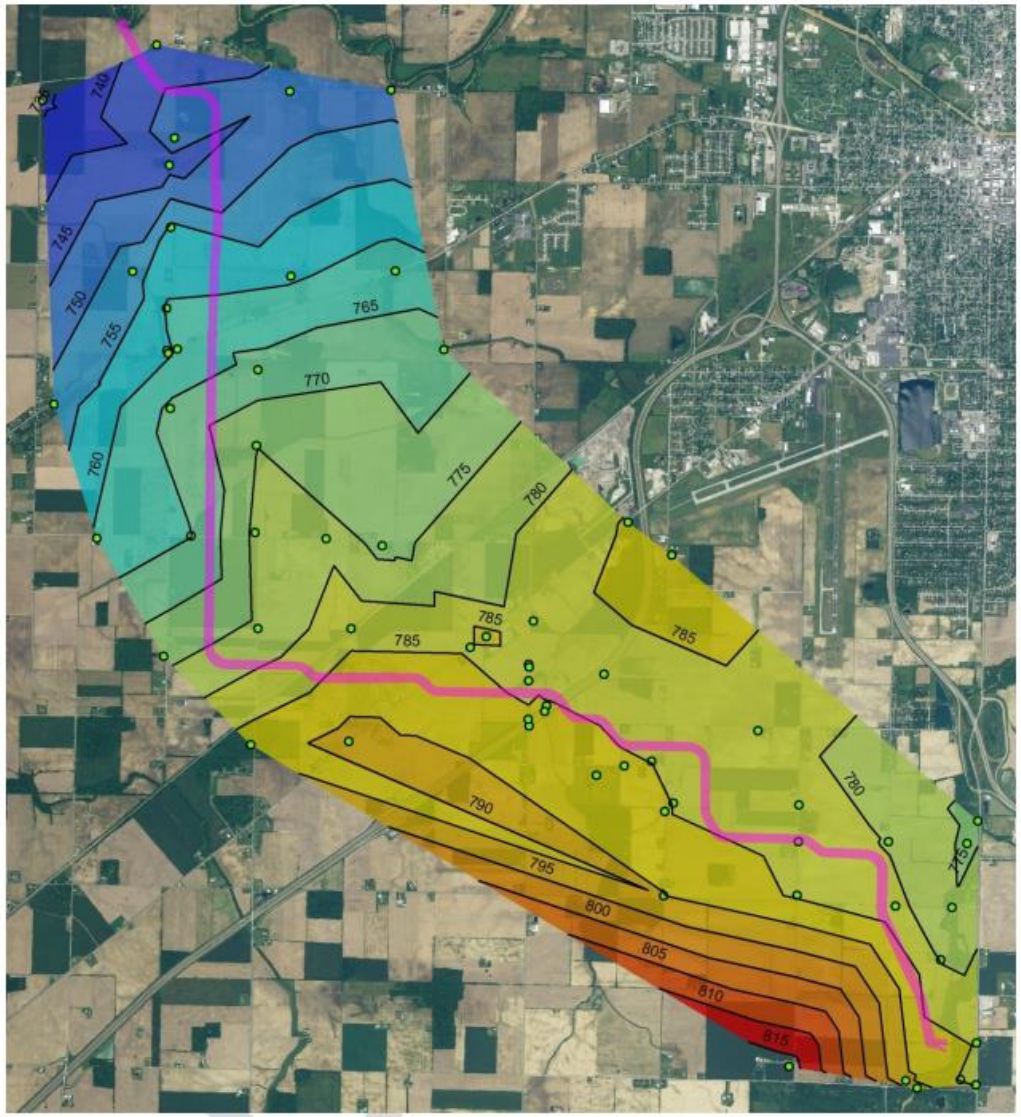


Figure 10 – Estimated bedrock topography (feet NAVD88) in vicinity of diversion channel (pink) with data points (green)

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Data We Reviewed

Costs

Benefits

Data Reviewed

- Reports
- Files on USACE External Hard Drive
- Public Data (USGS, ODOT, etc.)

Project Components

- H&H
- Base Map Data
- Geotechnical
- Transportation
- **Cost**
- **Economics**
- Design
- Environmental

Table 1: Project First Costs

Description	Amount	Cont.%	Cont. $	Total
01 – Lands and Damages	$ 5,511,000	19.4%	$ 1,068,000	$ 6,579,000
02 – Relocations	$ 11,443,000	27.5%	$ 3,147,000	$ 14,589,000
06 – Fish and Wildlife	$ 1,379,000	27.5%	$ 379,000	$ 1,758,000
08 – Road, Railroads & Bridges	$ 2,084,000	27.5%	$ 573,000	$ 2,657,000
09 – Channels and Canals	$ 27,127,000	27.5%	$ 7,460,000	$ 34,587,000
15 – Floodway Control & Diversion	$ 6,830,000	27.5%	$ 1,878,000	$ 8,709,000
18 – Cultural Resources	$ 543,000	27.5%	$ 149,000	$ 692,000
30 – Engineering & Design	$ 6,417,000	27.5%	$ 1,765,000	$ 8,182,000
31 – Construction Management	$ 2,470,000	27.5%	$ 679,000	$ 3,149,000
TOTAL	$ 63,804,000		$ 17,099,000	$ 80,902,000

Table 2: Annual O&M Costs

Item	O&M; Replacement Costs
Diversion Channel & Drainage Structures	$188,000
Movable Dam	$32,000
Total	$220,000

Q = 25-yr Diversion, NO BLCL, 100 cfs Assumption

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 3,283,450
Emergency Response Costs Avoided:	$ 121,100
NFIP Administrative Costs Avoided:	$ 6,200
Total AA Benefits:	$ 3,410,750

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 80,903,000
Interest During Construction:	$ 5,671,000
Total Investment Costs:	$ 86,574,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 3,445,000
Diversion Channel & Drainage Structures:	$ 188,000
Movable Dam:	$ 32,000
Total AA Costs:	$ 3,665,000

ECONOMIC ANALYSIS

FY16 Discount Rate = 3.125%

AVERAGE ANNUAL NET BENEFITS
$ (254,250)

BC ANALYSIS	
AA BENEFIT:	$ 3,410,750
AA COST:	$ 3,665,000
BC Ratio:	0.93

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES
$ 1,690,850

Stantec

Independent Data Review Analysis

Data Qs

Data Qs

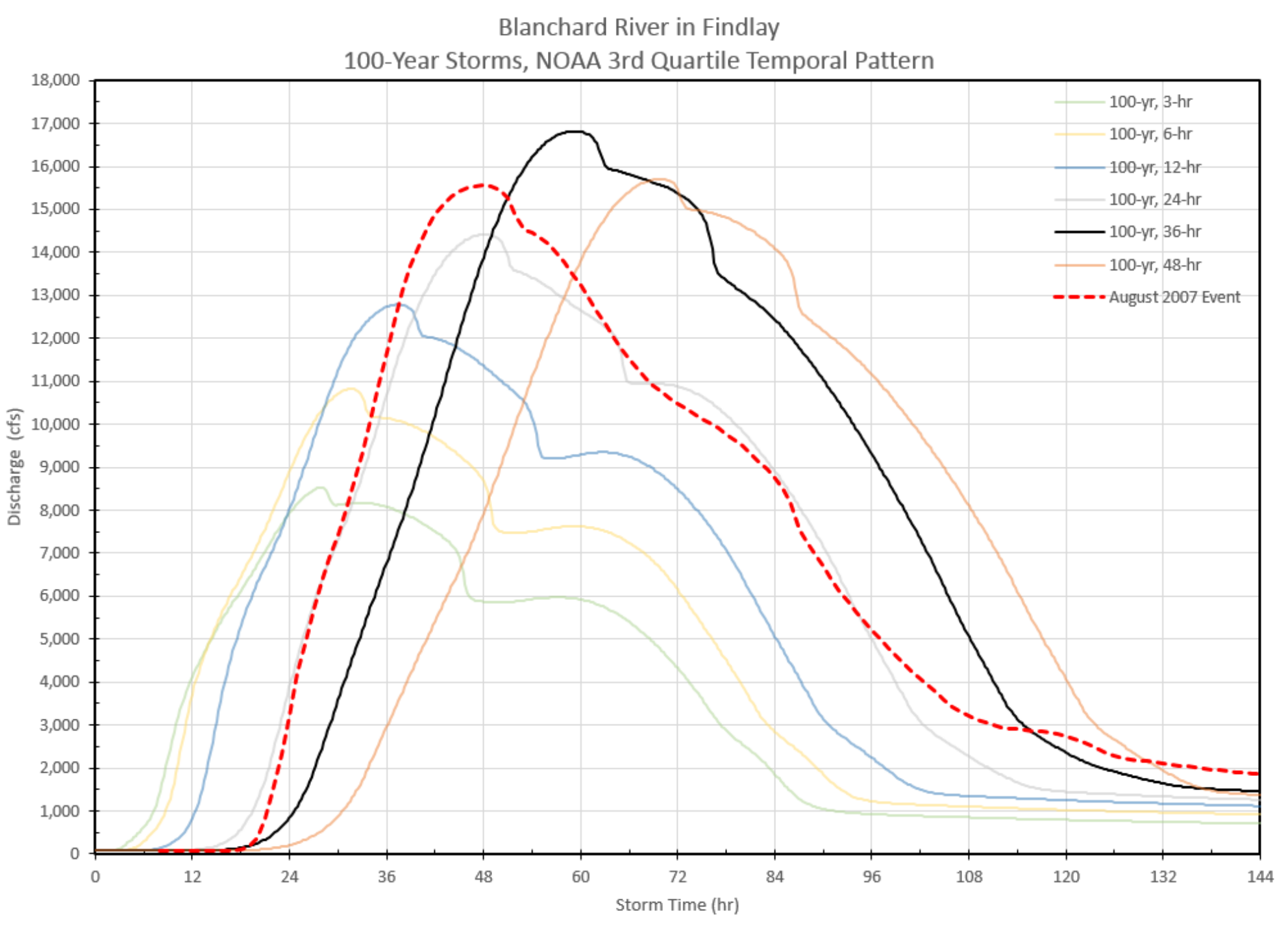
Project Objective?

"The overall objective of the study is to reduce flood risk and improve the overall quality of life for the residents of the Findlay, Ohio, area."

- More specific and measurable goal needed

Stantec

Hydrology



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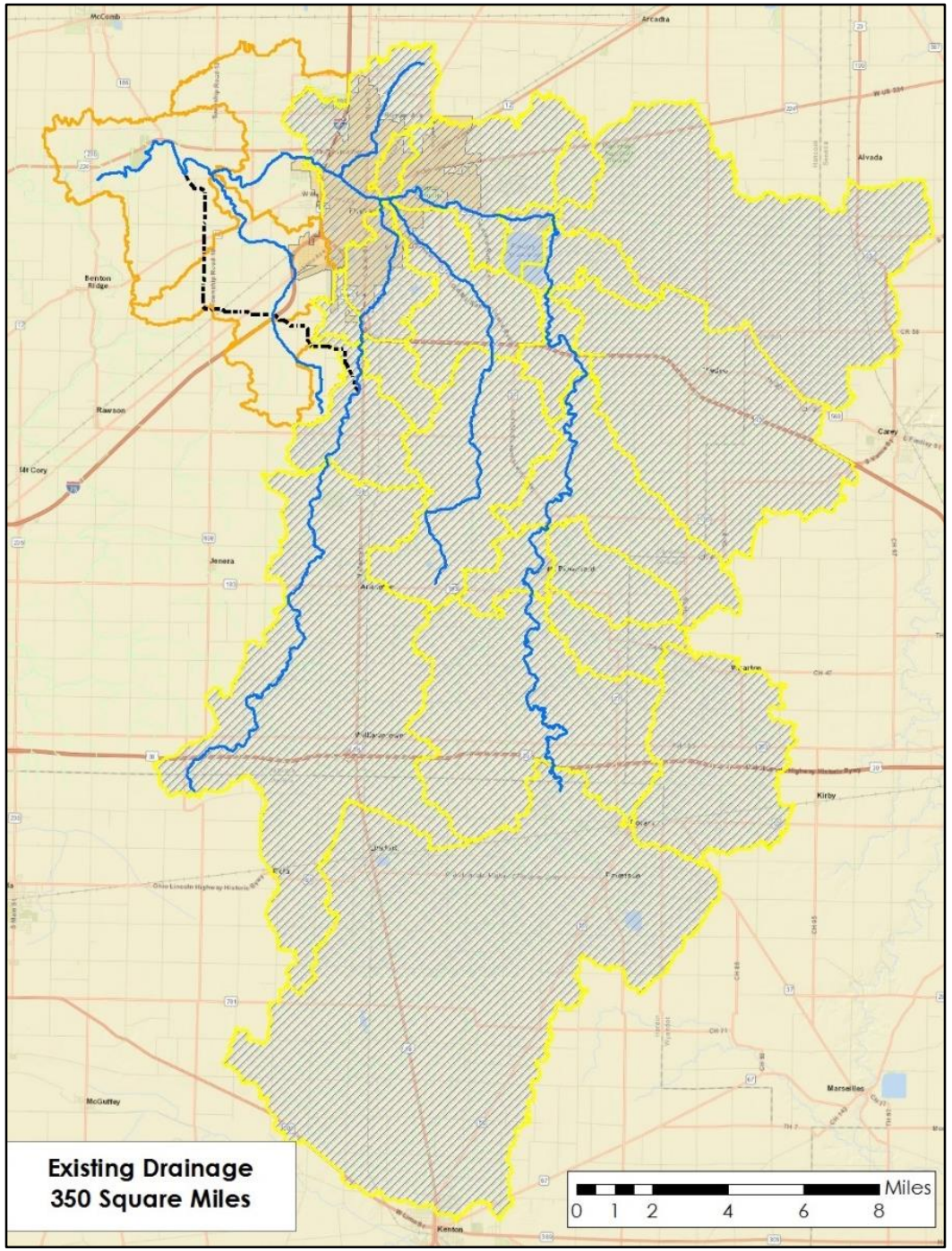
Data Qs

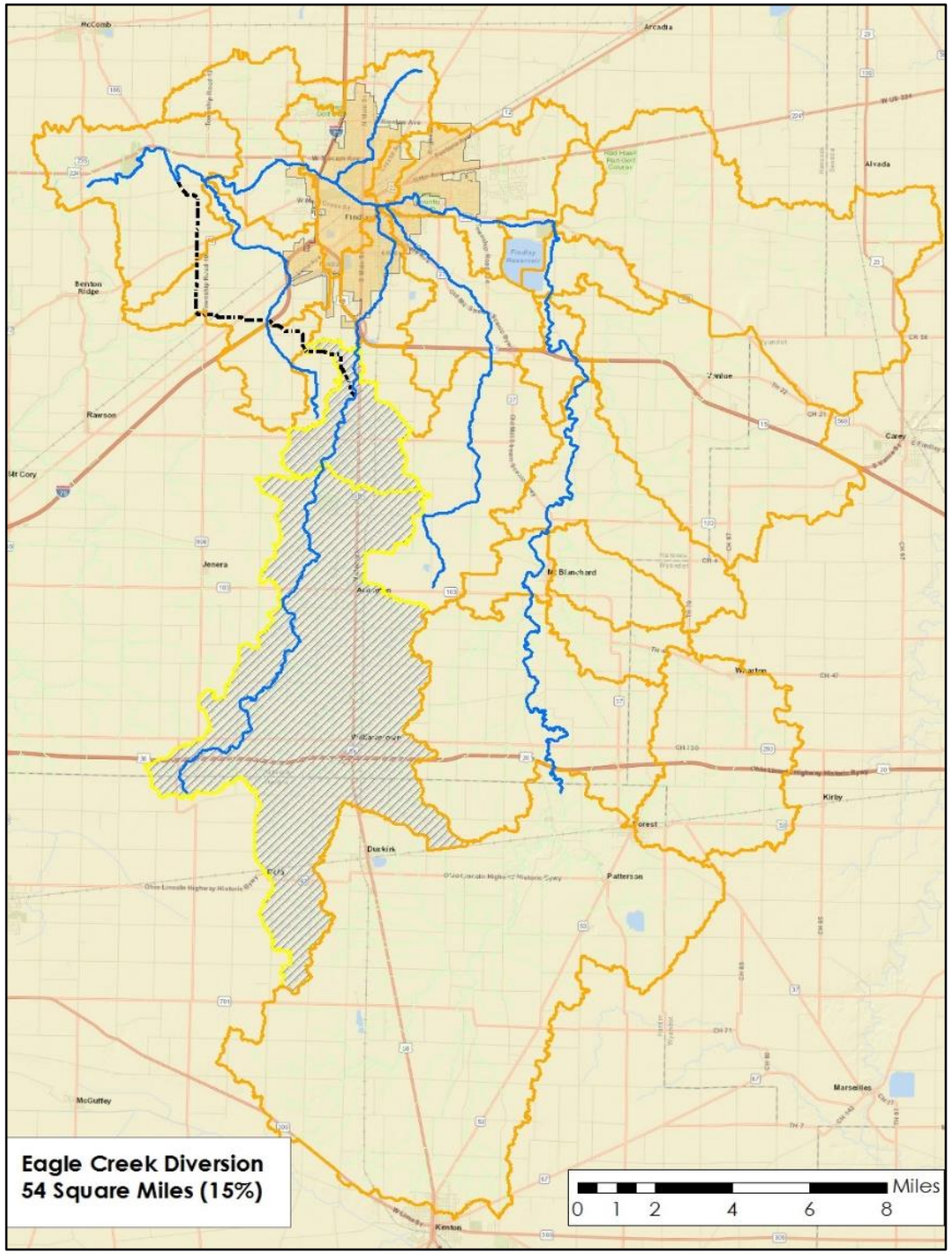
Residual Risk



Data Qs

Residual Risk

15% of Watershed Influenced if Only Eagle Creek is Addressed



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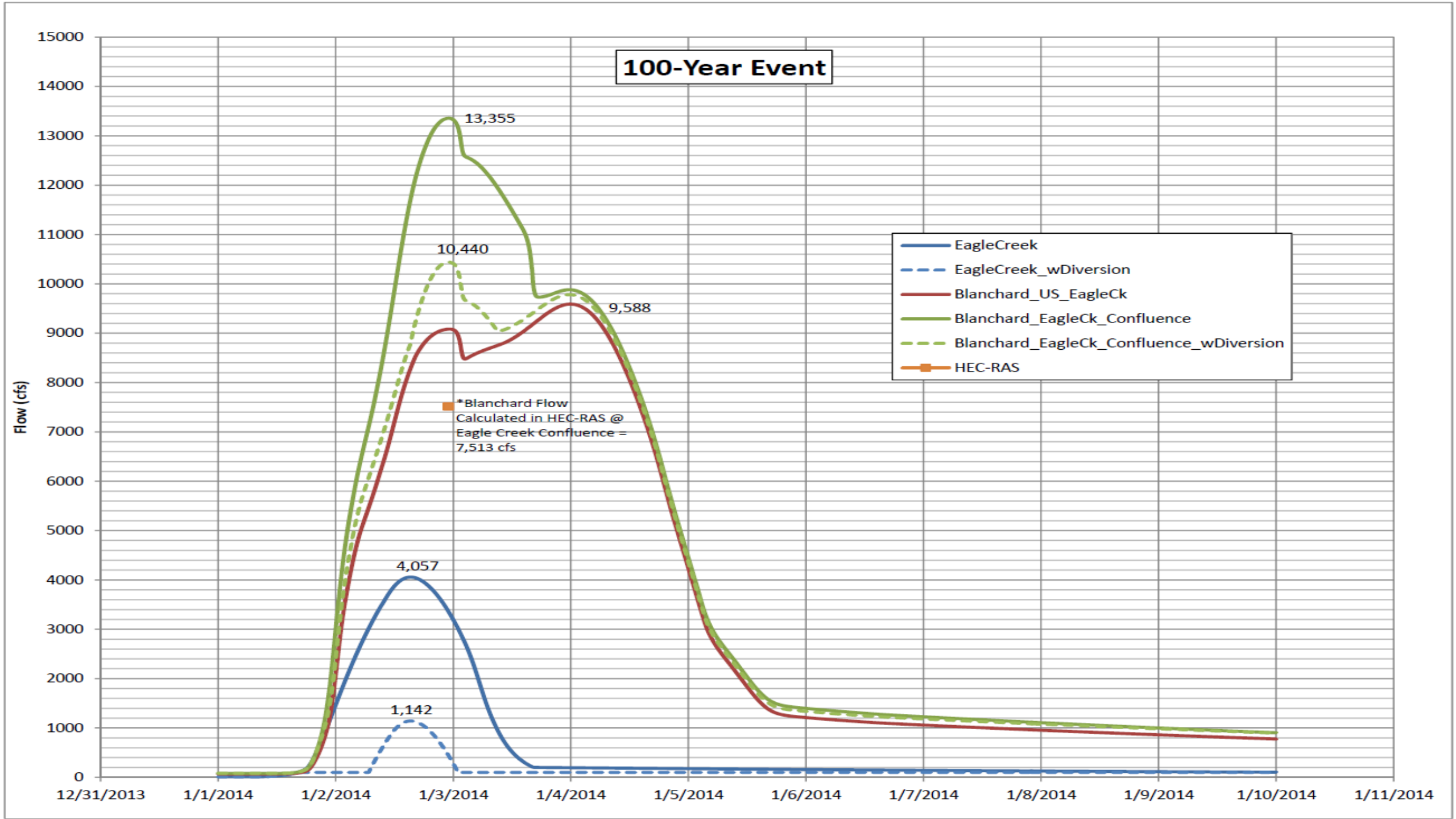
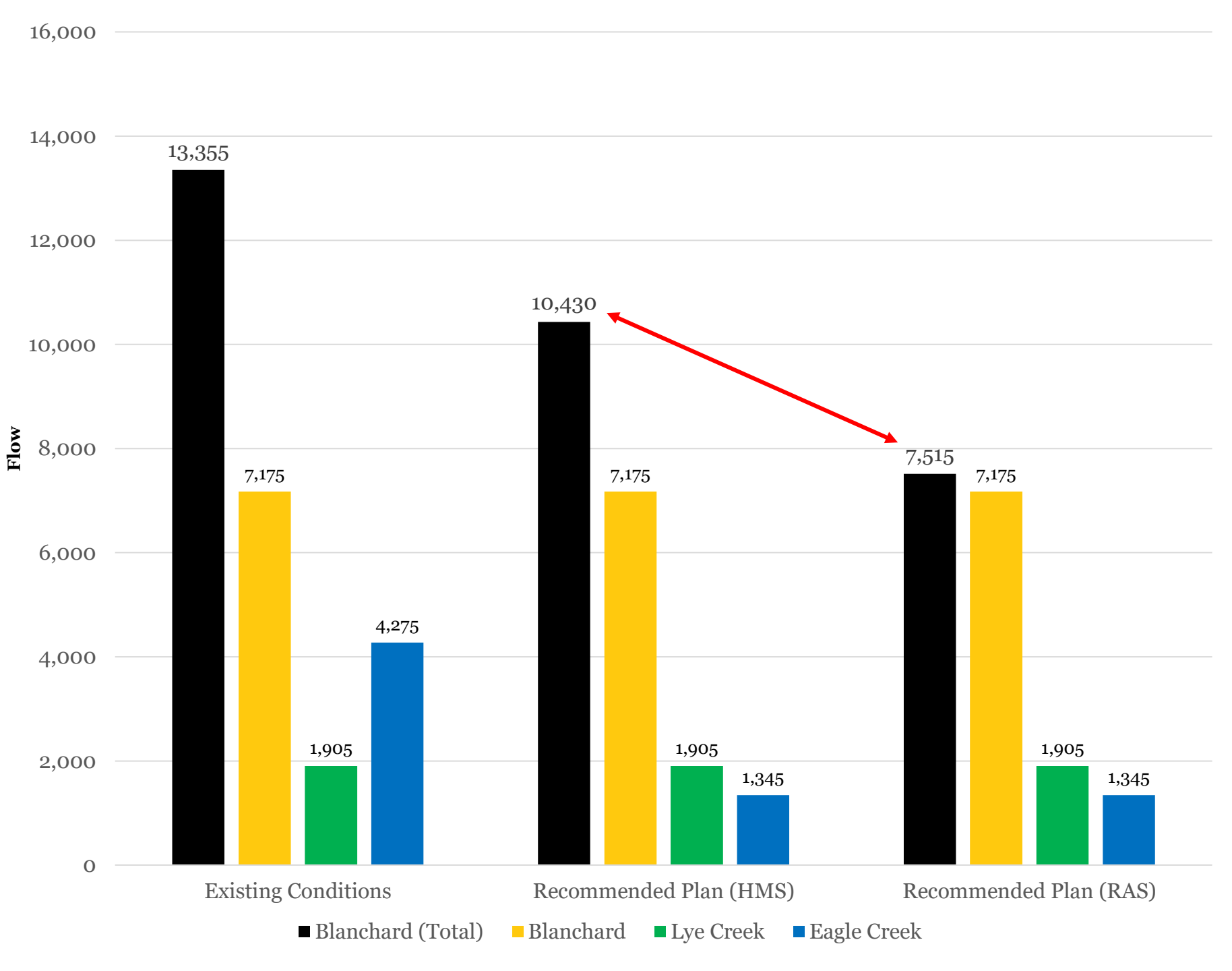

100-Year Event
13,355
10,440
9,588
4,057
1,142
*Blanchard Flow Calculated in HEC-RAS @ Eagle Creek Confluence = 7,513 cfs
EagleCreek
EagleCreek_wDiversion
Blanchard_US_EagleCk
Blanchard_EagleCk_Confluence
Blanchard_EagleCk_Confluence_wDiversion
HEC-RAS
Flow (cfs)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
12/31/2013
1/1/2014
1/2/2014
1/3/2014
1/4/2014
1/5/2014
1/6/2014
1/7/2014
1/8/2014
1/9/2014
1/10/2014
1/11/2014

Data Qs

1% ACE



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Data Qs

Alternative 13 (Recommended Plan)

- 25-year event diversion channel with Eagle Creek at 100 cfs.

Q = 25-yr Diversion, NO BLCL, 100 cfs Assumption

BENEFITS

AVERAGE ANNUAL BENEFITS		
Residential, Commercial, Auto Damages Avoided:	$	3,283,450
Emergency Response Costs Avoided:	$	121,100
NFIP Administrative Costs Avoided:	$	6,200
Total AA Benefits:	$	3,410,750

COSTS

INVESTMENT COSTS		
Total First Cost:	$	80,903,000
Interest During Construction:	$	5,671,000
Total Investment Costs:	$	86,574,000

AVERAGE ANNUAL COSTS		
Average Annual Investment Cost:	$	3,445,000
Diversion Channel & Drainage Structures:	$	188,000
Movable Dam:	$	32,000
Total AA Costs:	$	3,665,000

ECONOMIC ANALYSIS

FY16 Discount Rate = 3.125%

AVERAGE ANNUAL NET BENEFITS	
$	(254,250)

BC ANALYSIS		
AA BENEFIT:	$	3,410,750
AA COST:	$	3,665,000
BC Ratio:		0.93

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES	
$	1,690,850

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Data Qs

- Design and Engineering
  - Update project objective?
- Hydrology & Hydraulics (H&H)
  - Risk based evaluation?
  - HMS to RAS unsteady model update?
- Cost and Economics
  - Address BCR less than 1.0?

Stantec

USACE Coordination

- Stantec coordinated with USACE throughout data review
  - Questions for clarification

Tasks and Schedule

Design Deliverables

- Conceptual Design Advancement (Stage 1)
  - Phase 1 – Complete ☑
  - Phase 2 – Verify Concept
    - Part A – Data Acquisition
    - Part B – Concept Refinement
    - Part C – 30% Drawings
- 60% (Stage 2) ⟶ *(Permits)*
- 90%
- Final (Stage 3)

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“Phase 2”

Proof of Concept

Path Forward

Conceptual Design Advancement

Phase 2 – Work Plan – **Proof of Concept**

- **Part A**
  - **Additional Data Collection And Analysis**
- Part B
  - Refinement of Conceptual Design
- Part C
  - 30% Design Plans

?

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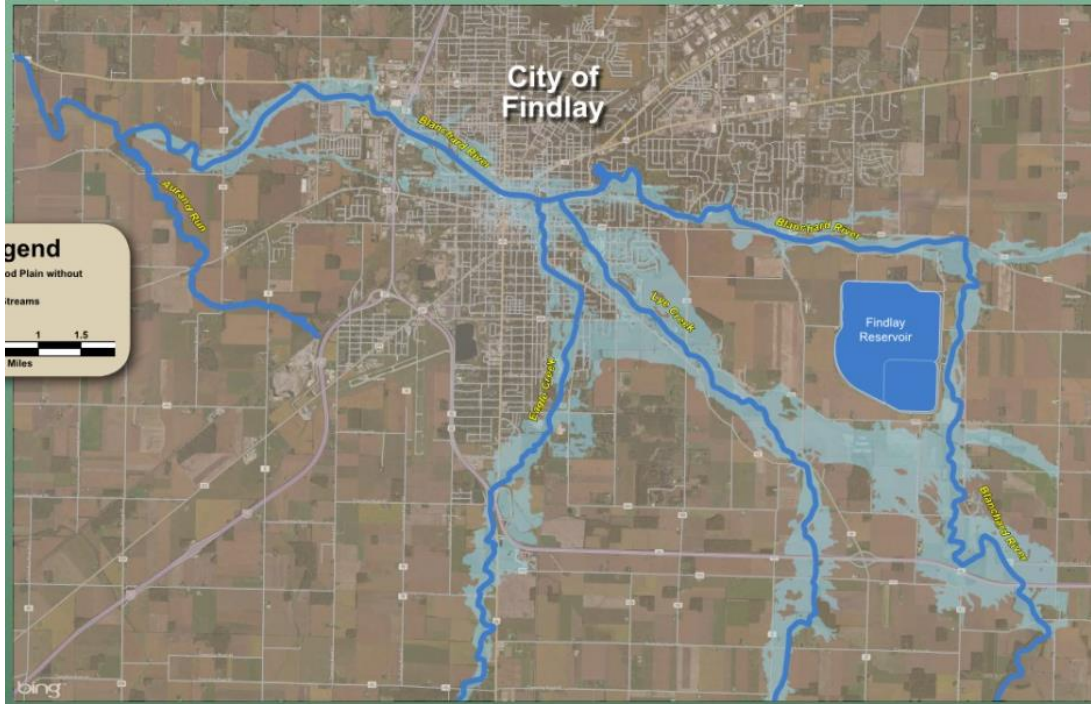
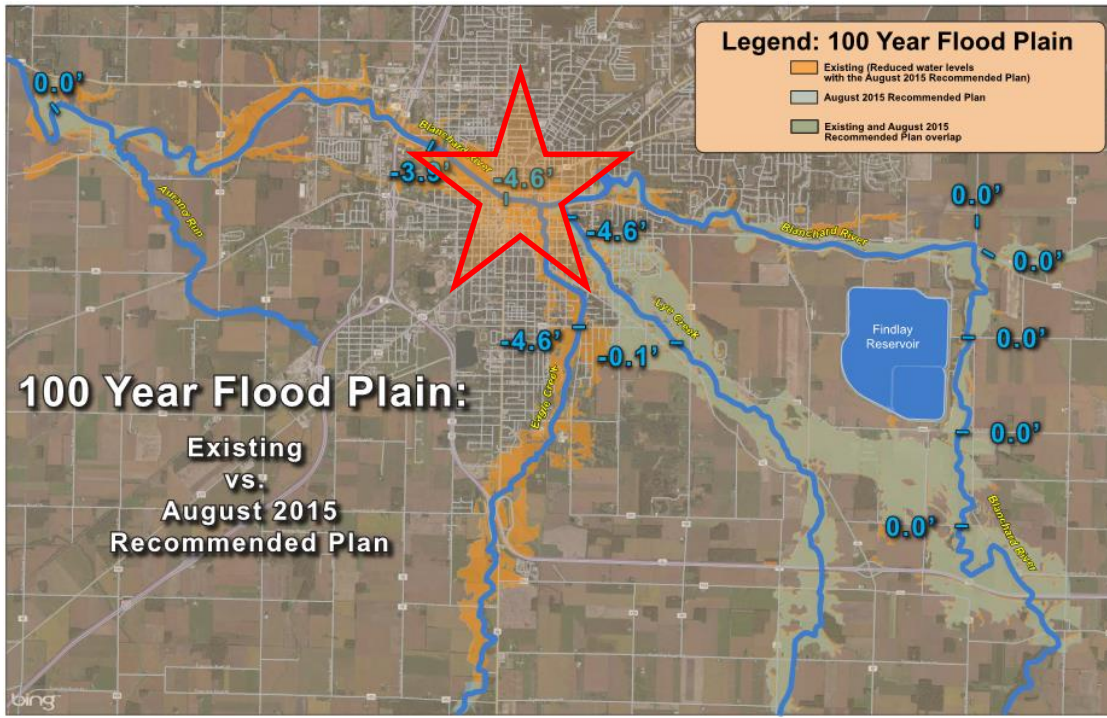
Project Objective

Alternative 13 (Recommended Plan)

- 25-year event diversion channel with Eagle Creek at 100 cfs
- Client requested project achieve 4'+ level of reduction on Blanchard River as planning level benchmark
- Specific and measurable project goal





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Path Forward

Additional Data Collection And Analysis

Part A

- Collect data for additional benefits (BCR > 1)
- H&H - Aggregate risk reduction of project
  - Refine model, gage analysis
- Environmental Pre-Application meetings
- Reconnaissance level mussel surveys
- Traffic Volumes and Bridge Type Studies

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Path Forward

Additional Data Collection And Analysis

Part A

- Collect data for additional benefits (BCR > 1)
  - Hire Jack Faucett Associates as sub-consultant

- Potential benefits include:
  - Road closures
  - Business losses
  - Lost income/wages
  - Agricultural losses
  - Others

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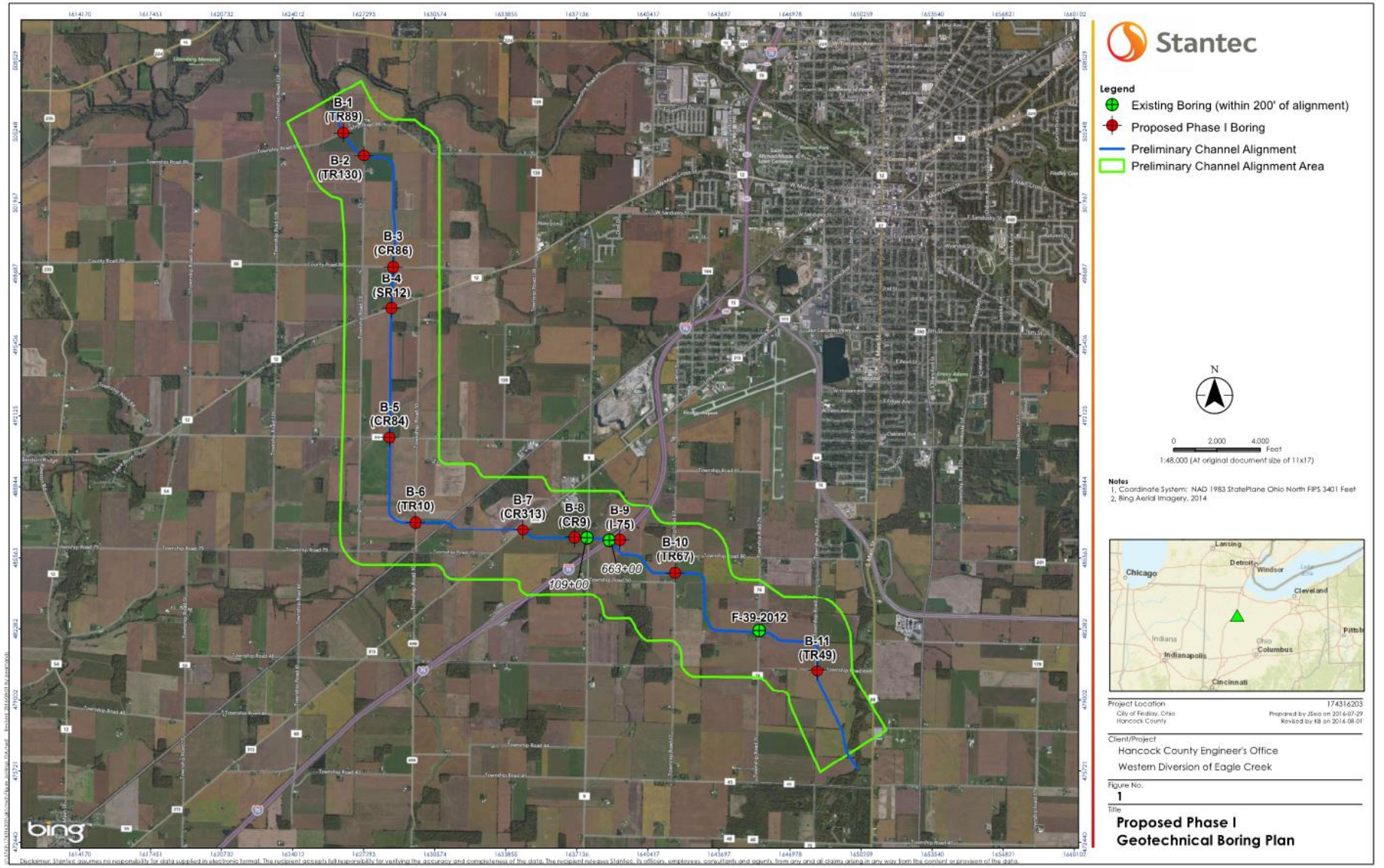
Economics
Public Policy
Planning
Jack Faucett Associates
Since 1963

Path Forward

Additional Data Collection And Analysis

Part A

- 11 proposed geotechnical borings



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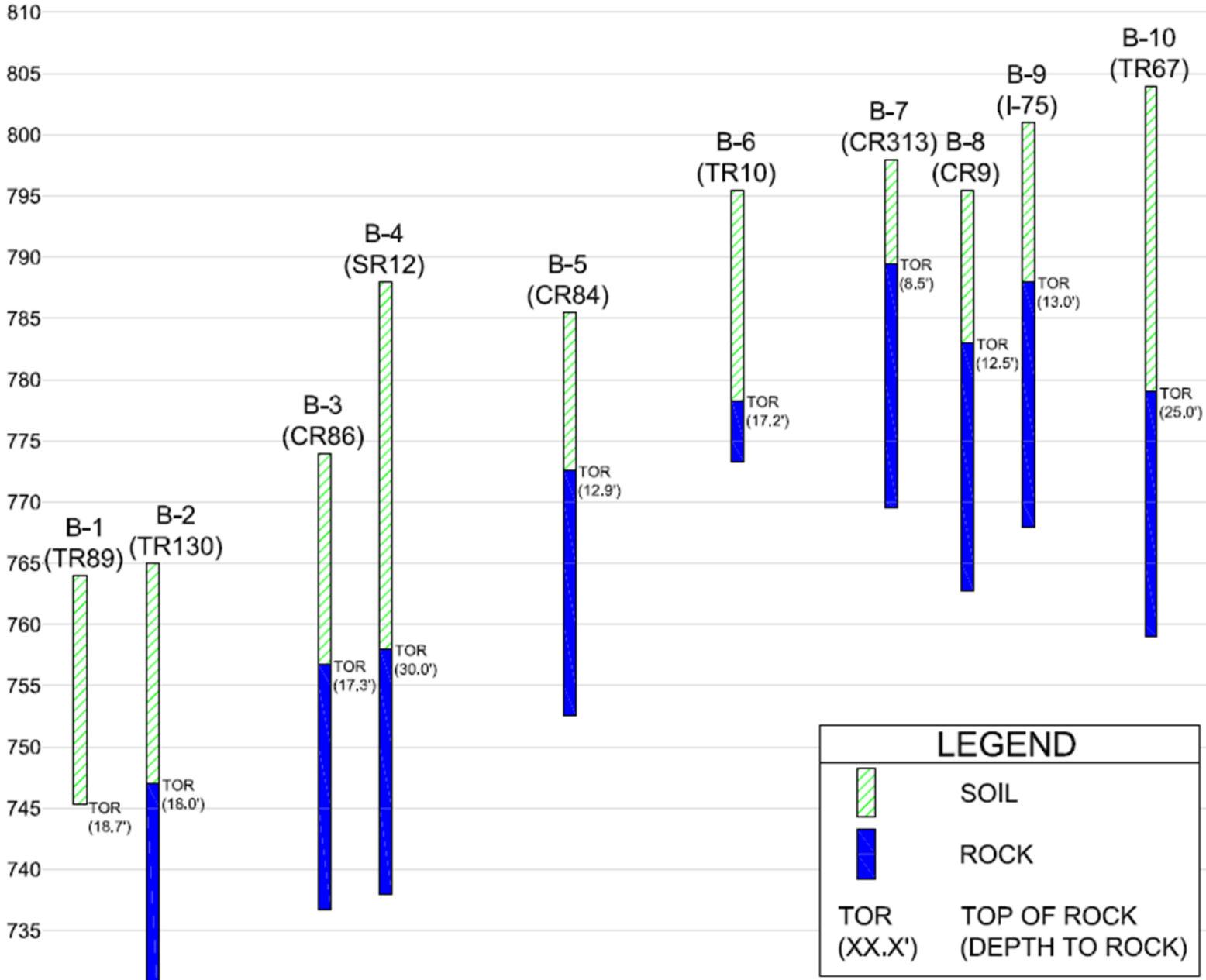
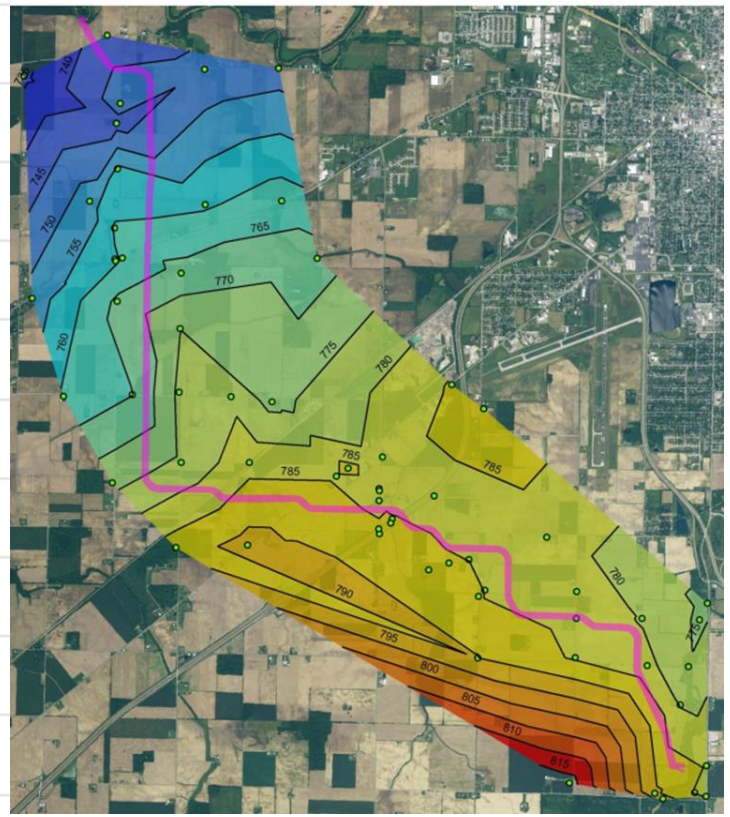
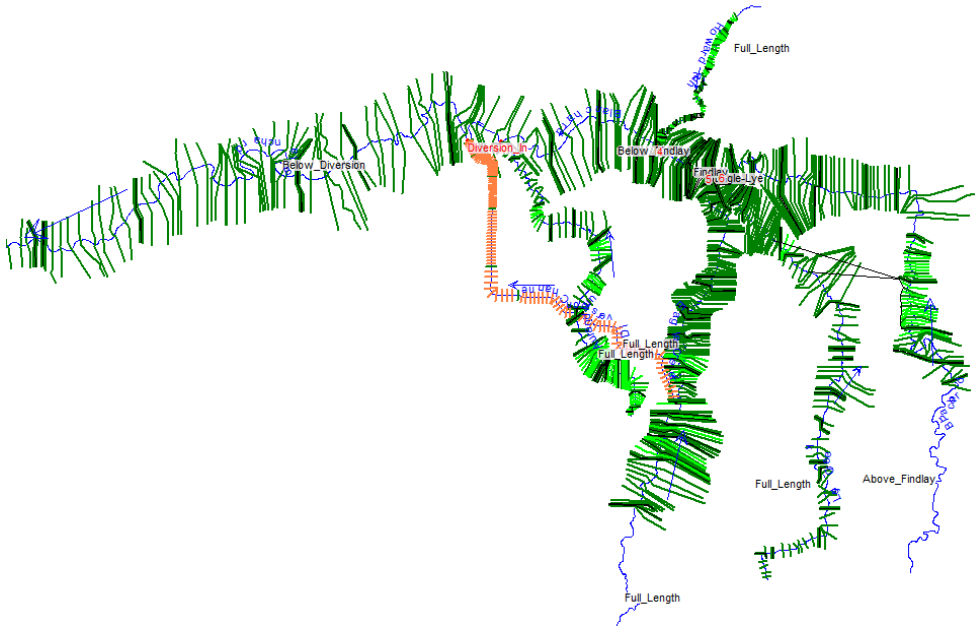

810
805
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
B-1 (TR89)
TOR (18.7')
B-2 (TR130)
TOR (18.0')
B-3 (CR86)
TOR (17.3')
B-4 (SR12)
TOR (30.0')
B-5 (CR84)
TOR (12.9')
B-6 (TR10)
TOR (17.2')
B-7 (CR313)
TOR (8.5')
B-8 (CR9)
TOR (12.5')
B-9 (I-75)
TOR (13.0')
B-10 (TR67)
TOR (25.0')
B-11 (TR49)
TOR (18.0')
LEGEND
SOIL
ROCK
TOR (XX.X')
TOP OF ROCK (DEPTH TO ROCK)

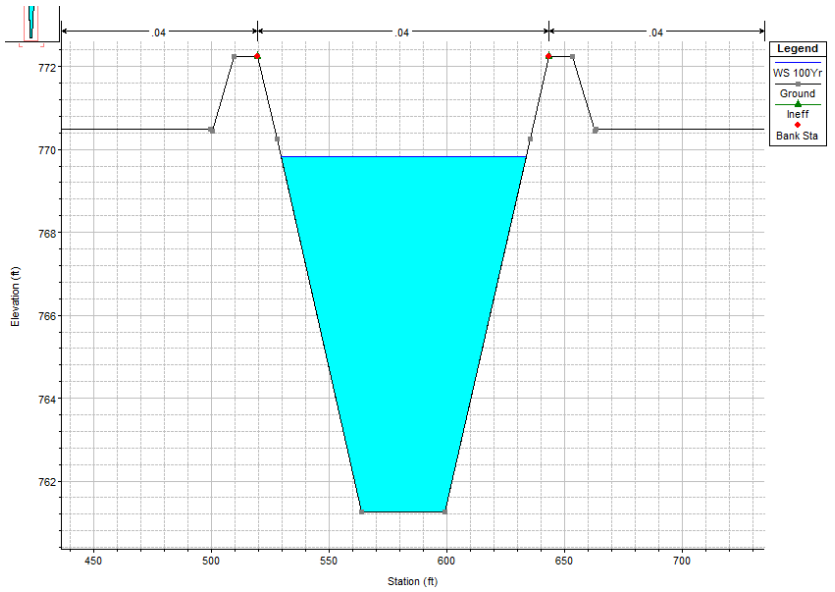

740
745
750
755
760
765
770
775
780
785
790
795
800
805
810
815

Hydraulics

HEC-RAS Model Updates

- Updated RAS into unsteady-state model, 2D
- Reviewed Blanchard XS's from survey data
- Reviewed bridge data from drawings

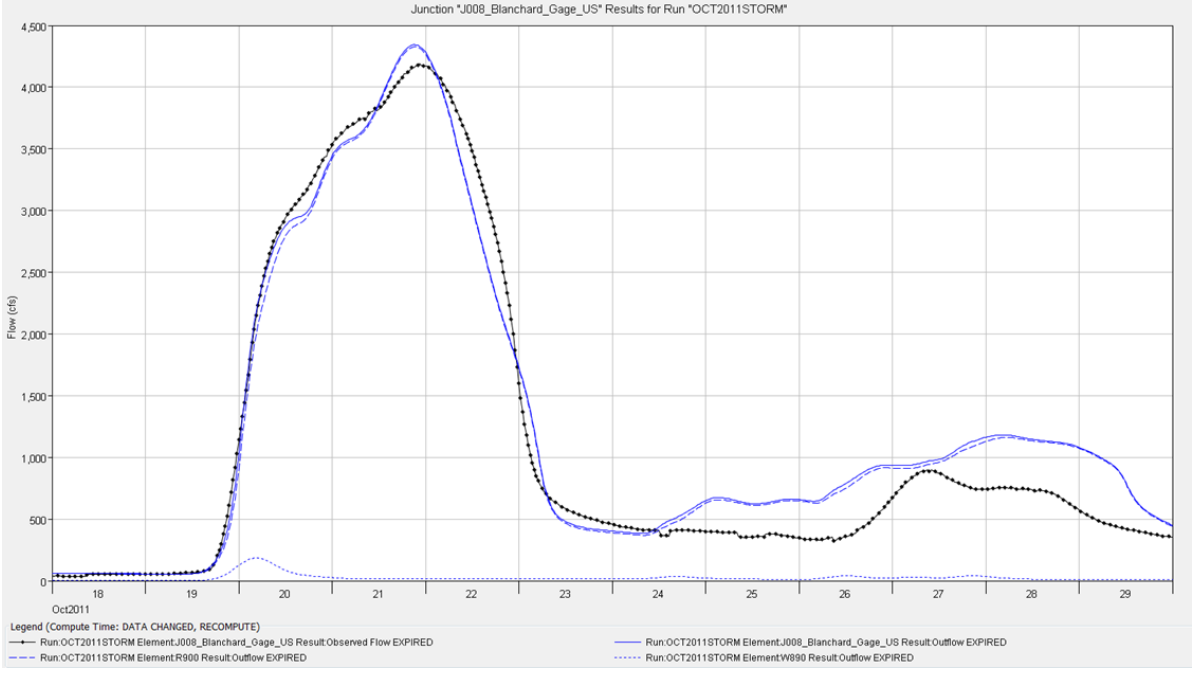




Hydrology

HEC-HMS Model Updates

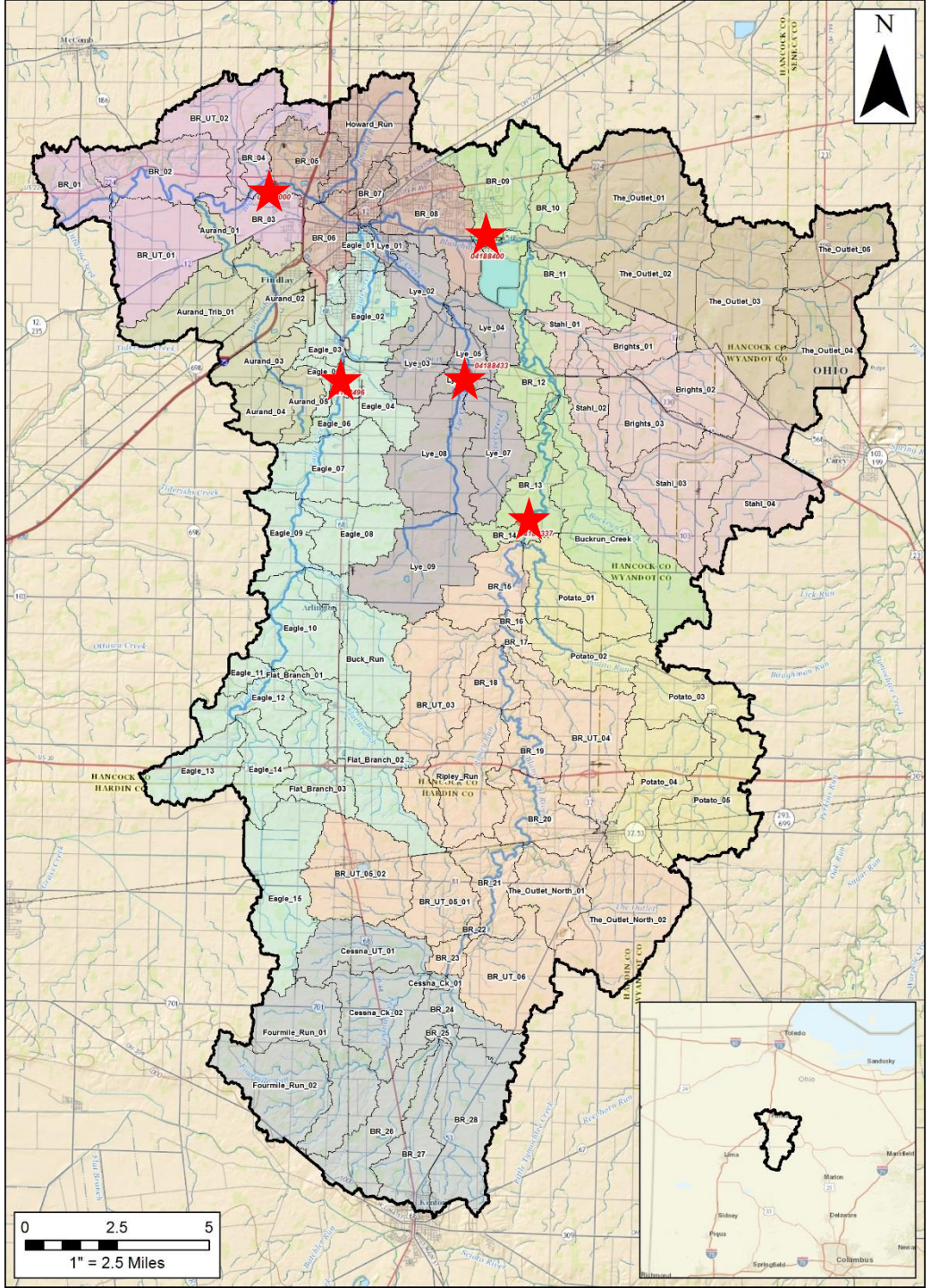
- Added nodes for HEC-RAS linkage
- Verified calibration results
- Statistical study



Stantec Hydrology Study

Stantec Hydrologic Study

- Calibration
- Spatial Distribution
- Temporal Patterns
- Gage Analyses

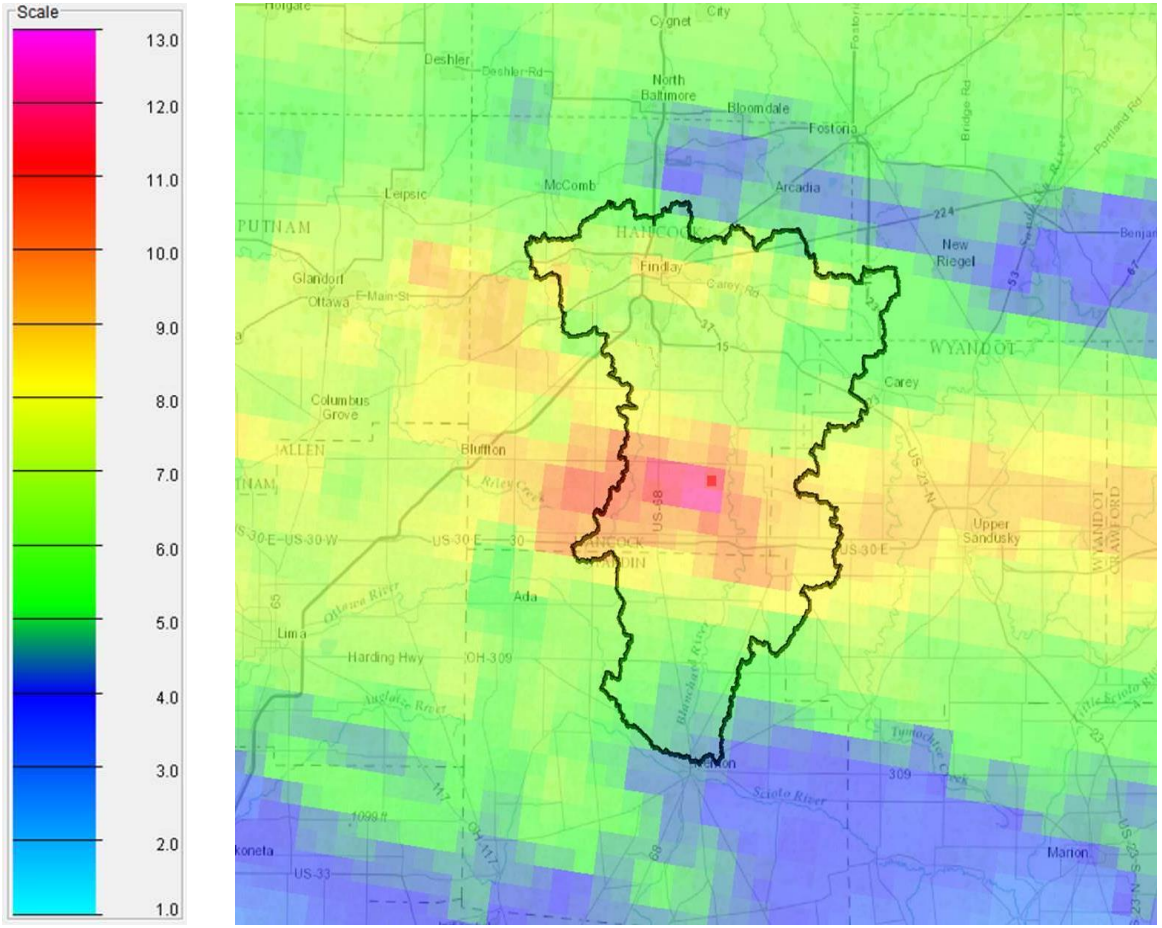


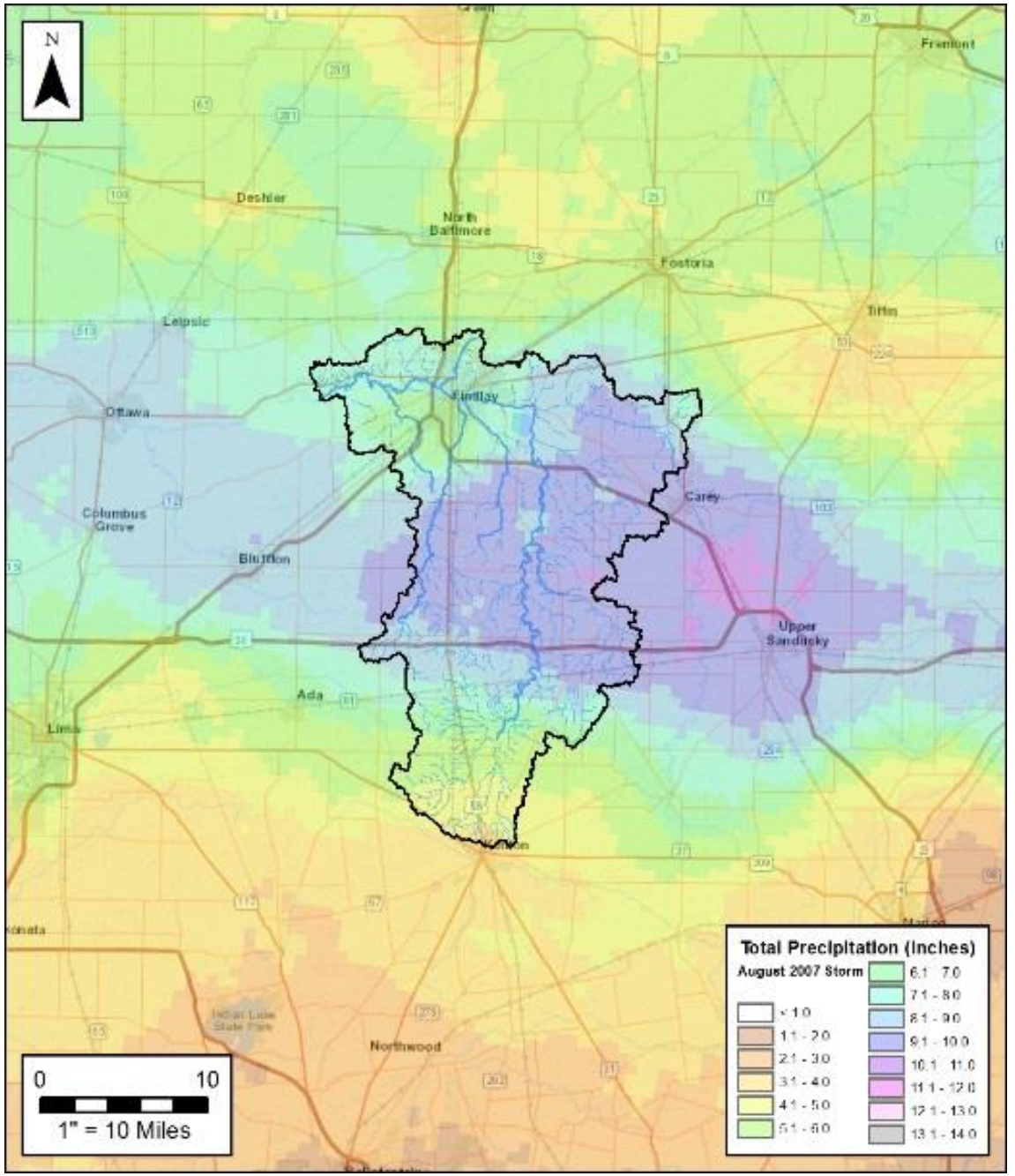
Stantec Hydrology Study

Revised Radar Data

Applied Weather Associates

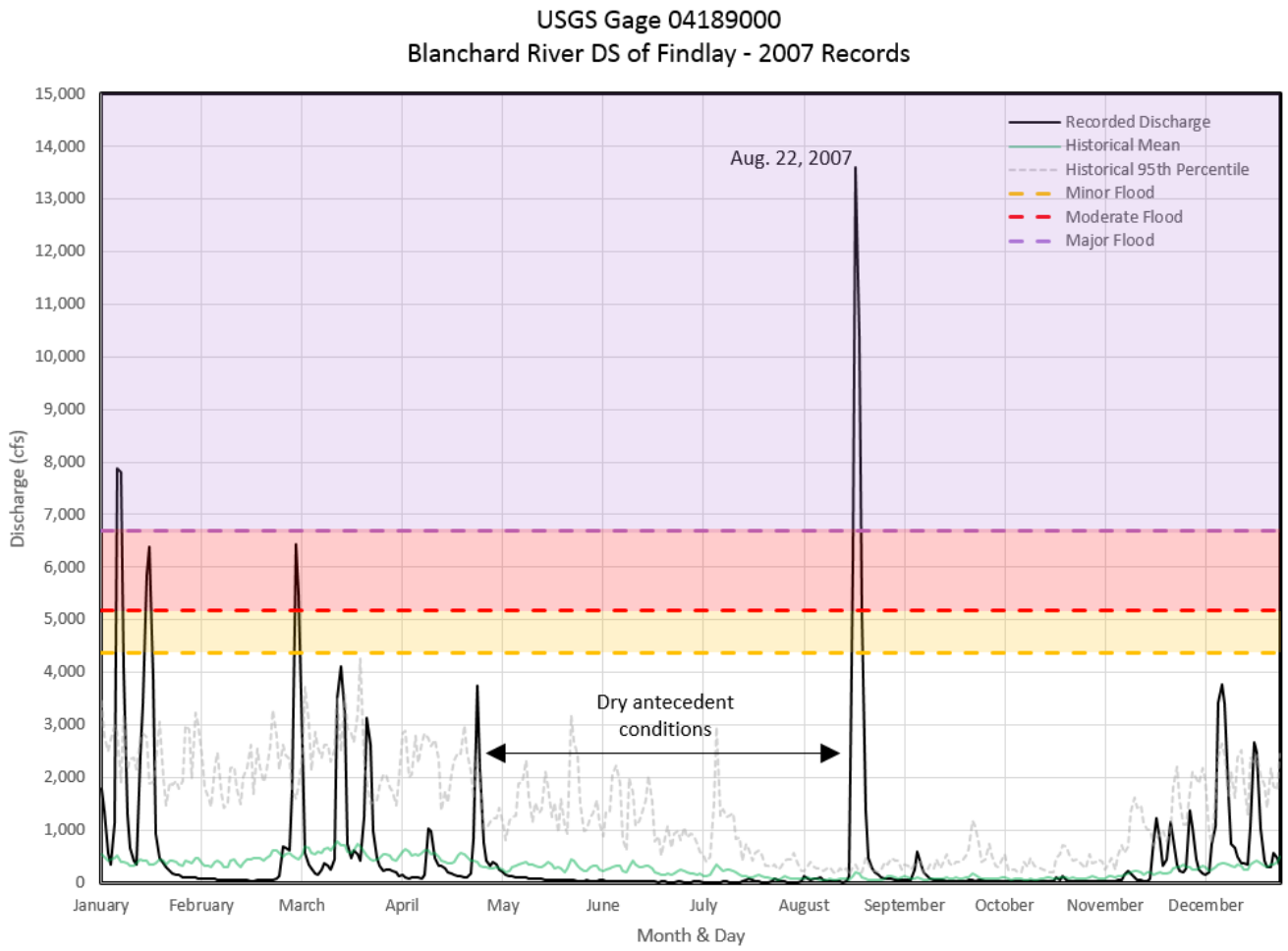
Stantec

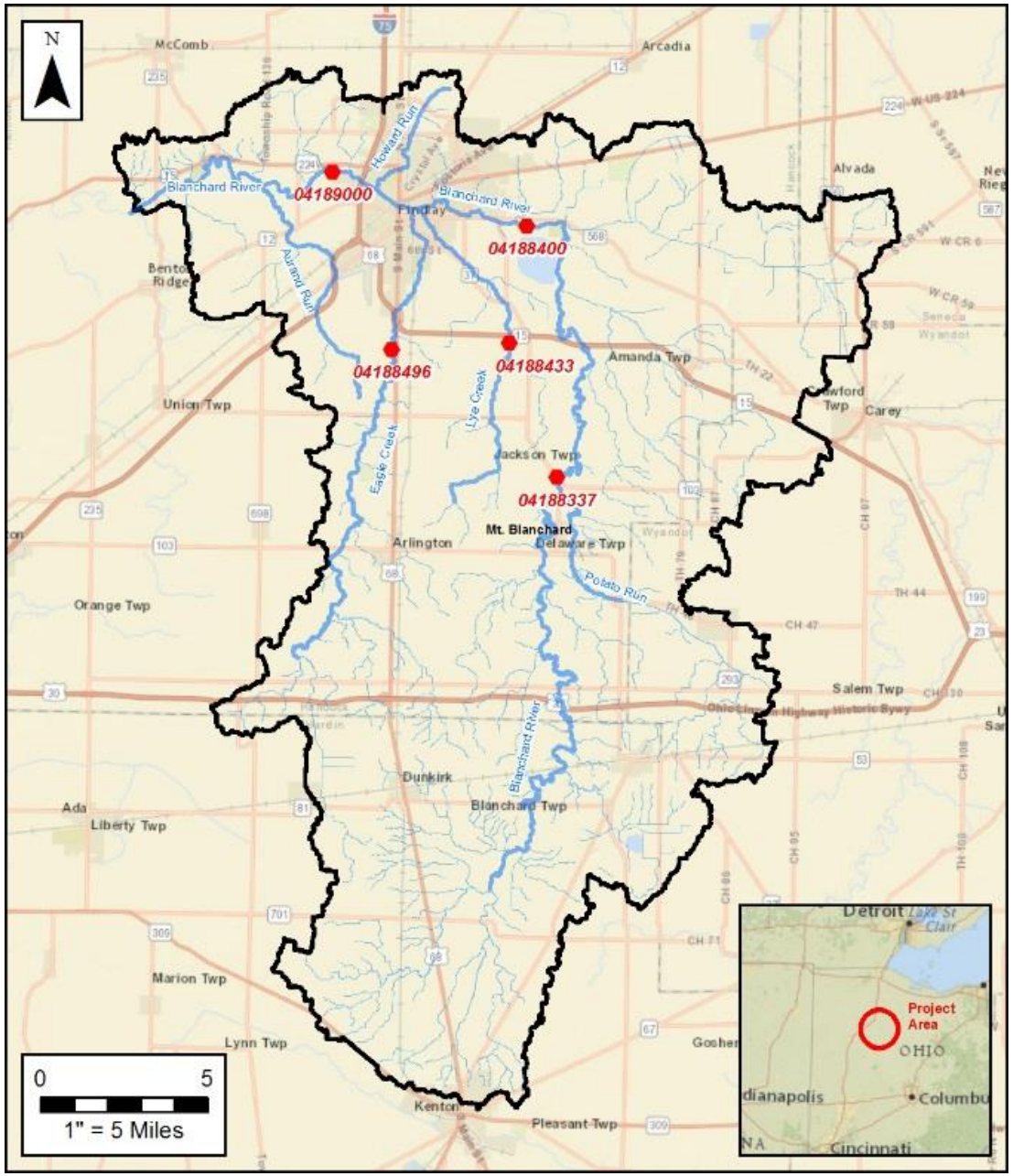




Calibration Events

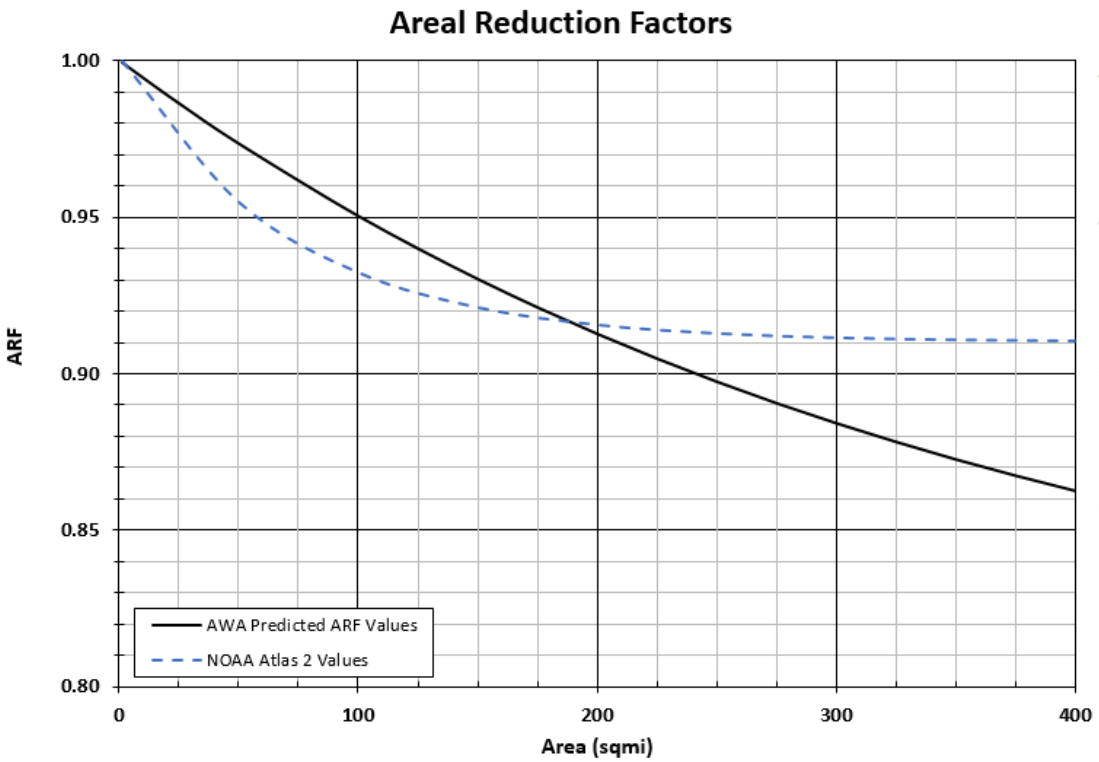
Stantec Hydrology Study

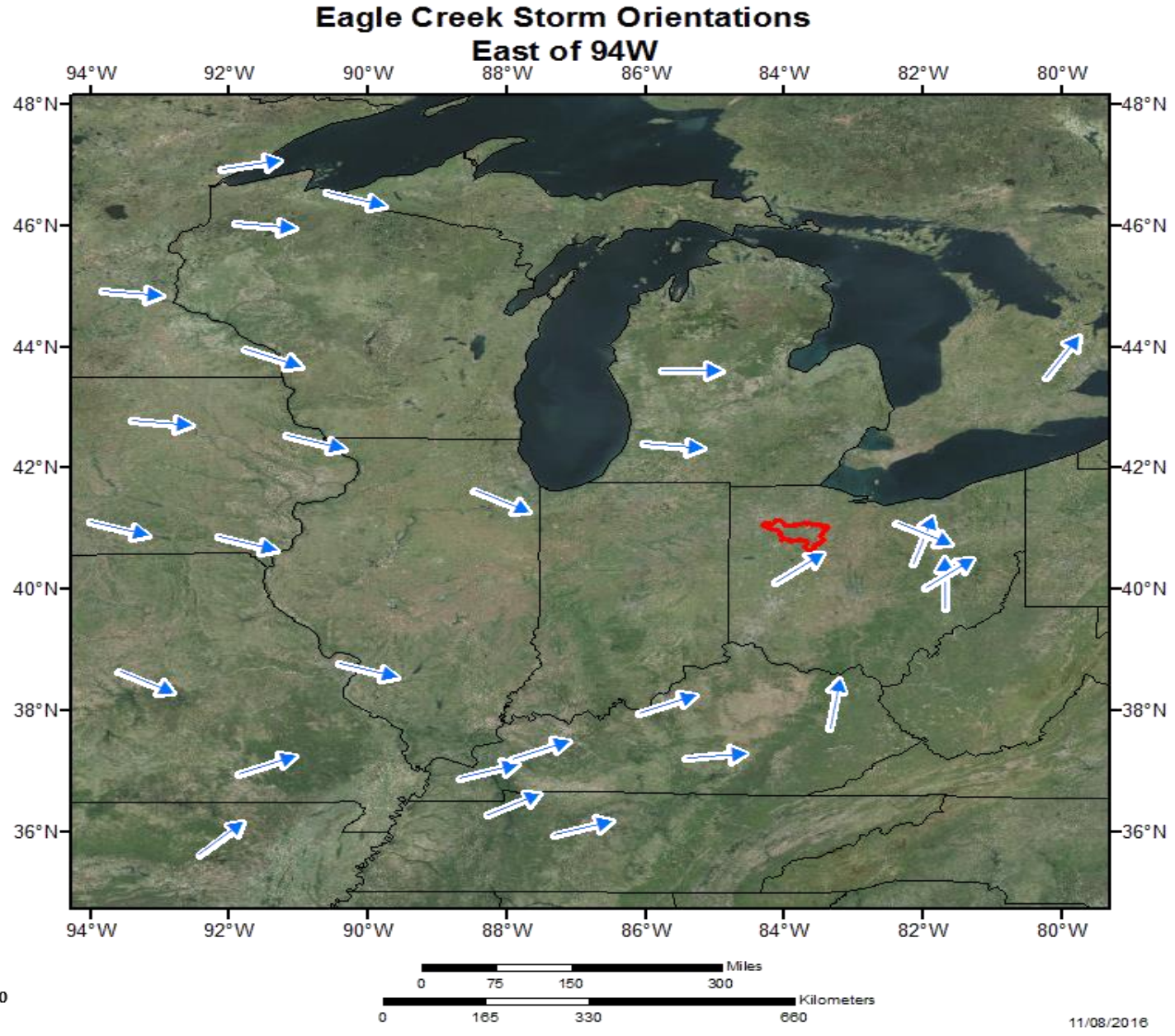




Spatial Distribution

Stantec
HEC-HMS
Model

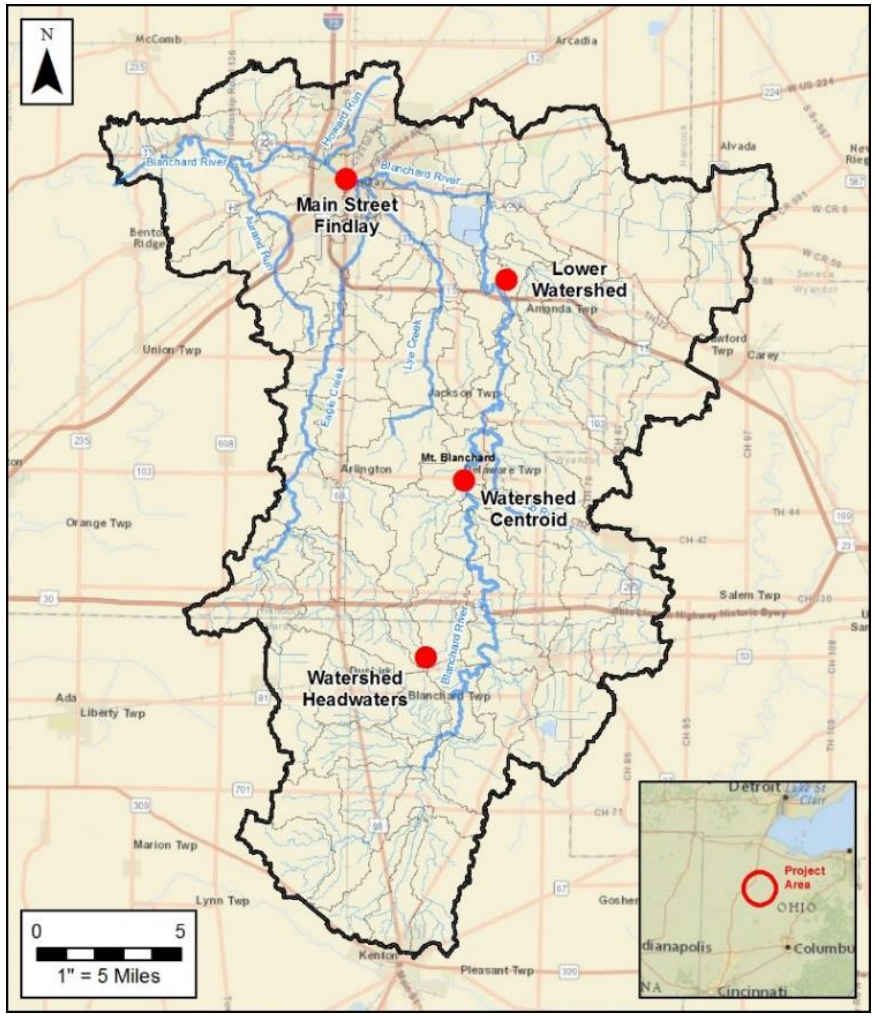


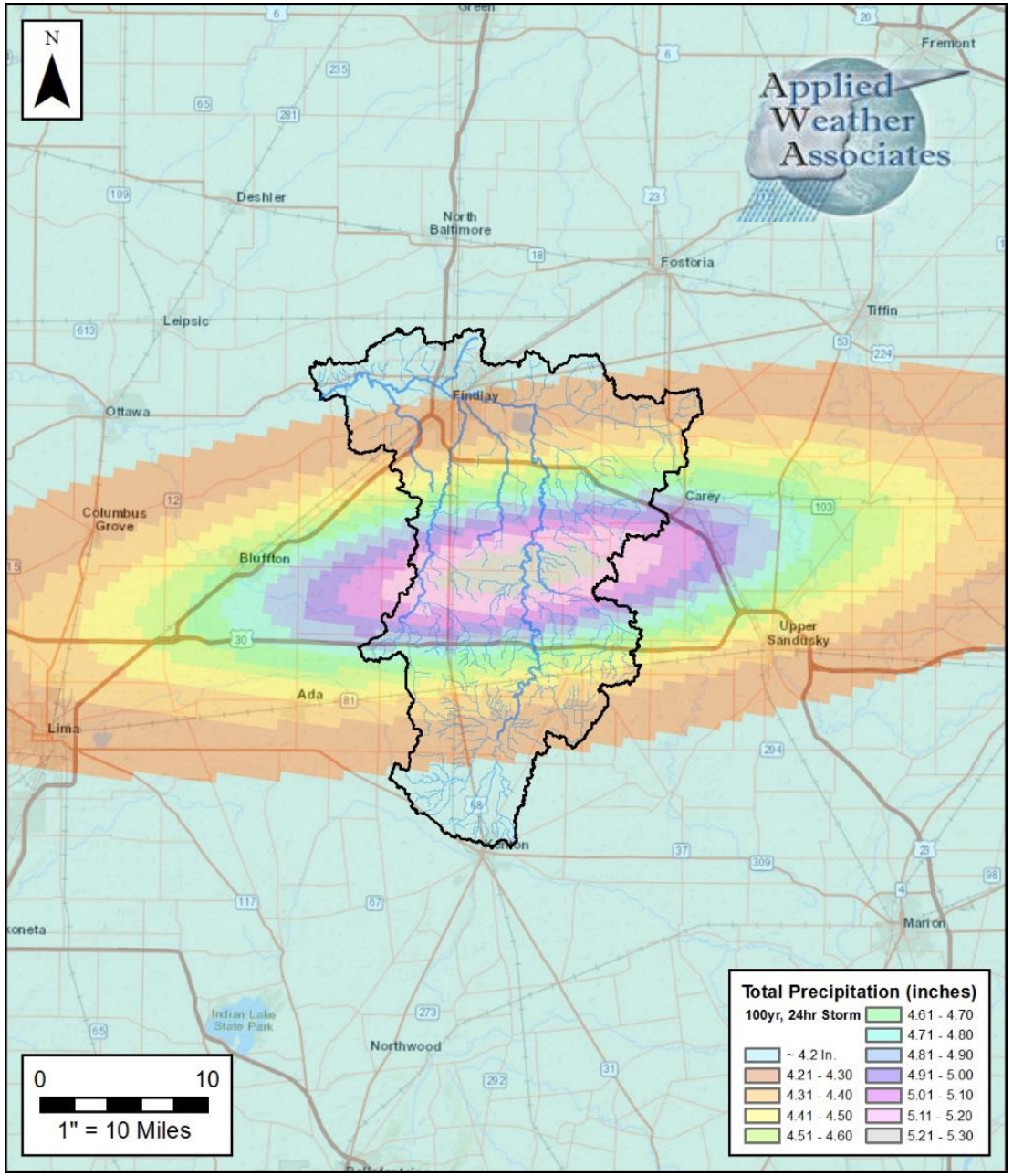


Stantec HEC-HMS Model

Spatial Distribution

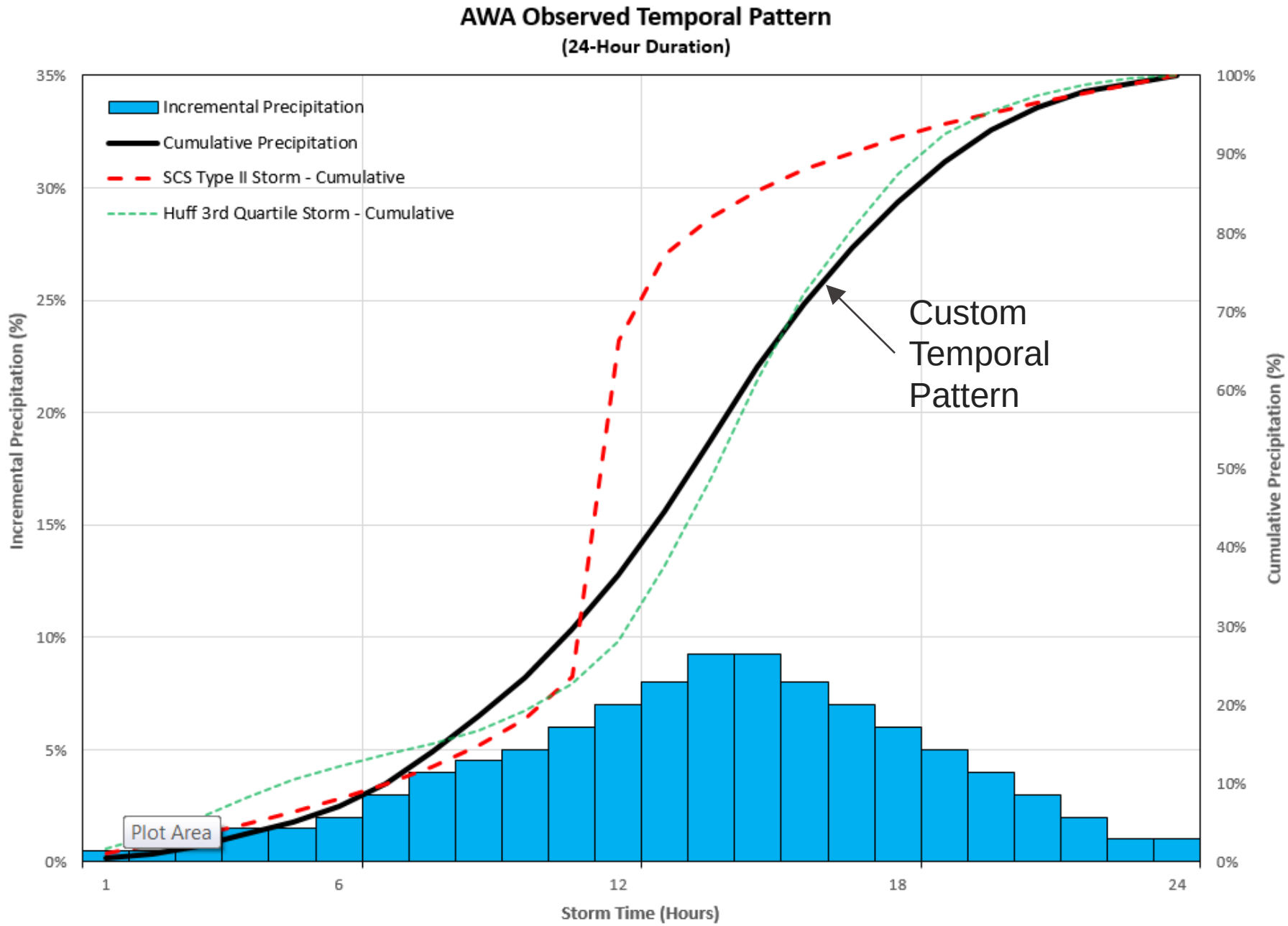
– Custom Hypothetical Storm





Stantec HEC-HMS Model

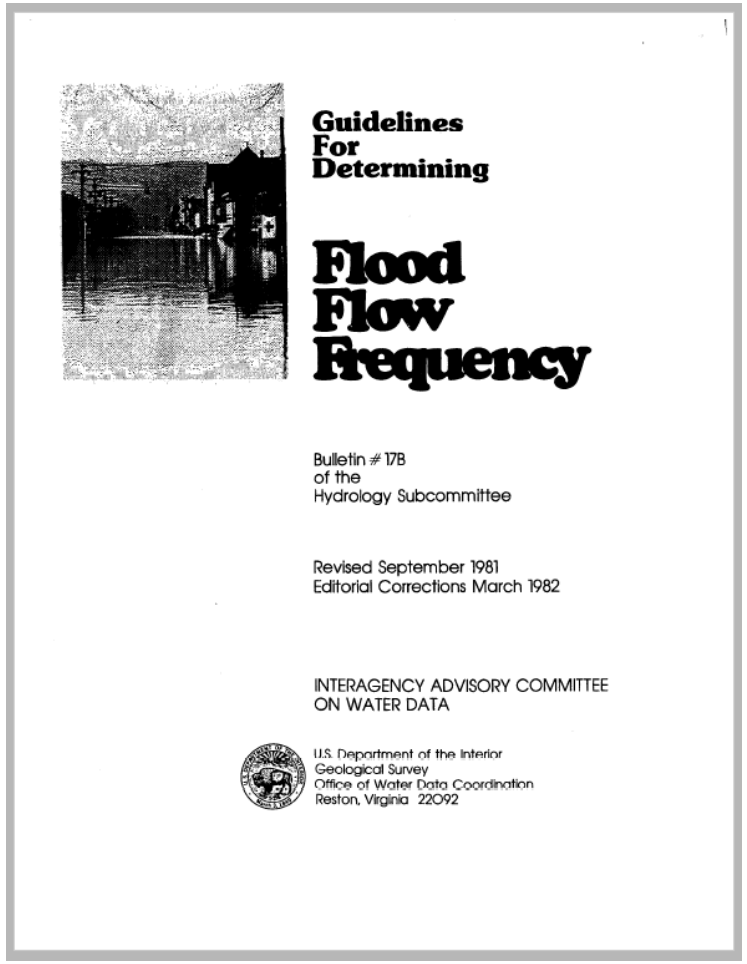
Temporal Patterns



Stantec Gage Frequency Analyses

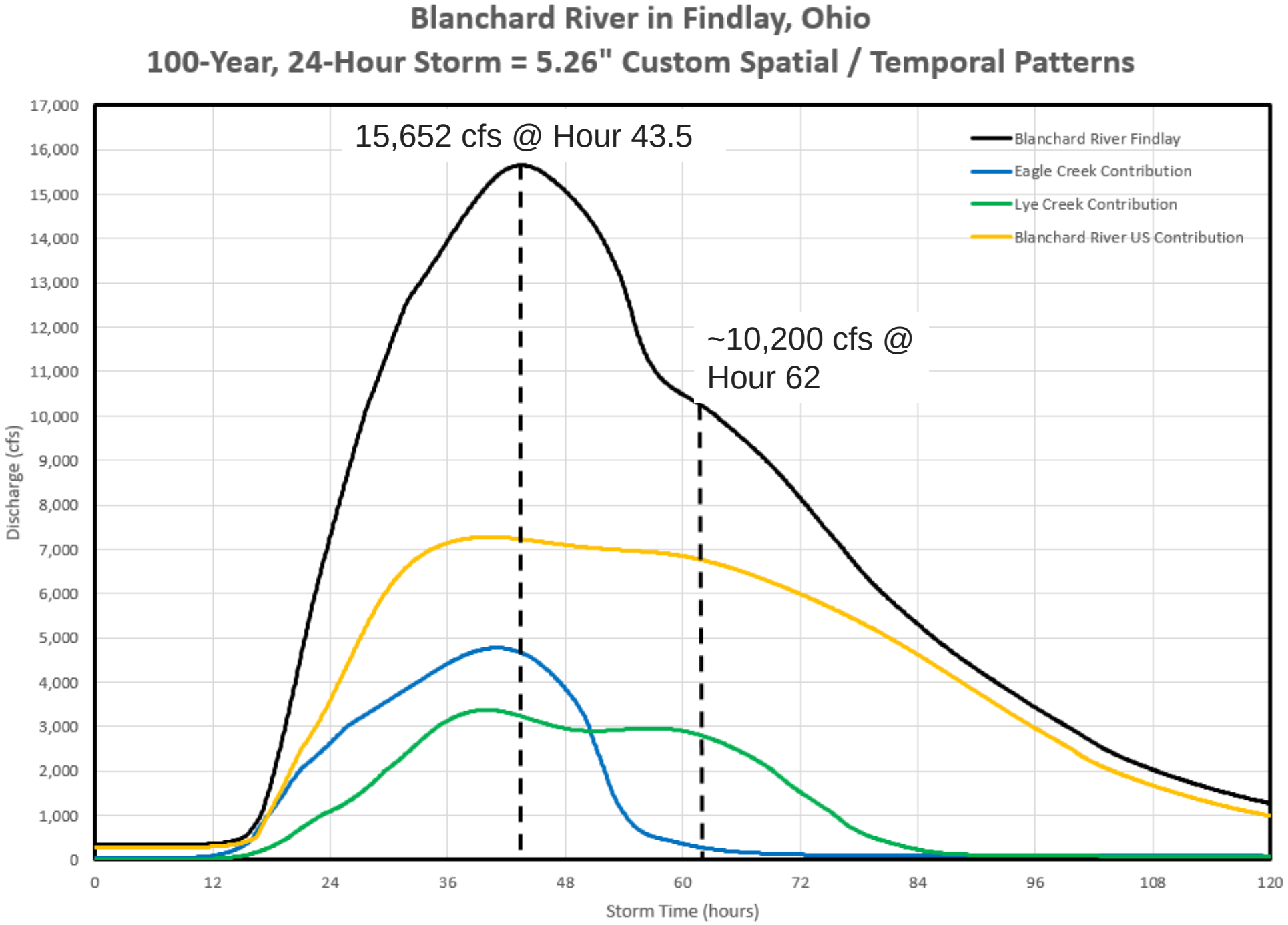
USGS Gage #04189000

Blanchard River Downstream of Findlay



Percent Chance Exceedance	Average Recurrence Interval (years)	Computed Discharge (cfs)	Confidence Limits 0.05	0.95
0.1	1000	17,117	20,649	14,715
0.2	500	16,156	19,351	13,964
0.5	200	14,811	17,552	12,903
1.0	***100***	***13,727***	16,120	12,039
2.0	50	12,576	14,619	11,113
4.0	25	11,346	13,037	10,111
10.0	10	9,559	10,788	8,625
20.0	5	8,028	8,918	7,319
50.0	2	5,530	6,020	5,086
99.9	1	875	1,084	667

Stantec HEC-HMS Design Storm



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Additional Data Collection Summary

Cost/Economics

- Jack Faucett reviewed additional benefits available

Geotechnical

- 11 localized borings completed

Survey Data

- Channel & Aerial surveys

H&H

- Updated HEC-RAS to unsteady-state
- Meteorology/risk analysis

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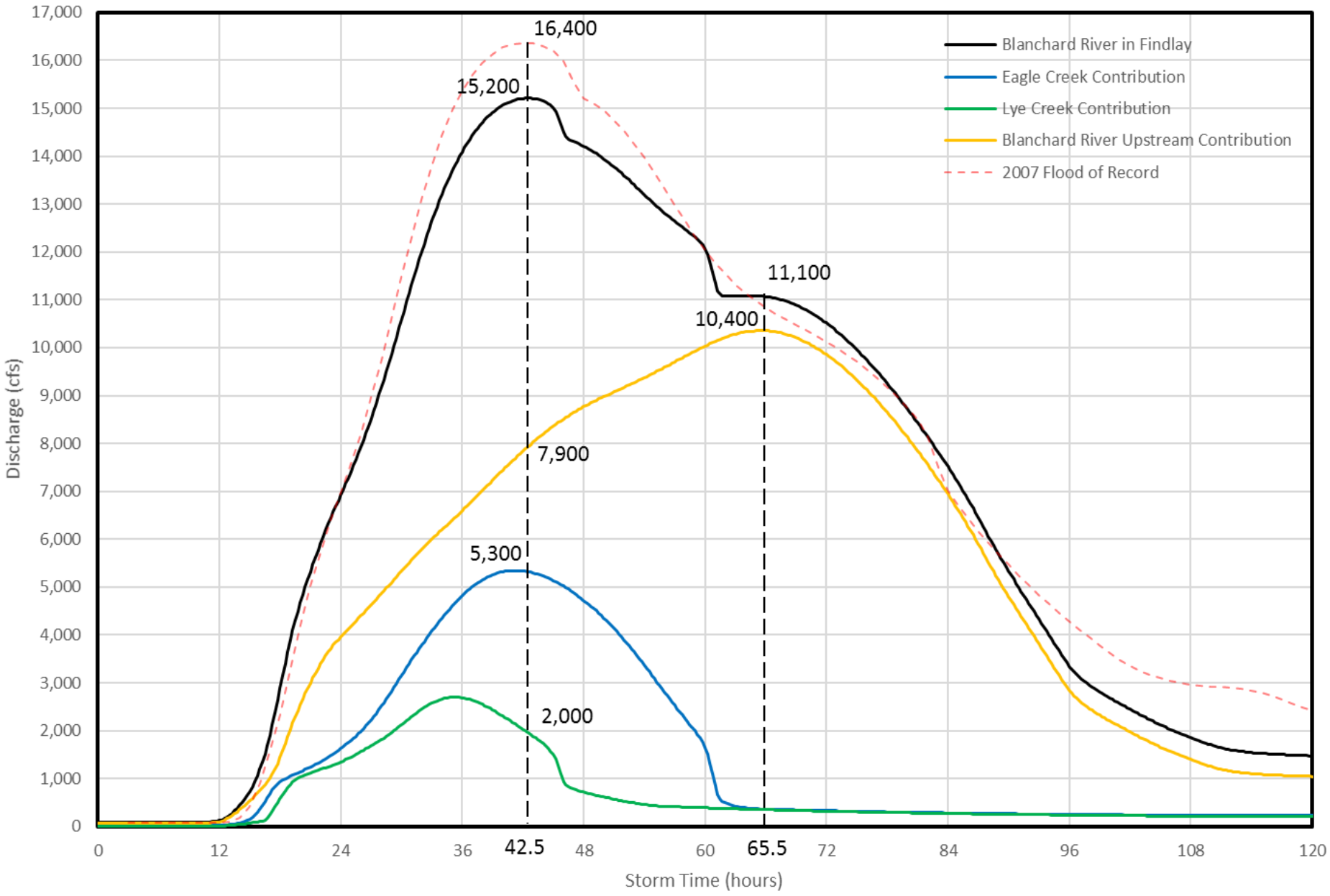
Conceptual Review

Project Refinements

Double Peak



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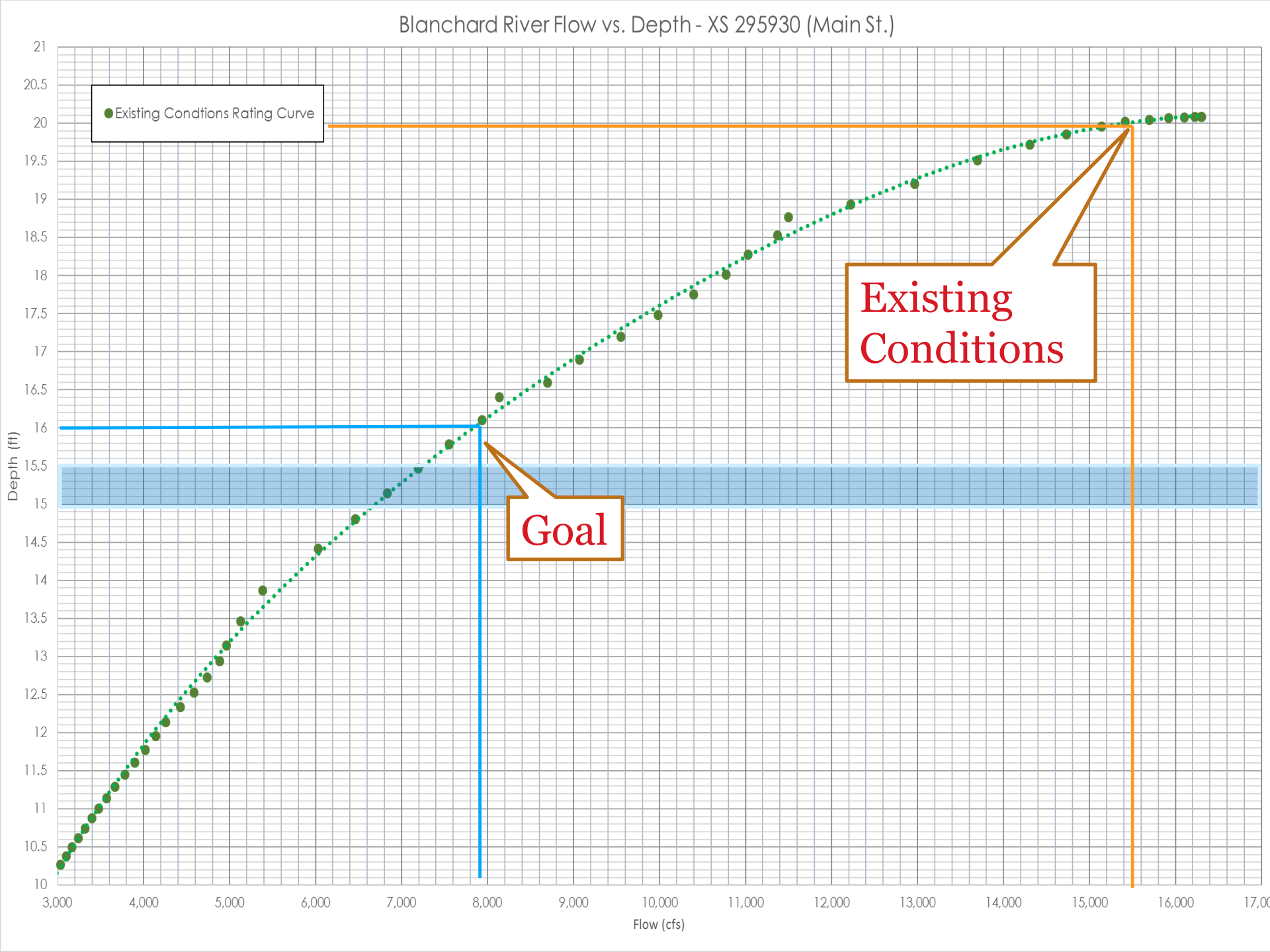
Blanchard River Rating Curve at Main Street



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Eagle Creek Flows

25-year 3,400 cfs

50-year 4,000 cfs

100-year 4,600 cfs

500-year 6,400 cfs

Flow Table – Blanchard River Main St. Bridge (XS 295930)

Event	Flow (cfs)	WSE (ft.)	Depth (ft.)
500-Year	20,860	778.9	21.4
200-Year	17,510	778.0	20.5
100-Year	15,480	777.2	19.7
50-Year	13,515	776.4	18.9
25-Year	11,645	775.2	17.7
10-Year	9,340	774.2	16.7
5-Year	7,695	773.2	15.7
2-Year	5,828	771.4	13.9
1-Year	4,340	769.8	12.3

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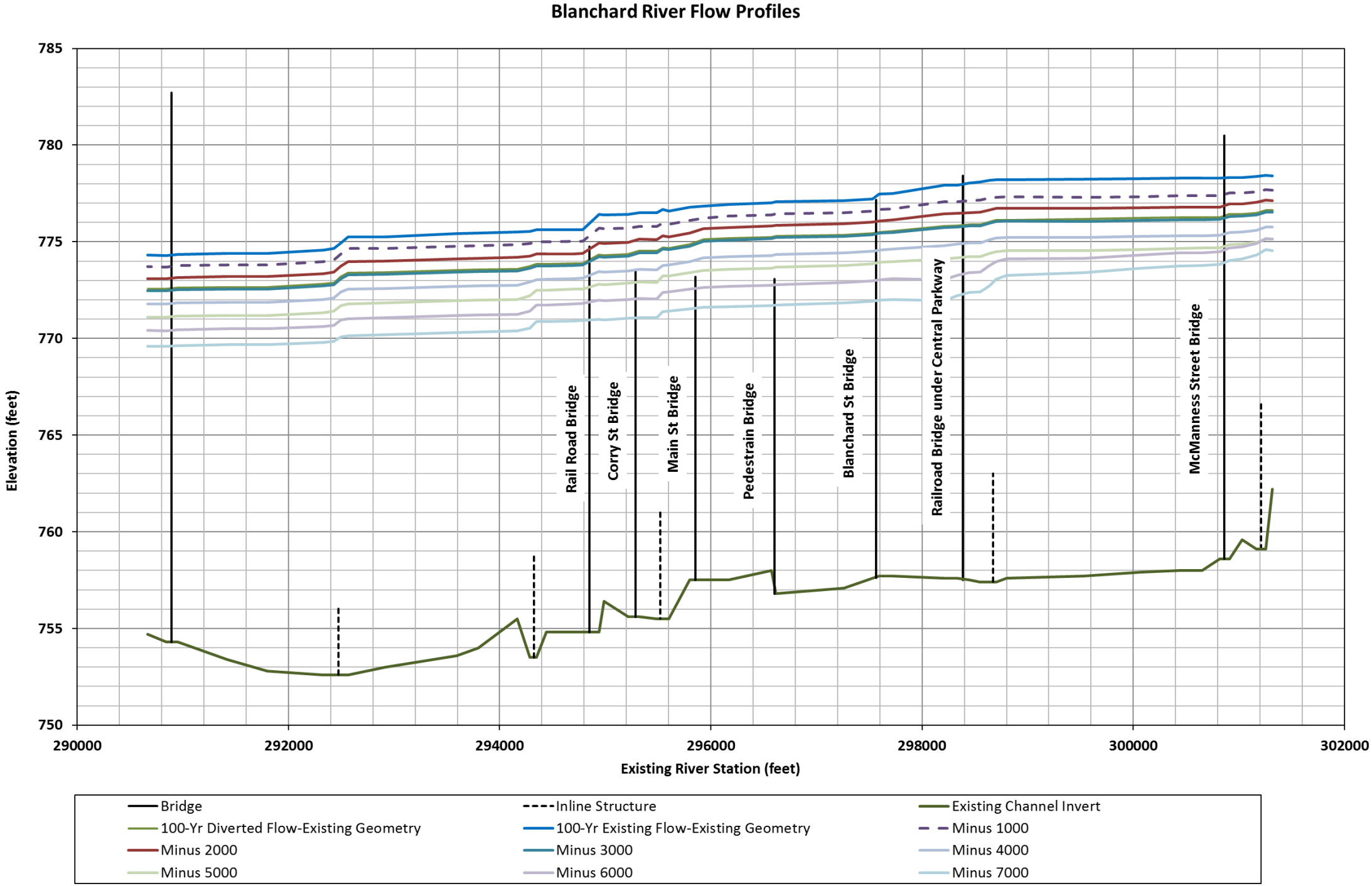
Blanchard River Flow Profiles
785
780
775
770
765
760
755
750
Elevation (feet)
290000
292000
294000
296000
298000
300000
302000
Existing River Station (feet)
Rail Road Bridge
Corry St Bridge
Main St Bridge
Pedestrain Bridge
Blanchard St Bridge
Railroad Bridge under Central Parkway
McManness Street Bridge
Bridge
Inline Structure
Existing Channel Invert
100-Yr Diverted Flow-Existing Geometry
100-Yr Existing Flow-Existing Geometry
Minus 1000
Minus 2000
Minus 3000
Minus 4000
Minus 5000
Minus 6000
Minus 7000

Path Forward

Conceptual Design Advancement

Phase 2 – Work Plan – **Proof of Concept**

- Part A
  - Additional Data Collection And Analysis
- **Part B**
  - **Refinement of Conceptual Design**
- Part C
  - 30% Design Plans

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Path Forward

Refinement of Conceptual Design

Part B

- Assess ways to improve the initial design

- Benefit/Cost Analysis
  - Refining costs (value engineering)
  - Evaluate additional benefits to achieve a BCR greater than 1

- H&H
  - Model refinement
  - Assess concepts to reduce the residual risk

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Concept Design Analysis

Eagle Creek Diversion Channel

Proof of Concept

- Relocate entrance
- Reduce diversion channel length
- At-grade intersection with Aurand Run
- Refine profile
  - Reduce overall excavation & waste
  - Reduce rock excavation
- Refine width for design discharge
  - 25yr -vs- 100yr capacity
- Cost refinement

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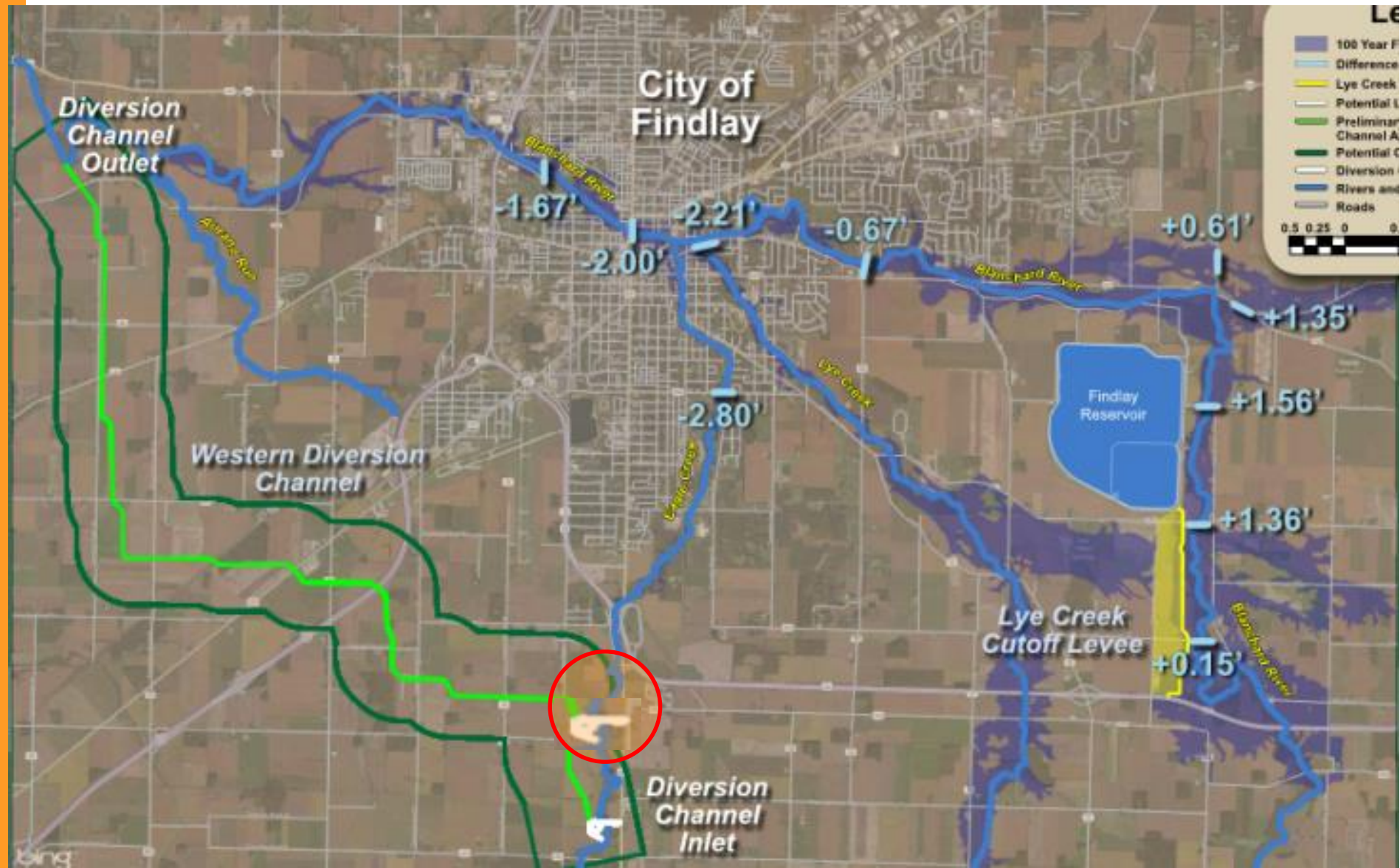
Concept
Design Analysis

Concept Design Charrette

- Diversion Inlet Relocation



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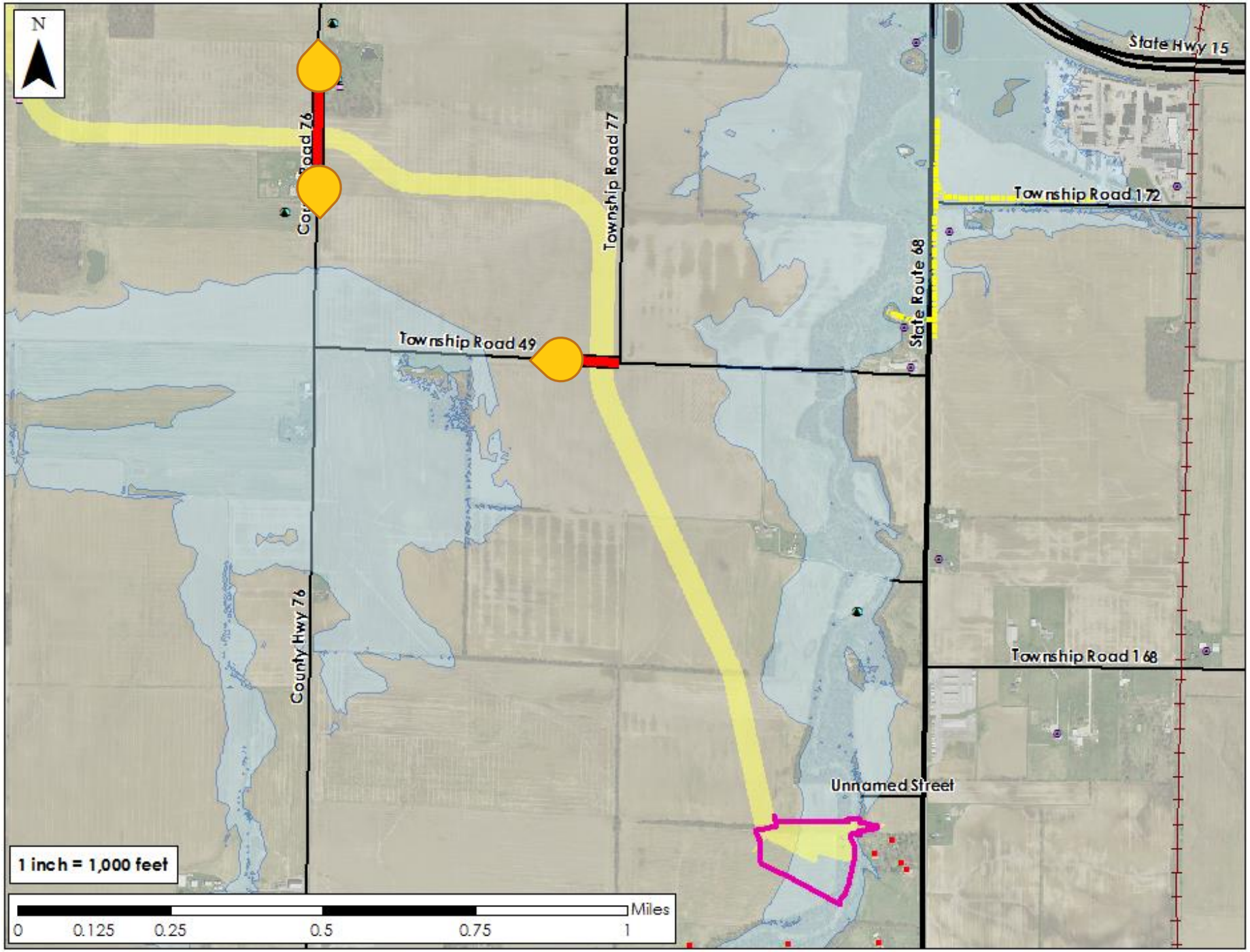
Concept Design Analysis

Diversion Channel Inlet Relocation

Rec. Plan



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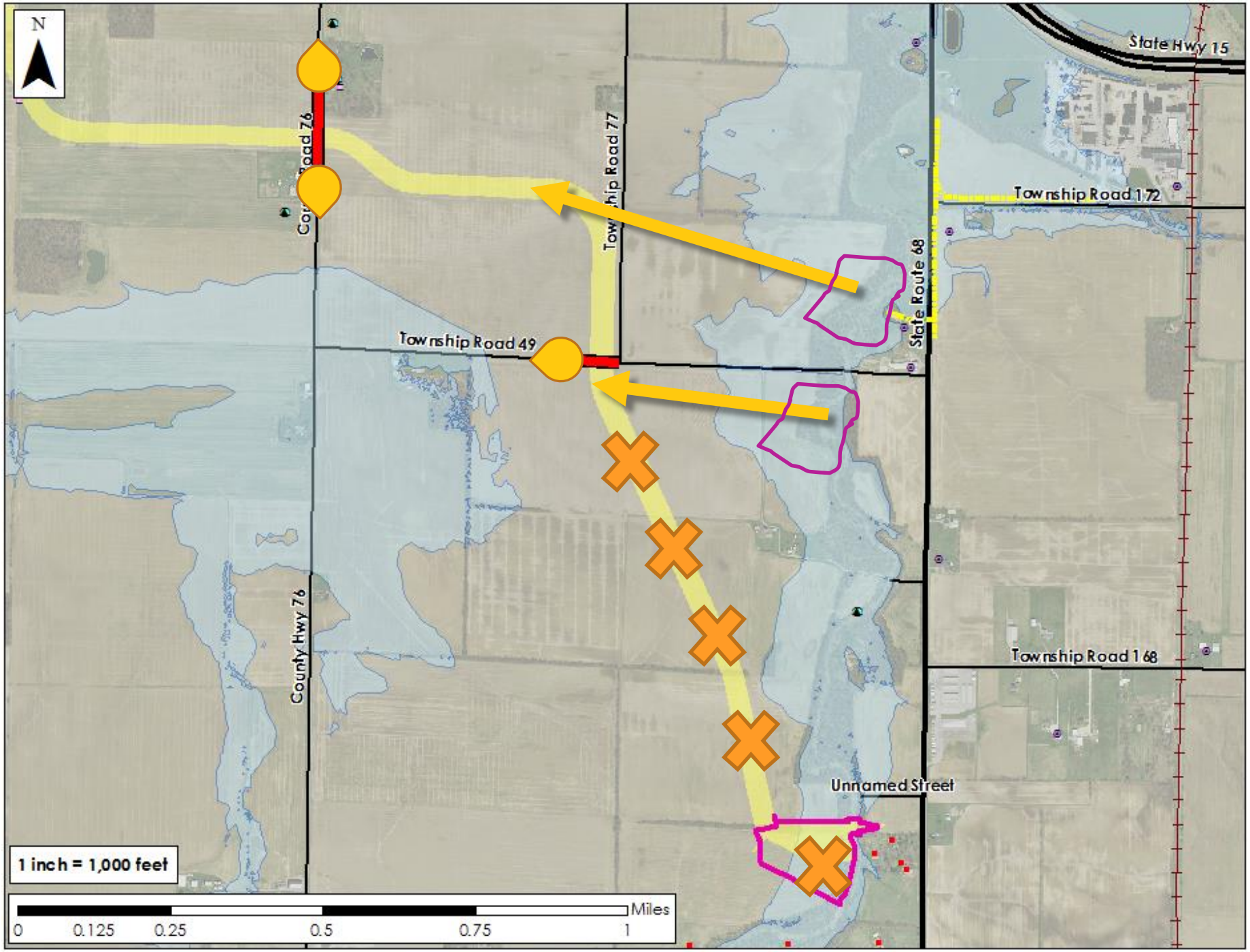
Concept Design Analysis

Diversion Channel Inlet Relocation



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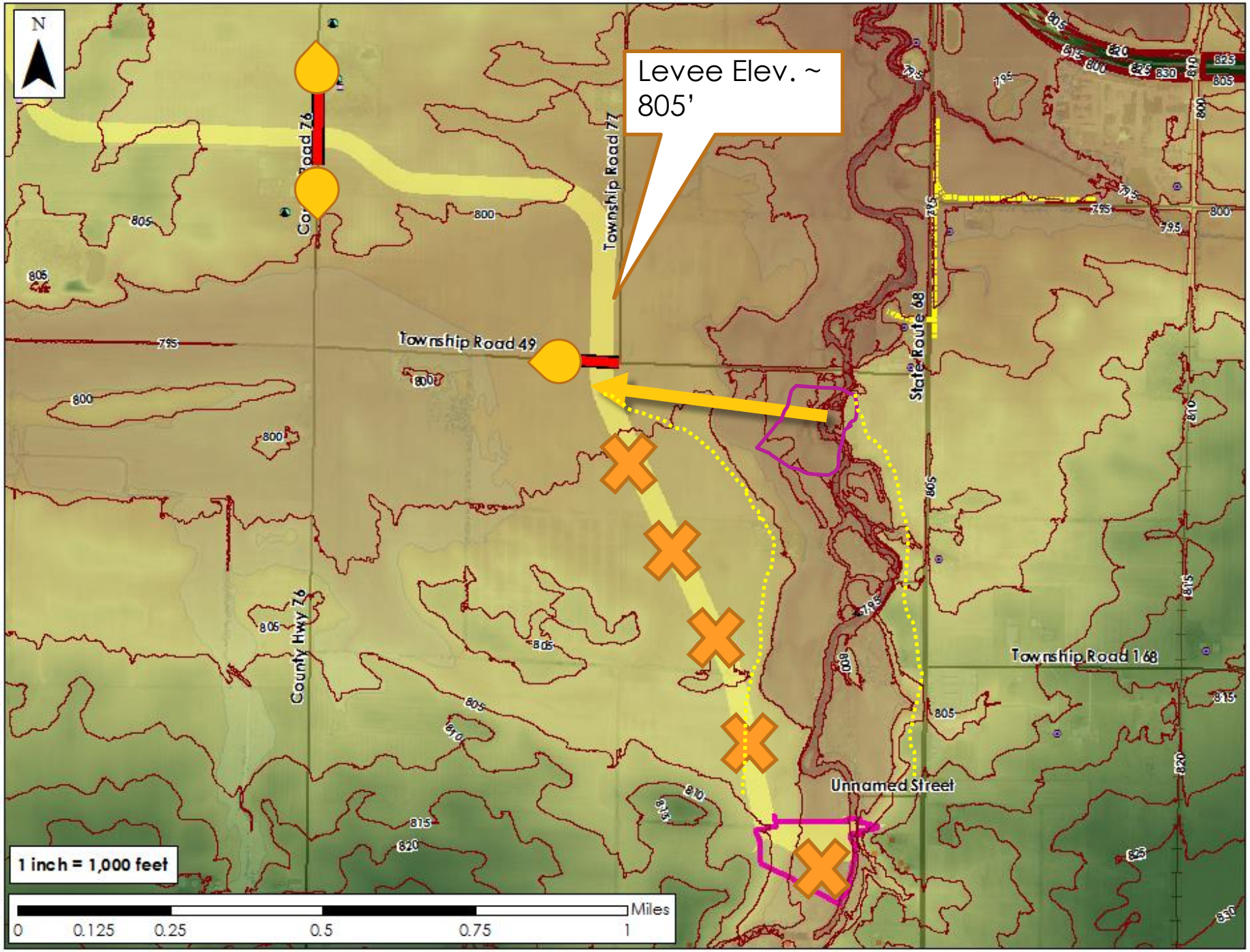
Concept Design Analysis

Diversion Channel Inlet Relocation



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Concept Design Charrette

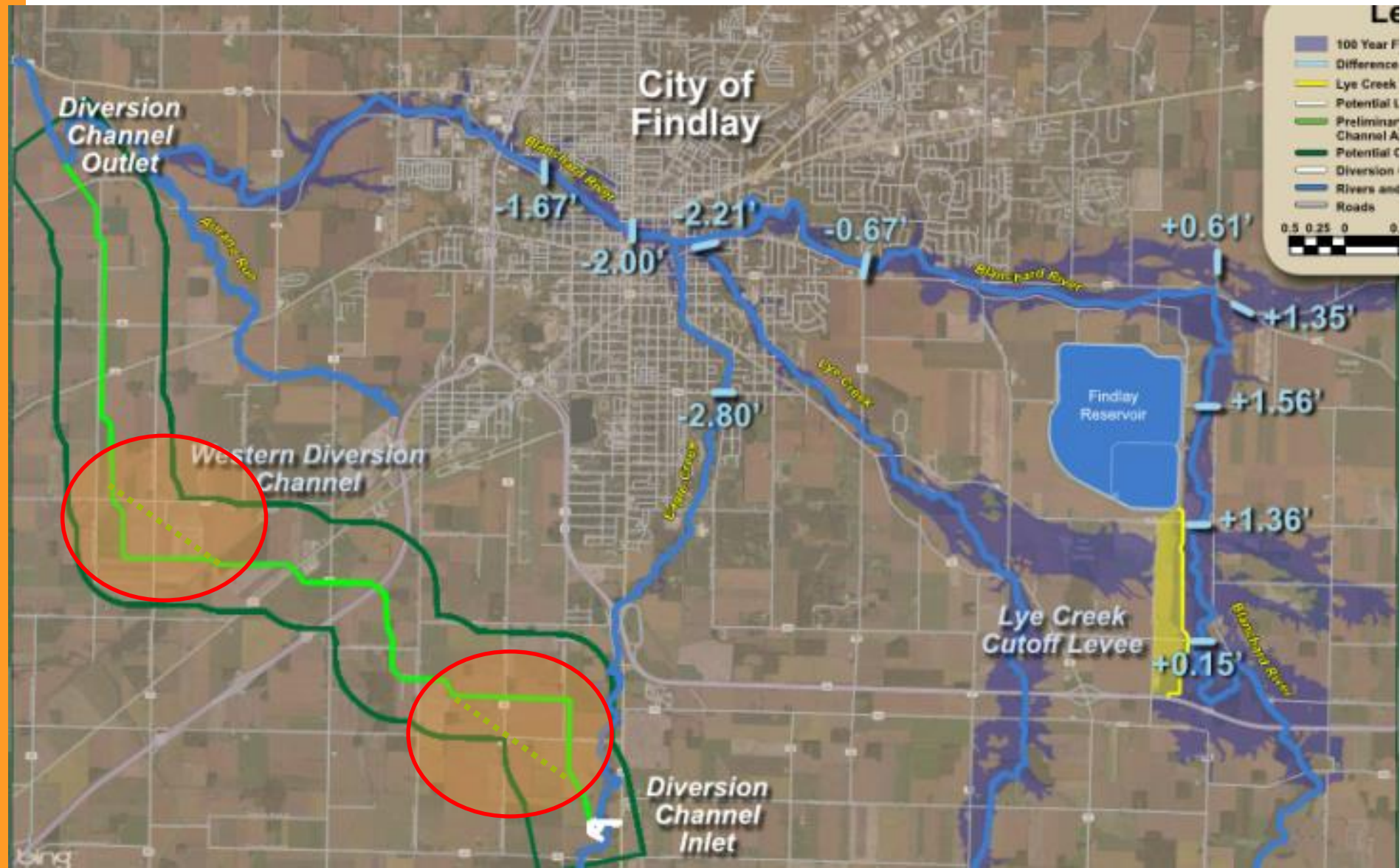
- Diversion Channel Refinement

Concept Design Analysis

Sizing

(Convey 25- 50-, 100-year?)

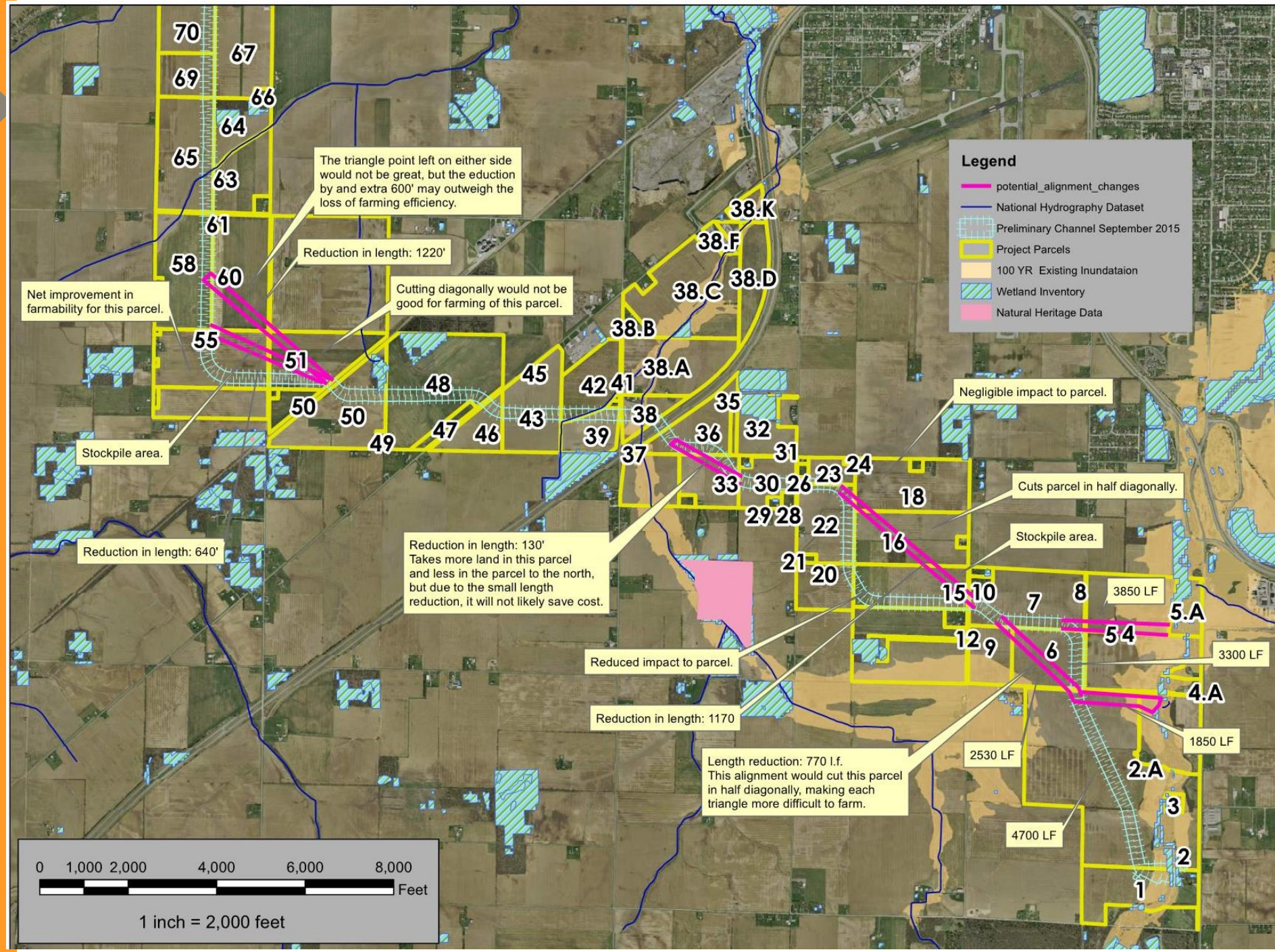
Alignment



Stantec

Concept Design Analysis

Diversion Channel Alignment



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Concept Design Analysis

Diversion Channel Alignment

Opportunities

- Reduce diversion channel length in multiple locations
  - Up to 3,150 feet (up to $4,725,000 in savings)
- Avoid 90° bends

Savings

- ~$1,500 / LF

From Cost Engineering Report	Current Plan	
Description	Cost	$/LF channel
01 – Lands and Damages	6,579,000	$ 134
02 – Relocations	14,589,000	$ 296
06 – Fish and Wildlife	1,758,000	$ 36
08 – Road, Railroads & Bridges	2,657,000	$ 54
09 – Channels and Canals	34,587,000	$ 703
15 – Floodway Control & Diversion	8,709,000	$ 177
18 – Cultural Resources	692,000	$ 14
30 – Engineering & Design	8,182,000	$ 166
31 – Construction Management	3,149,000	$ 64
Total	**80,902,000**	**$ 1,644**

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Eagle Creek Diversion Channel Geometry

USACE Feasibility Study 2015

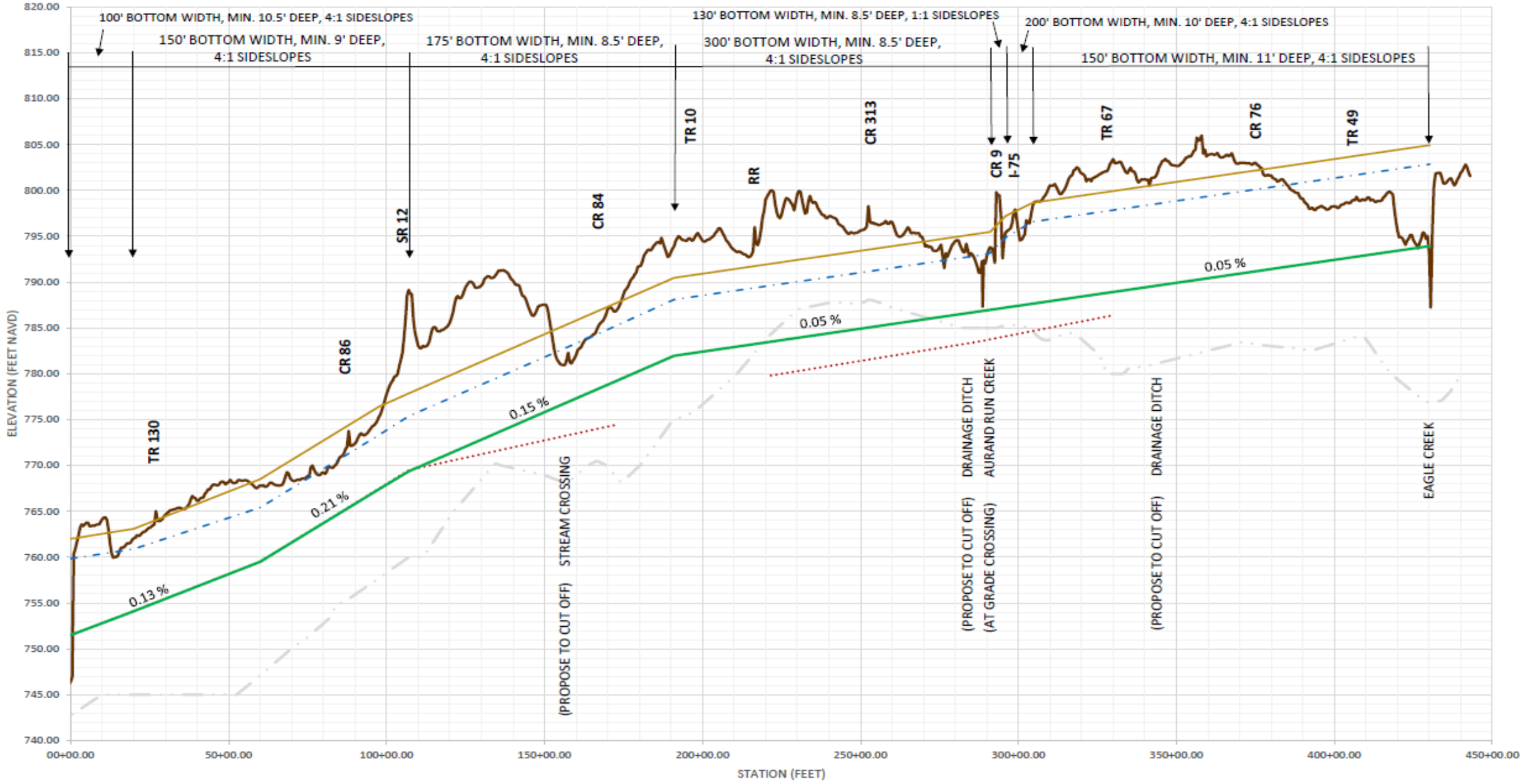
(1) The diversion channel has the following overall properties. Detailed dimension information is shown in Table 2:

- Channel Length: 9.2 miles
- Channel Shape: Trapezoidal
- Bottom Width: 25 to 52 feet
- Depth: 11 to 12 feet
- Side Slopes: 4H:1V

Table 2 – Diversion Channel Bottom Profile and Cross-Section Dimension

Start Station (feet)	End Station (feet)	Elevations (feet NAVD)	Bottom Slope	Channel Bottom Width (feet)	Channel Depth (feet)	Channel Sideslopes
0+00	20+00	751.5 – 754.1	0.13%	37	11.5	4H:1V
20+00	60+00	754.1 – 759.5	0.14%	37	11.0	4H:1V
60+00	107+00	759.5 – 769.5	0.21%	25	11.0	4H:1V
107+00	180+00	769.5 – 775.0	0.08%	42	12.0	4H:1V
180+00	230+00	775.0 – 779.5	0.09%	36	12.0	4H:1V
230+00	301+00	779.5 – 783.5	0.06%	52	12.0	4H:1V
301+00	478+00	783.5 – 795.4	0.07%	47	12.0	4H:1V
478+00	495+40	795.4 – 796.2	0.06%	47	12.0	4H:1V

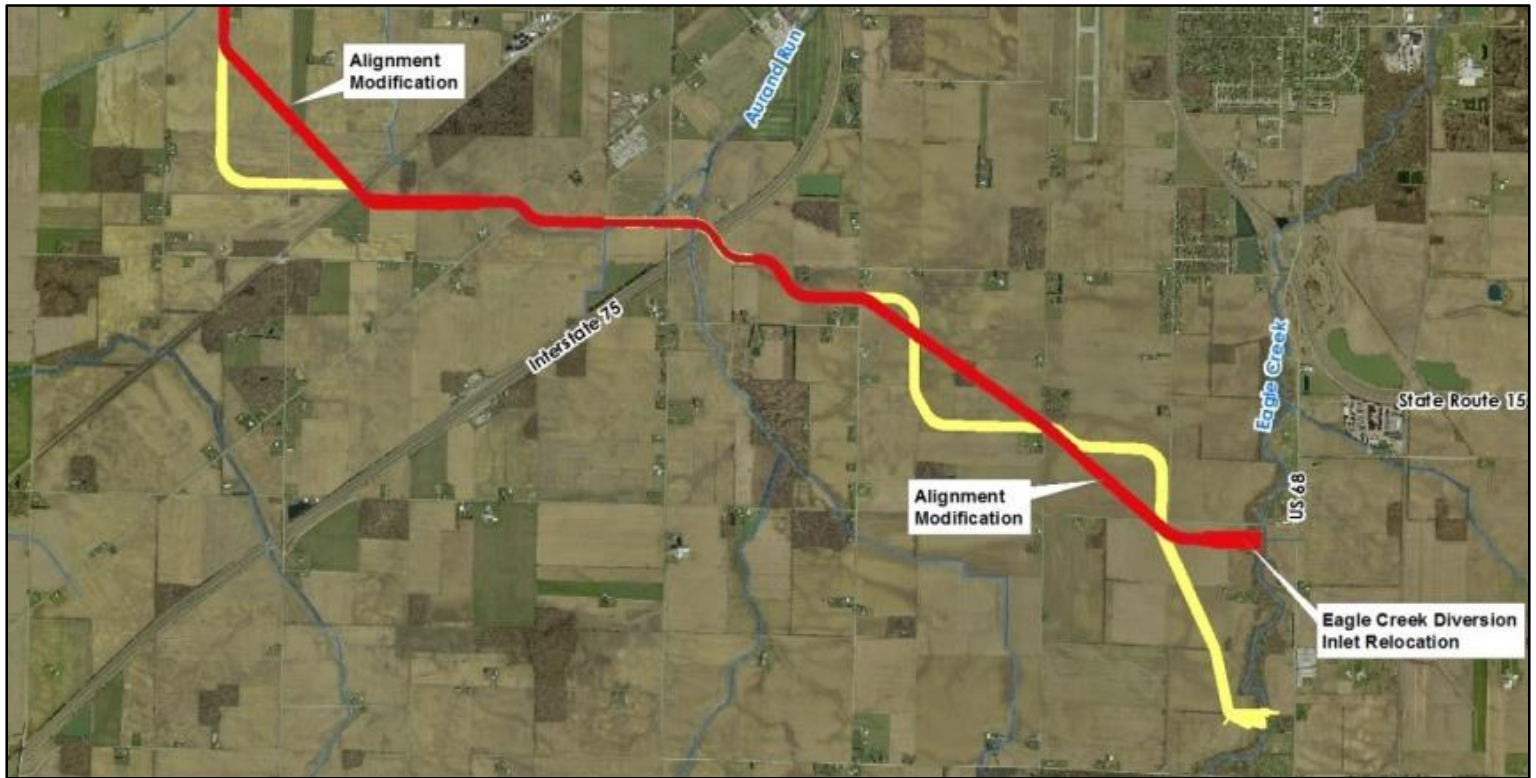
Eagle Creek Flood Diversion Streamlined Alt 13 Channel Alignment Profile View



Concept Design Refinement

Preliminary Recommendations

- Update capacity from 25-year to 100-year flows
- Reduce channel length
- Refine profile
- Estimated Cost $106 MM, incl. 30% contingency



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Additional Concepts Reviewed

Project Refinements

Concept Designs Reviewed

Blanchard River watershed
– 346 sq. miles

Eagle Creek Diversion watershed
– 51 sq. miles

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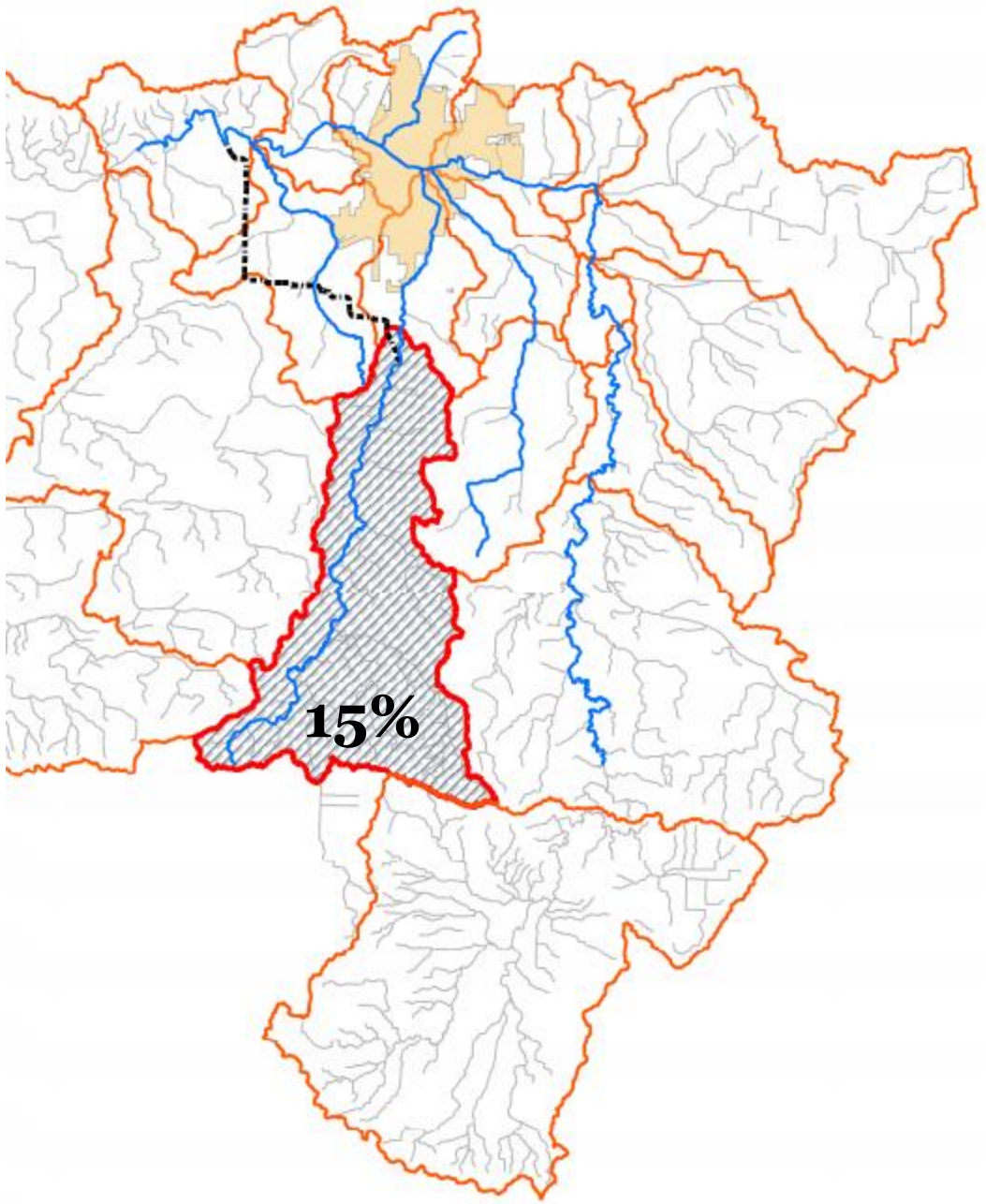
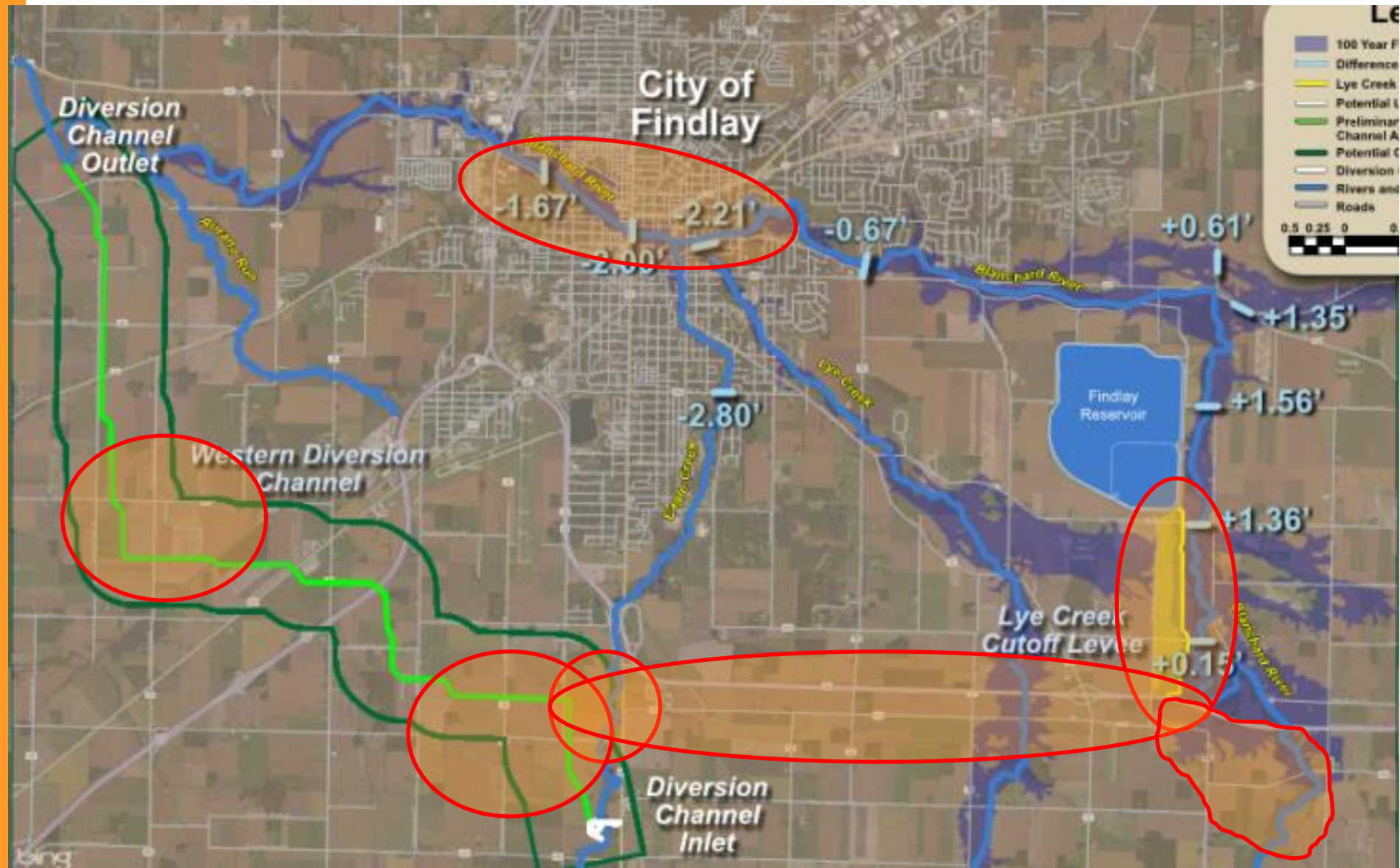
Potential Opportunities

– Projects covering other drainage basins
  - Reduces residual risk associated with varying rainfall



Concepts Considered



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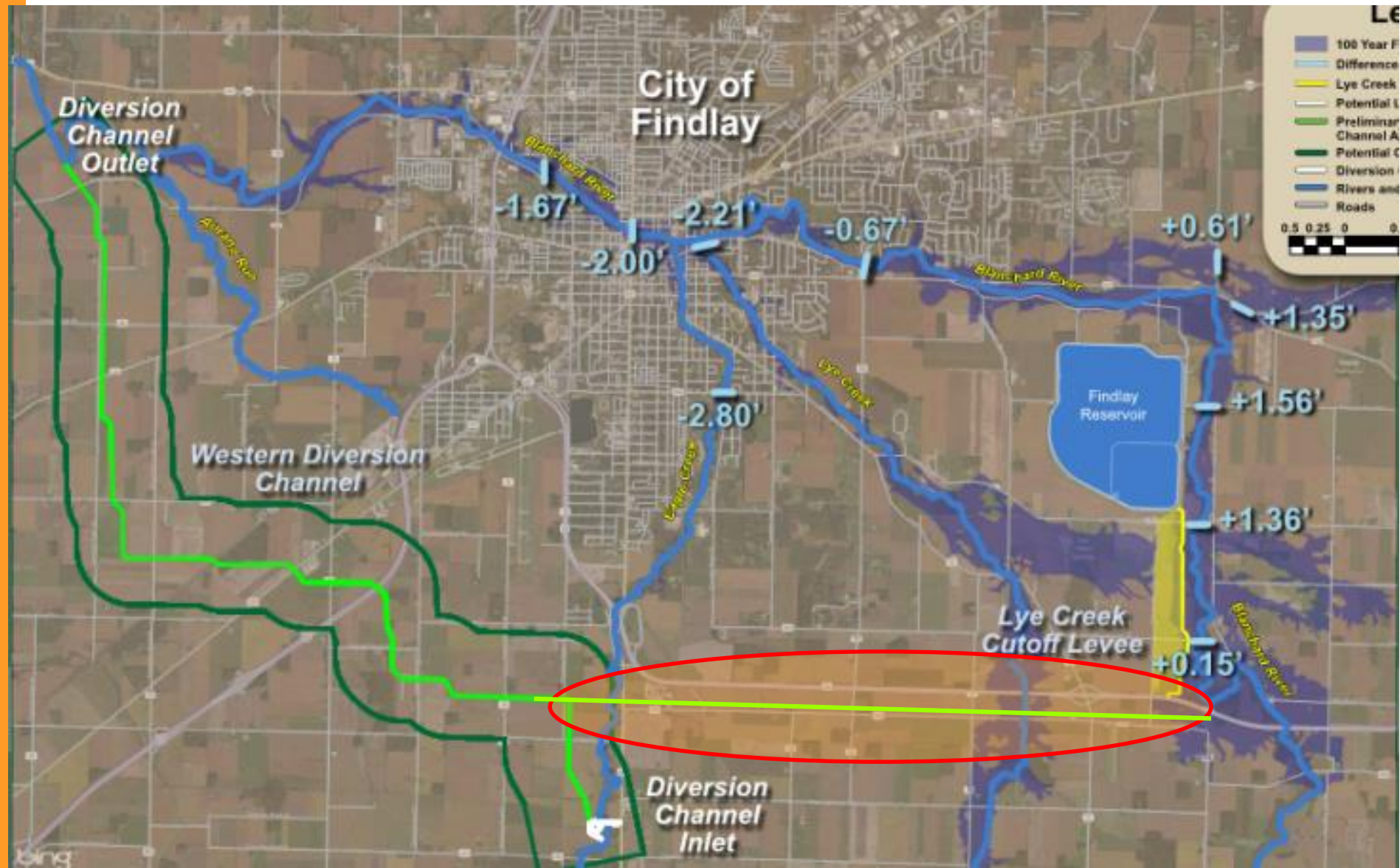
Concept
Design Analysis

Concept Design Charrette

- Diversion Channel Extension



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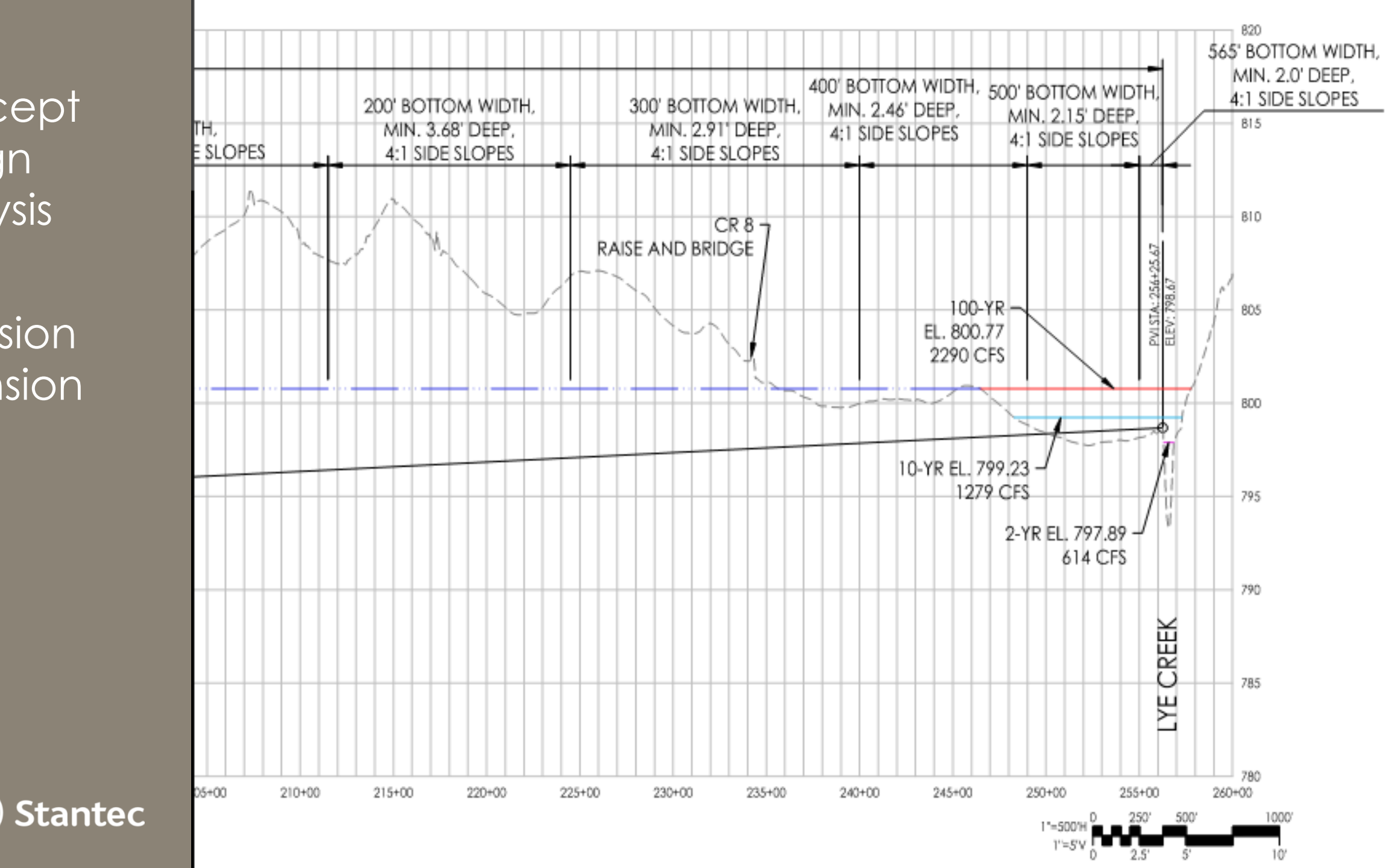
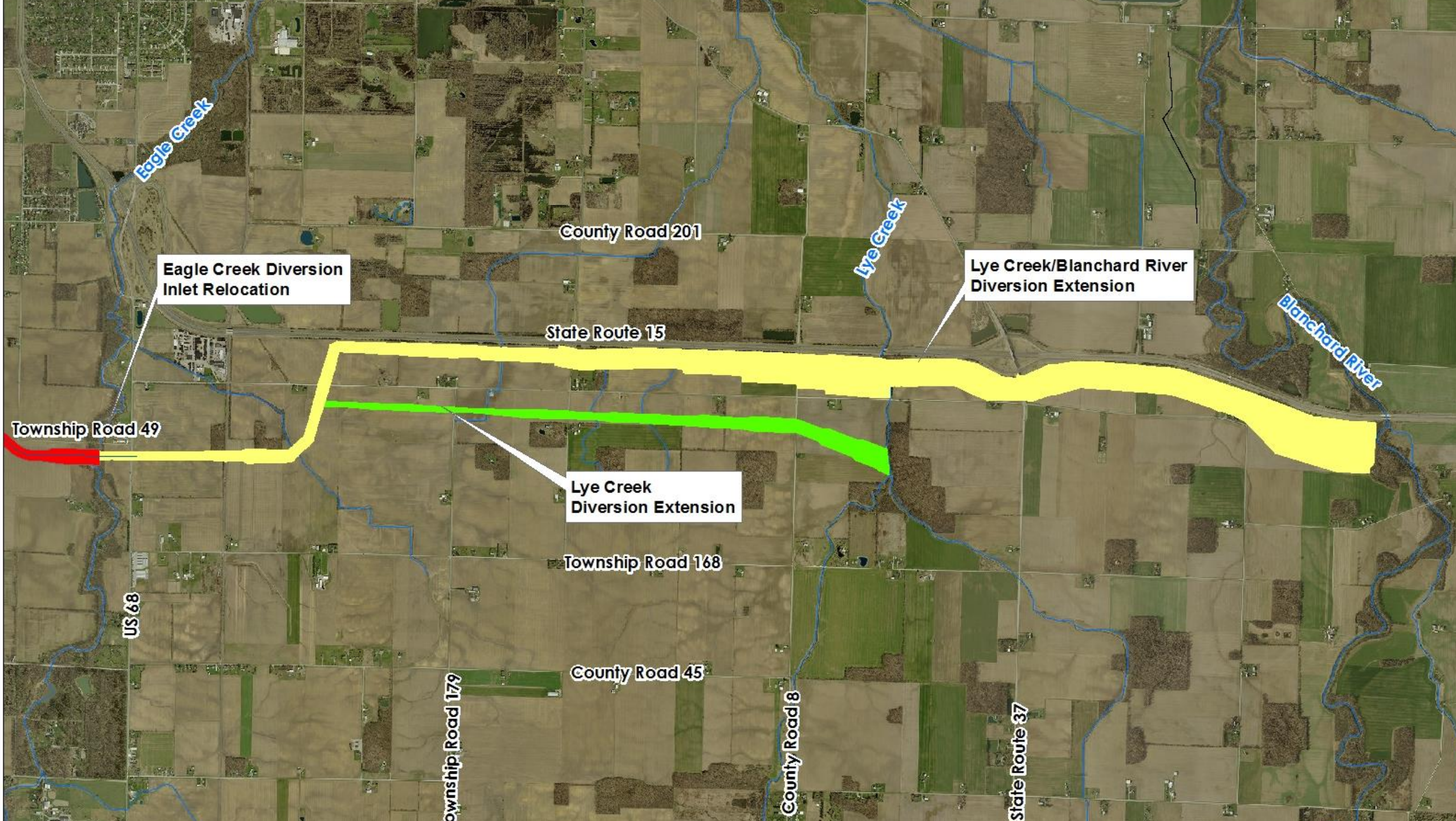
Concept Design Analysis

Diversion Extension



Stantec


Eagle Creek
Eagle Creek Diversion
Inlet Relocation
County Road 201
Lye Creek
Lye Creek/Blanchard River
Diversion Extension
Blanchard River
State Route 15
Township Road 49
Lye Creek
Diversion Extension
Township Road 168
US 68
County Road 45
Township Road 179
County Road 8
State Route 37

Concept Design Analysis

Diversion Channel Extension To Lye

Opportunities

- Divert up to 2,000 cfs more
- Reduce flooding on Lye
- Reduce flooding on Blanchard

Challenges

- Topography
- Extra diversion structure(s)
- Inlet location on Eagle Creek is challenging

Costs

- $32.5 MM

Reduction in WSE?

- ~1.5'

From Cost Engineering Report	Eagle-Lye (EL)	
Description	Cost	% of total
01 – Lands and Damages	$ 2,520,181.45	8%
02 – Relocations	$ 5,431,741.42	17%
06 – Fish and Wildlife	$ 654,534.33	2%
08 – Road, Railroads & Bridges	$ 1,139,496.91	4%
09 – Channels and Canals	$ 12,043,599.14	37%
15 – Floodway Control & Diversion	$ 5,806,000.00	18%
18 – Cultural Resources	$ 265,080.65	1%
30 – Engineering & Design	$ 3,298,038.66	10%
31 – Construction Management	$ 1,268,856.19	4%
Total	**$ 32,427,529**	**100%**

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Concept Design Analysis

Diversion Channel Extension To Blanchard

Opportunities

- Divert flow from Findlay
- Reduce flooding on Lye
- Reduce flooding on Blanchard

Challenges

- Topography
- Extra diversion structure(s)
- Inlet location on Eagle Creek is challenging

Costs

- $51.3 MM+

Reduction in WSE?

- ~1.5'+

From Cost Engineering Report	Eagle-Lye-Blanchard (ELB)	
Description	Cost	% of total
01 – Lands and Damages	$ 5,305,645	10%
02 – Relocations	$ 9,282,486	18%
06 – Fish and Wildlife	$ 1,118,556	2%
08 – Road, Railroads & Bridges	$ 1,844,212	4%
09 – Channels and Canals	$ 19,762,586	38%
15 – Floodway Control & Diversion	$ 6,452,199	13%
18 – Cultural Resources	$ 558,065	1%
30 – Engineering & Design	$ 5,063,380	10%
31 – Construction Management	$ 1,948,037	4%
Total	**$ 51,335,165**	

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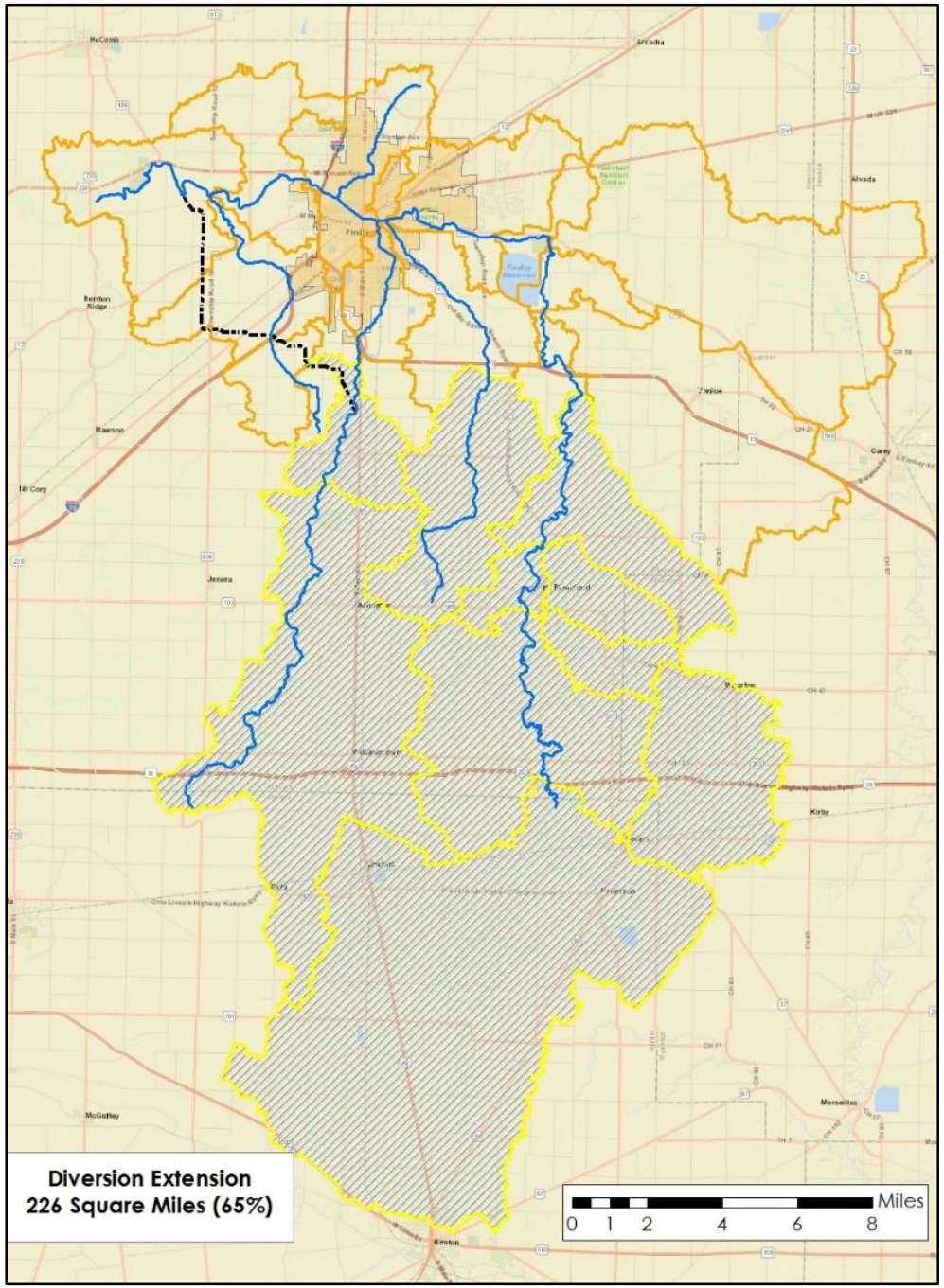
Percent of Watershed Influenced



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Concept Designs Reviewed

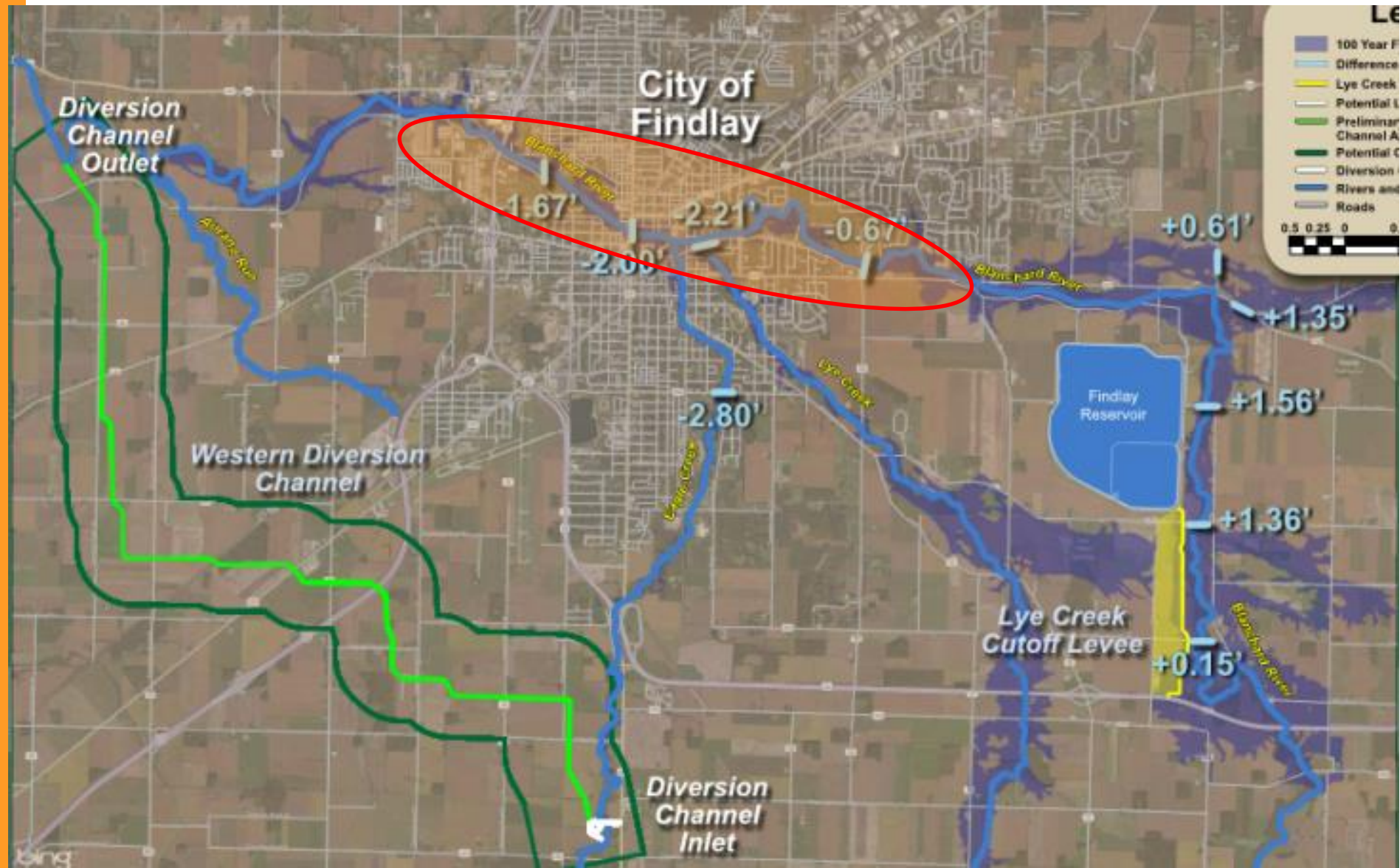
Remove inline structures

Channel widening

Structure modifications

Concept Design Charrette

- Blanchard River Modifications



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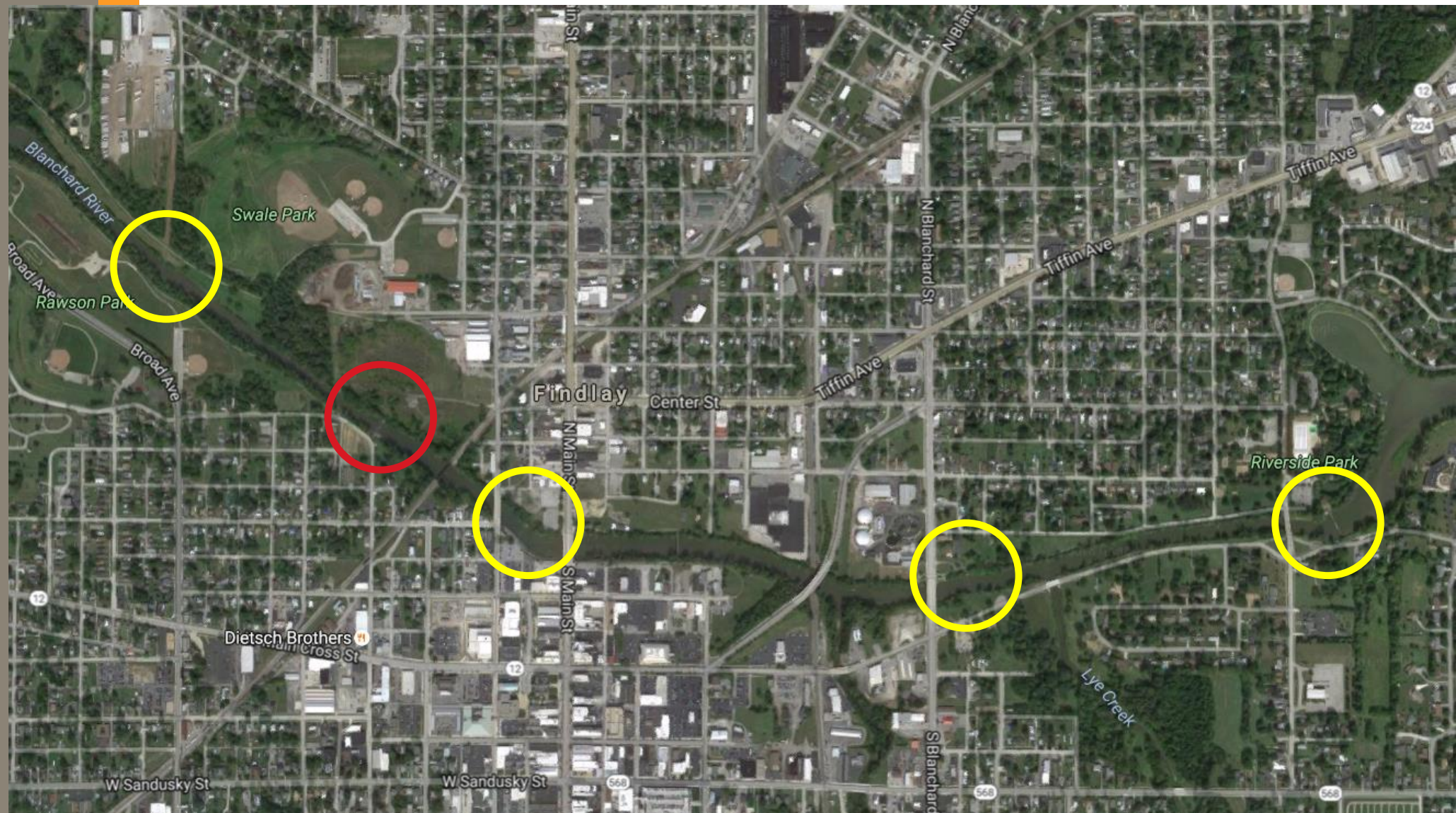
Inline Structures



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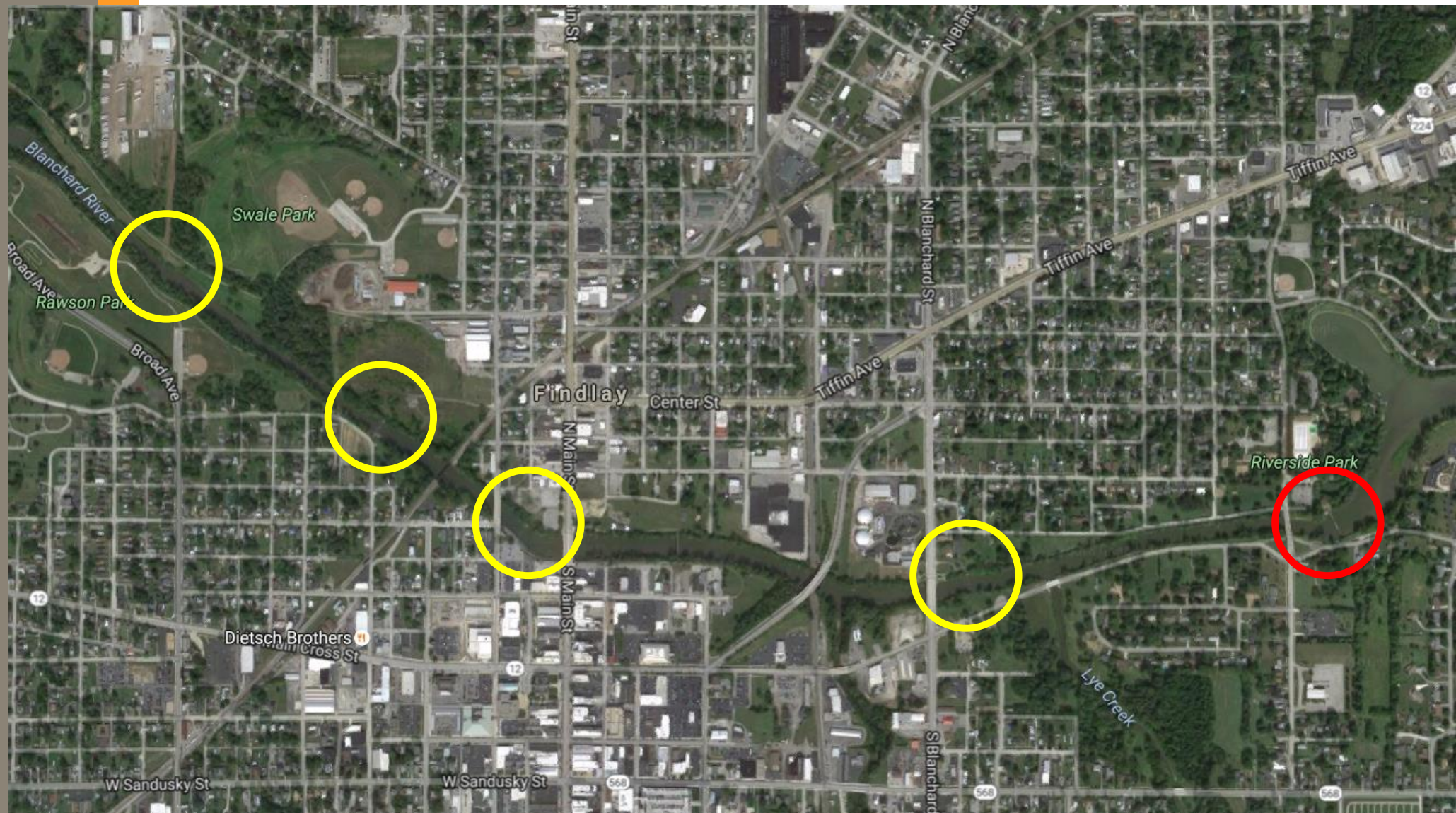
Downstream of RR Bridge

Inline Structures

Stantec

Inline Structures



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Riverside Park Waterfront and Waterfalls

Inline Structures

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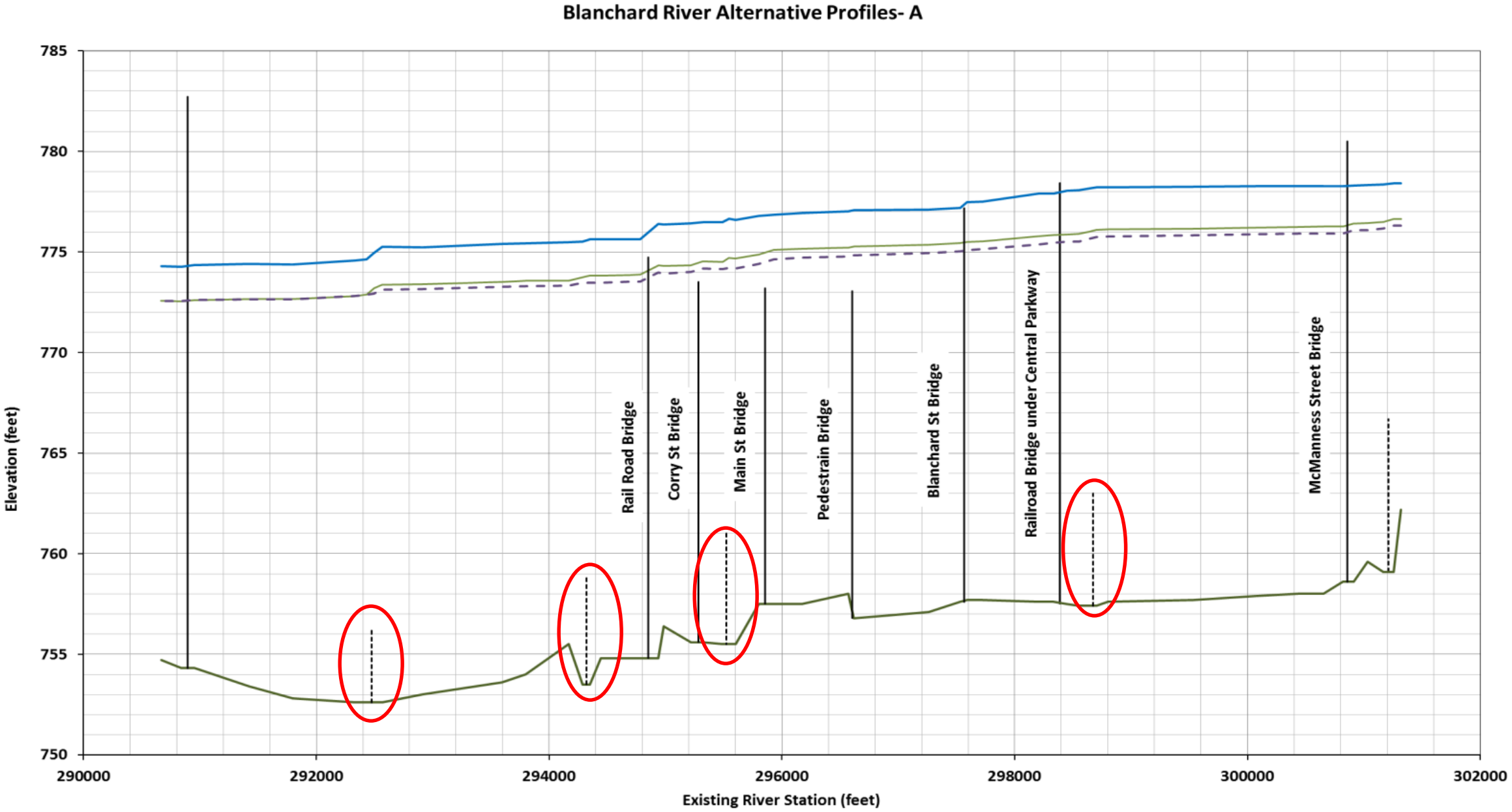
Blanchard River Alternative Profiles- A
Elevation (feet)
785
780
775
770
765
760
755
750
290000
292000
294000
296000
298000
300000
302000
Existing River Station (feet)
Rail Road Bridge
Corry St Bridge
Main St Bridge
Pedestrain Bridge
Blanchard St Bridge
Railroad Bridge under Central Parkway
McManness Street Bridge
Bridge
Inline Structure
Existing Channel Invert
100-Yr Diverted Flow-Existing Geometry
100-Yr Existing Flow-Existing Geometry
Three Inlines Structures Removal- 100-Yr Diverted

Concept Design Analysis

Blanchard River Modifications

Low Head Dam Removals

Opportunities

- 5 low head dam/riffle structures on the Blanchard
- Reduce WSE on the Blanchard River

Costs

- $~500,000 per removal of inline dam structure

Reduction in WSE?

- ~0.4’ removing 4 downstream riffle structures (diverted flow)

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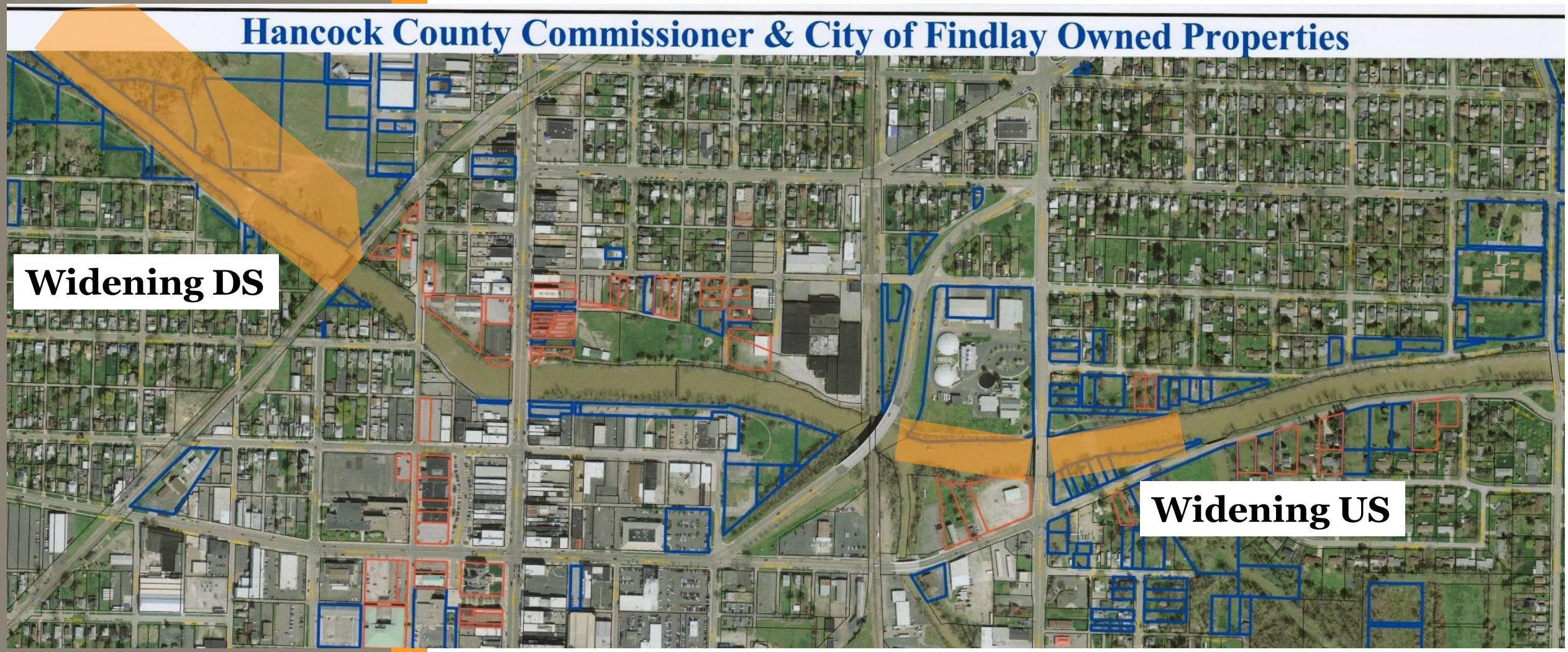
Channel Modification



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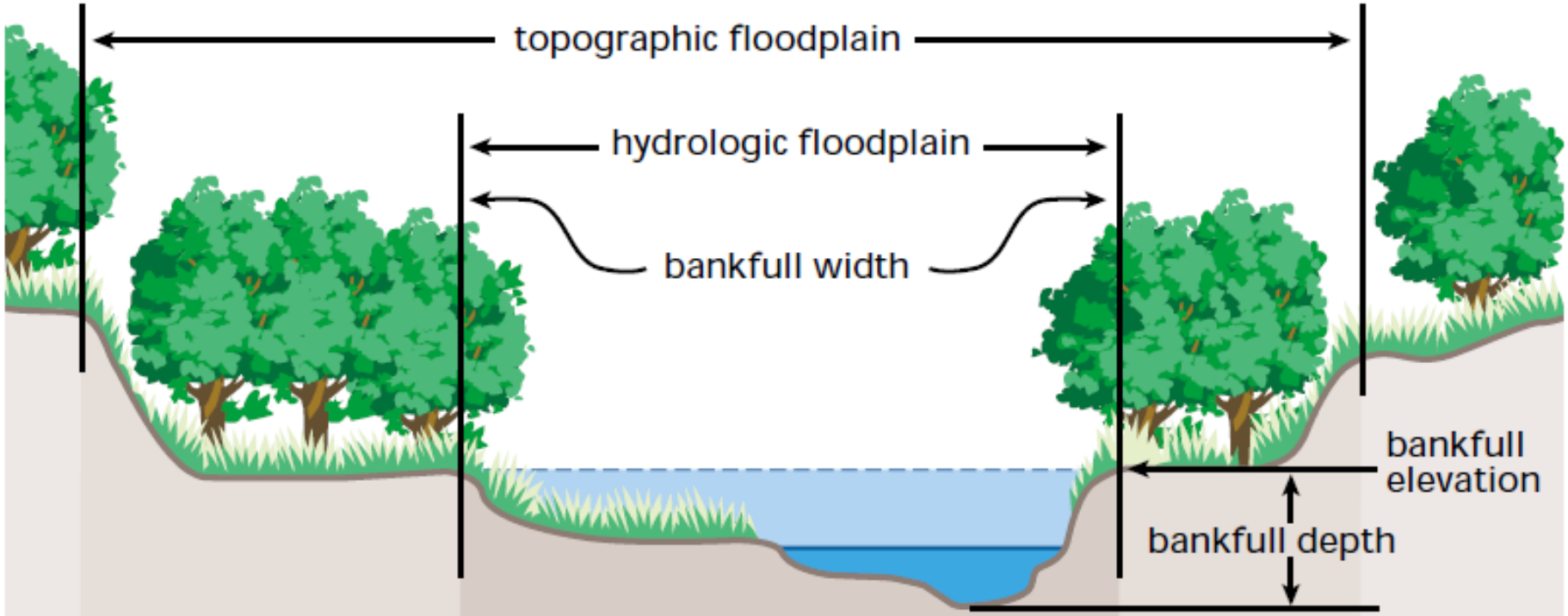
Channel Modification

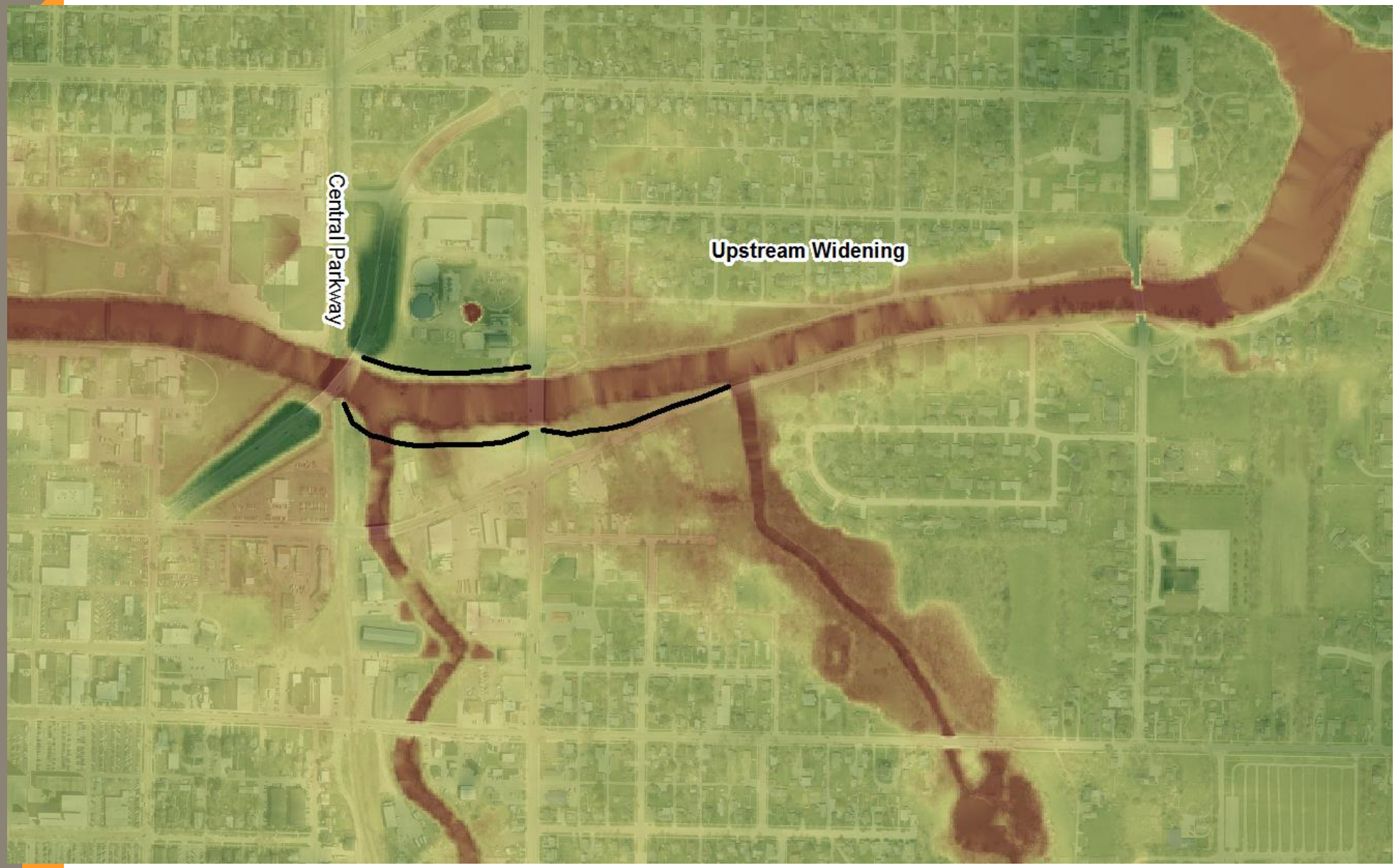
Channel Widening



Source: https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=637

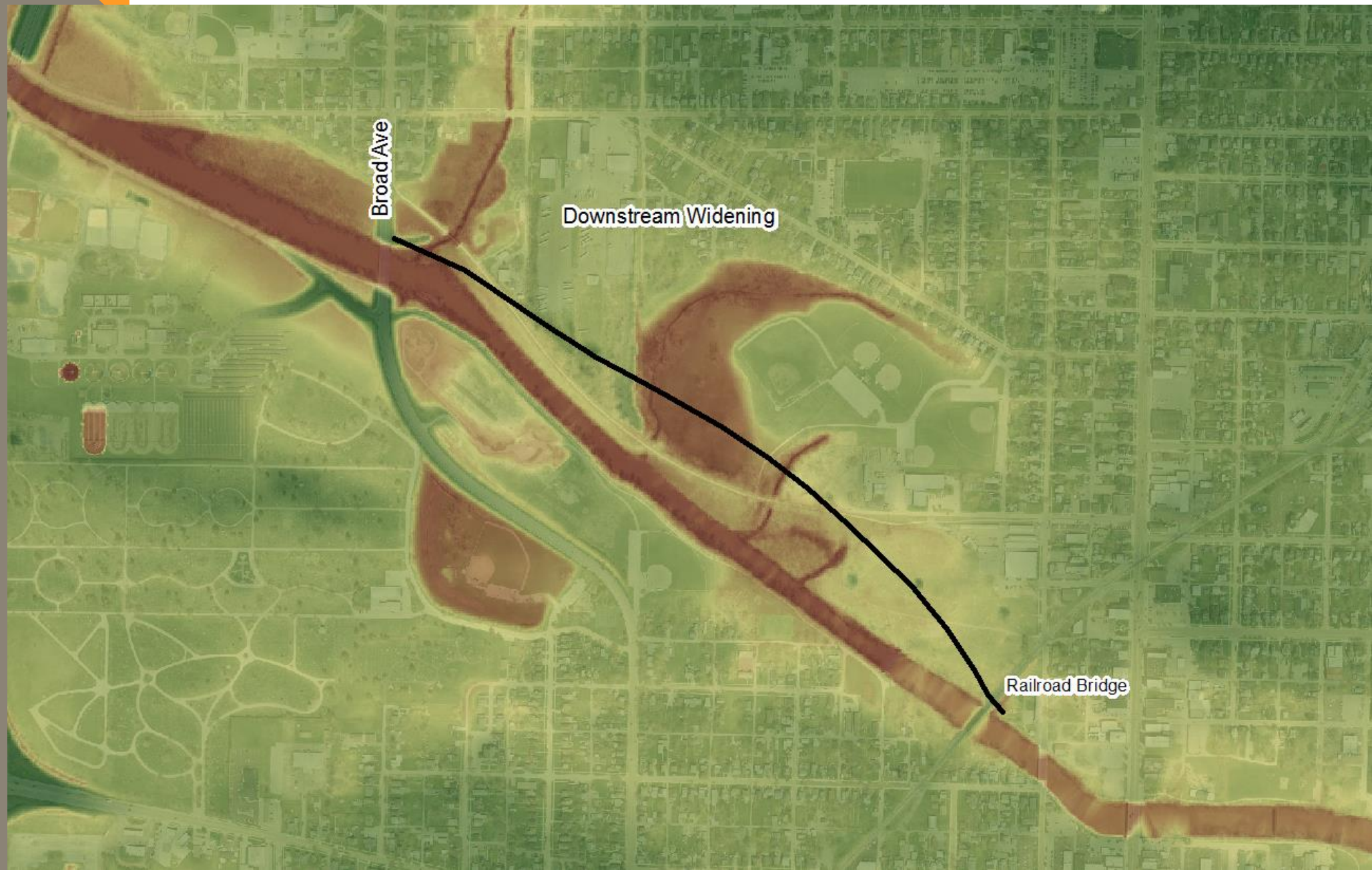
Stantec

Channel Modification



Stantec

Channel Modification



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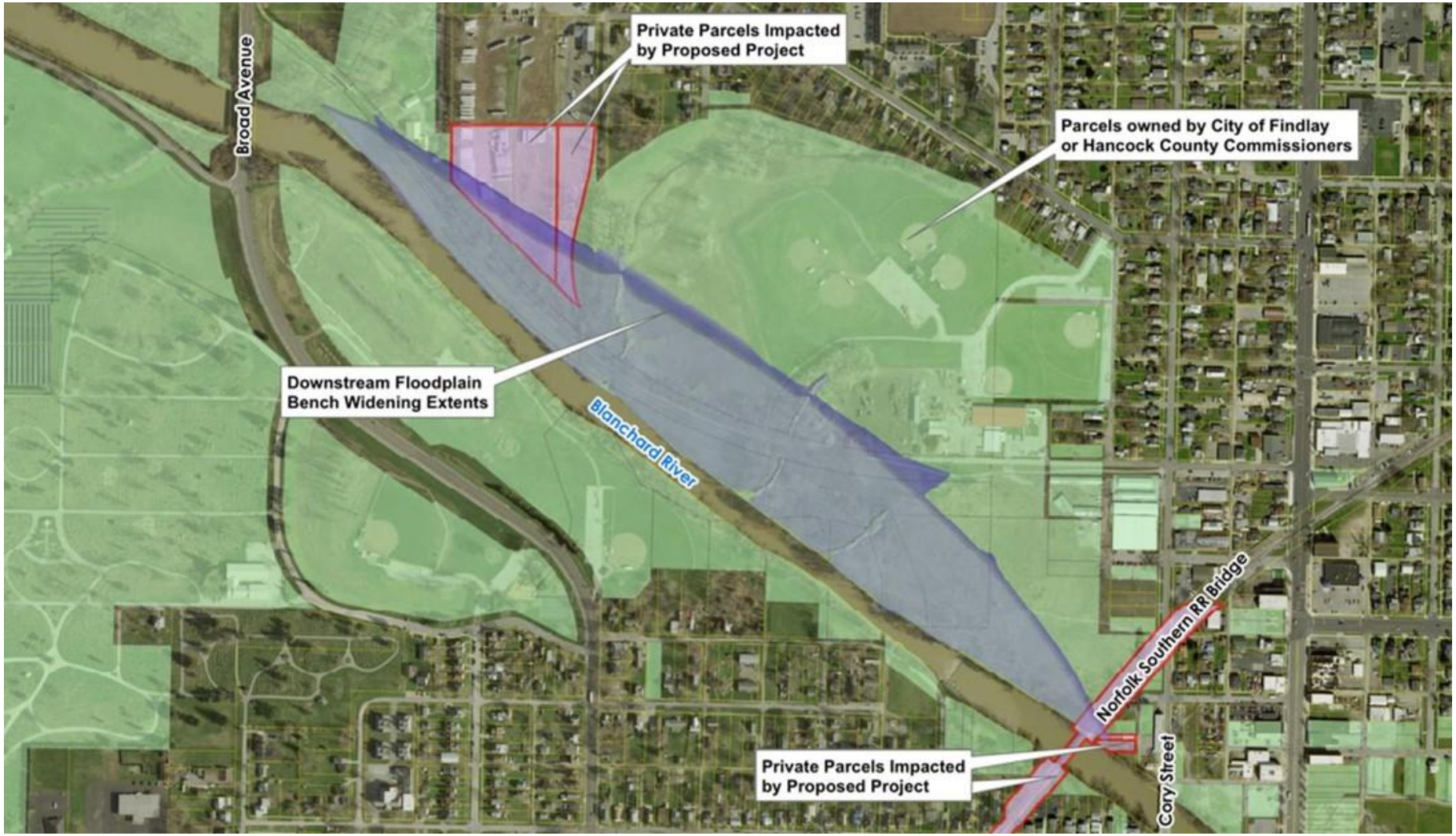
Hydraulic Improvements

Remove Inline Riffles/Dams

Floodplain Bench Widening

Bridge Modifications

Widening Currently in MWCD Official Plan



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Concept Design Analysis

Blanchard River Modifications

Widening

Opportunities

- Reduce WSE on the Blanchard River
- Much of corridor contains bought out parcels

Challenges

- HTRW sites?

Costs

– ~$11.5 MM for downstream widening

Reduction in WSE?

- ~0.6’ for downstream widening

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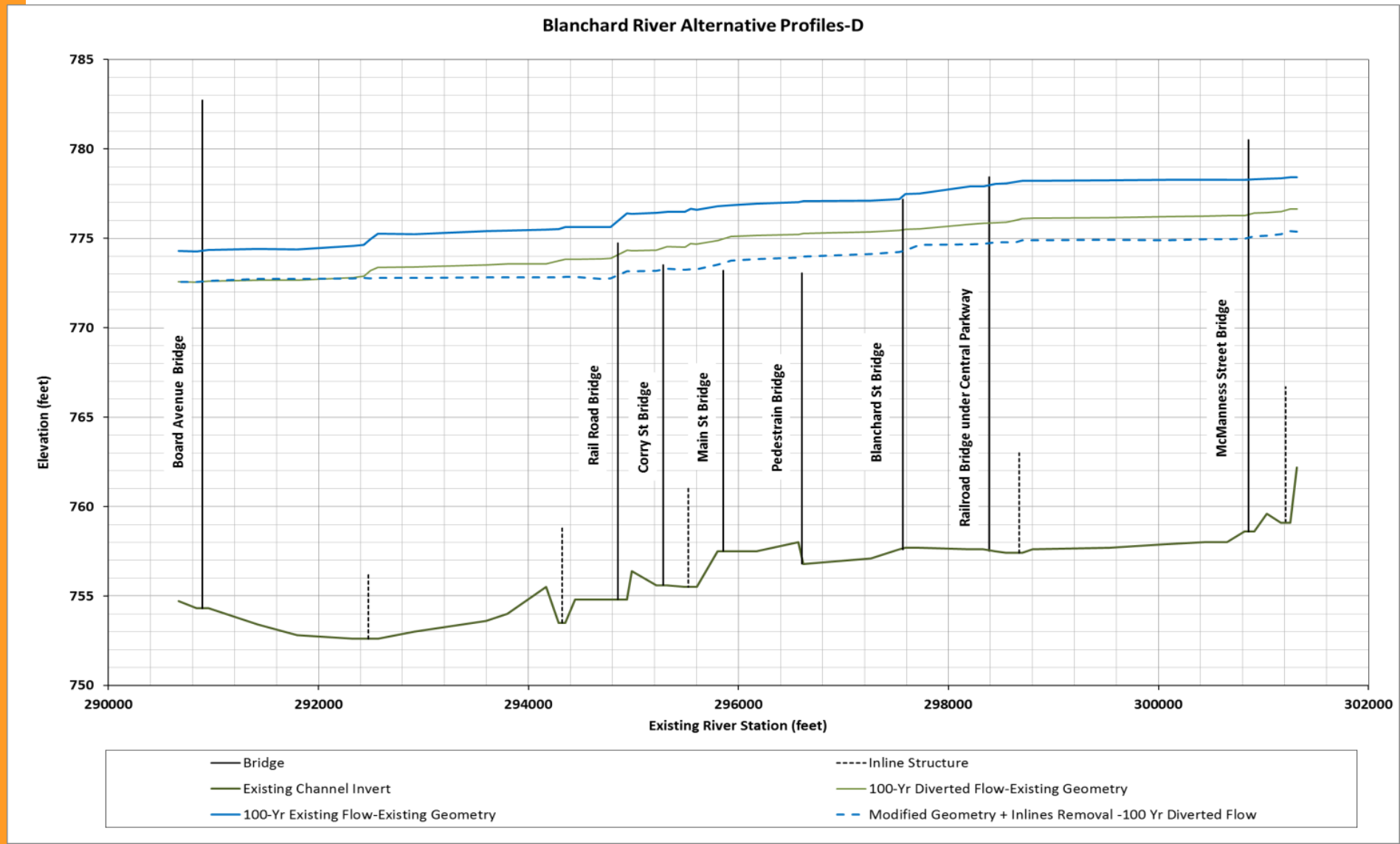
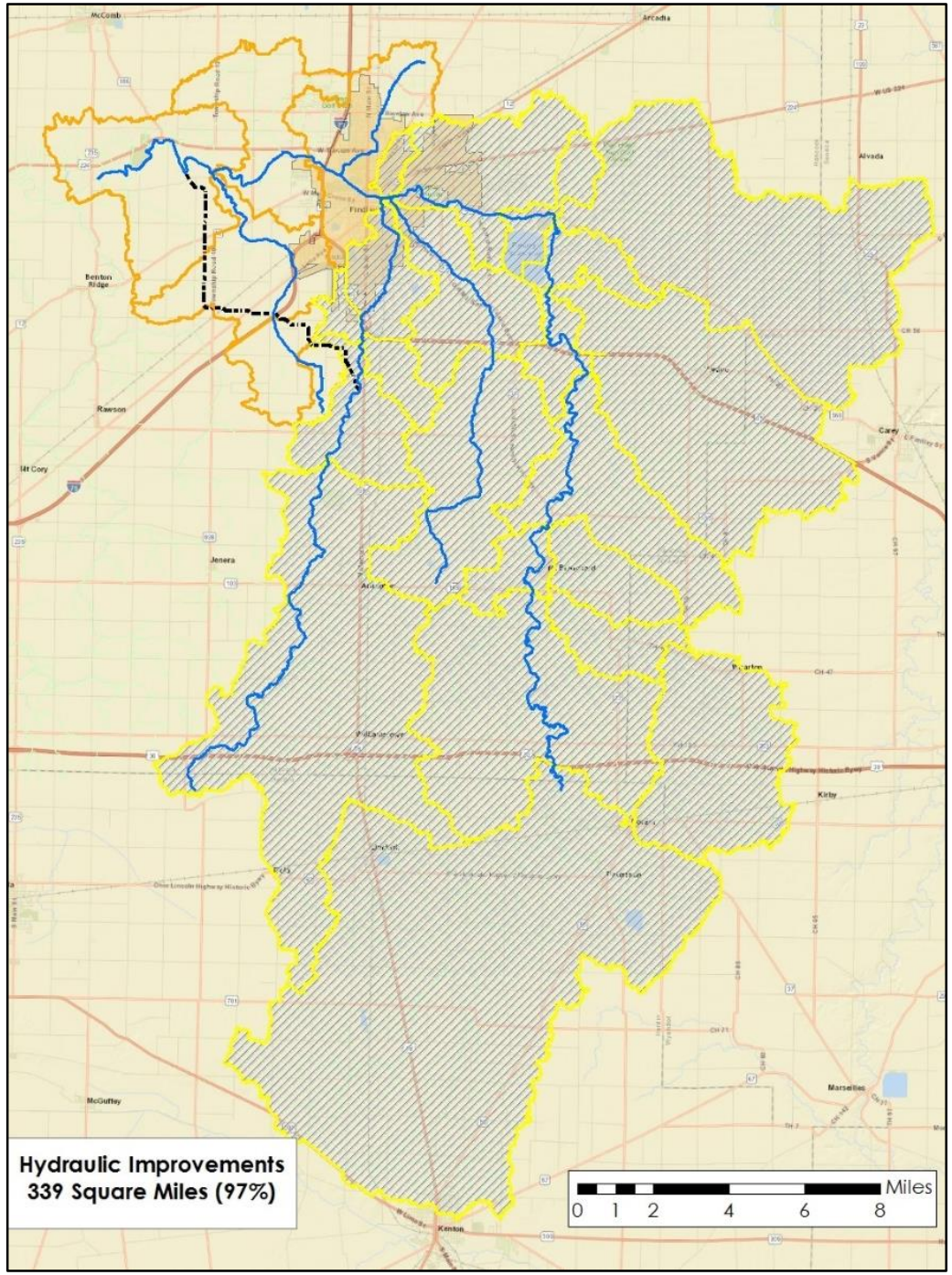
Profile: Channel Modifications+ Inline Structures Removal



Stantec

Percent of Watershed Influenced



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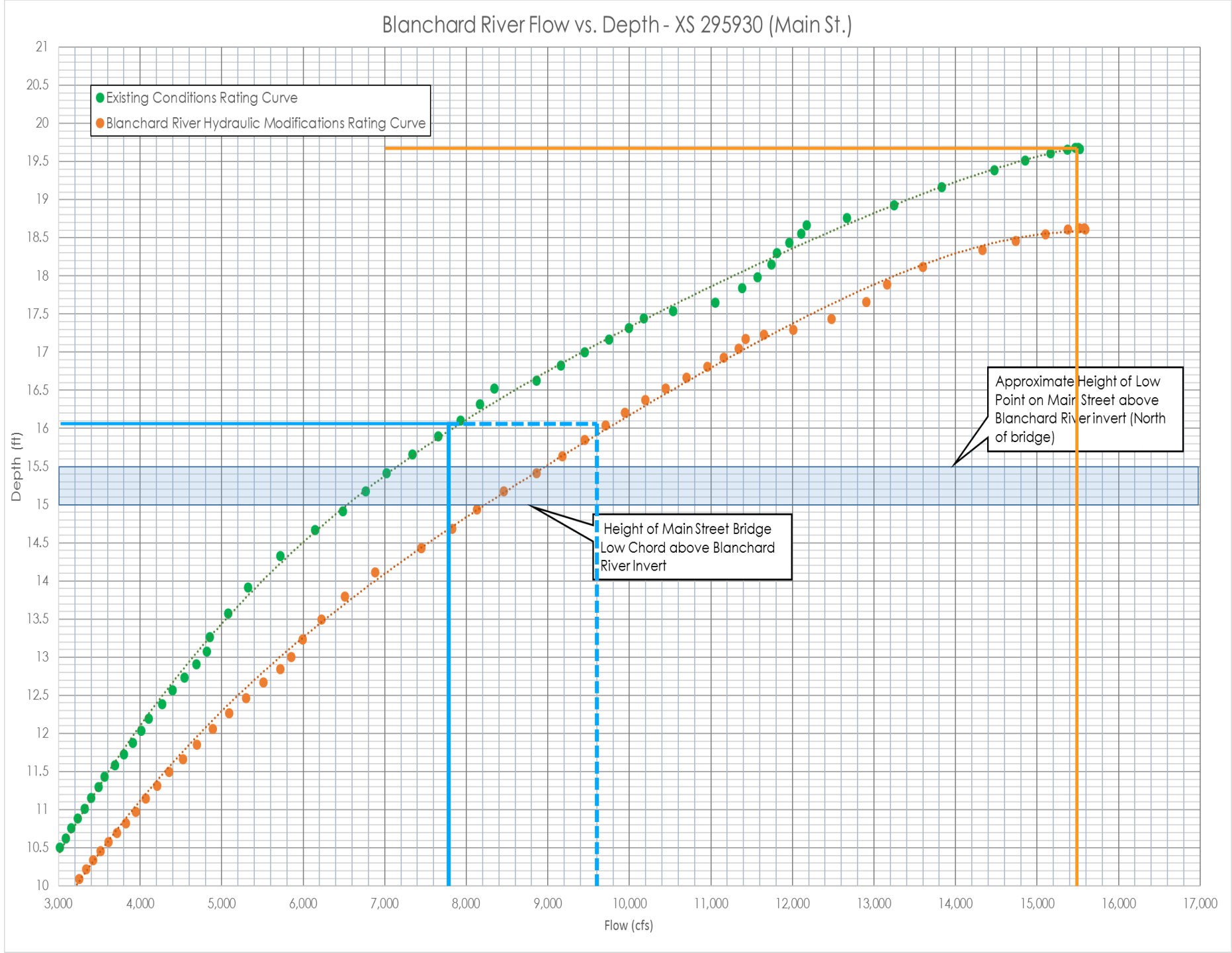
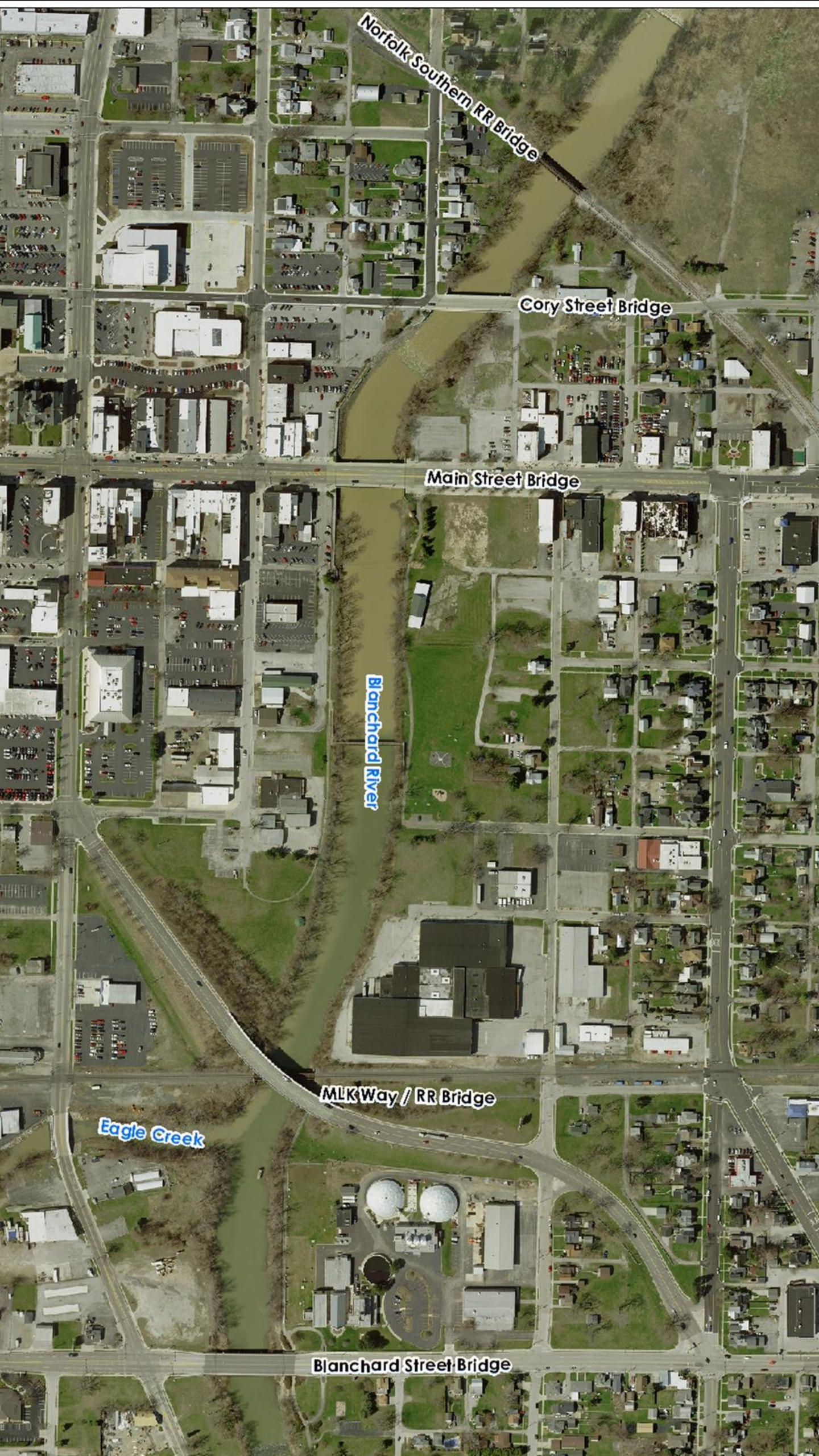
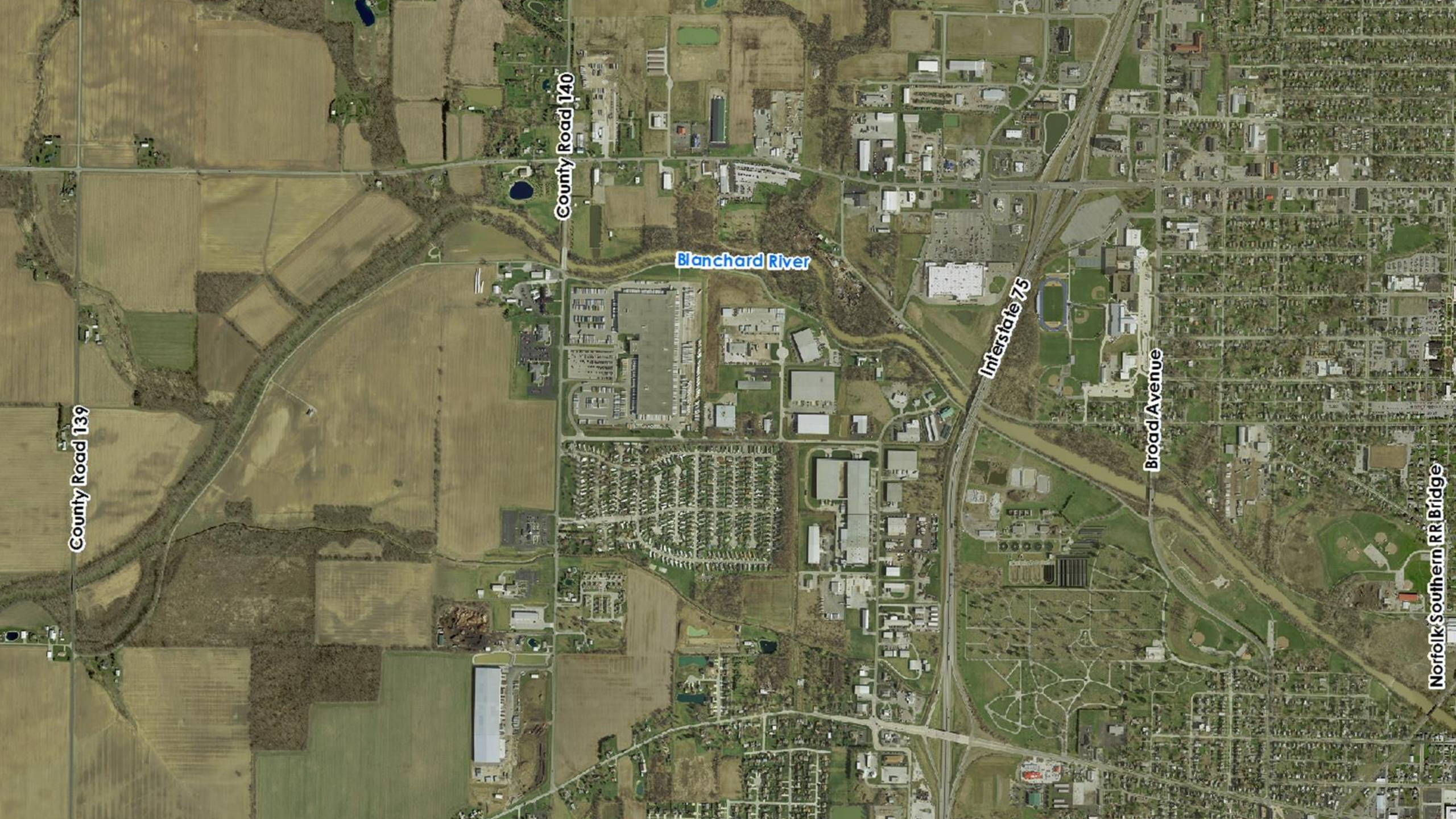
Hydraulic Improvements

Blanchard River Rating Curve at Main Street



Stantec


Norfolk Southern RR Bridge
Cory Street Bridge
Main Street Bridge
Blanchard River
MLK Way / RR Bridge
Eagle Creek
Blanchard Street Bridge


County Road 140
Blanchard River
Interstate 75
Broad Avenue
County Road 139
Norfolk Southern RR Bridge

Blanchard River

Facing Downstream

RR Bridge

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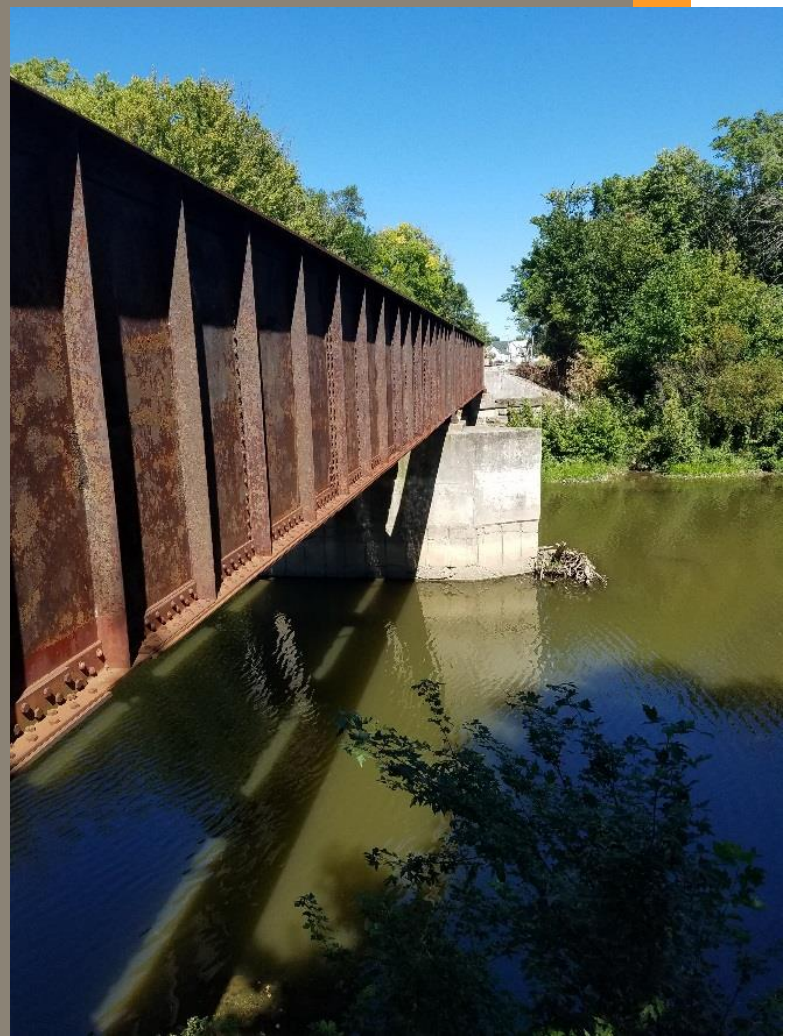
Single Rail Thru Plate Girder Structure



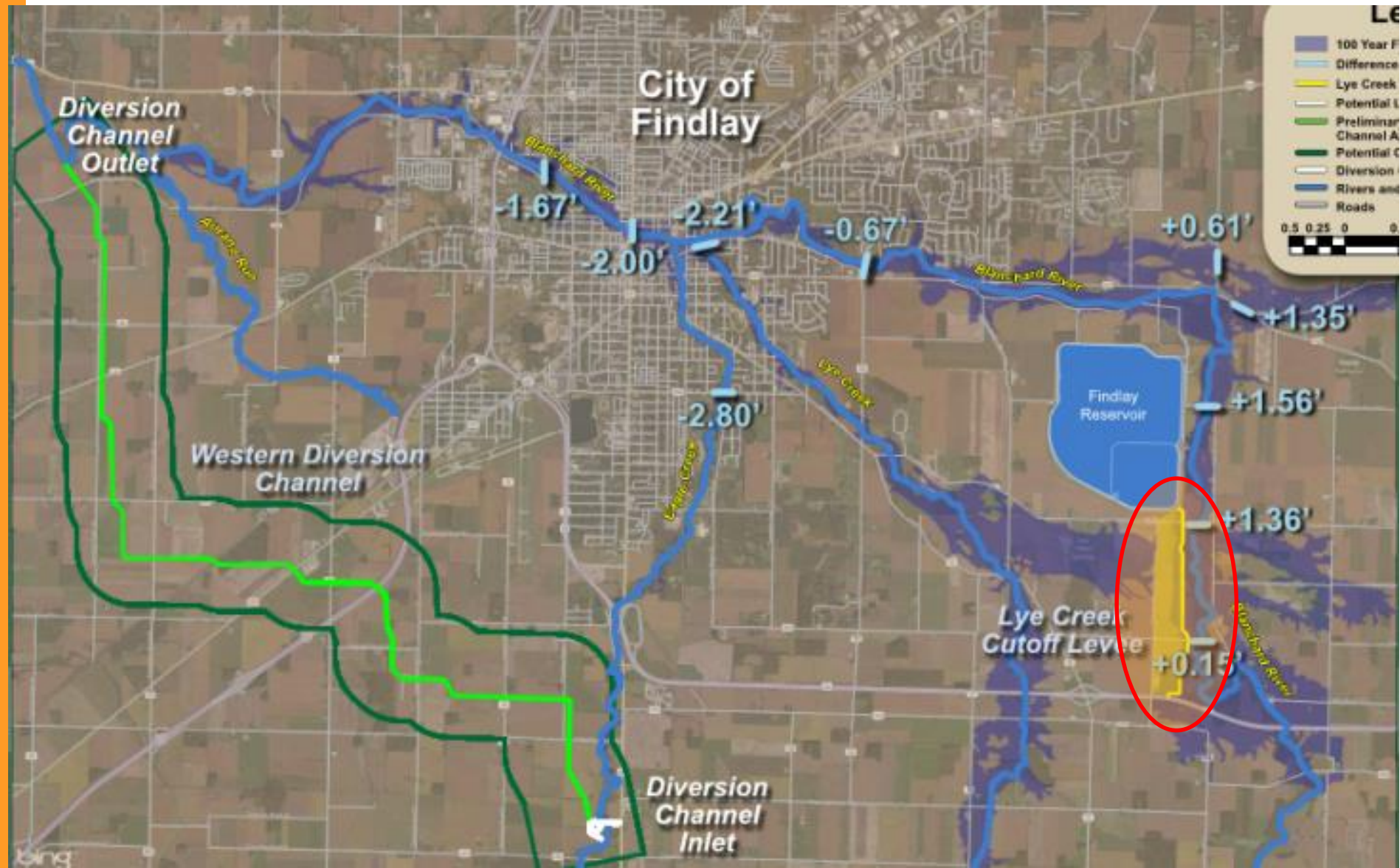
RR Bridge

Liberty St
Apple Alley
Blanchard River
50.11 ft
Washington St
Washington St
Washington St
Washington St
S West St
Meeks Ct
N Cory St
N Cory St

Concept Designs Reviewed

Concept Design Charrette

- Blanchard/Lye Cutoff Levee



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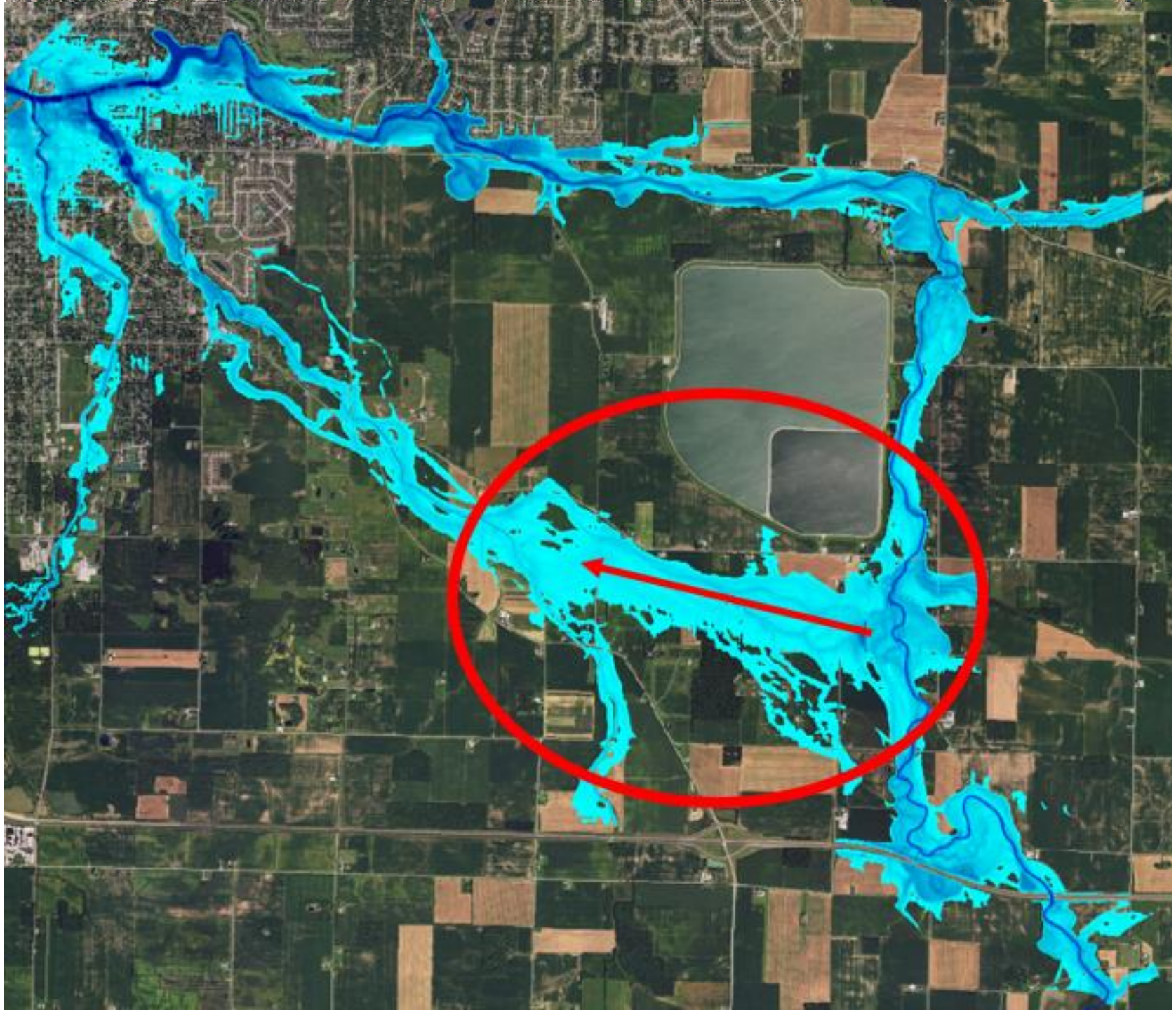
Concept Designs Reviewed

Blanchard/Lye Cutoff Levee

Existing Cond. 500-Year Maximum Depth



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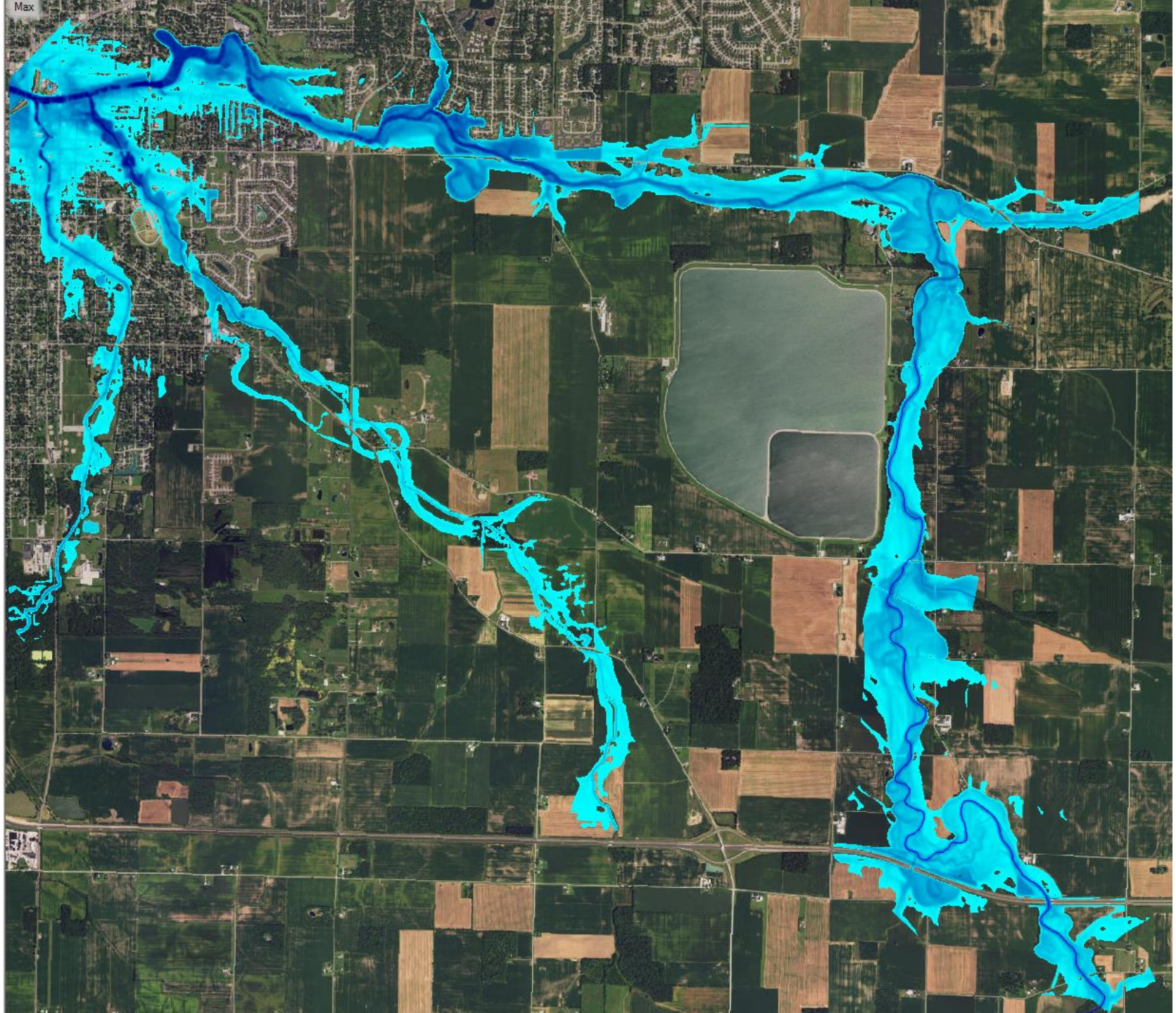
Concept Designs Reviewed

Blanchard/Lye Cutoff Levee

With Levee 500-Year Maximum Depth



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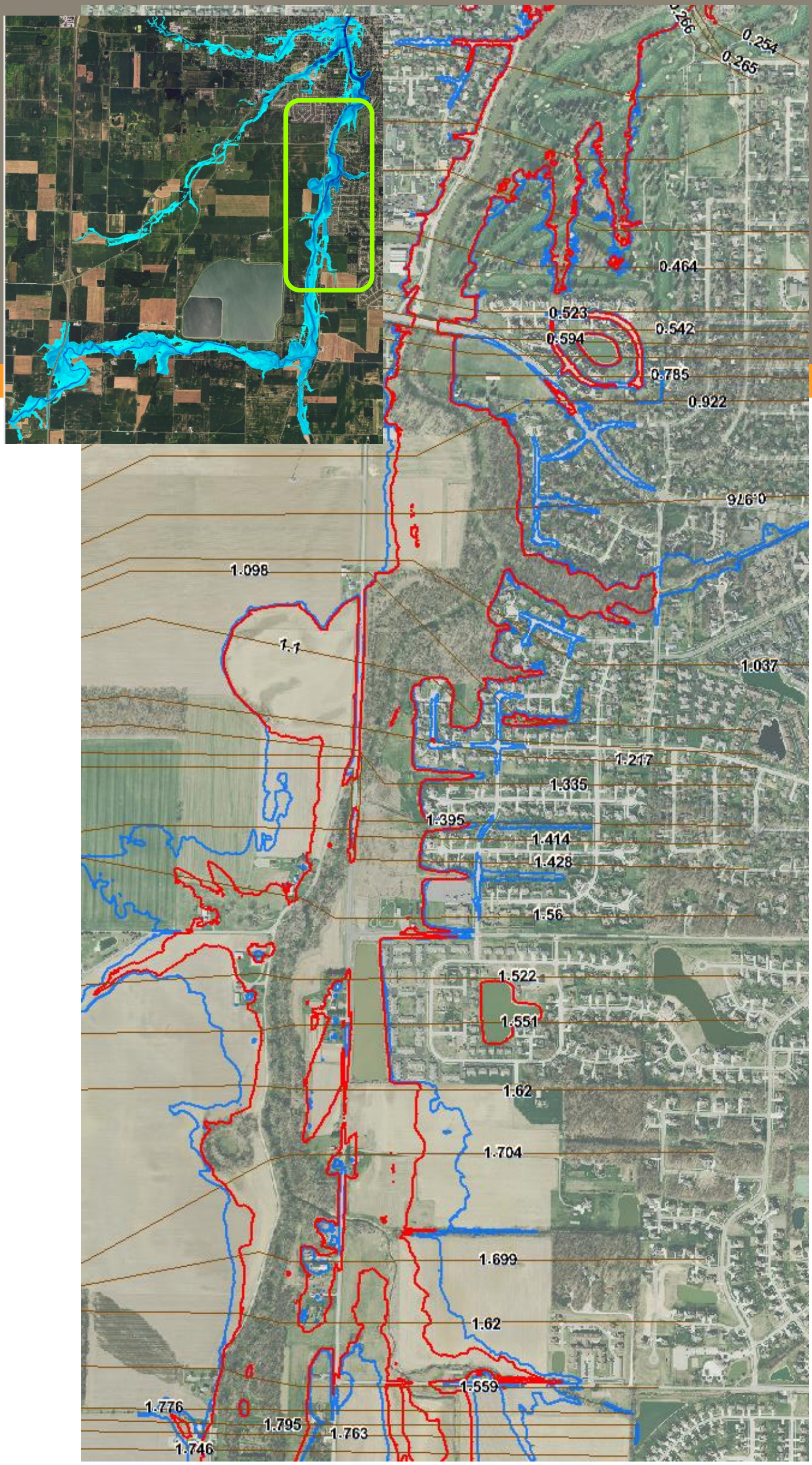
0.254
0.265
0.464
0.523
0.542
0.594
0.785
0.922
1.098
1.1
1.037
1.217
1.335
1.395
1.414
1.428
1.56
1.522
1.551
1.62
1.704
1.699
1.62
1.559
1.776
1.795
1.763
1.746

Concept Design Analysis

Cut-off Levee

Opportunities

- Reduce flooding along Lye Creek

Challenges

- Induced flooding along Blanchard River

Costs

- ~$8 MM for cutoff levee (from previous study)

Increase in WSE

- 0-2'

Table 13 - Blanchard River to Lye Creek Diversion Cutoff Cost Summary

Account Code	Description	Subtotal	Contingency (%)	Contingency ($)	Total
01	Lands & Damages	$3,762,500	25.0%	$ 940,625	$4,703,125
06	Fish & Wildlife	$ 40,500	22.3%	$ 9,011	$ 49,511
08	Roads, Railroads Bridges	$ 190,400	25.0%	$ 47,600	$ 238,000
11	Levees and Floodwalls	$1,624,200	23.7%	$ 385,585	$2,009,785
15	Flood Control	$ 332,400	20.0%	$ 66,414	$ 398,814
18	Cultural Resources	$ 20,000	35.9%	$ 7,182	$ 27,182
30	Eng & Design	$ 264,899	29.0%	$ 76,715	$ 341,614
31	Construction Management	$ 176,599	19.6%	$ 34,543	$ 211,142
				TOTAL FIRST COST:	$ 7,979,172

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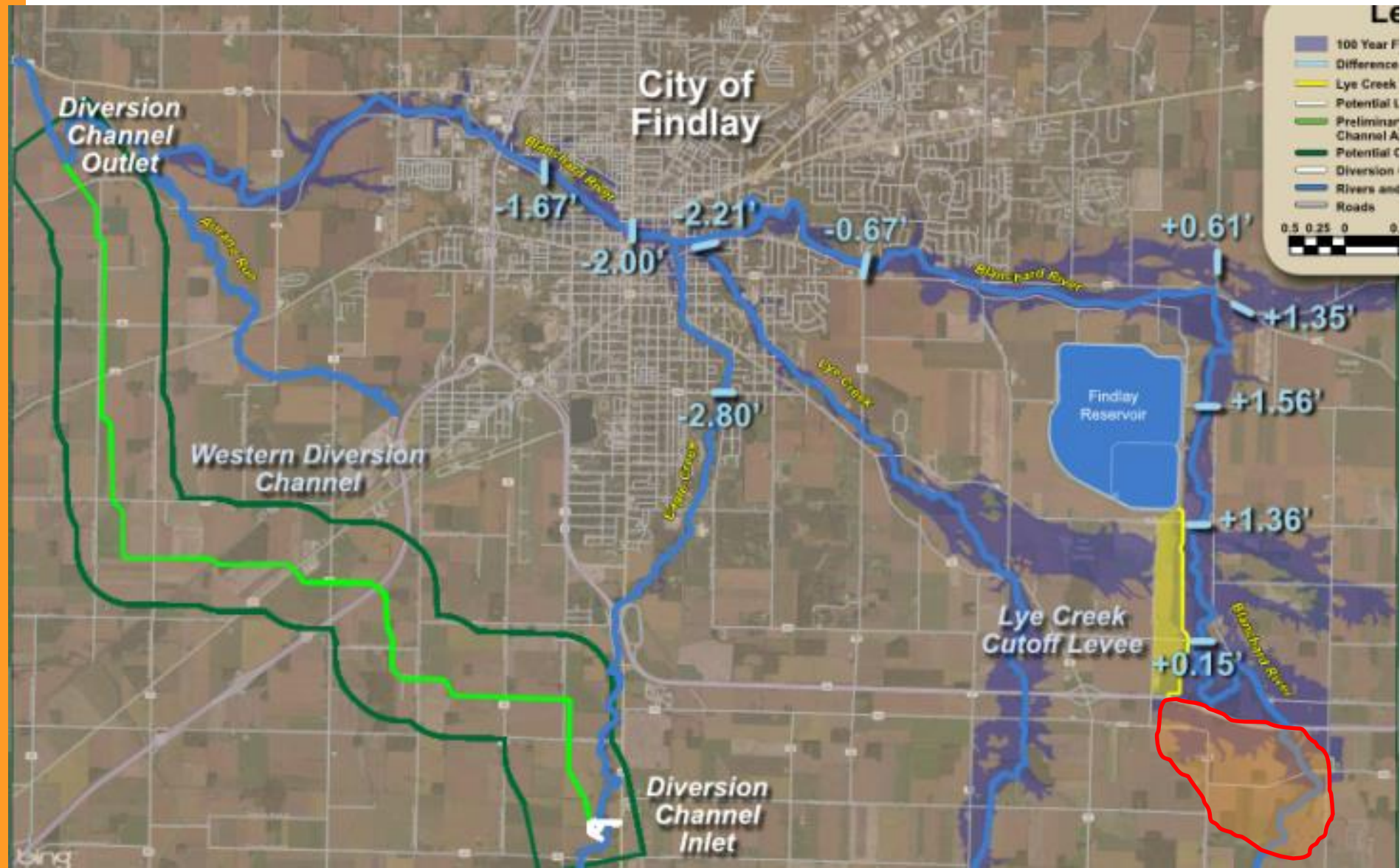
Concept Designs Reviewed

Multiple Locations Reviewed

Concept Design Charrette

- Storage



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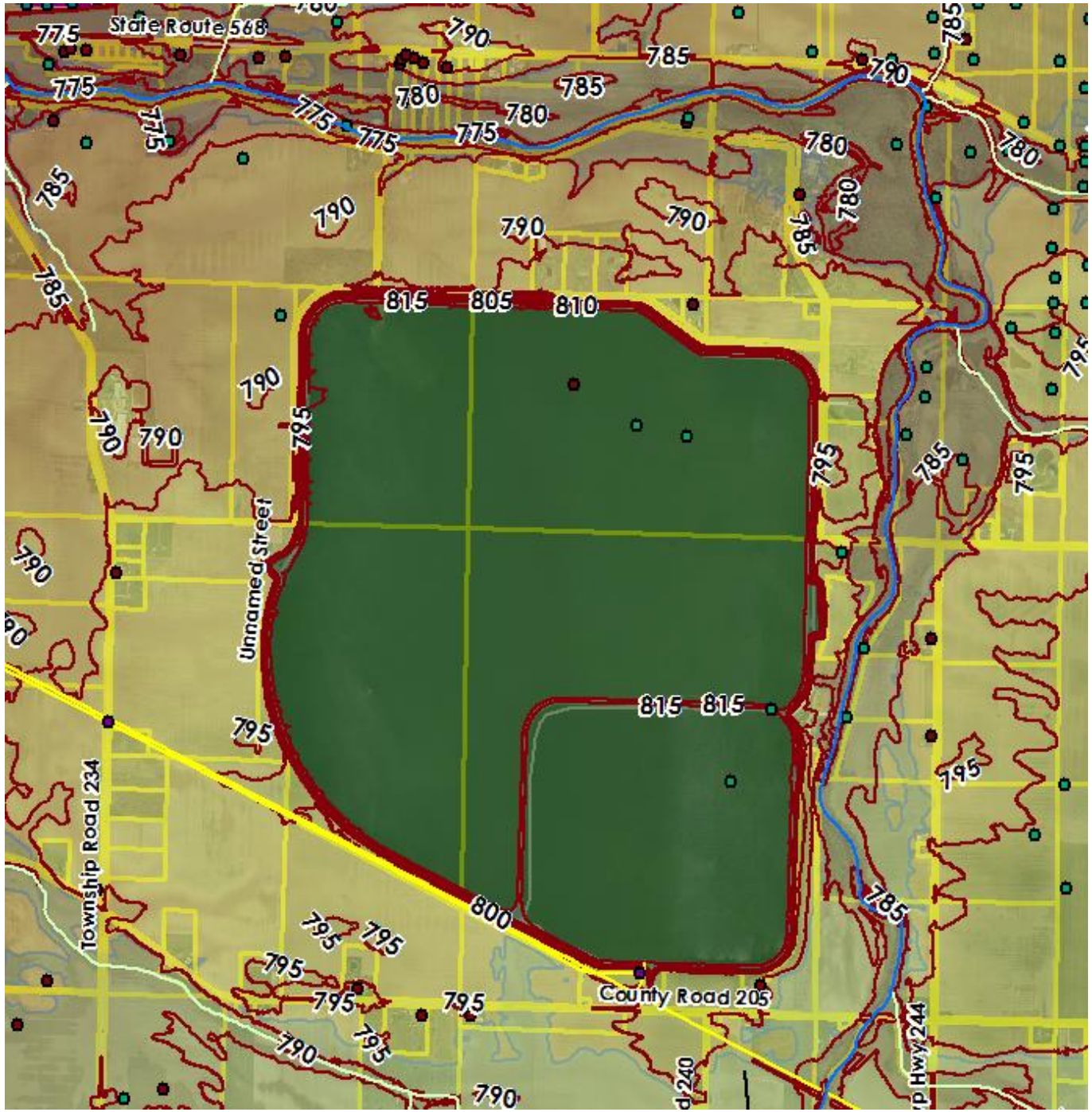
Water Reservoir



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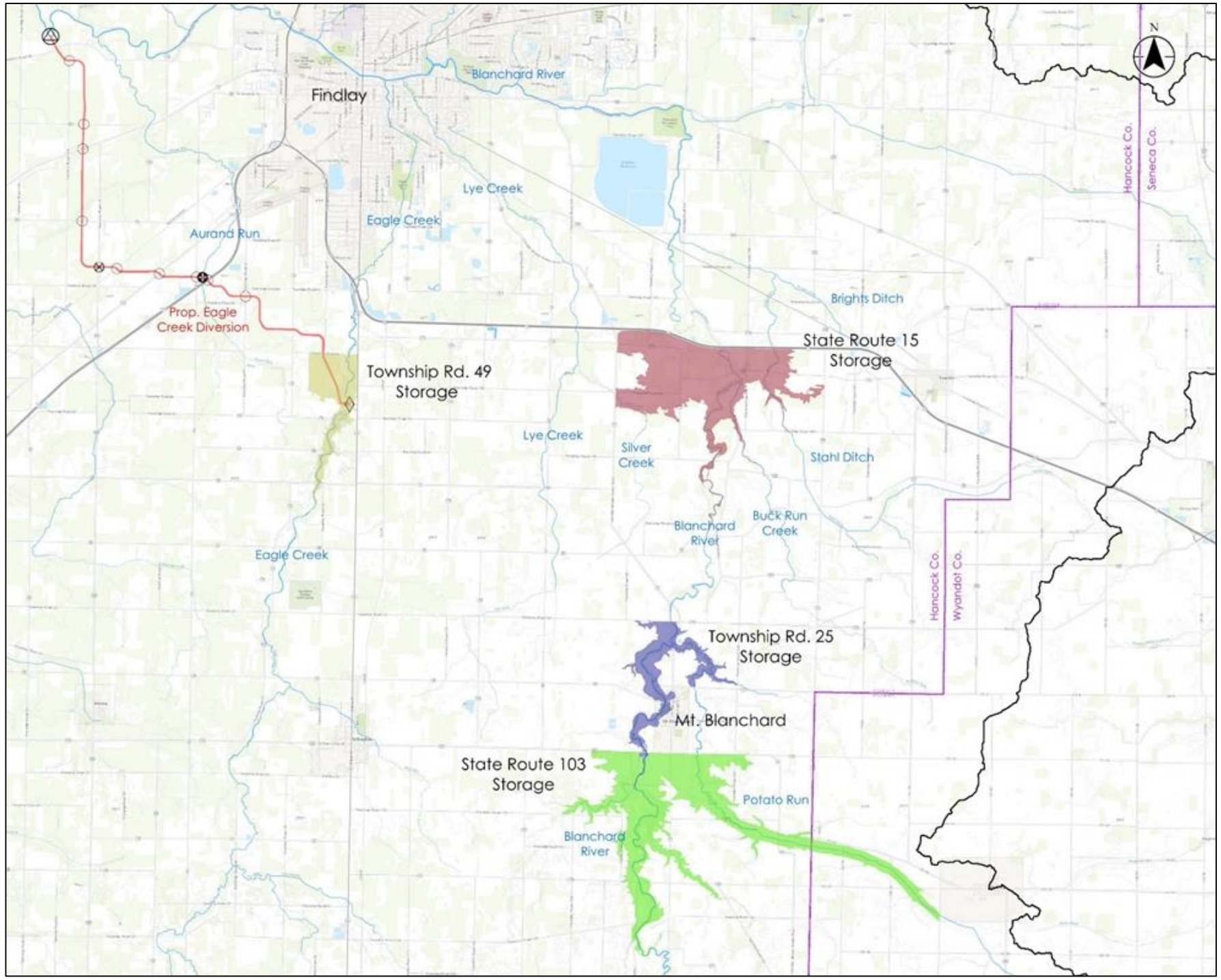
Storage



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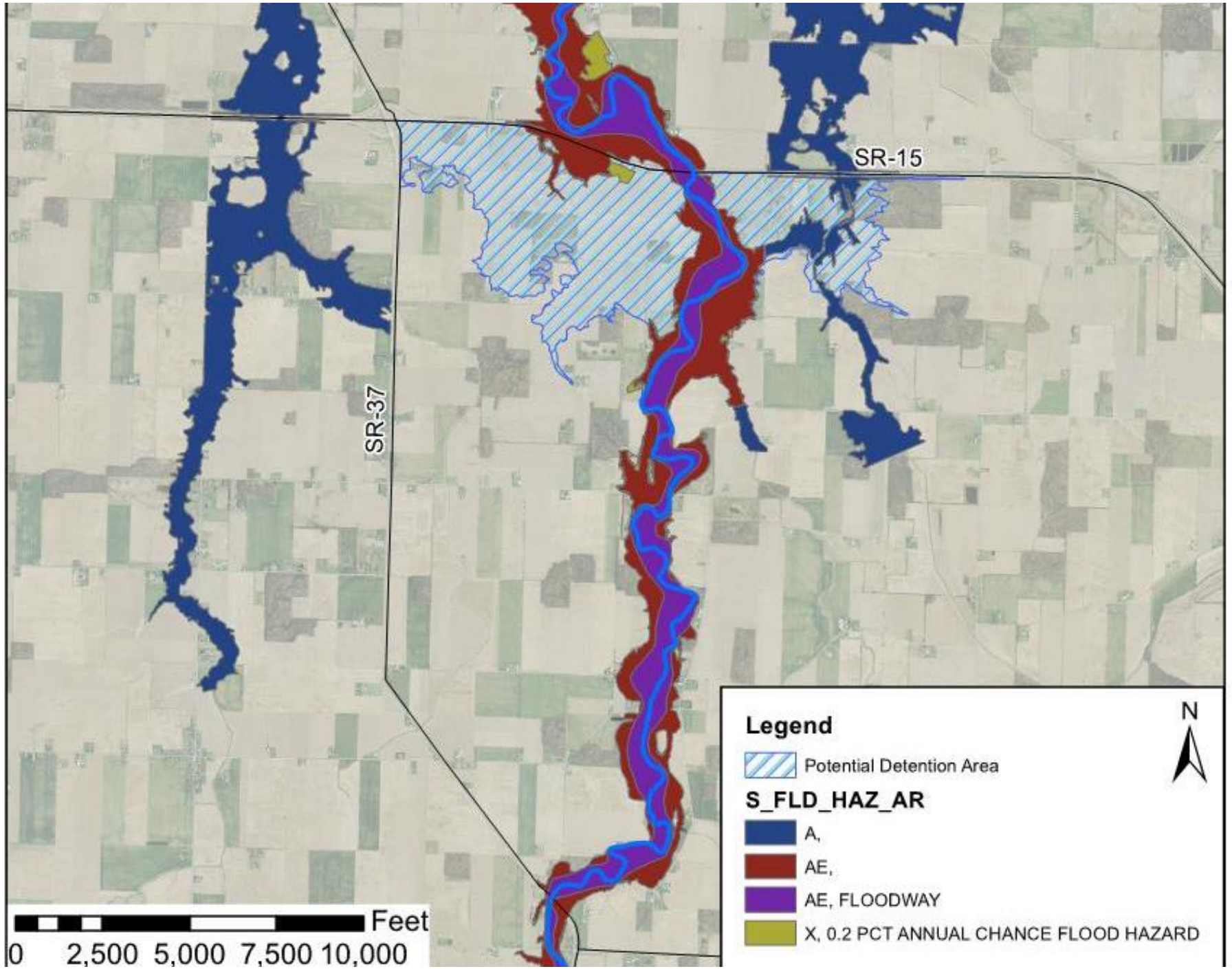
Concept Design Analysis

Storage Upstream of SR15 on Blanchard



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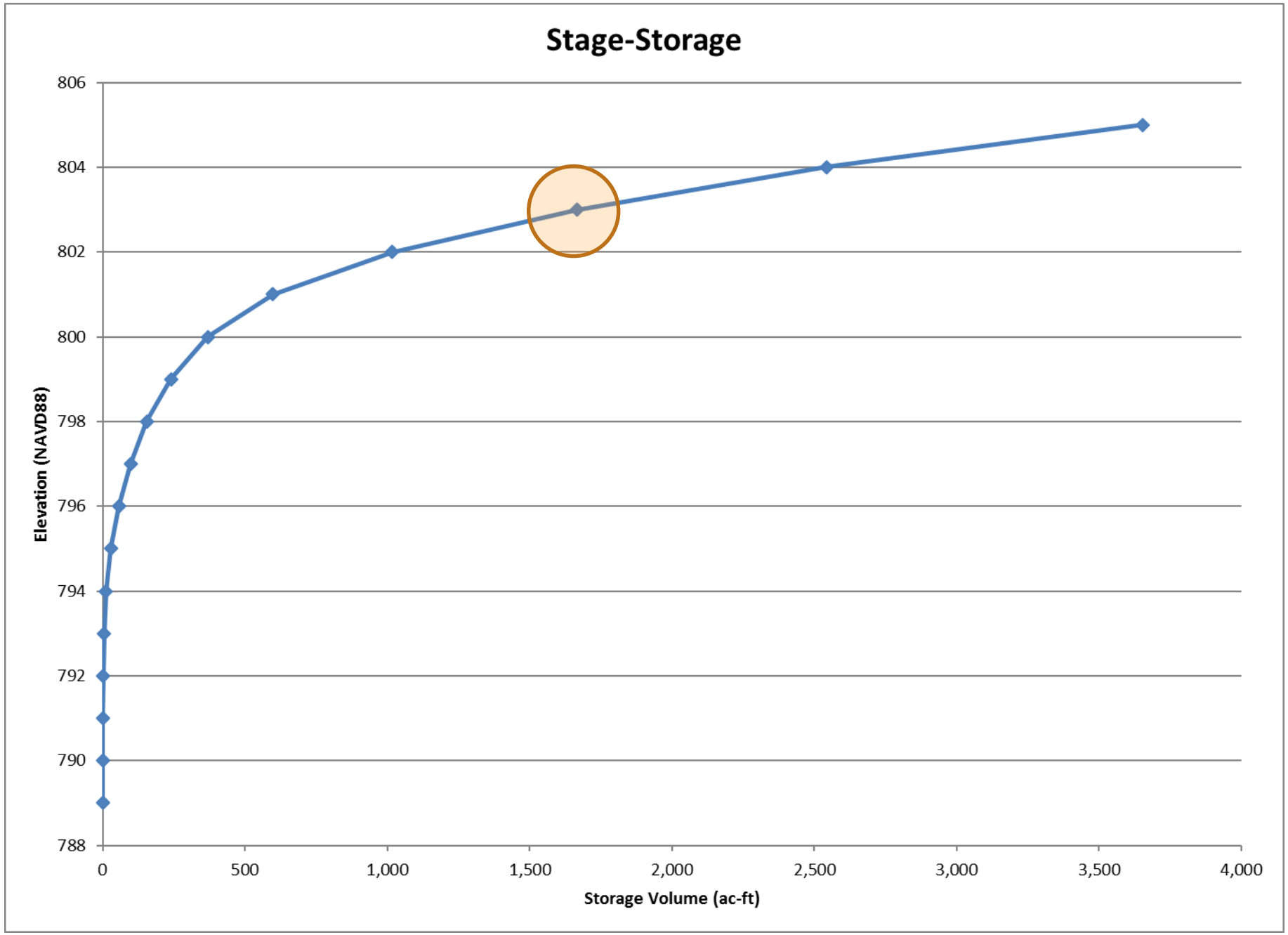
Concept Design Analysis

Storage Upstream of SR15 on Blanchard



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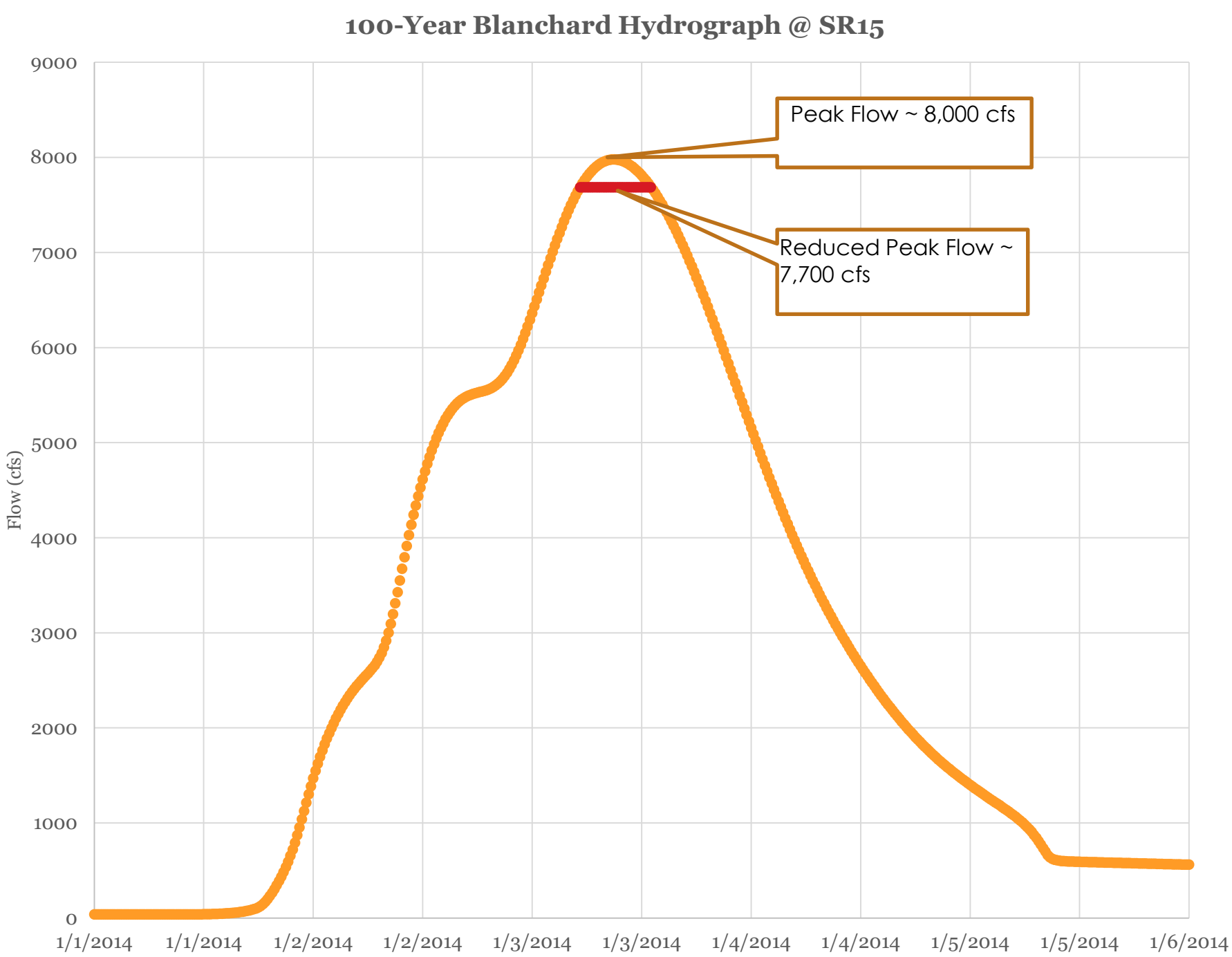
Concept Design Analysis

Storage Upstream of SR15 on Blanchard



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Concept Design Analysis

Storage

Opportunities

- Reduce peak flows on the Blanchard River / tributaries

Challenges

- ODNR
- ODOT
- FEMA
- Property / Environmental impacts

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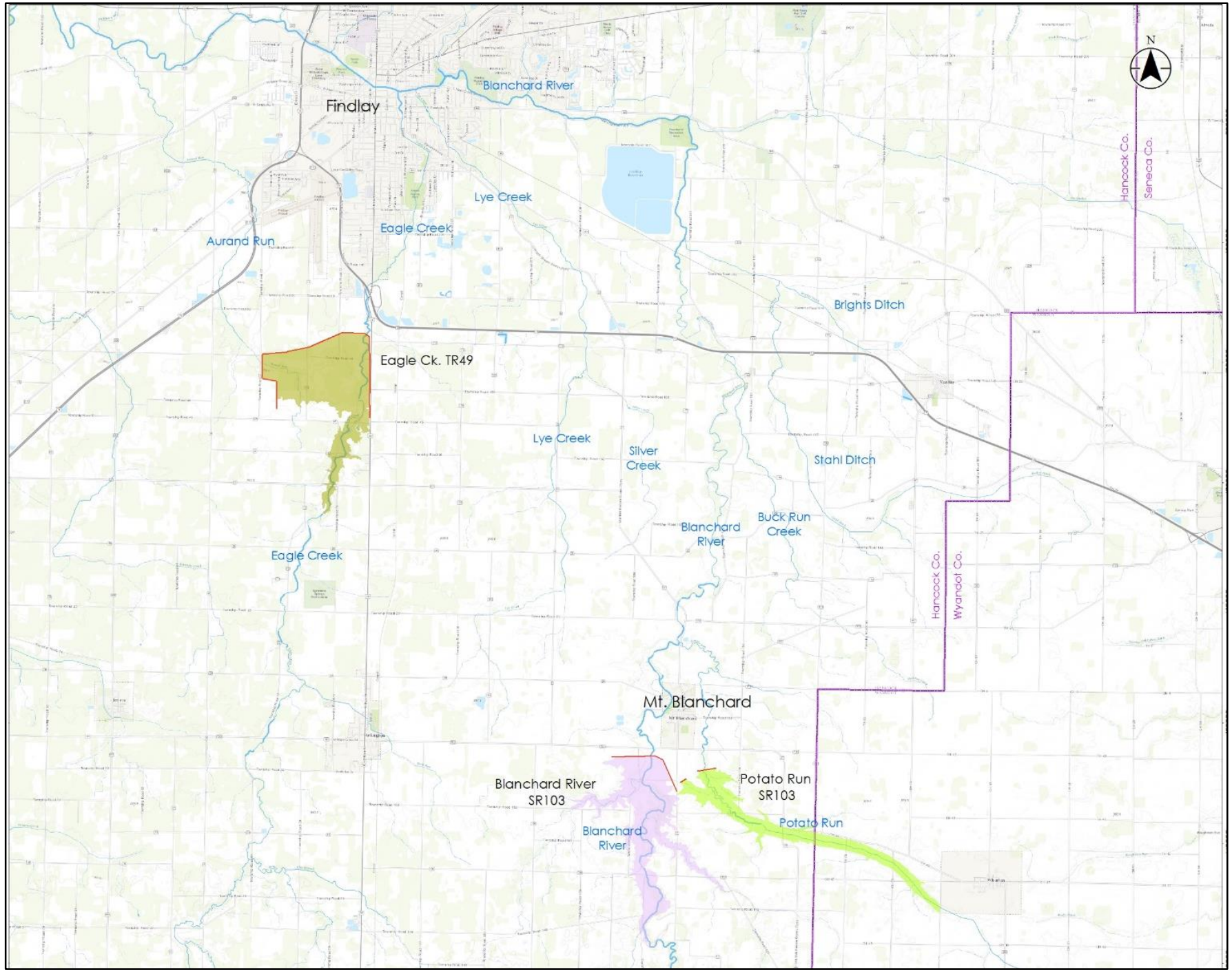
Storage



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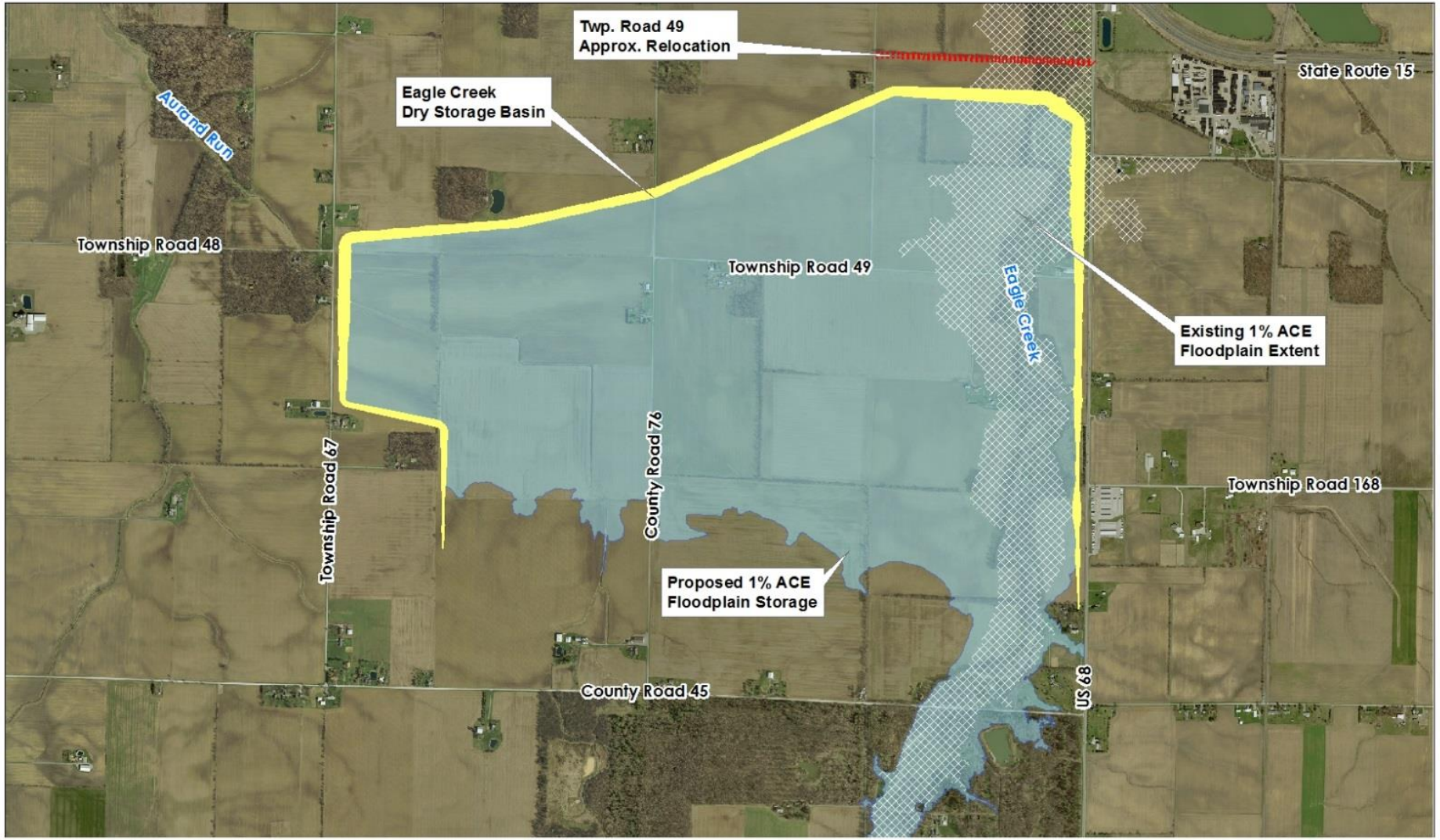
Storage

Eagle Creek Dry Storage



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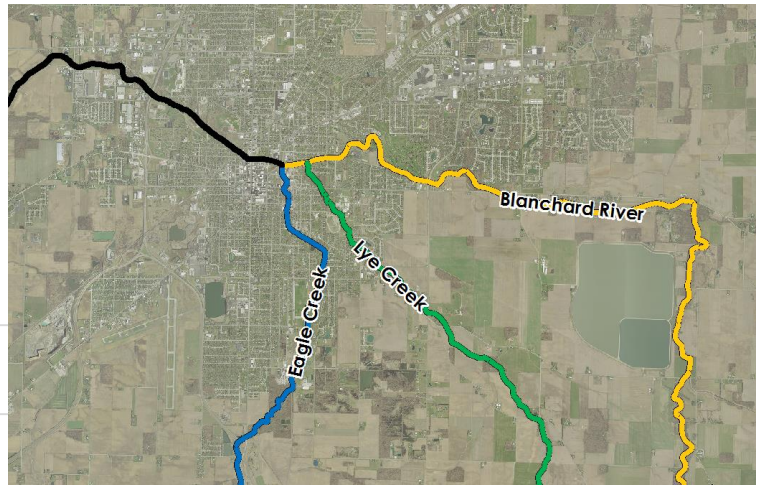
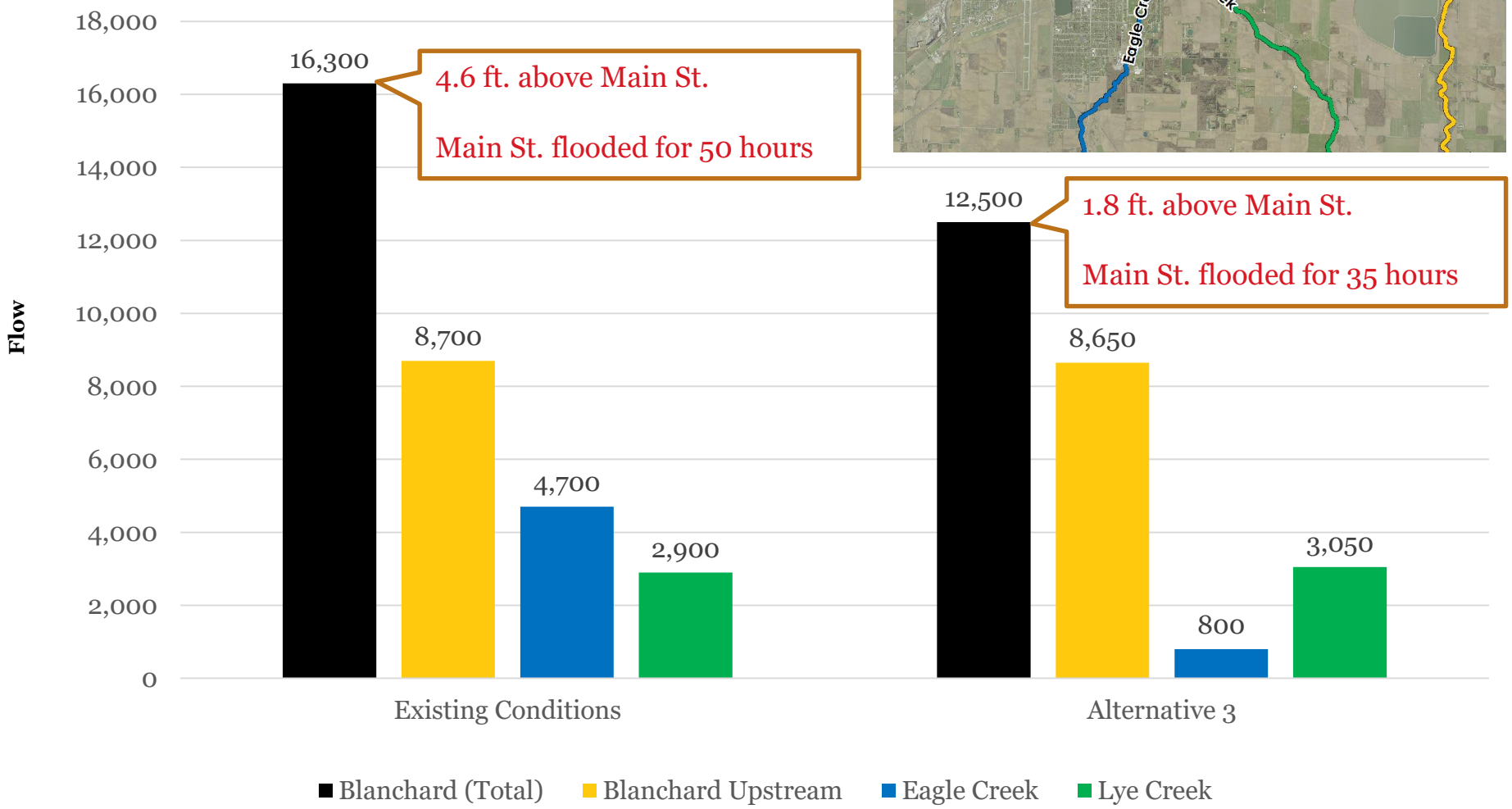
Eagle Creek Dry Storage

1% ACE
100-Year, 24-Hour
SCS Type II = 5.26"

Blanchard River in Findlay





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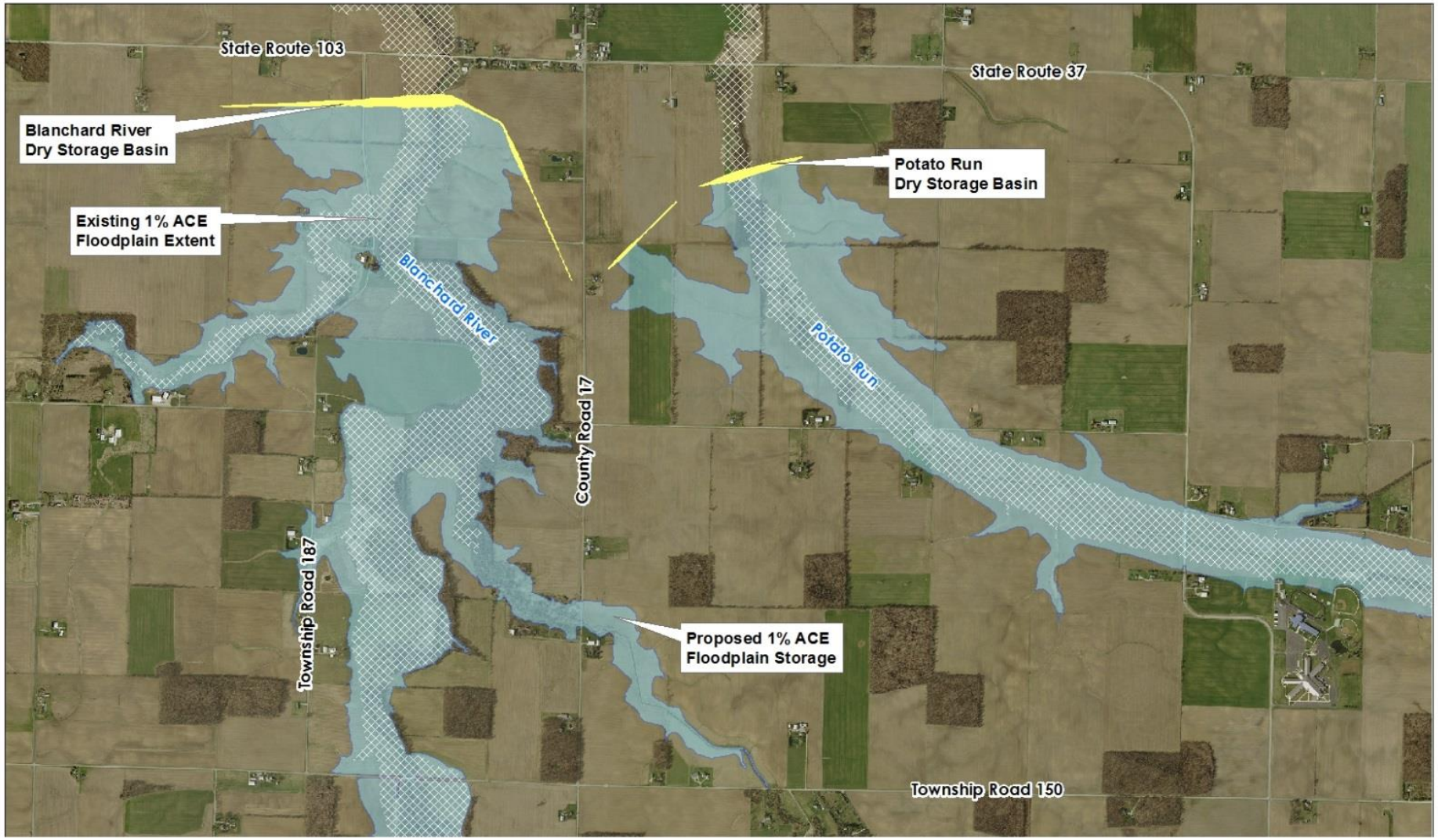
Storage

Blanchard River & Potato Run at Mt. Blanchard



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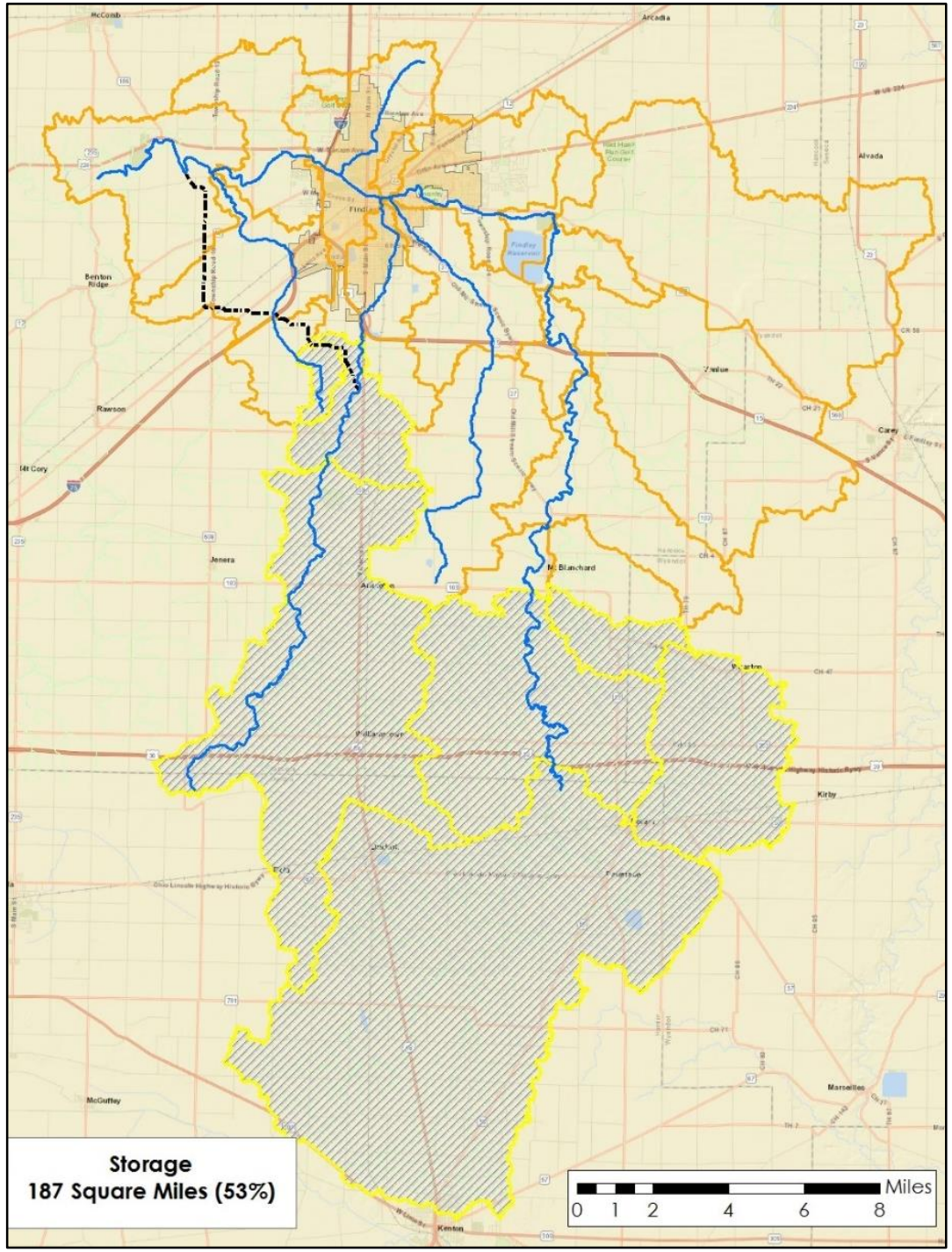
Percent of Watershed Influenced



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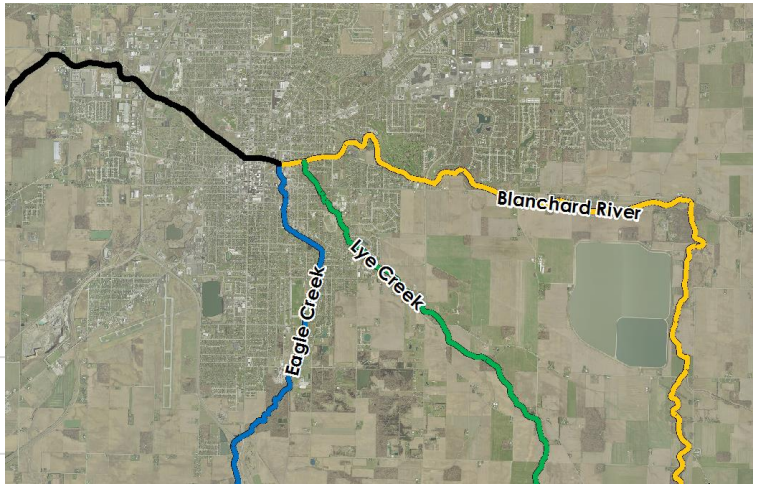
Eagle Creek Storage + Blanchard R. and Potato Run Storage

1% ACE
100-Year, 24-Hour
SCS Type II = 5.26"

Blanchard River in Findlay



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Summary

Project Refinements

Summary

- Diversion Channel (with extensions)
- Channel Modifications
- Structure Modifications
- Cut-off Levee
- Storage

Summary

- **Diversion Channel** (with extensions)
- **Channel Modifications**
- **Structure Modifications**
- Cut-off Levee
- **Storage**

Benefits and Impacts Summary

Alternative	Modeled Scenario	Reduction in WSE at Main St (Feet)	Max Water Depth on Main St (Feet)	Duration Water is 6" Above Main St (Hours)	Total Acres Directly Impacted by Project Construction	Home Buyouts	New Bridges or Cul-De-Sacs	Acres Impacted Outside of Ex. Regulatory Floodplain	Acres Removed from Floodplain	Agricultural Acres Removed from Floodplain	Parcels Directly Impacted by Project Construction	Parcels Removed from Floodplain
0	Existing Conditions	n/a	4.6	50	--	--	--	--	--	--	--	--
1	USACE Plan (25-Yr Diversion)	0.9	3.6	45	960	1	13	960	1,690	1,140	75	1,670
2	Blanchard R. Modifications	0.9	3.7	40	2	0	0	2	280	40	5	760
3	Blanchard R. + Eagle Cr. Storage	2.8	1.8	35	1,140	14	1	863	2,780	1,180	55	2,460
4	Blanchard R. + Eagle Cr. Storage + Blanchard & Potato Storage	3.6	1	15	2,430	19	2	1,514	5,060	2,850	135	2,850

Benefit / Impact Summary HEC-RAS Results (SCS Type II – NOAA Atlas 14 100-Year, 24-Hour event (5.26 inches) equally distributed across watershed)

Opinions of Probable Cost

Spatial Spread of Projects

Independent Projects that make up a Program

Alternatives

Alternative	Base Cost	Cost With Contingency
Alternative 0 – Existing Conditions	--	--
Alternative 1 – USACE Plan (25-Year Diversion of Eagle Creek)	$63,804,000	$80,902,000
Alternative 2 – Blanchard River Modifications	$15,280,000	$19,864,000
Alternative 3 – Alt. 2 + Eagle Creek Dry Storage Basin	$68,780,000	$89,414,000
Alternative 4 – Alt. 3 + Blanchard & Potato Dry Storage Basins	$122,880,000	$159,744,000

- Alternative 4 was Stantec's Recommended Plan
  - Hydraulic improvements
  - Eagle Creek dry storage basin
  - Blanchard River dry storage basin
  - Potato Run dry storage basin

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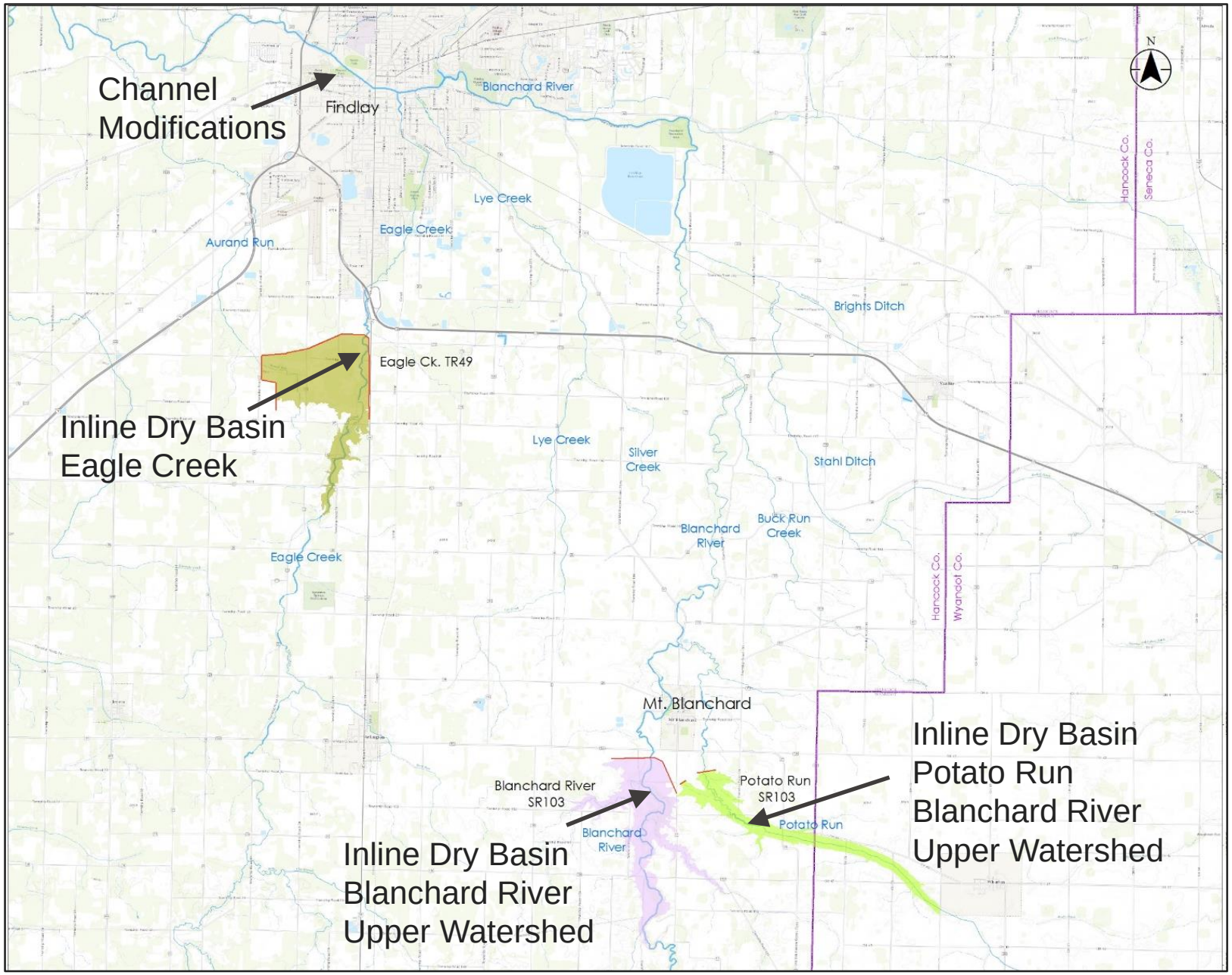
Stantec Conceptual Flood Risk Reduction Plan

Other Flood Risk Reduction Measures



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Hancock County Flood Risk Reduction Program: Benefit Cost Analysis

(STANTEC Project # 174316204)

Prepared for:

Stantec

Submitted by:

Economics
Public Policy
Planning
Jack Faucett Associates

Point of Contact:
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Bethesda, Maryland 20814
Phone: (301) 961-8835 Fax: (301) 469-3001
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March 2017

Opinion of Probable Construction Cost

Alternative Option	Base Cost	Cost With 30% Contingency
Riffle/Inline Structures Removal	$780,000	$1,014,000
Floodplain Bench Widening and Railroad Bridge Modifications	$14,500,000	$18,850,000
Total Hydraulic Improvements	**$15,280,000**	**$19,864,000**
Eagle Creek Dry Storage Basin	$53,500,000	$69,550,000
Blanchard River Dry Storage Basin	$34,400,000	$44,720,000
Potato Run Dry Storage Basin	$19,700,000	$25,610,000
Total Storage	**$107,600,000**	**$139,880,000**

Benefit-Cost Analysis

Full Program

Costs / Benefits - NPV

(Thousands of 2017 Dollars)

Category	Cost	Benefit	Benefit-Cost Ratio
Program Costs	$159,876		
Structures (Residential)		$107,450	
Structures (Business)		$42,867	
Motor Vehicles		$5,388	
Transportation		$8,992	
Emergency Response		$6,419	
NFIP Administrative Cost		$18,311	
Business Losses (Income)		$3,276	
Business Losses (Cleanup)		$3,153	
Business Losses Emergency Plan		$1,277	
Agricultural		$368	
Environmental		$57,707	
Total	**$159,876**	**$255,208**	**1.60**

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Economics
Public Policy
Planning
Jack Faucett Associates
Since 1963

Hydraulic Improvements – Phase 1 Design

Path Forward

Project Overview

Floodplain Bench Widening

Remove Inline Riffles/Dams

Norfolk-Southern RR Bridge Modifications in Phase 2

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Hydraulic Improvements (Phase 1)

Project Overview

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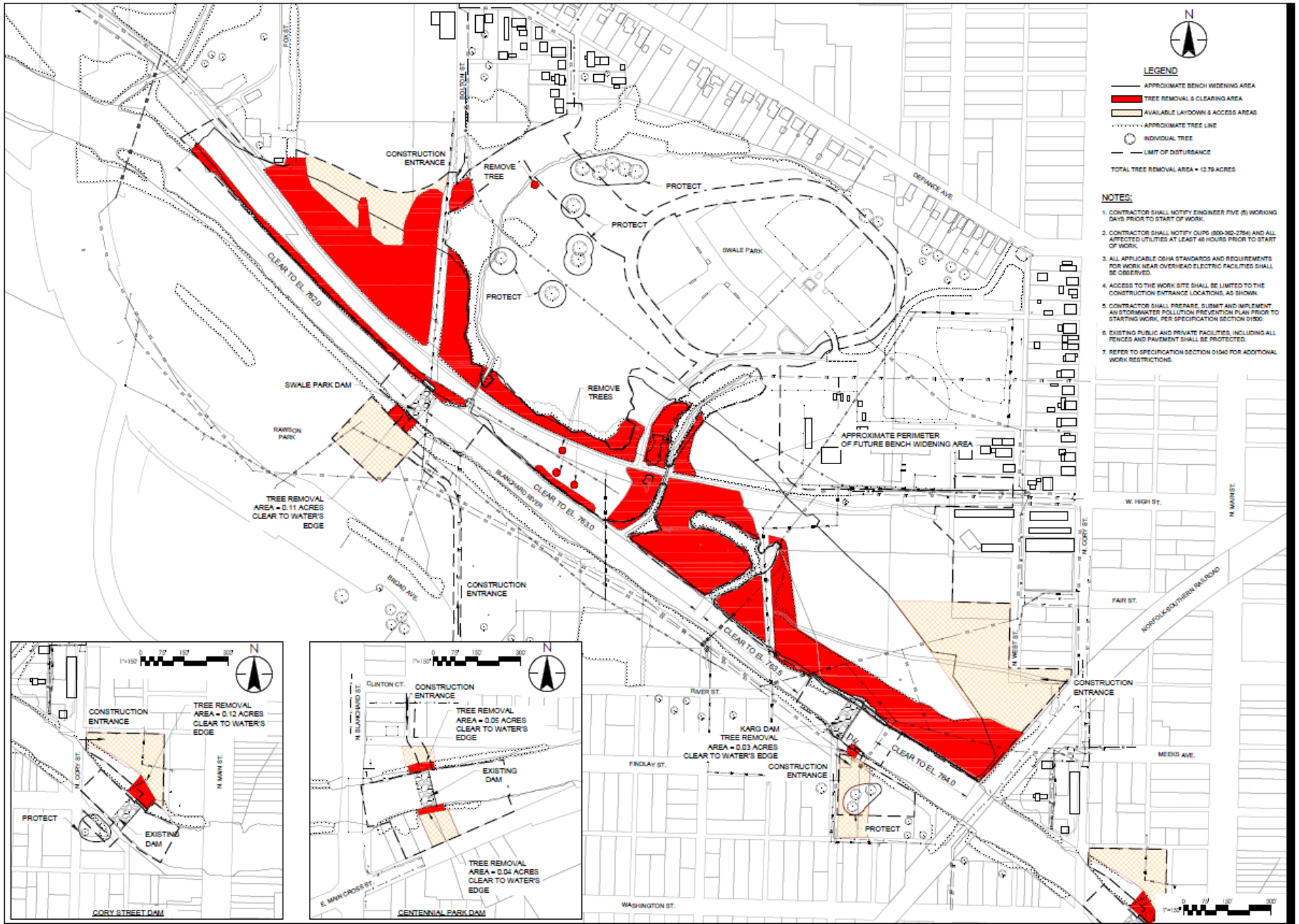
Tree Clearing



Project Overview

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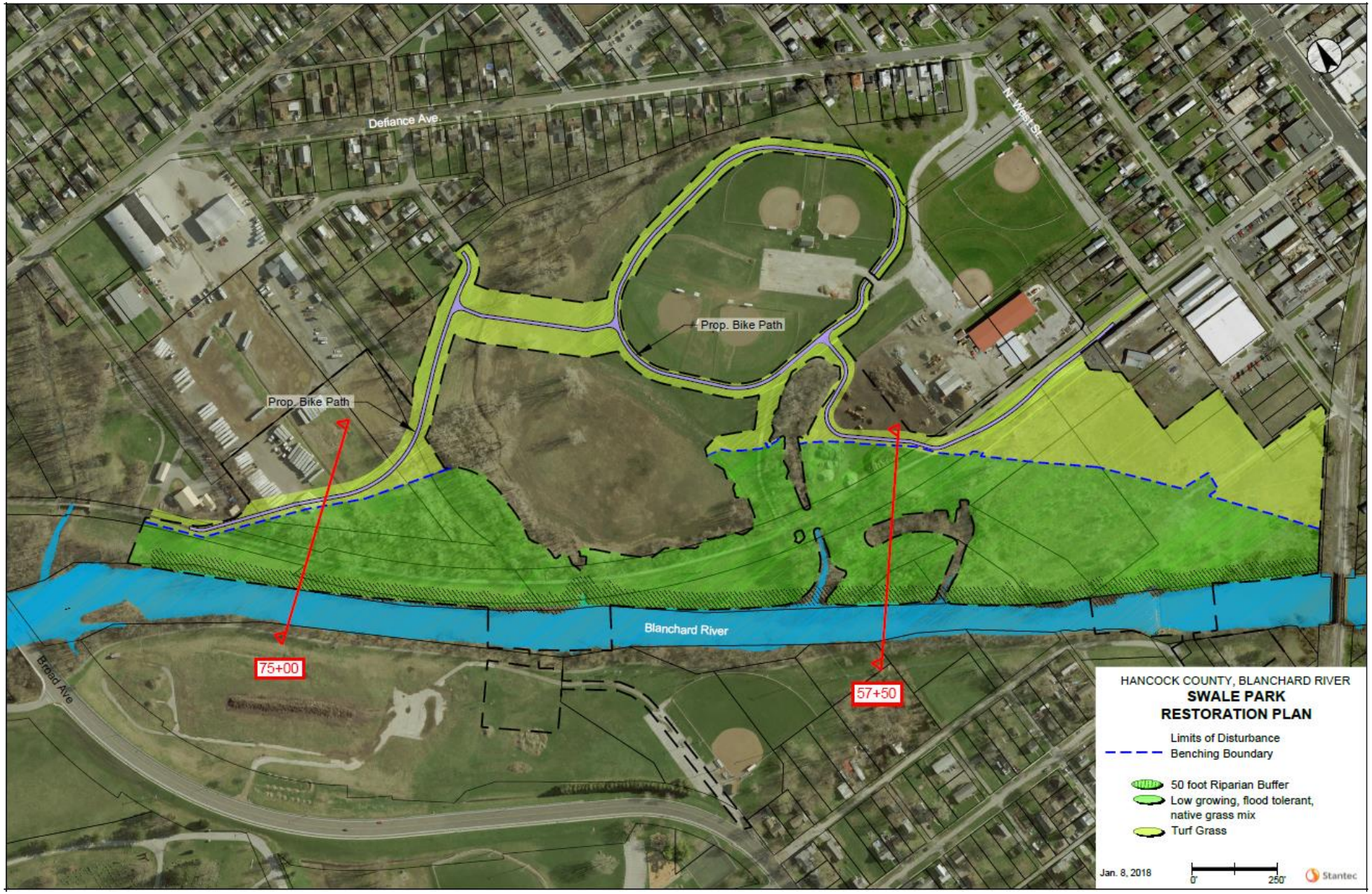
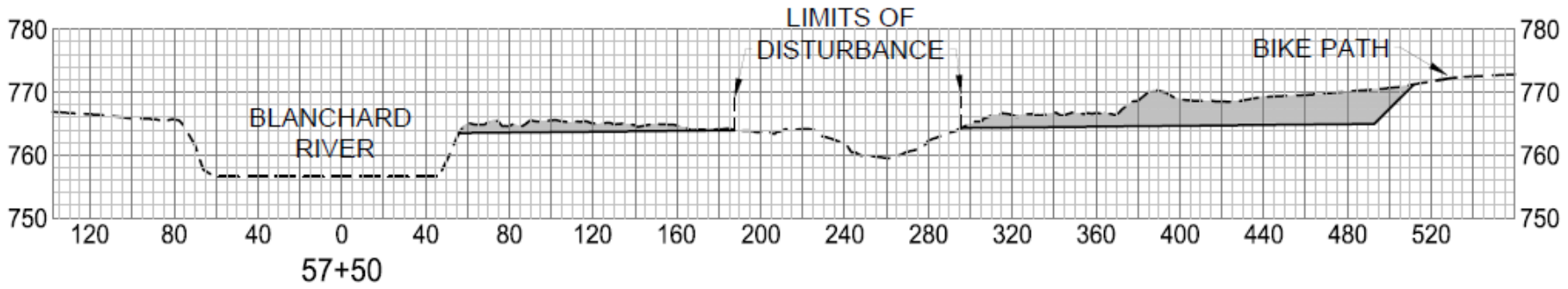
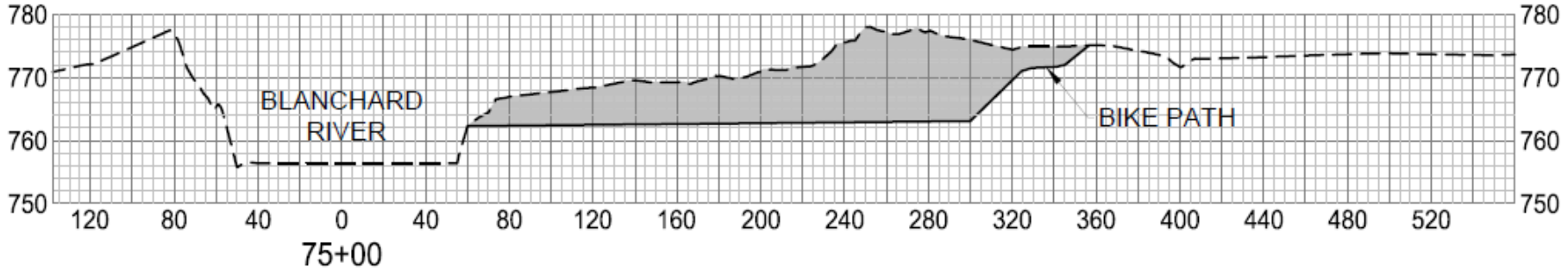
Floodplain Benching



Project Overview

Floodplain Benching Cross Sections





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Project Overview

Existing Inline Structure Removals

Figure 1 – Blanchard River – Existing Inline Structure - (Cory Street Dam)

Figure 2 – Blanchard River – Existing Inline Structure - (Centennial Park Dam)

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Project Overview

Constructed Riffles

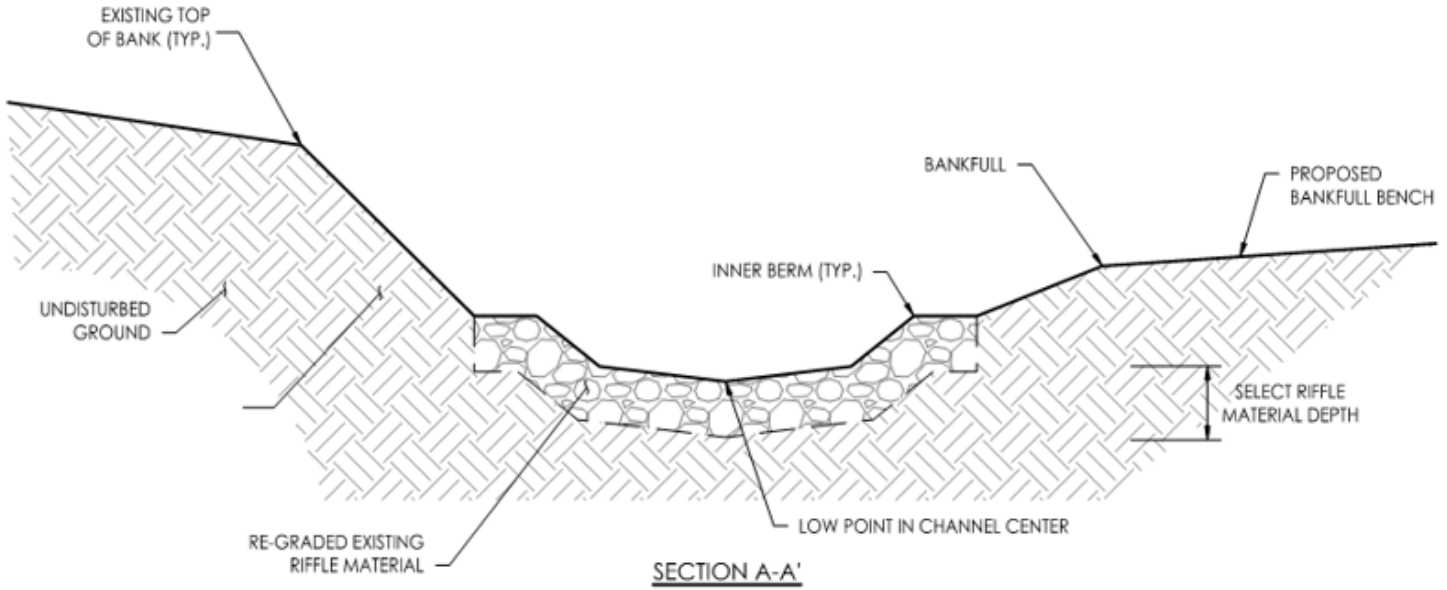

Figure 5 – Example Constructed Riffle – (Section Detail)

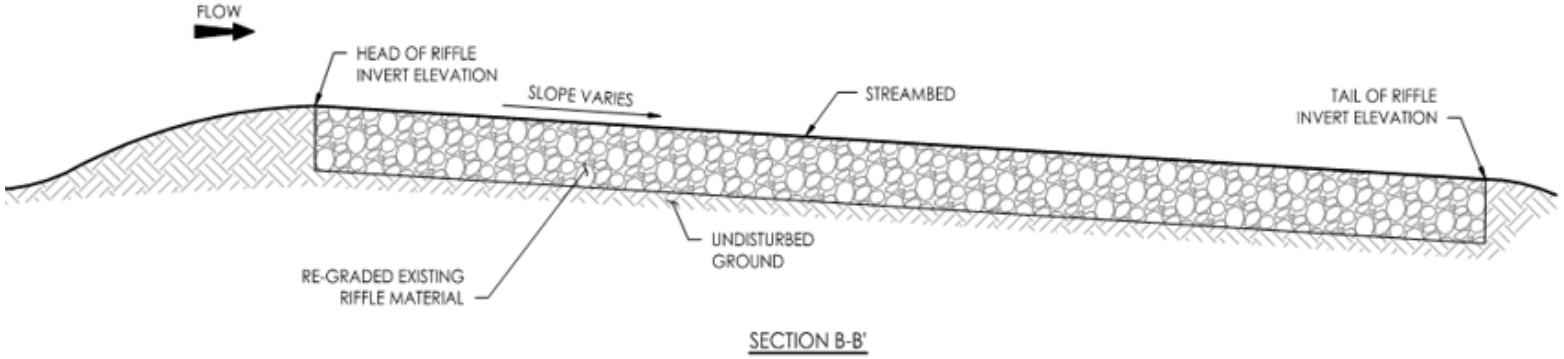

Figure 6 – Example Constructed Riffle – (Profile View)

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Project Overview

Example Project

Proposed Riffle Structures

Figure 7 – Kalamazoo River – Example Before Dam Removal (Pre-Construction)

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Project Overview

Example Project

Proposed Riffle Structures

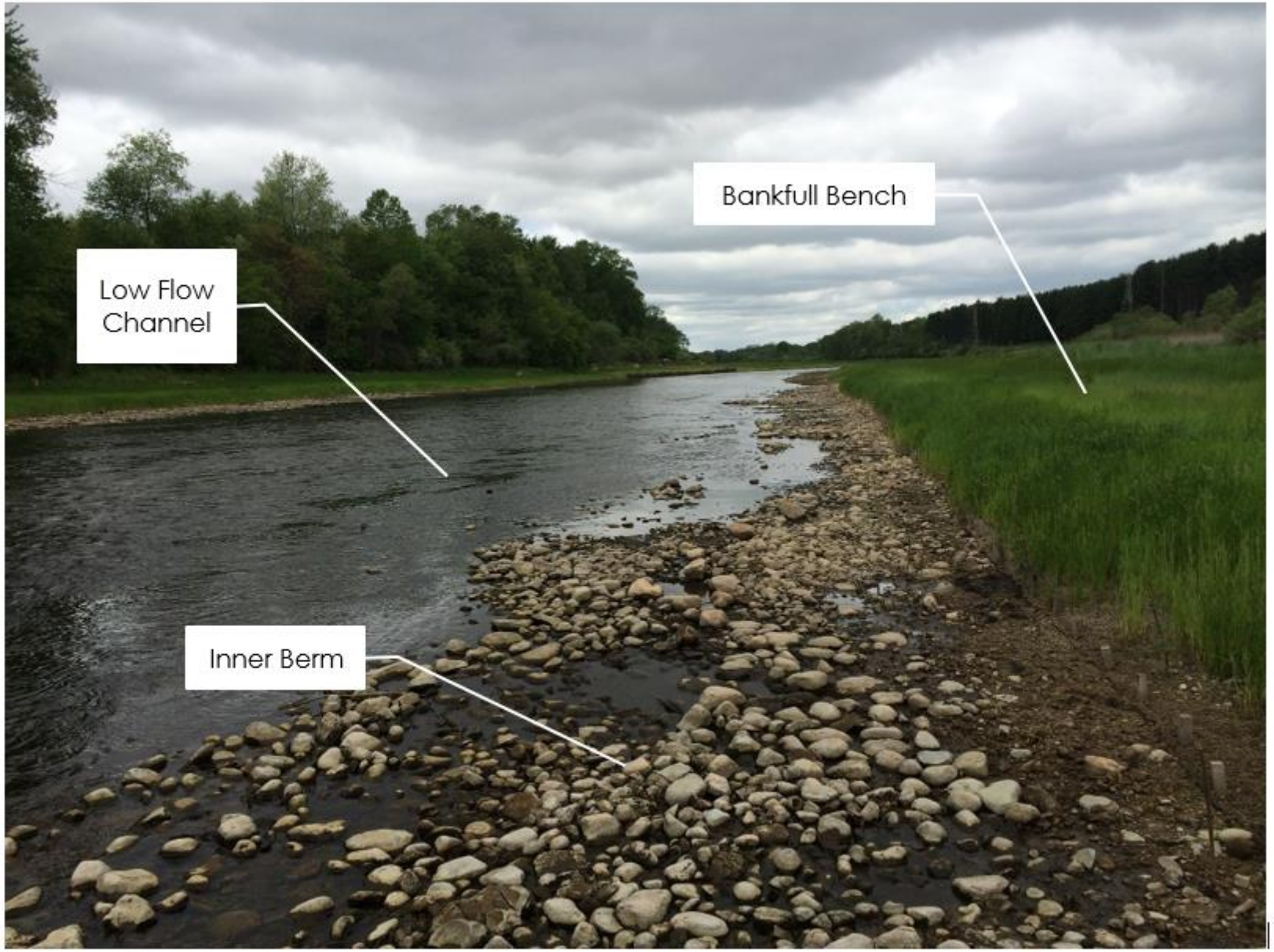

Figure 8 – Kalamazoo River – Constructed Riffle (Post-Construction)

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Project Overview

Wetland Area Avoidance

Utility Coordination

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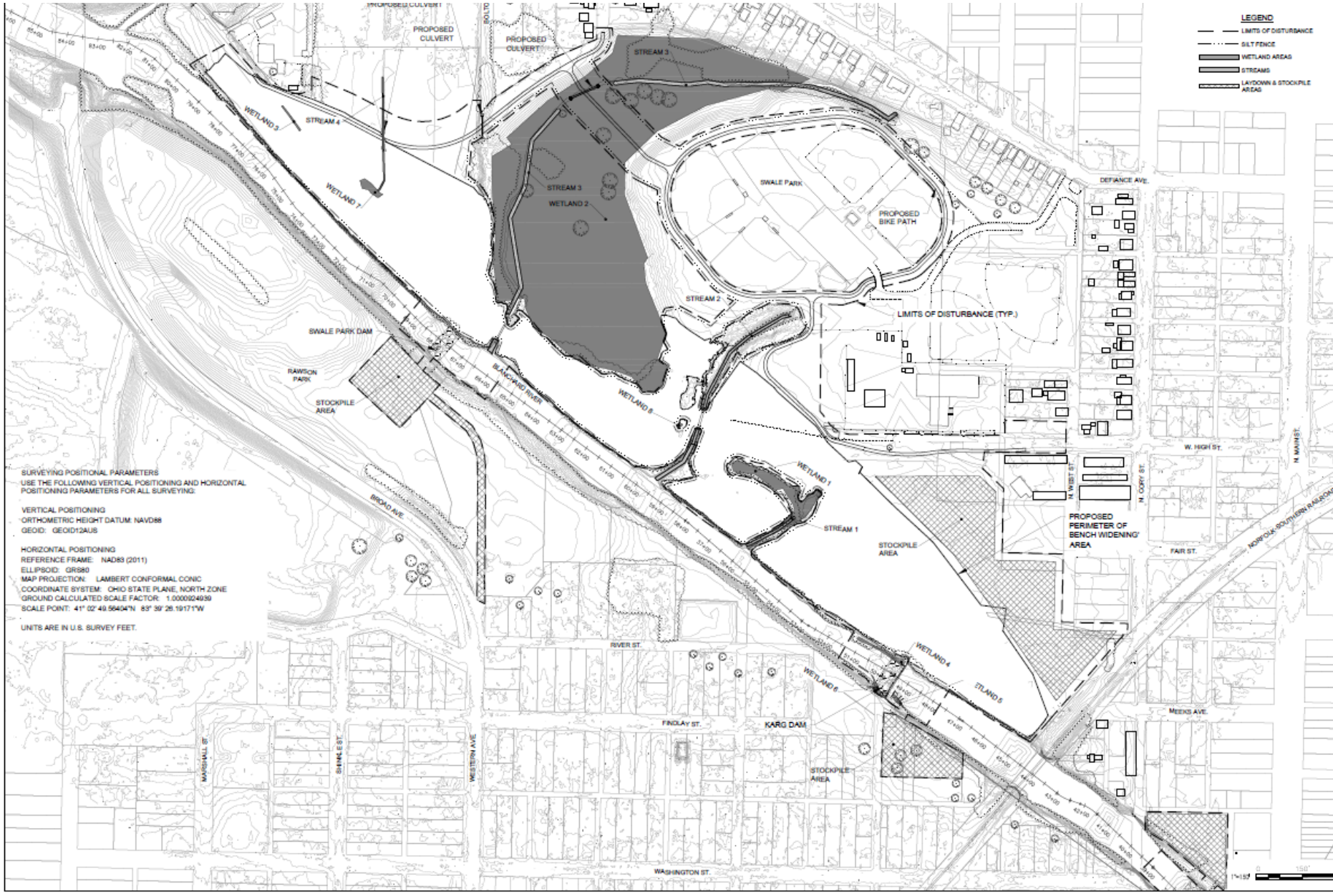
Design



Opinion of Probable Costs

Hydraulic Improvements (Phase 1) Only

Project Costs

Hydraulic Improvements - Phase I - Opinion of Probable Costs	
Description	**Amount**
Construction Costs	
In-Stream Improvements:	$1,401,000
Floodplain Bench Widening Improvements:	$7,179,000
Utility and Bike Path Improvements:	$1,222,000
Utility Coordination:	$750,000
CONSTRUCTION SUBTOTAL	**$10,552,000**
Contingency (15%)	$1,583,000
CONSTRUCTION TOTAL	**$12,135,000**
Other Costs	
Tree Removal (Including Debris Removal)	$105,000
Stream Wetland and T&E Mitigation	$75,000
Construction Administration (5%)	$607,000
OTHER SUBTOTAL	**$787,000**
TOTAL PROJECT COSTS	**$12,922,000**

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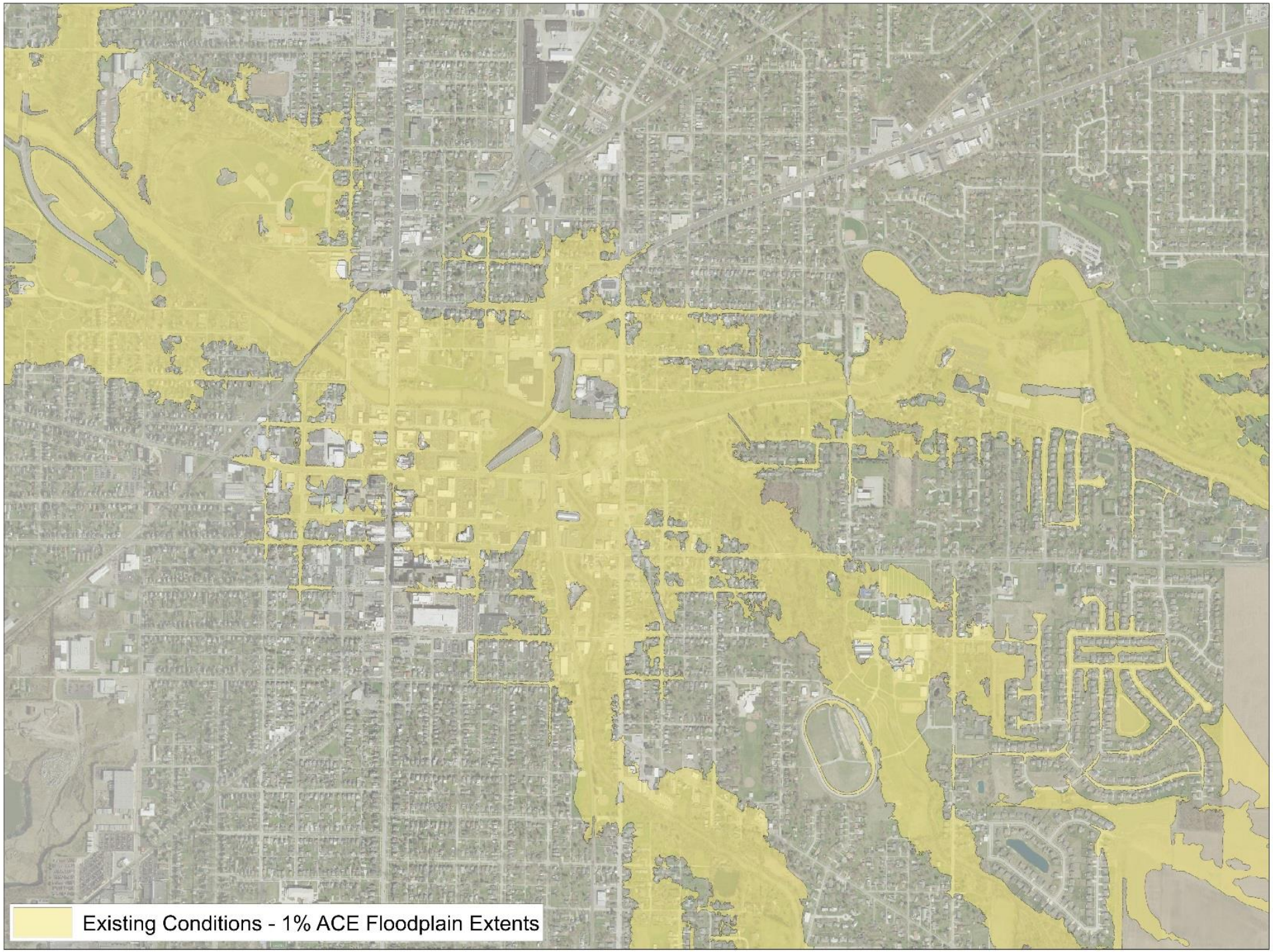
1% ACE Floodplain



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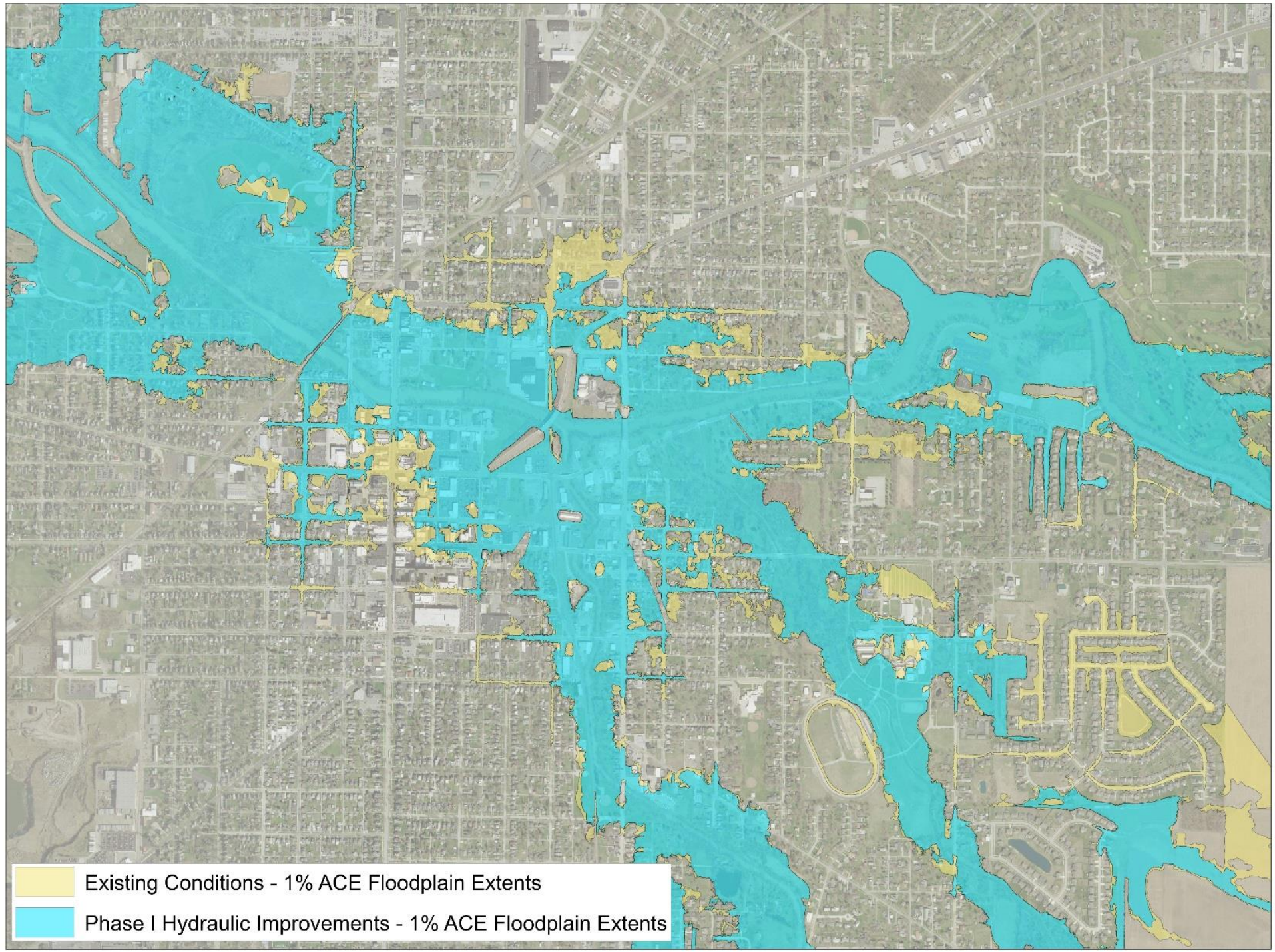
1% ACE Floodplain

Anticipated Benefits



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Anticipated Benefits

New Blanchard River Rating Curve at Main Street

July 2017 Event
~ 10,500 CFS

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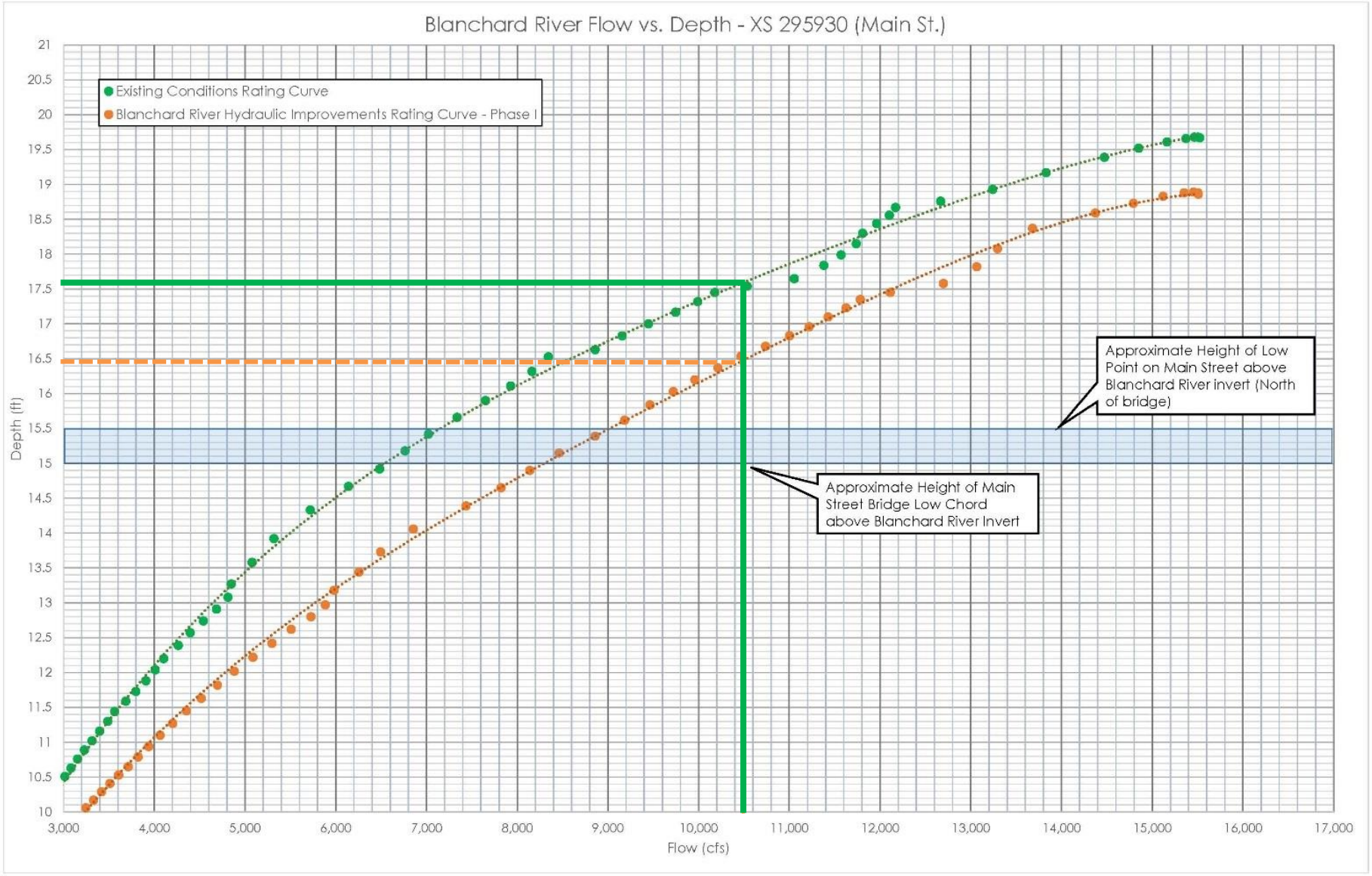
River Flow vs Depth at Main Street



Anticipated Benefits

- Increased Wetland Function
- Improved Water Quality
- Fish Passage & Aquatic Habitat
- Enhanced Recreational Opportunities
- Reduced Transportation Impacts
- ***1% ACE Floodplain Reduction*** ~ LOMR To Be Filed Following Construction

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Anticipated Schedule

Critical Path of Project is through Permitting

Design & Construction

- Tree Clearing Project
  - NTP: Feb. 2018
  - S.C.: Mar. 2018 / F.C.: May 2018
- Final Design
  - 60% Design submitted Dec. 2017
  - 95% Design due May 2018
  - Final IFB Package (estimated July 2018)
- Construction
  - Bidding & Award: Aug. 2018 / NTP: Sep. 2018(**)
  - S.C.: Aug. 2019 / F.C.: Oct. 2019(**)

***** Targeting permits to be issued Summer 2018 ****

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Hancock County Flood Risk Reduction Program - Watershed Planning Case Study

Lessons Learned

Conclusions

Hancock County Flood Risk Reduction Program

Gap Analysis / ITR

- Independent review is critical prior to proceeding through design

Community Driven Projects

- May allow for additional solutions

Combination of Projects

- Large watershed with multiple tributaries

Multi-faceted Team

- Working closely together on a tight schedule provides benefits.

More Information

www.HancockCountyFlooding.com

Questions & Comments

David Hayson – david.hayson@stantec.com
Stantec Consulting Services Inc.

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Questions?