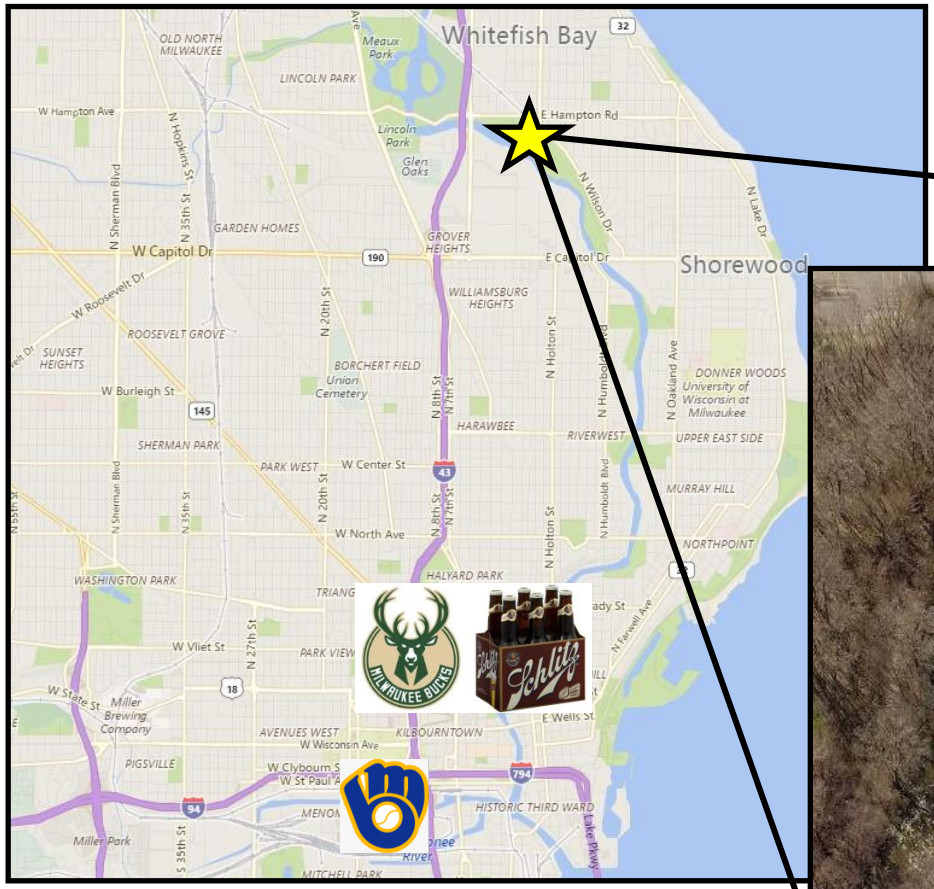
Estabrook Dam Improvements

IAFSM Annual Conference
March 9, 2017

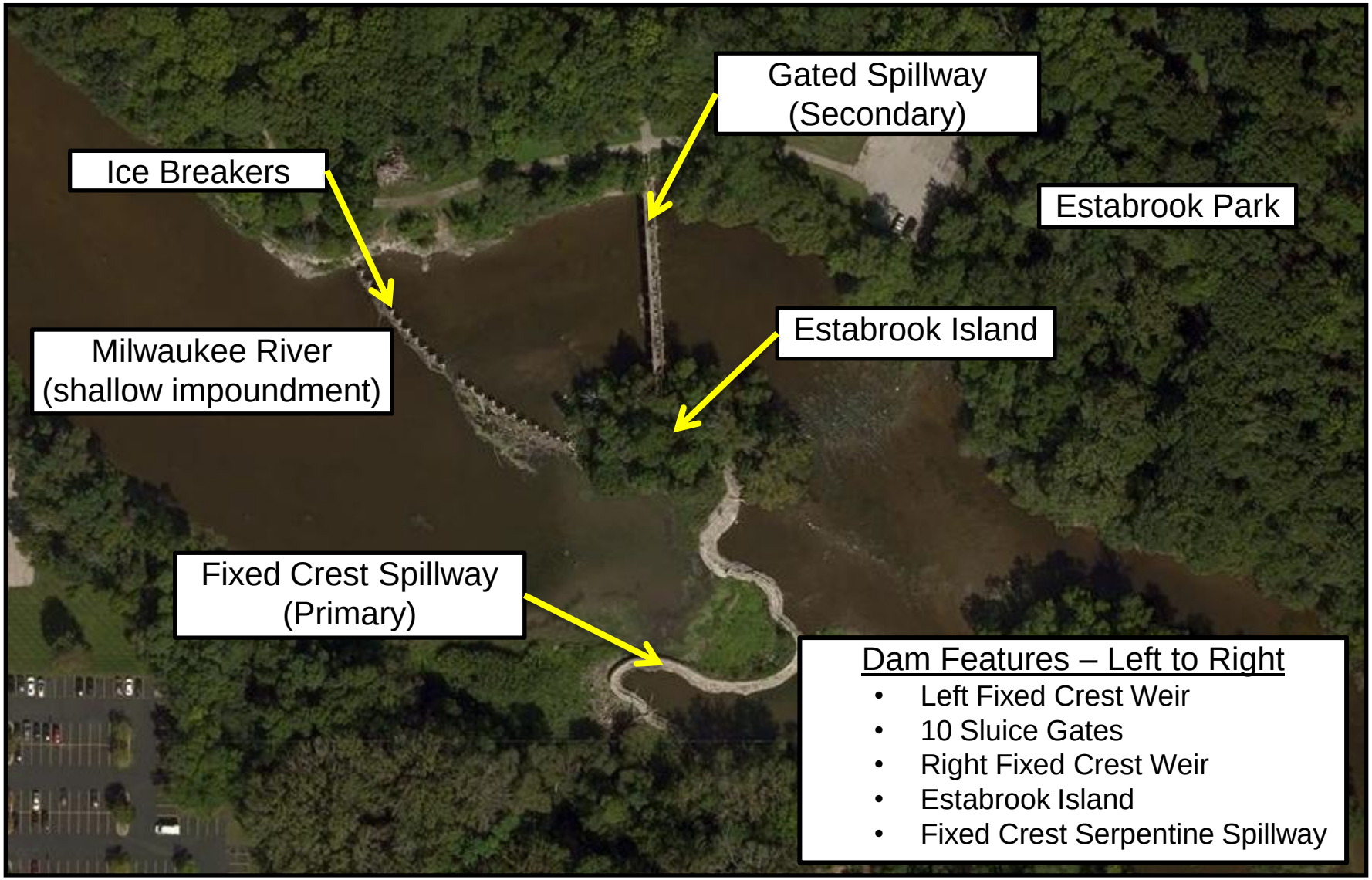
AECOM

Project Location – Milwaukee County, WI

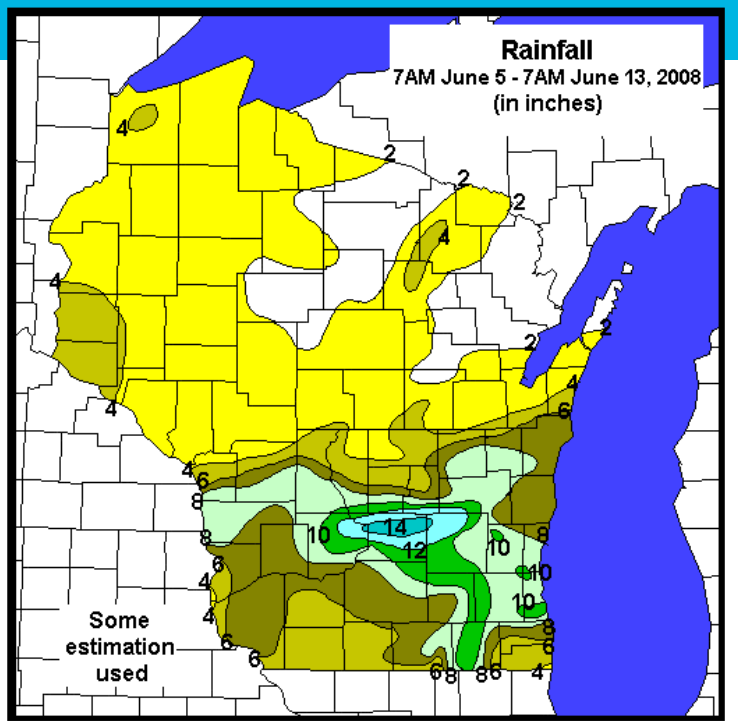


– Estabrook Dam
  - Milwaukee River, Milwaukee County
  - Owner: Milwaukee Metropolitan Sewerage District
  - Low Hazard Dam
  - Constructed 1930s
  - Impoundment Size: 200 acre-feet
  - Structural Height: 15 feet
  - Spillway Capacity: 25,800 cfs

Estabrook Dam – Pertinent Information



WDNR Administrative Order - 2009



- June 2008 Midwest Floods
  - IL, IN, IA, MI, MN, MO, WI
  - 30 Counties in WI – Declared State of Emergency
  - Lake Delton Failure – June 9, 2008
  - Increased Dam Safety Awareness Across the State
- 2009 the WDNR Inspected the Dam
  - WDNR Noted dam safety deficiencies
    - Upgrade Sluice Gates / Ice Breakers
    - Remove trees near the Dam
    - Remove woody debris upstream of dam
    - Perform a structural analysis of dam
  - July 28, 2009 – WDNR Administrative Order to the Dam Owner (Milwaukee County) to drawdown the impoundment until either repaired or abandoned
  - Summer 2009 – Milwaukee County opened sluice gates
  - Spring 2010 – Milwaukee County Hired AECOM
    - Inspect the Dam
    - Construction Drawings / Technical Specifications and Permitting Documents to repair the dam

AECOM 2010 – Repair Ice Breakers & Sluice Gates

Gated Spillway Repairs

- Concrete repairs to piers
- Concrete repair to walkway above gates
- Repair / Replace / Refurbish Sluice Gates
- Concrete repairs to fixed crest

Ice Breaker Repairs

- Concrete repairs to ice breakers
- Restore missing ice breaker

AECOM 2010 – Did I Mention the Woody Debris?

Fixed Crest Spillway

- Remove woody debris upstream of fixed crest spillway

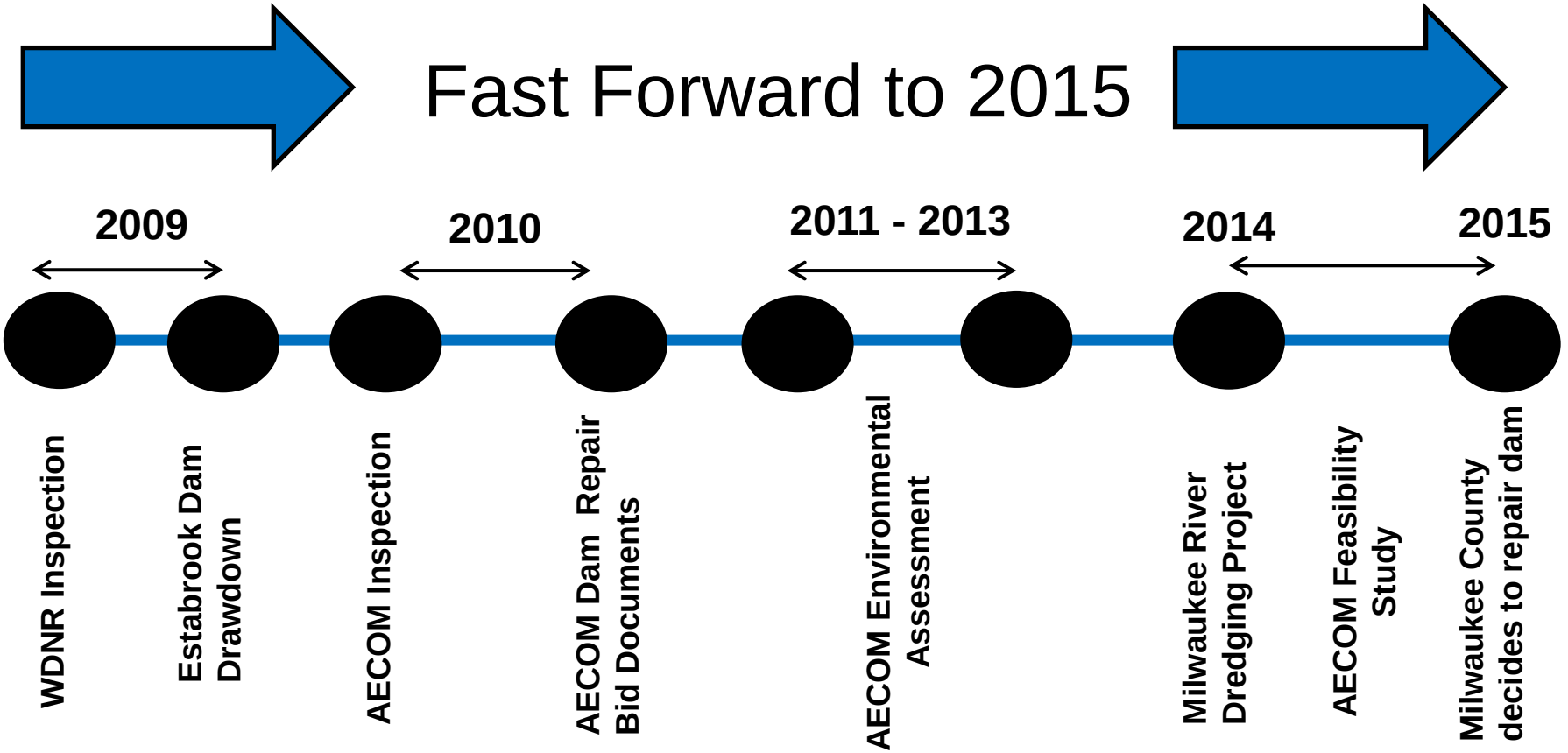
AECOM 2010 – Structural Analysis and Design

- AECOM prepared structural analysis and design of concrete repairs
  - Design Drawings / Technical Specifications included:
    - Ice Breaker Repair
    - Gated Spillway / Sluice Gate Repair
    - Fixed Crest Spillway Concrete / Flashboard Repair
    - Shoreline Restoration

- Contractor Bidding Documents issued late 2010

Project is Delayed Until Further Notice

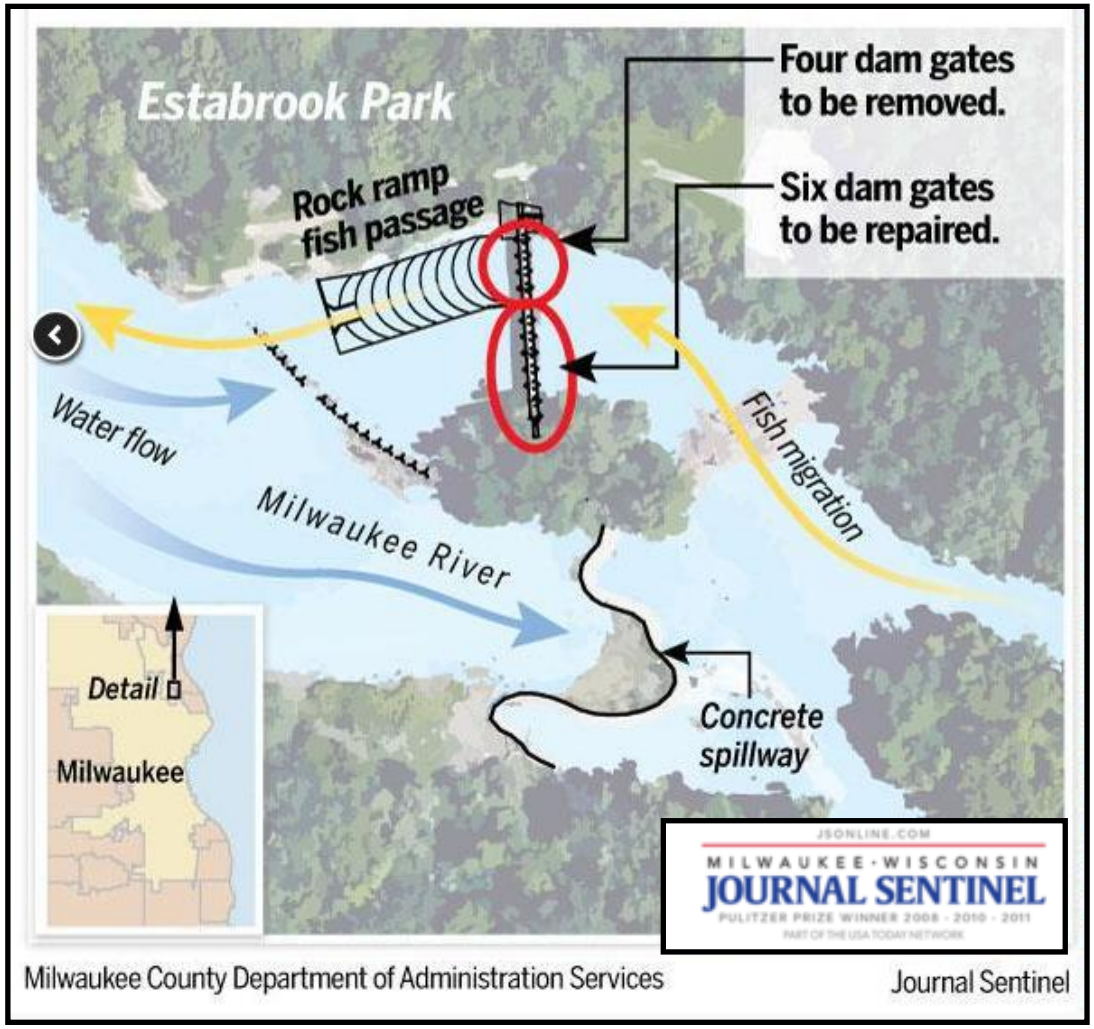
– Late 2010 – Project is Delayed....
  - Project was determined to require an environmental assessment, causing a delay to 2015



2015 – AECOM authorized by Milwaukee County to repair dam and integrate fish passage

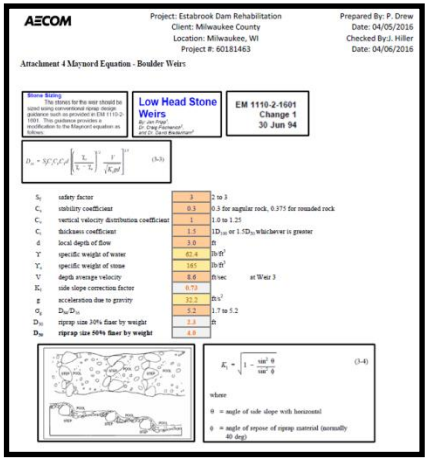
AECOM – 2016 Design

- 2015 to 2016 – AECOM hired by Milwaukee County to repair dam and integrate fish passage
- Update 2010 Construction Drawings / Technical Specifications
- WDNR & USACE Permitting
- Hydraulic Analysis for Fish Passage and Dam Modifications
- Primary Spillway (Formally Fixed Crest)
  - Fish Passage
  - 6 Remaining Sluice Gates
- Secondary Spillway (Formally Gates)
  - Fixed Crest Spillway



Fish Passage Design

- Fish Passage Design
  - Reconnection Rivers: Natural Channel Design in Dam Removal and Fish Passage – Luther Aadland
  - Worked directly with WDNR – Will Wawrzyn to determine design criteria for Northern Pike migration during spring runoff
  - 10% of Milwaukee River flow during Spring Runoff (1,250 cfs) is routed through fish passage
  - Velocity in rock ramp limited to 1 – 3 ft./sec
  - Flow depth ~ 1.5 feet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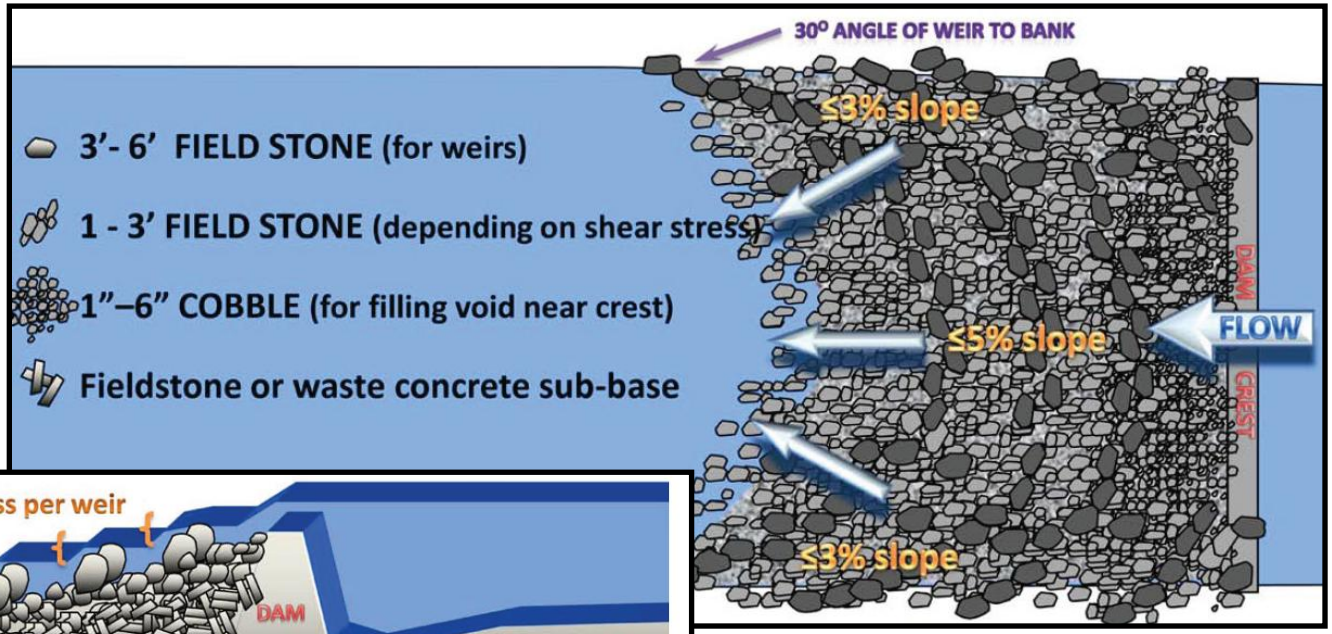
Project: Estabrook Dam Rehabilitation
Client: Milwaukee County
Location: Milwaukee, WI
Project #: 60181463

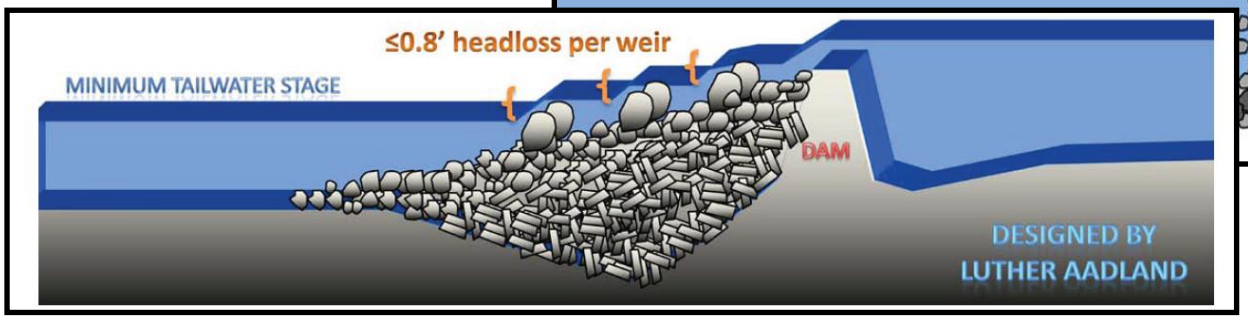
Prepared By: P. Drew
Date: 04/05/2016
Checked By:J. Hiller
Date: 04/06/2016

Attachment 4 Maynord Equation - Boulder Weirs

Low Head Stone Weirs

EM 1110-2-1601
Change 1
30 Jun 94





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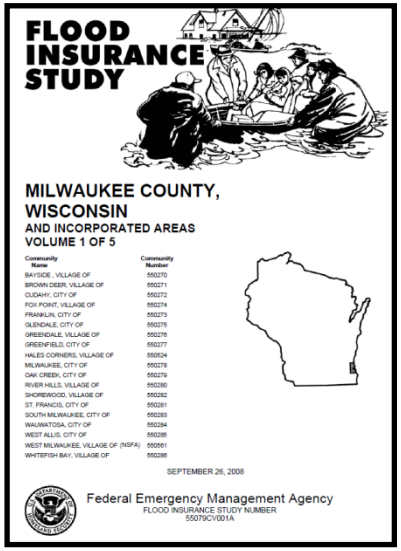
AECOM – Hydraulic Analysis

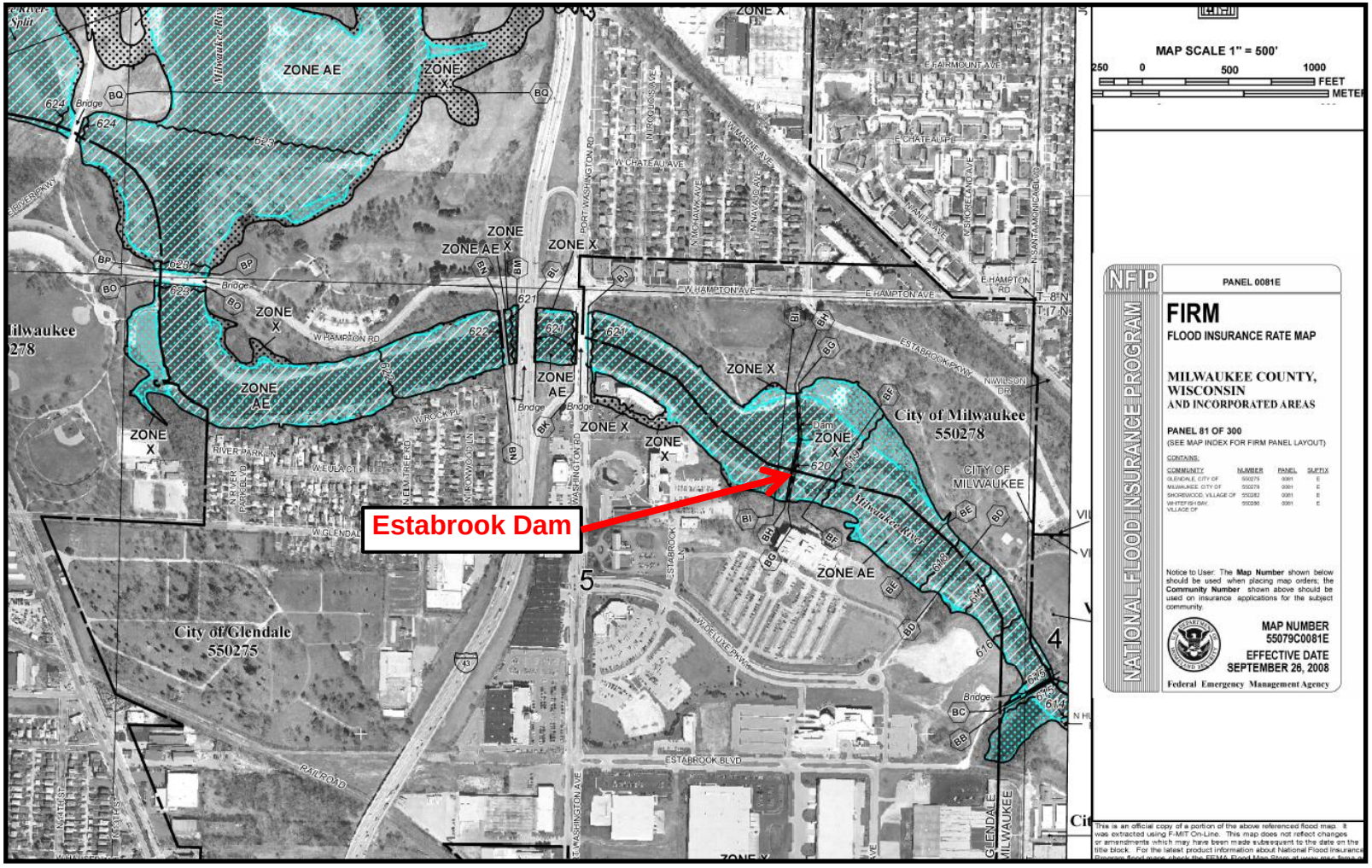
– Hydraulic Analysis for Fish Passage Design

- To Permit the proposed fish passage through the WDNR Floodplain and Dam Safety Programs the hydraulic analysis must demonstrate the configuration of fish passage, along with necessary dam modifications:
  - Results in no net change to the Regulatory Base Flood Elevation (BFE)
  - Provides no reduction in spillway capacity for the Spillway Design Flood (SDF) = 100 year storm
  - Provides Fish Migration Gate Operation Plan to dictate flow rates, velocities to promote Northern Pike migration
  - Provides Normal Gate Operation Plan for Milwaukee River Storm Events



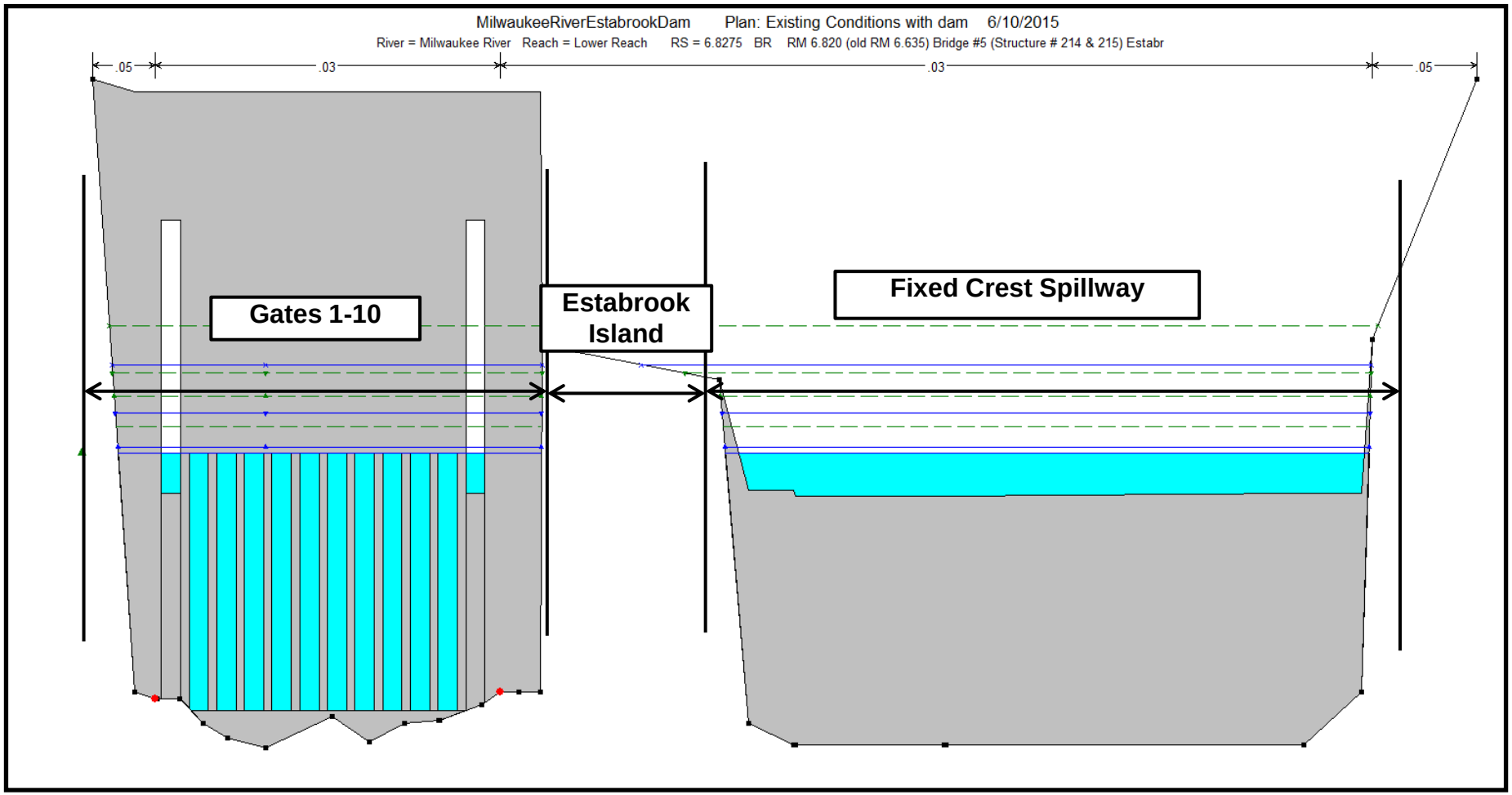
AECOM – Hydraulic Analysis

– Effective HEC-RAS Model Southwestern Wisconsin Regional Planning Commission (SEWRPC) – 2014



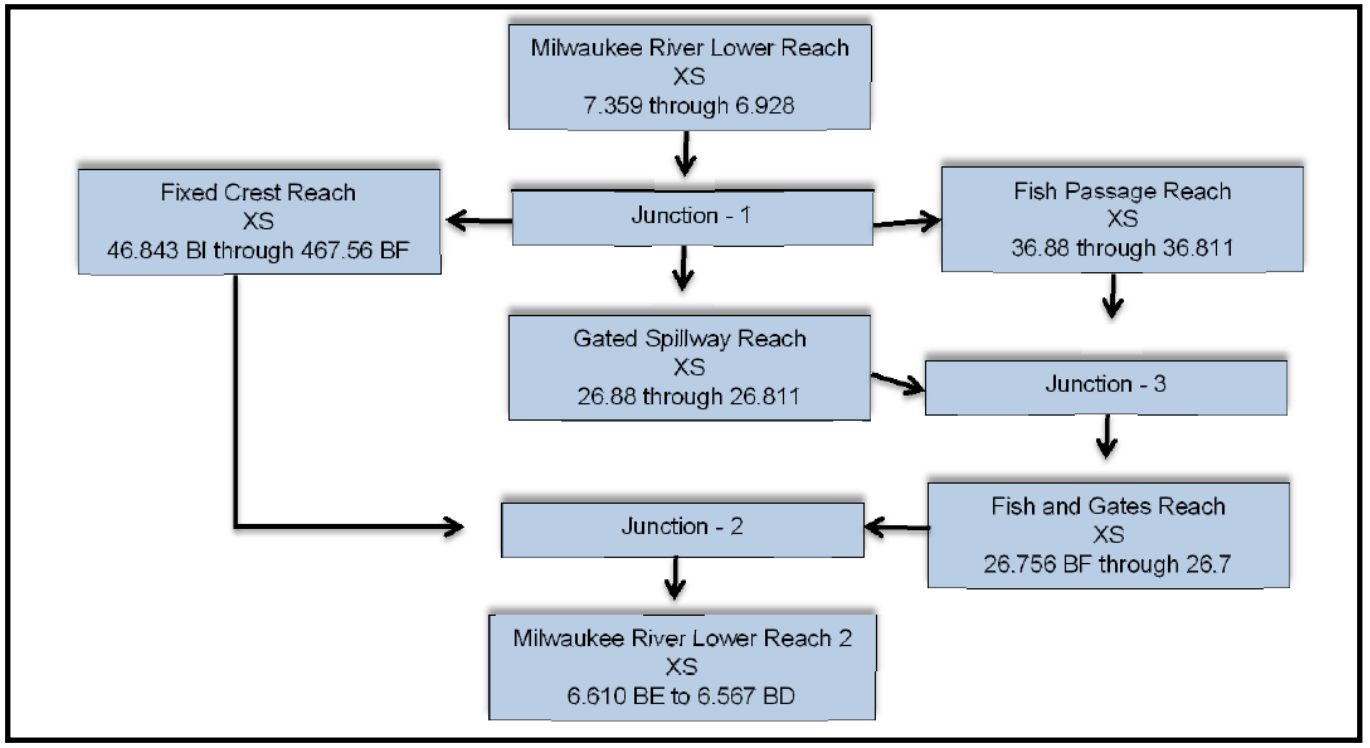
AECOM – Hydraulic Analysis

– Estabrook Dam Modeled as single Bridge Routine



AECOM – Hydraulic Analysis

– Corrected Effective HEC-RAS Model
  - Truncated to include only areas immediately upstream and downstream of Dam
  - Milwaukee River split into multiple “river reaches” for direct comparison to “Post Project Model”
  - Estabrook Dam (bridge routine) was replaced by inline structure with 10 gates
  - Ice-breakers added as HEC-RAS “obstructions”
  - Updated Survey Data



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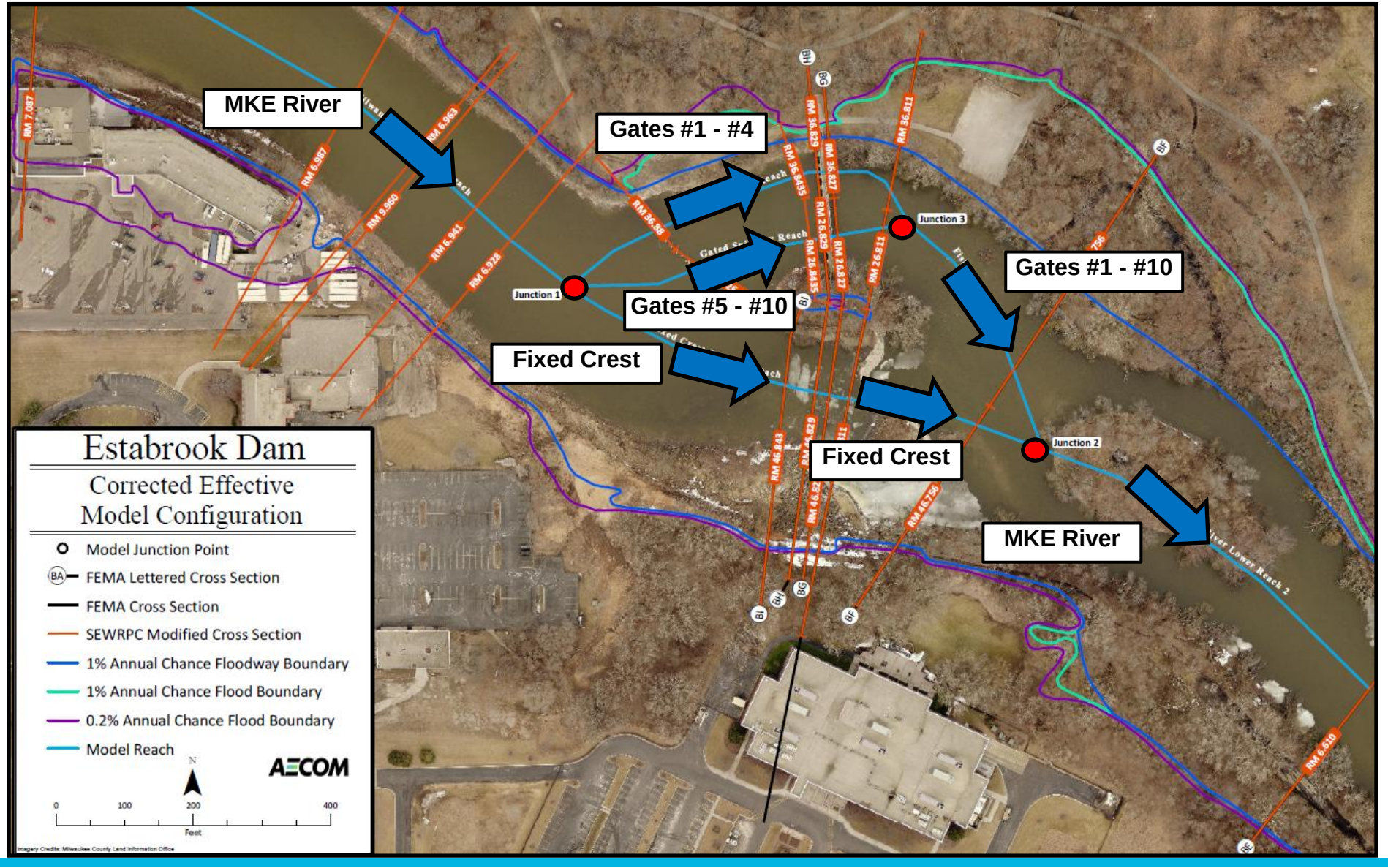
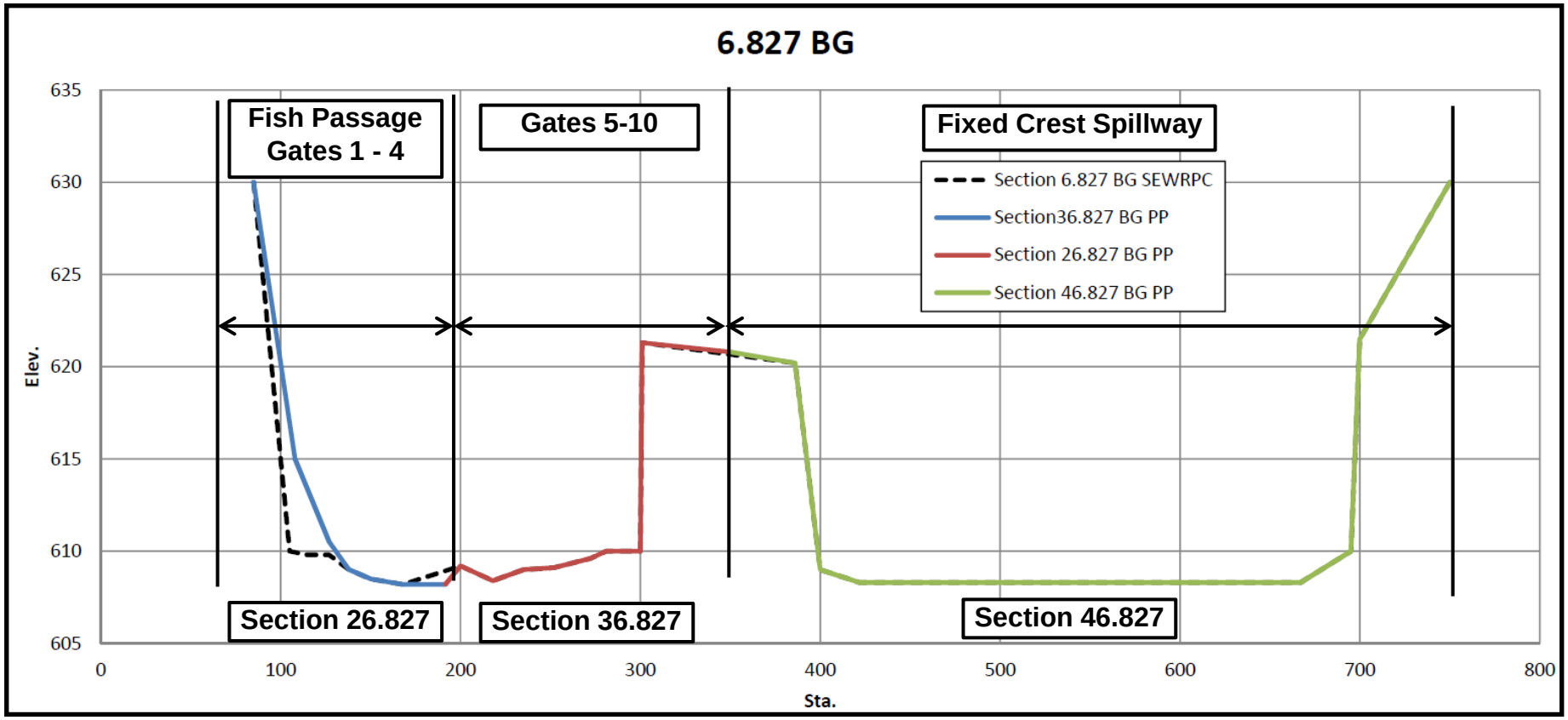
Corrected Effective HEC-RAS Configuration



Corrected Effective HEC-RAS Configuration

– Corrected Effective HEC-RAS Model
  - Effective cross sections were split into multiple sections to represent geometry for individual reaches



Corrected Effective HEC-RAS Split Flow

– Corrected Effective HEC-RAS Model
  - Total Flow is separated into multiple river reaches
  - Split flow optimized separately into each reach so upstream energy grade line in all split river reaches is within 0.01 feet

100-Year			
Reach	**Cross Section**	**Flow (cfs)**	**E.G. Elev. (feet)**
Milwaukee River Lower Reach	6.928	14,800	620.91
Junction - 1			
Fish Passage	36.88	3,007	620.64
Gated Spillway	26.88	4,409	620.65
Fixed Crest	46.843 BI	7,384	620.64
Total Flow (cfs) / Tolerance (feet)		**14,800**	**(0.01)**

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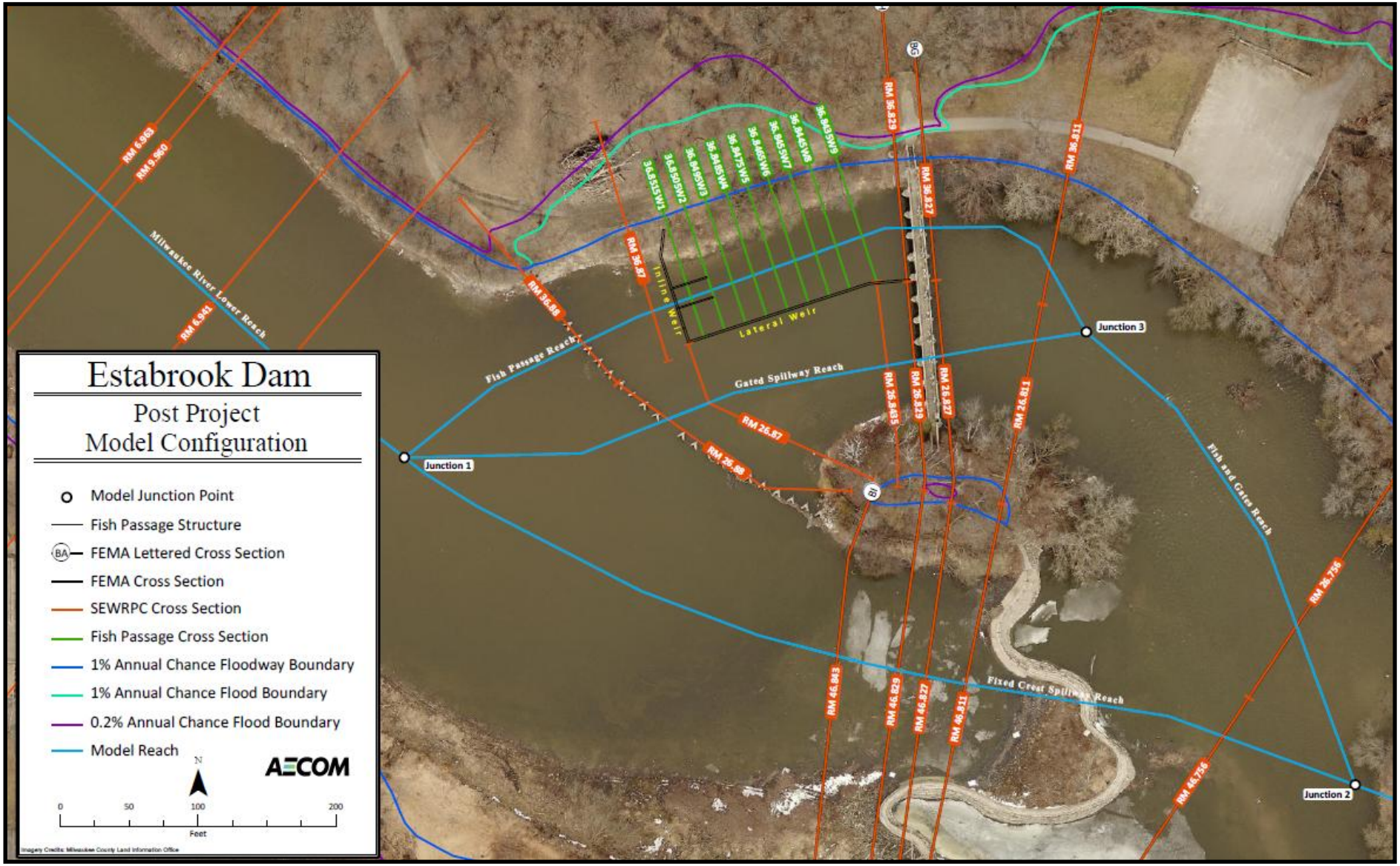
Effective vs. Corrected Effective

– Corrected Effective HEC-RAS Model Results

- Upstream WSEL differences in the Effective to Corrected Effective were limited to (0.12) feet
  - Noted Changes in multiple river reaches and split flow
  - Gated Spillway vs. bridge routine

Flow Direction →	Cross Section (River Mile)	100-year Peak Flow (cfs)	SEWRPC 2014 WS Elevation (feet)	Corrected Effective WS Elevation (feet)	Comparison Difference WS Elevation (feet)
	7.359	14,800	621.87	621.79	(0.08)
	7.199 BN	14,800	621.54	621.45	(0.09)
	Interstate 43 On Ramp				
	7.189	14,800	621.44	621.35	(0.09)
	7.183 BM	14,800	621.41	621.32	(0.09)
	Interstate 43				
	7.160 BL	14,800	621.28	621.18	(0.10)
	7.117 BK	14,800	621.19	621.09	(0.10)
	7.110 Port Washington Road				
	7.103 BJ	14,800	621.13	621.03	(0.10)
	7.087	14,800	621.15	621.05	(0.10)
	6.987	14,800	620.82	620.71	(0.11)
	6.963	14,800	620.70	620.58	(0.12)
	6.960	14,800	620.69	620.57	(0.12)
	6.941	14,800	620.66	620.55	(0.11)
	6.928	14,800	620.63	620.51	(0.12)

Post Project HEC-RAS Configuration



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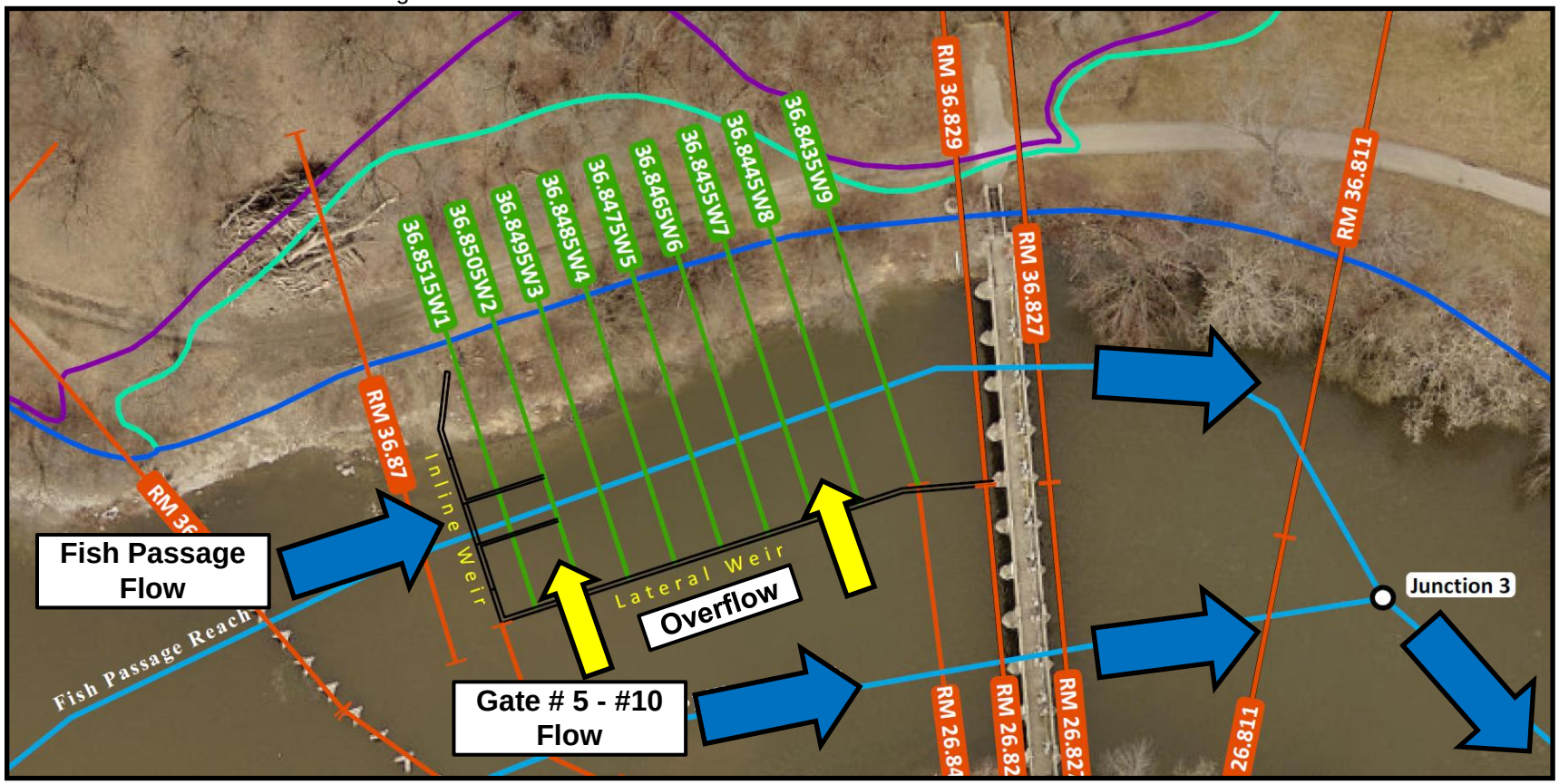
Post Project HEC-RAS Configuration

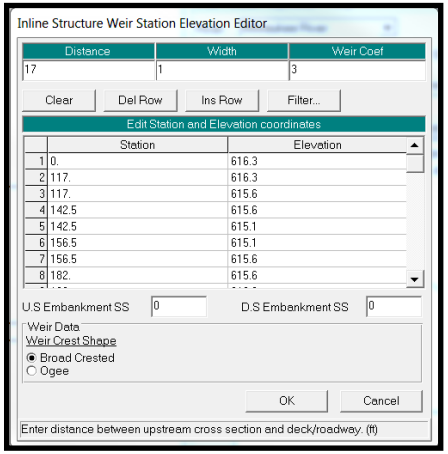
– Post Project HEC-RAS Model – Proposed Fish Passage Structure

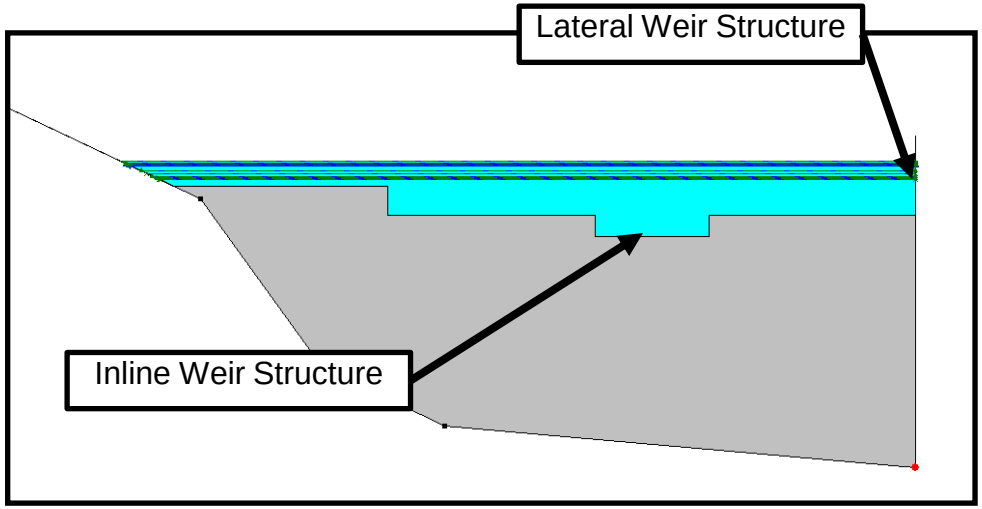
- Located on the left bank located upstream of sluice gates #1-4
- Upstream Concrete Weir to direct flow through fish passage structure
- Lateral Weir Wall that connects to existing dam pier for extreme flood events
- Rock Ramp composed on 9 rock boulder weirs spaced approximately 16 feet apart with 0.8 feet drop resulting in 5% longitudinal slope
- Remove Gates # 1 through #4

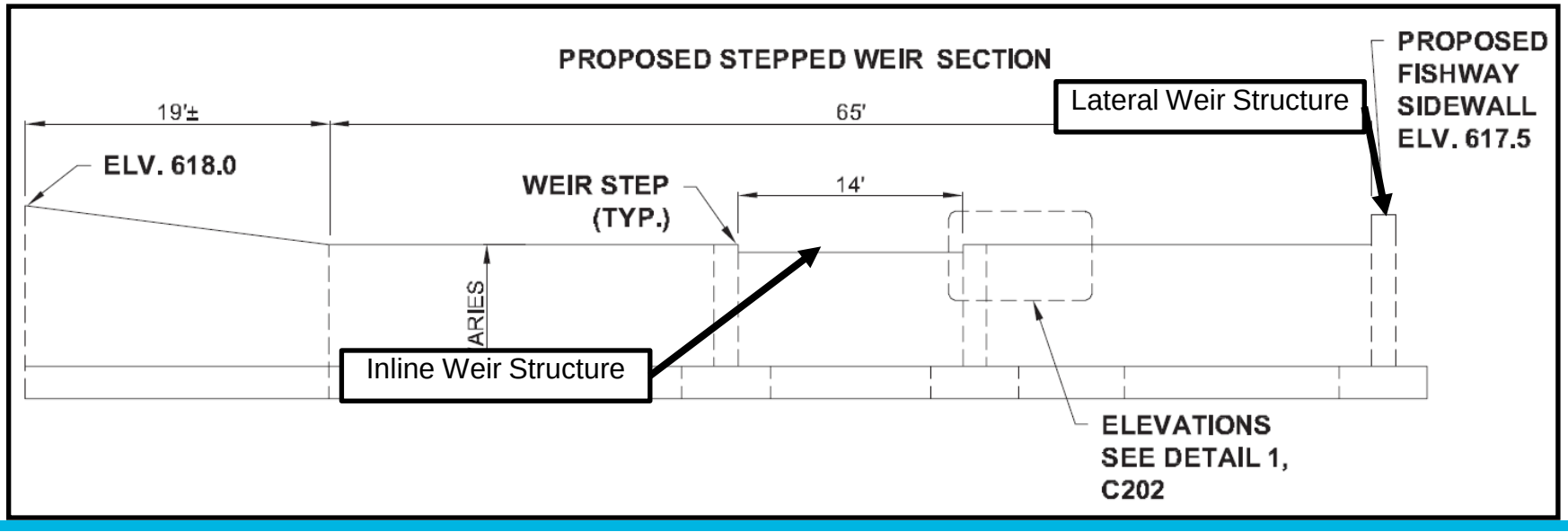


Post Project HEC-RAS Configuration

– Post Project HEC-RAS Model – Proposed Fish Passage Structure – Inline and Lateral Weirs

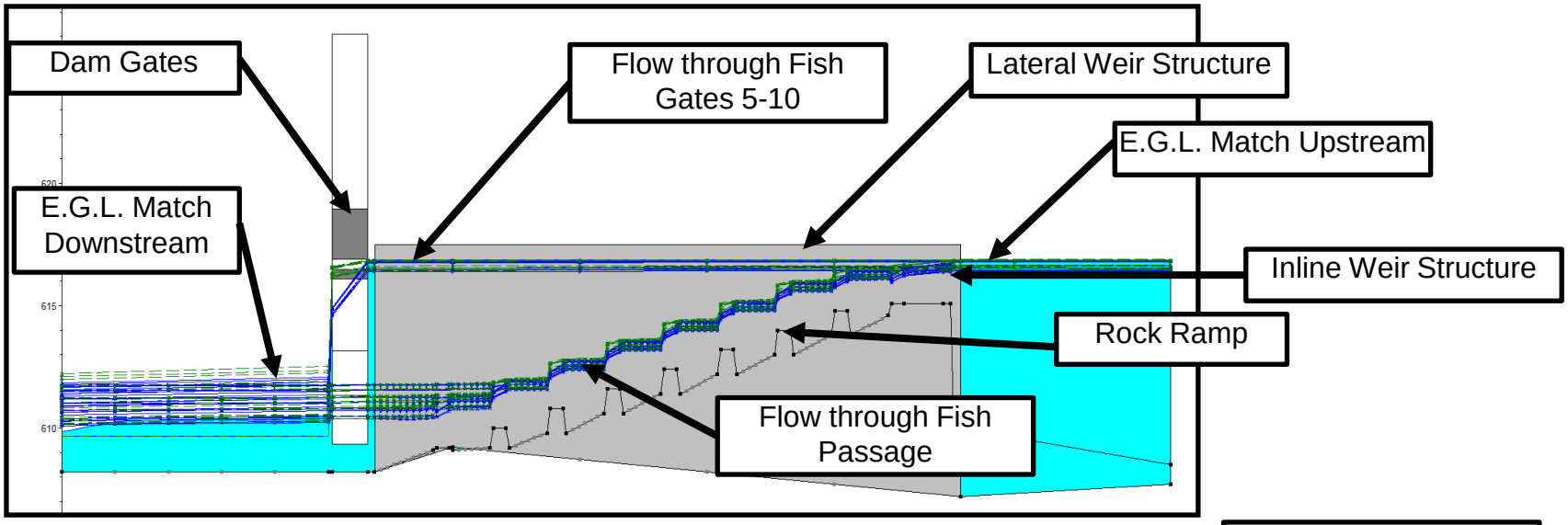


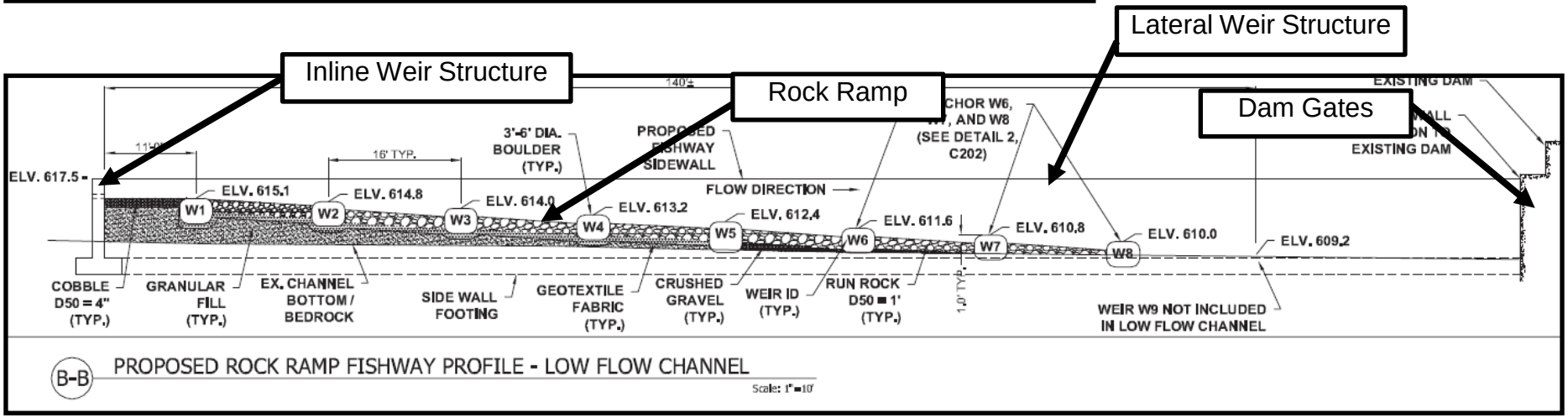




Post Project HEC-RAS Configuration

– Post Project HEC-RAS Model – Proposed Fish Passage Structure





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Post Project HEC-RAS Results

– Post Project HEC-RAS Model Results

- Results show that the proposed dam modifications and fish passage cause no rise to the upstream BFE. – **Regulatory Floodplain Requirement Meet.**
  - Removal of Gates #1 through # 4 required to provide necessary additional capacity to prevent upstream rise

Flow Direction →

Cross Section (River Mile)	100-year Peak Flow (cfs)	Corrected Effective WS Elevation (feet)	Post Project with Modifications WS Elevation (feet)	Comparison Difference WS Elevation (feet)
7.359	14,800	621.79	621.79	0.00
7.199 BN	14,800	621.45	621.45	0.00
7.190 Interstate 43 Ramp				
7.189	14,800	621.35	621.35	0.00
7.183 BM	14,800	621.32	621.32	0.00
7.170 Interstate 43				
7.160 BL	14,800	621.18	621.18	0.00
7.117 BK	14,800	621.09	621.09	0.00
7.110 Port Washington Road				
7.103 BJ	14,800	621.03	621.03	0.00
7.087	14,800	621.05	621.05	0.00
6.987	14,800	620.71	620.71	0.00
6.963	14,800	620.58	620.58	0.00
6.960	14,800	620.57	620.57	0.00
6.941	14,800	620.55	620.55	0.00
6.928	14,800	620.51	620.51	0.00

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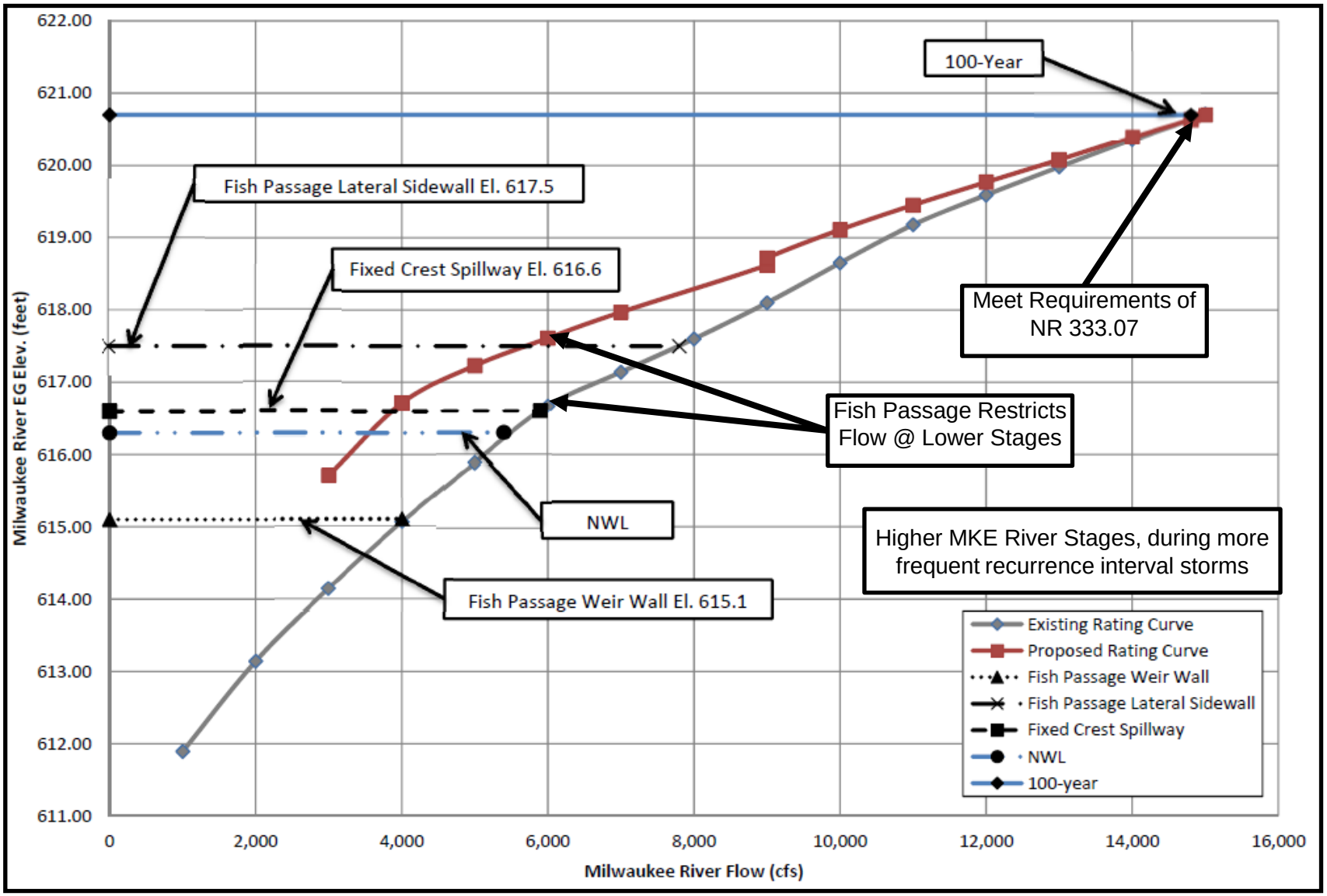
Estabrook Dam Spillway Capacity Check



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Fish Passage Gate Operation Plan

– Developed Fish Migration Gate Operation Plan (Spring)

- From low flow to 400 cfs, gates #5 through # 10 closed
- > 400 cfs gate operations of #5 through # 10 commence
- One gate will have a minimum of four gate operating positions
  - Closed
  - Two feet open
  - Half open (3.8 feet)
  - Fully open (7.5 feet)
- All other gates, fully open or fully closed

Flow Range (cfs)	Gate Condition	Total River Flow (cfs)	Fish Passage Flow (cfs)	Impoundment Water Surface Elevation (feet)
0 - 400	All Gates Closed	400	249	616.9
400 - 600	Gate 6 Open 2 Feet	400	146	616.5
		600	230	616.8
600 - 800	Gate 6 Open 3.8 feet	600	127	616.5
		800	226	616.8
800 - 1,050	Gate 6 Fully Open	800	137	616.5
		1050	230	616.8
1,050 - 1,250	Gate 6 -2 feet Open, Gate 7 Fully Open	1050	140	616.5
		1250	220	616.8
1,250 - 1,550	Gate 6 Half Open, Gate 7 Fully Open	1250	128	616.5
		1550	232	616.8
1,550 - 1,750	Gate 6 Close, Open Gate 7&8 Open	1550	180	616.7
		1750	232	616.8
1,750 - 2,000	Gate 6 2' Open Gate 7&8 Open	1750	167	616.6
		2000	231	616.8
2,000 - 2,250	Gate 6 Half Gate 7,8 Open	2000	177	616.7
		2250	238	616.9
2,250 2,500	Gate 6,7,8 Open	2250	194	616.7
		2500	248	616.9
2,500 - 2,750	Gate 6 - 2' Open, 7,8,9 Open	2500	197	616.7
		2750	255	616.9
2,750 - 3,200	Gate 6,7,8,9 Open	2750	158	616.6
		3200	255	616.9
3,200 - 3,800	Gate 6,7,8,9,10 Open	3200	127	616.5
		3800	257	616.9
3,800 - 4,250	Gate 6 Half Open, Gates 5,7,8,9,10 Open	3800	182	616.7
		4250	263	616.9
Over 4,250	All Gates Open	4250	238	616.9

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Normal Gate Operation Plan

– Developed Normal Gate Operation Plan (Summer - Winter)

- Establish Normal Operating Band per WDNR – 616.6 +/- 6”
- Considered range of flows from USGS Gages
- During Normal Operations, Gates #5 – #10 are closed < 750 cfs
- Starting at 750 cfs, Gates #5 - # 10 commence

Trigger Gate Opening Action					After Gate Opening Action				Trigger Gate Closing Action				
Flow (cfs)	Gate Condition	WS El. (feet)	HEC-RAS Profile ID	Action	Flow (cfs)	Gate Condition	WS El. (feet)	HEC-RAS Profile ID	Flow (cfs)	Gate Condition	WS El. (feet)	HEC-RAS Profile ID	Action
750	Gates Closed	617.2	*750 Closed*	**Open Gate 6 Halfway**	750	Gate 6 Halfway Open	616.8	*750 G6 Half*	550	Gate 6 Halfway Open	616.3	*550 G6 Half*	**Close Gate 6**
1,250	G6 Halfway Open	617.2	*1,250 G6 Half*	**Open Gate 6**	1,250	Gate 6 Open	617.0	*1,250 G6*	550	Gate 6 Open	616.2	*550 G6 Half*	**Close Gate 6**
1,500	G6 Open	617.1	*1,500 G6 Half*	**Open Gate 7**	1,500	Gate 6&7 Open	616.6	*1,500 G6 G7*	1,250	Gate 6&7 Open	616.1	*1,250 G6 G7*	**Close Gate 7**
2,250	Gate 6&7 Open	617.2	*2,250 G6 G7*	**Open Gate 8**	2,250	Gate 6,7&8 Open	616.7	*2,250 G6 G7 G8*	1,800	Gate 6,7&8 Open	616.0	*1,800 G6 G7 G8*	**Close Gate 8**
2,800	Gate 6,7&8 Open	617.1	*2,800 G6 G7 G8*	**Open Gate 9**	2,800	Gate 6,7,8&9	616.6	*2,800 G6 G7 G8 G9*	2,400	Gate 6,7,8&9	616.1	*2,400 G6 G7 G8 G9*	**Close Gate 9**
3,500	Gate 6,7,8,9 Open	617.0	*3,500 G6 G7 G8 G9*	**Open Gate 10**	3,500	Gate 6,7,8,9&10 Open	616.7	*3,500 G6 G7 G8 G9 G10*	2,900	Gate 6,7,8,9&10	616.10	*2,900 G6 G7 G8 G9 G10*	**Close Gate 10**
4,200	Gates 6,7,8,9&10 Open	617.1	*4,200 G6 G7 G8 G9 G10*	**Open Gate 5**	4,200	All Gates Open	616.8	*4,200 All Gates*	3,250	All Gates Open	616.0	*3,250 All Gates*	**Close Gate 5**

Conclusion

- Project Satisfied Project Requirements
  - Results in no net change to the Regulatory Base Flood Elevation (BFE)
  - Provides no reduction in spillway capacity for the Spillway Design Flood (SDF) = 100 year storm
  - Provides Normal Gate Operation Plan for Milwaukee River Storm Events
  - Provides Fish Migration Gate Operation Plan to dictate flow rates, velocities to promote fish migration
- Received WDNR and USACE approval – Summer 2016
- Contractor Bidding – Summer 2016
- Low Contractor Bid ~ $4.1 Million
- Approved Milwaukee County Funding ~ $3.5 Million
- Approximately $600,000 Short
- Milwaukee County - December 31, 2016 deadline from WDNR
- Considerable Cost Savings to Remove Dam based on Environmental Assessment (Dam Removal Estimates Range from $1.7 to $2.5 Million)
- Strong Public and Local Government Support to remove dam due to cost savings and benefit to the environment

Estabrook Dam Next Steps

- End of 2016 – Milwaukee County sells ownership of approximately 4 acres at Estabrook Park to Milwaukee Metropolitan Sewerage District (MMSD) for $1.
- MMSD Hired AECOM in January 2017 to prepare **Dam Removal** Plans. Scope includes:
  - Hydraulic Analysis
  - Geomorphic Assessment
  - Environmental Services
  - Permitting
  - Dam Removal Plans & Specifications
- Estabrook Dam Removal ~ Possible Presentation Topic IAFSM 2018/ 2019 ~

Acknowledgements

- **MMSD**
  - Tom Chapman, P.E.
- **Milwaukee County**
  - Karl Stave, P.E.
  - Kevin Haley
- **AECOM**
  - Jaren Hiller, P.E.
  - Paul Drew, P.E., CFM
  - Chuck Dean, P.E.
  - Don Pirrung, P.E.
- **WDNR**
  - Bill Sturtevant, P.E.
  - Tanya Lourigan, P.E.
  - Will Wawrzyn

Questions?

Paul Drew, P.E., CFM
Project Manager

AECOM, Milwaukee WI

March, 9, 2017