Managing Risk – Balancing Design Criteria with Site Constraints

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Overview

- INDOT Design Criteria
- Managing Risk:
  - How
  - Why
- Case Studies/Examples

Why do we have design criteria?

- To provide minimum standards for design
  - Cost-efficient design while:
    - Minimizing risk to users
    - Minimizing disruption of service
    - Not increasing negative impact to adjacent properties

How Design Criteria is Applied

- High traffic/high speed roads
  - Higher risk for accidents
  - Potentially more disruption to traffic
  - Higher design criteria
  - More redundancy required
  - Less likely to allow exceptions
- Low traffic
  - Lower risk
  - Lower design criteria

Type of Facility	Design Frequency	Allowable Spread, T
Freeway	2% Annual EP	Edge of travel lane
Non-Freeway, ≥ 4 Lanes	10 % Annual EP	Across one-half travel lane
Two-Lane Facility	10 % Annual EP	4 ft onto travel lane
Bridge Deck, Non-Freeway $V \geq 50$ mph $V < 50$ mph	 10 % Annual EP 10% Annual EP	 Edge of travel lane 3 ft onto travel lane
Ramp $V \geq 50$ mph $V < 50$ mph	 10% Annual EP 10% Annual EP	 Edge of travel lane 3 ft onto travel lane

Functional Classification	**Allowable Backwater, Annual EP**	**Roadway Serviceability, Annual EP**	**Service-ability Freeboard ***	**Bridge, Allowable Velocity, Annual EP**	**Culvert, Allowable Velocity, Annual EP**
Freeway	1%	1%	2 ft	1%	2%
Ramp	1%	1%	0 ft	1%	2%
Non-Freeway, 4 or More Lanes	1%	1%	2 ft	1%	2%
Two-Lane Facility, AADT > 3000	1%	1%	1 ft	1%	2%
Two-Lane Facility, 1000 < AADT ≤ 3000	1%	4%	0 ft	1%	4%
Two-Lane Facility, AADT ≤ 1000	1%	10%	0 ft	1%	10%
Drive	1%	10%	0 ft	1%	10%

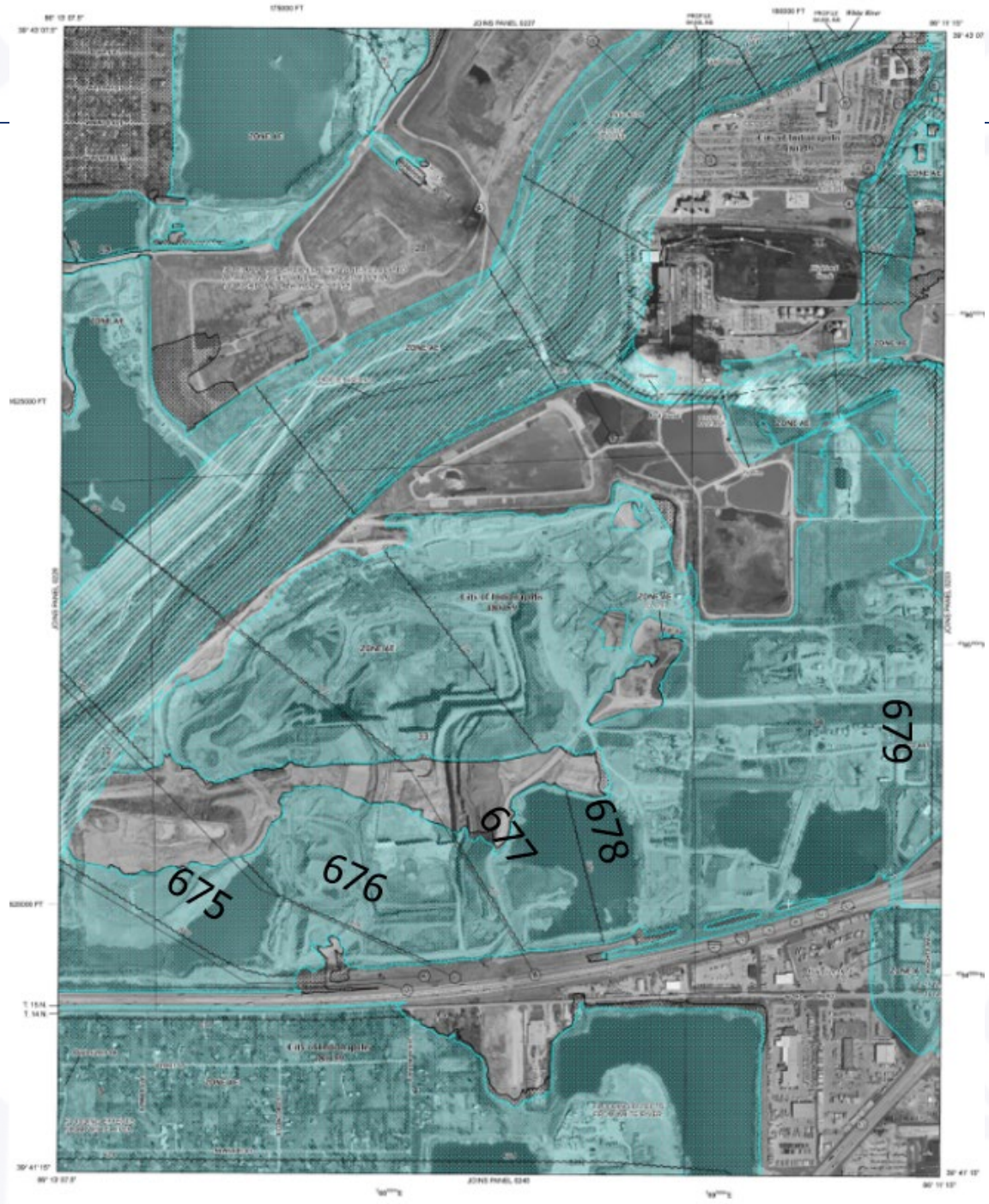
Start to Finish

- Identify Design Criteria
  - Road Classification
  - Traffic Data
- Gather site data
  - Hydrologic inputs/analysis
  - Site parameters
  - Hydraulic analysis
- Analyze results and compare to design criteria – typically serviceability is the controlling parameter
- **Weigh options – upsize infrastructure? Reach out to INDOT Hydraulics**

Case Study No. 1 – I-465 Profile Grade/White River

Case Study No. 1 – I-465 Profile Grade/White River

- I-465 between the White River and Harding Street on the south side of Indianapolis
- I-465 roughly parallels White River.
- Base Flood Elevations rise along the Westbound Shoulder, from west to east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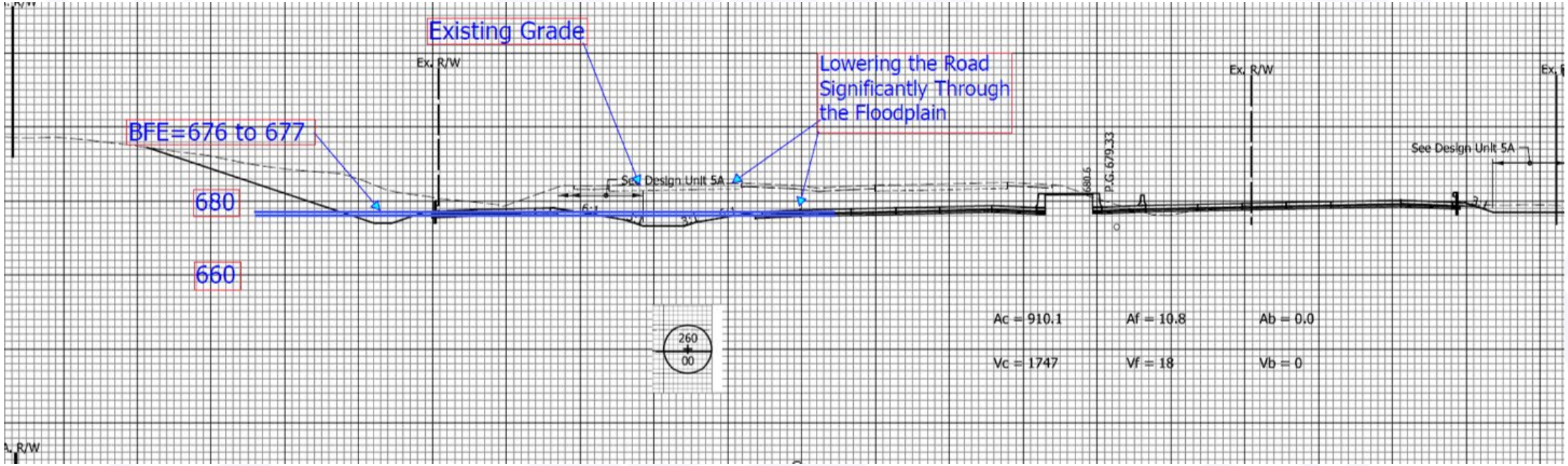
Case Study No. 1 – I-465 Profile Grade/White River

- 203-3.02(02) Road-Serviceability Freeboard [Rev. Apr. 2017] The headwater elevation from the bridge should maintain a roadway serviceability freeboard to the edge of pavement based on the functional classification shown in Figure 203-2C. If the functional classification allows, embankment overtopping may be incorporated into the design, but should be located away from the bridge abutments and superstructure. The required road serviceability should be maintained throughout the entire flood reach of the stream.

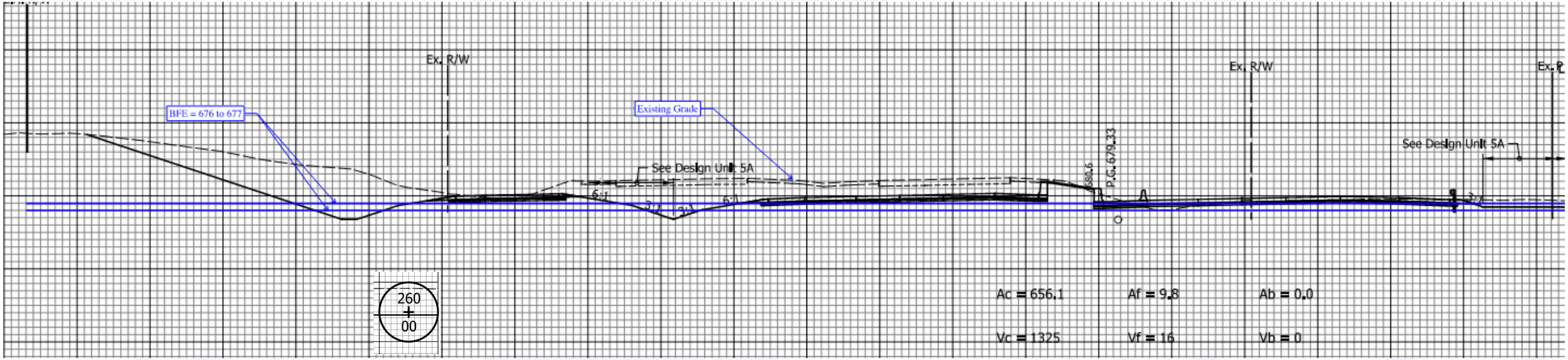
Case Study No. 1 – I-465 Profile Grade/White River

- The plans showed I-456 being lowered
- The proposed travel lane would be below the BFE in some areas
- If you just looked at the bridge headwater it looked ok but the flood plain parallels the road



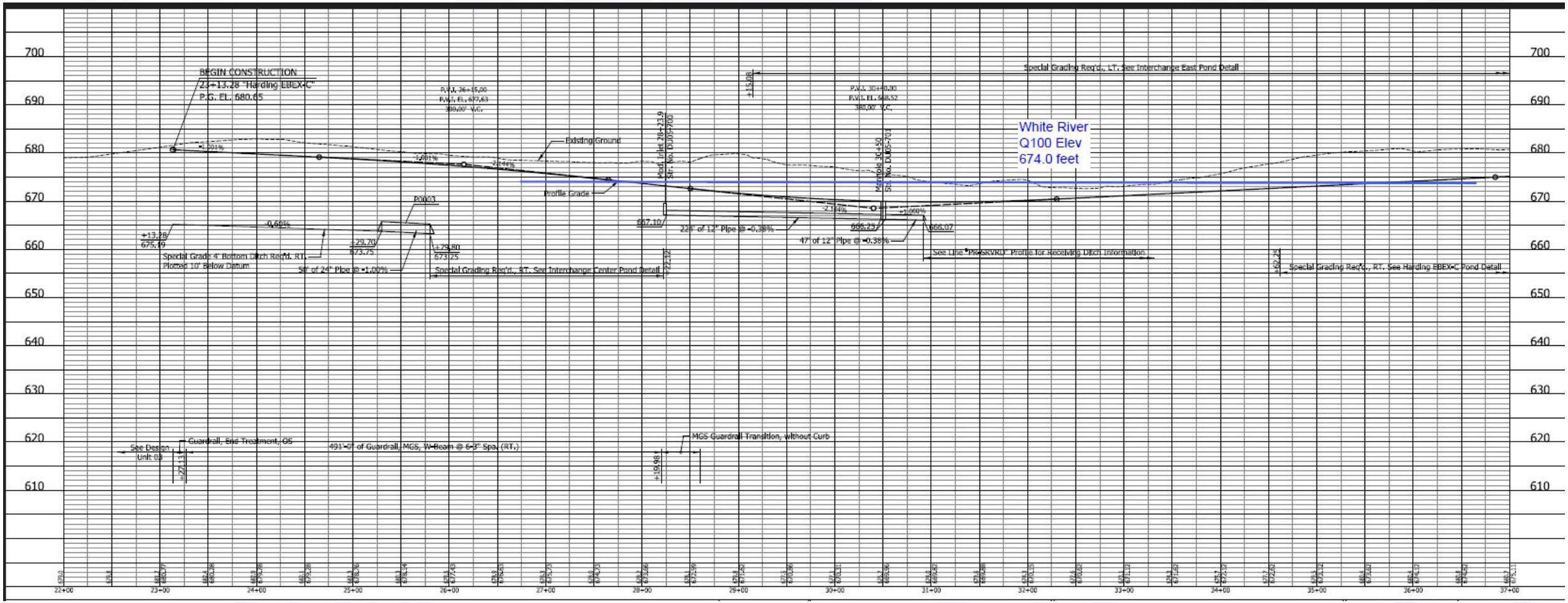
Case Study No. 1 – I-465 Profile Grade/White River

- Solutions for the Mainline
  - Where the road was 2ft or less above the adjacent BFE it should not be lowered
  - Where the existing road was greater than 2ft above adjacent BFE it could be lowered to 2ft above



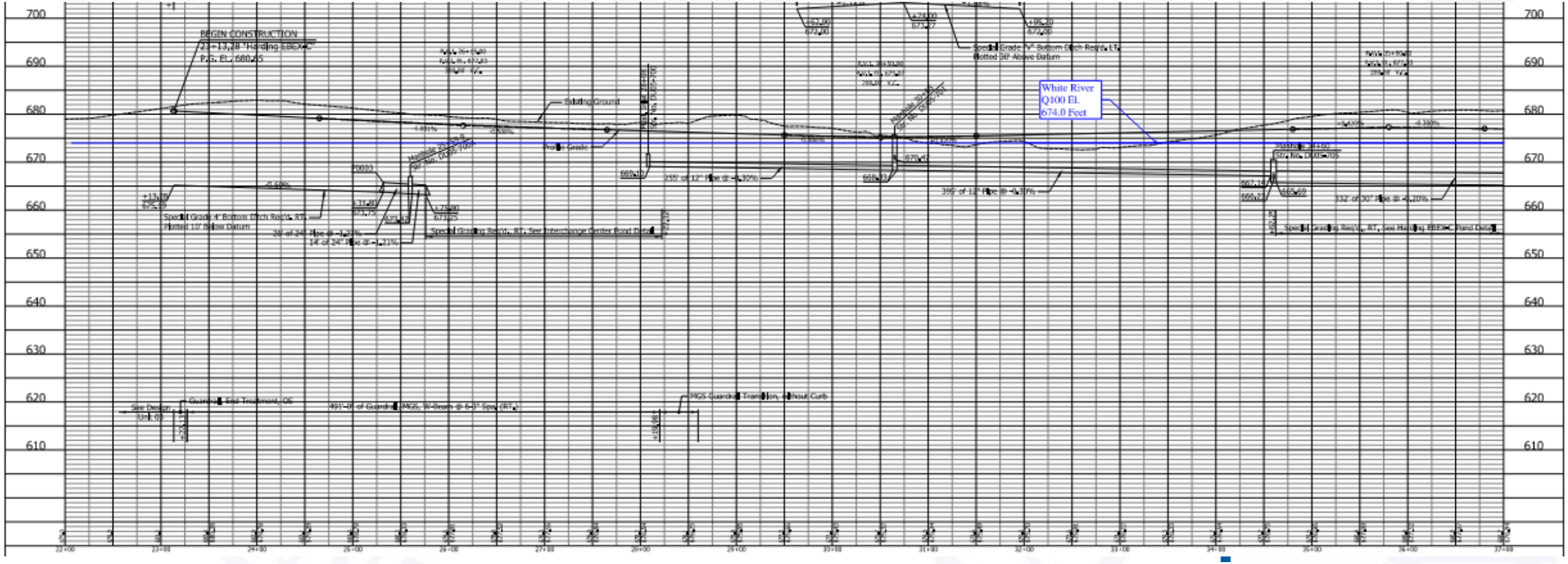
Case Study No. 1 – I-465 Profile Grade/White River

- Ramp Elevation
  - Ramp sag was lower than the BFE



Case Study No. 1 – I-465 Profile Grade/White River

- Solutions for the Ramp
  - Raised the sag above the Q100 at the downstream face of the bridge
  - Changed vertical and horizontal road alignment overpass



Case Study No. 1 – I-465 Profile Grade/White River

2008 flooding

Flood waters rise around the businesses at the Pilot Truck stop at south Harding Street just north of I-465 Saturday afternoon on the southwest side of Indianapolis. (from WTHR Chopper 13)

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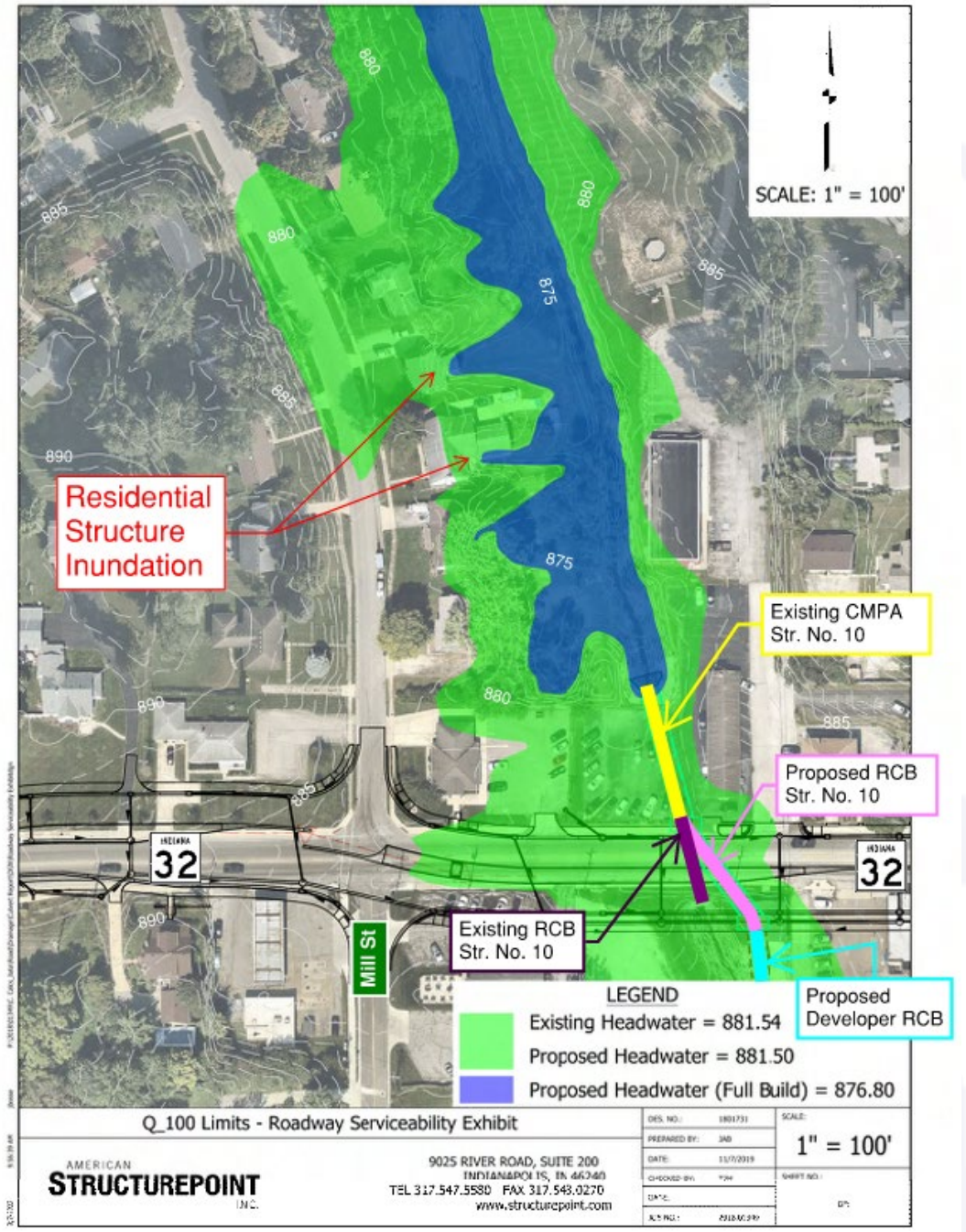
Case Study No. 2 – SR 32 Downtown Westfield Culvert Crossing

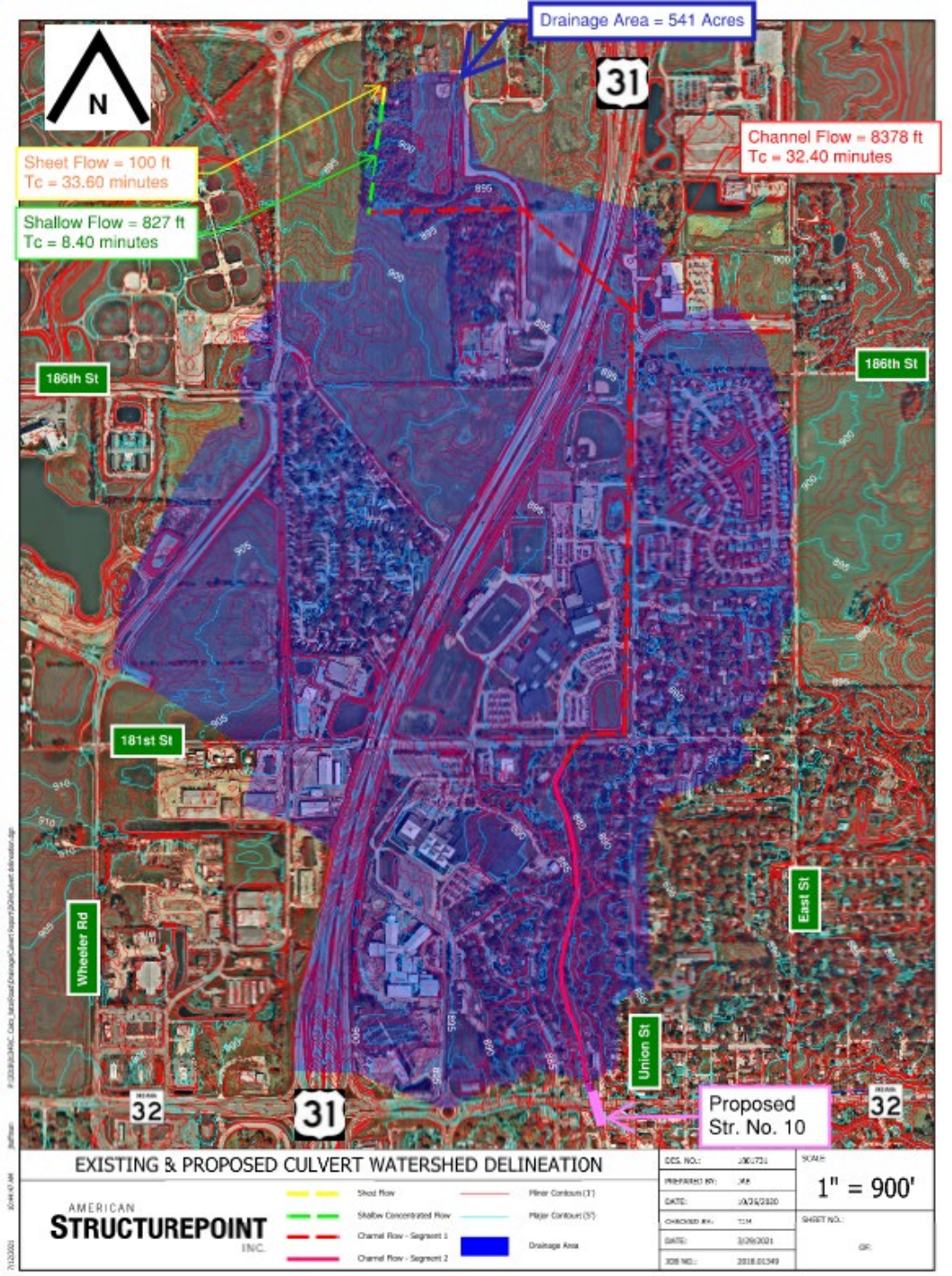
Case Study No. 2 – SR 32 Downtown Westfield Culvert Crossing

- Existing composite CMPA/RCB showing significant inundation of roadway and surrounding properties
- Complex hydrologic and hydraulic analysis
- Future downstream encapsulation



Case Study No. 2 – SR 32 Downtown Westfield Culvert Crossing

- Large mixed-use drainage area
  - Partially dense urban
  - Suburban
  - Rural/agricultural
- 72” storm sewer pipe restricting flow upstream



Case Study No. 3 – I-70 Added Travel Lanes

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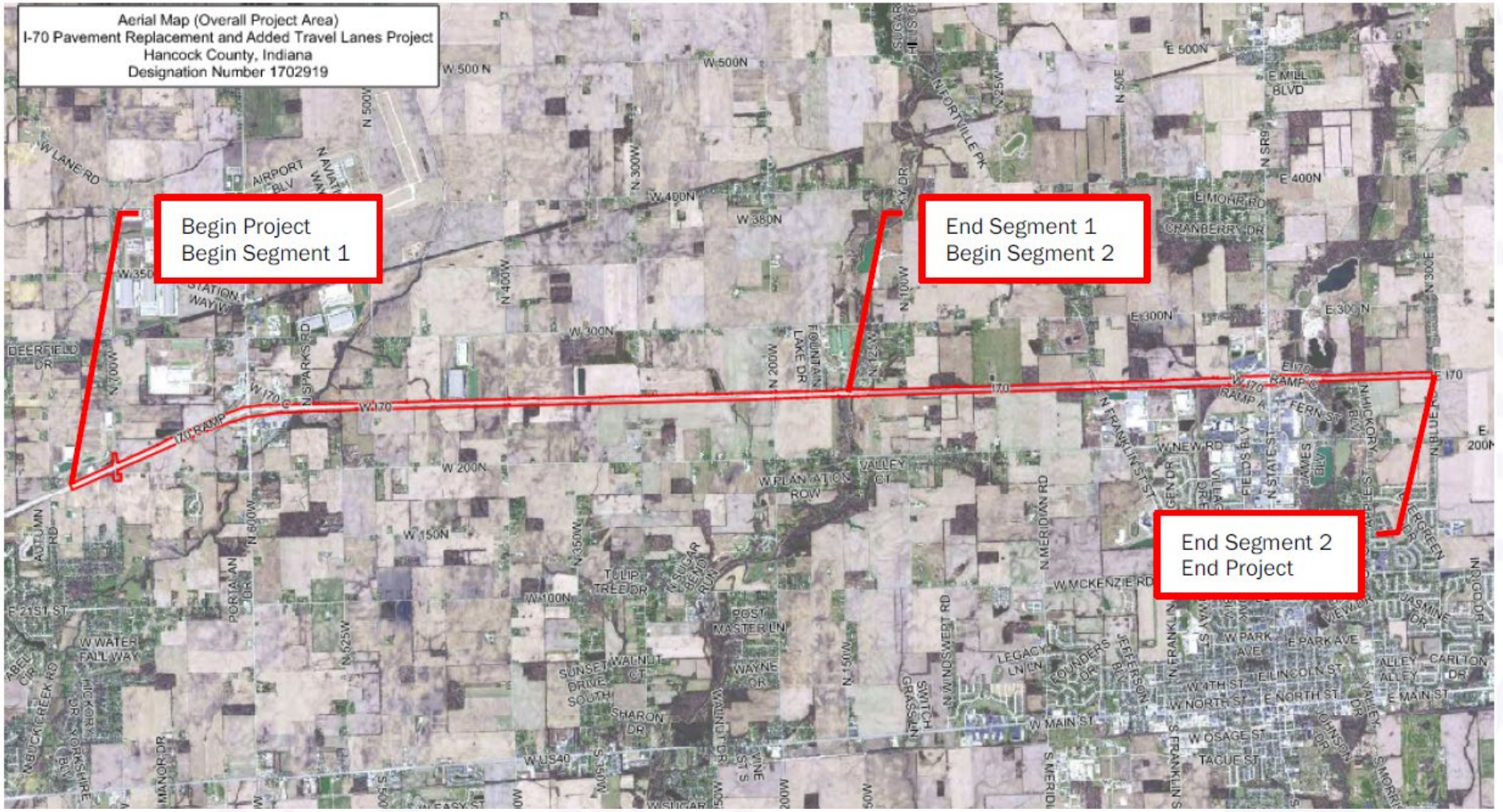
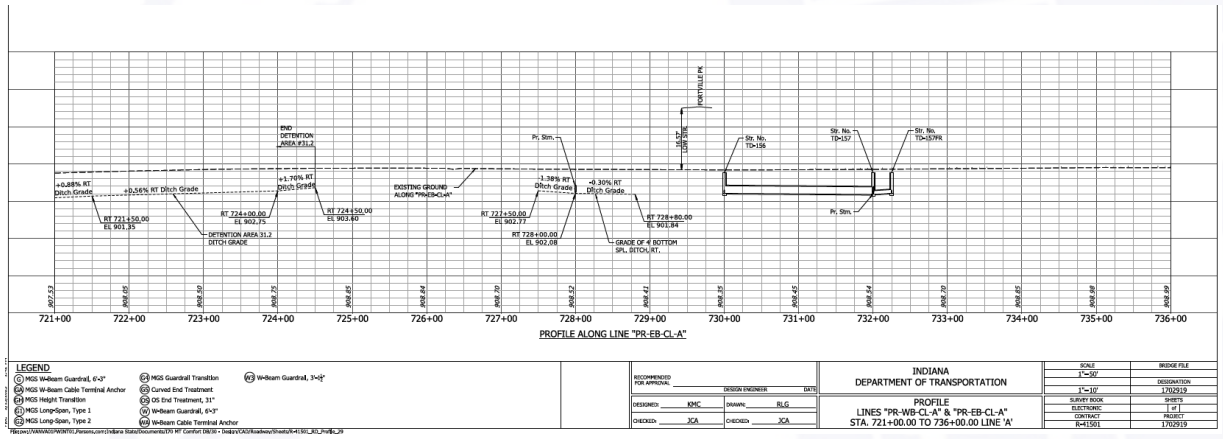
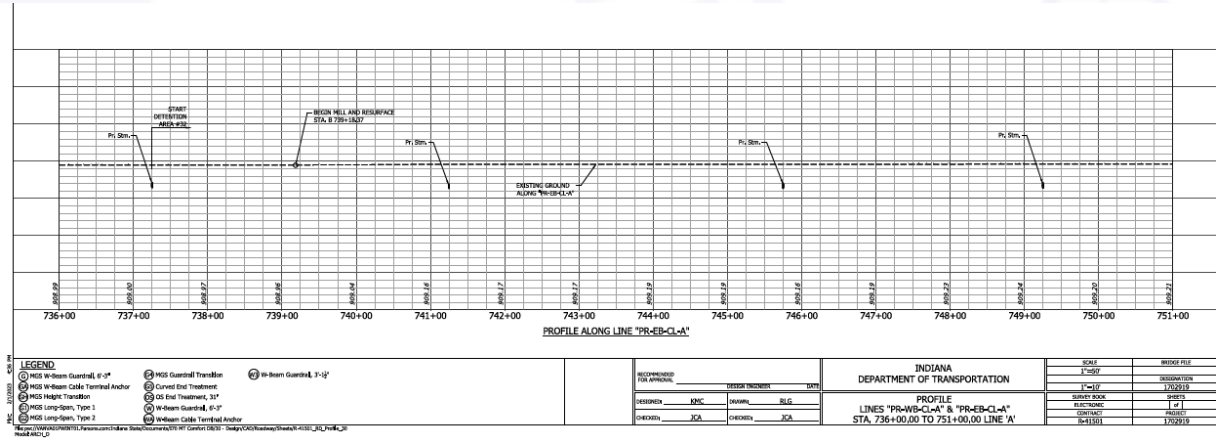
- Project adding lanes to the inside with a barrier wall

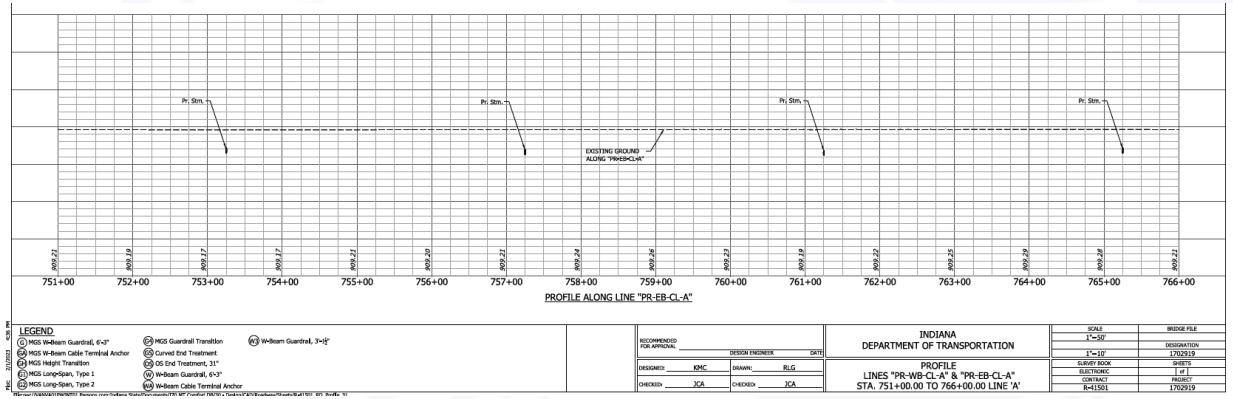


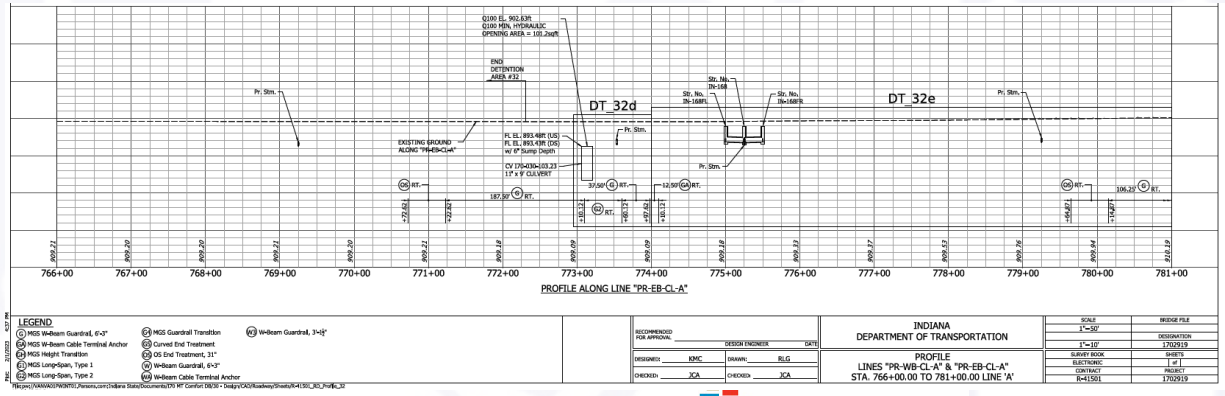
Case Study No. 3 – I-70 Added Travel Lanes

- Existing flat stretch of road east of Mount Comfort Road
- No opportunity to fix the profile slope in project









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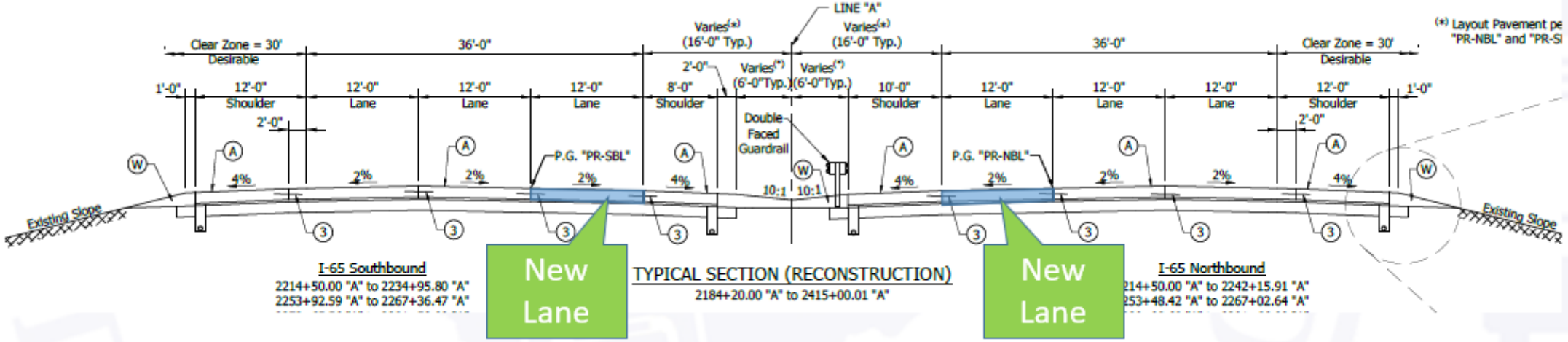
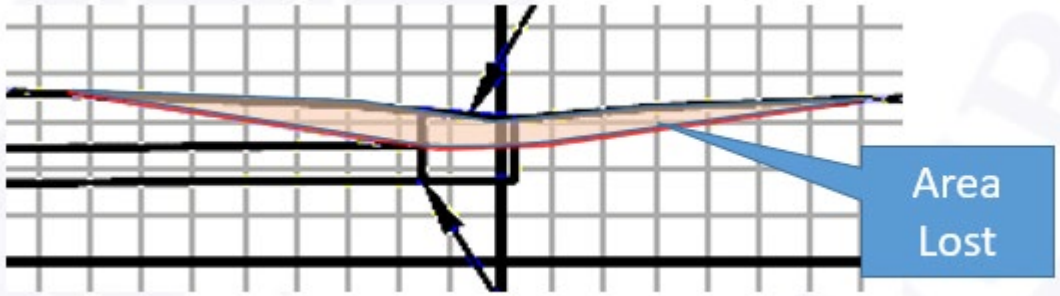
Case Study No. 3 – I-70 Added Travel Lanes

- Added lanes encroach into the existing median
  - Median loses waterway conveyance area
  - Inside edge of travel lane becomes a lower elevation (2% x 12 ft = 0.24 ft)





Case Study No. 3 – I-70 ATL

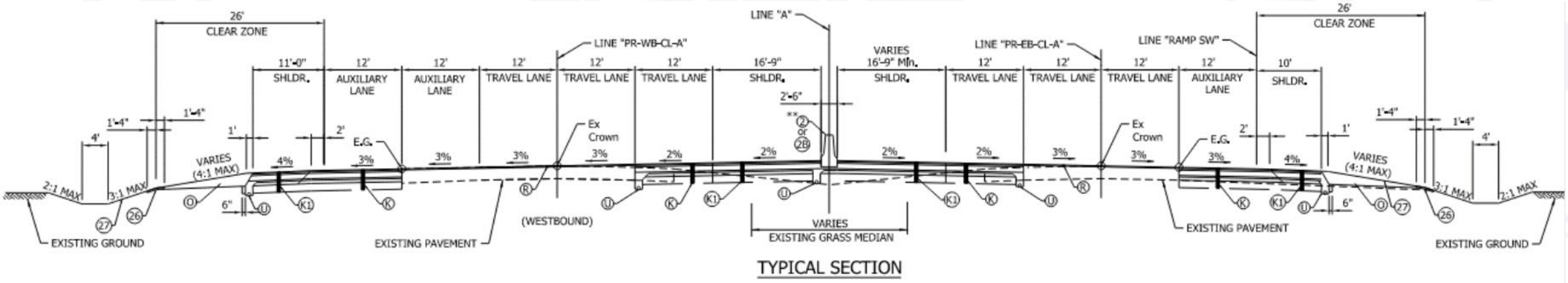
- Initial design - rolling the shoulder between 2%-6% cross slope
- Design Worked hydraulically
  - INDOT Maintenance was concerned
  - INDOT Standards and Road Design concerned
    - Future MOT
    - Emergency access
    - Constructability issues

INSIDE SHOULDER CROSS SLOPE INFORMATION

		Westbound			Eastbound		
Station		Shoulder Elevation at Median Barrier	Shoulder Cross Slope		Shoulder Elevation at Median Barrier	Shoulder Cross Slope	Description
765+25		907.73	6.00%		907.72	-6.00%	Low Spot
765+50		907.80	5.50%		907.80	-5.49%	
765+75		907.89	5.00%		907.86	-5.00%	
766+00		907.97	4.50%		907.92	-4.50%	
766+25		908.05	4.00%		907.99	-4.00%	↑
766+50		908.12	3.50%		908.07	-3.50%	
766+75		908.20	3.00%		908.16	-3.00%	
767+00		908.29	2.50%		908.25	-2.50%	
767+25		908.38	2.00%		908.35	-2.00%	High Spot
767+50		908.31	2.38%		908.28	-2.38%	
767+75		908.25	2.75%		908.22	-2.75%	
768+00		908.19	3.12%		908.16	-3.13%	
768+25		908.12	3.50%		908.10	-3.50%	↓
768+50		908.06	3.87%		908.05	-3.88%	
768+75		908.01	4.25%		907.98	-4.25%	
769+00		907.96	4.63%		907.91	-4.63%	
769+25		907.89	5.00%		907.85	-5.00%	Low Spot
769+50		907.95	4.62%		907.91	-4.63%	
769+75		908.01	4.25%		907.97	-4.25%	
770+00		908.06	3.87%		908.03	-3.87%	
770+25		908.14	3.50%		908.10	-3.50%	↑
770+50		908.20	3.12%		908.17	-3.13%	
770+75		908.28	2.75%		908.23	-2.75%	
771+00		908.34	2.38%		908.29	-2.38%	
771+25		908.39	2.00%		908.35	-2.00%	High Spot
771+50		908.30	2.37%		908.27	-2.38%	
771+75		908.24	2.75%		908.21	-2.75%	
772+00		908.17	3.12%		908.15	-3.12%	↓
772+25		908.09	3.50%		908.08	-3.50%	
772+50		908.01	3.87%		908.01	-3.87%	
772+75		907.97	4.25%		907.90	-4.25%	
773+00		907.91	4.63%		907.78	-4.63%	↓
773+25		907.83	5.00%		907.72	-5.00%	Low Spot
773+50		907.96	4.25%		907.86	-4.25%	
773+75		908.09	3.50%		908.00	-3.50%	↑
774+00		908.23	2.75%		908.11	-2.75%	
774+25		908.37	2.00%		908.22	-2.00%	High Spot
774+50		908.24	3.00%		908.07	-3.00%	
774+75		908.10	4.00%		907.94	-4.00%	↓
775+00		907.97	5.00%		907.81	-5.00%	
775+25		907.82	6.00%		907.68	-6.00%	Low Spot
775+50		907.89	5.72%		907.76	-5.72%	
775+75		907.94	5.43%		907.84	-5.43%	
776+00		908.02	5.14%		907.93	-5.14%	
776+25		908.09	4.86%		908.00	-4.86%	↑
776+50		908.15	4.57%		908.05	-4.57%	
776+75		908.21	4.29%		908.10	-4.28%	
777+00		908.29	4.00%		908.16	-4.00%	

Case Study No. 3 – I-70 ATL

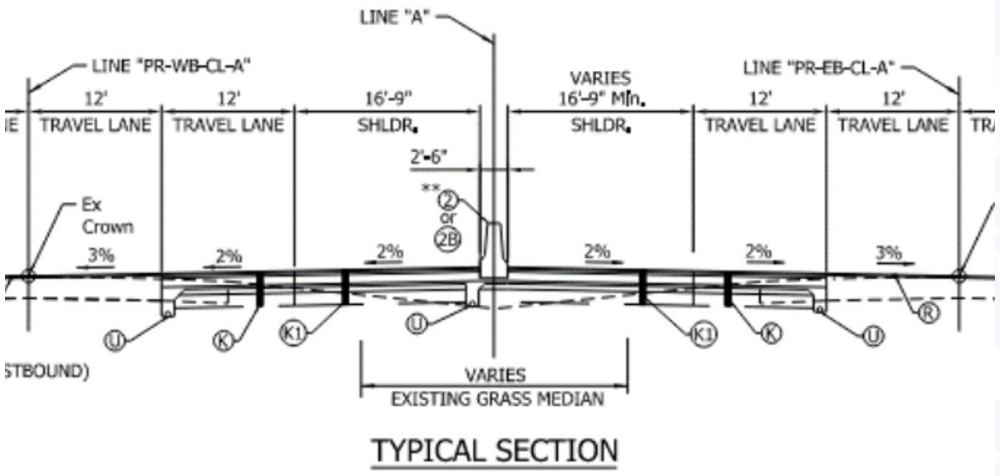
- Second Proposal - Drain everything to outside
  - Hydroplaning Concerns
    - >5 lanes draining across pavement
    - Depth of flow a concern
  - Draining median to the outside
    - FHWA HEC-22- Median areas should not be drained across lanes



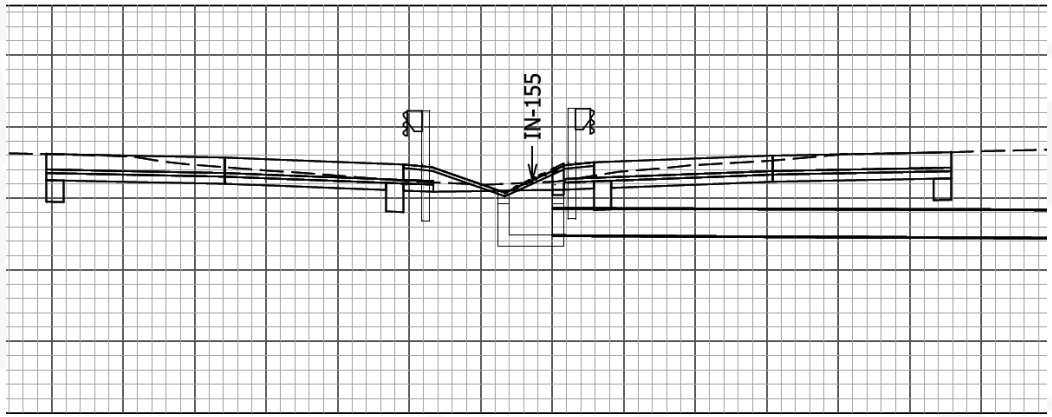
TYPICAL SECTION

Case Study No. 3 – I-70 ATL

- Solution – change the proposed road section
  - Eliminate the barrier wall and keep open ditch
  - Create high points in ditch to slope to inlets



TYPICAL SECTION



Case Study No. 4 – Flex Road Borman Expressway

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- Need for additional lane due to high traffic
- Proposed using median shoulder as travel lane

Case Study No. 4 – Flex Road Borman Expressway

- No shoulder so there is no room for allowable spread

Type of Facility	Design Frequency	Allowable Spread, T
Freeway	2% Annual EP	Edge of travel lane
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Two-Lane Facility	10 % Annual EP	4 ft onto travel lane
Bridge Deck, Non-Freeway $V \geq 50$ mph $V < 50$ mph	10 % Annual EP 10% Annual EP	Edge of travel lane 3 ft onto travel lane
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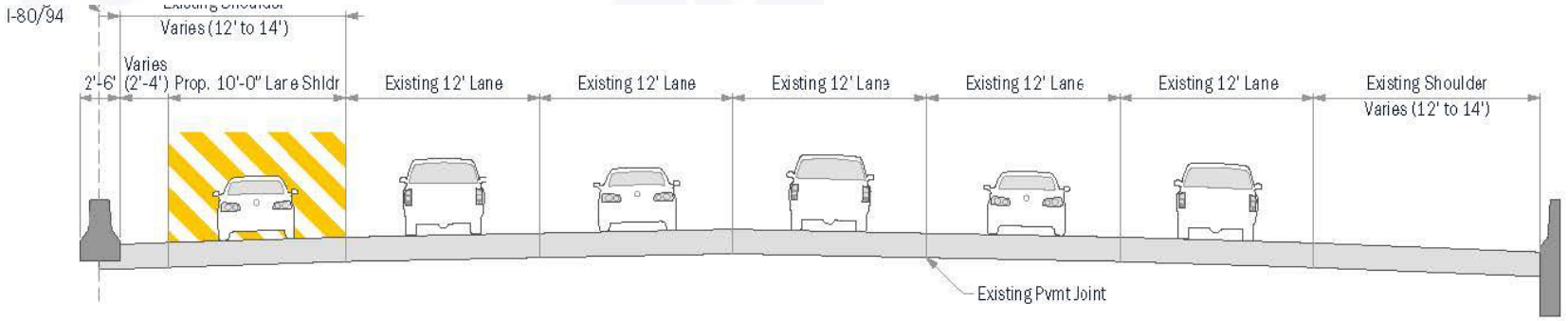


Figure 4.3: Proposed Typical Section of Inside Dynamic Shoulder Riding for Eastbound Direction

(Westbound would mirror the typical sections)

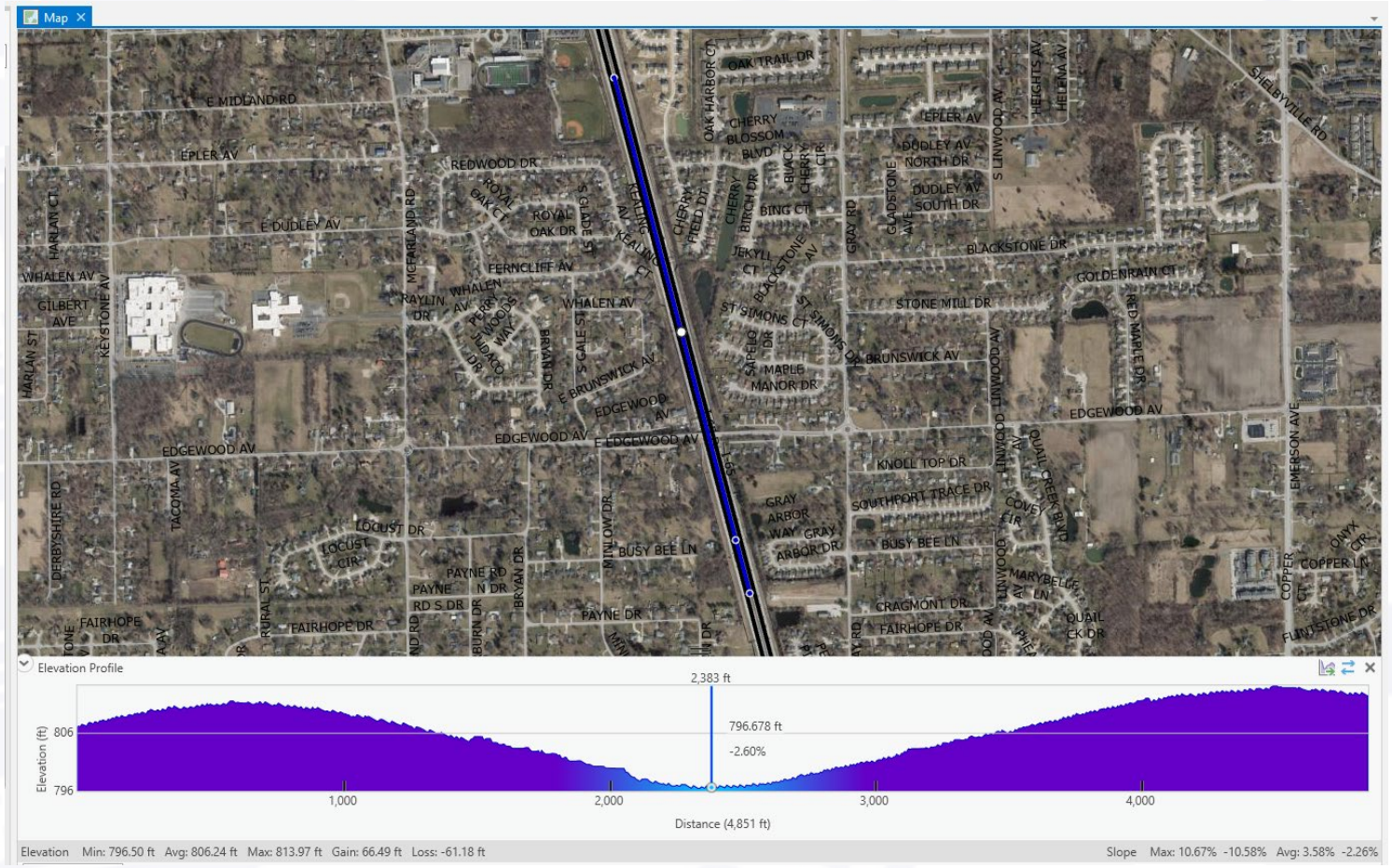
Case Study No. 4 – Flex Road Borman Expressway

- Solution
  - Designer proposed over head signals to close the lane when there is rain event

Case Study No. 5 – I-65 Added Travel Lanes Near Edgewood Avenue

Case Study No. 5 – I-65 Added Travel Lanes

- I65 ATL Project Near Edgewood Ave
  - Added Travel Lane Project
  - Lanes added to the outside
  - Existing drainage to inside not studied
    - N-12 inlet with a very large drainage area
    - On-grade E-7 inlets were clogged
    - No redundancy – need flanking inlets



Case Study No. 5 – I-65 Added Travel Lanes

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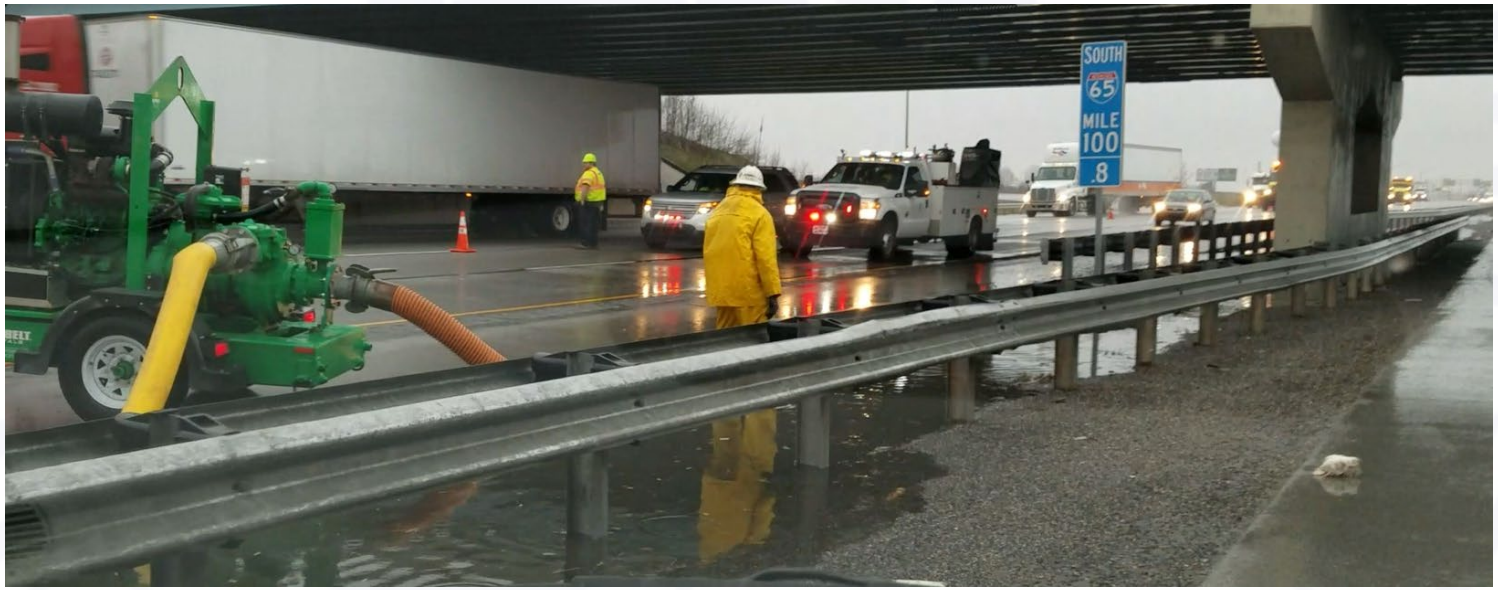
Case Study No. 5 – I-65 Added Travel Lanes

- The N-12 inlet was over half clogged within a year

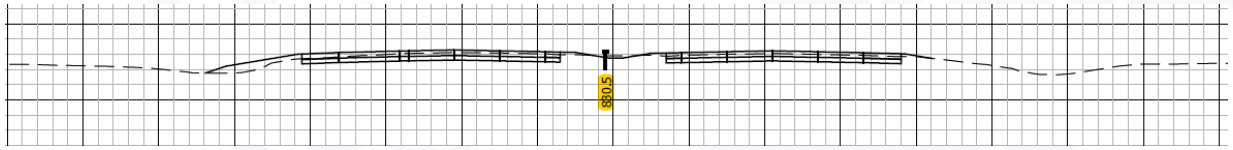
Case Study No. 6 – I-65 Added Travel Lanes

Case Study No. 6 – I-65 Added Travel Lanes

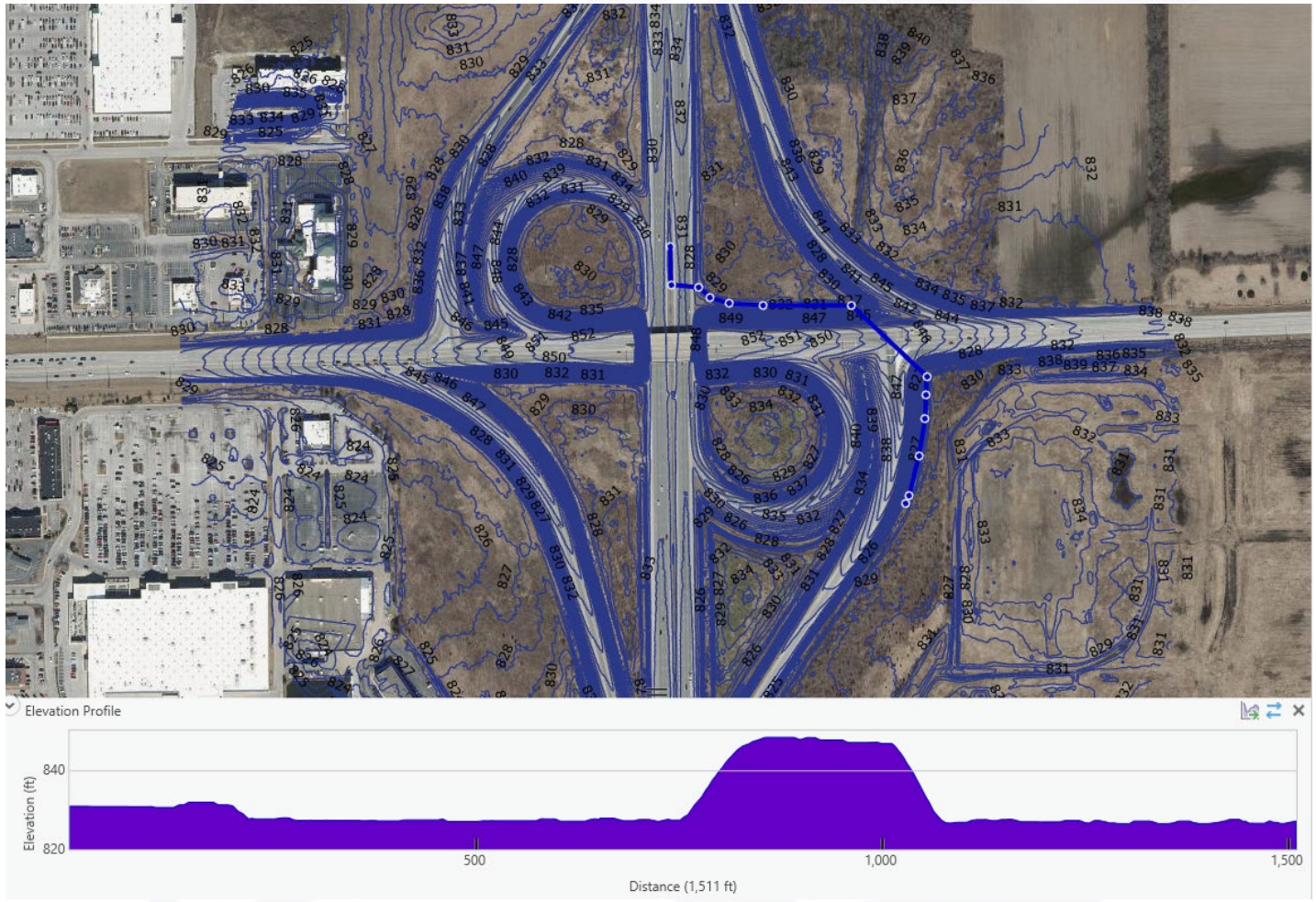
- Area 2 – County Line Road
  - Added travel lanes
  - New lanes to inside
  - Designer analyzed the median drains but
    - Median drains drained to an infield
    - Downstream culvert headwater impacted the performance of the median drains



Case Study No. 6 – I-65 Added Travel Lanes



Case Study No. 6 – I-65 Added Travel Lanes



Case Study No. 7 – I-65 Added Travel Lanes

Case Study No. 7 – I-65 Added Travel Lanes

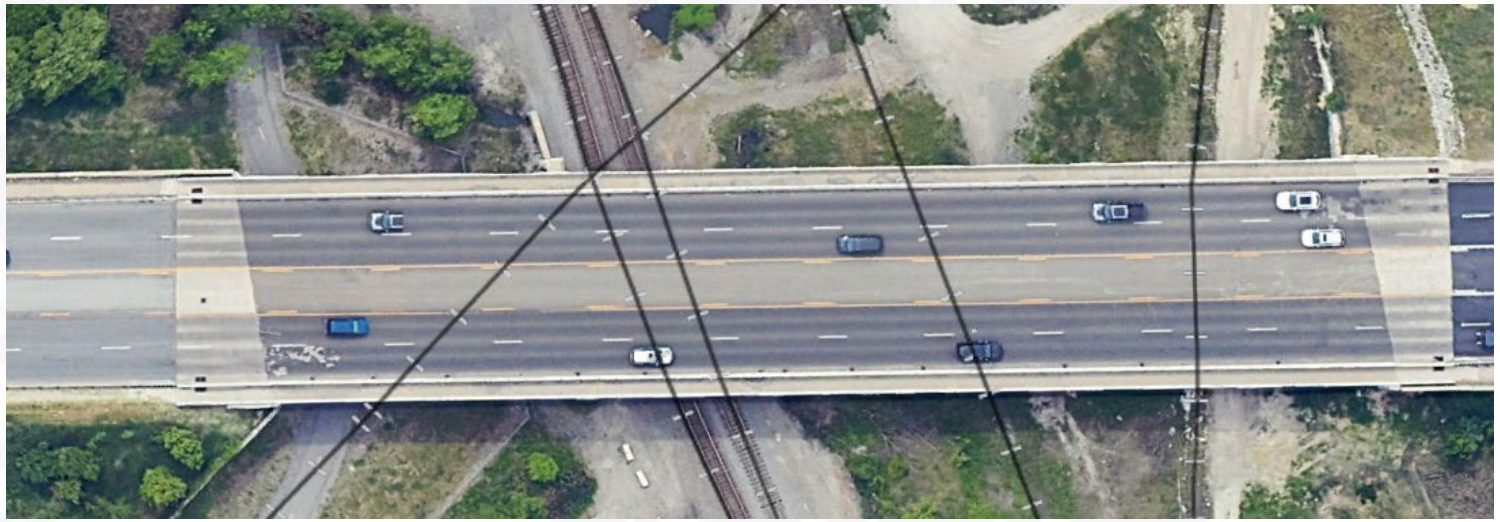
Bridge over Little Buck Creek

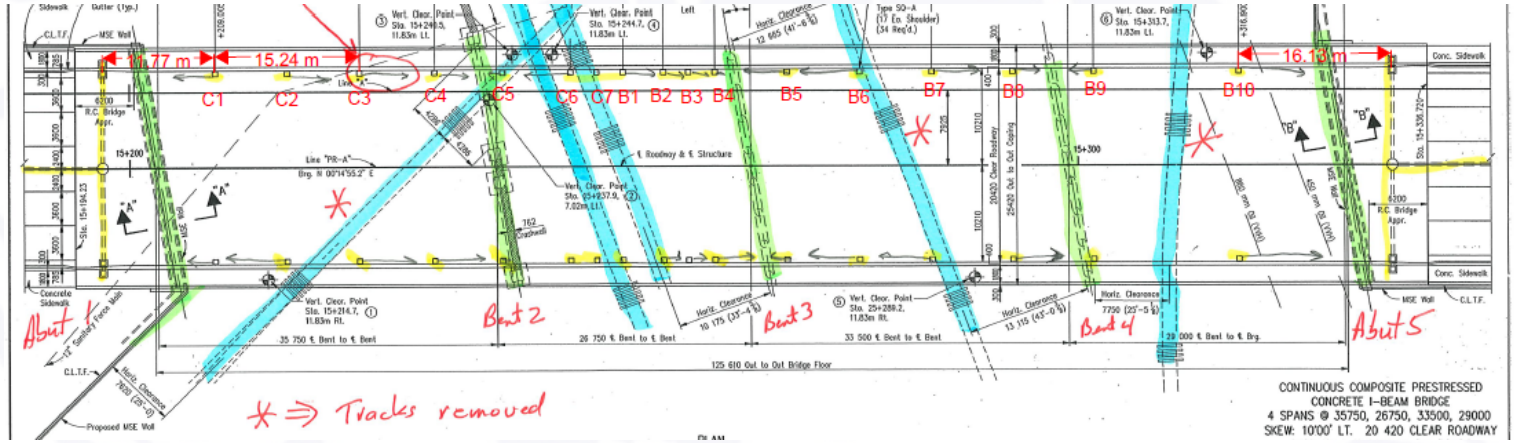
- The median drain clogged
- Berm was higher than the edge of lane
- Water backed up into the lane

Case Study No. 8 – US 41 Bridge Near St John

Case Study No. 8 – US 41 Bridge Near St John

- INDOT and Railroad concerned with maintenance old deck drains

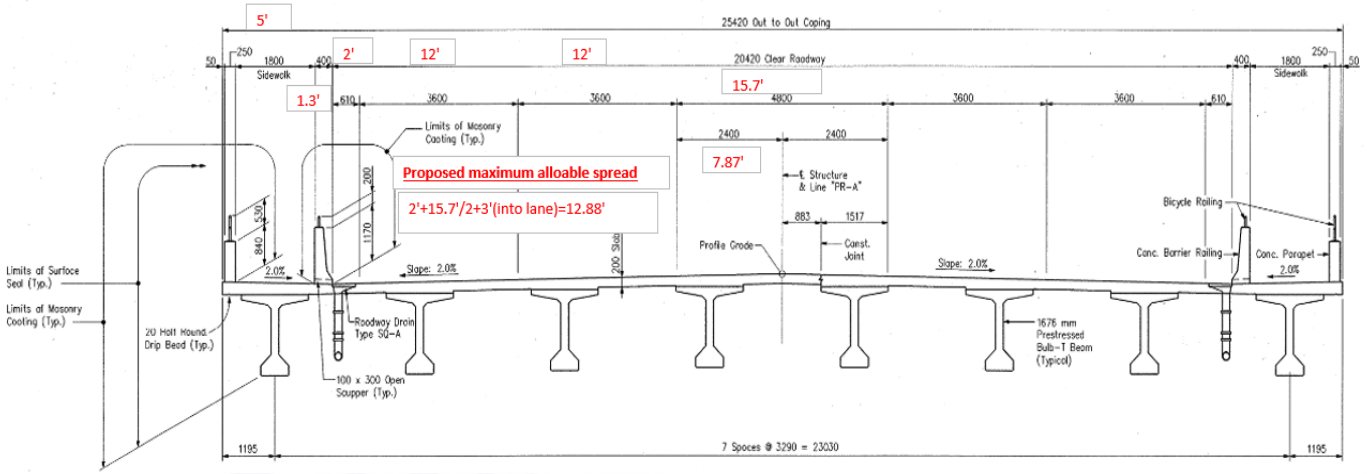




Case Study No. 8 – US 41 Near St John Bridge

- Proposed eliminating the center “turn” lane
- Shifting the lanes in to create additional shoulder
- Spread was met with new shoulder and no inlet structures

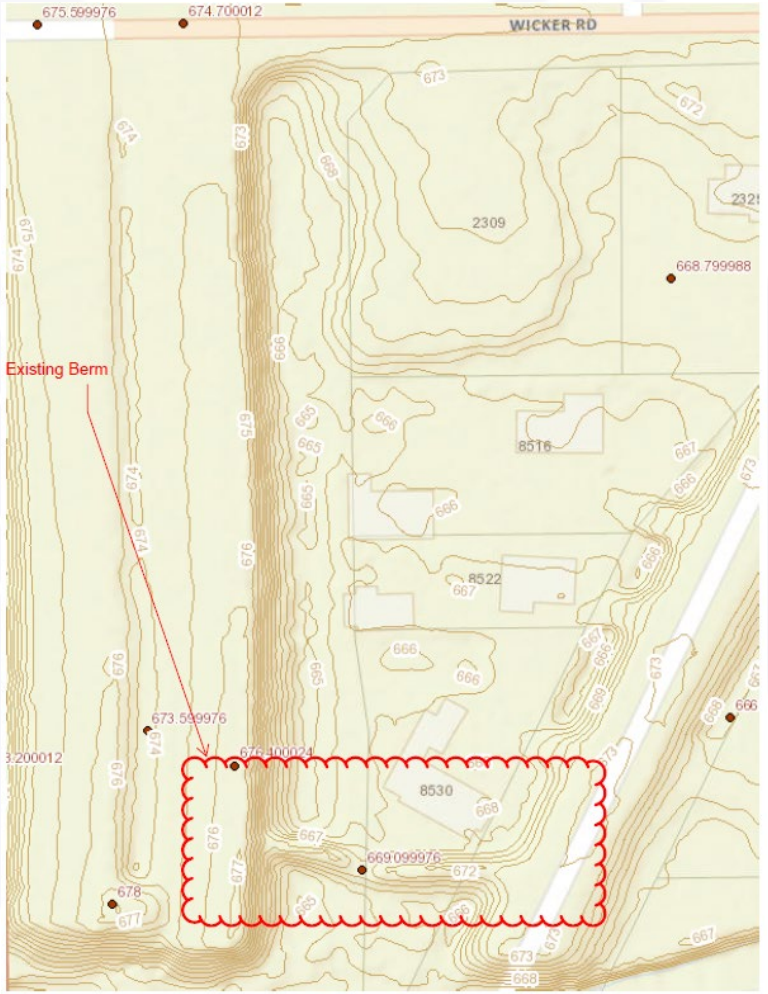
Type of Facility	Design Frequency	Allowable Spread, T
Freeway	2% Annual EP	Edge of travel lane
Non-Freeway, ≥ 4 Lanes	10 % Annual EP	Across one-half travel lane
Two-Lane Facility	10 % Annual EP	4 ft onto travel lane
Bridge Deck, Non-Freeway		
$V \geq 50$ mph	10 % Annual EP	Edge of travel lane
$V < 50$ mph	10% Annual EP	3 ft onto travel lane
Ramp		
$V \geq 50$ mph	10% Annual EP	Edge of travel lane
$V < 50$ mph	10% Annual EP	3 ft onto travel lane



Case Study No. 9 – I-69 Private Berm

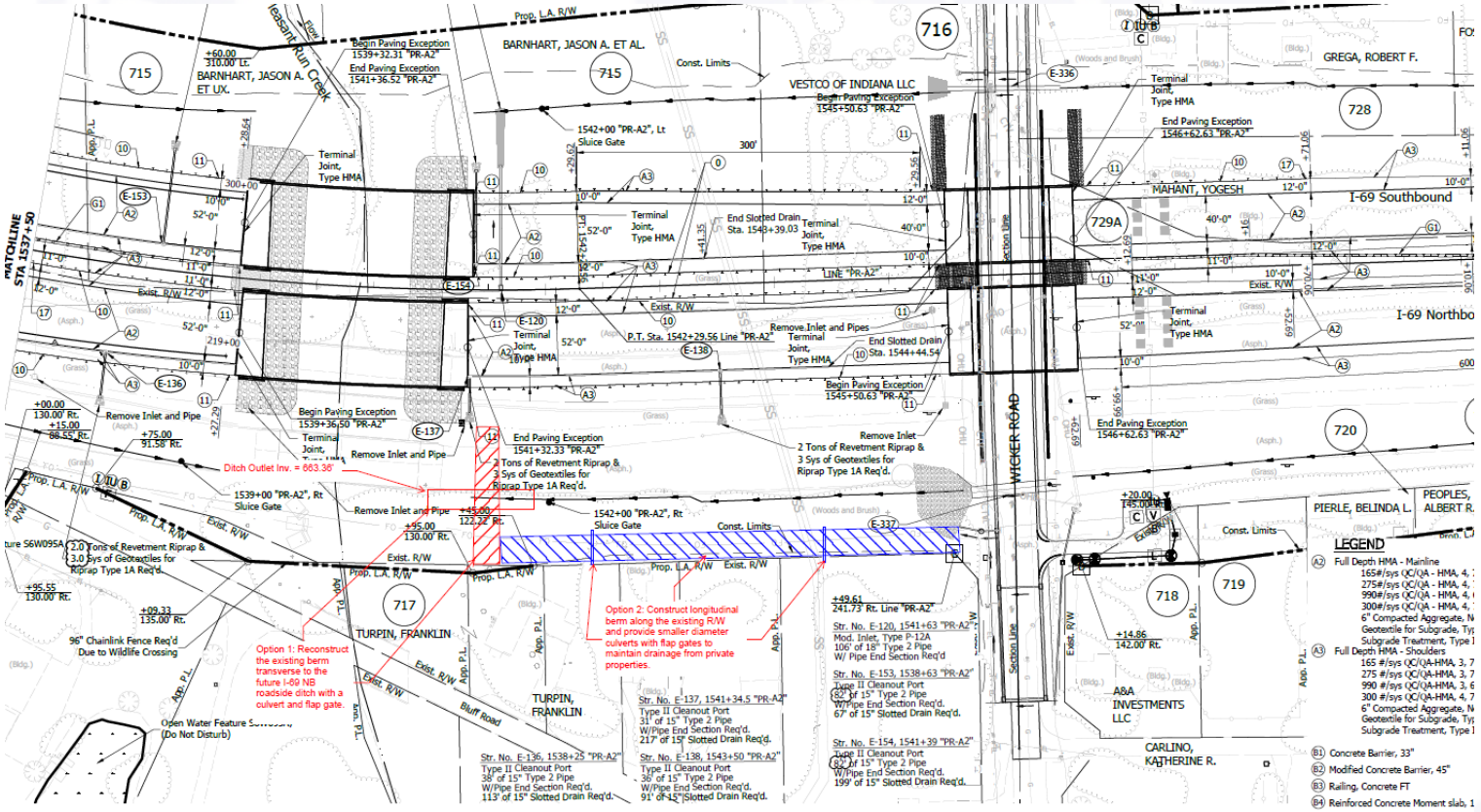
Case Study No. 9 – I-69 Private Berm

- Survey did not identify existing berm
  - Berm and low flow pipe removed
- It appeared to be protecting a small subdivision from small storm floods
- Construction contacted hydraulics



Case Study No. 9 – I-69 Private Berm

- Solution reconstruct the berm to most closely match existing conditions
  - Included weir overflow
  - Backflow prevention



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THANK YOU!

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