

COMMON ERRORS and ISSUES For Culvert Rehabilitation and Culvert Replacements

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Why THIS Presentation??? – 2 MAIN Reasons

- Both Reasons Are Mutually Beneficial
 - Reduce Total Number of Re-submittals
 - Reduce Time to Review Consultant submittals

Common Errors and Issues

- General
 - HY-8 Related
 - Submitting for Hydraulics
- Culvert Rehabilitation
 - Liners
 - Bored Pipes
 - Paved Inverts
- Culvert Replacements

Common Errors and Issues

(website) = INDOT Hydraulics Website

Std. Dwg = INDOT Standard Drawings

IDM = Indiana Design Manual

Web Addresses Provided at the End

General Errors/Issues – HY-8

- 1. When to use Outlet Depth vs Tailwater depth?

203-2.04(03) Tailwater Factors

3. The existing outlet depth may be used in lieu of the tailwater depth if the culvert outlet is operating with a low tailwater depth or a free outfall.

Sooo....

If the Existing Q100 Outlet Depth > Q100 Tailwater Depth → Use The EXISTING Q100 Outlet Depth in your backwater computations in lieu of tailwater depth.

General Errors/Issues – HY-8

Culvert Summary Table - Existing Condition

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	773.03	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
6.83	6.83	774.86	1.83	0.0*	5-S2n	1.00	1.04	1.00	0.30	6.48	2.70
13.66	11.80	776.84	3.81	3.75	6-FFc	1.25	1.25	1.25	0.38	9.62	3.21
20.49	11.90	776.90	3.87	3.80	6-FFc	1.25	1.25	1.25	0.45	9.70	3.55
27.32	11.96	776.93	3.90	3.83	6-FFc	1.25	1.25	1.25	0.50	9.75	3.82
34.15	12.01	776.96	3.93	3.86	6-FFc	1.25	1.25	1.25	0.54	9.79	4.04
40.98	12.05	776.98	3.95	3.88	6-FFc	1.25	1.25	1.25	0.58	9.82	4.23
47.81	12.09	777.00	3.97	3.90	6-FFc	1.25	1.25	1.25	0.61	9.85	4.39
54.64	12.13	777.02	3.99	3.92	6-FFc	1.25	1.25	1.25	0.65	9.88	4.54
61.47	12.16	777.04	4.01	3.93	6-FFc	1.25	1.25	1.25	0.67	9.91	4.68
68.30	12.19	777.06	4.03	3.95	6-FFc	1.25	1.25	1.25	0.70	9.94	4.80

Display: Crossing Summary Table Culvert Summary Table Water Surface Profiles Improved Inlet Table

Geometry: Inlet Elevation: 773.03 ft, Outlet Elevation: 772.61 ft, Culvert Length: 42.40 ft, Culvert Slope: 0.0099, Inlet Crest: 0.00 ft

Plot:

General Errors/Issues – HY-8



INDIANA DEPARTMENT OF TRANSPORTATION

100 North Senate Avenue
Room N642-BR
Indianapolis, Indiana 46204

PHONE: (317) 233-2096
FAX: (317) 233-4929

Eric Holcomb, Governor
Joe McGuinness,
Commissioner

<Date>

TO: 0000000 00000000
INDOT Project Manager

FROM: 0000000 00000000
Consultant Engineer
<email>
<firm>

< Signature >

THROUGH: 0000000 00000000
INDOT Engineer

< Signature >

< Designer Stamp >

SUBJECT: Hydraulic Review
Des. #:
Structure #: <(Culvert or Bridge Asset ID)>
County:
Location: <(Determined from BIAS or SPMS)>
Crossing: <(stream crossing)>
DNR CIF Permit Required (Y/N): Choose an item.
Legal Drain (Y/N): Choose an item.



Site Parameters		
Drainage Area	(Area)	
Q ₁₀₀ Discharge	(discharge)	cfs
Choose an item. Discharge for velocity	(discharge)	cfs
Q ₁₀ Outlet Depth		ft.
US Edge of Travel Lane	(road elev)	ft.
Design Roadway Serviceability Elevation	(serv. elev)	ft.

General Errors/Issues – HY-8

- 2. How to model a flared metal end section (or other type) in HY-8?
 - INDOT Hydraulics Website - <https://www.in.gov/indot/3595.htm> (Website)

Related Links and Documents

Design Guidance

- [Indiana Design Manual](#)
- [Standard Drawings](#)
- [Archived Project's Plan Request](#)
- [Waterway Permit Manual](#)
- [Driveway Permit Manual](#)
- [INDOT Driveway Permit Checklist](#)
- [BIAS](#)
- [HEC-RAS Bridge and Scour Modeling Procedures](#)
- [Bevel Edge Headwall Figures](#)
- [Culvert Inlet Coefficients](#)

General Errors/Issues – HY-8

End-Treatment Type	Pipe Material Type	K_E	HY-8 Inlet Edge Condition Used	Standard Drawing	Picture
Flared Metal Pipe End Section	Corrugated Metal Pipe, end section conforming to fill slope	0.5	Square Edge with Headwall	E 715-MPES	

General Errors/Issues – HY-8

- 3. What to do if a pipe has an adverse or reverse slope (sloped the wrong way)?
 - HY-8 Version 7.2 (Currently accepted version) will not allow for adverse slopes.
- (INDOT Hydraulics Website FAQ)
- *If the existing pipe has a reverse slope, we recommend bringing the inlet invert to the elevation of the outlet creating a flat pipe.*

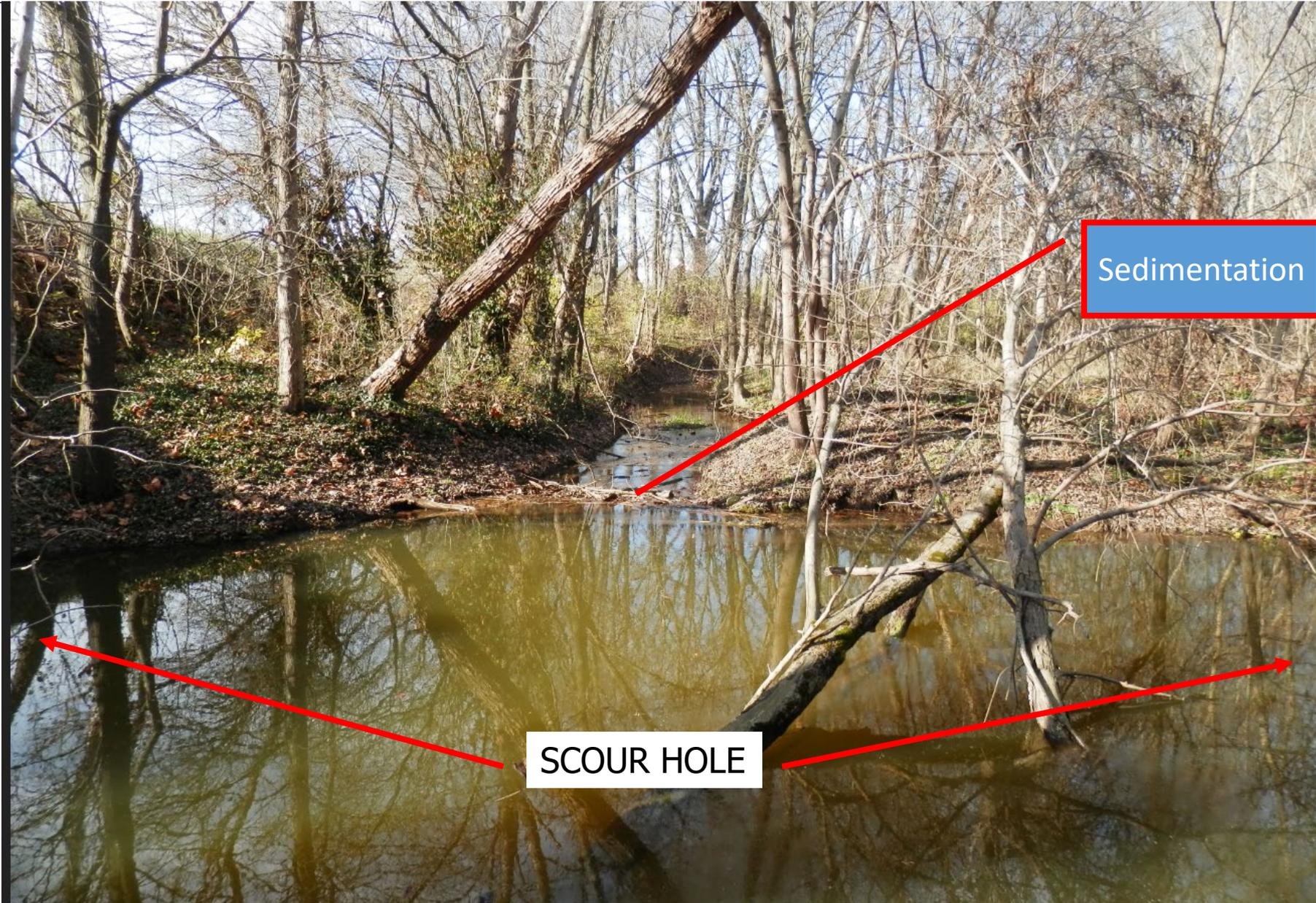
General Errors/Issues – HY-8

- 4. Where do I survey the downstream cross section for HY-8



General Errors/Issues – HY-8

- Scour
- Holes



General Errors/Issues – HY-8

- Scour
- Hole
- And
- A
- Free
- Outfall

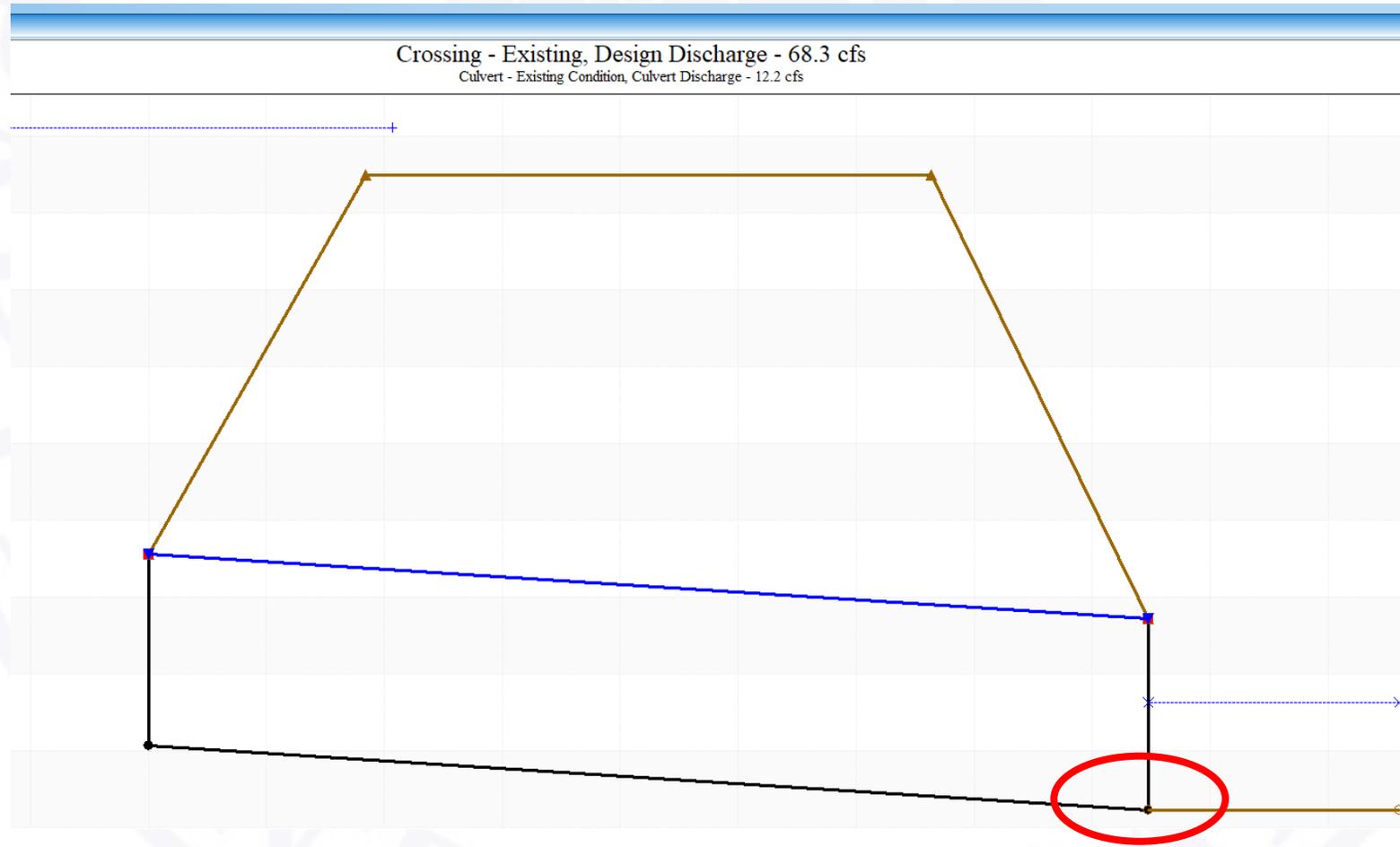


General Errors/Issues – HY-8



General Errors/Issues – HY-8

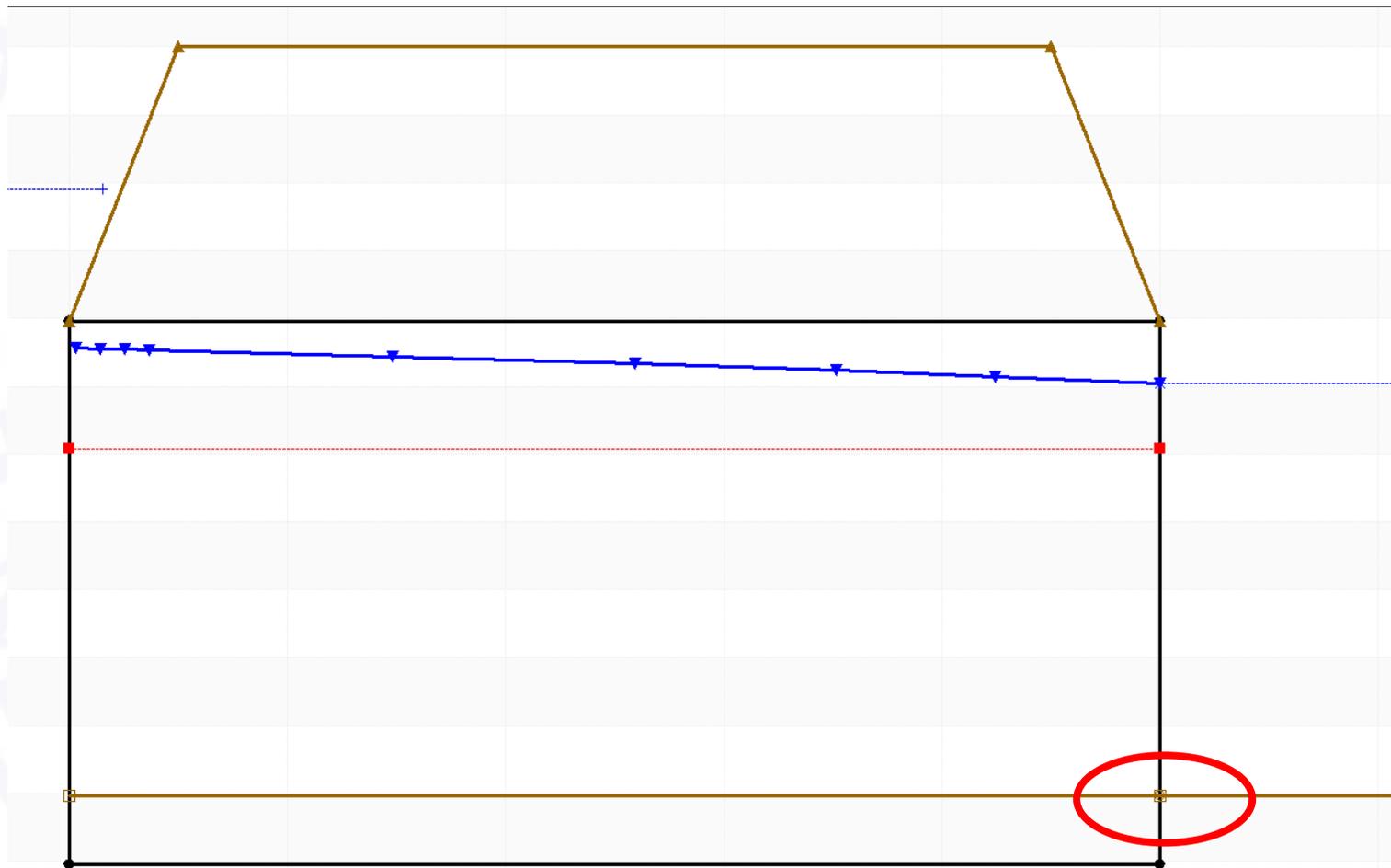
- 5. Inverts/Flowlines and quick visual Checks (*For most projects*)
- Downstream channel Flowline and Cross section should be adjusted so that the flowline elevation matches the Existing Outlet pipe invert



General Errors/Issues – HY-8

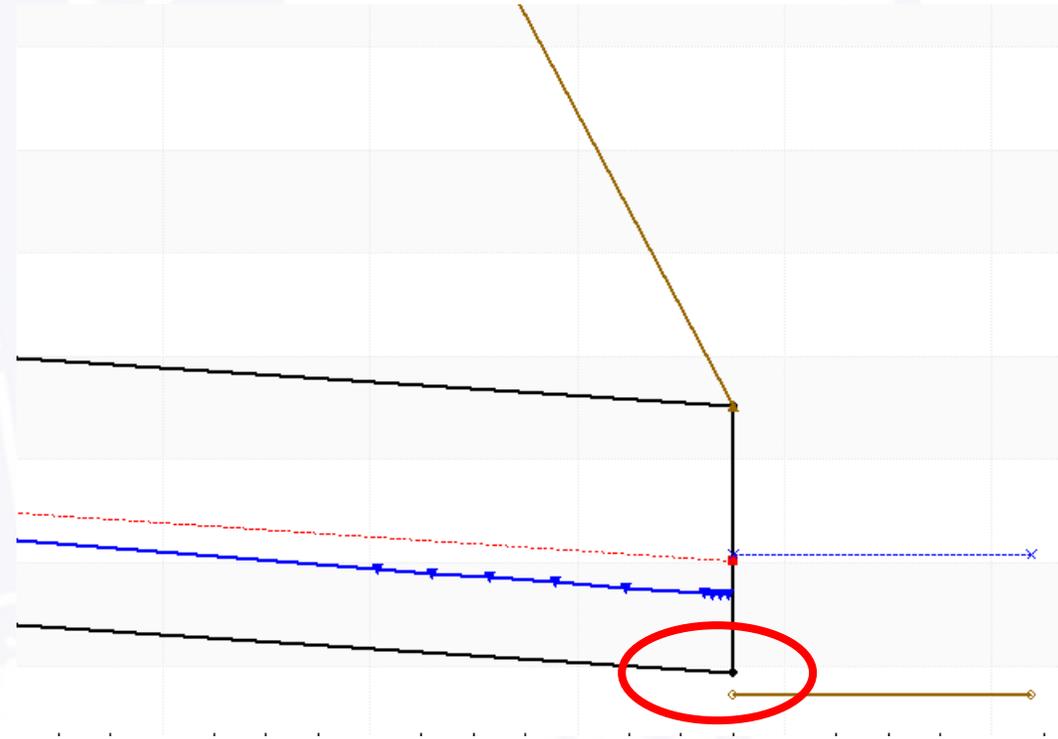
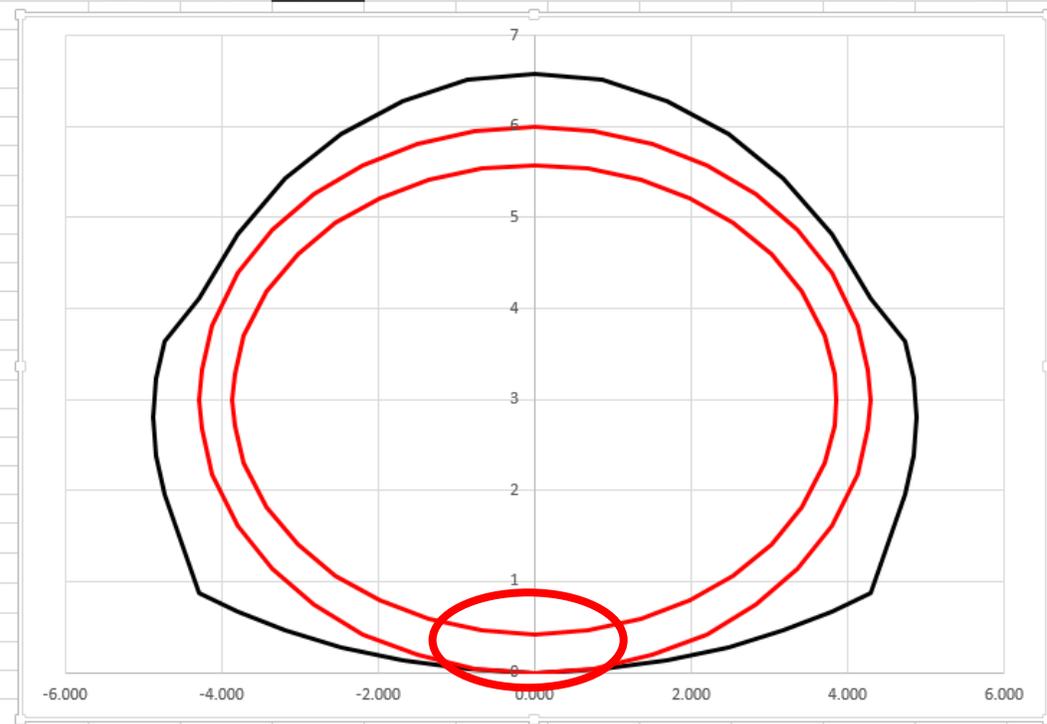
- 5. Inverts/Flowlines and quick visual Checks (*For most projects*) – (Cont.)
- Proposed Sumped Flowline Should Match Existing Flowline

Crossing - Repl - Specialty, Design Discharge - 855.0 cfs
Culvert - 13 ft by 8 ft RCB, Culvert Discharge - 855.0 cfs



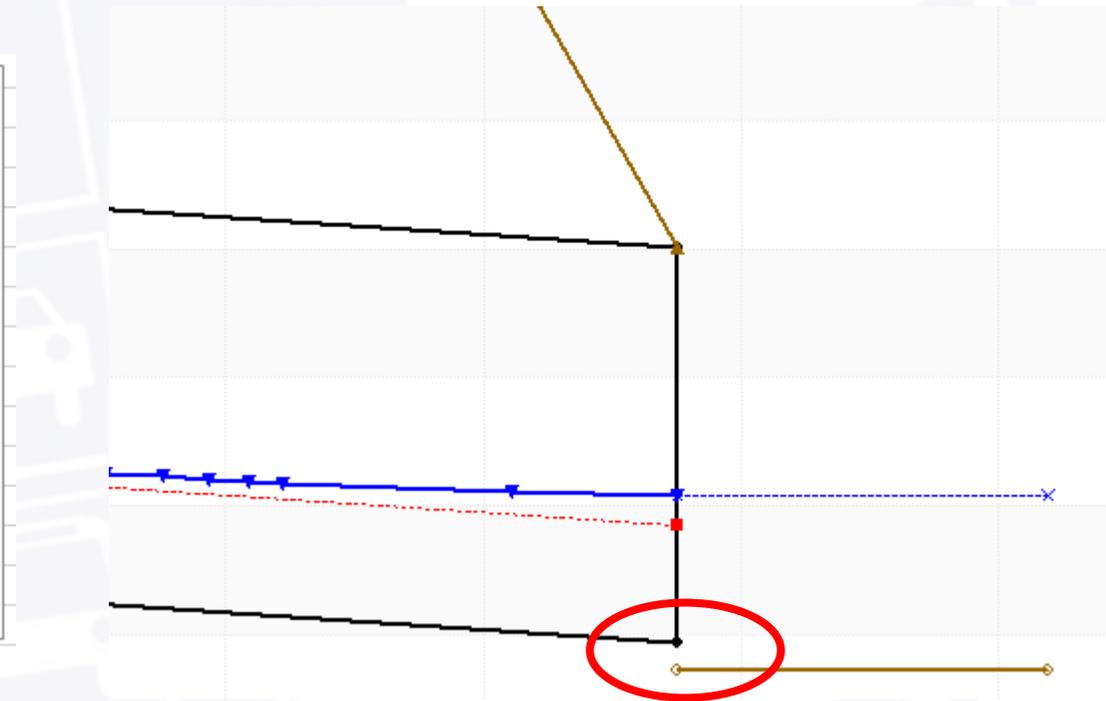
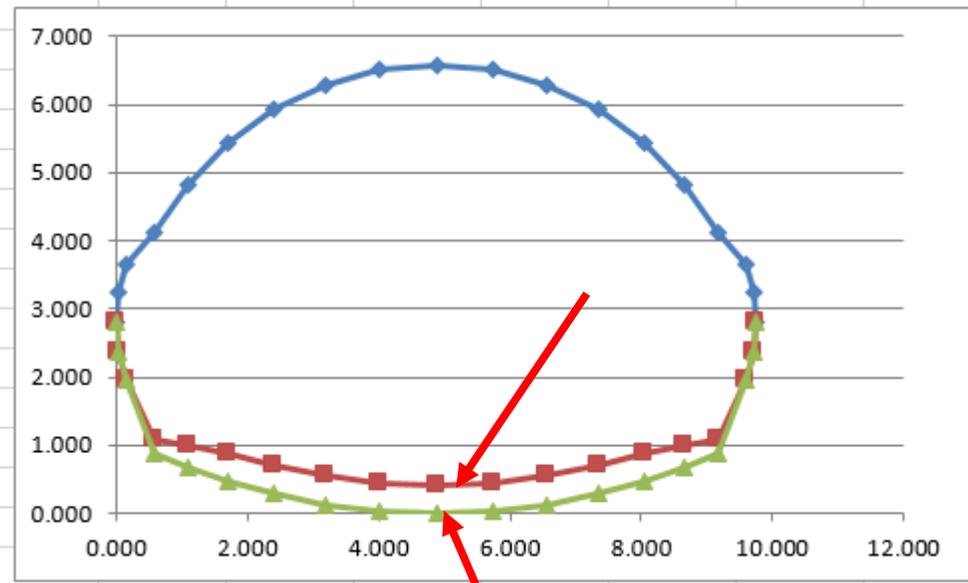
General Errors/Issues – HY-8

- 5. Inverts/Flowlines and quick visual Checks (*For most projects*) – (Cont.)
- Proposed Liner invert should be slightly above Existing flowline



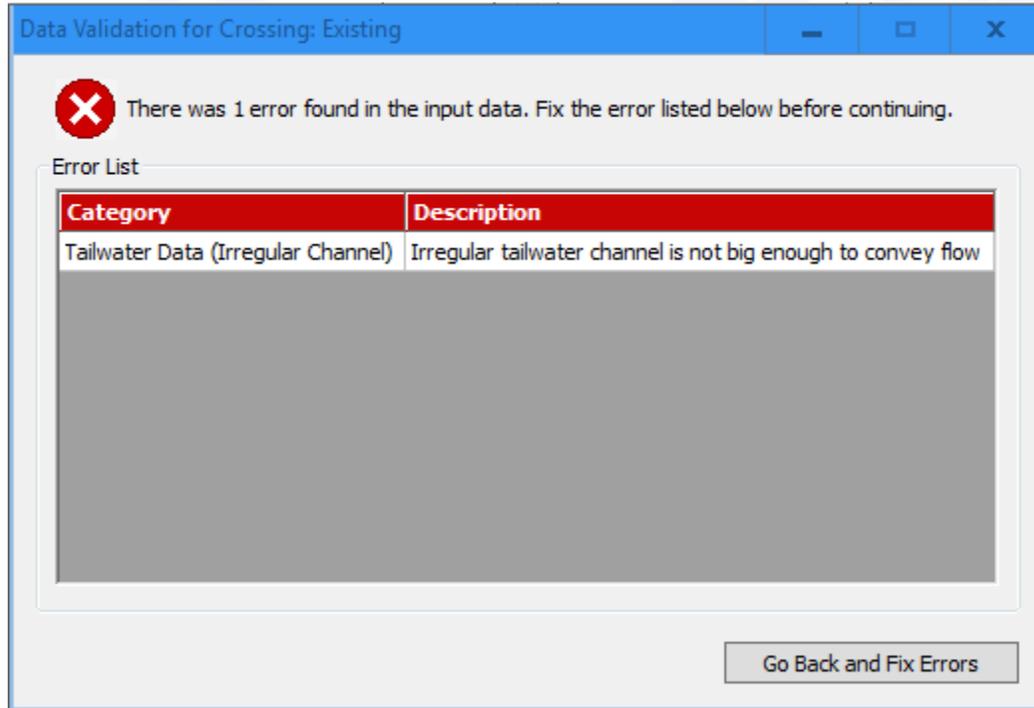
General Errors/Issues – HY-8

- 5. Inverts/Flowlines and quick visual Checks (*For most projects*) – (Cont.)
- Proposed Paved Invert should be 5" above Existing flowline



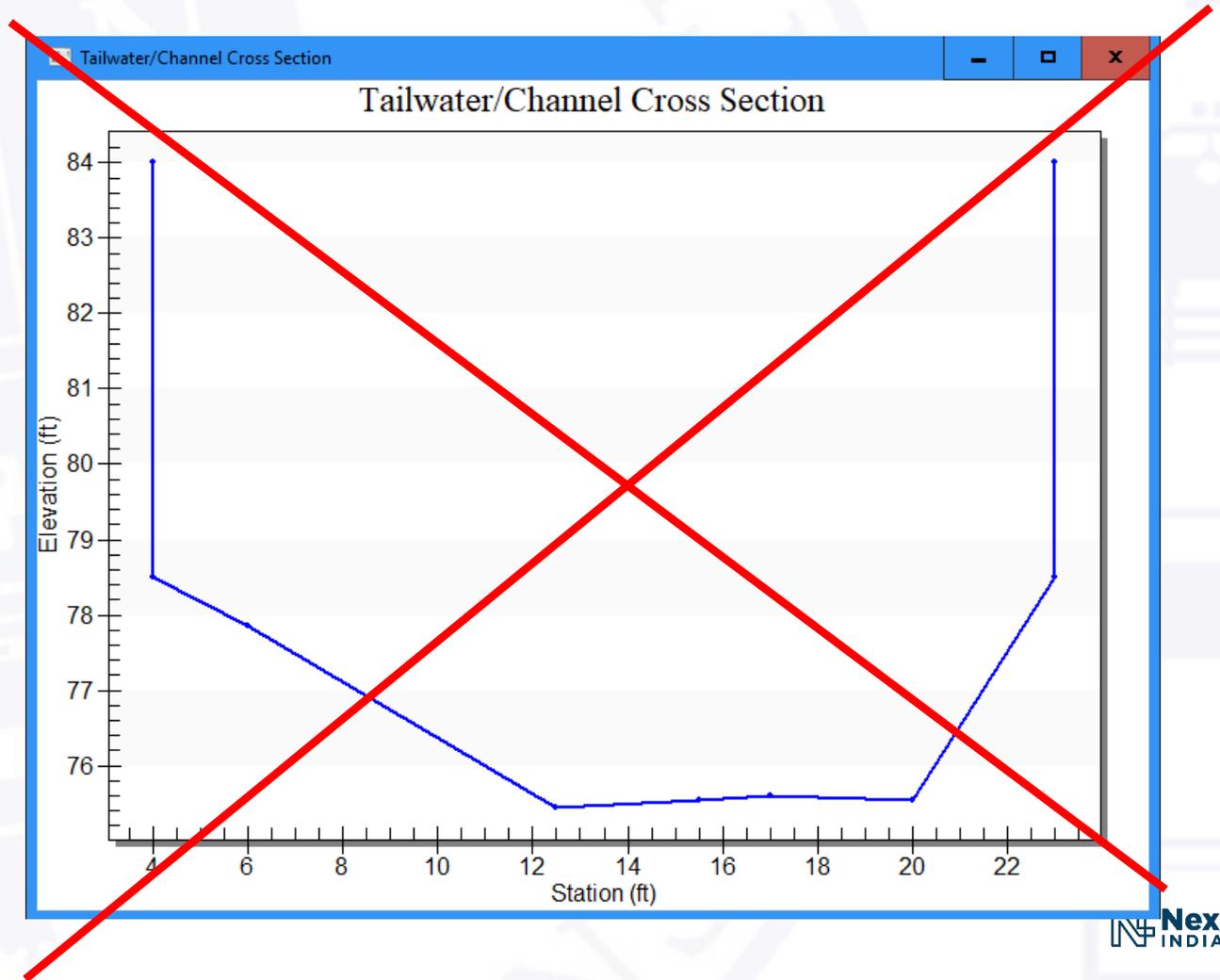
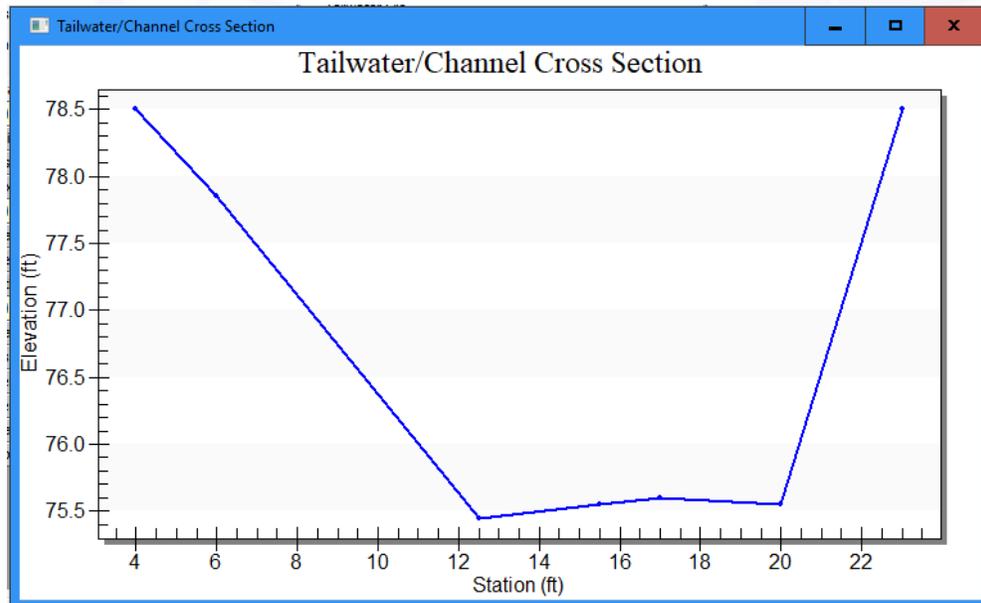
General Errors/Issues – HY-8

- 6. Most of us have gotten this error in HY-8



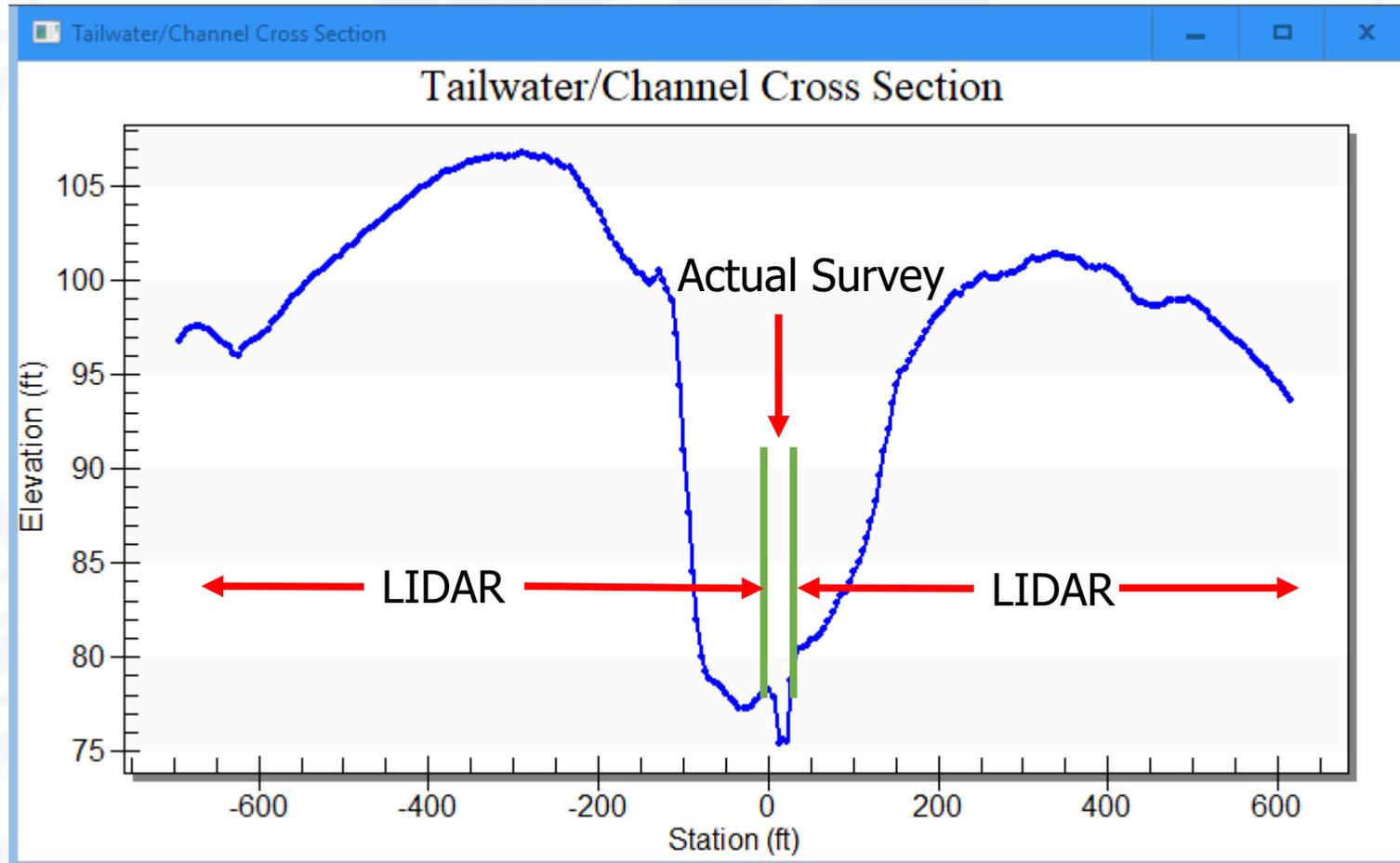
General Errors/Issues – HY-8

- 6. Your initial field surveyed section may look like this?
- Some people like to try this →



General Errors/Issues – HY-8

- 6. Supplement the cross section data with more realistic site conditions (LIDAR or Survey)

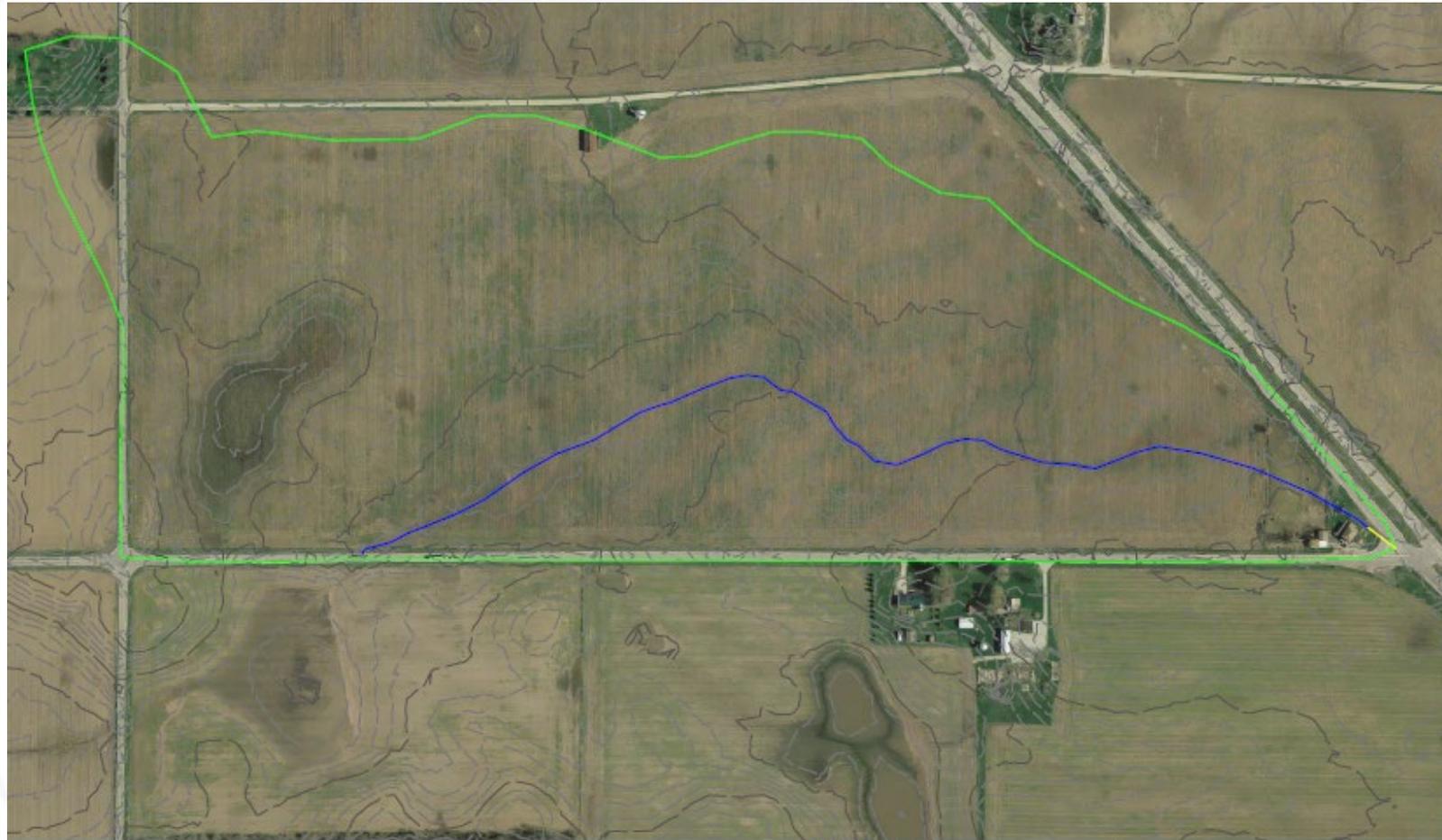


General Errors/Issues -

SUBMITTALS

General Errors and Issues - Submittals

- 1. Show Drainage Area Delineation with Contours and TC Path for EACH Culvert



Appendix G
Watershed Delineation
SR 28 Culvert 2

LEGEND

- Watershed Boundary 
- Sheet Flow 
- Shallow Concentrated Flow 

SCALE



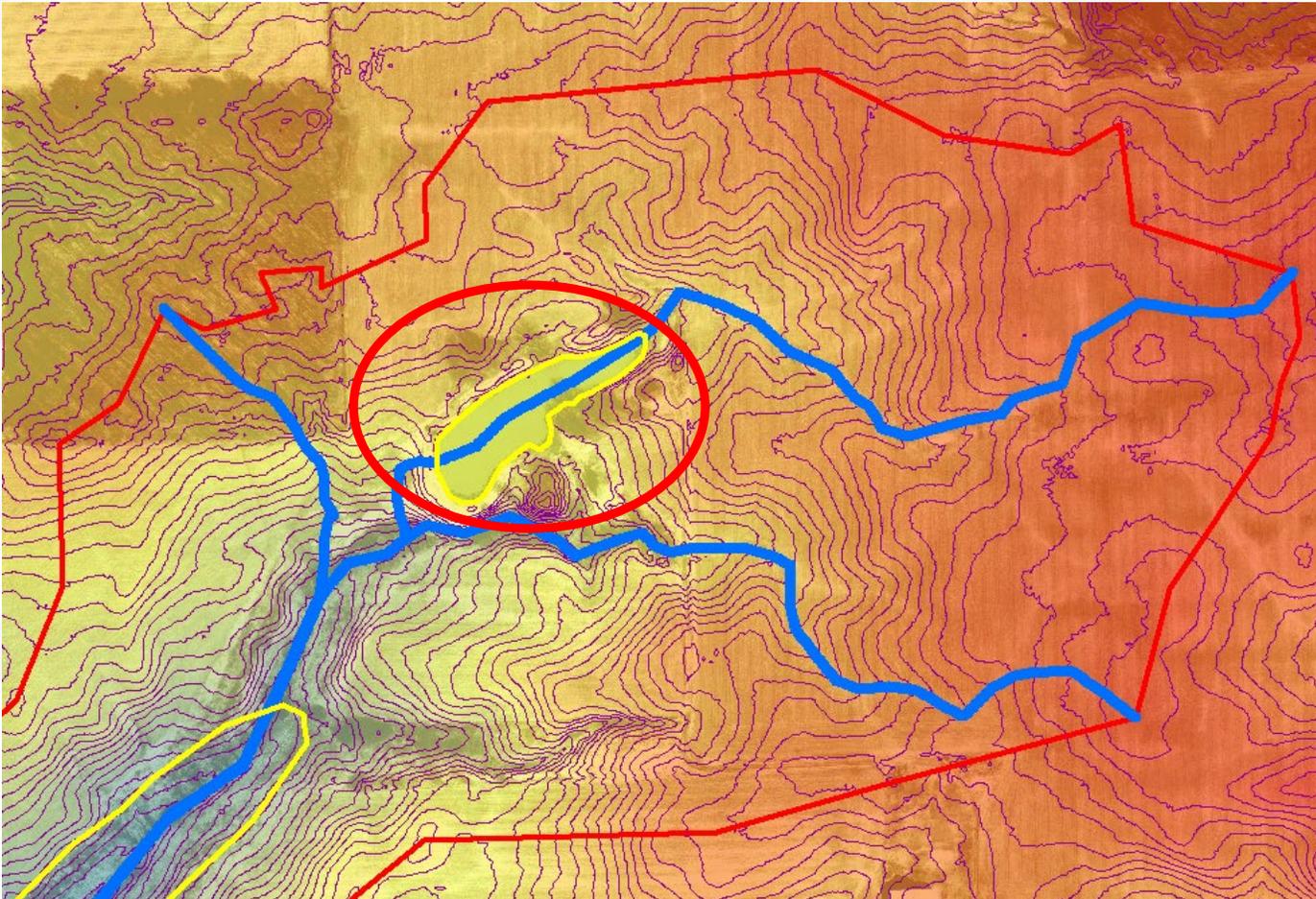
ants

General Errors and Issues - Submittals

- 3. Submit your HY-8 , HEC-RAS, and HEC-HMS, models with your submittals – Not just screen shots of the output.
- FOR HY-8
 - Existing and Proposed Runs should be in together in 1 HY-8 file
 - You should have 1 HY-8 files for Each Individual Culvert

General Errors and Issues - Submittals

- 4. For Time of Concentration computations, any part of the Path through a pond should be excluded from the time. So it will take no time from when the water enters a pond, to where it exits the pond.



General Errors and Issues - Submittals

- 5. Structure Size and Type in the Model should match the Hydraulic Memo
- 6. Provide Inlet, Outlet, and downstream channel photos (minimum)

PHOTO NOTES:



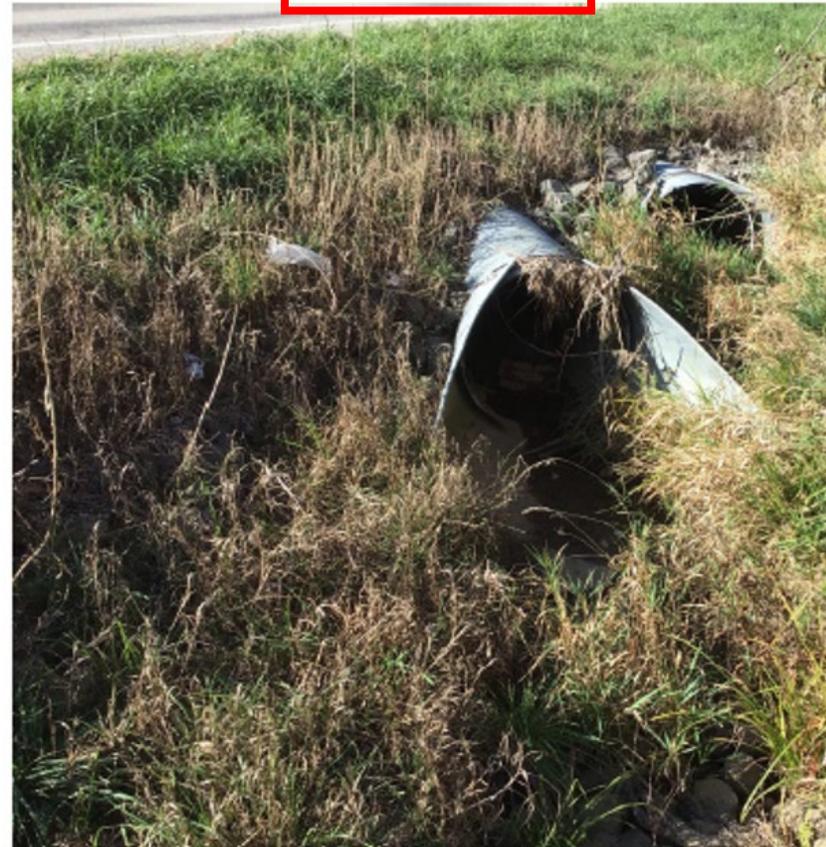
= Upstream

Photo1.jpg



Photo2.jpg

Downstream



General Errors and Issues - Submittals

- 6. Provide Inlet, Outlet, and downstream channel photos (Cont.)

Photo2.jpg

Downstream



General Errors and Issues - Submittals

- 7. HY-8 7.2 is the only currently accepted version. (Website)
 - HY-8 v.7.2 is currently the only version permitted for use by the INDOT Office of Hydraulics. The link to upload the software is on the [Active Design Memoranda](#) page under number 16-34.
- 8. Due to a recent Windows 10 update, if you try to install HY-8, there is a necessary file that is now missing. (Website)
- So if you already have HY-8 7.2 installed 
- If you haven't? : Visit INDOT Hydraulics Website
 - Due to Window's updates, HY-8 v.7.2 will not install without first installing the application that can be downloaded by [clicking here](#). After this application is installed, HY-8 v.7.2 may be installed.

General Errors and Issues - Submittals

- Large Design Submittals ...
 - Break Them up – Separate Reports and Submittals
 - Culverts (~10 culverts per submittal)
 - -Break up by watershed
 - Detention Separate Submittal
 - Median Drains Separate Submittal
 - Storm Drains Separate Submittal

General Errors and Issues - Submittals

10. Situations it would be prudent to have a PRE-Submittal Meeting with INDOT Hydraulics or a phone call at a minimum.
 - a. There is no defined channel downstream (Farm fields on both sides) – may consider matching existing rather than upsizing to meet current IDM.
 - b. Planning requires altering the existing drainage pattern.
 - c. The model shows roadway overtopping, but in order to eliminate it, will require a significant change to the scope of the project. (Grade raise required or Pipe size increases from 4' Diameter to 20' RCB)
 - d. Anything you haven't encountered or seen before



General Errors and Issues - Submittals



Culvert Rehabilitation

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 1. When analyzing an existing structure that has been lined, or extended with a different size/type, you should use the ORIGINAL Structure Size and Type for modeling the existing condition.
- So if a 4'x4' RCB has been extended on both ends with a 4' diameter CMP, you would analyze the existing as if it were a 4'x4' RCB

And

If you are looking to replace a 48" CMP that has been lined with a 36" HDPE, you should analyze the existing as if it were the 48" CMP

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

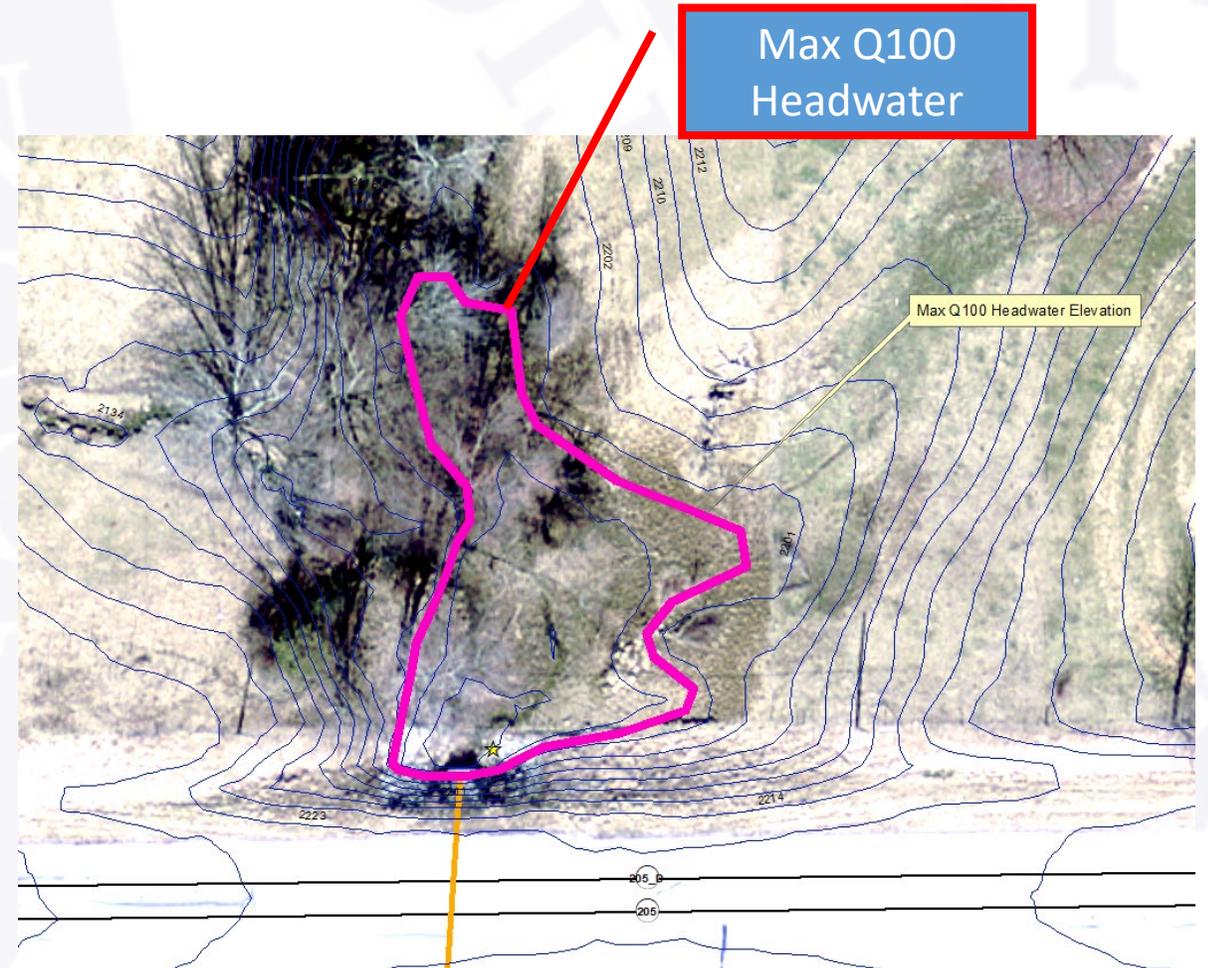
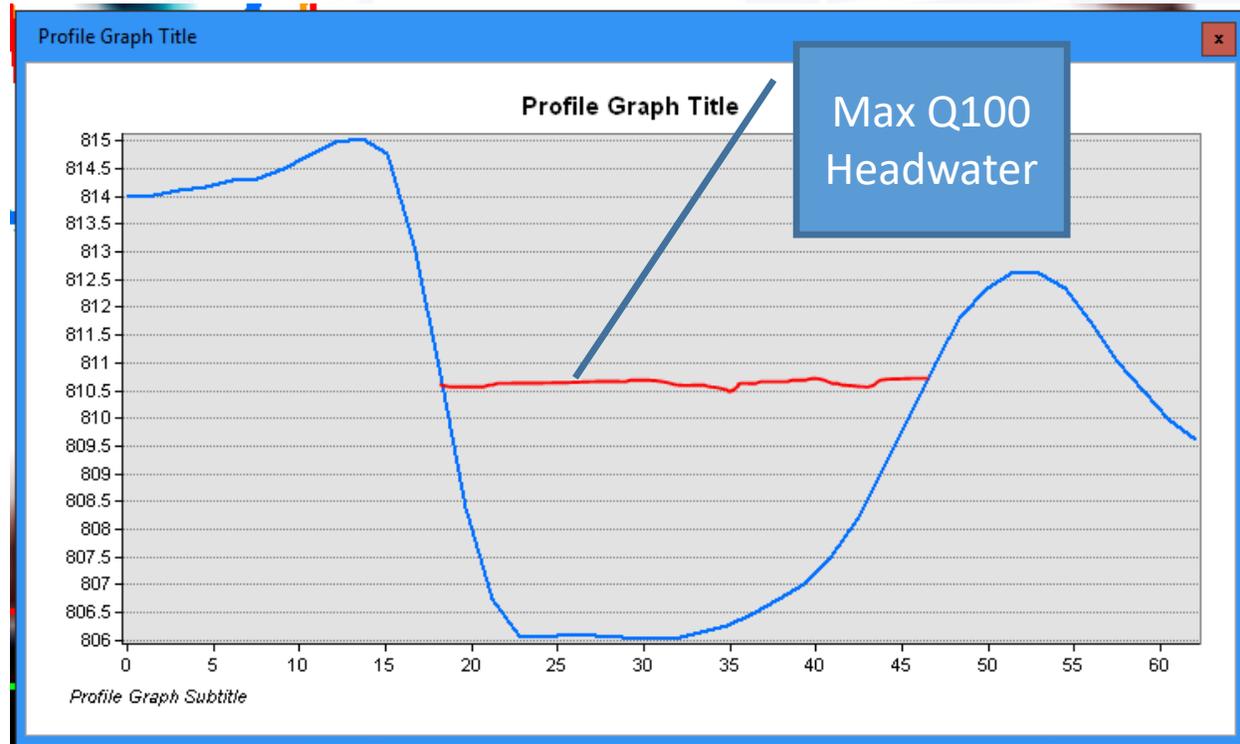
- 2. What inlet condition do I use in HY-8 for a liner/Paved Invert? (Website)
 - **What kind of inlet type should I choose when lining a pipe?**
 - *When initially lining a pipe with CIPP, the inlet configuration should match whatever is in the field, unless the existing pipe is projecting. In which case, the liner should have an inlet configuration of mitered to conform to slope.*
 - *When initially lining a pipe with HDPE liner, the inlet configuration should have an inlet configuration of mitered to conform to slope even if the existing pipe has a headwall. If a headwall or bevel edge is needed for the HDPE liner to perform correctly, it will need to be constructed with the project.*
 - *If you are putting in a 5" paved invert, the inlet configuration should simply match the existing configuration. If you need to improve the inlet configuration, then adding a headwall or a headwall with bevel edge is acceptable with the proposal.*

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 3. For Liners, if your liner increases the headwater > Existing Headwater:
- IDM (203-2.02(13)) → 2. Design Criteria. A structure may not increase backwater over existing conditions. Exceptions to this will require justification and approval by the Office of Hydraulics.
- Provide Justification **IN THE MEMO** (i.e. contained in the ditch, contained on INDOT R/W, Flood Easements)
- Provide visual evidence (Contour boundary of Headwater or section showing headwater in the ditch)

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 3 (Cont.) – Headwater – Show it.



Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 4. When installing a Bored Pipe adjacent to a lined pipe, what elevation should I set the inverts? (Website)

- The invert of a jack and bored pipes will be set to a minimum of 1 ft above the invert of the existing pipe to be lined. If this is not feasible due to site constraints, please coordinate with the Office of Hydraulics.

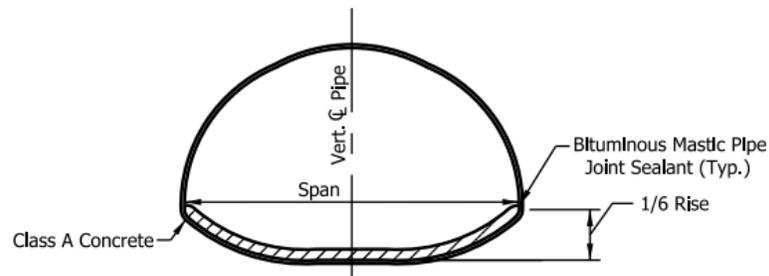
For Low Q100 Elevations, we will typically allow the bored pipe to be set 6" above the existing.

- 5. What is the minimum internal diameter of a bored pipe?
(Website)

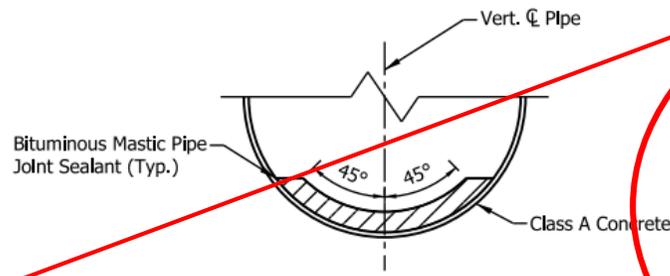
- Jack and bore pipes as part of a culvert liner project under the interstate are required to have a minimum inner diameter of 18 inches.

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

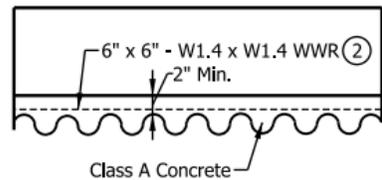
- 6. When providing Liner Options, we typically would also like to see a 5" paved invert option if it meets Liner design Criteria.
- Standard Drawing → Std Dwg. E 715-Pipe-02



STRUCTURAL PLATE
PIPE-ARCH CULVERT
ELEVATION

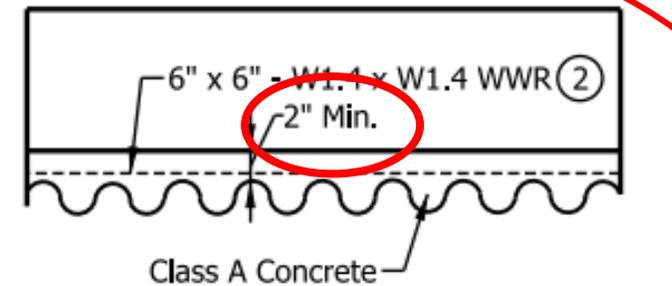


STRUCTURAL PLATE
PIPE CULVERT



TYPICAL LONGITUDINAL SECTION

CONCRETE FIELD PAVED INVERT DETAILS



TYPICAL LONGITUDINAL SECTION

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 6. Must State the Thickness of the Paved Invert in the Memo

Site Parameters		
Drainage Area	(Area)	
Q ₁₀₀ Discharge	(discharge)	cfs
QChoose an item. Discharge for velocity	(discharge)	cfs
Q ₁₀₀ Choose an item. Depth	(TW depth)	ft.
US Edge of Travel Lane	(road elev)	ft.
Design Roadway Serviceability Elevation	(serv. elev)	ft.

Culvert Properties								
Parameter	Existing		Proposal 1		Proposal 2		Proposal 3	
Structure Size & Type					5" Paved Invert		(delete column if not needed)	
Q ₁₀₀ Headwater Elevation		ft.		ft.		ft.		ft.
QChoose an item. Headwater Elevation		ft.		ft.		ft.		ft.
Meets Roadway Serviceability @ QChoose an item.	Choose an item.		Choose an item.		Choose an item.		Choose an item.	
Backwater		ft.		ft.		ft.		ft.
Minimal Low Structure Elevation (DS)		ft.		ft.		ft.		ft.
Assumed Flowline Elevation (DS)		ft.		ft.		ft.		ft.
Sump Depth		in.		in.		in.		in.

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 6. Spreadsheet for Coordinates in HY-8: (Website)

Other Links and Forms

- [Field Data Form](#)
- [Safety Briefing Form](#)
- [INDOT Traffic Count Database System](#)
- [5" Paved Invert Worksheet](#)
- [Minimum Culvert Cover Worksheet](#)
- [Elliptical HDPE Pipe Lining Worksheet](#)
- [Huff Distribution Regions](#)
- [CIPP Lining Worksheet](#)
- [Specialty Structure Coordinate Generator](#)
- [TR-20 Input Files](#)
- [Proposed Structures Flow Chart](#)
- [INDOT Method Inlet Spacing Worksheet](#)

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 6. Paved Invert (Cont.)

2) Input the Yellow Highlighted information into HY8

-2.500	0.000	0.000	0.00
-2.344	0.870	-0.870	-0.87
-2.031	1.457	-1.457	-1.46
-1.719	1.815	-1.815	-1.62
-1.406	2.067	-2.067	-1.74
-1.094	2.248	-2.248	-1.83
-0.781	2.375	-2.375	-1.95
-0.469	2.456	-2.456	-2.036
-0.156	2.495	-2.495	-2.075
0.000	2.500	-2.500	-2.080
0.156	2.495	-2.495	-2.075
0.469	2.456	-2.456	-2.036
0.781	2.375	-2.375	-1.955
1.094	2.248	-2.248	-1.828
1.406	2.067	-2.067	-1.737
1.719	1.815	-1.815	-1.615
2.031	1.457	-1.457	-1.457
2.344	0.870	-0.870	-0.870
2.500	0.000	0.000	0.000

Pipe Type Circular

Arch Circular

CMPA

Circular

Dia 5

1) input original arch coordinates from HY-8 user defined shapes

“This spreadsheet is intended as a tool to provide convenience in hydraulic design. There is no guarantee, either implied or explicit, as to the accuracy or reliability of the results provided by these spreadsheets. By using this spreadsheet, the user agrees to take full responsibility for the input data and for the interpretation and use of the spreadsheet results.”

Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 6. Paved Invert (Cont.)



Culvert Rehabilitation (Liners, Paved Inverts, Bored Pipes)

- 6. What is the minimum Pipe Size for a Paved Invert (Constructability)?
 - (Website)
- **What is the minimum pipe size for a paved invert option?**
 - *The minimum pipe size for a paved invert rehabilitation is for the existing pipe to have a minimum span and rise of 4 ft.*

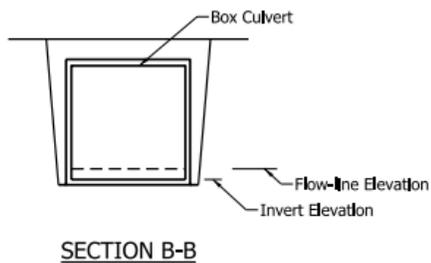
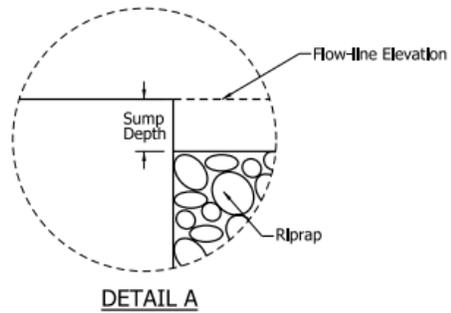
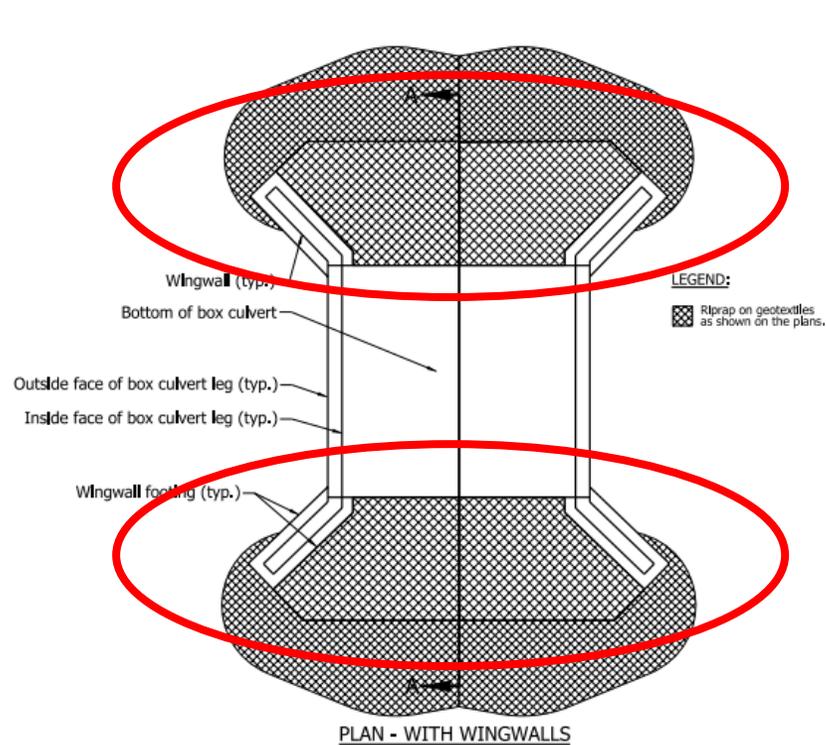
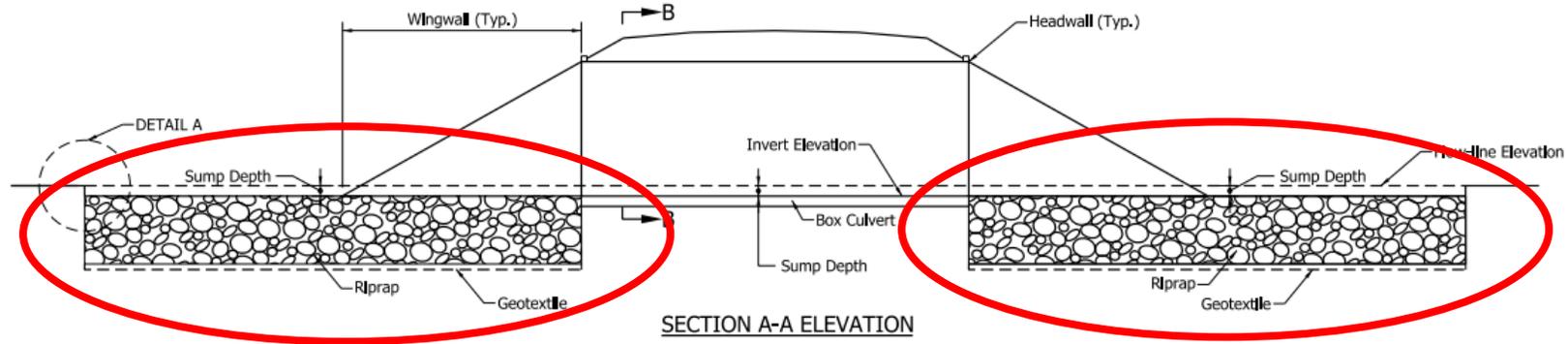
Culvert Replacement

Culvert Replacement

Culvert Replacement

- 1. RCB's and 3-Sided Structures will require riprap placed at the INLET and OUTLET According to their standard drawings.
- RCB → E 714-BCSP-01

Culvert Replacement



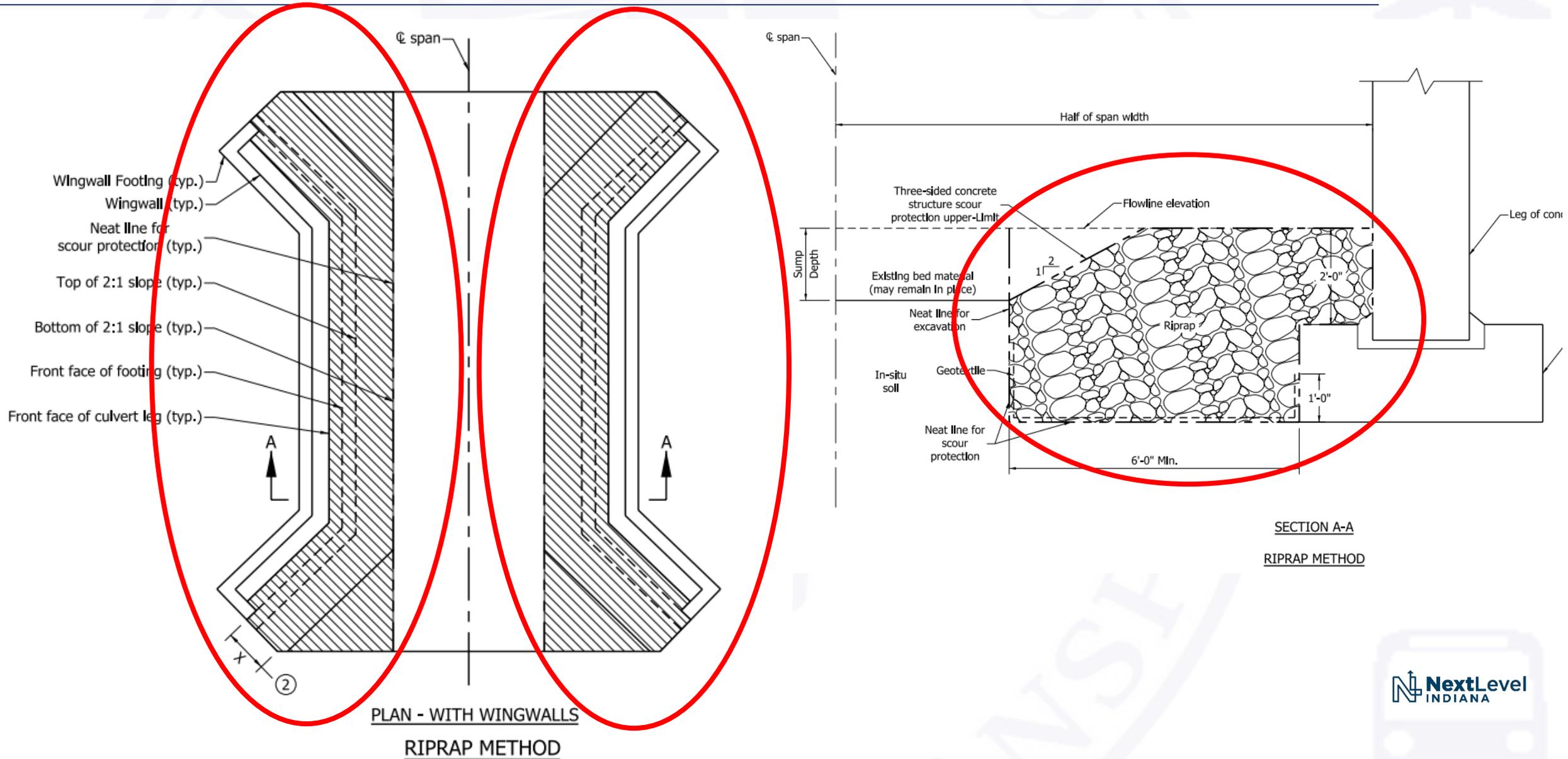
LEGEND:
 Riprap on geotextiles as shown on the plans.

INDIANA DEPARTMENT OF TRANSPORTATION	
BOX CULVERT SUMPING AND SCOUR PROTECTION	
SEPTEMBER 2011	
STANDARD DRAWING NO.	E 714-BCSP-01
	/s/ Richard L. VanCleave 09/01/11
	DESIGN STANDARDS ENGINEER DATE
	/s/ Mark A. Miller 09/01/11
	CHIEF HIGHWAY ENGINEER DATE
DESIGN STANDARDS ENGINEER	

Culvert Replacement

- 1. RCB's and 3-Sided Structures will require riprap placed at the INLET and OUTLET According to their standard drawings.
- 3-Sided Structures → E 723 CCSP (series)

Culvert Replacement



Culvert Replacement

2. Haunches for RCB's and 3-Sided Flat-Top Structures:



Culvert Replacement

2. Haunches for RCB's and 3-Sided Flat-Top Structures:

Spans < 18', Haunches should be modeled (Website)

Spreadsheet providing Coordinates is available on Website

- Reinforced concrete boxes and 3 sided structures under 18 foot span should incorporate corner haunches as produced by the manufacturer. The spreadsheet provided below, named Specialty Structure Coordinate Generator under Other Links and Forms, includes the haunch data from the manufacturers.

Culvert Replacement

2. Haunches - (Cont.)

RCB			
Sump Depth (in)	Span (ft)	Rise (ft)	Haunch (in)
12	10	8	12

Pts	X	Y-top	Y-Bot
1	1	2	2
2	1	8	2
3	2	9	1
4	10	9	1
5	11	8	2
6	11	2	2

Copy & Paste This Coordinate Set Into HY-8

6 Points	X	Y-top	Y-bot
1	0	1.1	1.1
2	0	7	1
3	1	8	0
4	9	8	0
5	10	7	1
6	10	1.1	1.1

-RCB haunch size: For 9 ft to 24 ft span 12 in. rise and run
 -RCB haunch size: For 6 ft to 8 ft span 12 in. or 8 in. rise and run.
 -RCB haunch size: For 3 ft to 5 ft span 8 in. or 7 in. rise and run.

Use largest Haunch For size listed

RCB Plot

So, for a 4'x4' RCB, you would Conservatively use an 8" Haunch

Culvert Replacement

3. A Sump is no longer required for 3-Sided Structures

Unless it is a County Regulated Drain and the County Surveyor/Drainage Board has requested a sump.

The End.

Questions???

Links:

INDOT Hydraulics:

<https://www.in.gov/indot/3595.htm>

INDOT IDM:

https://www.in.gov/indot/design_manual/design_manual_2013.htm

INDOT Standard Drawings:

<https://www.in.gov/dot/div/contracts/standards/drawings/sep19/sep.htm>

Historical Plans Request Website:

<https://entapps.indot.in.gov/OPSM/Dashboard/UserRequest>