WisDOT Aquatic Organism Passage Design Study

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National Hydraulic Engineering Conf.

Iowa City, Iowa

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WisDOT AOP Design Study Presentation Outline

1. Overview
2. Site Locations
3. Field Data Collection
    a. Survey – Cross Sections (At least 3 US and DS)
    b. Survey – Stream Thalweg (> 200 ft US and DS) and Existing Culvert Data
    c. Stream Bed Samples – Upstream and Downstream
    d. Stream Crossing Field Data
    e. Site Photos

WisDOT AOP Study Presentation Outline (cont.)

4. Hydrology Analysis
   a. Drainage Basin Mapping
   b. USGS Regression and HydroCAD
   c. Flow Selection
5. HEC-RAS/HY-8 Modeling
6. Stream Profile Analysis
7. Culvert Bed Gradation Selection
8. HEC-26 Analysis
9. Study Results

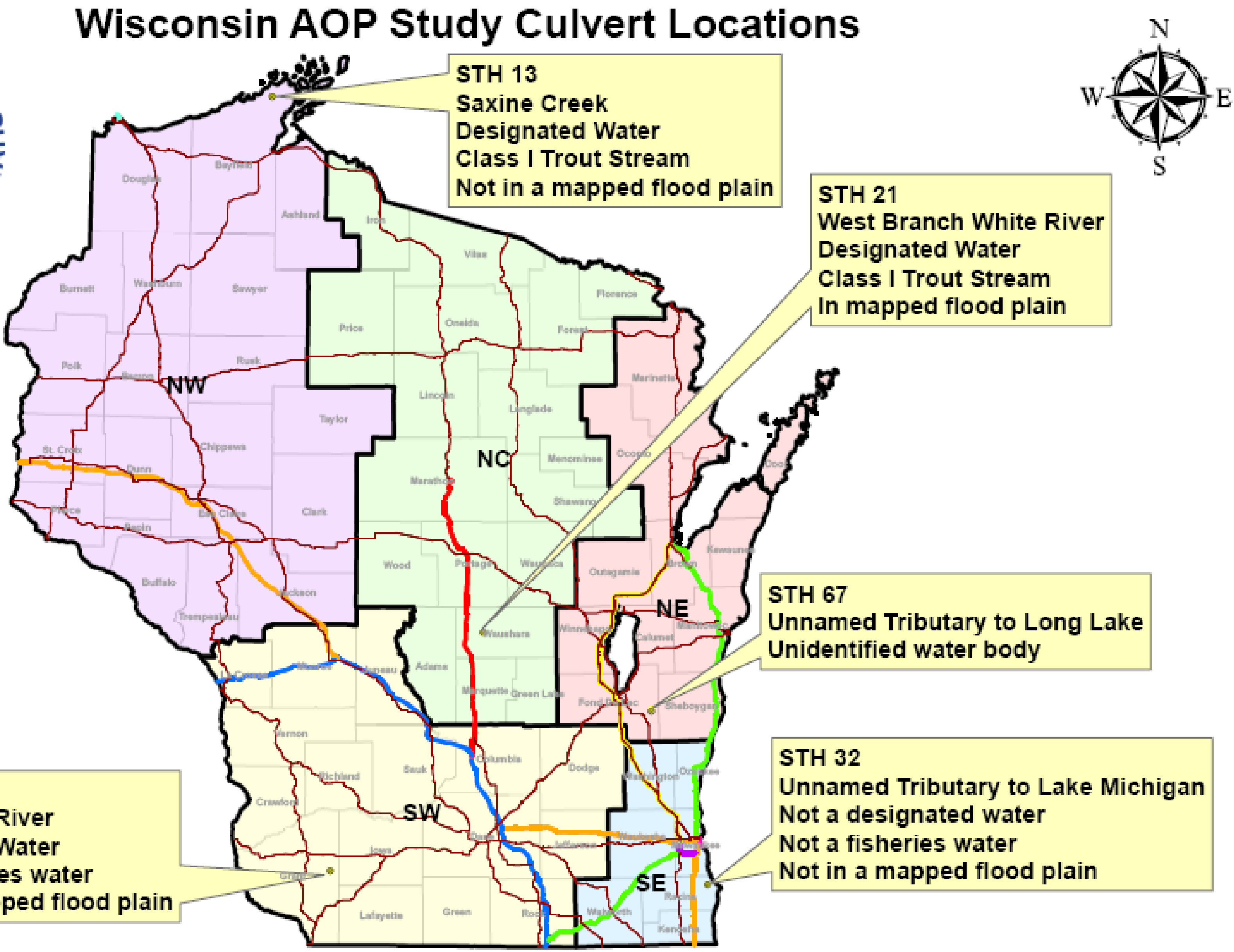
WisDOT AOP Study Overview

- WisDOT currently does not have a procedure for AOP design.
- WDNR is requesting consideration of AOP more frequently on projects.
- Evaluate HEC-26 as an appropriate tool for AOP Design
- Compare current culvert design procedures with recently released HEC 26 – *Culvert Design for Aquatic Organism Passage*

WisDOT AOP Study Overview

- WisDOT is working in cooperation with the WDNR on this study
- Results used to develop policy to define where AOP should be applied and to what extent
- And develop AOP design procedures based on results of the study

Site Locations



STH 13 – Saxine Creek in Bayfield County

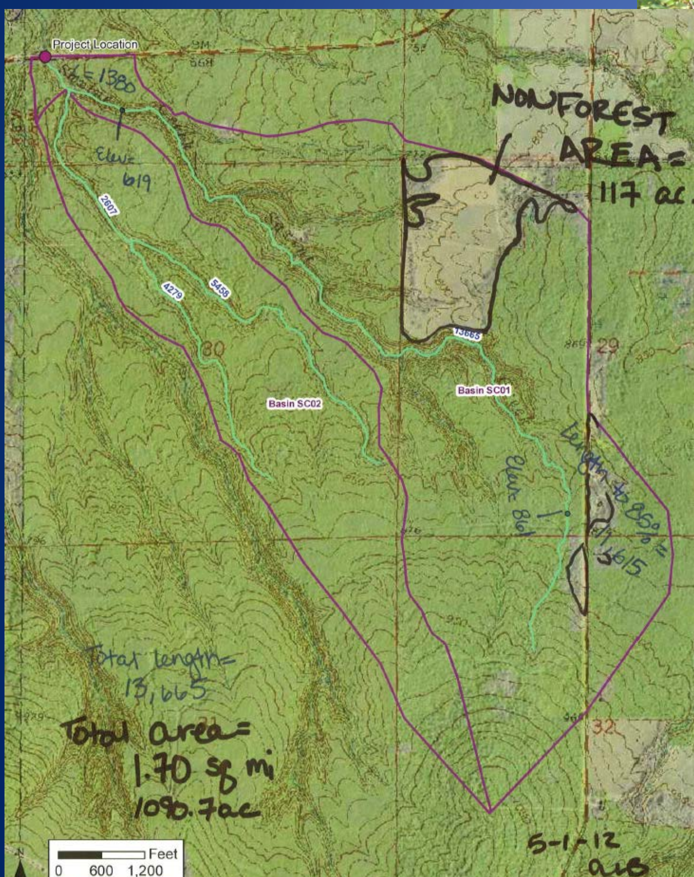


Table 2.2.6 Stream Crossing Field Data	
Bank Flow Width (ft)	12.5
Measured Structure Water Velocity (ft/sec)	3.07
Stream Velocity (ft/sec)	1.19
Stream Depth (ft)	0.35
Scour Pool Length and Width (ft)	20.4' x 38.75'
Scour Pool Depth (ft)	3.3
Upstream Pond Length and Width (ft)	None
Upstream Pond Depth	None
Is the outlet of the structure perched?	Yes
Is the structure water velocity greater than 3 feet/second during baseflow?	Yes

STH 21 - White River in Waushara County

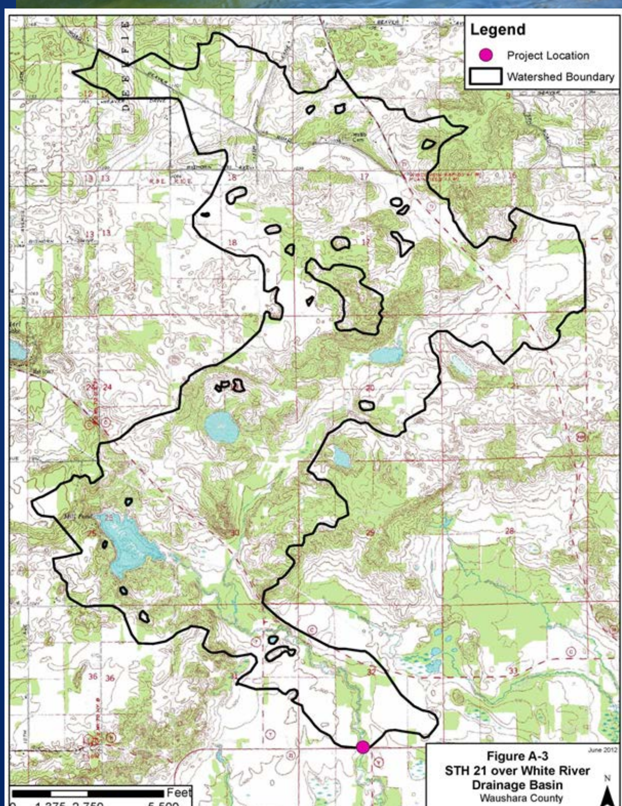


Table 2.3.6	
Stream Crossing Field Data	
Bank Flow Width (ft)	23.75
Measured Structure Water Velocity (ft/sec)	6.4
Stream Velocity (ft/sec)	2.02
Stream Depth (ft)	2.0
Scour Pool Length and Width (ft)	66' x 43.5'
Scour Pool Depth (ft)	4
Upstream Pond Length and Width (ft)	None
Upstream Pond Depth	None
Is the outlet of the structure perched?	No
Is the structure water velocity greater than 3 feet/second during baseflow?	Yes
Is the depth ratio less than 0.1?	No

STH 80 – Little Platt River in Grant County

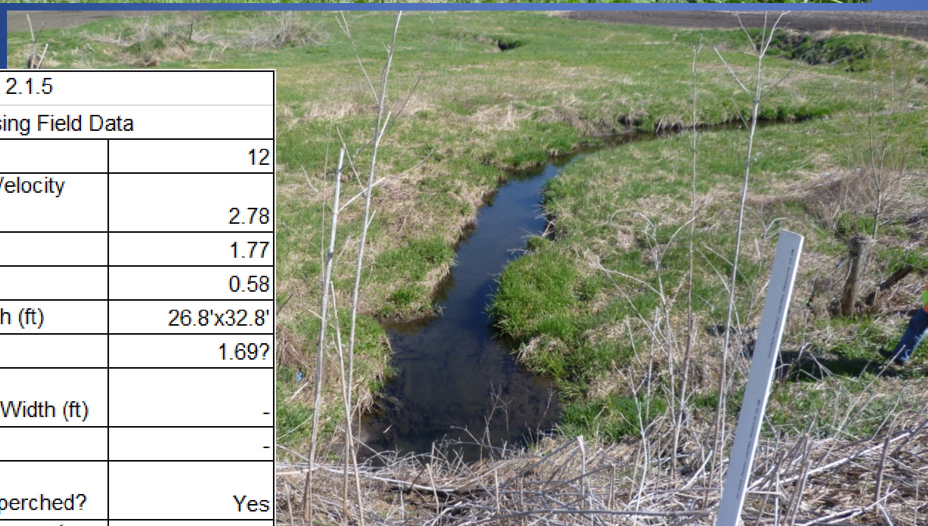
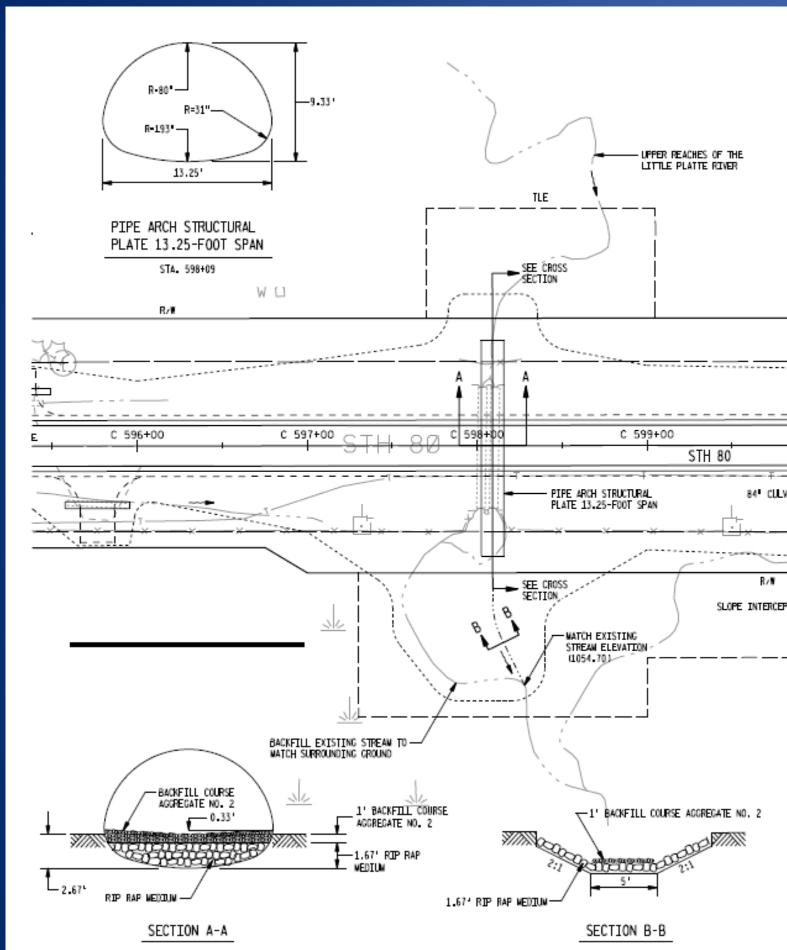


Table 2.1.5	
Stream Crossing Field Data	
Bank Flow Width (ft)	12
Measured Structure Water Velocity (ft/sec)	2.78
Stream Velocity (ft/sec)	1.77
Stream Depth (ft)	0.58
Scour Pool Length and Width (ft)	26.8'x32.8'
Scour Pool Depth (ft)	1.69?
Upstream Pond Length and Width (ft)	-
Upstream Pond Depth (ft)	-
Is the outlet of the structure perched?	Yes
Is the structure water velocity greater than 3 feet/second during baseflow?	No
Is the depth ratio less than 0.1?	?

STH 80 – Little Platt River in Grant County



STH 67 – Unnamed Trib to Long Lake in Fond du Lac County

Table 2.1.5	
Stream Crossing Field Data	
Bank Flow Width (ft)	11.16
Measured Structure Water Velocity (ft/sec)	1.1
Stream Velocity (ft/sec)	1.44
Stream Depth (ft)	0.1
Scour Pool Length and Width (ft)	13.4'x13.6'
Scour Pool Depth (ft)	1.0'
Upstream Pond Length and Width (ft)	43'x3.2'
Upstream Pond Depth (ft)	look at survey datat
Is the outlet of the structure perched?	Yes
Is the structure water velocity greater than 3 feet/second during baseflow?	No
Is the depth ratio less than 0.1?	No

STH 32 – Unnamed Trib to Lake Michigan – Racine County

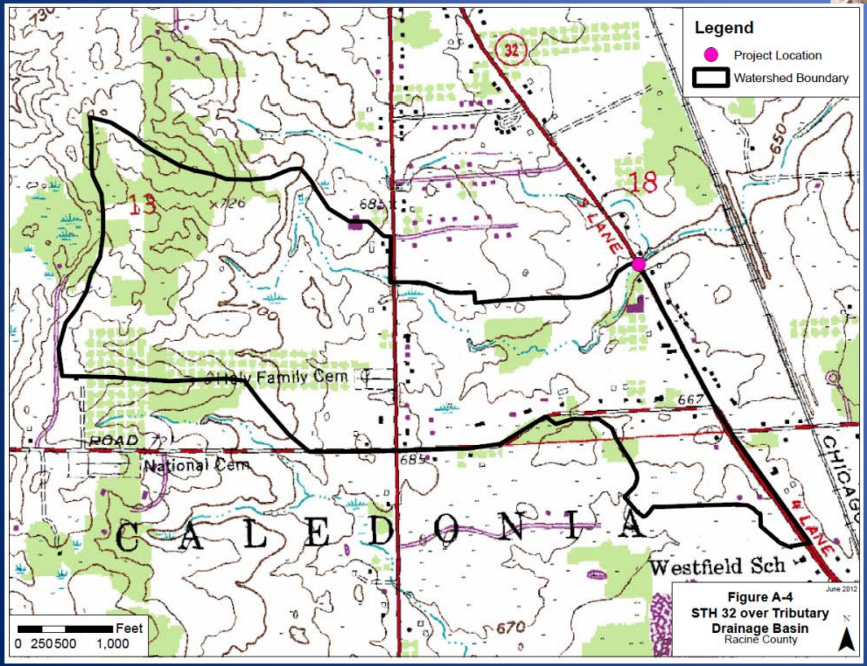


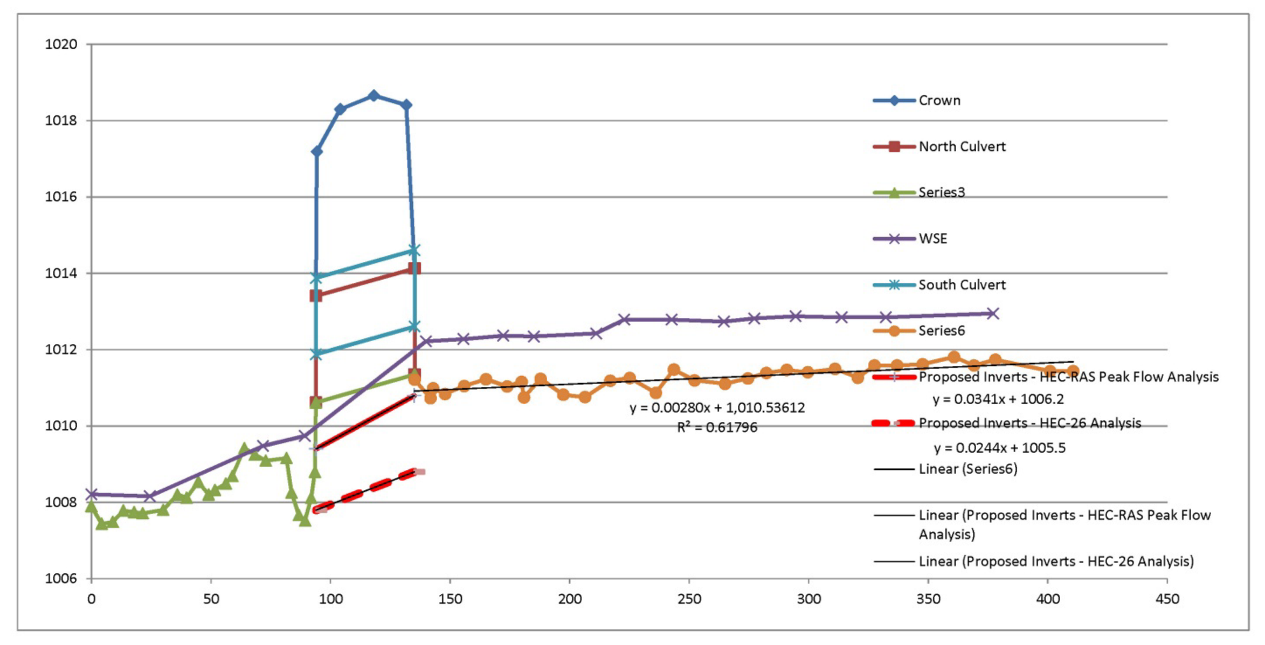
Table 2.1.5	
Stream Crossing Field Data	
Bank Flow Width (ft)	10.66
Measured Structure Water Velocity (ft/sec)	0.55
Stream Velocity (ft/sec)	0.42
Stream Depth (ft)	0.3
Scour Pool Length and Width (ft)	33.3' x 14.4'
Scour Pool Depth (ft)	look at survey datat
Upstream Pond Length and Width (ft)	None
Upstream Pond Depth (ft)	None
Is the outlet of the structure perched?	Yes
Is the structure water velocity greater than 3 feet/second during baseflow?	No
Is the depth ratio less than 0.1?	No

Field Data Collection

Survey – Cross Sections (At least 3 US and DS)

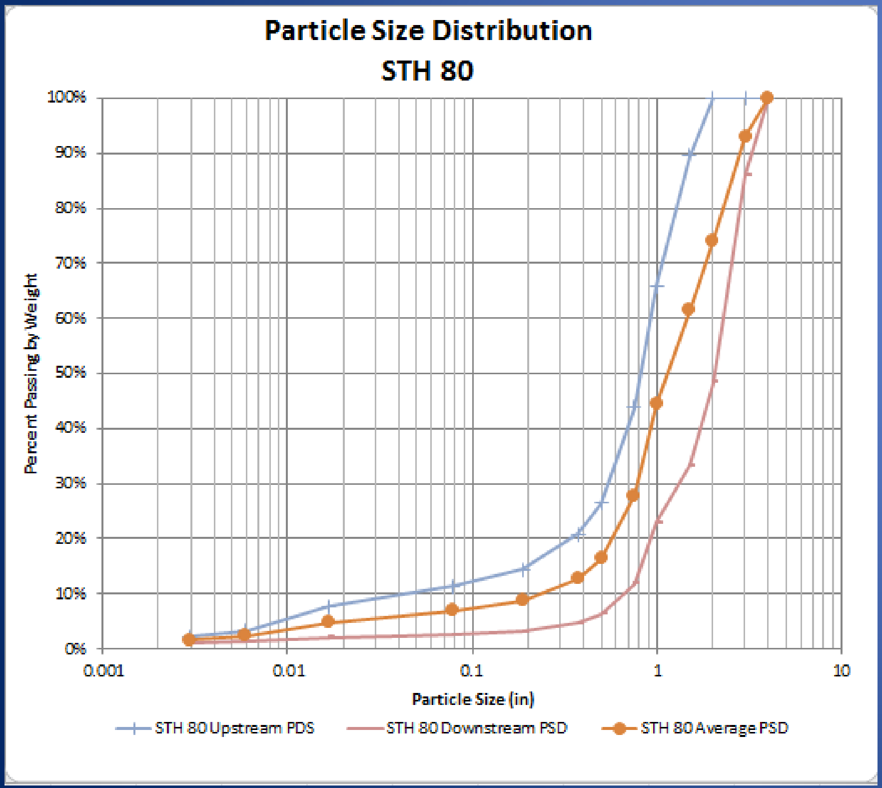
Field Data Collection

Survey – Stream Thalweg (> 200 ft US and DS) and Existing Culvert Data



Field Data Collection

Stream Bed Samples
Upstream and Downstream



Material Description: Poorly graded sand with silt
Date: 8/26/11
USCS Classification: SP-SM

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
12353.70	0.00	0.00	.5	0.00	100.0
			.375	245.80	98.0
			#4	1331.60	89.2
			#8	2655.10	78.5
			#10	2846.30	77.0
			#16	3669.90	70.3
			#30	5052.60	59.1
			#40	6553.50	47.0
			#50	9347.80	24.3
			#100	11506.60	6.9
			#200	11620.40	5.9

Fractional Components

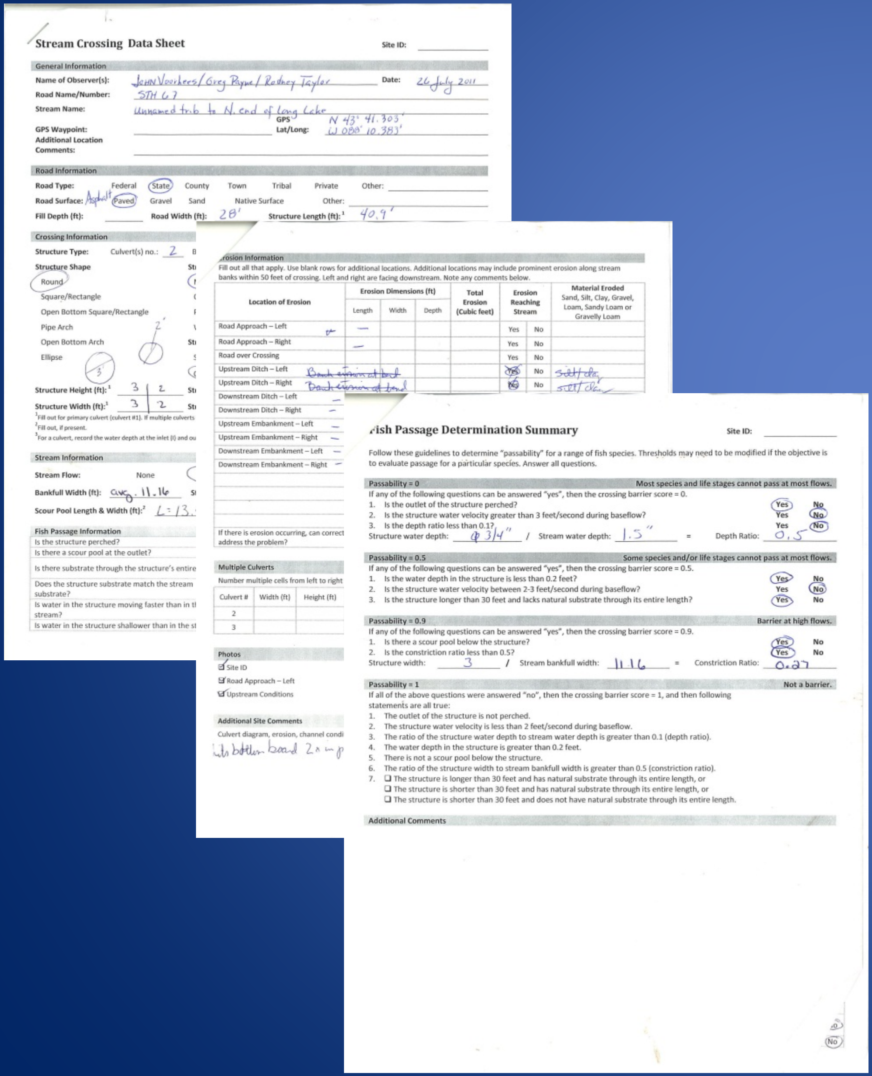
Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	10.8	10.8	12.2	30.0	41.1	83.3			5.9

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.2016	0.2447	0.2765	0.3281	0.4516	0.6246	2.6785	3.6994	4.9855	7.1070

Fineness Modulus	C_u	C_c
2.74	3.10	0.85

Field Data Collection

Stream Crossing Field Data



Stream Crossing Data Sheet

General Information

Road Information

Crossing Information

Stream Information

Fish Passage Information

Erosion Information

Fish Passage Determination Summary

Additional Comments

Table 2.2.6 Stream Crossing Field Data	
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Measured Structure Water Velocity (ft/sec)	3.07
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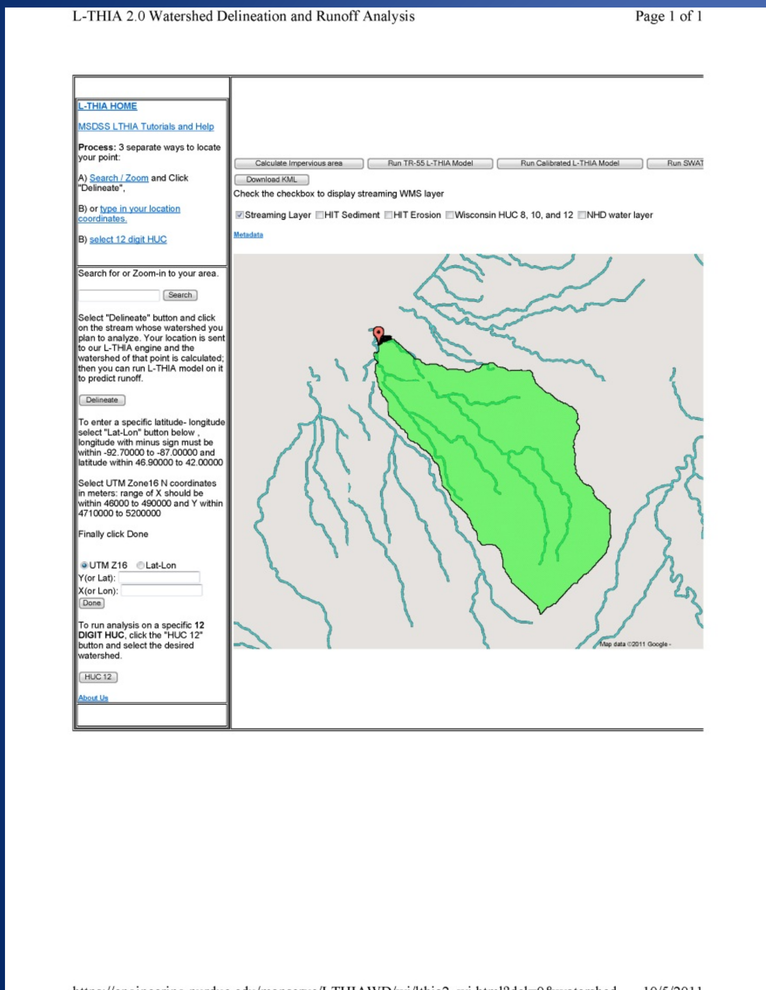
Upstream Pond Length and Width (ft)	None
Upstream Pond Depth	None
Is the outlet of the structure perched?	Yes
Is the structure water velocity greater than 3 feet/second during baseflow?	Yes

Field Data Collection

Site Photos

Hydrology Analysis

Drainage Basin Mapping


L-THIA 2.0 Watershed Delineation and Runoff Analysis — Page 1 of 1

L-THIA HOME

MSDSS LTHIA Tutorials and Help

Process: 3 separate ways to locate your point:

A) Search / Zoom and Click "Delineate",

B) or type in your location coordinates.

B) select 12 digit HUC

Search for or Zoom-in to your area.

Search

Select "Delineate" button and click on the stream whose watershed you plan to analyze. Your location is sent to our L-THIA engine and the watershed of that point is calculated; then you can run L-THIA model on it to predict runoff.

Delineate

To enter a specific latitude- longitude select "Lat-Lon" button below , longitude with minus sign must be within -92.70000 to -87.00000 and latitude within 46.90000 to 42.00000

Select UTM Zone16 N coordinates in meters: range of X should be within 46000 to 490000 and Y within 4710000 to 5200000

Finally click Done

UTM Z16 Lat-Lon

Y(or Lat):

X(or Lon):

Done

To run analysis on a specific 12 **DIGIT HUC**, click the "HUC 12" button and select the desired watershed.

HUC 12

About Us

Calculate Impervious area | Run TR-55 L-THIA Model | Run Calibrated L-THIA Model | Run SWAT

Download KML

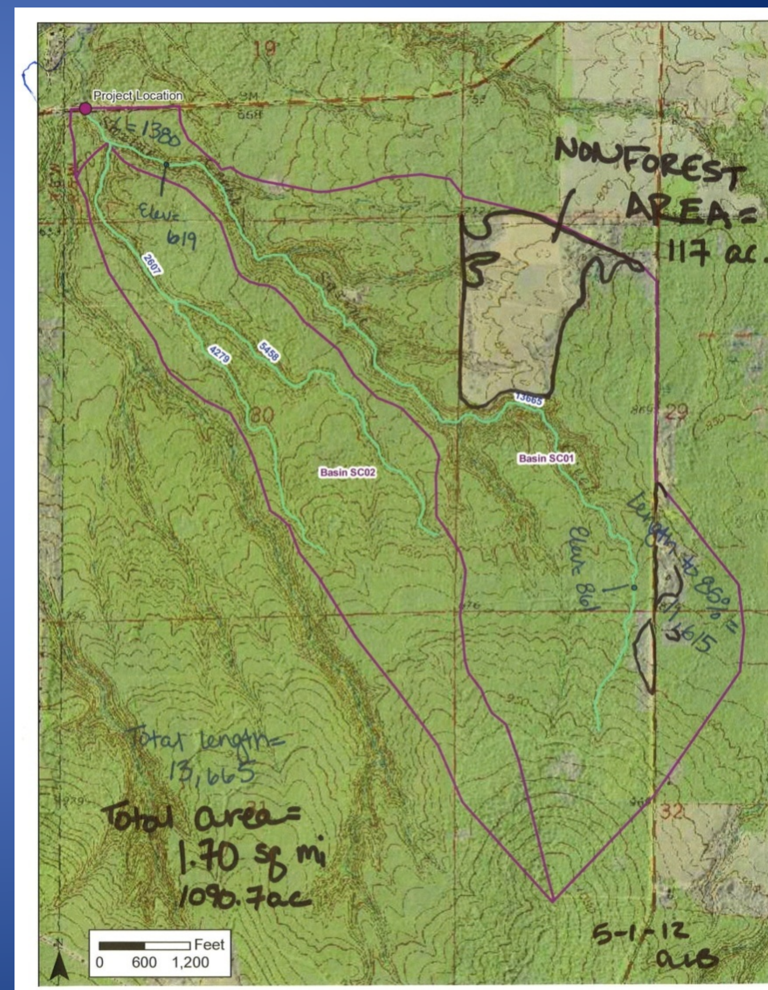
Check the checkbox to display streaming WMS layer

Streaming Layer | HIT Sediment | HIT Erosion | Wisconsin HUC 8, 10, and 12 | NHD water layer

Metadata

Map data ©2011 Google

https://engineering.purdue.edu/mapserve/LTHIAWD/wi/lthia2_wi.html?del=0&watershed... 10/5/2011



Hydrology Analysis

USGS Regression and HydroCAD

Drainage Basin Characteristics:

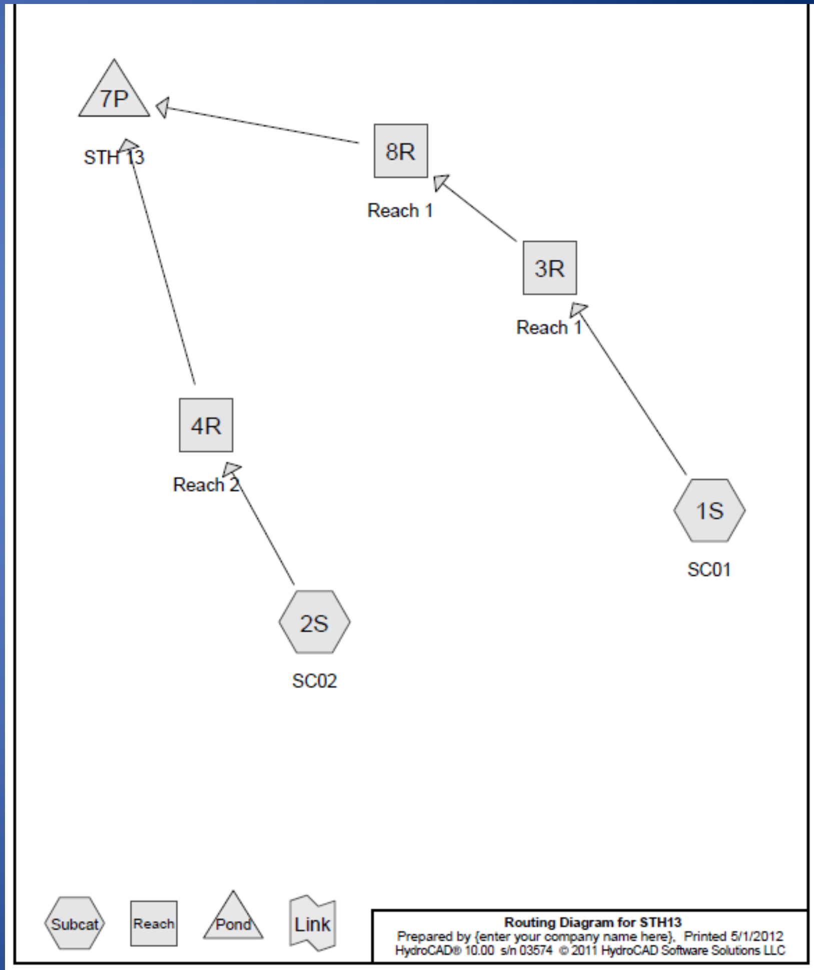
Area Equations =	4	
Drainage Area =	1.7	mi.^2
Slope (S):		
@ 10% , Elevation is approximately =	619	ft.
@ 85% , Elevation is approximately =	861	ft.
total length is approximately =	2.6	mi.
S =	124	ft./mi.
Storage (ST) =	1.0	%
Forest Cover (FOR) =	89.3%	
Precipitation Intensity Index (INTENS):		
$I_{24,25}$ value to be used in computations =	4.79	in.
Annual Snowfall (SN):		
Value from chart =	70	in.
Soil Permeability (SP):		
Value from chart =	0.12	in./hr.

Technique 1 - Regression Equation Vaules at Project Site:

Area Equation Number =	4				
Drainage Area (A) =	1.70	sq. mi.	Ave. Annual Snow. (SN) =	70	inches
Slope (S) =	124	ft./mi.	Precip Int. Index (I24,25) =	4.79	inches
Storage (ST) =	1	%	Soil Permeability (SP) =	0.12	in./hr.
Forest Cover (FOR) =	89	%			
Q(2) =	181	cfs			
Q(5) =	314	cfs			
Q(10) =	416	cfs			
Q(25) =	551	cfs			
Q(50) =	652	cfs			
Q(100) =	759	cfs			

Technique 2- Gage Comparisons:

Gage Station #	**4026200 Sand River Tributary near Red Cliff, WI**	
	Project Site	*Gage Station*
Basin Number =	4	*4*



Hydrology Analysis

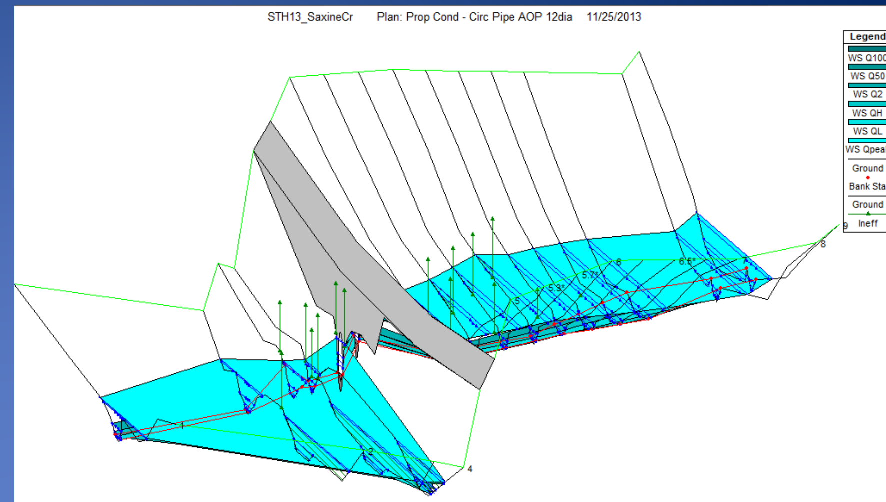
Flow Selection

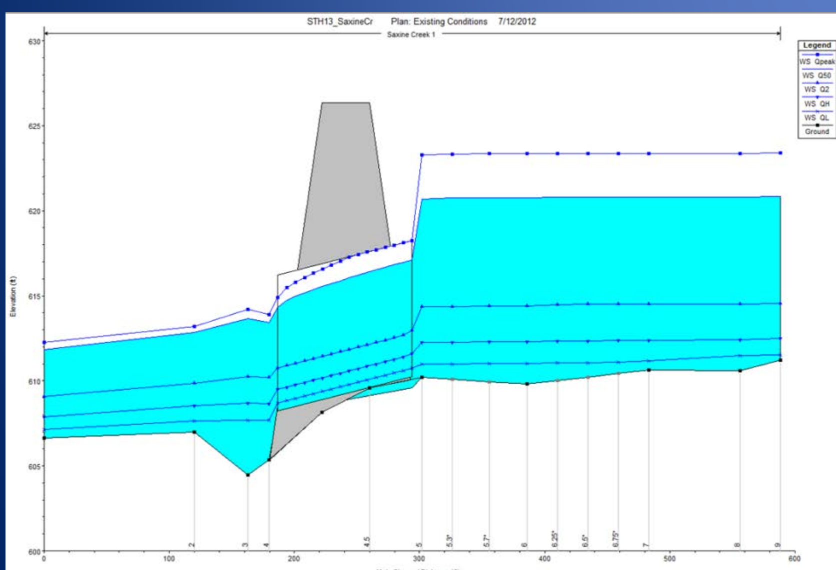
Table 2.2.2 Flow Value Summary				
Recurrence Interval	Peak Flows (cfs)			
	HydroCAD		USGS Regression Equation	Selected
	Inflow	Outflow		
Q_L[1]	-	-	-	4
Q_H[1]	26	24	45	30
2-yr	103	96	181	118
25-yr	458	377	551	401
50-yr	534	447	651	575
100-yr	682	520	759	700

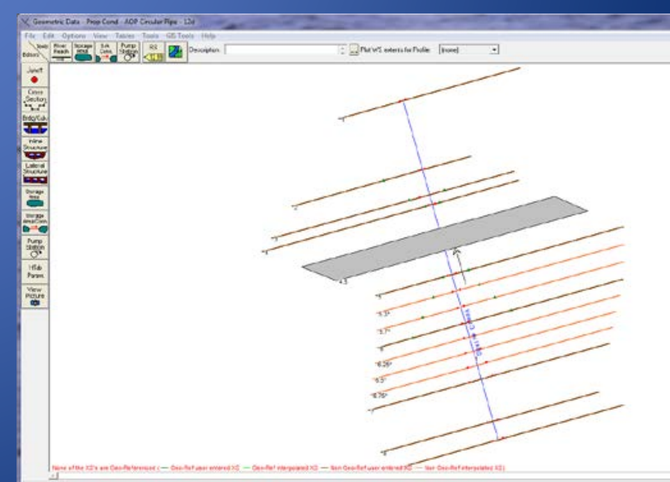
[1]QL and QH are the low and high flows, respectively, used to evaluate the AOP culvert size, as described in HEC-26. QH is 25% of the 2-year flow.

Hydraulic Analysis – HEC-RAS Modeling

For -
- Sizing culverts for peak and low flows
- Evaluating channel velocities

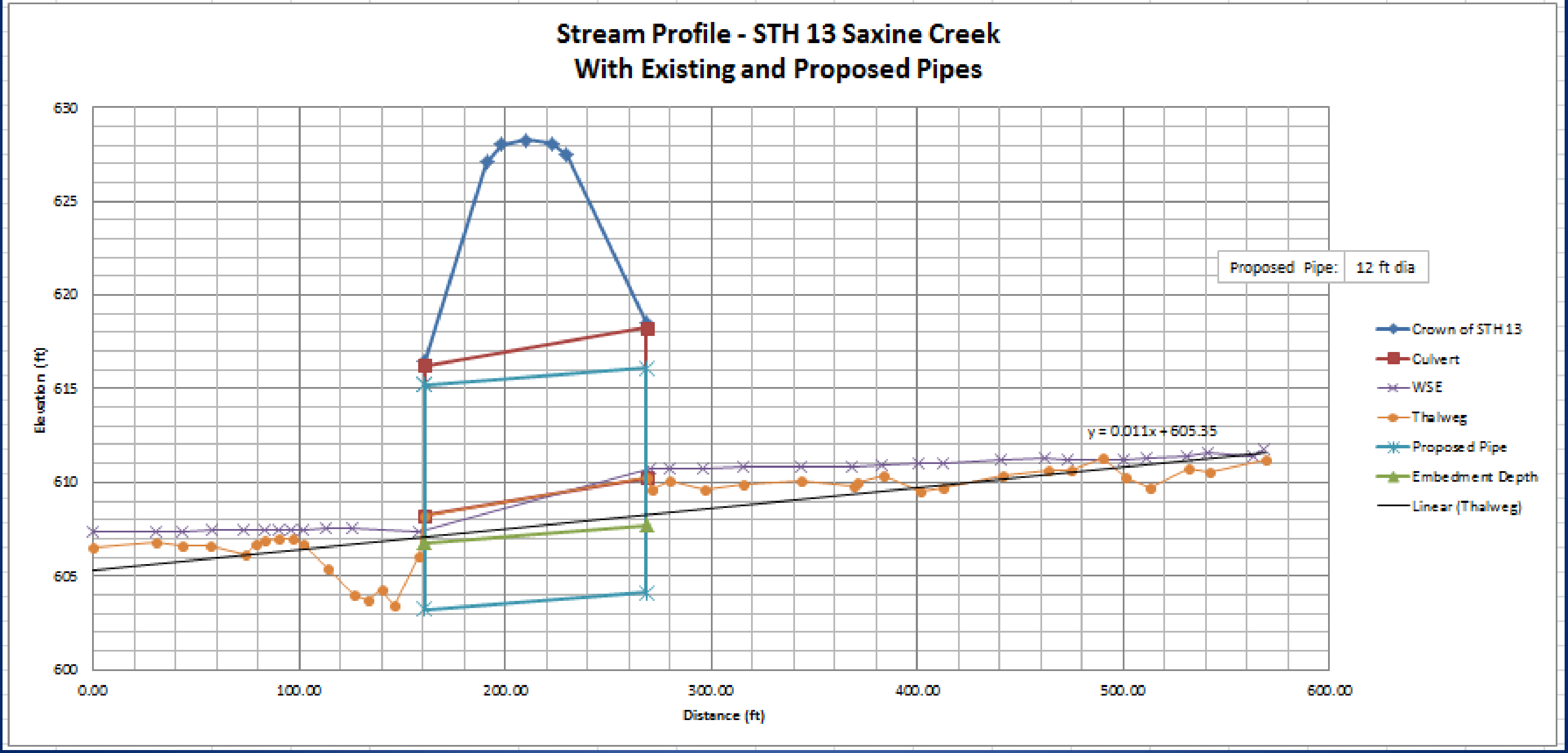






Stream Profile Analysis

Stream Profile Analysis



. . . to set pipe slope and embedment depth

Culvert Bed Gradation Selection

Particle Size Distribution

GRAIN SIZE DISTRIBUTION TEST DATA 9/19/2011

Project: STH 13
Project Number: 60220570
Sample Number: STH-13 8-21-11
Material Description: Poorly graded sand with silt
Date: 8/26/11
USCS Classification: SP-SM

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
12675.50	0.00	0.00	.75	0.00	100.0
			.5	281.00	97.8
			.375	298.40	97.6
			#4	864.50	93.2
			#8	1844.20	85.5
			#10	2117.00	83.3
			#16	3120.20	75.4
			#30	5110.70	59.7
			#40	7178.20	43.4
			#50	10259.70	19.1
			#100	11850.90	6.5
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D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1968	0.2545	0.3049	0.3528	0.4765	0.6056	1.5837	2.2775	3.4820	5.7983

Fineness Modulus	C_u	C_c
2.63	3.08	1.04

AECOM

GRAIN SIZE DISTRIBUTION TEST DATA 9/19/2011

Project: STH 13
Project Number: 60220570
Sample Number: STH-13 8-17-11
Material Description: Poorly graded sand with silt
Date: 8/26/11
USCS Classification: SP-SM

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
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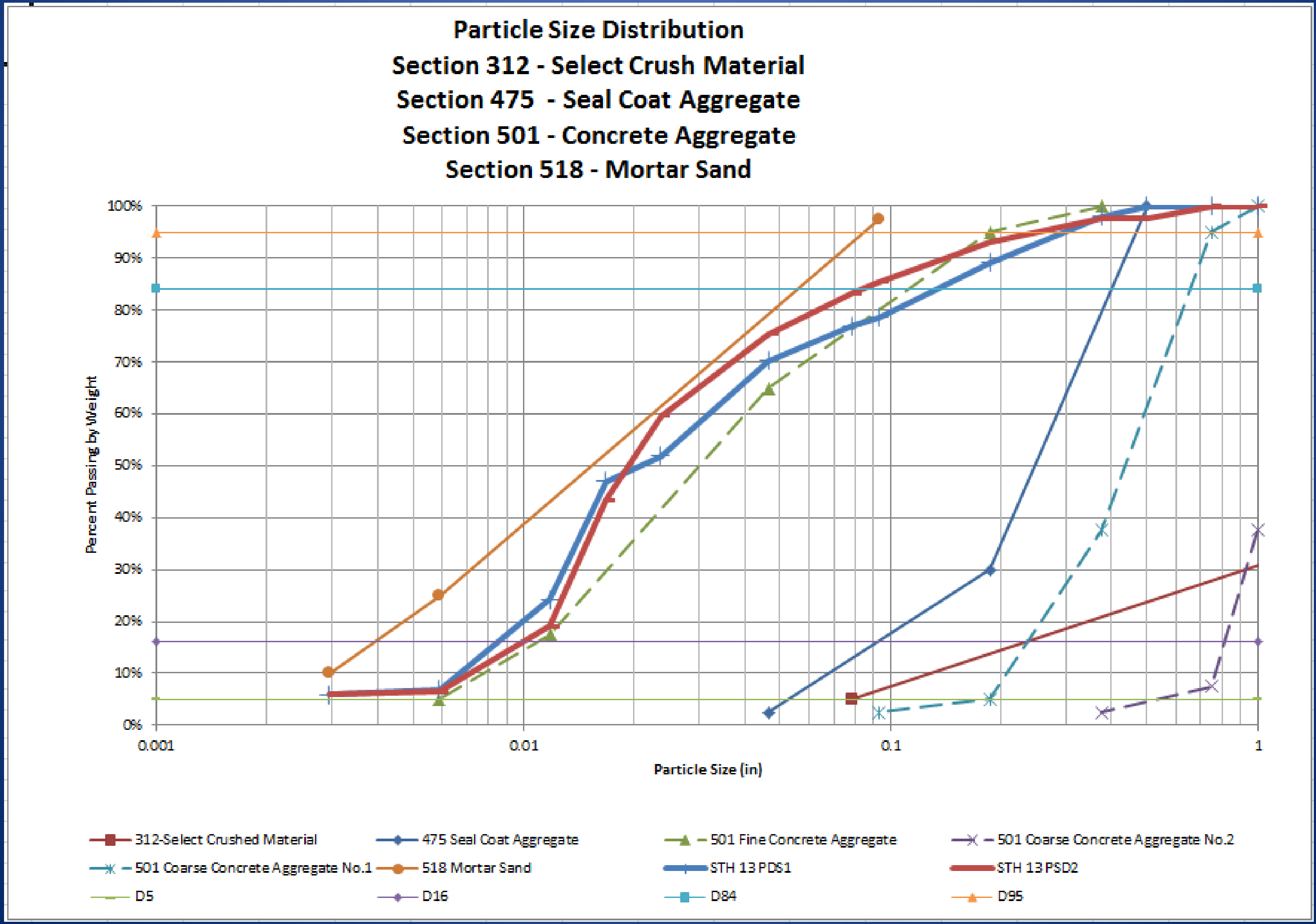
0.2016	0.2447	0.2765	0.3281	0.4516	0.6246	2.6785	3.6994	4.9855	7.1070

Fineness Modulus	C_u	C_c
2.74	3.10	0.85

AECOM

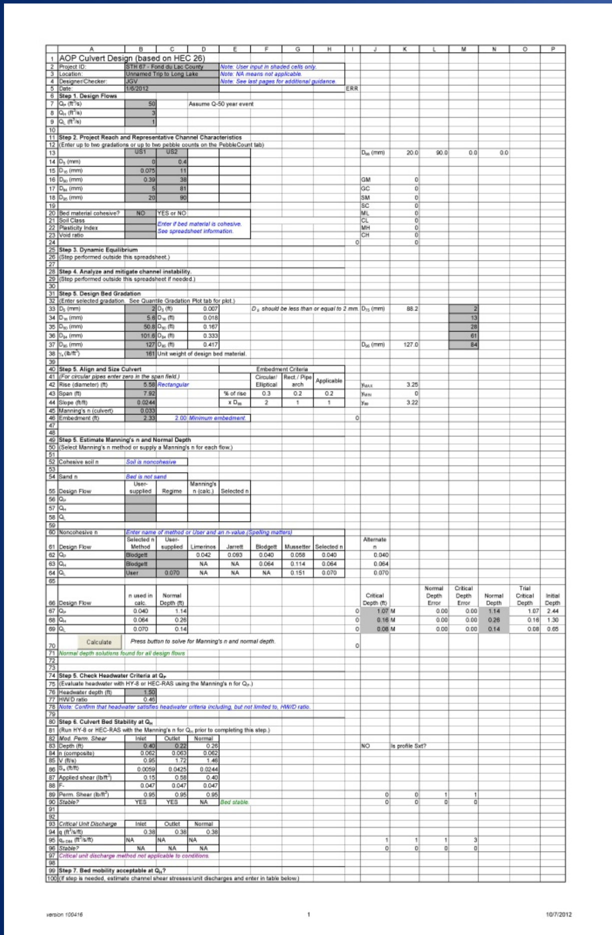
Culvert Bed Gradation Selection

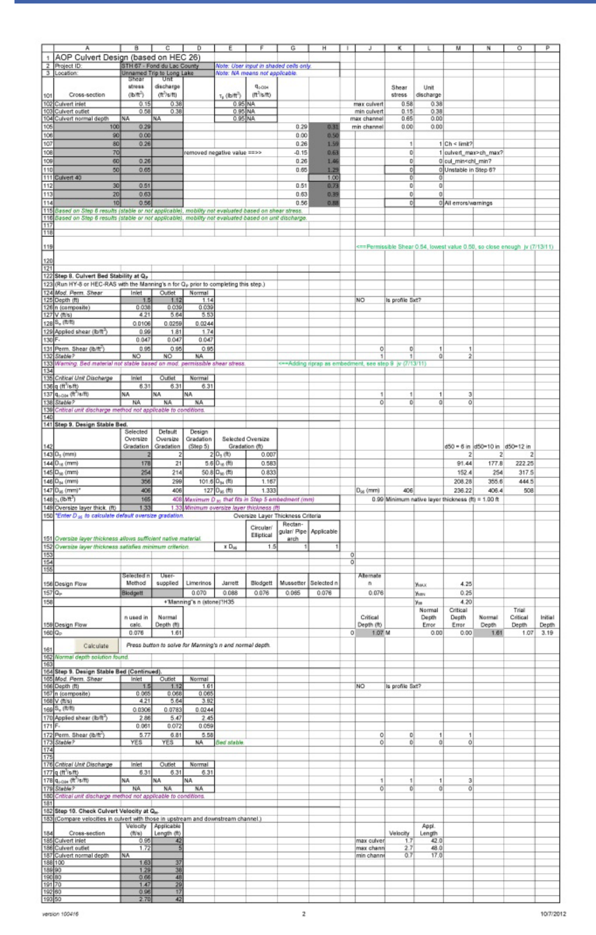
Site and WisDOT Standard PSDs

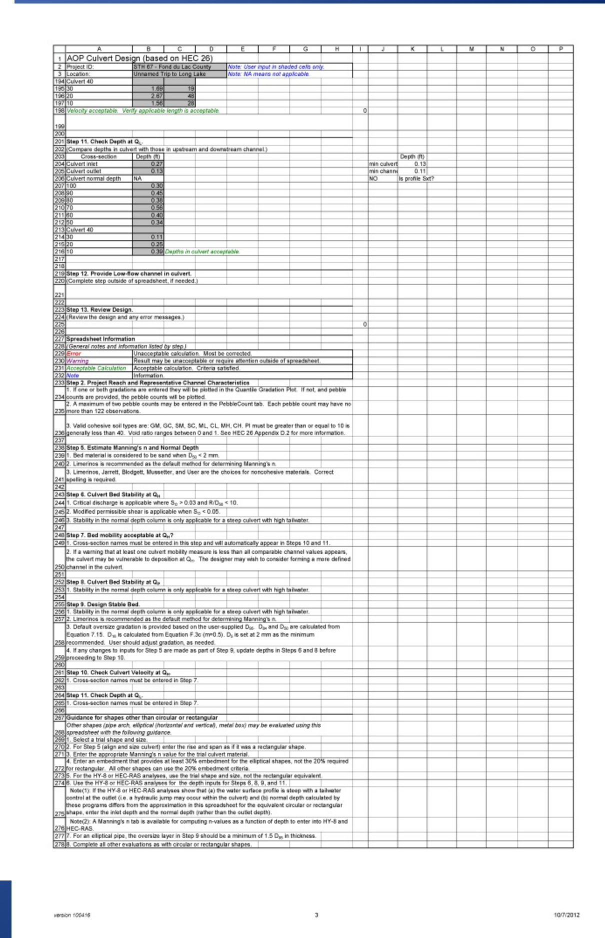


HEC-26 Analysis

Iterative Design Approach Using HEC-26 and HEC-RAS







Study Results

Culvert Sized for AOP at each Site

Table 2.2.5
Culvert Characteristic Comparisons

Characteristic	Existing Culvert	Proposed Standard Design Culvert	Proposed AOP Culvert
Shape	Circular	Circular	Circular
Pipe Type/Material	Corrugated Metal Pipe	Corrugated Metal Pipe	Corrugated Metal Pipe
End Treatment	Pipe Projecting From Fill	Headwall	Headwall
Pipe Length	107.4	107.4	107.4
Upstream Invert Elevation	610.26	607.70	604.10
Downstream Invert Elevation	608.22	606.80	603.20
Diameter (ft)	8.0	8.0	12.0
Span (ft)	-	-	-
Height (ft)	-	-	-
Pipe slope (ft/ft)	0.019	0.0084	0.0083
Embedment Depth (ft)	0.0	0.0	3.6
Manning's n for Top	0.03	0.024	0.024
Manning's n for Bottom	n/a	n/a	0.040

- **Evaluation of Suitability of HEC-26 Process for WisDOT Highways**
- **Policy Recommendations to WisDOT for Addressing AOP Issues**

Study Results

Existing and Proposed Culverts - Draft

Highway	Creek	Existing Pipe	Bank Flow Width	Proposed Pipe	Embedment Depth
STH 13	Saxine Creek	8' Dia. CM Pipe	12.5'	12' Dia. CM Pipe	3.6'
STH 21	White River	6' Dia. CM Pipe	23.75'	5' x 20' Box Culvert	2'
STH 80	Little Platte River	2 - 5' Dia. CM Pipes	12'	9.33' x 12.25' CM Arch Pipe	2.67'
STH 67	Unnamed Trib to Long Lake	3' Dia. CM Pipe 2' Dia. CM Pipe	11.2'	5.92' x 8.59' CM Arch Pipe	2.33'
STH 32	Unnamed Trib to Lake Michigan	6' x 4' Box Culvert	10.66'	8' x 6' Box Culvert	2'

Questions?