Site Assessment:

Planform Characteristics

Longitudinal Profile

Cross Sections

Bed/Bank Sediments and Characteristics

Geotechnical Investigation

Site Risk Assessment

Stream Simulation Design:

Horizontal Alignment

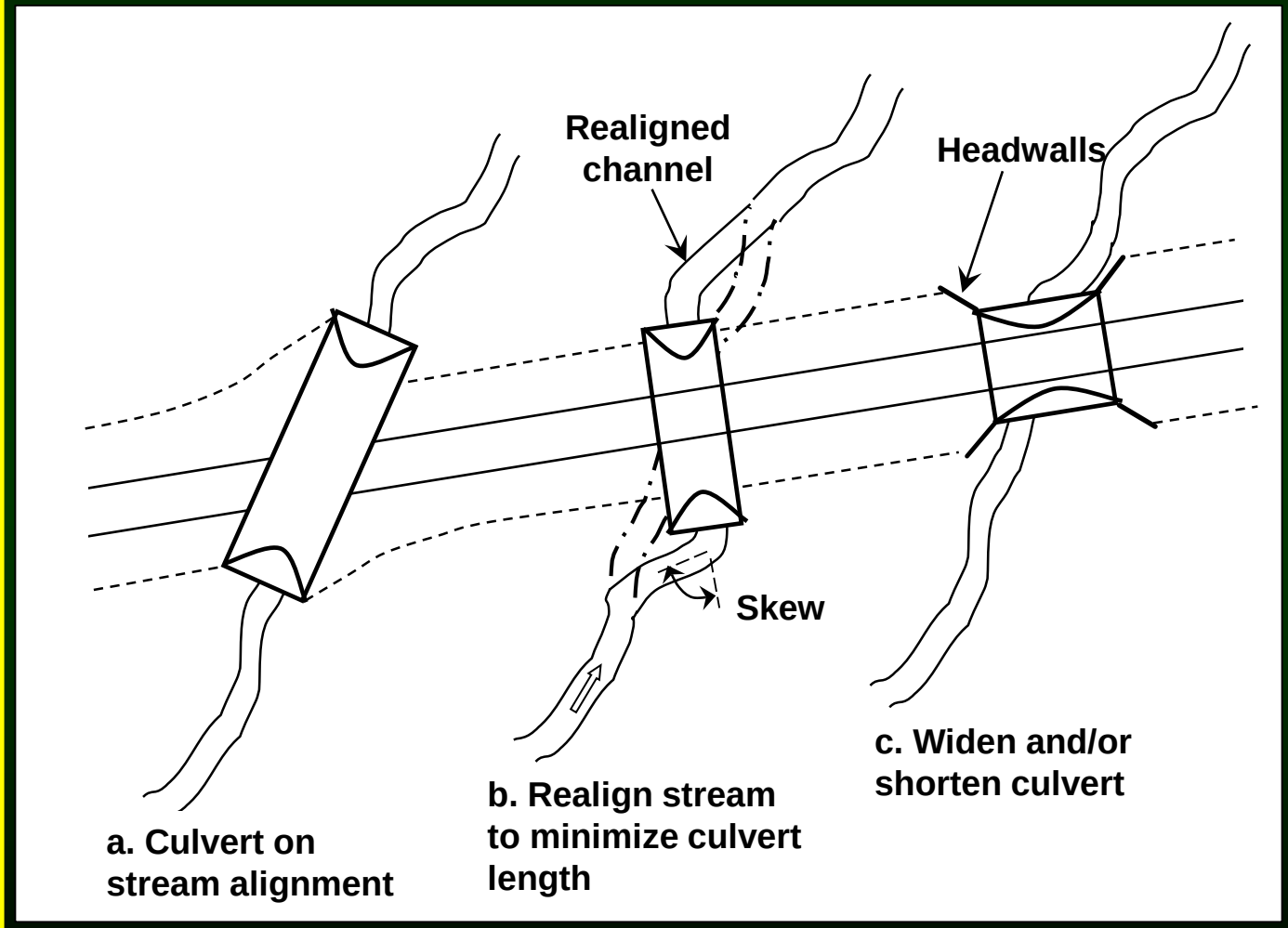
Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Typical Culvert Alignment Options



Stream Simulation Design:

Horizontal Alignment

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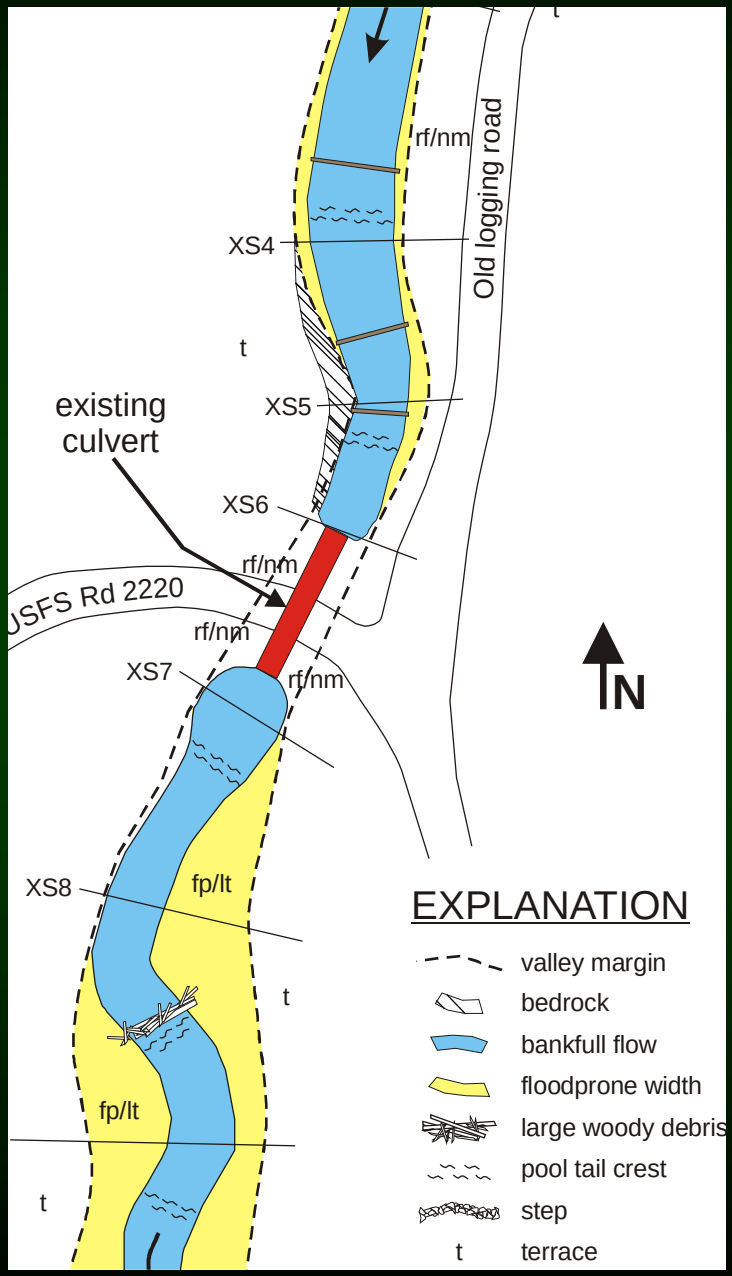
- Reference Reach

Cross Section Shape

Bed/Bank Sediments



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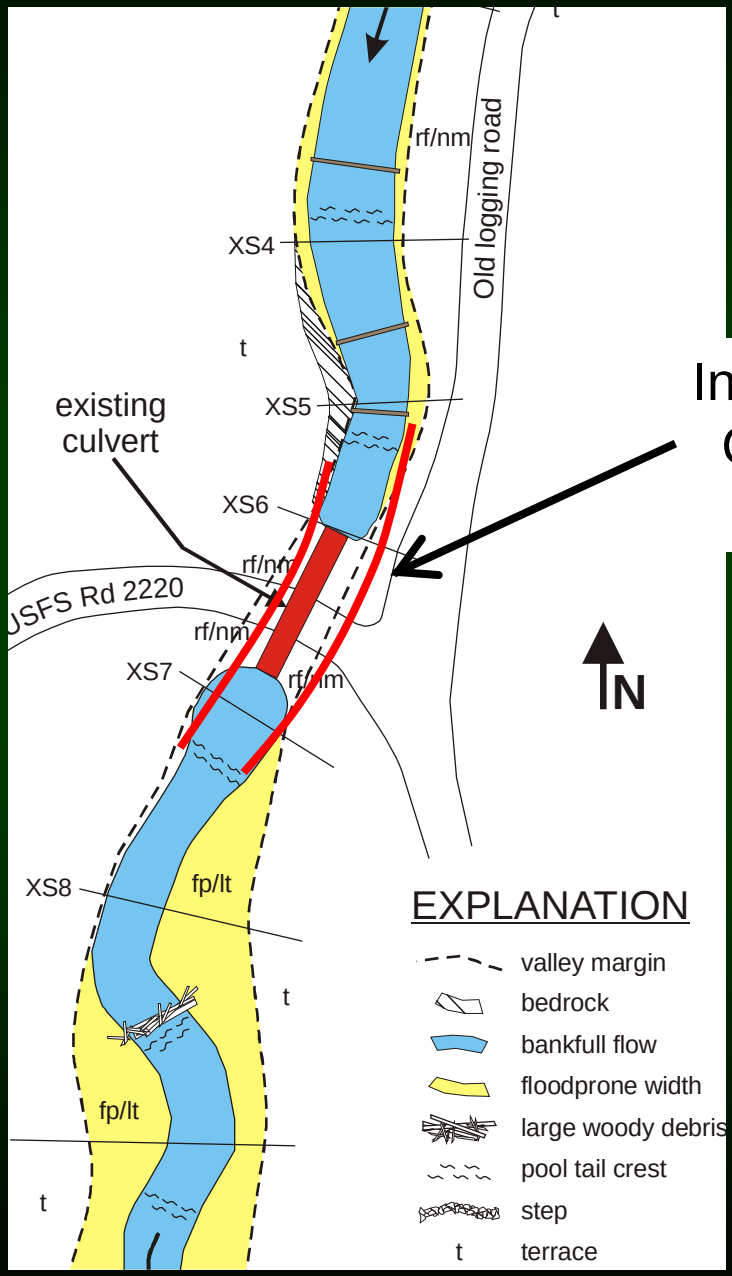
Bed/Bank Sediments



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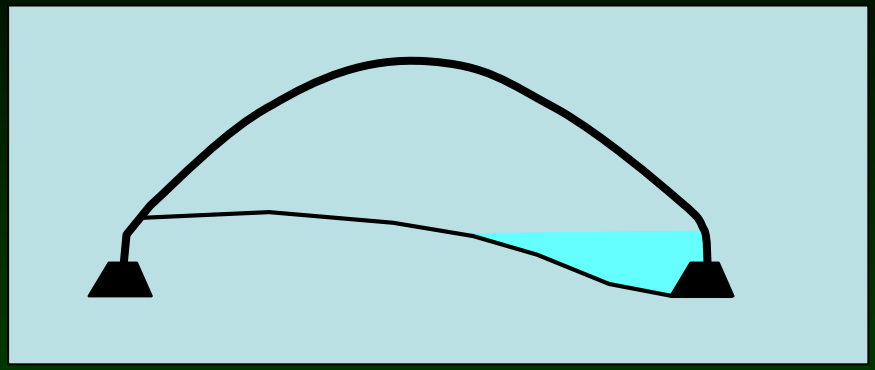
Cross Section Shape

Bed/Bank Sediments



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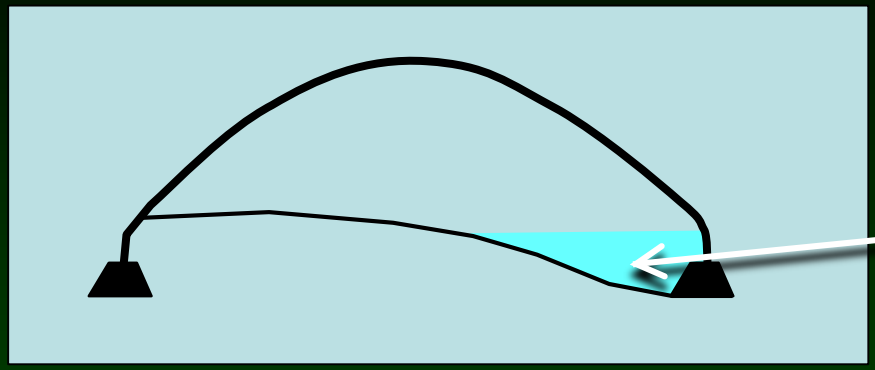

Pool along outer bend

Stream Simulation Design:

Horizontal Alignment

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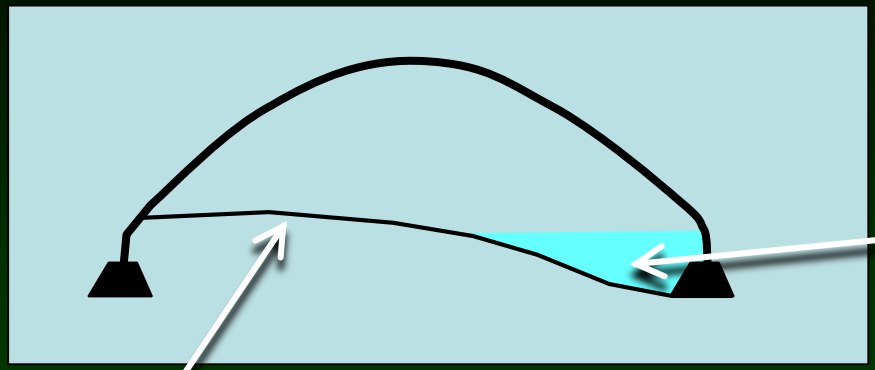
- Reference Reach

Cross Section Shape

Bed/Bank Sediments



Pool along outer bend

Point bar

Stream Simulation Design:

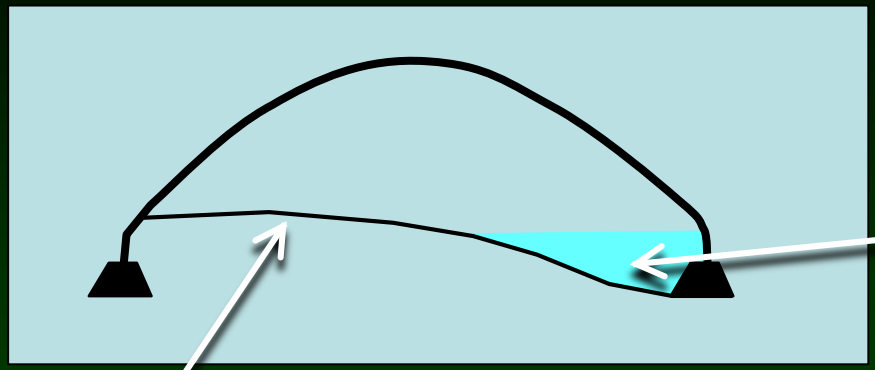
Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments



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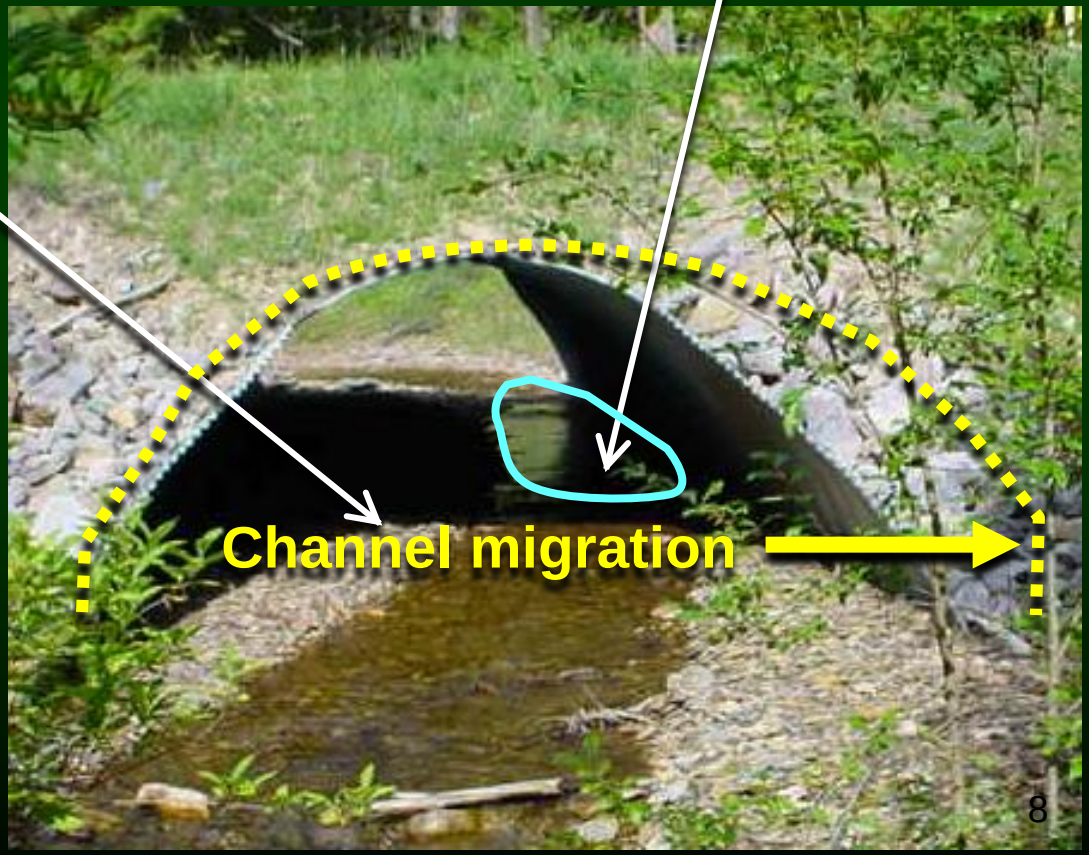


Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

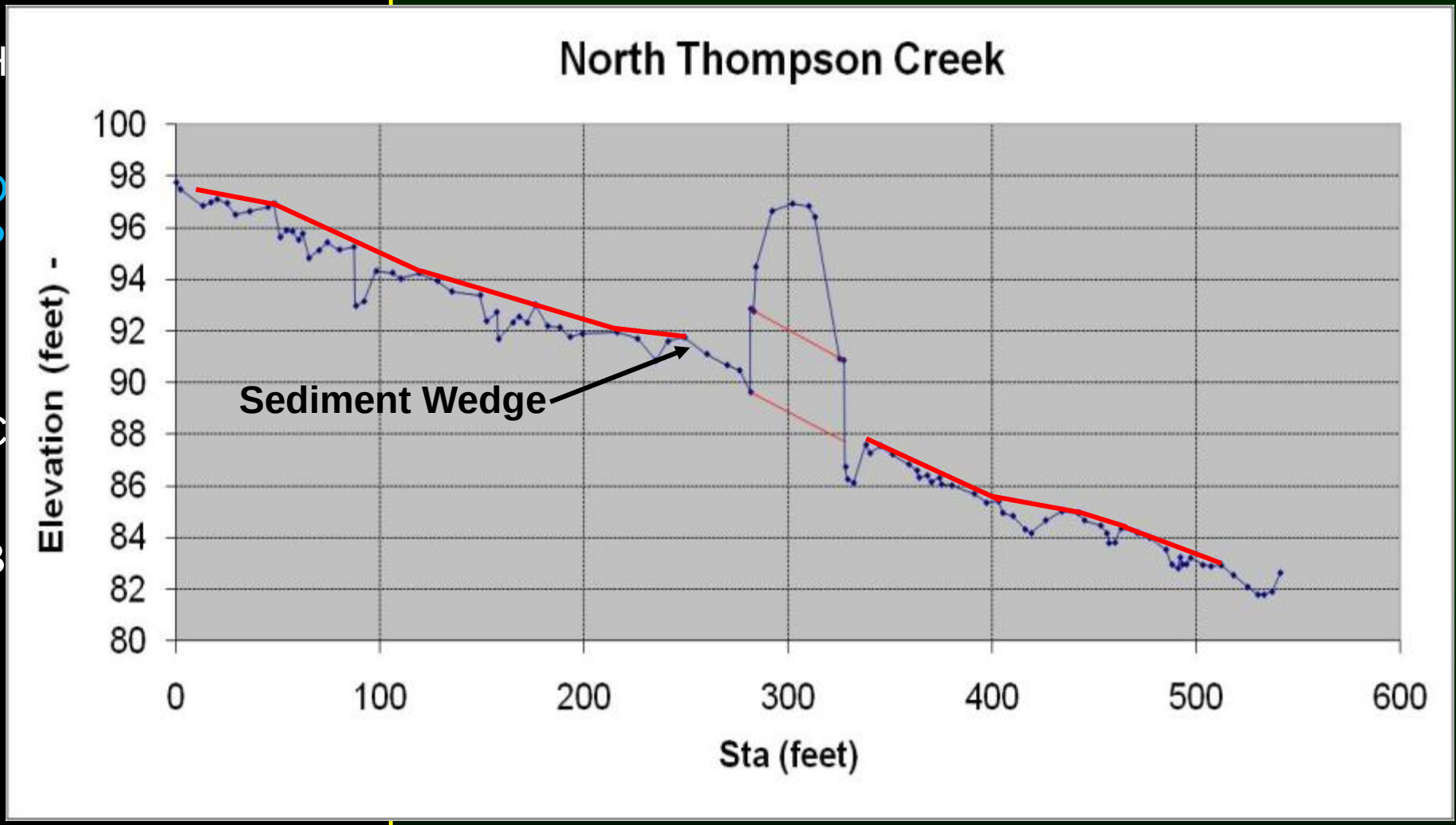
Cross Section Shape

Bed/Bank Sediments

Project Design Profile

Stream Simulation Design:

Project Design Profile



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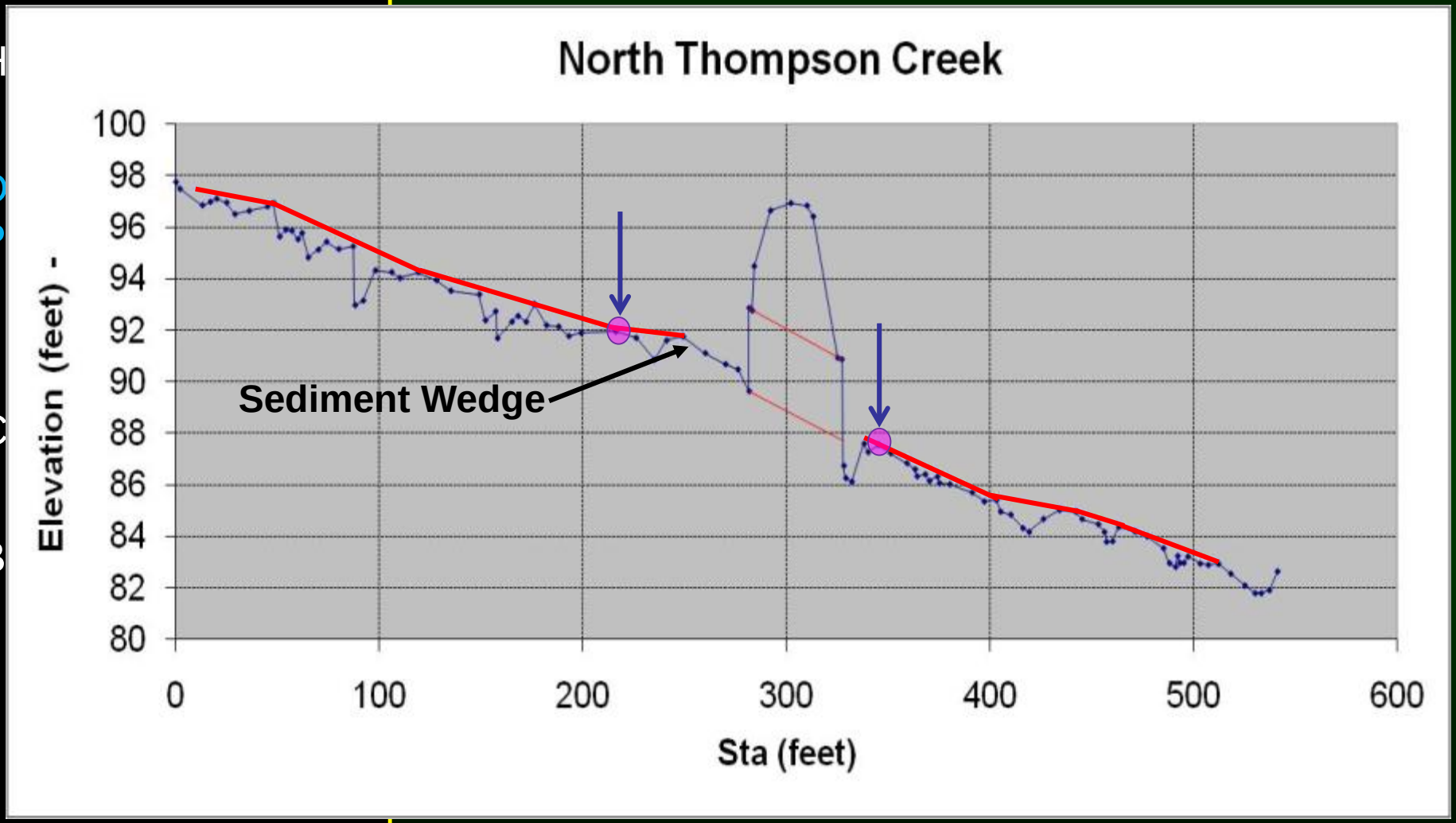
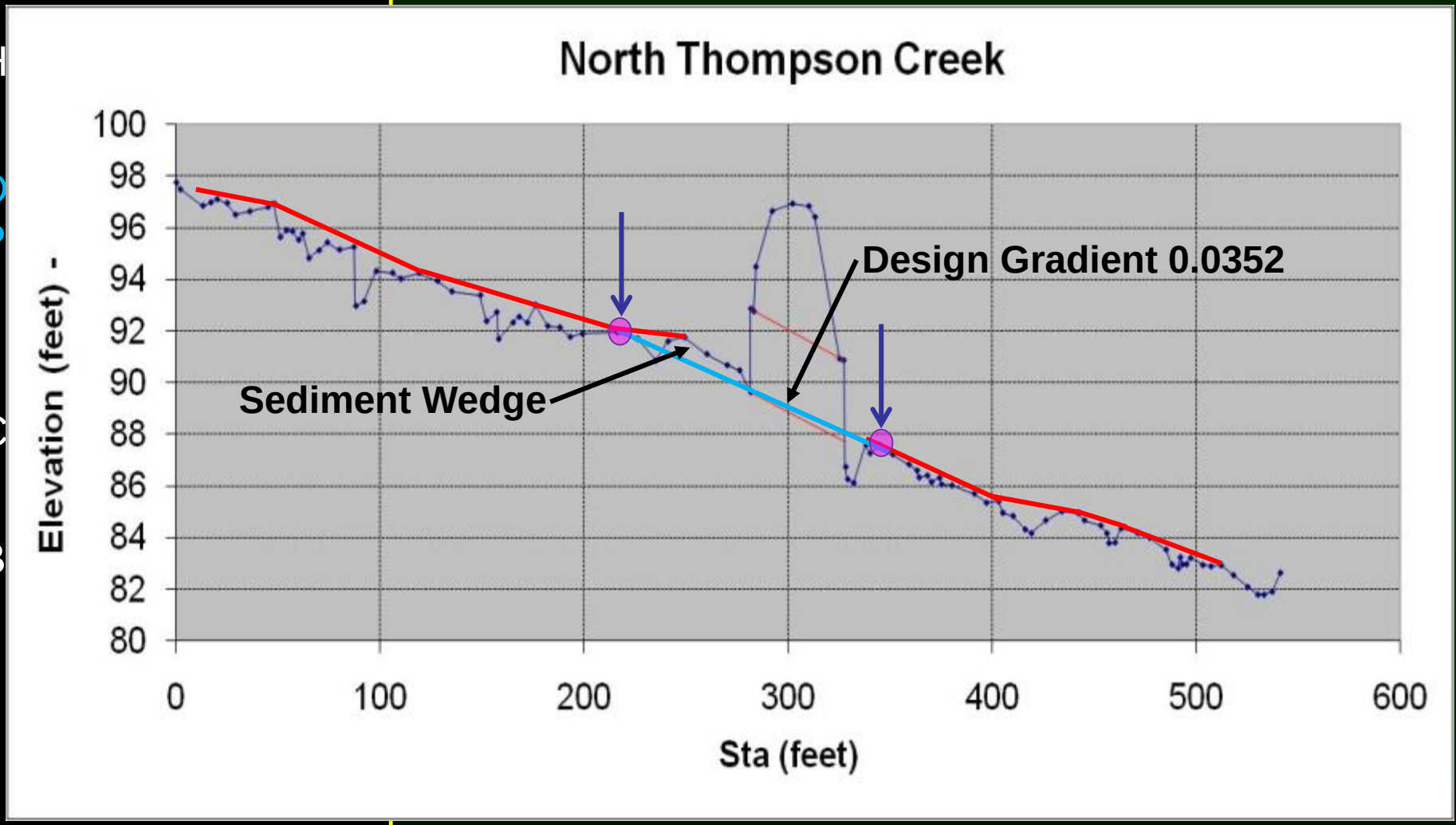
Project Design Profile



Stream Simulation Design:

Project Design Profile



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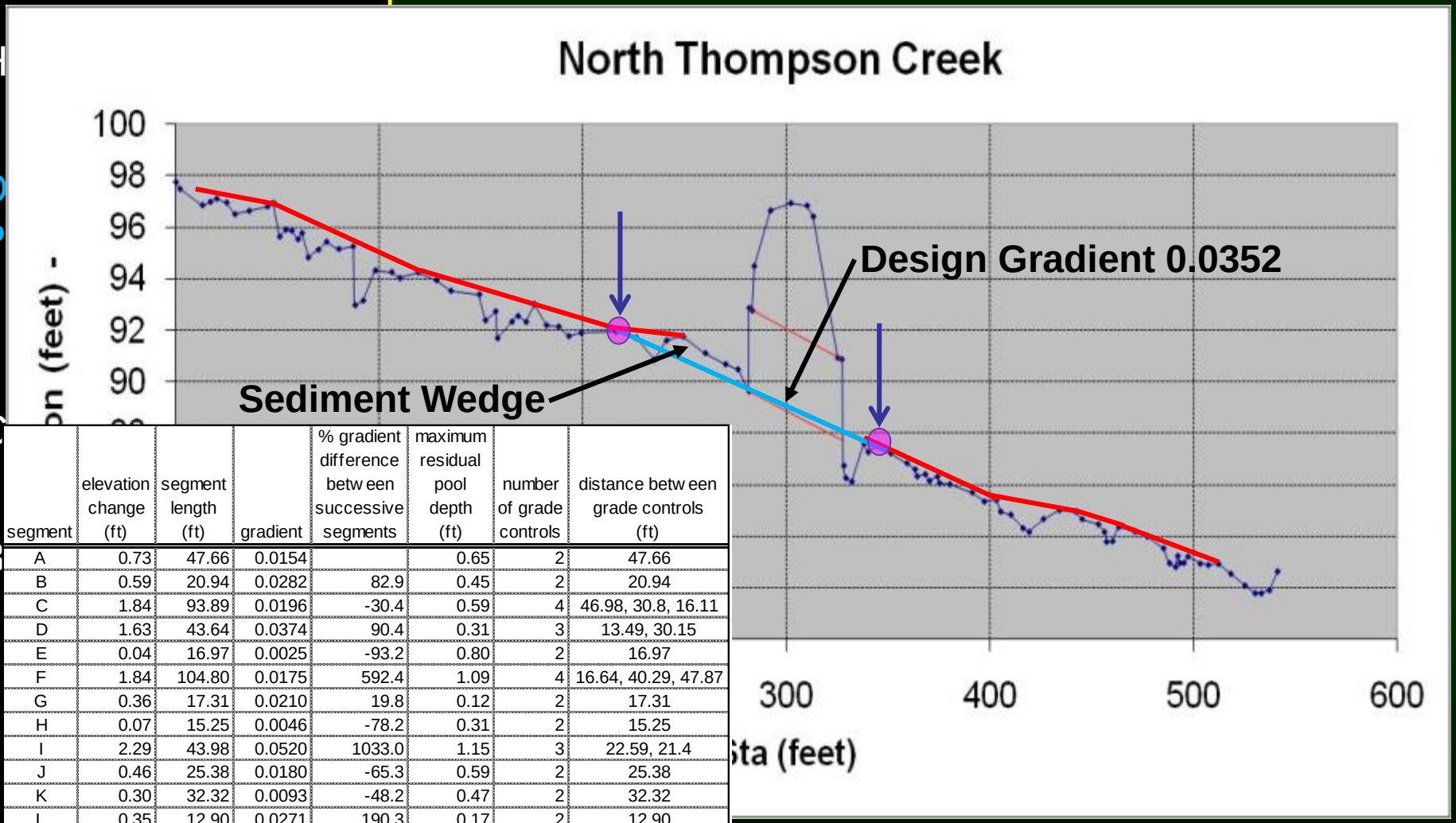
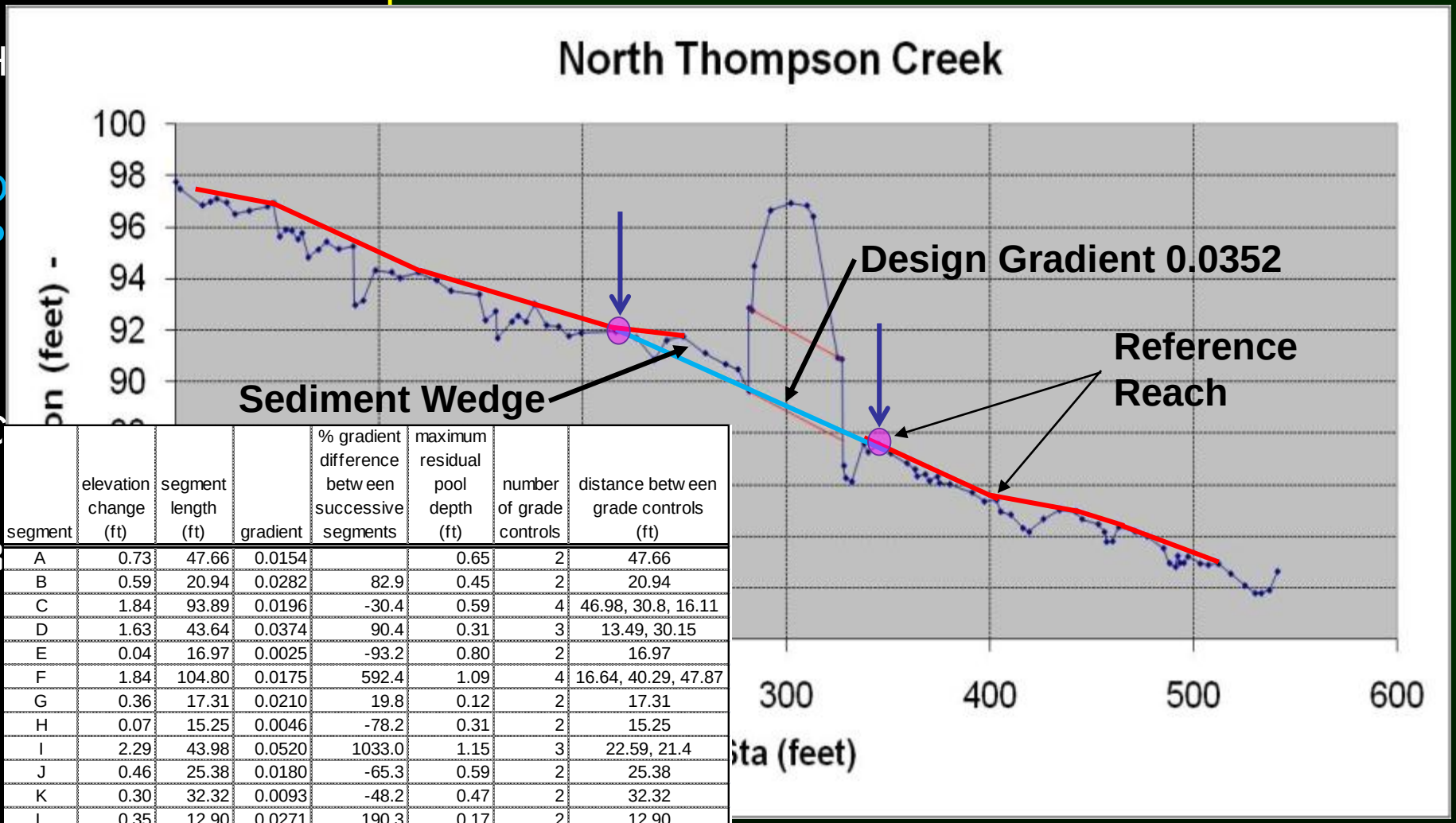


segment	elevation change (ft)	segment length (ft)	gradient	% gradient difference between successive segments	maximum residual pool depth (ft)	number of grade controls	distance between grade controls (ft)
A	0.73	47.66	0.0154		0.65	2	47.66
B	0.59	20.94	0.0282	82.9	0.45	2	20.94
C	1.84	93.89	0.0196	-30.4	0.59	4	46.98, 30.8, 16.11
D	1.63	43.64	0.0374	90.4	0.31	3	13.49, 30.15
E	0.04	16.97	0.0025	-93.2	0.80	2	16.97
F	1.84	104.80	0.0175	592.4	1.09	4	16.64, 40.29, 47.87
G	0.36	17.31	0.0210	19.8	0.12	2	17.31
H	0.07	15.25	0.0046	-78.2	0.31	2	15.25
I	2.29	43.98	0.0520	1033.0	1.15	3	22.59, 21.4
J	0.46	25.38	0.0180	-65.3	0.59	2	25.38
K	0.30	32.32	0.0093	-48.2	0.47	2	32.32
L	0.35	12.90	0.0271	190.3	0.17	2	12.90
culvert	1.82	44.88	0.0405				

Stream Simulation Design:

Project Design Profile



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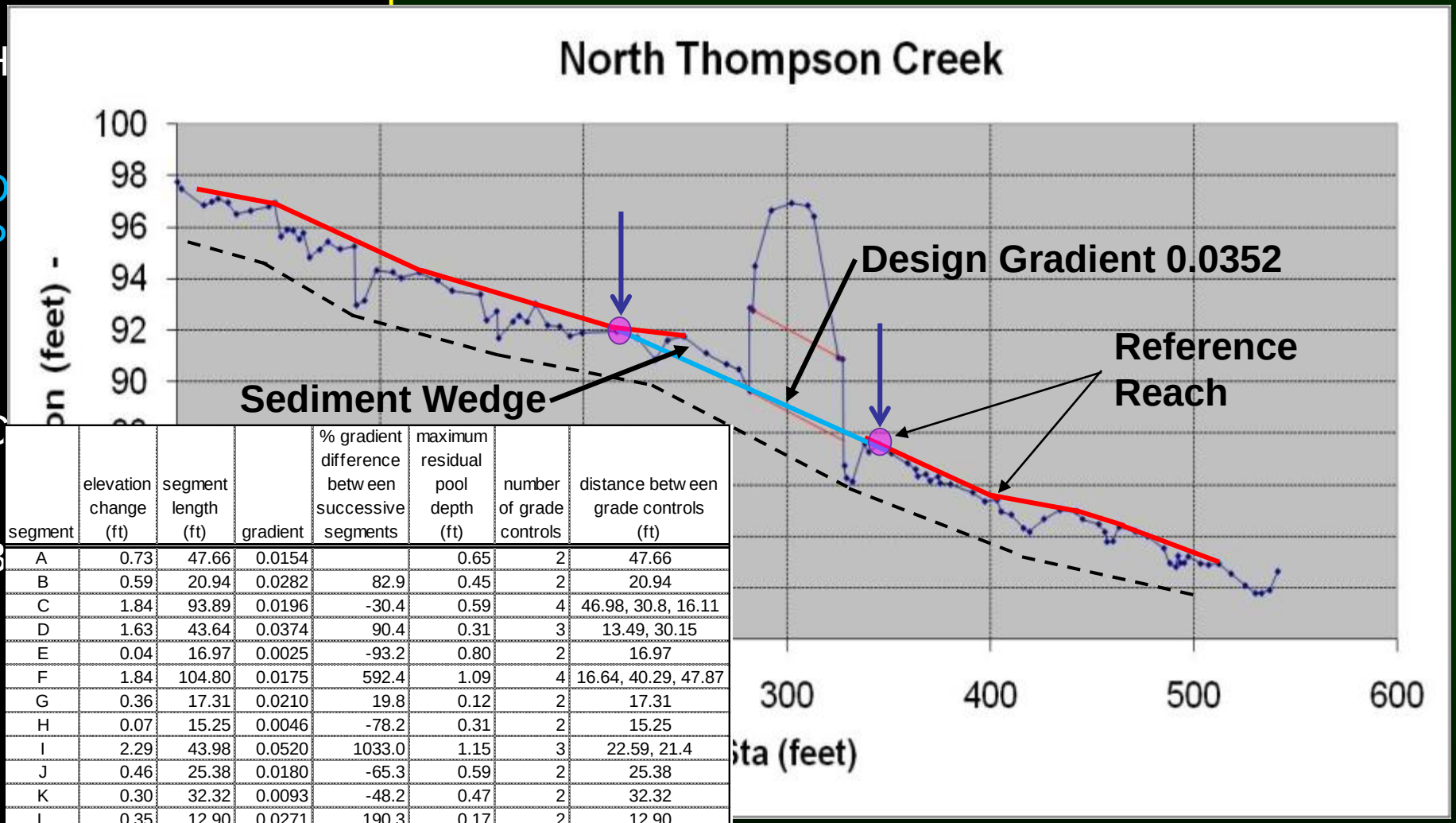
Project Design Profile



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Stream Simulation Design:

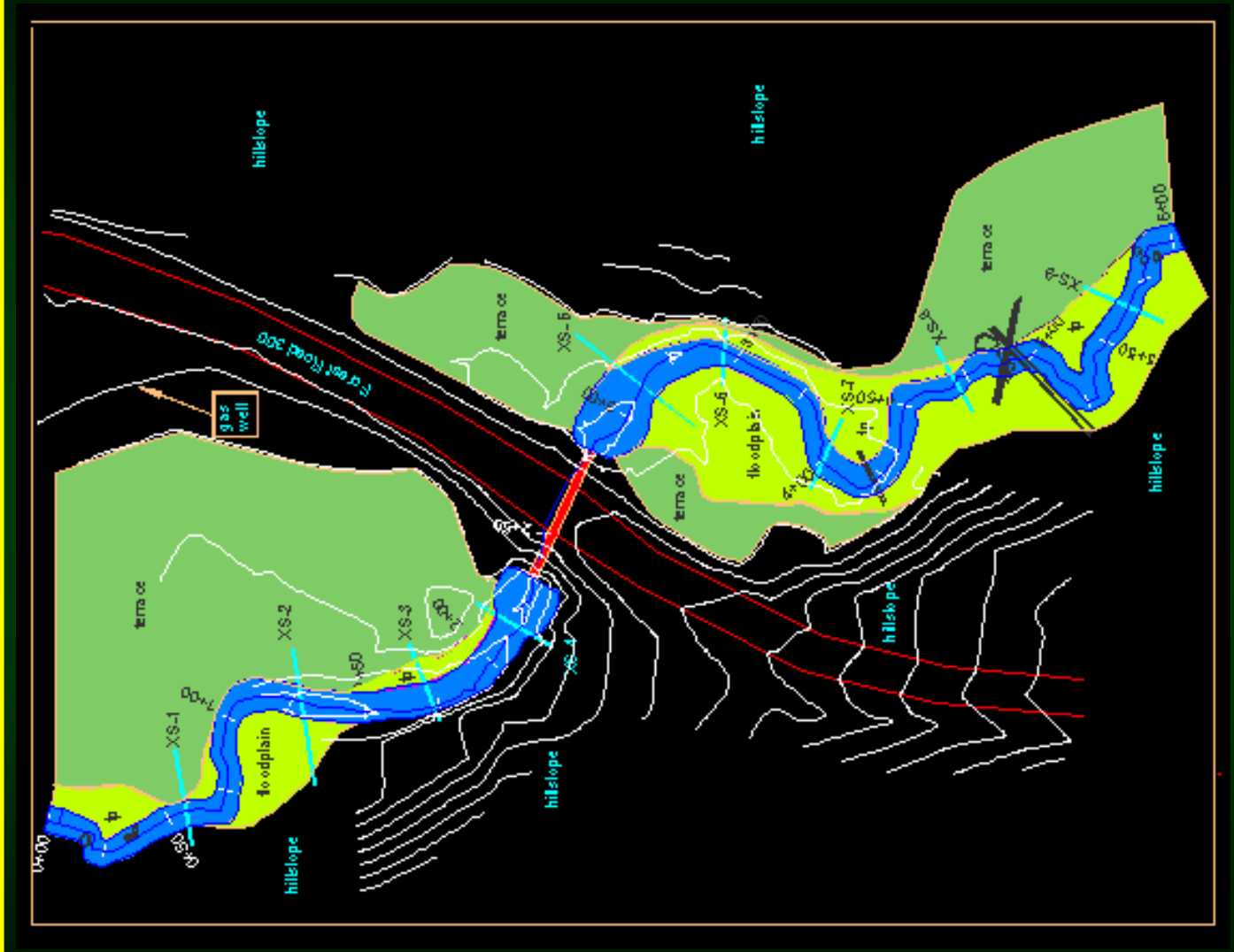
Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments



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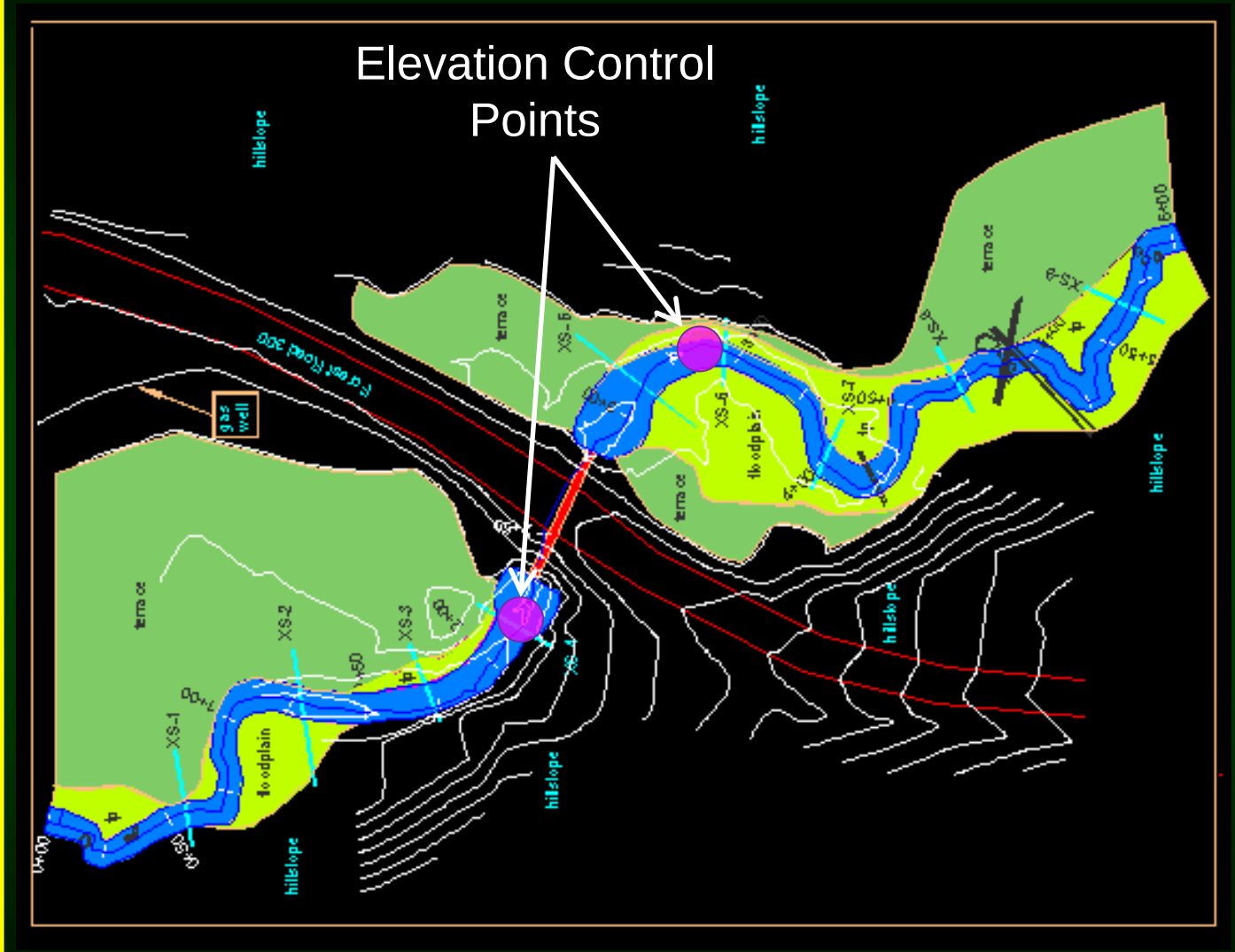
Cross Section Shape

Bed/Bank Sediments



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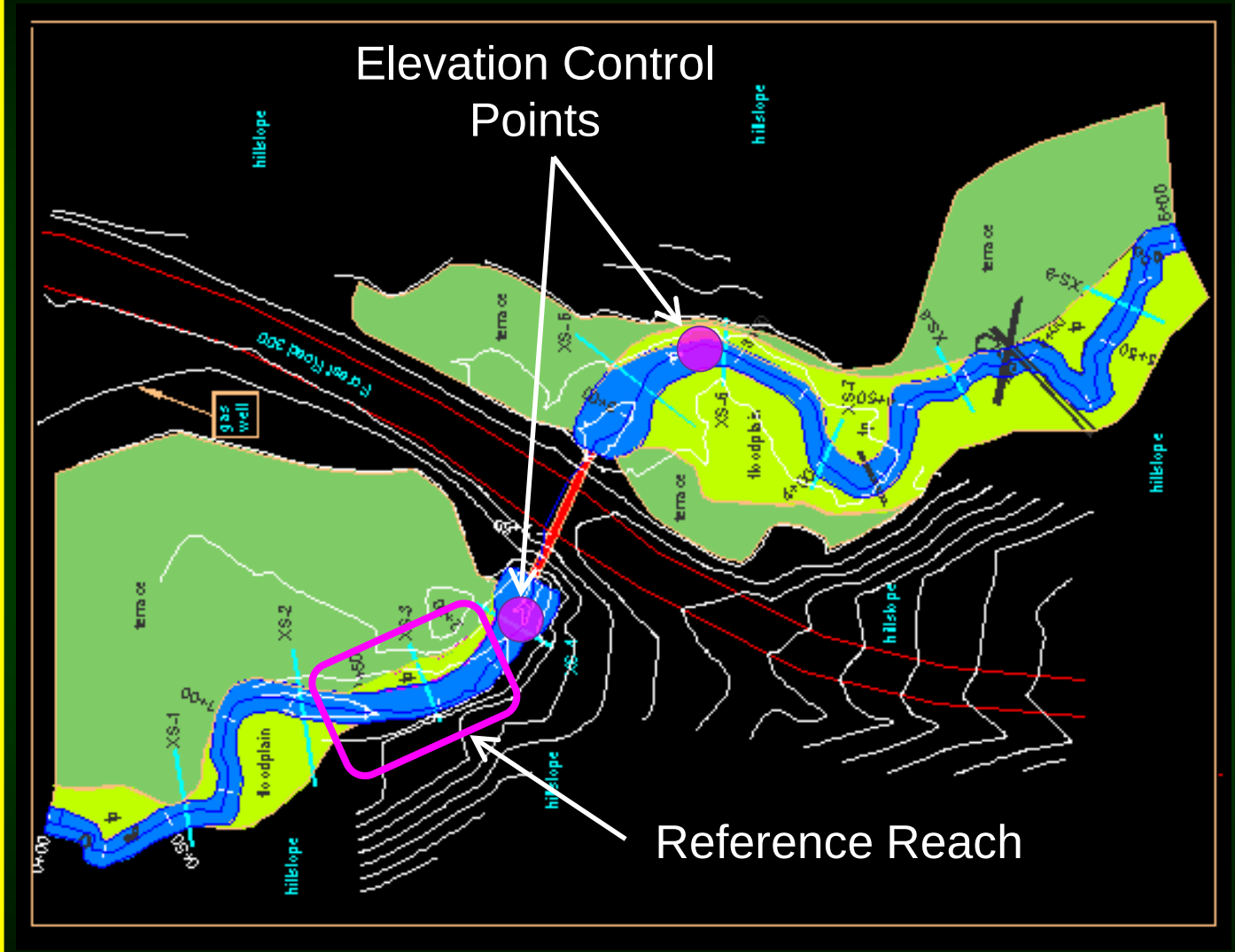
Cross Section Shape

Bed/Bank Sediments



Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Reference Reach Concept ~ TEMPLATE

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Reference Reach Concept ~ TEMPLATE

- Selected to match project gradient

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Reference Reach Concept ~ TEMPLATE

- Selected to match project gradient
- Consider length, confinement, planform

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Reference Reach Concept ~ TEMPLATE

- Selected to match project gradient
- Consider length, confinement, planform
- Out of the influence of existing crossing

Stream Simulation Design:

Horizontal Alignment

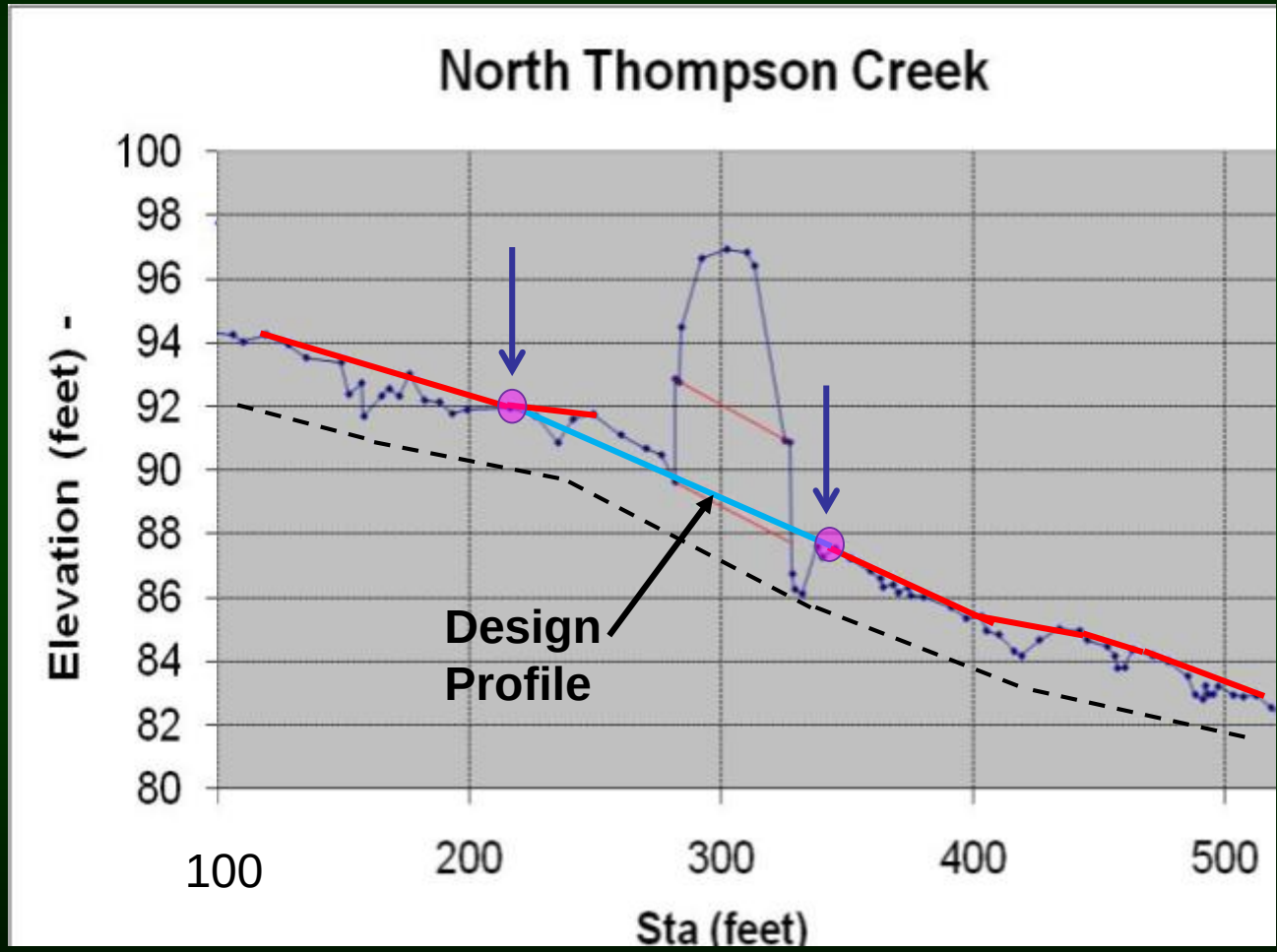
Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Project Design Profile – Grade Control



Stream Simulation Design:

Horizontal Alignment

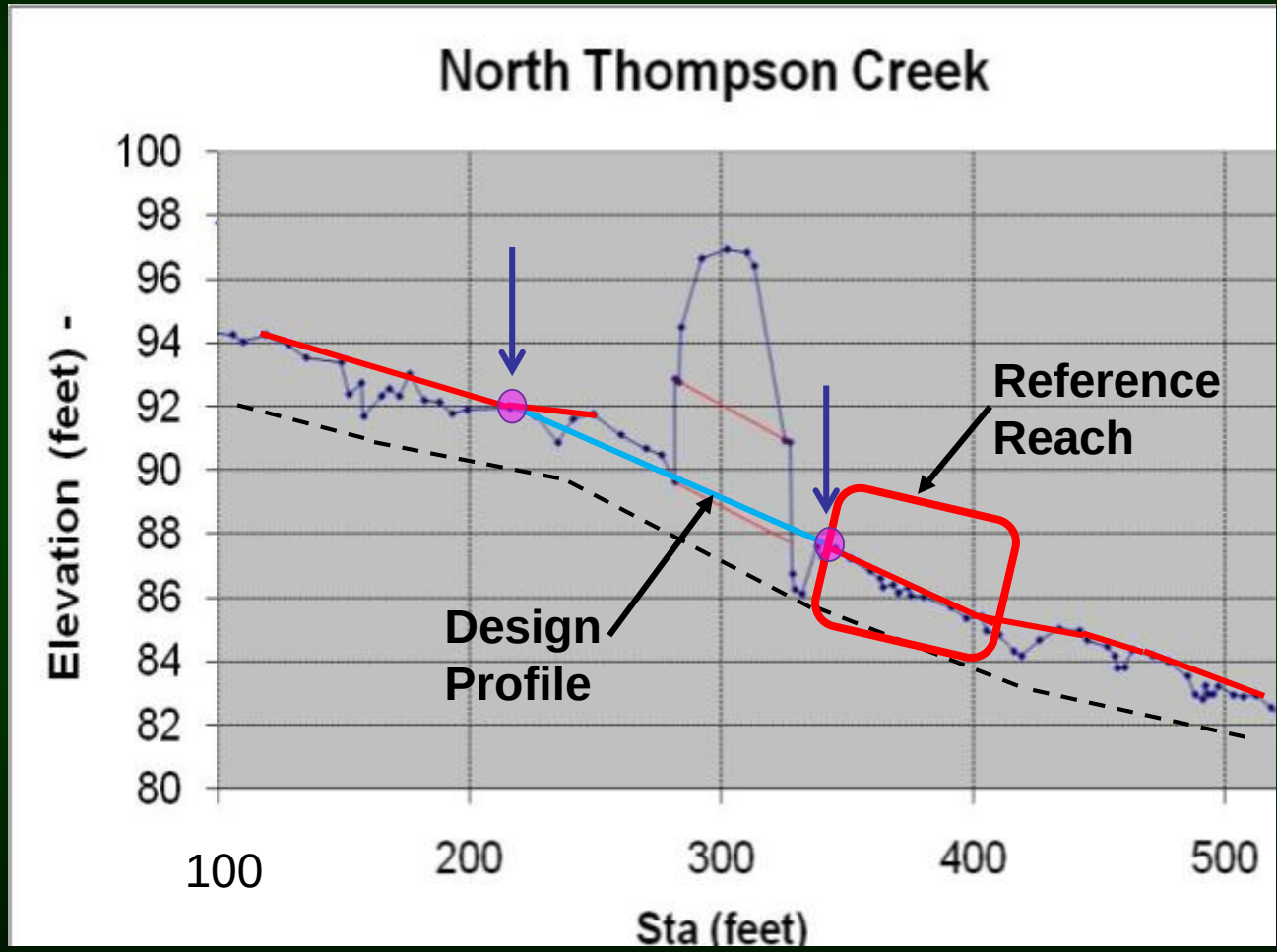
Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Project Design Profile – Grade Control



Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

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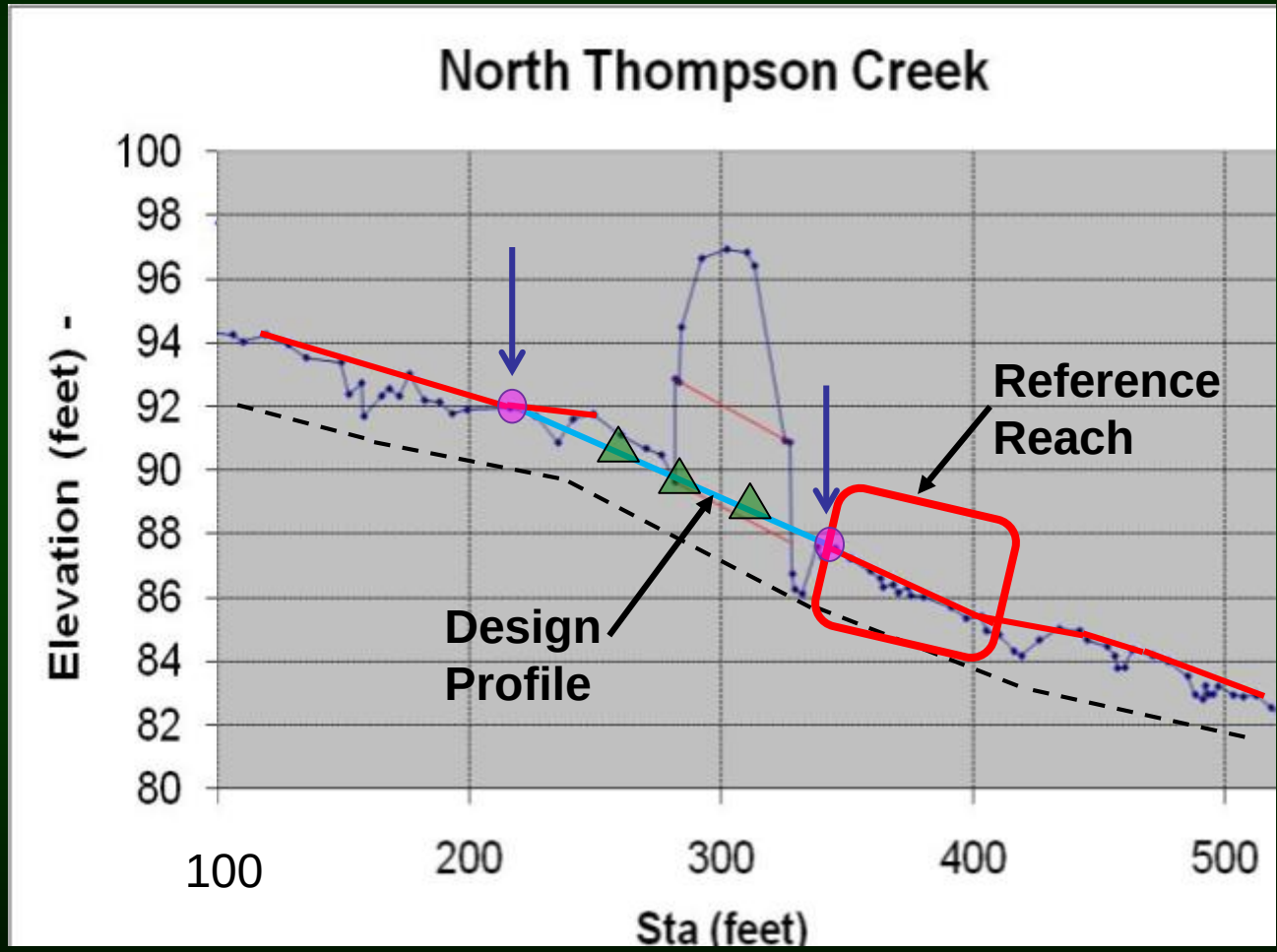
Cross Section Shape

Bed/Bank Sediments

Project Design Profile – Grade Control



Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

- From reference reach channel shape

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

- From reference reach channel shape

- Produces similar hydraulics and sediment transport

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

- Bed shape ~ channel complexity
- Simulate bank line variability

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Bank lines ~ natural width variability and roughness

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Stream Bed Material

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Stream Bed Material

Stream Simulation Design:

Horizontal Alignment

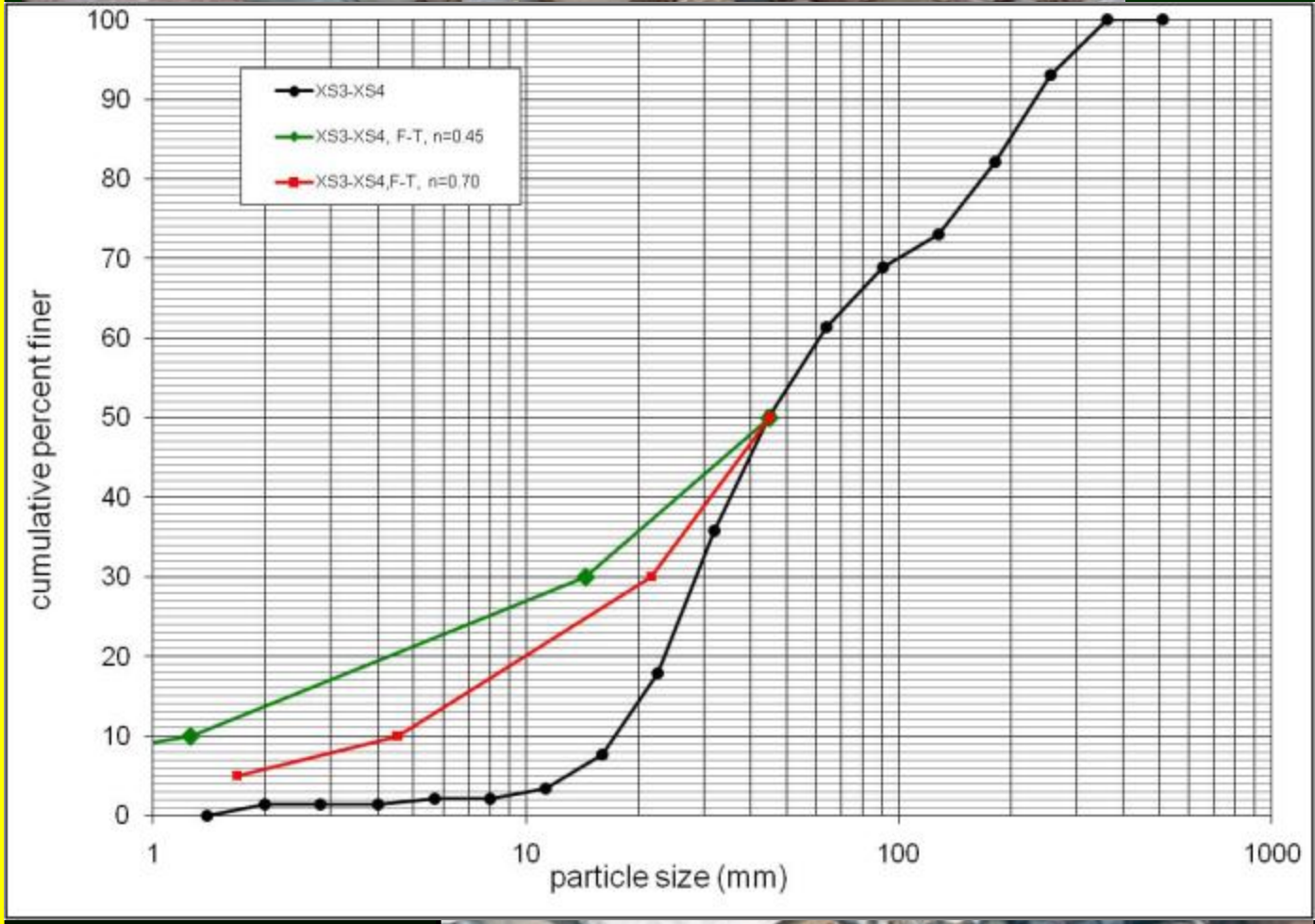
Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Stream Bed Material



Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Key Pieces

Stream Simulation Design:

Horizontal Alignment

Design Longitudinal Profile

- Reference Reach

Cross Section Shape

Bed/Bank Sediments

Key Pieces

Final Design & Contract Preparation:

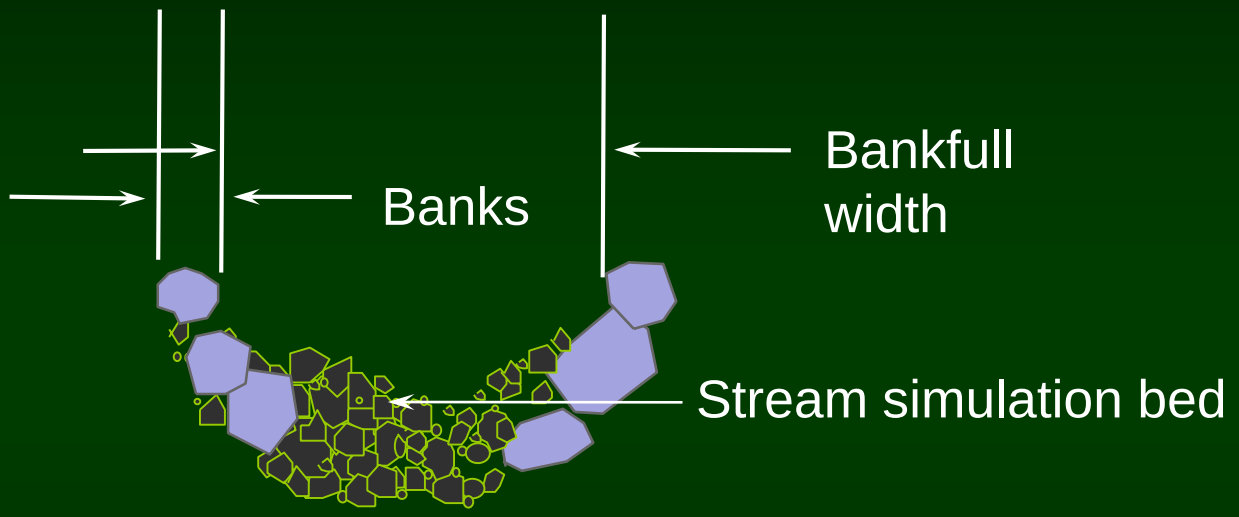
Structure Selection

Bed Mobility/Stability

Hydraulic Capacity

Final Bed Material Specifications

Contract Drawings



Procedure:

1. Fit structure over cross section and banks
2. Check Scour limits and bedrock issues
3. Check cover and max fill requirements
4. If OK proceed to final design and check HW/D, flood plain conveyance, and width against final key piece sizes . If not try another shape and size.

Final Design & Contract Preparation:

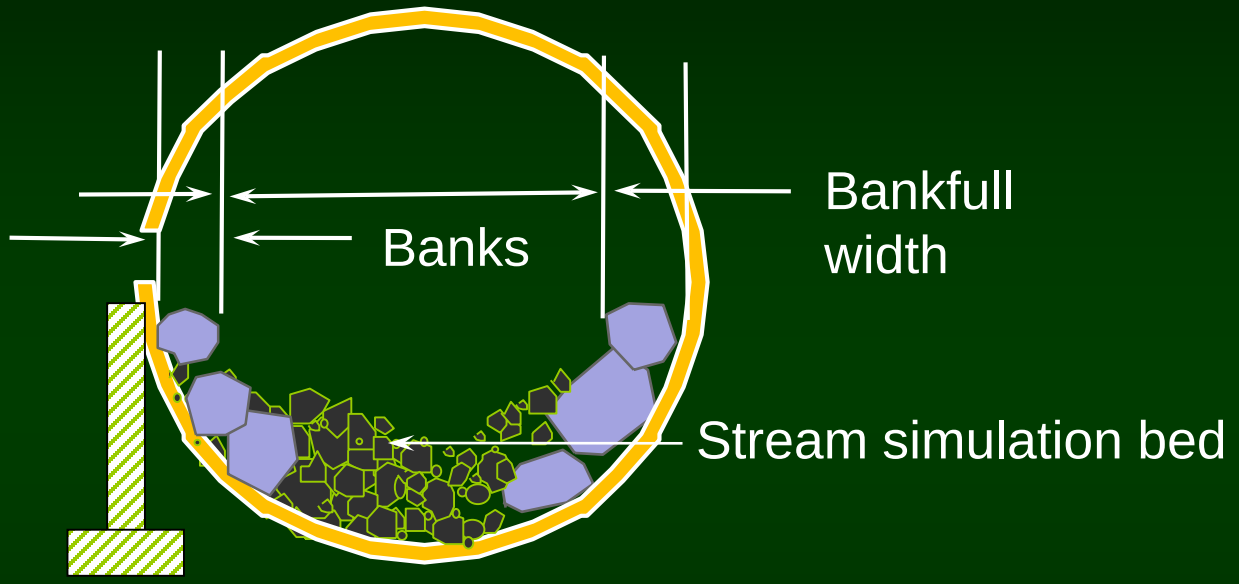
Structure Selection

Bed Mobility/Stability

Hydraulic Capacity

Final Bed Material Specifications

Contract Drawings



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Hydraulic Capacity

Final Bed Material Specifications

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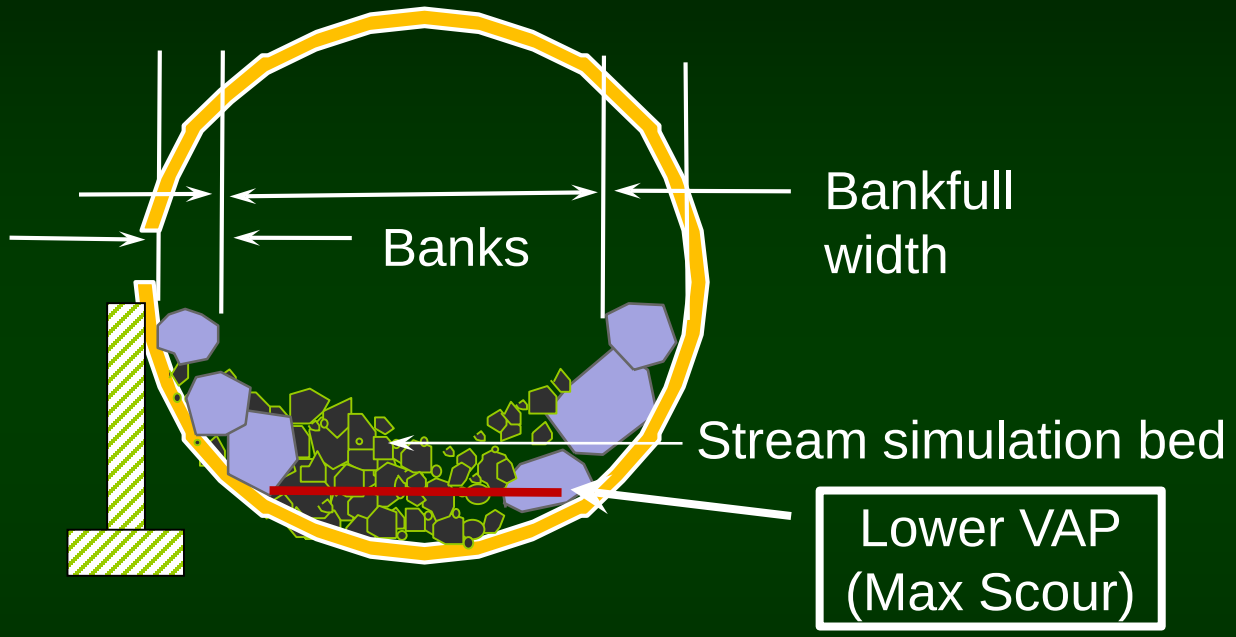

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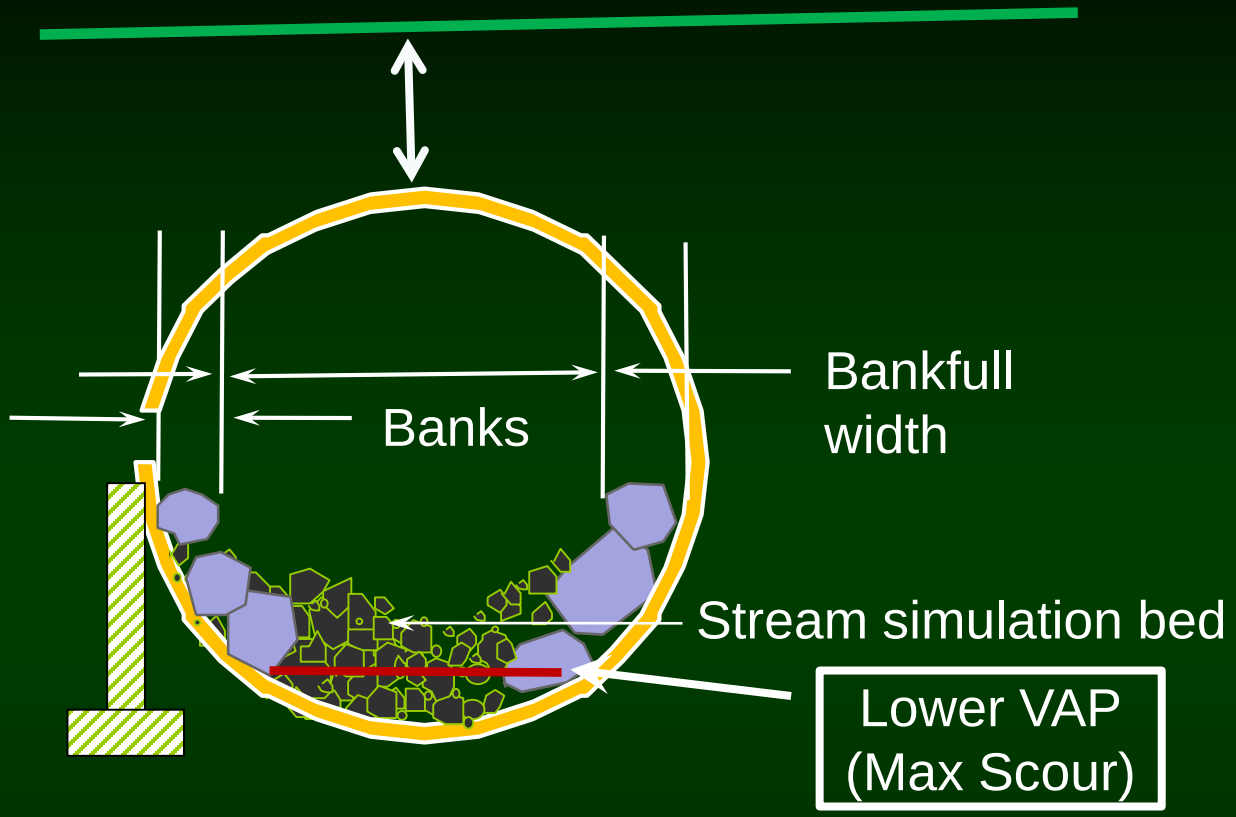
Hydraulic Capacity

Final Bed Material Specifications

Contract Drawings



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Final Design & Contract Preparation:

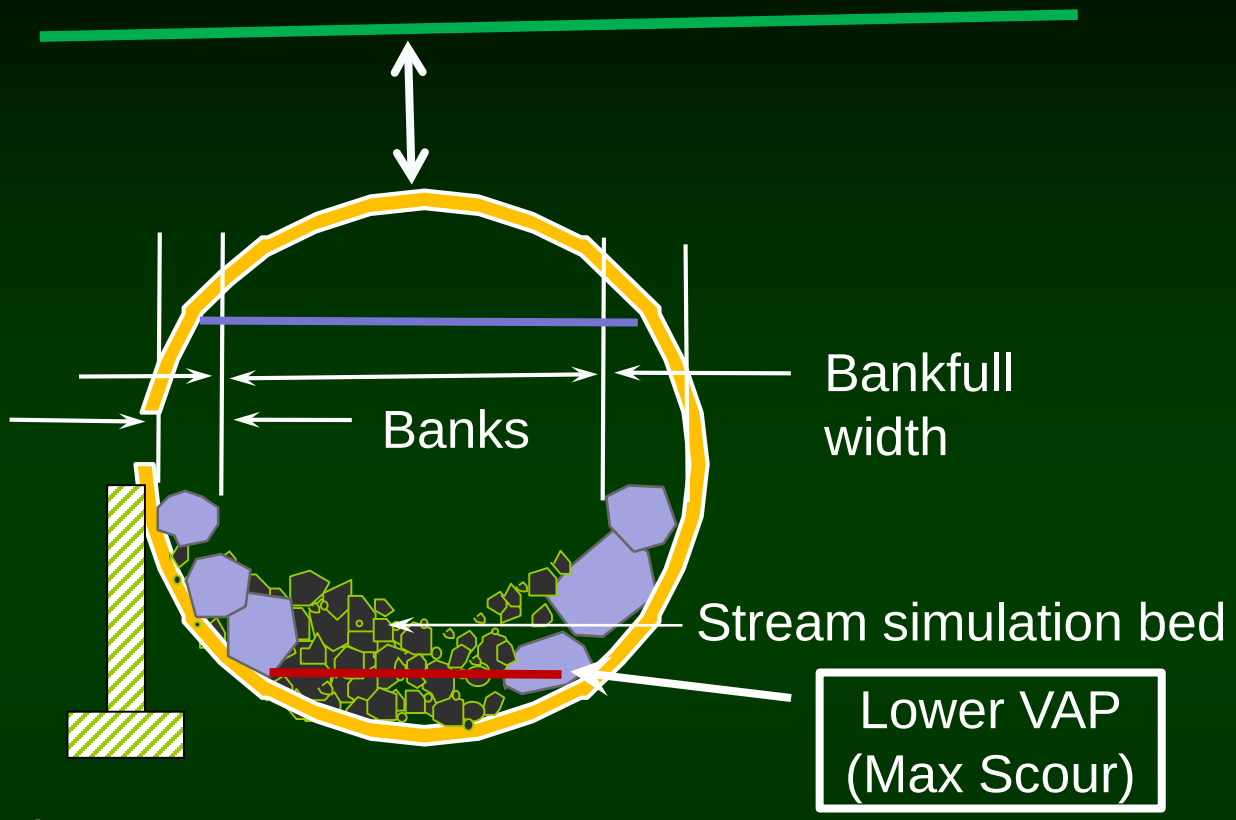
Structure Selection

Bed Mobility/Stability

Hydraulic Capacity

Final Bed Material Specifications

Contract Drawings



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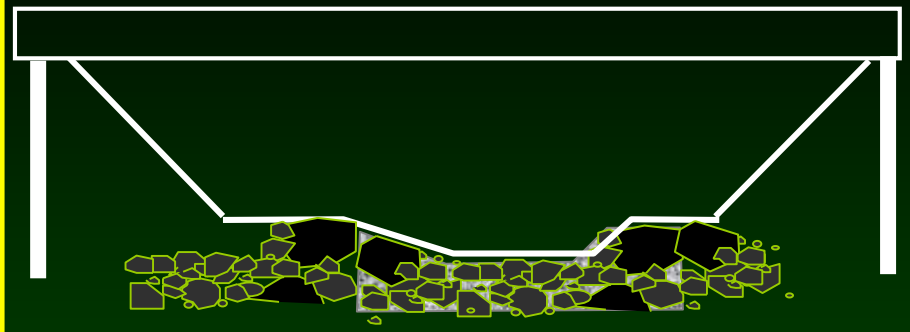
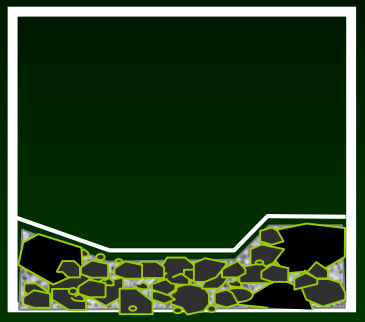
Final Design & Contract Preparation:

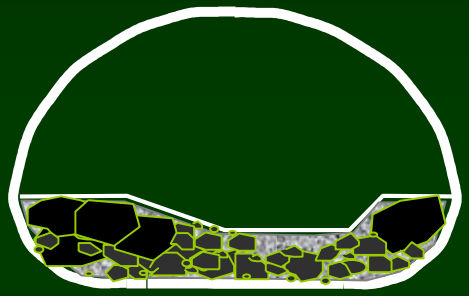
- Structure Selection
- Bed Mobility/Stability
- Hydraulic Capacity
- Final Bed Material Specifications
- Contract Drawings



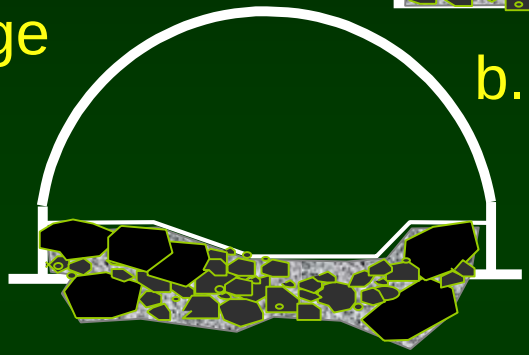
a. Bridge



b. Box

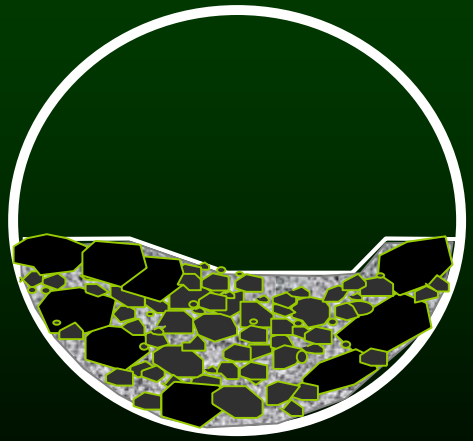


c. Pipe Arch



d. Bottomless Arch

- Same cross section and bed design
- embankment height, embedment depth, and constructability can be limitations.



e. Embedded Round

Final Design & Contract Preparation:

- Structure Selection
- Bed Mobility/Stability
- Hydraulic Capacity
- Final Bed Material Specifications
- Contract Drawings

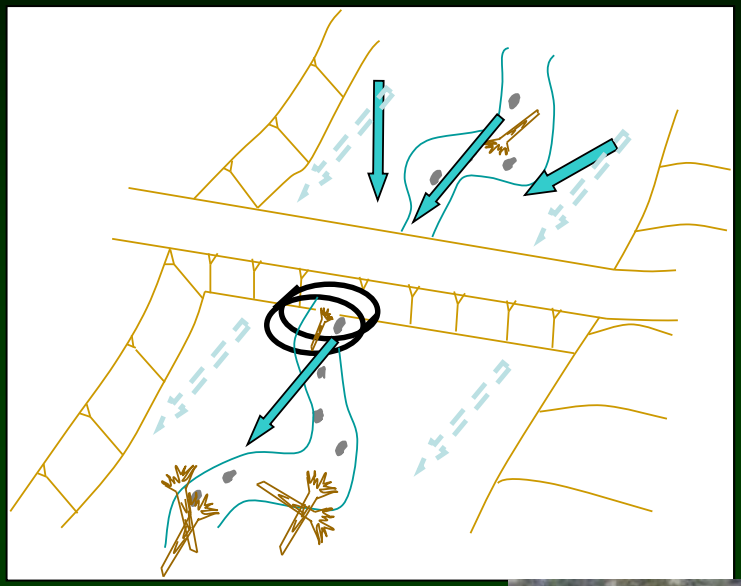
Floodplain Conveyance Considerations

Confined/incised channels - minimal floodplain

Final Design & Contract Preparation:

- Structure Selection
- Bed Mobility/Stability
- Hydraulic Capacity
- Final Bed Material Specifications
- Contract Drawings

Floodplain Conveyance Considerations



Unconfined – minor floodplain conveyance

Final Design & Contract Preparation:

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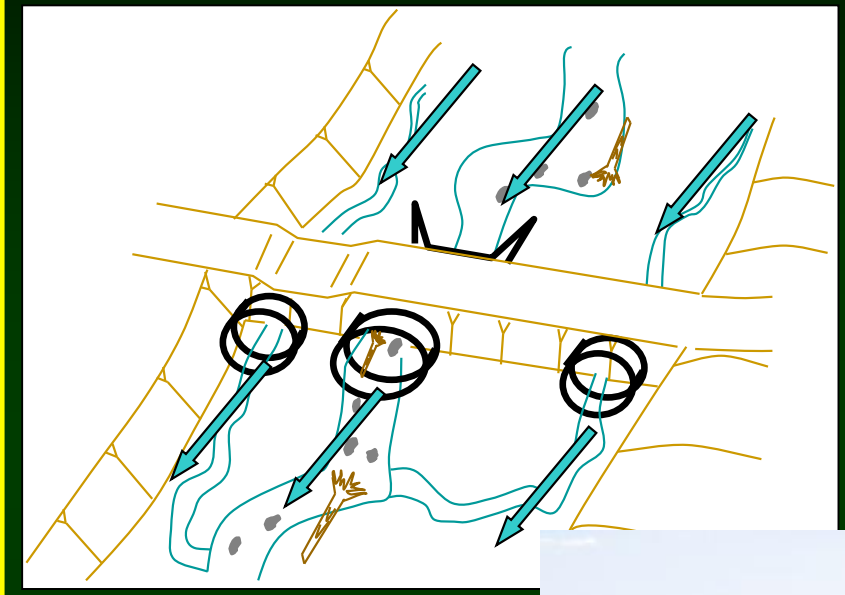
- Hydraulic Capacity
- Final Bed Material Specifications
- Contract Drawings

Floodplain Conveyance Considerations



Unconfined – high conveyance over wide floodplain

Final Design & Contract Preparation:

Structure Selection

Bed Mobility/Stability

Hydraulic Capacity

Final Bed Material Specifications

Contract Drawings

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Bed Material: Similar Mobility?

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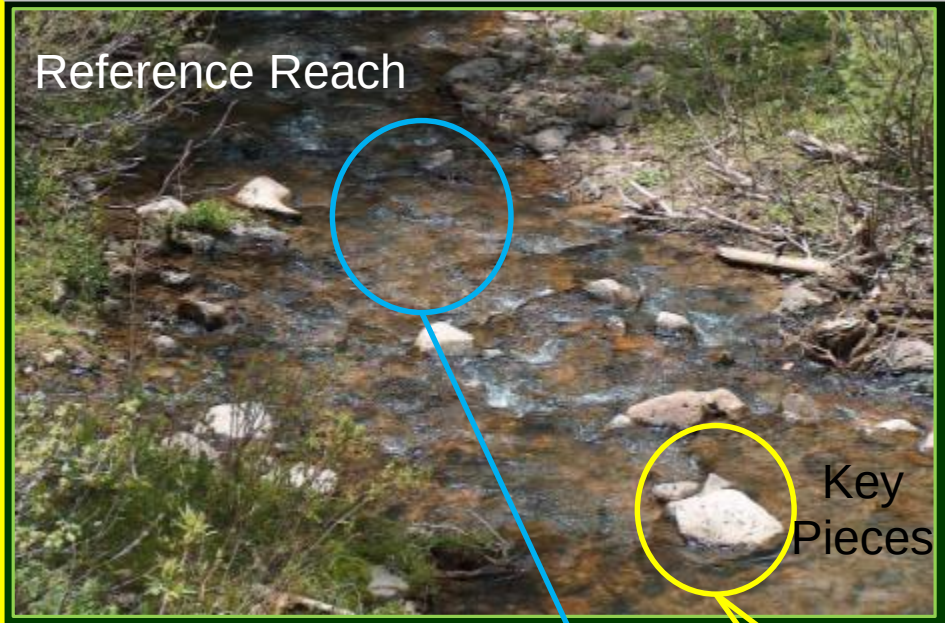

Key Pieces Stable?

Bed Material: Similar Mobility?

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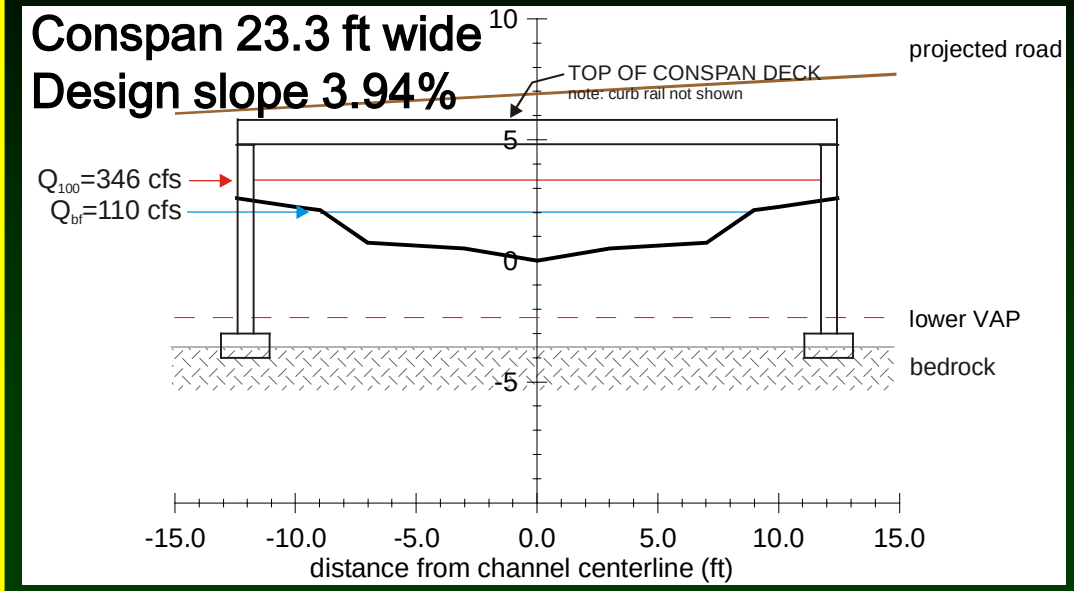

Headwater to depth ratio = 0.70 for Q100

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Headwater : Diameter Ratio (HW/D)

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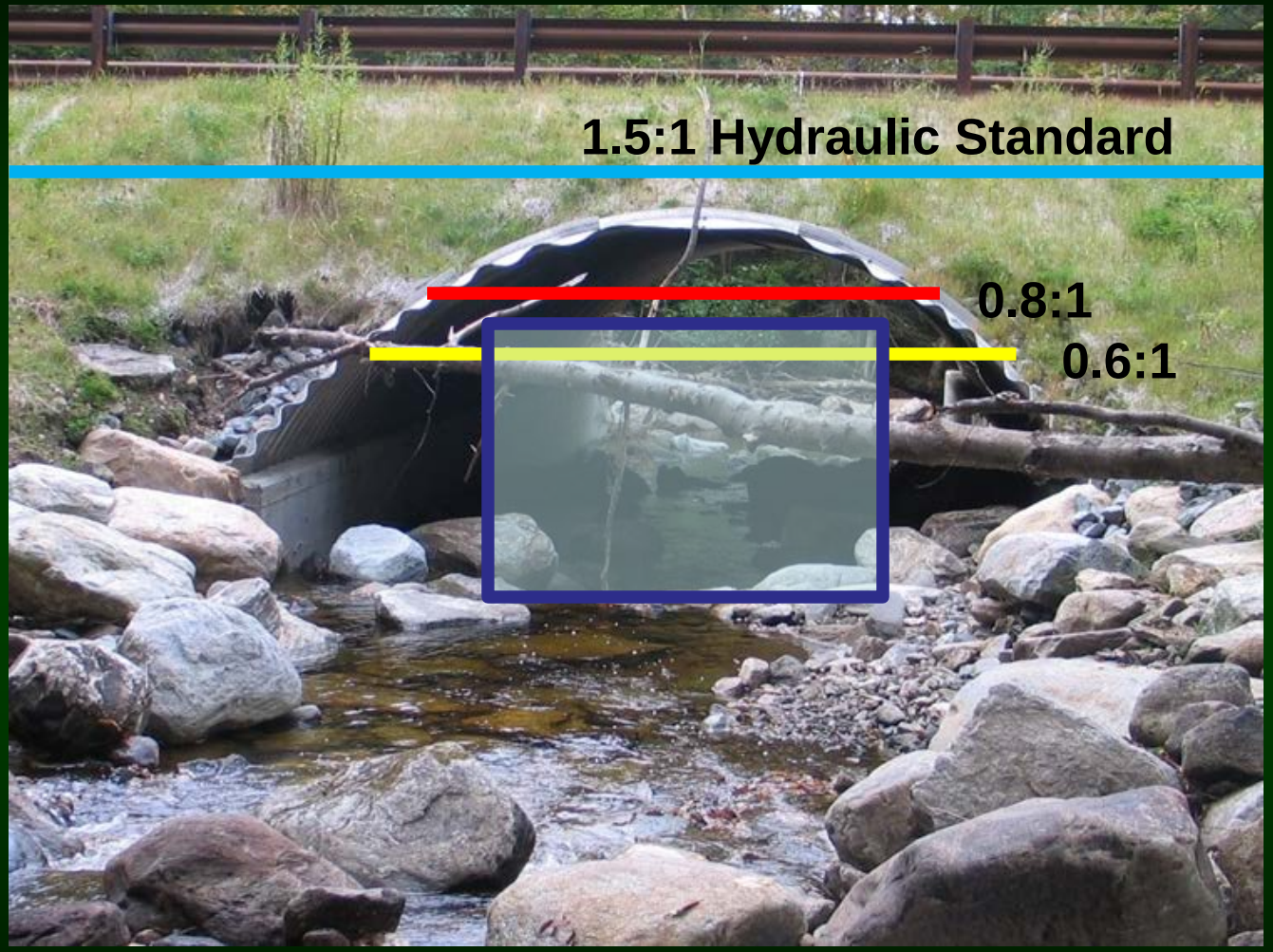

Headwater : Diameter Ratio (HW/D)

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Green Mountain N.F., Vermont

Completed 2010

Post TS Irene
September 2011

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Contract Drawings

Sieve Size (mm)	Sieve Size (inches)	Method A[b], Percent
512		**100**
305	12	
230	9	**79**
150	6	
100	4	**46**
75	3	
50	2	
25	1	**25**
19	3/4	
4.8	#4 (0.187)	
2.4	#8 (0.937)	**10**
1.2	#16(0.018)	

- Bed Design based on results from mobility analysis

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Hydraulic Capacity

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Contract Drawings

Sieve Size (mm)	Sieve Size (inches)	Method A[b], Percent
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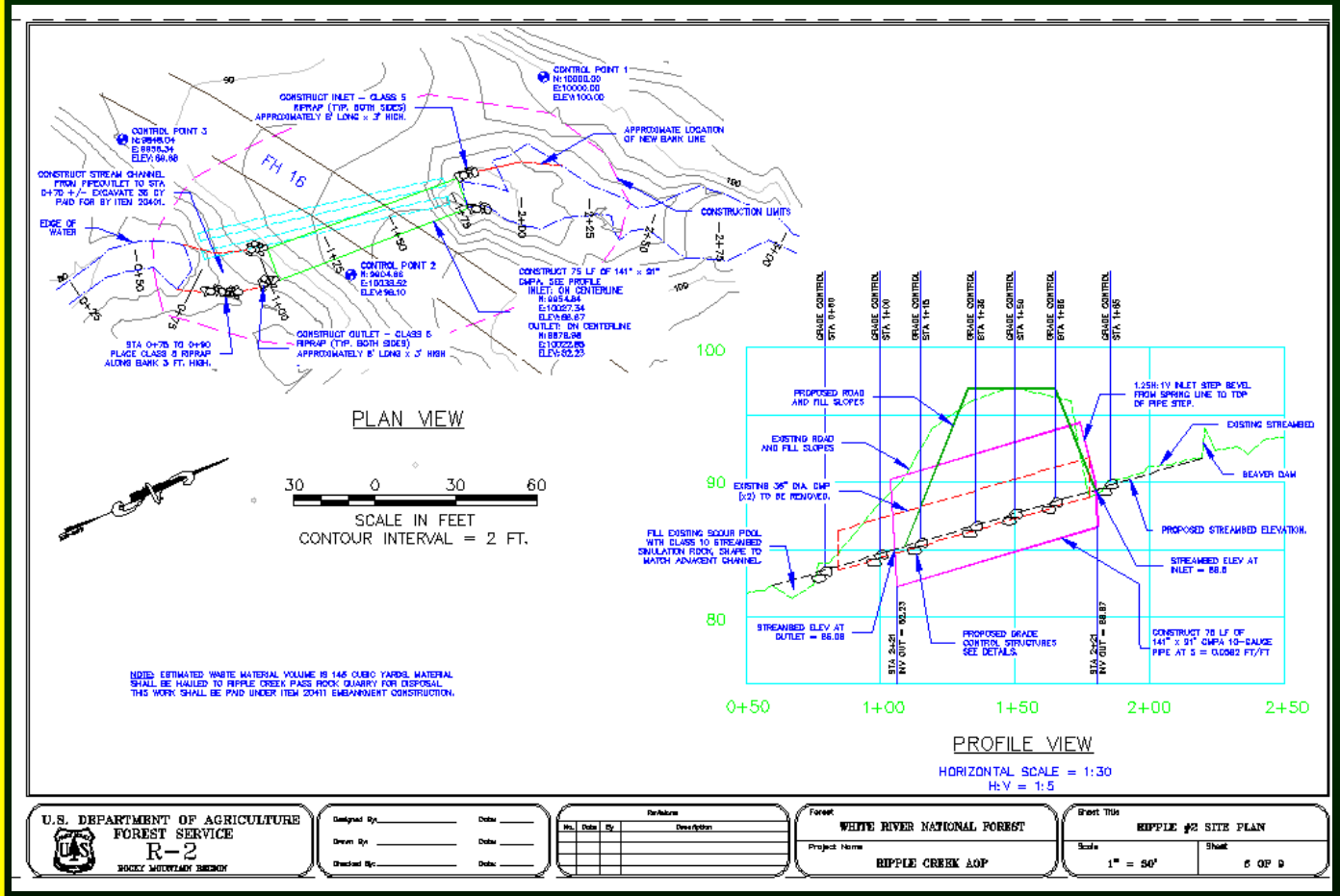
4.8	#4 (0.187)	
2.4	#8 (0.937)	**10**
1.2	#16(0.018)	

- Bed Design based on results from mobility analysis
- Banks and grade control (steep streams only) based on results from stability analysis

Final Design & Contract Preparation:

- Structure Selection
- Bed Mobility/Stability
- Hydraulic Capacity
- Final Bed Material Specifications
- Contract Drawings

Plan and Profile Drawings



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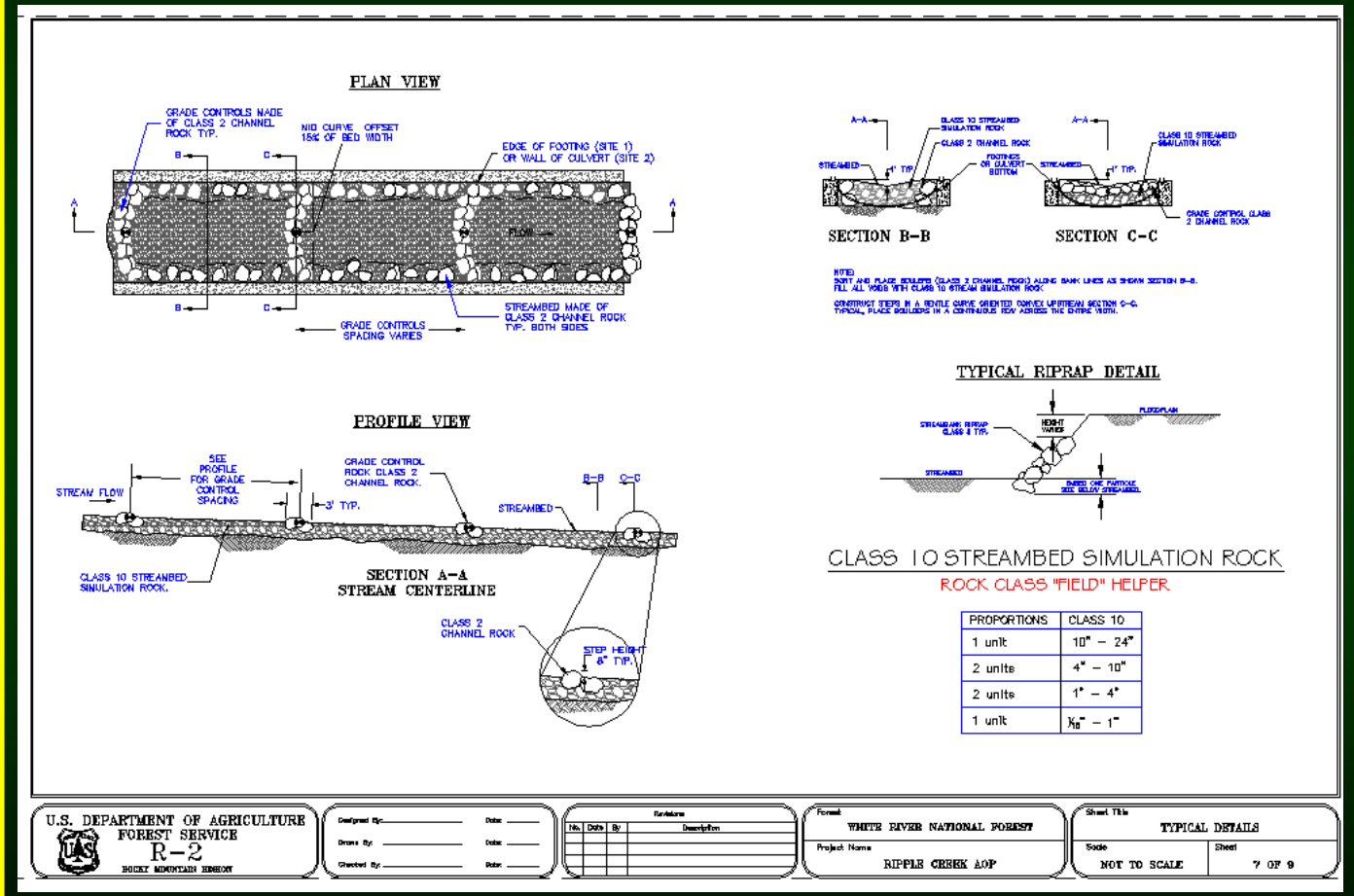
Typical Details



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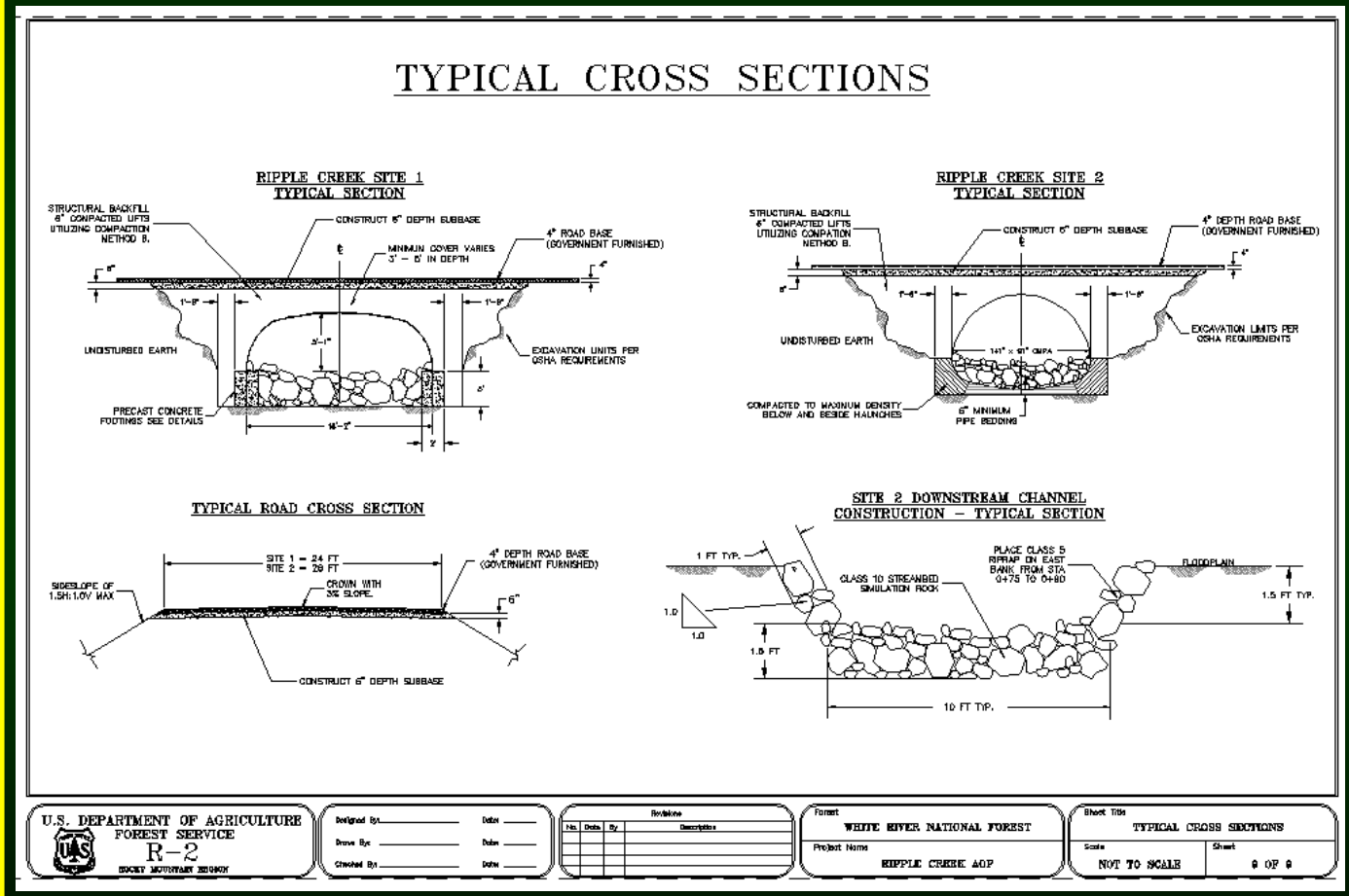
Typical Cross Sections



Construction:

Traffic Control

Fish Removal

Dewatering

Bed preparation

Banding culverts

Accurate surveys

Material placement

- Stream bed
- Grade controls

Examples

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Examples

Tongass N.F., Alaska

Construction:

- Traffic Control
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- Dewatering
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- Banding culverts
- Accurate surveys
- Material placement
  - Stream bed
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Examples

Tongass N.F., Alaska

Reference Reach

Design Channel

Construction:

- Traffic Control
- Fish Removal
- Dewatering
- Bed preparation
- Banding culverts
- Accurate surveys
- Material placement
  - Stream bed
  - Grade controls

Examples

White River N.F., Colorado

Construction:

- Traffic Control
- Fish Removal
- Dewatering
- Bed preparation
- Banding culverts
- Accurate surveys
- Material placement
  - Stream bed
  - Grade controls

Examples

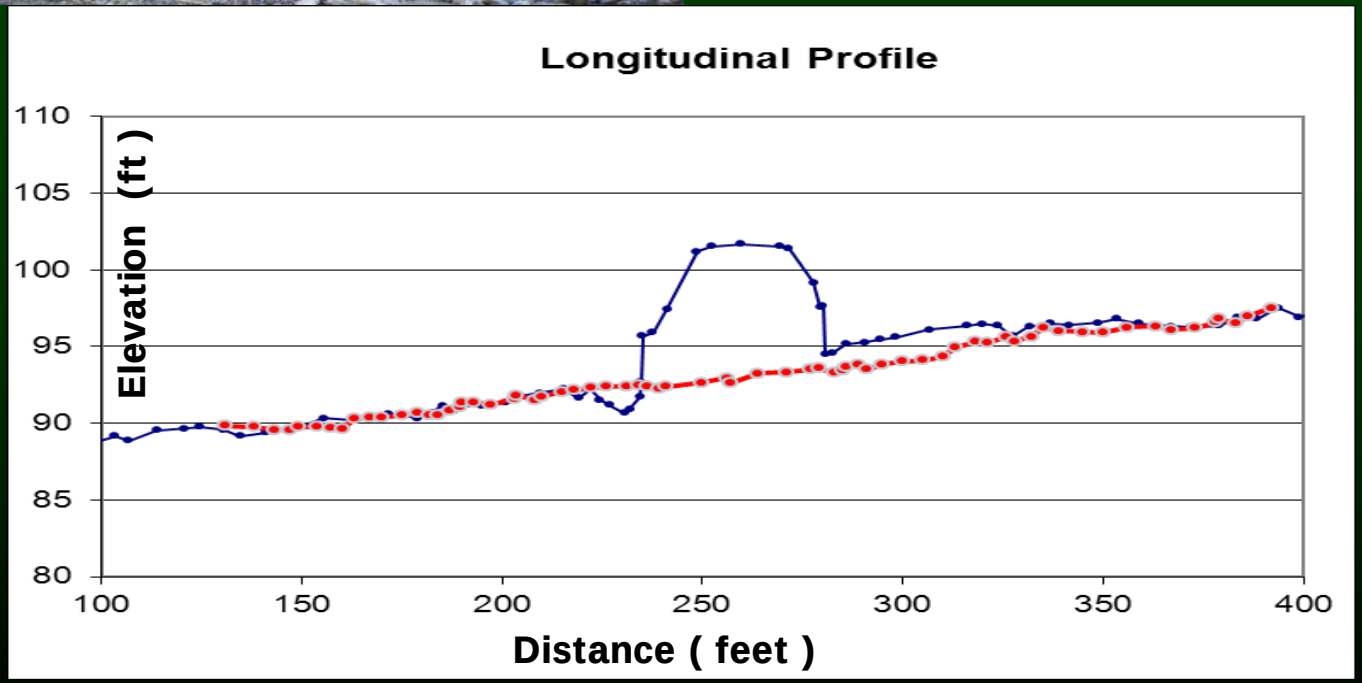
White River N.F., Colorado

Monitoring:

Physical

- Implementation
- Effectiveness

Biological



Monitoring:

Physical

Implementation

Effectiveness

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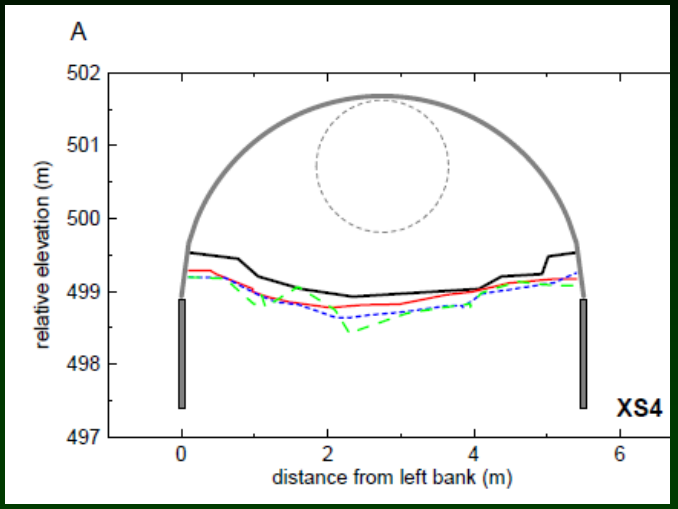
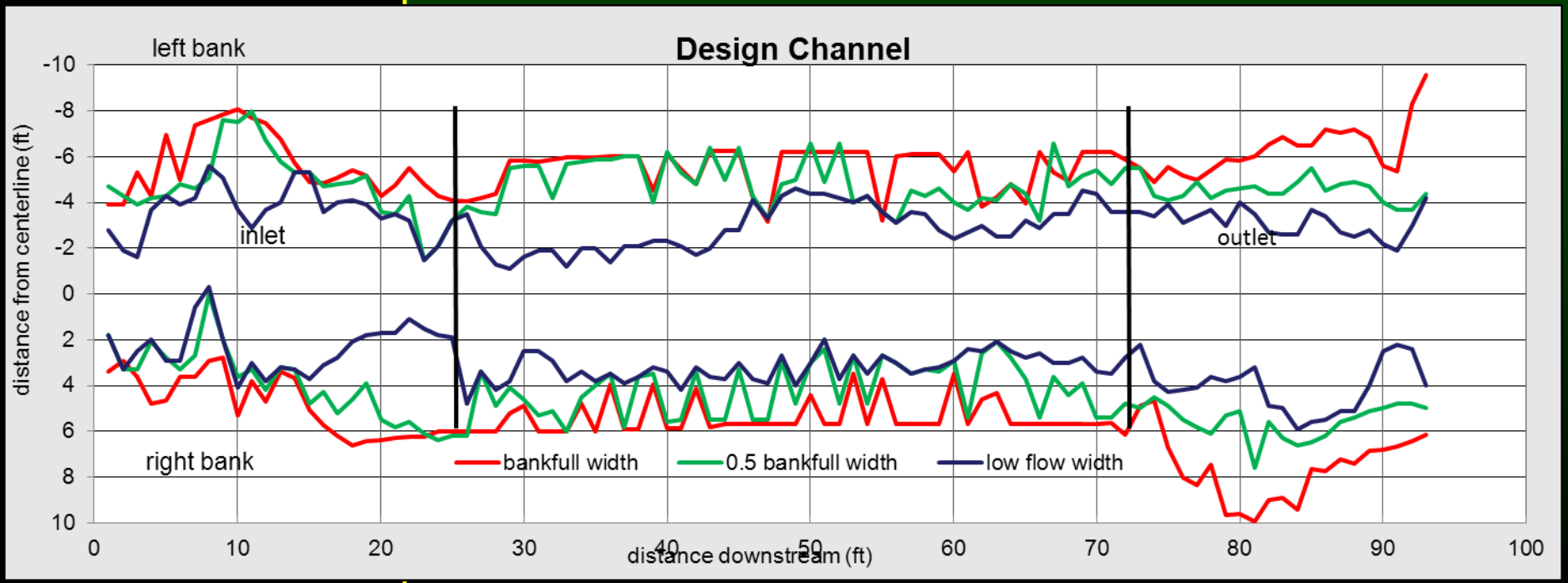




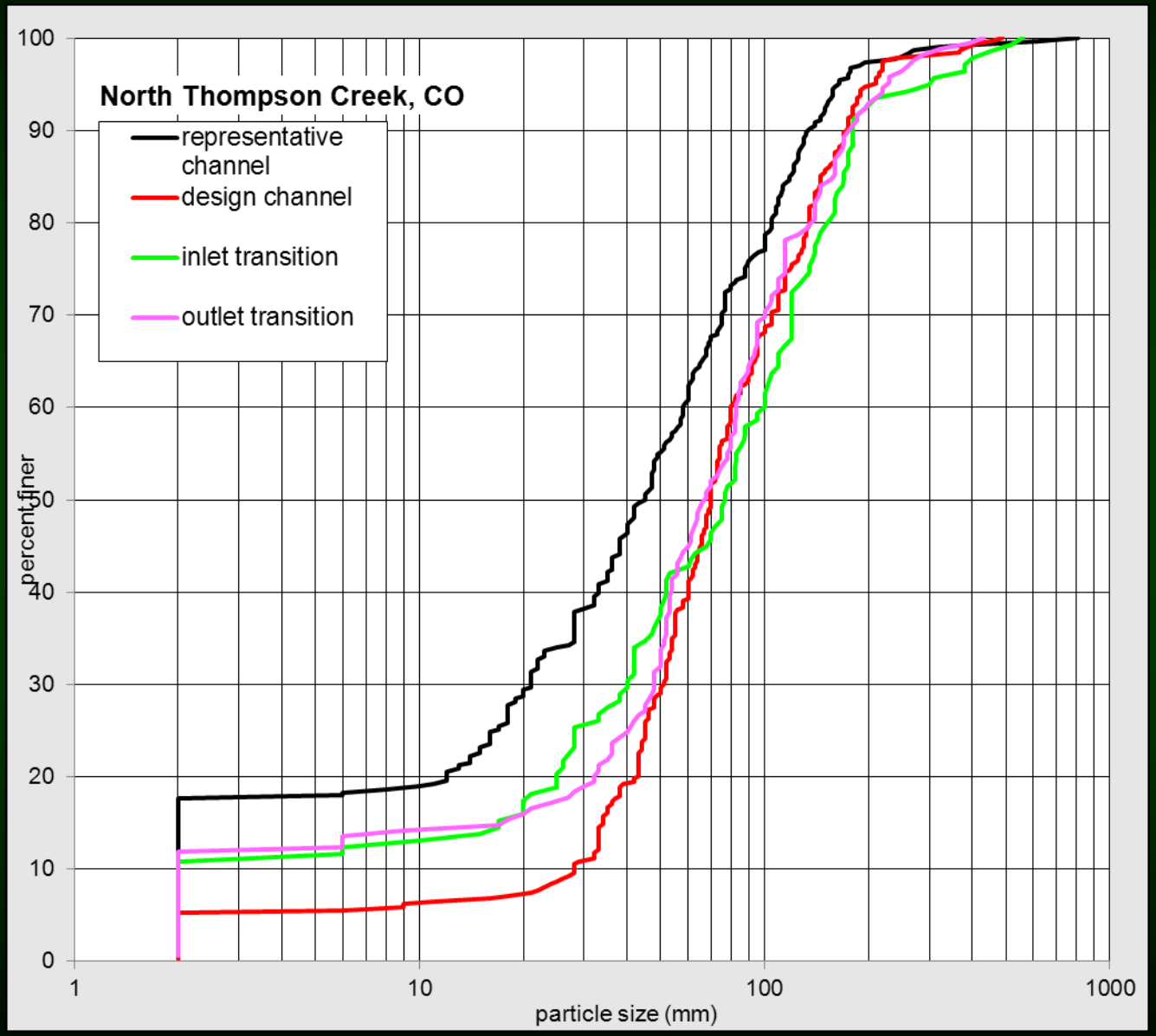
Monitoring:

Physical

Implementation

Effectiveness

Biological



Monitoring:

Physical

- Implementation
- Effectiveness

Biological

Distance (feet)

AOP
Aquatic Organism Passage

USDA

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

Minnesota 2011

Coconino NF
2009

AOP
Aquatic Organism Passage

USDA

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Again… This is a solvable problem with multiple, significant benefits !