Fish Passage, Stream Design, Bridge Scour







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Washington State Department of Transportation

Fish Passage

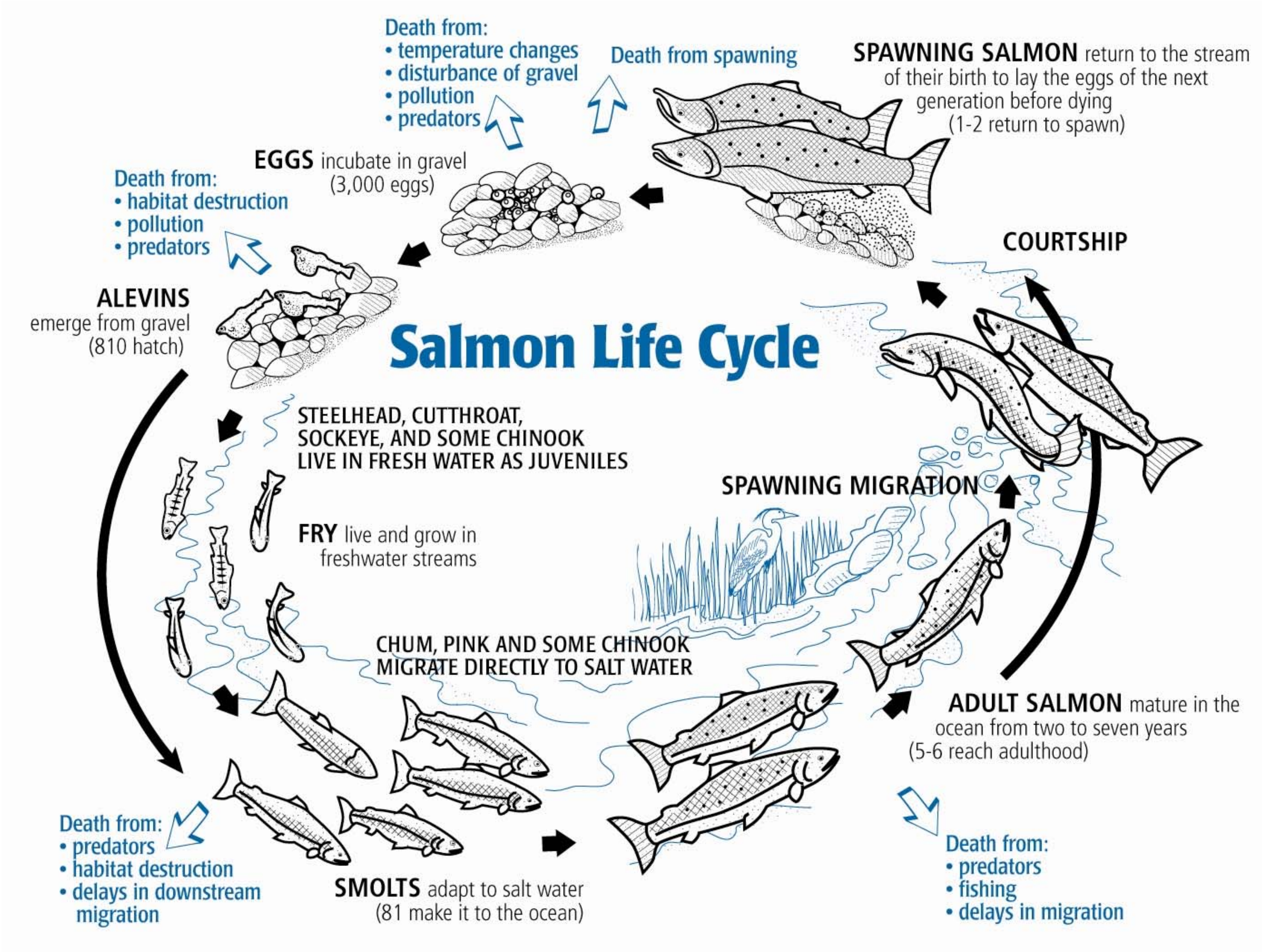
Top: SR 542 High Creek, built 2016
Bottom: SR 9 Lake Creek, built 2015

Fish Passage—Why is it Important?

- **Improves fish access**
- **Helps in protecting and restoring fish populations**
- **Federal Court Injunction**

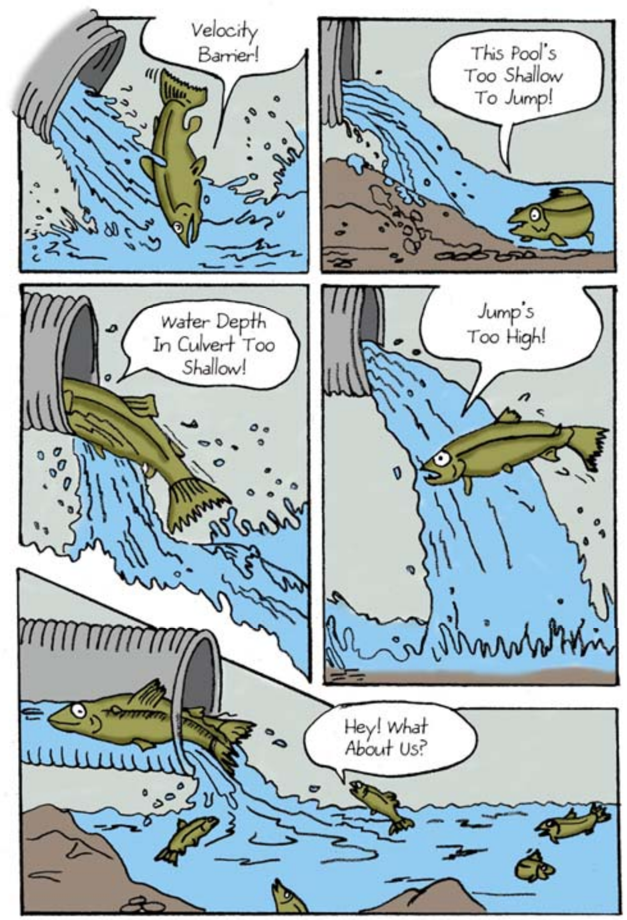
SR 532 Secret Creek, built 2016

Fish Passage—Why is it Important?



What is a Fish Barrier?

- **Anything that hinders any life stage of fish from moving through a water way**
- **Types:**
  - **Velocity**
  - **Water depth**
  - **Water Surface drop**
  - **Slope**
  - **Tidegate or Floodgate**



WSDOT-Redrawn from Fish Passage Short Course, John Runyon

What is a Fish Barrier?

<table>
<tr><th>Parameter</th><th>Value</th><th>Range</th><th>Passability</th></tr>
<tr><td rowspan="3">Water Surface Drop</td><td rowspan="3">≥ 0.8 ft</td><td>≥ 0.8 ft to < 1.6 ft</td><td>0.67</td></tr>
<tr><td>≥ 1.6 ft to < 3.3 ft</td><td>0.33</td></tr>
<tr><td>≥ 3.3 ft</td><td>0</td></tr>
<tr><td rowspan="3">Slope (Culverts ≤ 60 feet length)</td><td rowspan="3">≥ 1%</td><td>≥ 1% to < 2%</td><td>0.67</td></tr>
<tr><td>≥ 2% to < 4%</td><td>0.33</td></tr>
<tr><td>≥ 4%</td><td>0</td></tr>
<tr><td rowspan="2">Slope (Culverts ≥ 60 feet length)</td><td rowspan="2">≥ 1%</td><td>≥ 1% to < 2%</td><td>0.33</td></tr>
<tr><td>≥ 2%</td><td>0</td></tr>
<tr><td rowspan="2">Velocity (Level B Results)</td><td rowspan="2"><table><tr><th>Culvert Length</th><th>Maximum Velocity</th></tr><tr><td>10 - 100 ft.</td><td>4.0 feet per second</td></tr><tr><td>100 - 200 ft.</td><td>3.0 feet per second</td></tr><tr><td>> 200 ft.</td><td>2.0 feet per second</td></tr></table></td><td>< 2 ft/s over criterion for 6 in trout</td><td>0.67</td></tr>
<tr><td>≥ 2 ft/s over criterion for 6 in trout</td><td>0.33</td></tr>
<tr><td rowspan="3">Depth (Level B Results)</td><td rowspan="3">≤ 1 ft</td><td>≥ 0.5 ft to < 1.0 ft</td><td>0.67</td></tr>
<tr><td>≥ 0.16 ft to < 0.5 ft</td><td>0.33</td></tr>
<tr><td>≥ 0.16 ft</td><td>0</td></tr>
</table>

Converted from metric. Table 3.3 from WDFW Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual

By the numbers…

- **Statewide 1,989 culverts are barriers on the highway system**
- **1,530 are fish barriers with more than 200m of upstream habitat**
- **As of 2016 WSDOT completed 301 projects statewide and improved access to 1,000 miles of upstream habitat**

SR 522 Lyon Creek, built 2015

Who does the work?

- **Stream Design: HQ Hydraulics or an engineer approved by HQ Hydraulics (Region or consultant)**
- **Roadway Geometrics: Project Offices**
  - **Burlington PEO (Mikkel Lamay)**
  - **Sno-King Design (John Chi)**
  - **Olympia PEO (Kim Mueller)**
  - **Chehalis PEO (Colin Newell)**
  - **Wenatchee PEO (Dan Lewis)**

SR 112 Trib to Pysht River

So my project has a barrier…

- **Contact HQ ESO/Hydraulics at the beginning of the project (scoping phase if possible)**
- **A Hydraulic Design Report (PHD/FHD) will be needed.**
- **HQ Hydraulics will work with you to create a design that meets the WAC and injunction**

SR 112 Jansen Creek, built 2016

We need to put in what?

- **New structures are often much larger than existing**
- **Stream simulation min: 1.2*bankfull width+2 ft.**
- **Unconfined floodplains can yield structures larger than stream simulation**

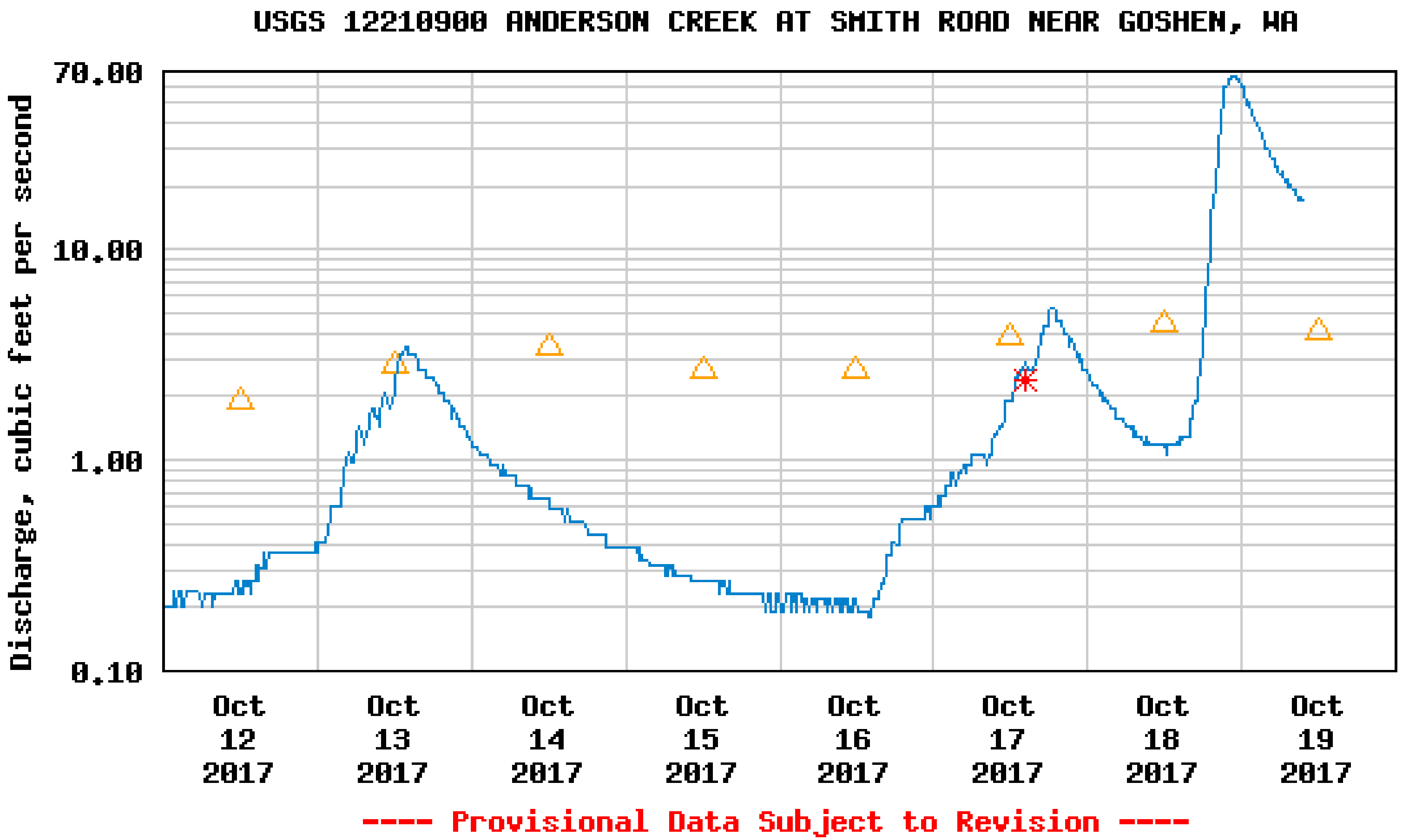
SR 542 Anderson Creek, unaffected reach

SR 542 Anderson Creek Before

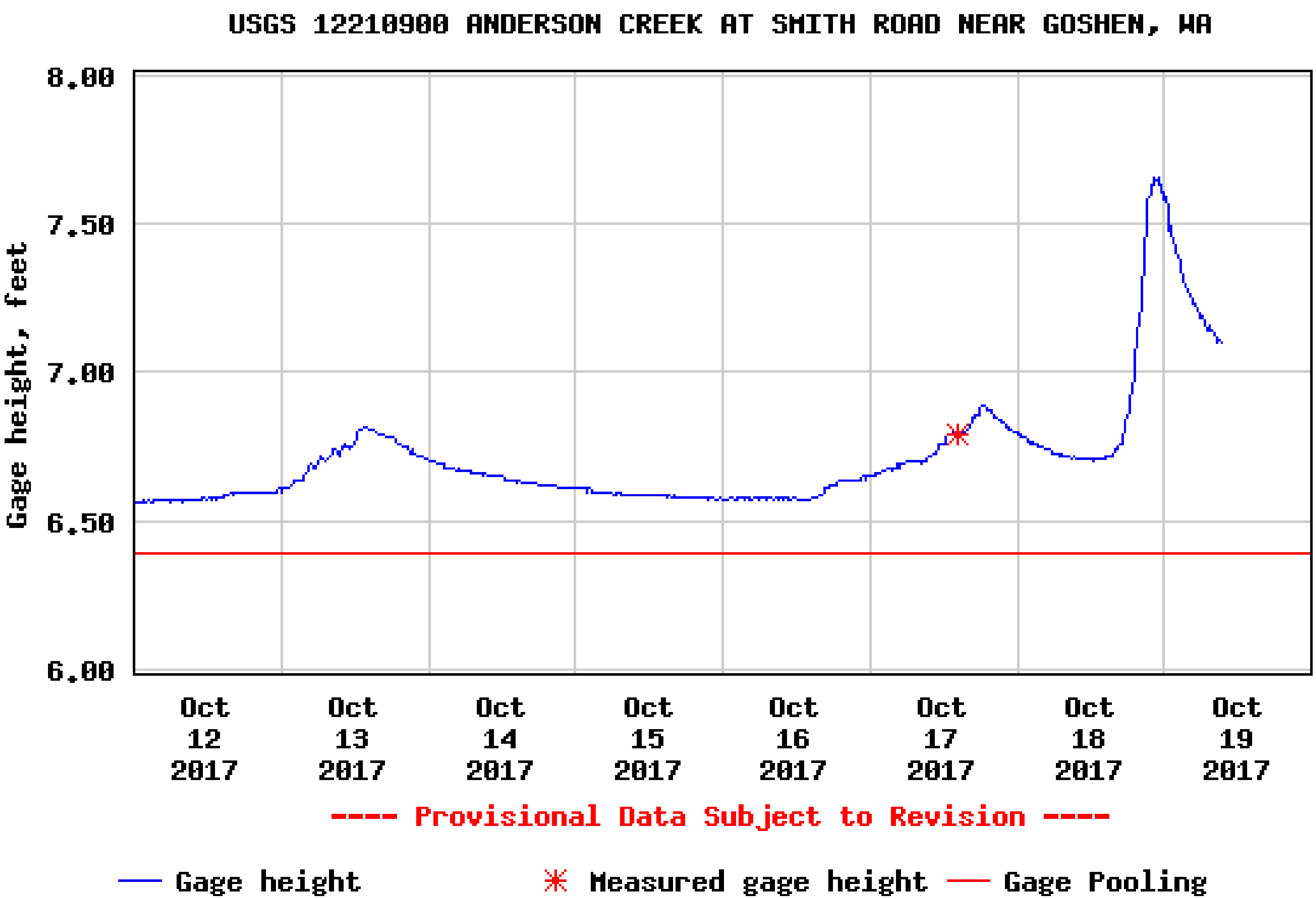
SR 542 Anderson Creek After

SR 542 Anderson Creek After

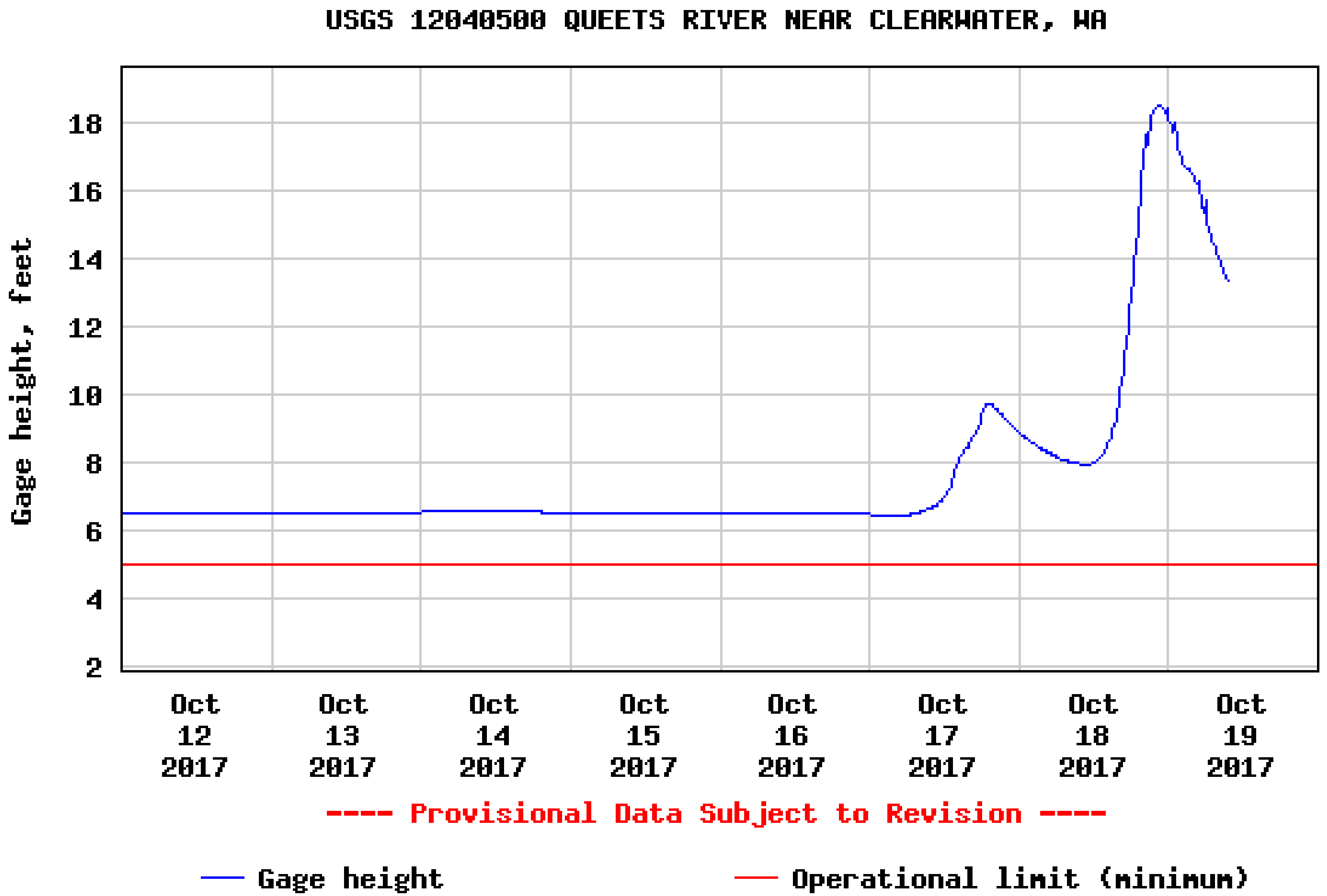
Anderson Creek Hydrograph



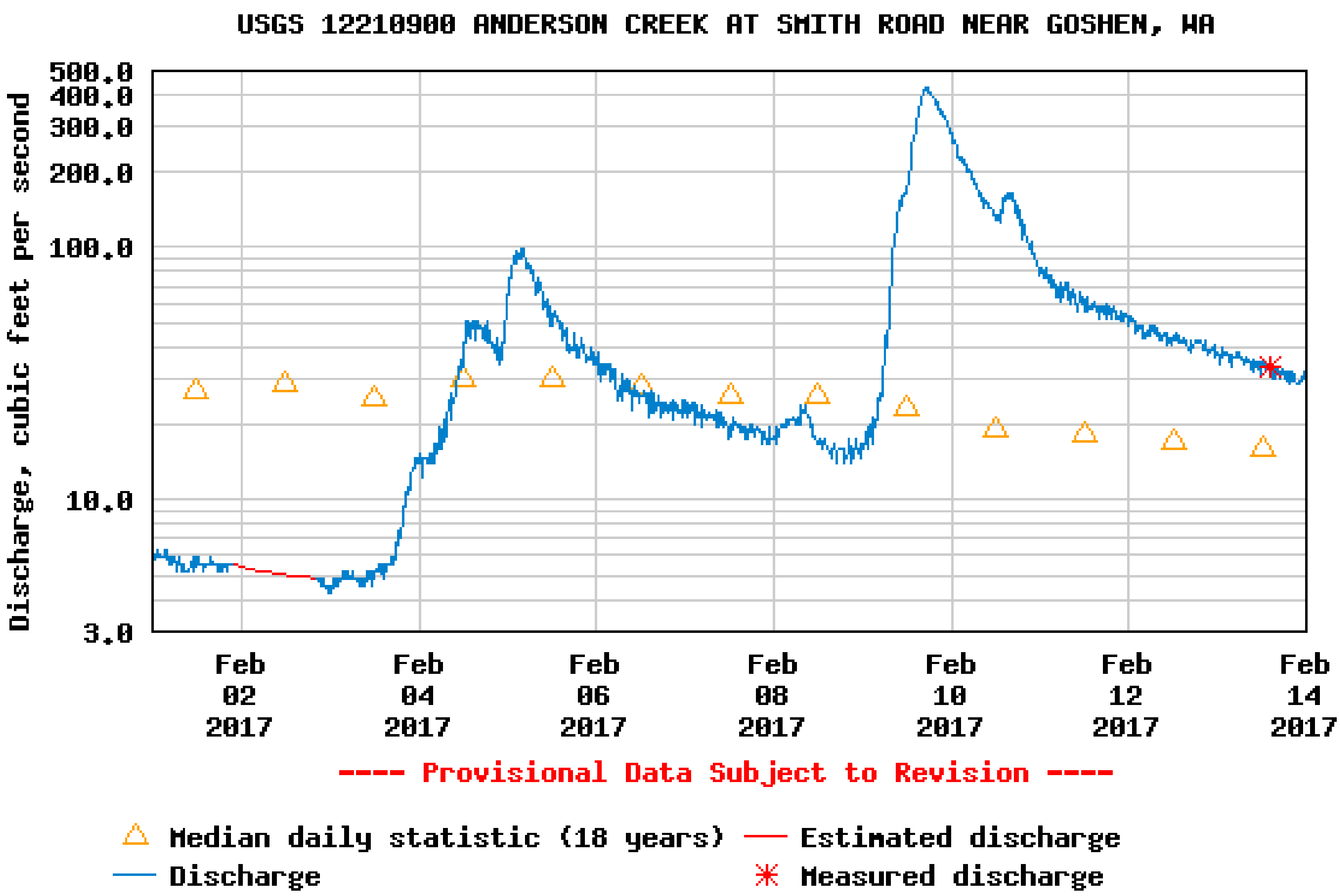
Anderson Creek Gage Depth



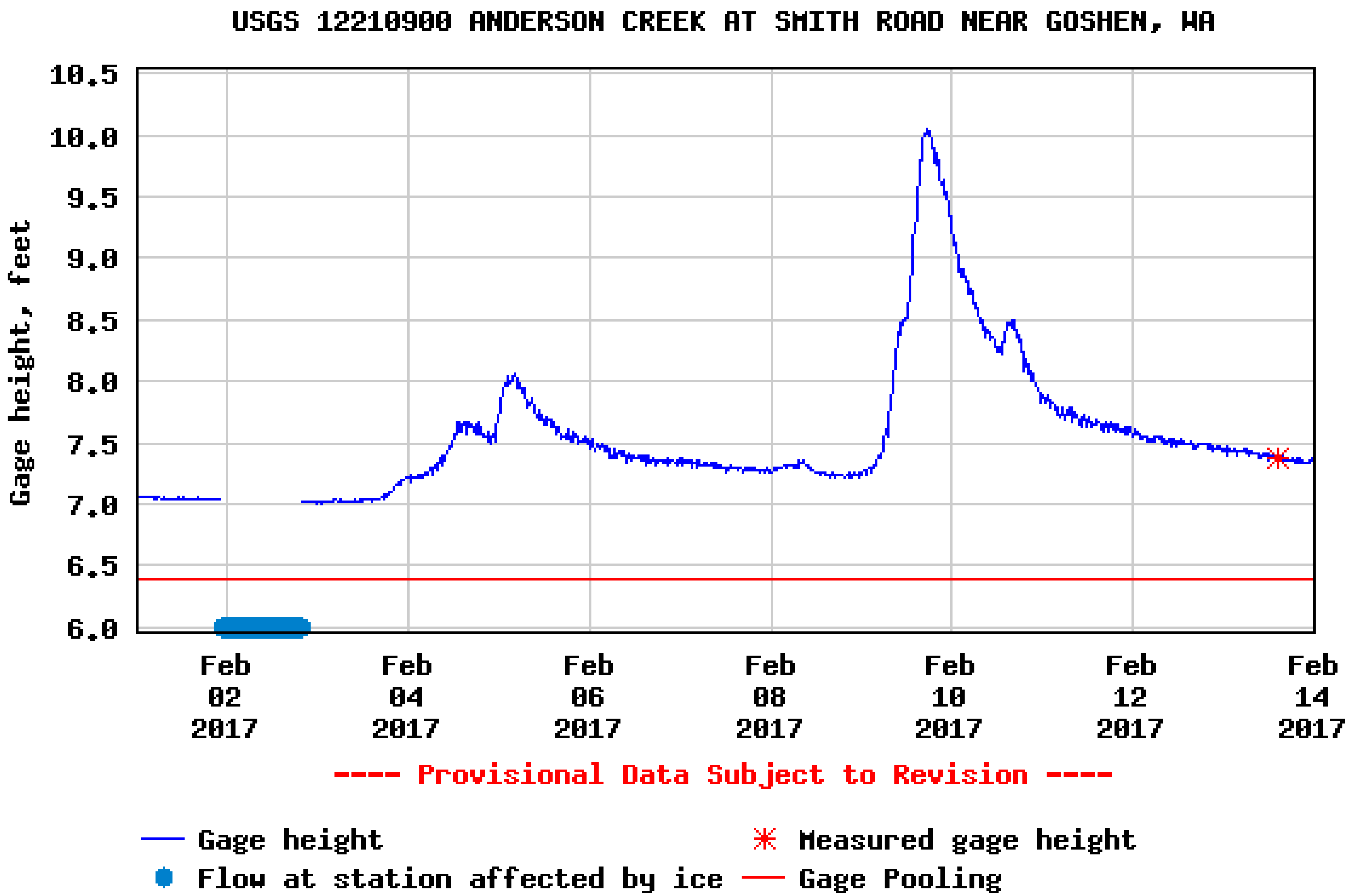
Queets River Gage Depths



Anderson Creek Hydrograph



Anderson Creek Gage Depth



Anderson Creek Downstream

Above: 10/2/15, Below: 11/18/15

Above: 11/2/15, Below: 12/14/15

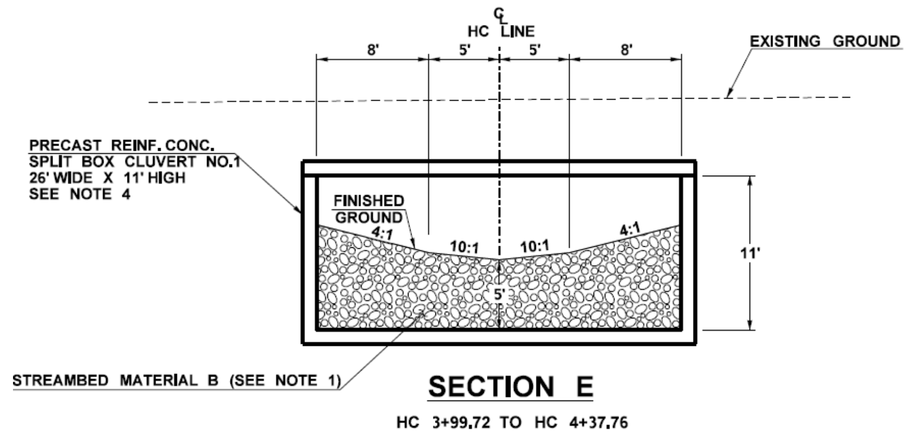
Anderson Creek Upstream

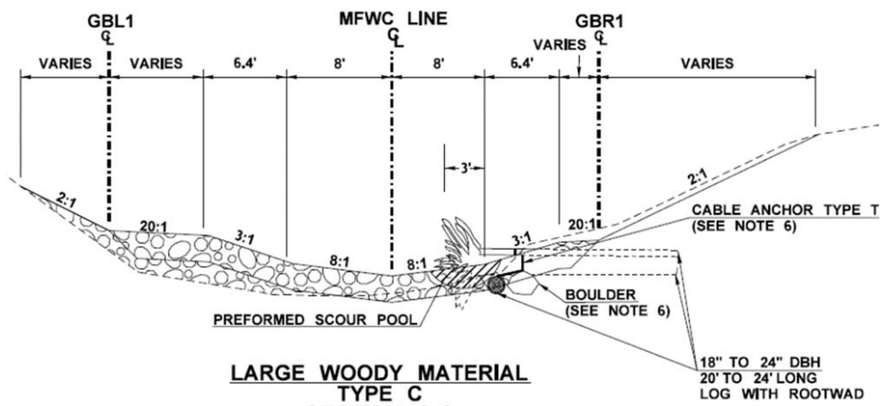
Above: 10/6/15, Below: 11/14/15

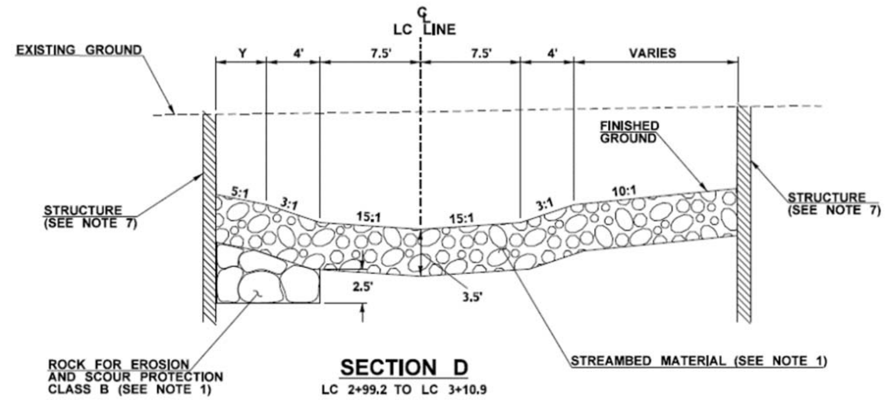
Above: 11/2/15, Below: 12/14/15

Washington State Department of Transportation

Stream Design







PEO/AEO Roles

- **Work with hydraulics office to identify constraints**
- **Provide CAD/InRoads Support**
  - **HQ Hydraulics has training material, standard templates, and cells for modeling streams**
  - **Working with CAE to get the Plans Prep manual updated**
  - **For support contact Catherine LaPointe**
- **Lead in coordination between Tribes, Agencies, Property Owners, support groups, Etc.**
- **Roadway geometrics/construction planning**

Guidance Documents

- **FHWA HEC 18**
- **FHWA HEC 20**
- **FHWA HEC 23**
- **WSDOT HM Chapter 7 (major update coming soon)**
- **WDFW Water Crossing Design Guidelines (WCDG)**
- **WDFW Integrated Stream Protection Guidelines (ISPG)**

Overview

- Methods to assess site conditions and reference reach (Stream Survey, Stream Gaging, Pebble Count/Grab Samples, etc)
- Understanding basin hydrology, stream/river hydrodynamics, and sediment supply
- Importance of understanding design is site specific
- Hydraulic Modeling
- Methods used to design streambed gradation
- Methods for constructing design

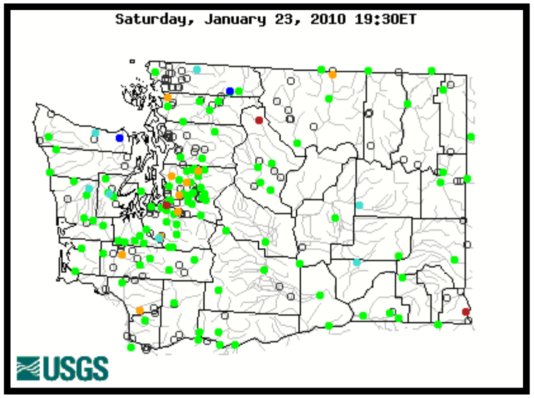
Methods to Assess Site Conditions

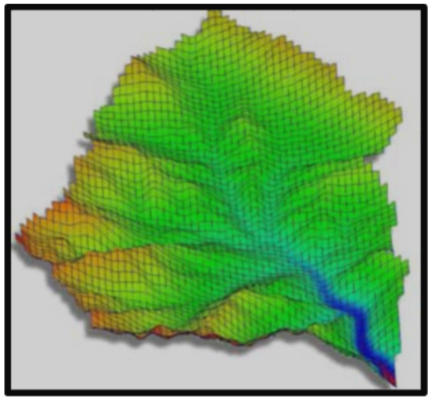
- **Reference Reach**
- **Stream Gaging/Hydrology Investigation**
- **Stream Survey (i.e. Longitudinal Profile, Cross Sections, Geomorphic Features, etc)**
- **Wolman Pebble Count/ Grab Samples**
- **Photographs**
- **Site Visits**

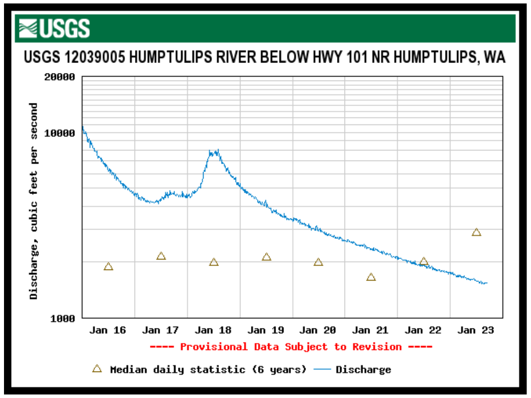
Appropriate Reference Reach

- **Stream simulation is meant to mimic natural conditions in a unaffected reach**
- **Reference reach assists the designer in determining the appropriate slope, sediment size, and channel shape**
- **Reference reach should have a basin size that is similar to the crossing in question**

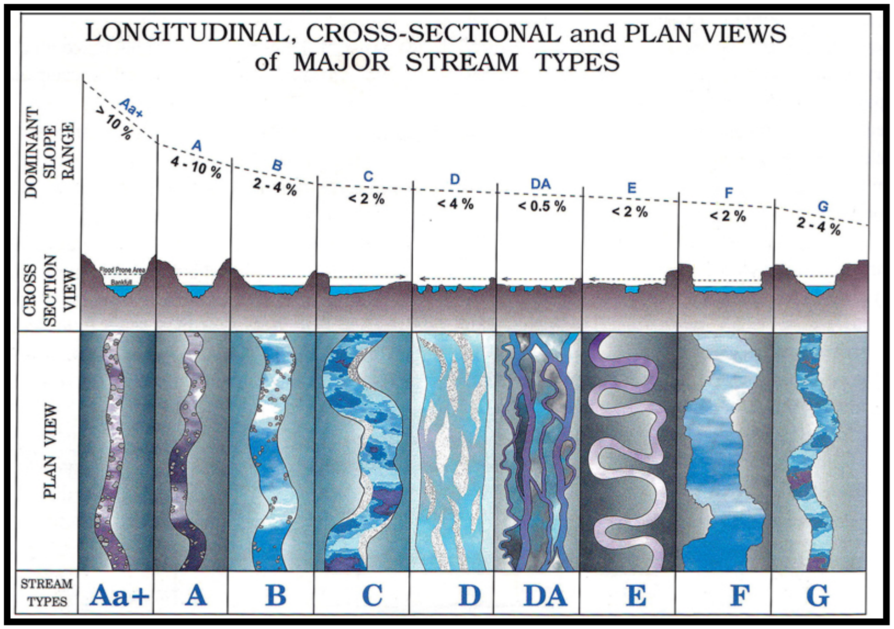
Basin Hydrology







Site Conditions

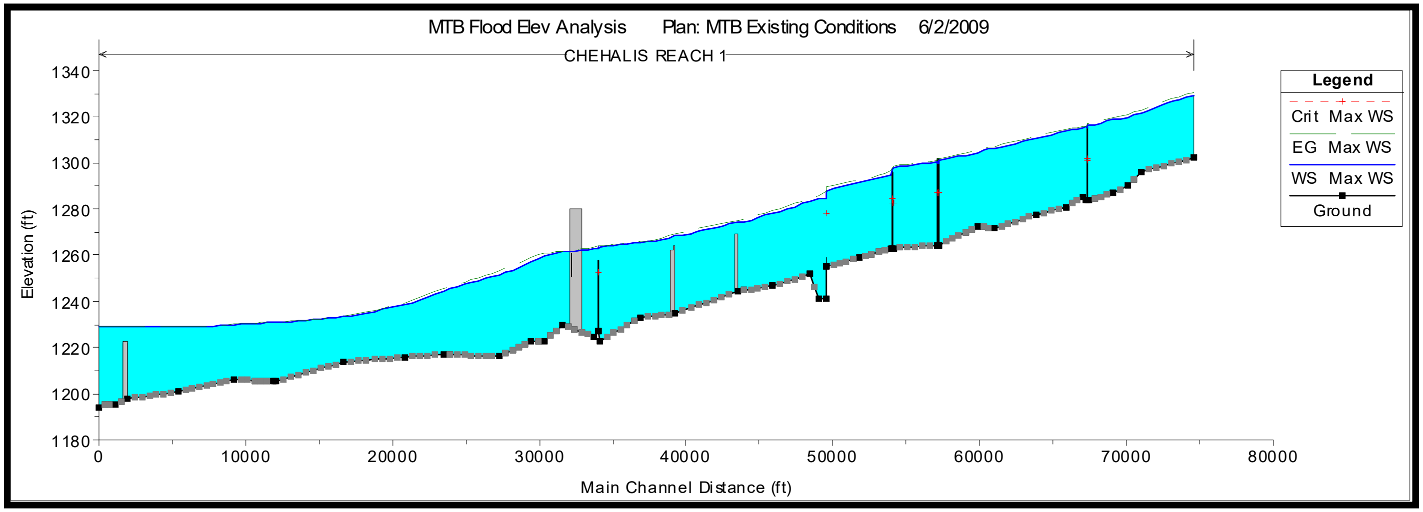


	Braided	Regime	Pool-Riffle	Plane-Bed	Step-Pool	Cascade	Bedrock	Colluvial
Typical Bed Material	Variable	Sand	Gravel	Gravel, cobble	Cobble, boulder	Boulder	N/A	Variable
Bedform Pattern	Laterally oscillary	Multi-layered	Laterally oscillary	None	Vertically oscillary	None	•	Variable
Reach Type	Response	Response	Response	Response	Transport	Transport	Transport	Source
Dominant Roughness Elements	Bedforms (bars, pools)	Sinuosity, bedforms (dunes, ripples, bars) banks	Bedforms (bars, pools), grains, LWD, sinuosity, banks	Grains, banks	Bedforms (steps, pools), grains, LWD, banks	Grains, banks	Boundaries (bed & banks)	Grains, LWD
Dominant Sediment Sources	Fluvial, bank failure, debris flow	Fluvial, bank failure, inactive channel	Fluvial, bank failure, inactive channel, debris flows	Fluvial, bank failure, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Hillslope, debris flow
Sediment Storage Elements	Overbank, bedforms	Overbank, bedforms, inactive channel	Overbank, bedforms, inactive channel	Overbank, inactive channel	Bedforms	Lee & stoss sides of flow obstructions	•	Bed
Typical Slope (m/m)	S < 0.03	S < 0.001	0.001 < S and S < 0.02	0.01 < S and S < 0.03	0.03 < S and S < 0.08	0.08 < S and S < 0.30	Variable	S > 0.20
Typical Confinement	Unconfined	Unconfined	Unconfined	Variable	Confined	Confined	Confined	Confined
Pool Spacing (Channel Widths)	Variable	5 to 7	5 to 7	none	1 to 4	< 1	Variable	Variable

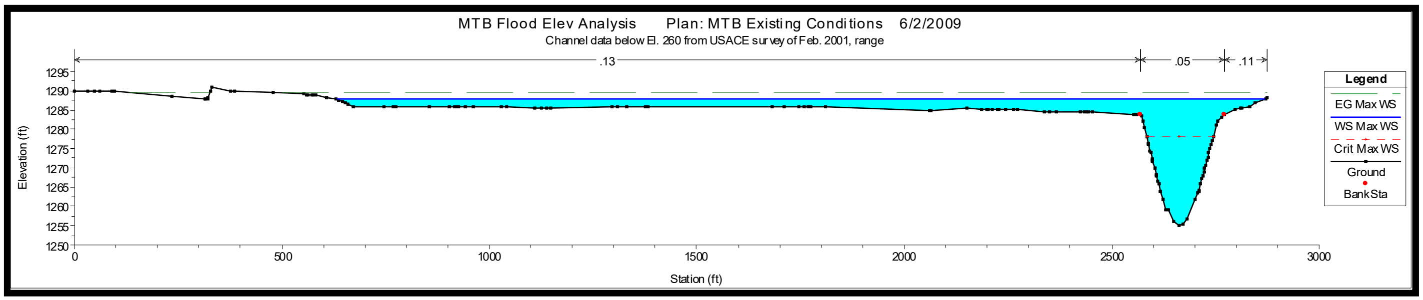
Source: Montgomery and Buffington, 1993.

Wolman Pebble Count/Grab Samples

Stream Survey



Profile



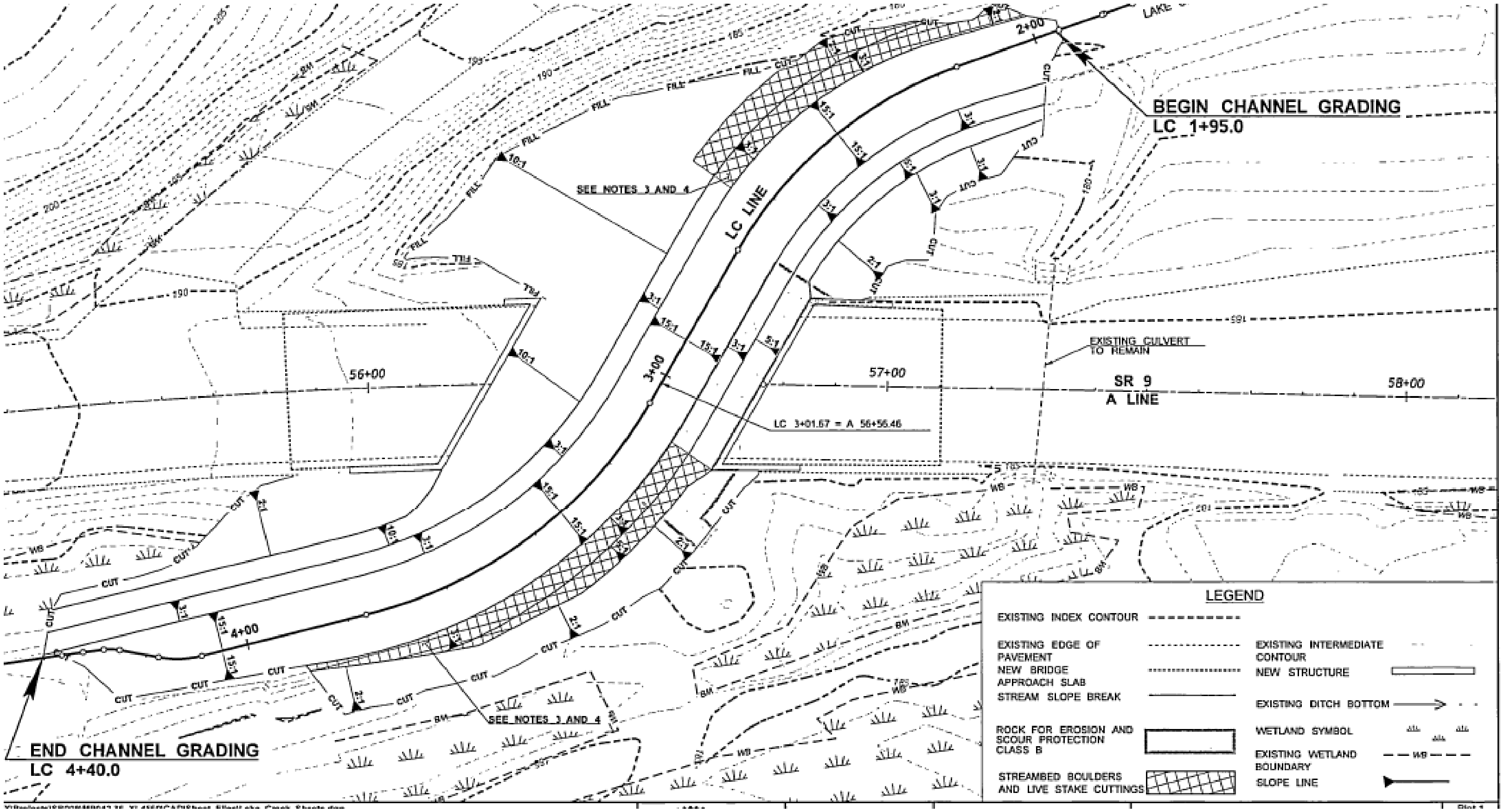
Cross Section

Channel Alignment

- **Review As-builts and RoW plans**
- **Review project geometric constraints**
- **Bend severity vs. length of structure**
- **Local topography**
- **Reduce impacts to vegetation/sensitive areas when possible**

Channel Alignment

Channel Alignment

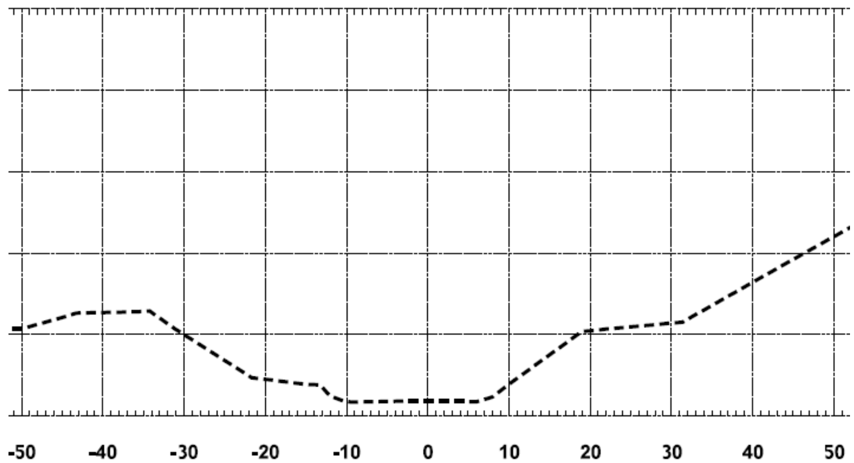


Channel Shape

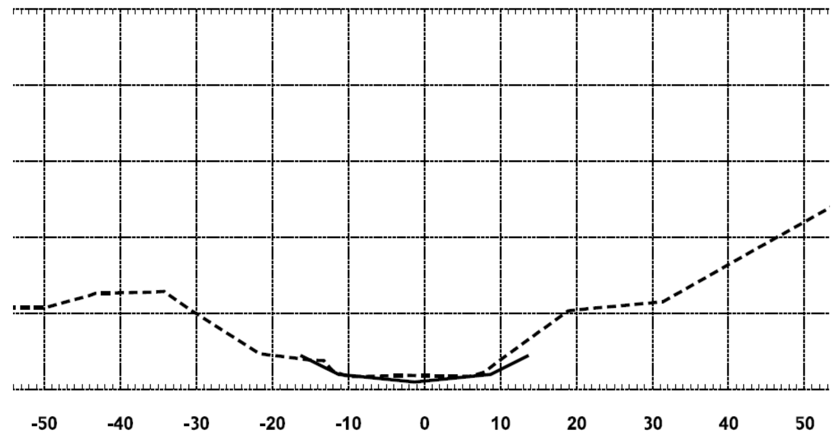
Identify existing key features:

- **Overbank areas**
- **Thalweg**
- **Bankfull**

Channel Shape



9+50



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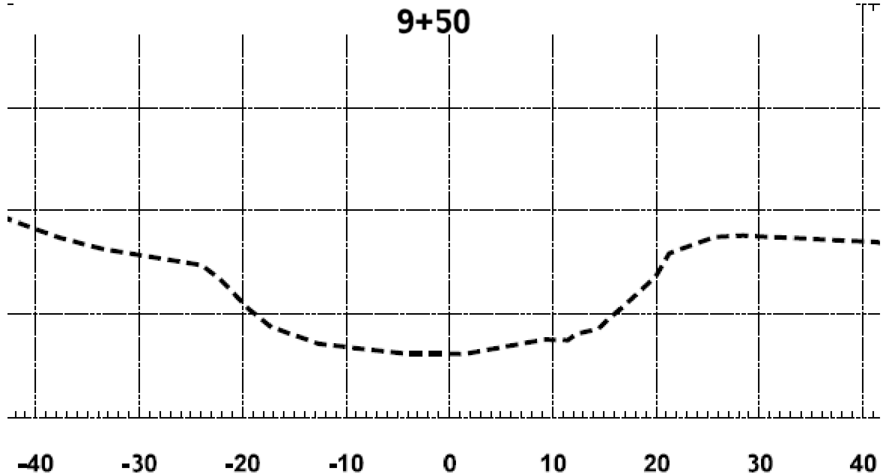
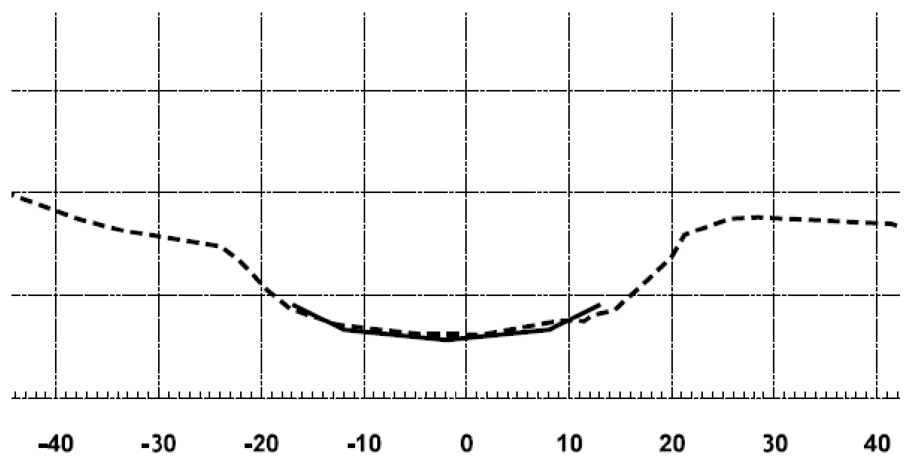
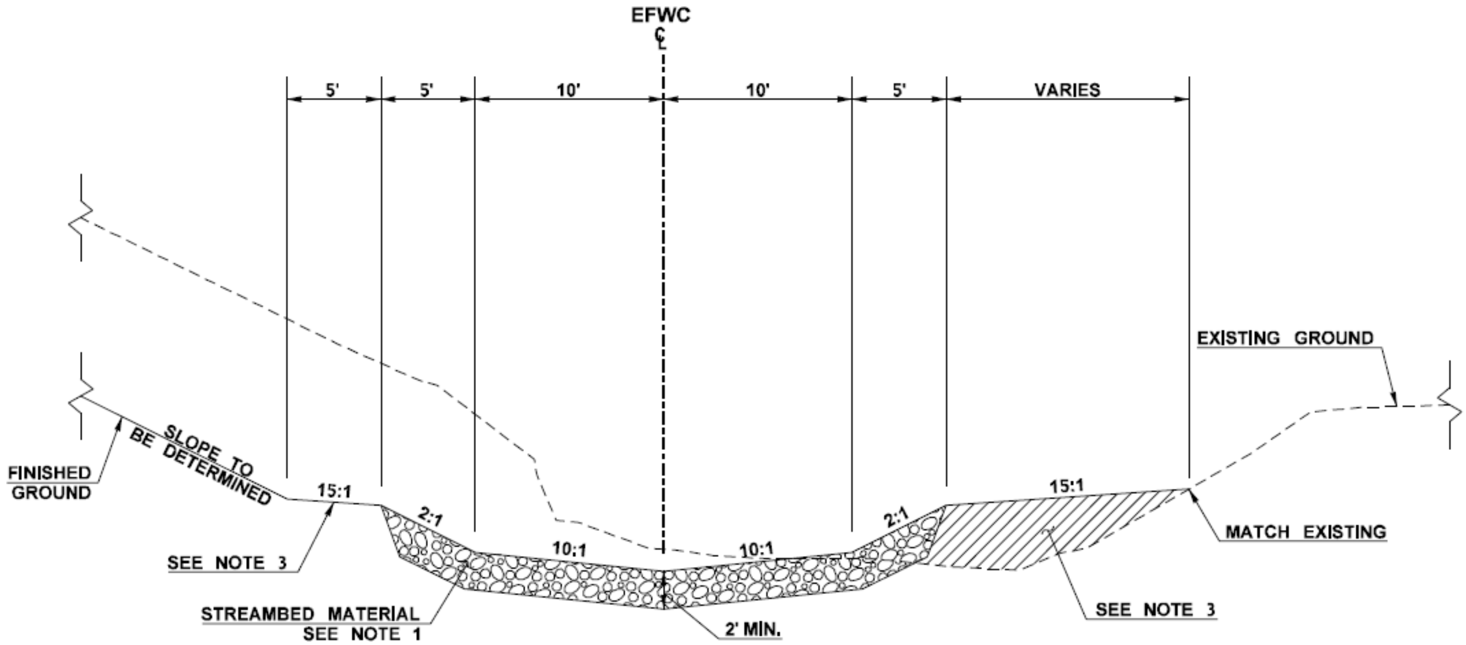


4+10



4+10

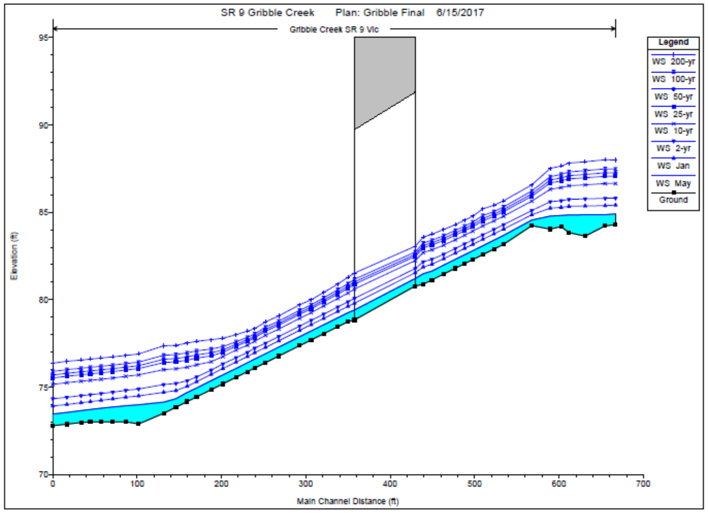
Proposed Section

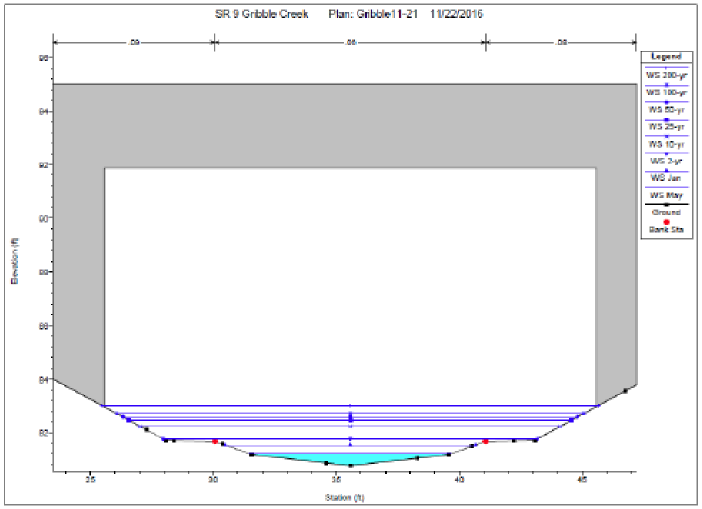


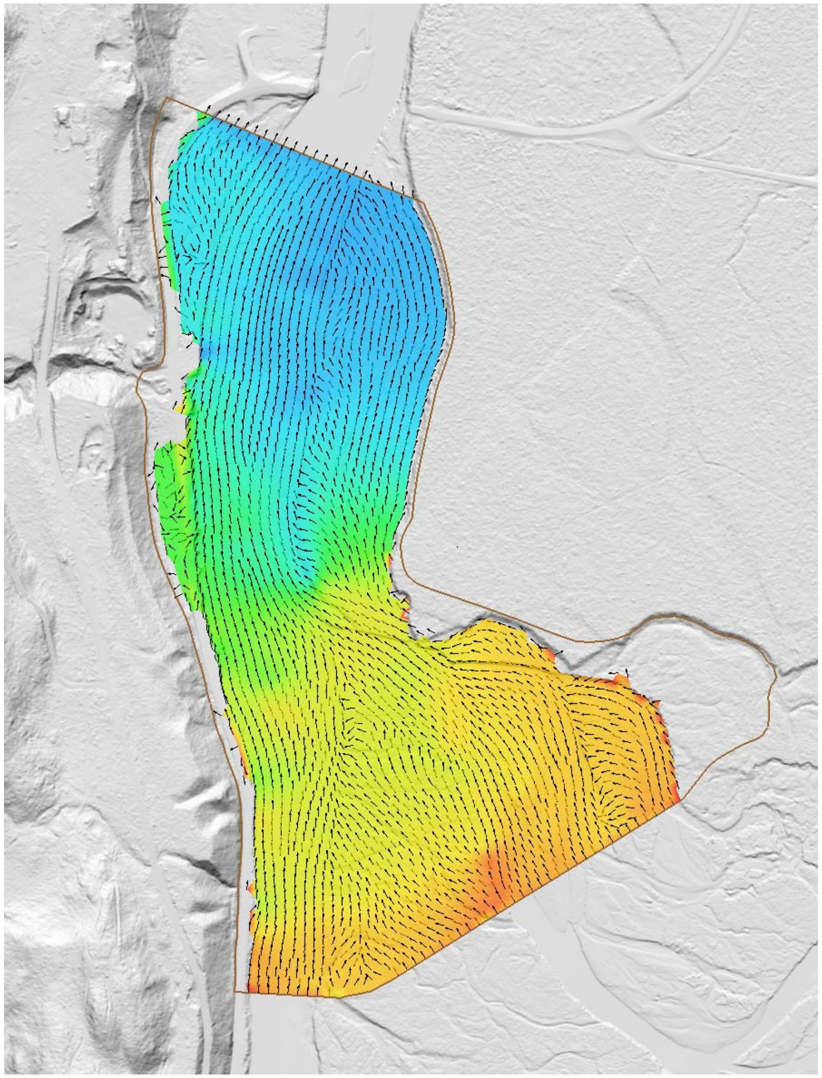
EF WILDCAT CREEK SECTION B

EFWC 4+15.00 TO EFWC 4+45.00

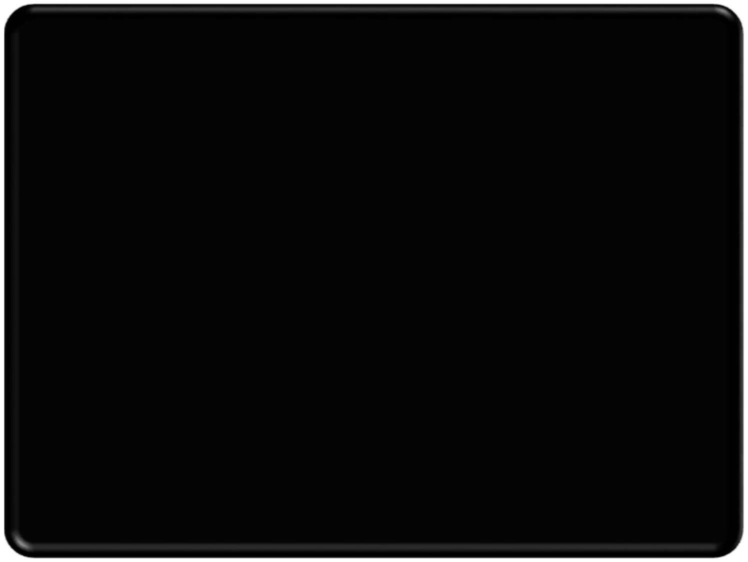
Hydraulic Modeling

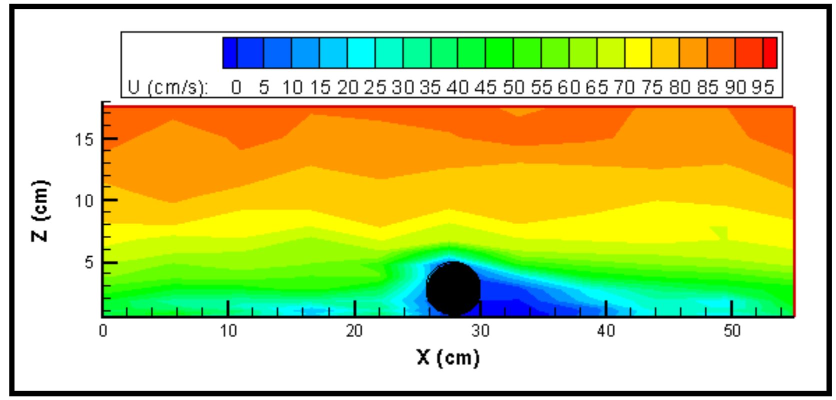


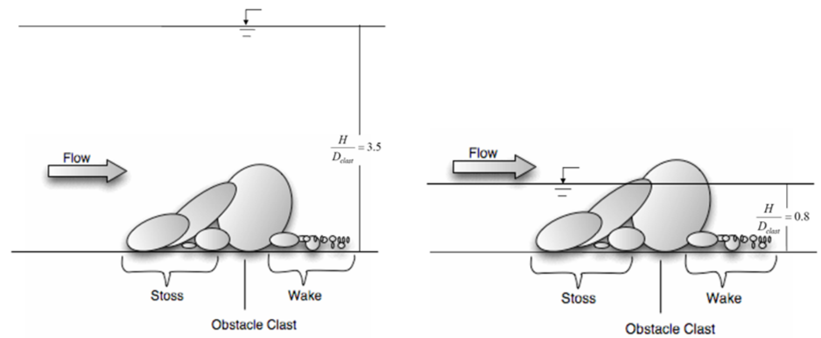




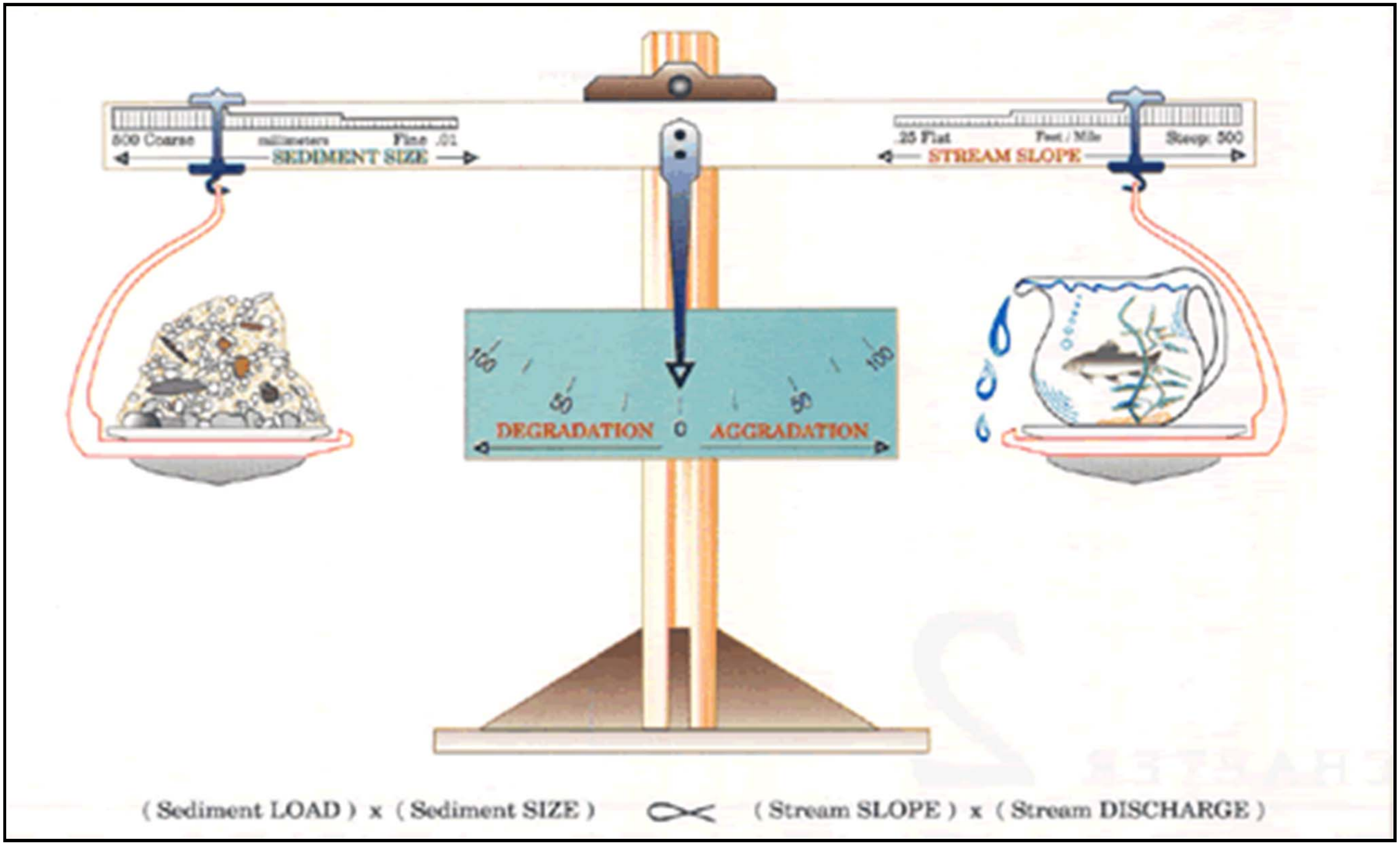
Sediment Movement



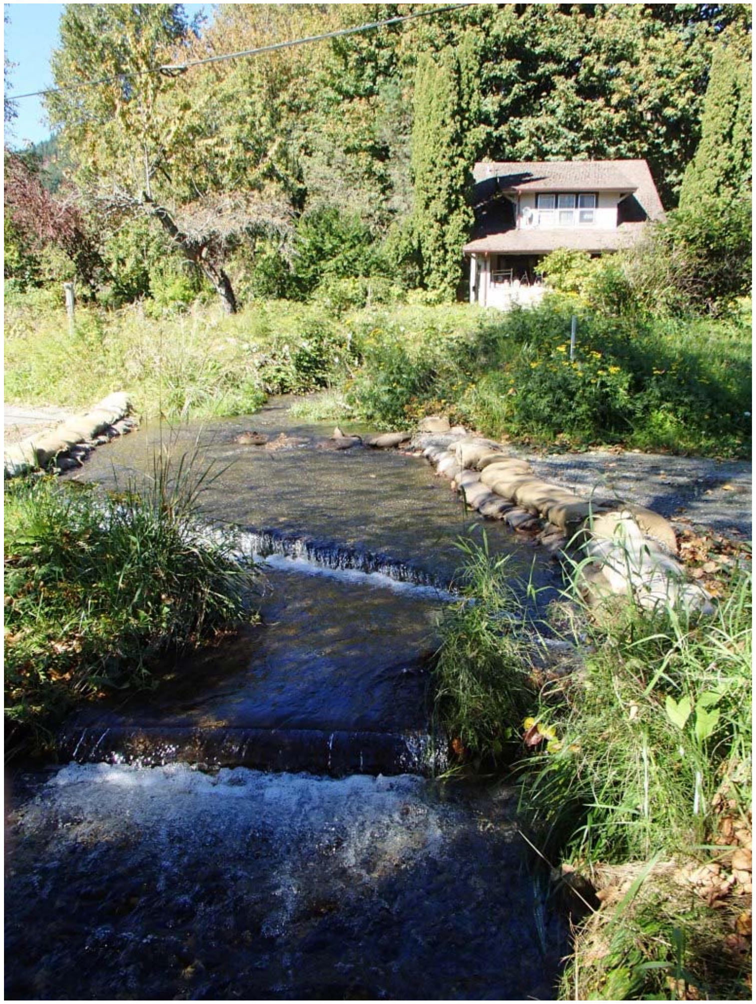




Sediment Supply



Sediment Supply



Aggradation

Degradation

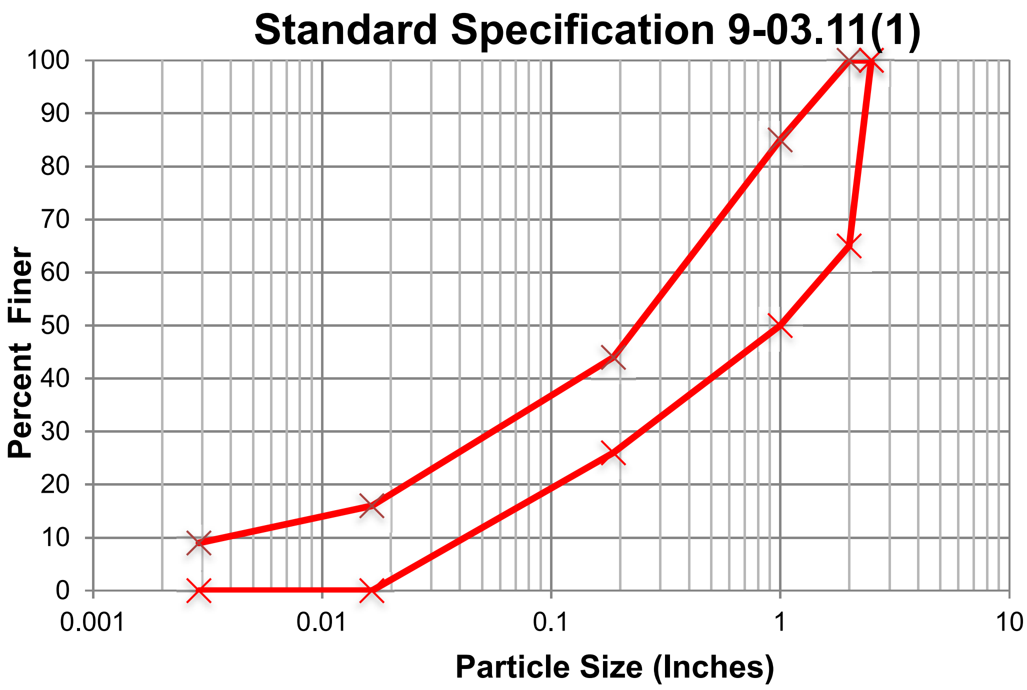
Methods to Size Sediment

- **Critical Unit Discharge (Bathurst)**
- **Modified Shields Equation**
- **Pebble Counts**

Materials

9-01.11(1) Streambed Sediment

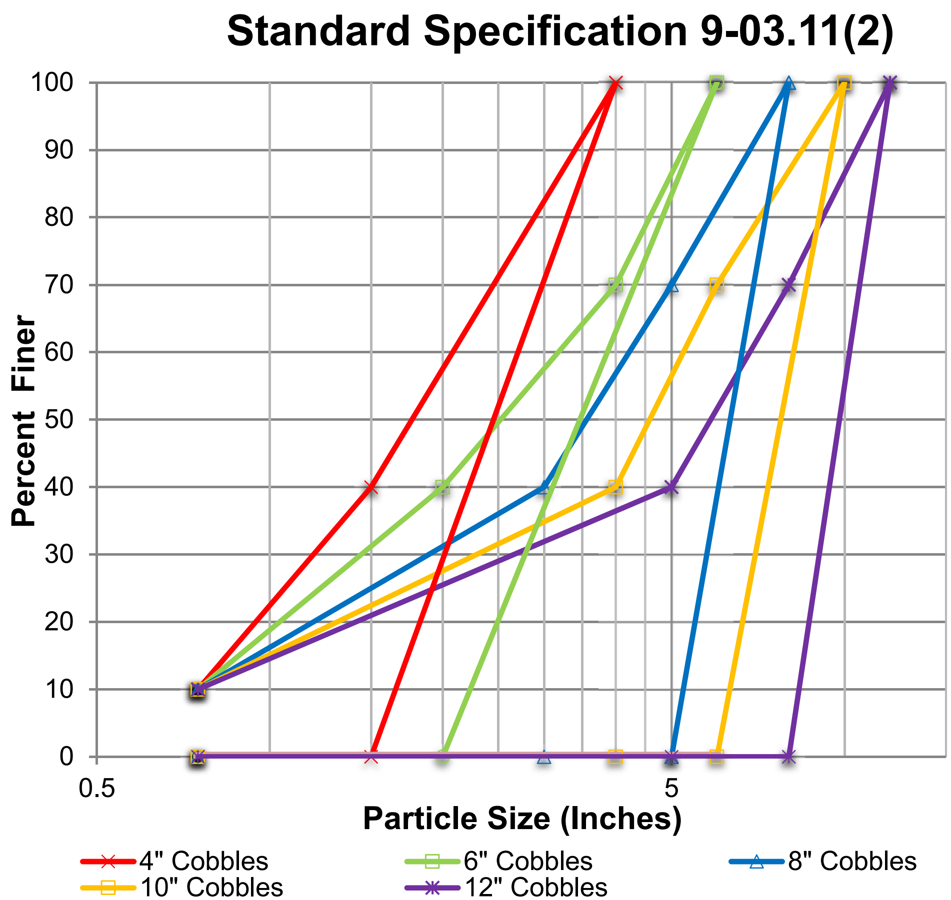
Sieve Size	Percent Passing
2 1/2" square	100
2" square	65 – 100
1" square	50 – 85
No. 4	26 – 44
No. 40	16 max.
No. 200	5.0 – 9.0



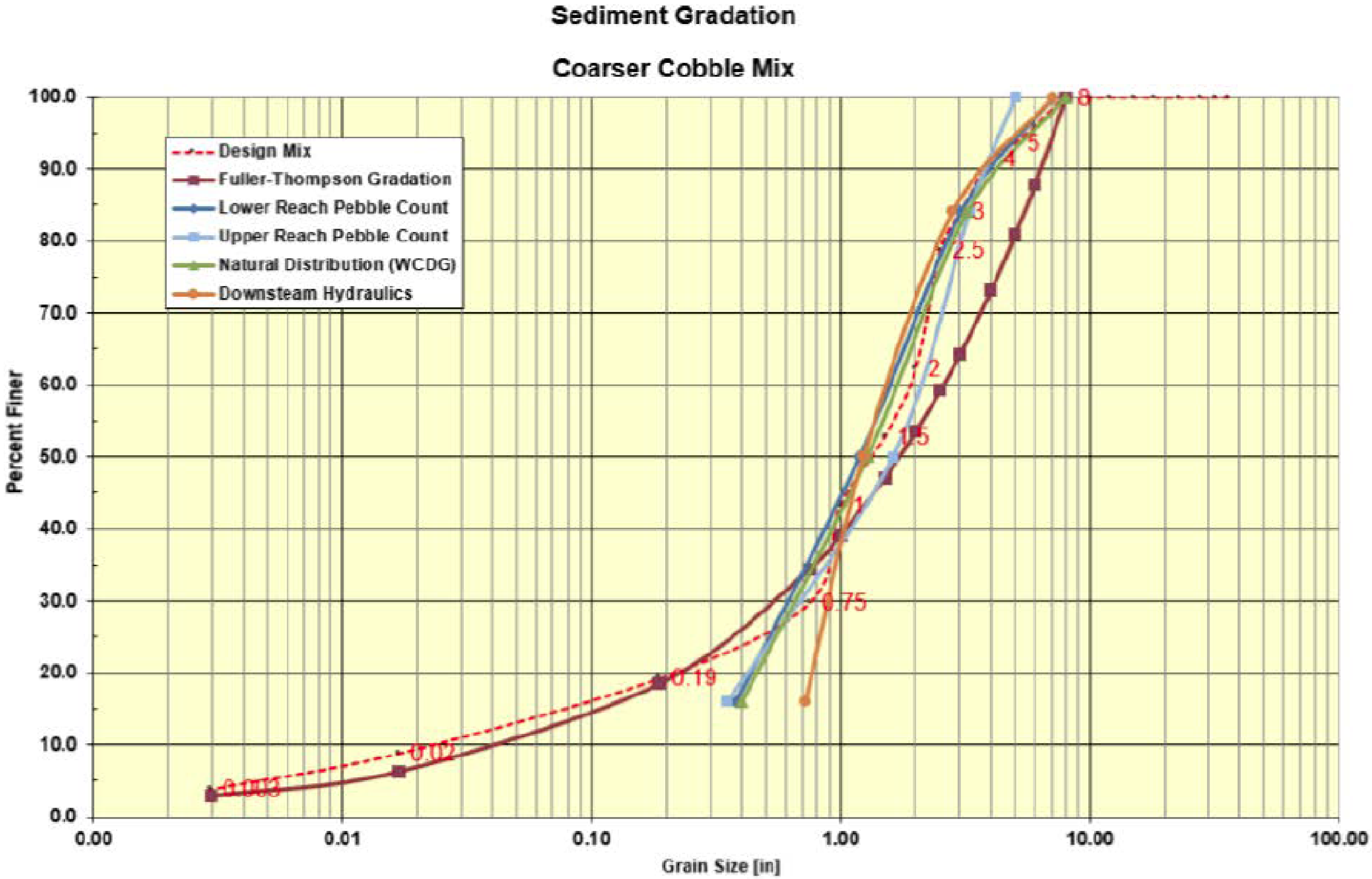
Materials

9-03.11(2) Streambed Cobbles

Approx. Size	Percent Passing				
	4" Cobbles	6" Cobbles	8" Cobbles	10" Cobbles	12" Cobbles
12"					100
10"				100	
8"			100		70 max.
6"		100		70 max.	
5"			70 max.		40 max.
4"	100	70 max.		40 max.	
3"			40 max.		
2"		40 max.			
1 ½"	40 max.				
¾"	10 max.	10 max.	10 max.	10 max.	10 max.



Materials

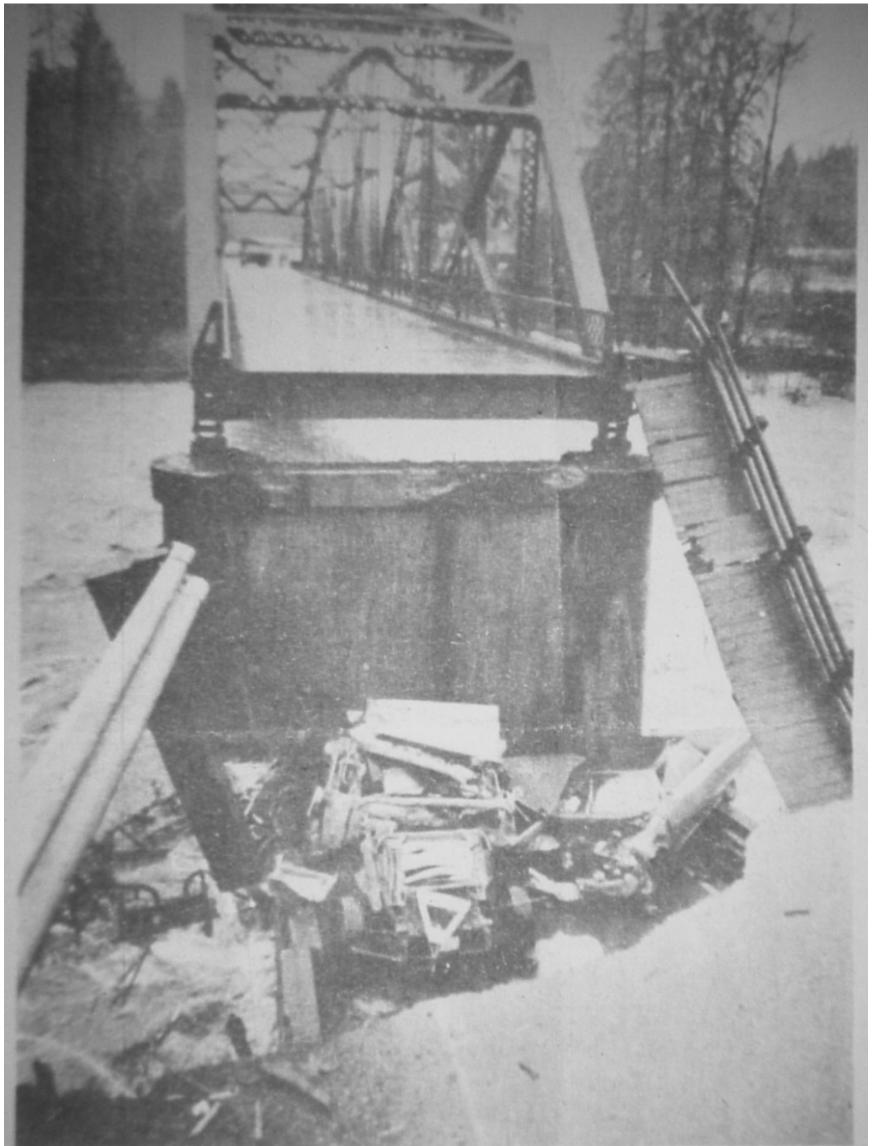


Sediment Gradation
Coarser Cobble Mix
Design Mix
Fuller-Thompson Gradation
Lower Reach Pebble Count
Upper Reach Pebble Count
Natural Distribution (WCDG)
Downsteam Hydraulics
Percent Finer
Grain Size [in]
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.00
0.01
0.10
1.00
10.00
100.00
0.003
0.02
0.19
0.75
1
1.5
2
2.5
3
4
5
8

Sediment—Final Product

Washington State
Department of Transportation

Bridge Scour



Bridge washes out

FORKS — A sander-dump truck and a log truck plunged into the Bogachiel River early Friday after a washout on Highway 101 took out part of this bridge. The bridge, about six miles south of Forks, left one person dead and three wrecked vehicles in the river. (AP Laserphoto)

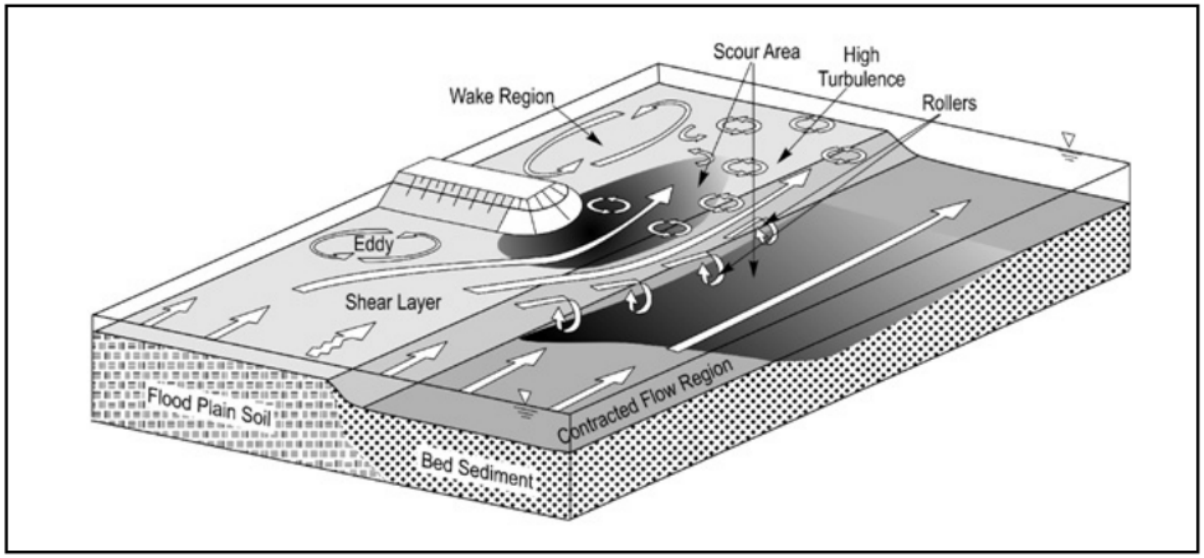
Why is it Important?

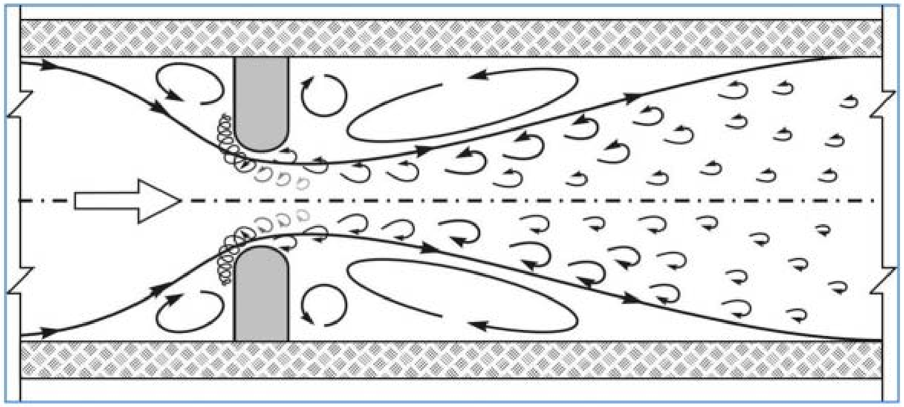
- Most common cause of bridge failure
- Determines the necessary depth of foundation

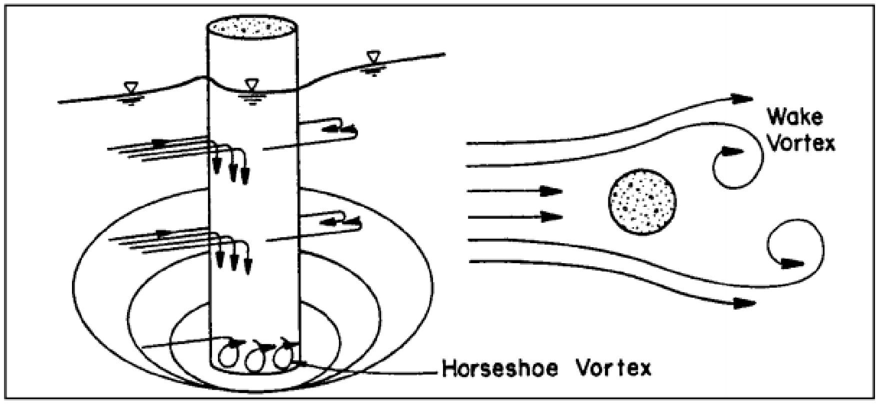
Location: SR 542 Gallup Creek
Cause: Flood washed out abutment, dropped 4'6"; 1962

Types of Scour

- Contraction Scour
- Local Scour
- Long Term Degradation
- Lateral Migration

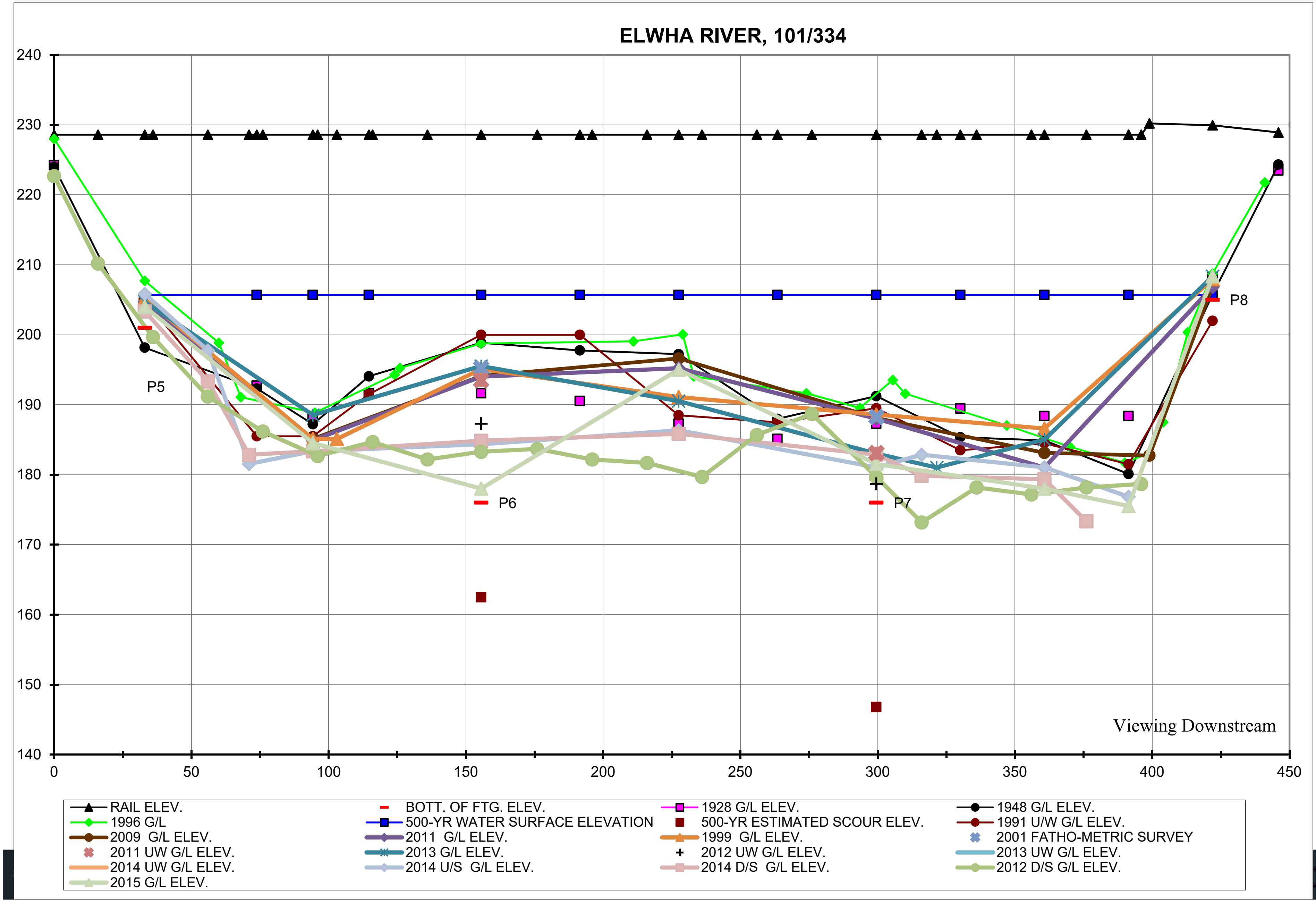




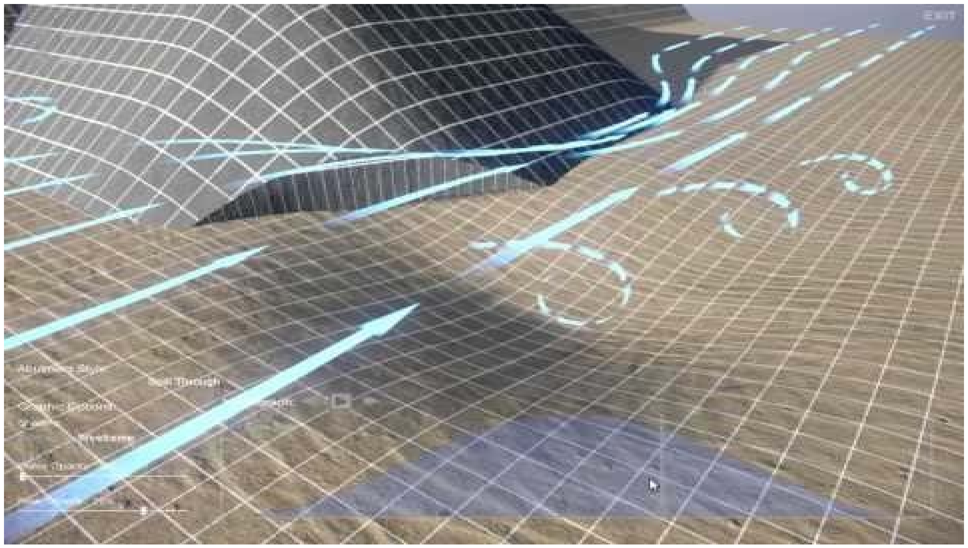


Types of Scour

Lateral Migration/Degradation



What Causes It?



Water around an obstruction (foundation, debris, etc) removes sediment and leaves behind a hole.

Location: SR 508 Bear Creek
Cause: Flood/Debris bent center and 2 trusses

What can be done?

- Existing Structures:
  - Regular inspections
  - Monitor (Plan of Action)
  - Apply countermeasures
- New Structures:
  - Plan for scour and design appropriately

Questions?