Fish Passage and Stream Restoration Training

Module 13: Hydraulic Design Report Template [Version 2022-10]

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Prepared by: Anna Mallonee, PE (HDR) and Shaun Bevan, PE (HDR)

Shaun Bevan

Olympic Region Fish Passage Design Manager
Sr. Water Resources Engineer
Gig Harbor, WA
HDR Engineering, Inc.

Current Duties

- OR Fish Passage Design Manager
- PHD author
- FHD author

Education

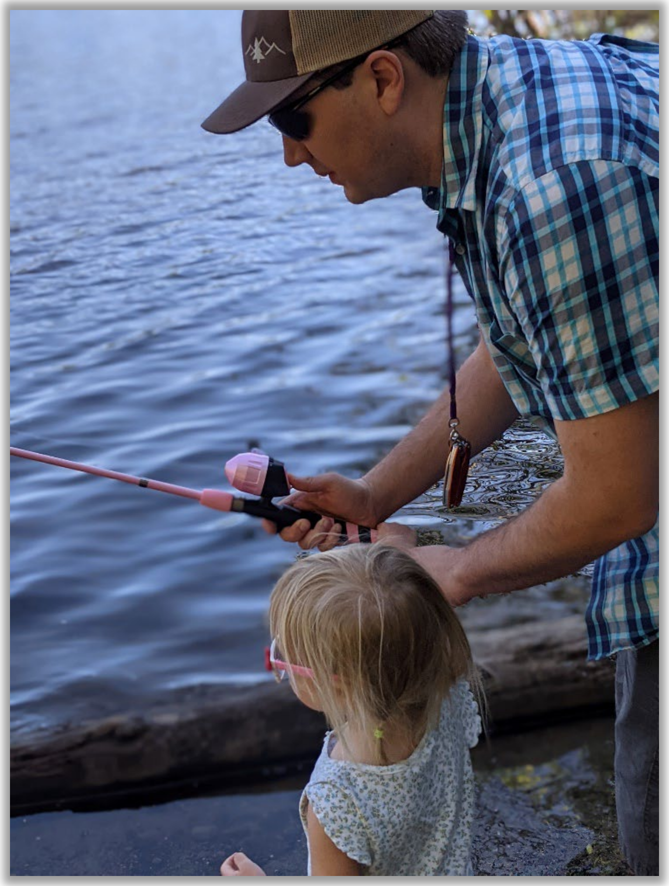
- B.S. Civil Engineering (UW)
- M.S. Civil Engineering (UW)

Background and Experience

- 10 years of fish passage design
- 6 years of WSDOT
- Water crossings, fish ladders, LWM, and floating surface collectors

Personal Interests

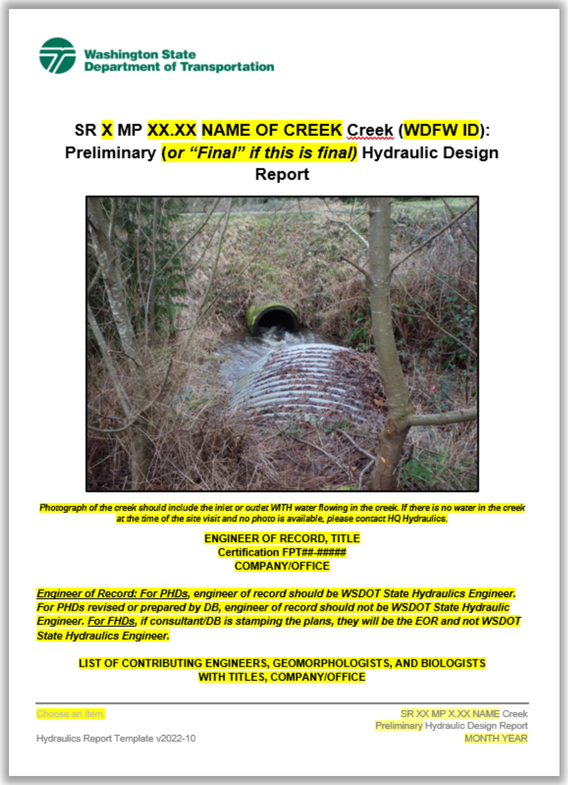
- Father of 3
- House Projects
- Local Breweries



Agenda

- Purpose of Training Module
- Template History
- PHD/FHD Purpose and Expectations
- PHD/FHD Sections
- Q&A

Purpose of Training Module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SR X MP XX.XX NAME OF CREEK Creek (WDFW ID): Preliminary (or "Final" if this is final) Hydraulic Design Report

Photograph of the creek should include the inlet or outlet WITH water flowing in the creek. If there is no water in the creek at the time of the site visit and no photo is available, please contact HQ Hydraulics.

ENGINEER OF RECORD, TITLE
Certification FPT##-#####
COMPANY/OFFICE

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LIST OF CONTRIBUTING ENGINEERS, GEOMORPHOLOGISTS, AND BIOLOGISTS WITH TITLES, COMPANY/OFFICE

Choose an item.

SR XX MP X.XX NAME Creek
Preliminary Hydraulic Design Report
MONTH YEAR

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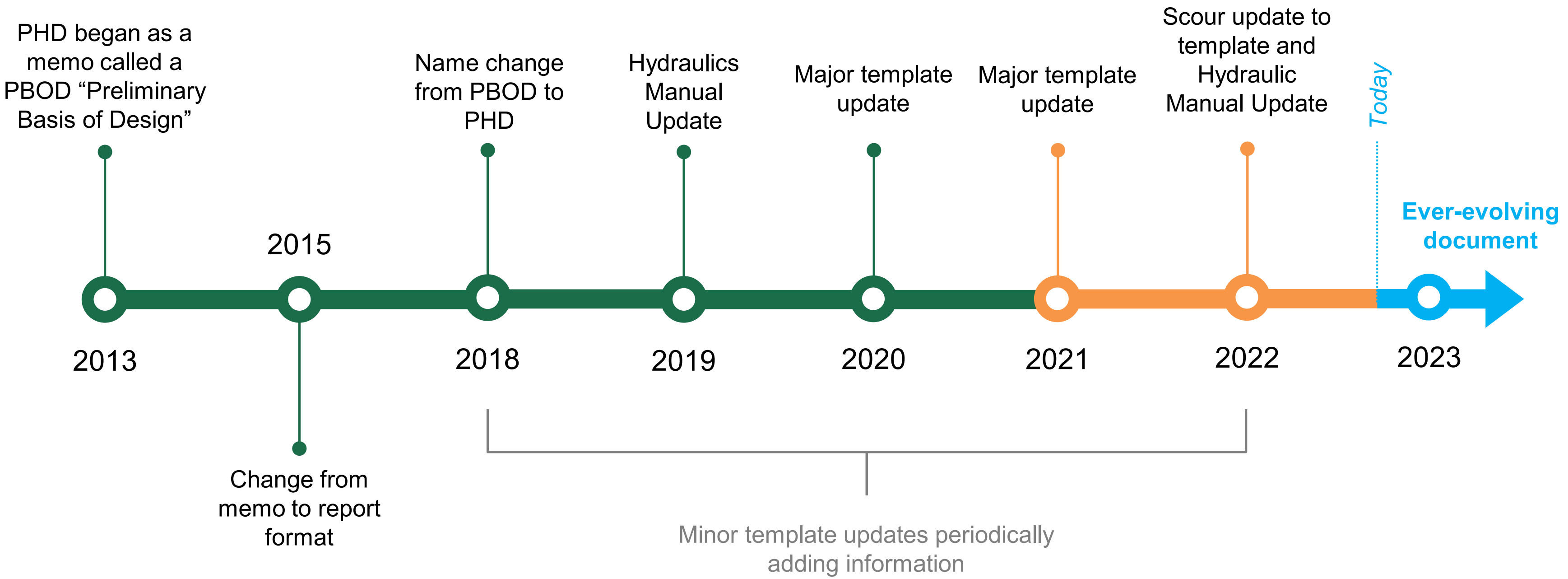
- Replace previous training modules
- Comprehensively cover most recent PHD/FHD template
- Focus on purpose of individual sections and how they inform design
- Template and checklist
- *Note:* module does not cover everything in PHD template

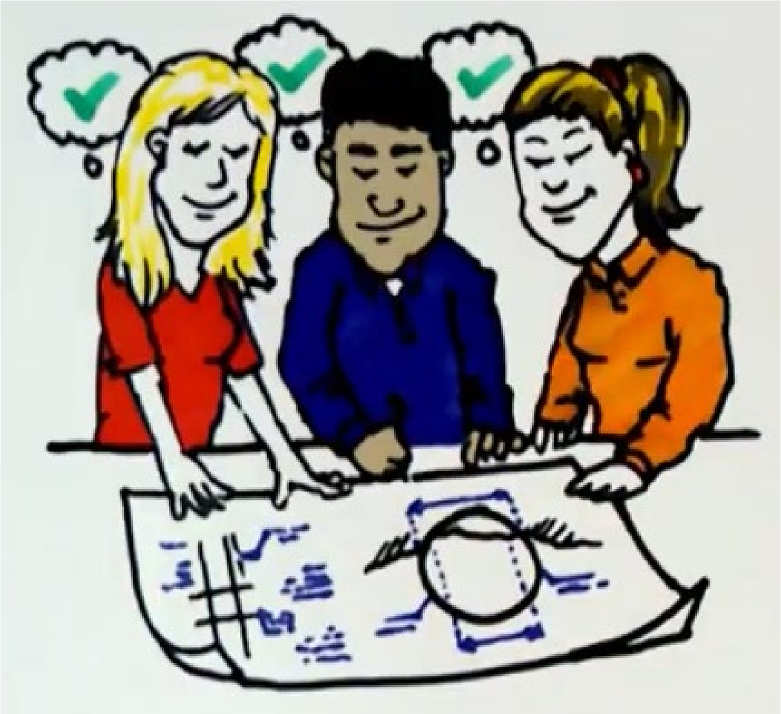
Template History



*Hydraulics Manual also being updated periodically – should be consulted during PHD / FHD development

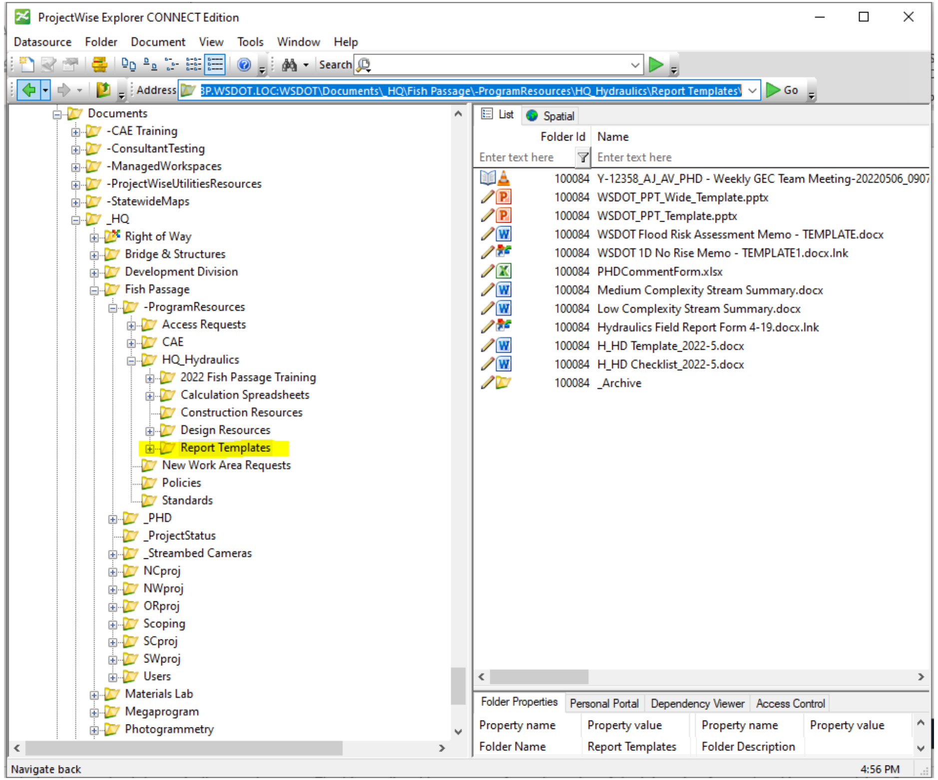
PHD/FHD Purpose

- Document design decisions
- Place where multiple disciplines (and comanagers) can go
- Illustrates how design meets or does not meet guidelines



PHD/FHD Expectations

- Use most recent template as it is written
  - Approval from HQ Hydraulics required for any modifications to template
  - Respond to all prompts
- Use checklist while writing and performing QC
- Use alongside **Hydraulics Manual**
- Think critically, tell the story



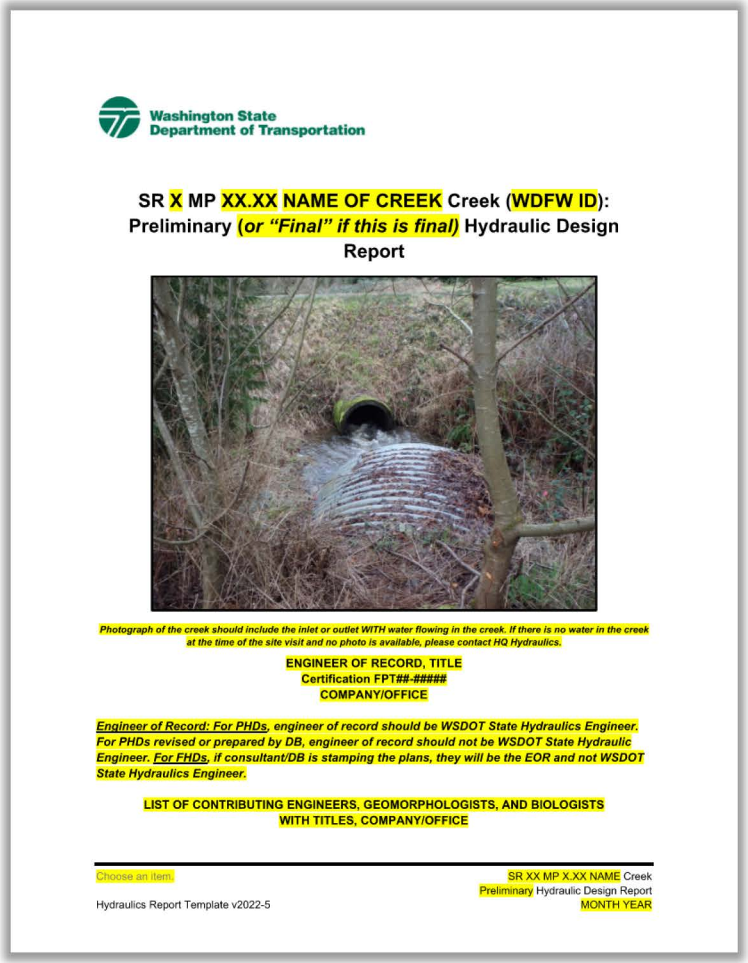
PHD/FHD Sections

Cover

1. Introduction
2. Watershed and Site Assessment
3. Hydrology
4. Water Crossing Design
5. Hydraulic Analysis
6. Floodplain Evaluation
7. Scour Analysis
8. Scour Countermeasures
9. Summary

References

Appendices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Preliminary Hydraulic Design Report
MONTH YEAR

Cover Page

Purpose:

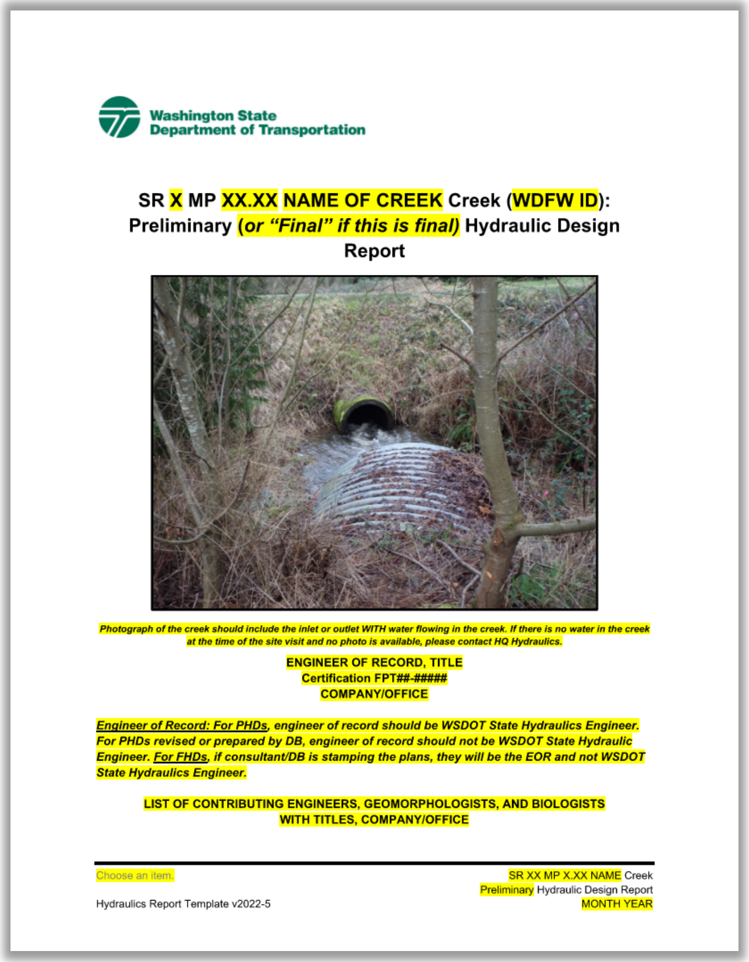
- Clearly identify site, authors, PHD/FHD template version, review stage

Key Items:

- Certification numbers
- Photograph

Lessons Learned:

- Prime consultants should be author and be reviewing subconsultant's work



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SR XX MP X.XX NAME Creek
Preliminary Hydraulic Design Report
MONTH YEAR

1 Introduction

Purpose:

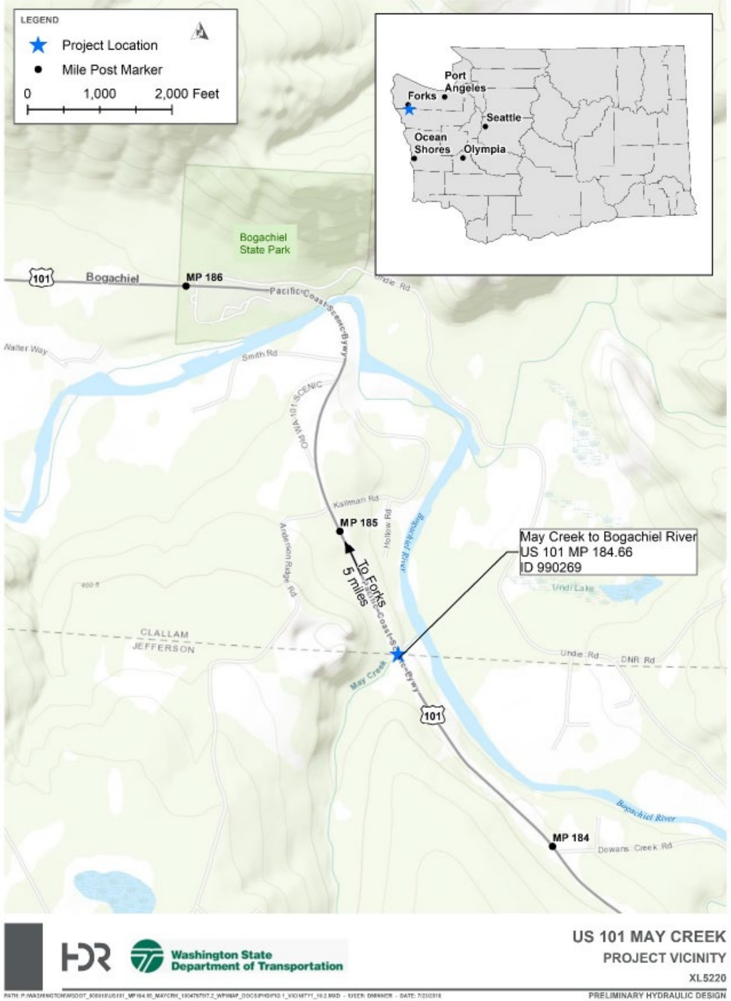
- Document project location and summarize design strategy and proposed hydraulic width

Key Items:

- Project vicinity figure

Lessons Learned:

- Design deviations should be mentioned here (if applicable)



2 Watershed & Site Assessment

Purpose:

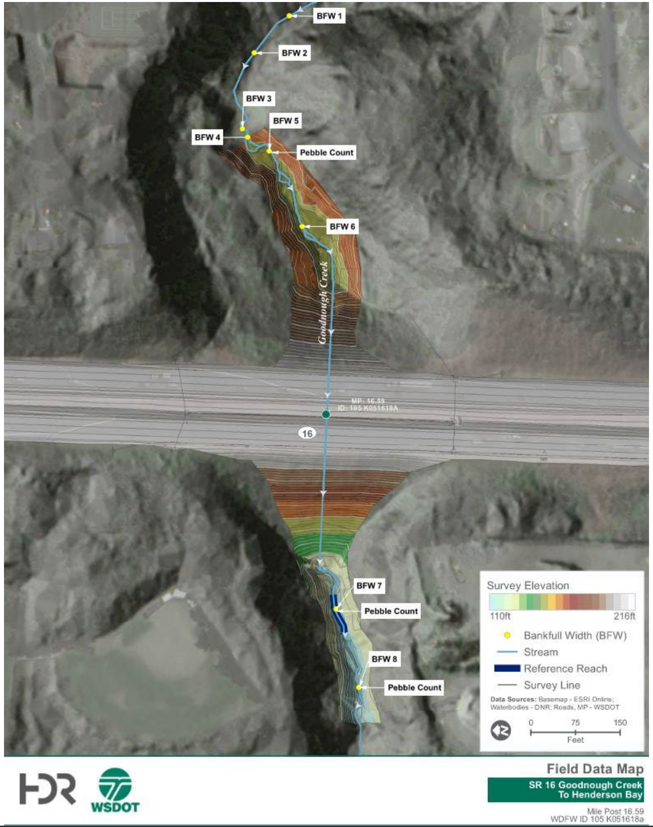
- Summarize existing conditions at both a watershed scale and local site scale.

Key Items:

- Reference reach
- Bankfull width concurrence
- Longitudinal profile
- FUR
- Sediment

Lessons Learned:

- Wildlife Connectivity should not change minimum hydraulics recommendation.
- Heavily document channel morphology, especially in step-pool systems.

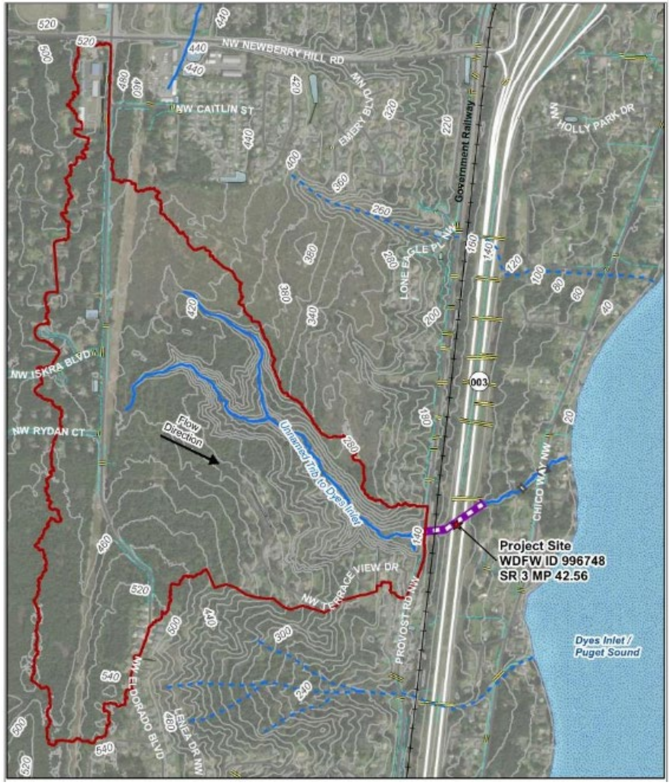


2.1 Site Description

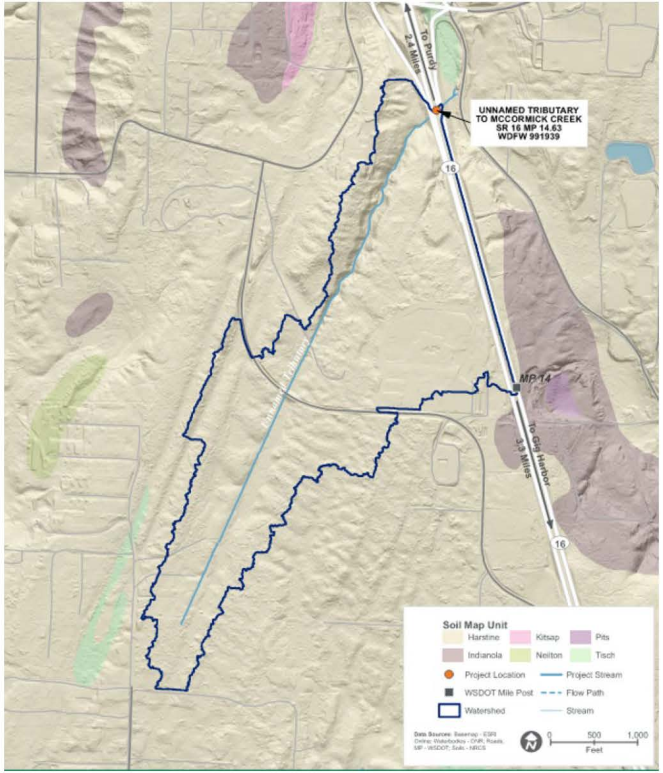
- Barrier status and impact to fish life
- Is the crossing a failing structure or CED
- Maintenance/Repair history
- Flood history
- Total length of habitat gain

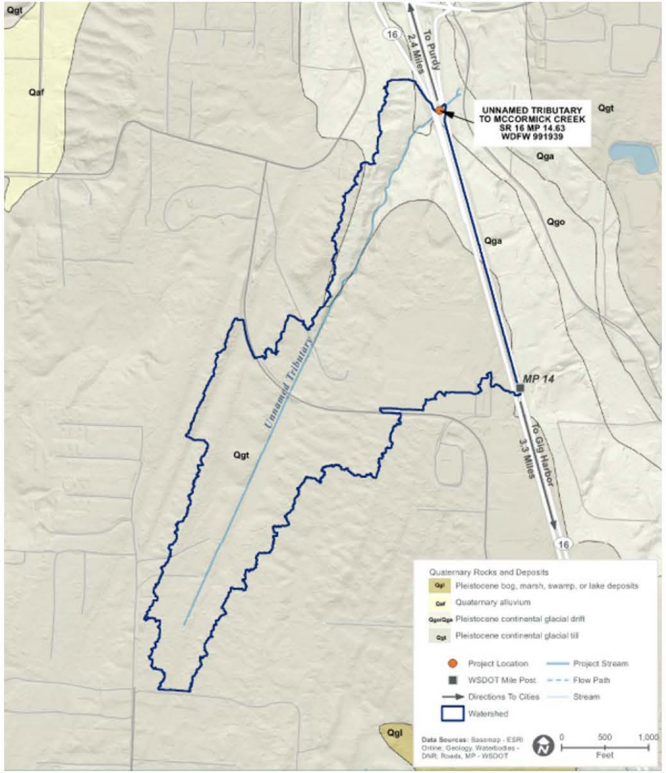
2.2 Watershed and Land Cover

- Size and location of watershed
- Major tributaries
- Topography
- Land Cover
- Prevailing land uses



2.3 Geology and Soils





2.4 Fish Presence in the Project Area

- Species identified
- Sources
  - Spawner Surveys
  - WDFW Fish Passage Database
  - RSFS data
  - Scoping Reports
  - Scoping bios

2.5 Wildlife Connectivity

- PHD and FHD summarize wildlife connectivity information provided by others.
  - HQ Hydraulics does not make the decision to increase structure width to accommodate

2.6 Site Assessment

- 2.6.1 Data Collection
- 2.6.2 Existing Conditions
- 2.6.3 Fish Habitat Character and Quality
- 2.6.4 Riparian Conditions, Large Wood, and Other Habitat Features

2.7 Geomorphology

- 2.7.1 Reference Reach Selection
- 2.7.2 Channel Geometry
  - 2.7.2.1 Floodplain Utilization Ratio
- 2.7.3 Sediment
- 2.7.4 Vertical Channel Stability
- 2.7.5 Channel Migration

*See Module 9: Reference Reaches

*See Module 10: Bankfull Width

*See Module 8: Geomorphology

3 Hydrology

Purpose:

- Summarize hydrology methodology explored and which is selected for design.

Key Items:

- Clearly document available hydrologic data and why method was chosen
- WSDOT using 2080 100yr, when practicable

Lessons Learned:

- Don't just jump right to MGSFlood or USGS Regression, do some background research

Mean recurrence interval (MRI) (years)	USGS regression equation (Region 3) (cfs)	MGSFlood (cfs)
2	XX	XX
10	XX	XX
25	XX	XX
50	XX	XX
100	XX	XX
500	XX	XX
Projected 2080 100	XX	XX

4 Water Crossing Design

Purpose:

- Documents design methodology and decisions

Key Items:

- 4.1 Channel Design
- 4.2 Minimum Hydraulic Opening
- 4.3 Streambed Design

Lessons Learned:

- Existing site conditions should all be documented previously and referred to throughout this section as the basis for making design decisions

*See Module 4: Hydraulic Design Process

4.1 Channel Design

Purpose:

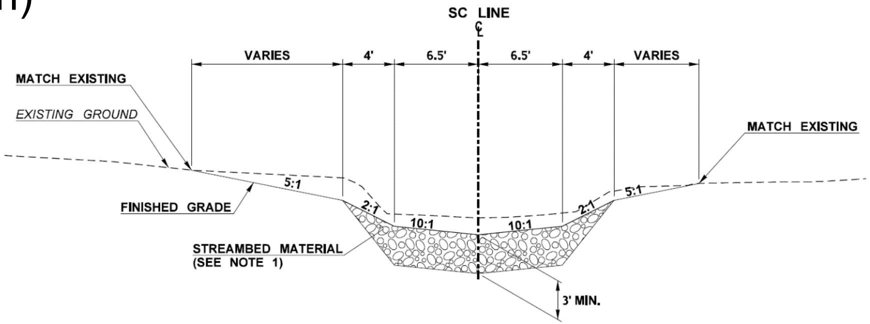
- Describe proposed channel shape, alignment, and gradient

Key Items:

- Channel shape (provide justification)
- Gradient (meeting WAC, WCDG, and HM slope ratio)

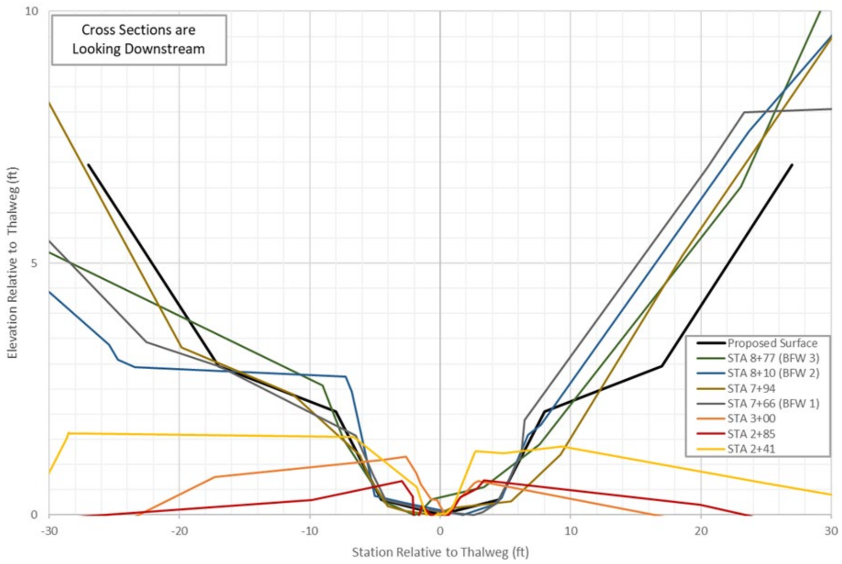
Lessons Learned:

- Avoids extreme bends into and out of structure if possible
- Success of this section relies heavily on clear explanation/ justification for basis of design.



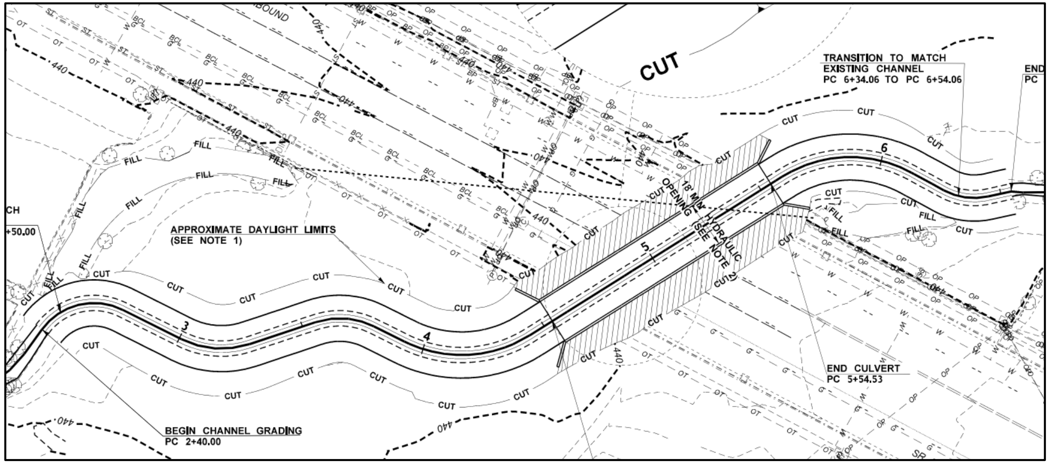
4.1.1 Channel Planform and Shape

- HM Section 7-4.3 Channel Cross Section
  - Mimic reference reach
  - Highly modified systems
    - Designed channel shape
    - Or to match adjacent reach
- Documentation
  - Description of proposed shape
  - Channel shape justification
    - Comparison to reference reach
  - Meander amplitude assessment (if needed)



4.1.2 Channel Alignment

- Grading length and limits
- Any realignment proposed?
- Sinuosity
- Description of any constraints that drove the previous items



4.1.3 Channel Gradient

- Proposed channel gradient
- Slope ratio
  - Within 25% of reference reach?
- Brief degradation and aggradation summary
  - Reason to prevent long-term degradation?

4.1.3 Channel Gradient

What is the slope ratio? How does the slope compare to what would be found on the site naturally? If it is different, why is it different? Is long-term degradation/aggradation expected? If so, how much? Is there a reason to contain the long-term degradation?

- *Keep aggradation/degradation discussion brief here and just summarize results. Refer to Section 7.2 for further details. Detailed discussion and analysis for how it was quantified should be discussed in detail in Section 7.2.*

4.2 Minimum Hydraulic Opening

- 4.2.1 Design Methodology
- 4.2.2 Hydraulic Width
- 4.2.3 Vertical Clearance
- 4.2.4 Hydraulic Length
- 4.2.5 Future Corridor Plans
- 4.2.6 Structure Type

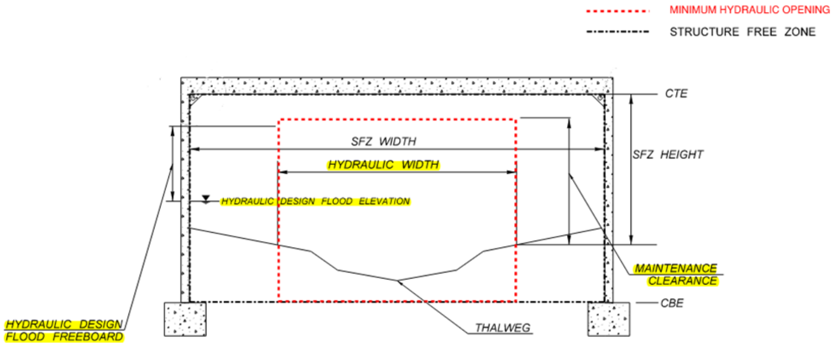


Table 7: Velocity comparison for X-foot structure

Location	100-year velocity (ft/s)	Projected 2080 100-year velocity (ft/s)
Reference reach (STA XX+XX)		
Upstream of structure (STA XX+X)		
Any other locations that are relevant		
Through structure (STA XX+XX)		
Downstream of structure (STA XX+XX)		

4.2.1 Design Methodology

Purpose:

- Present design methodology:
  - stream simulation
  - confined bridge
  - unconfined bridge
  - hydraulic design

Key Items:

- Concisely summarize design method and reason it was used

Lessons Learned:

- Don't dive into design parameters, stick with just methodology

- *Bankfull width: refer to Section 2.7.2*
- *Floodplain utilization ratio (FUR): refer to Section 2.7.2.1*
- *Slope ratio of proposed channel to the existing channel: refer to Section 4.1.3*
- *Length of the proposed crossing: refer to Section 4.1.2*
  - *Footprint of the fill*
    - *Report elevation of existing roadway and height above proposed channel thalweg. Very large embankments (long crossings) are more likely to be clear span bridge rather than buried structure.*
- *Channel stability, including potential aggradation or degradation: refer to Section 7.2*
- *Channel migration: refer to Sections 2.7.5 and 4.1.1*
- *Climate resilience*

4.2.2 Hydraulic Width

- Minimum hydraulic width
  - Greater of two equations below
- Any iterations of width due to velocity ratio, lateral migration, floodplain connectivity, channel processes, etc.
- Final minimum hydraulic width used for design

Table 7: Velocity comparison for X-foot structure

Location	100-year velocity (ft/s)	Projected 2080 100-year velocity (ft/s)
Reference reach (STA XX+XX)		
Upstream of structure (STA XX+X)		
Any other locations that are relevant		
Through structure (STA XX+XX)		
Downstream of structure (STA XX+XX)		

$$W_{HYO} = 1.2 * W_{bf} + 2 \text{ feet}$$

$$W_{HYO} = 1.3 * W_{bf}$$

Where

W_{HYO}= width of hydraulic opening

W_{bf}= BFW

4.2.3 Vertical Clearance

- Present all potential vertical clearance values (both recommended and required)
- Determine required and recommended minimum structure low chord given constraints

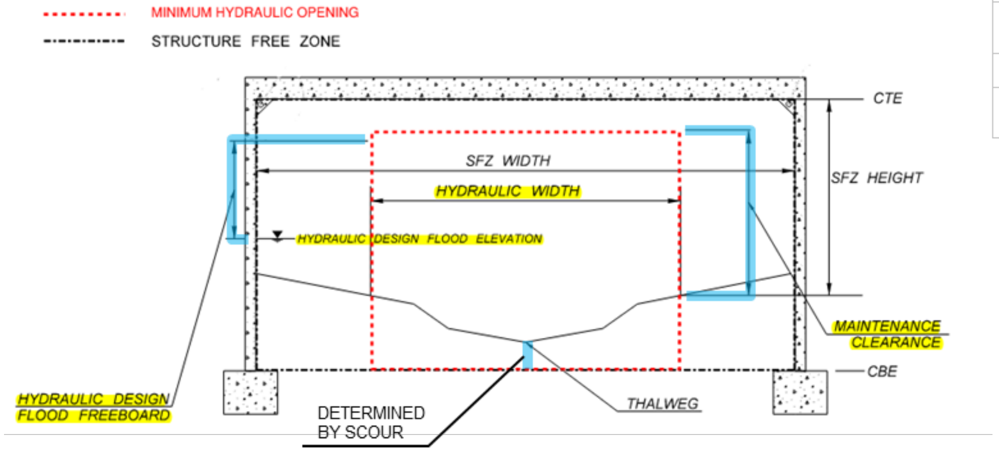
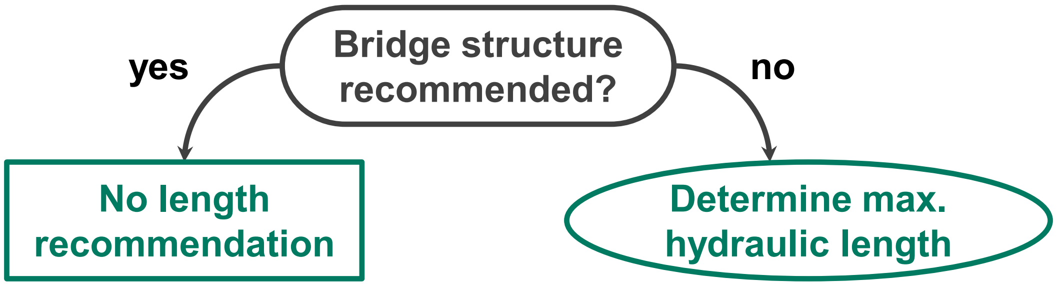


Table 9: Vertical clearance summary

Parameter	Downstream face of structure	Upstream face of structure
Station		
Thalweg elevation (ft)		
Highest streambed ground elevation within hydraulic width (ft)		
100-year WSE (ft)		
2080 100-year WSE (ft)		
Required freeboard (ft)	1, 2, 3, or more if aggradation risk	1, 2, 3, or more if aggradation risk
Recommended/Required maintenance clearance (ft)	Typically 6 or 10	Typically 6 or 10
Required minimum low chord, 100-year WSE + freeboard (ft)		
Required minimum low chord, 2080 100-year WSE + freeboard (ft) *if discussion in section states not practical to meet freeboard at 2080 100-year flow delete this row.*		
Recommended/Required minimum low chord, highest streambed ground elevation within hydraulic width + maintenance clearance (ft)		
Required minimum low chord (ft) *select highest of above REQUIRED low chords*		
Recommended minimum low chord (ft) *select highest of all the above RECOMMENDED and REQUIRED low chords; delete row if all the above are required*		

4.2.4 Hydraulic Length

- Document length recommendation based on structure type / size



Note: long culvert criteria (length : span > 10)

4.2.5 Future Corridor Plans

- Request any plans from Region PEO
- If plans exist, describe how structure is forward-compatible

4.2.6 Structure Type

- Structure recommendation:
  - No structure type
  - Bridge structure
  - Buried structure

Need description on WHY a specific structure is recommended

4.3 Streambed Design

*See Module 11: LWM & Module 12: Streambed Design

Purpose:

- Present proposed material size and channel complexity features

Key Items:

- Clear comparison of observed and proposed bed material
- PHD conceptual complexity sketch
- FHD detailed complexity design
- LWM within structure must be approved by HQ Hydraulics

Lessons Learned:

- Fox and Bolton 75th percentile wood are targets

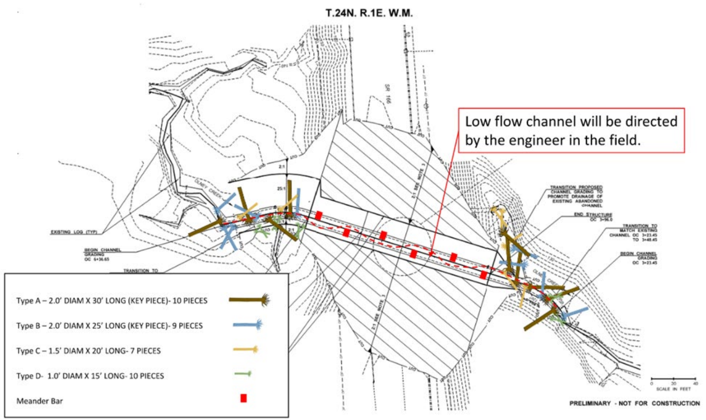


Table 10: Comparison of observed and proposed streambed material

Sediment size	Observed diameter for design (in)	Proposed diameter (in)	Meander bar diameter (in) *(if applicable)*
D_{16}			
D_{50}			
D_{84}			
D_{95}			
D_{100}			

4.3.1 Bed Material

*See Module 12: Streambed Design

- Section 7-4.7 of Hydraulic Manual
- Two Methods
  - No Constraints
    - Match existing (within 20% of D50)
  - Constraints
    - Risk assessment
- WSDOT Standard Specification Materials
  - Minimum 30% streambed sediment
  - Constructible ratios

4.3.2 Channel Complexity

- Describe anticipated channel morphology
  - Proposed elements outside of structure
  - Proposed elements within structure
- Document Fox and Bolton 75th percentile wood targets
  - Include stream length within structure
  - These are goals
- Document proposed design and how it compared to targets
- Proposed layout, stability of complexity features, restoration plan, and other

*See Module 11: LWM and Habitat Features

5 Hydraulic Analysis

*See Module 6: Modeling with SRH-2D

Purpose:

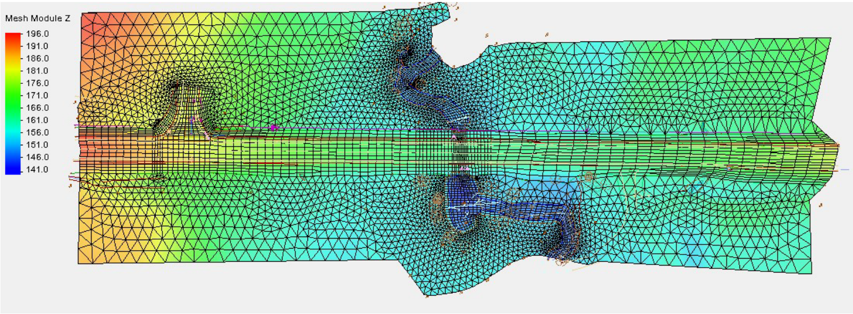
- Describe model development and results

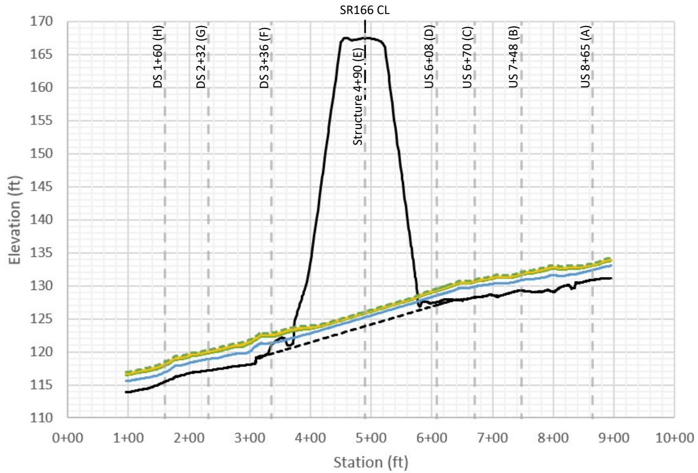
Key Items:

- Topographic information and sources
- Mesh, materials/roughness, boundary conditions,
- Existing, natural, and proposed conditions results

Lessons Learned:

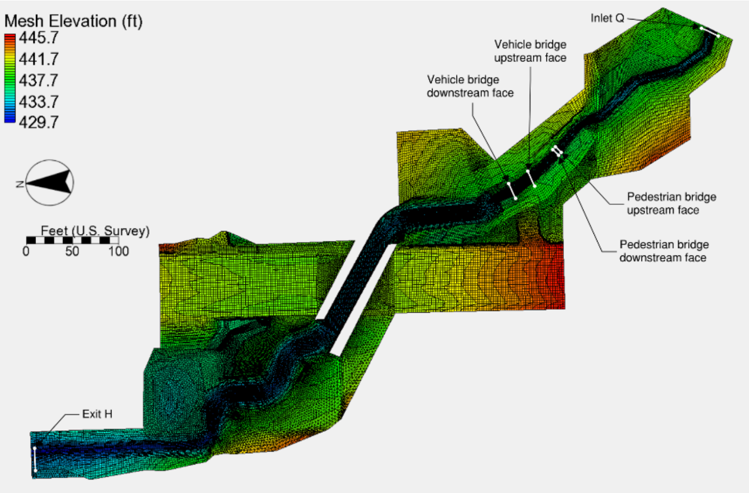
- Make sure hydraulic results match throughout document
- Document modeling assumptions





5.1 Model Development

- 5.1.1 Topography and Bathymetric Data
- 5.1.2 Model Extent and Computational Mesh
- 5.1.3 Materials/Roughness
- 5.1.4 Boundary Conditions
- 5.1.5 Model Run Controls
- 5.1.6 Model Assumptions and Limitations



5.2/5.3/5.4 Existing/Natural/ Proposed Conditions

- Natural conditions only for unconfined
- Minimum show results for:
  - Existing 2yr, 100yr, and 500yr
  - Natural/Proposed 2yr, 100yr, 2080 100yr, and 500yr
- Cross section summary tables
- Profile
- 100-year velocity map
- Appendix H for more detailed results

Table 13: Average main channel hydraulic results for existing conditions

Hydraulic parameter	Cross section	2-year	100-year	500-year
Average WSE (ft)	DS XX+XX (A)			
	DS XX+XX (B)			
	DS XX+XX (C)			
	Structure (D)	NA	NA	NA
	US XX+XX (E)			
	US XX+XX (F)			
	US XX+XX (G)			
Max depth (ft)	DS XX+XX (A)			
	DS XX+XX (B)			
	DS XX+XX (C)			
	Structure (D)	NA	NA	NA
	US XX+XX (E)			
	US XX+XX (F)			
	US XX+XX (G)			
Average velocity (ft/s)	DS XX+XX (A)			
	DS XX+XX (B)			
	DS XX+XX (C)			
	Structure (D)	NA	NA	NA
	US XX+XX (E)			
	US XX+XX (F)			
	US XX+XX (G)			
Average shear (lb/SF)	DS XX+XX (A)			
	DS XX+XX (B)			
	DS XX+XX (C)			
	Structure (D)	NA	NA	NA
	US XX+XX (E)			
	US XX+XX (F)			
	US XX+XX (G)			

Main channel extents were approximated explain methodology (e.g., by 2-year event water surface top widths, inspection of the topographic grade breaks, combination, etc.).

6 Floodplain Evaluation

*See Module 16: FRA

Purpose:

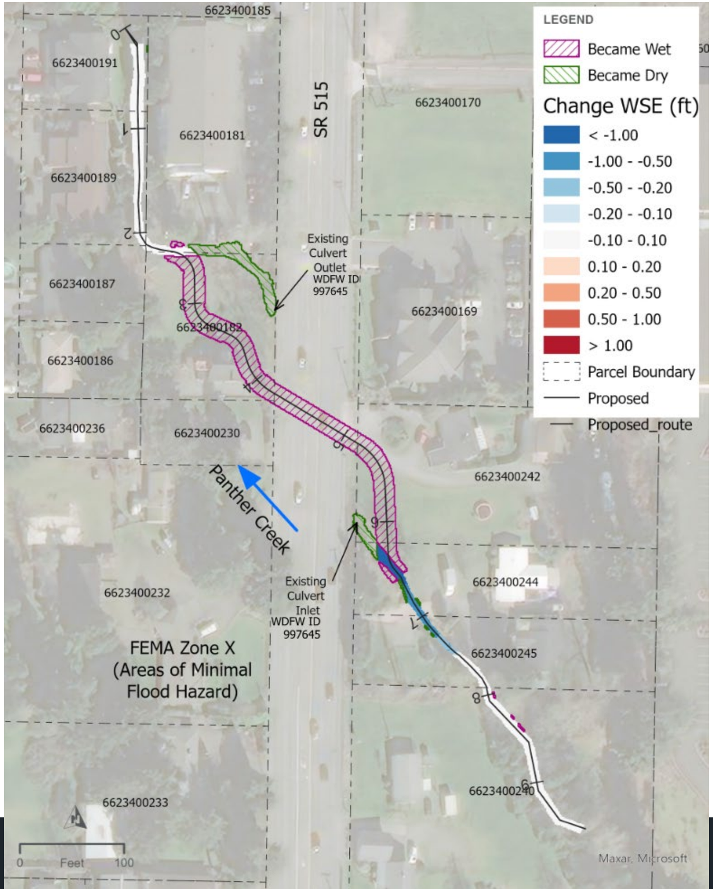
- Document the floodplain changes

Key Items:

- FEMA special flood hazard area
- Changes to WSEL (PHD only)
  - Profile and plan figures

Lessons Learned:

- Clearly describe changes to floodplains



7 Scour Analysis

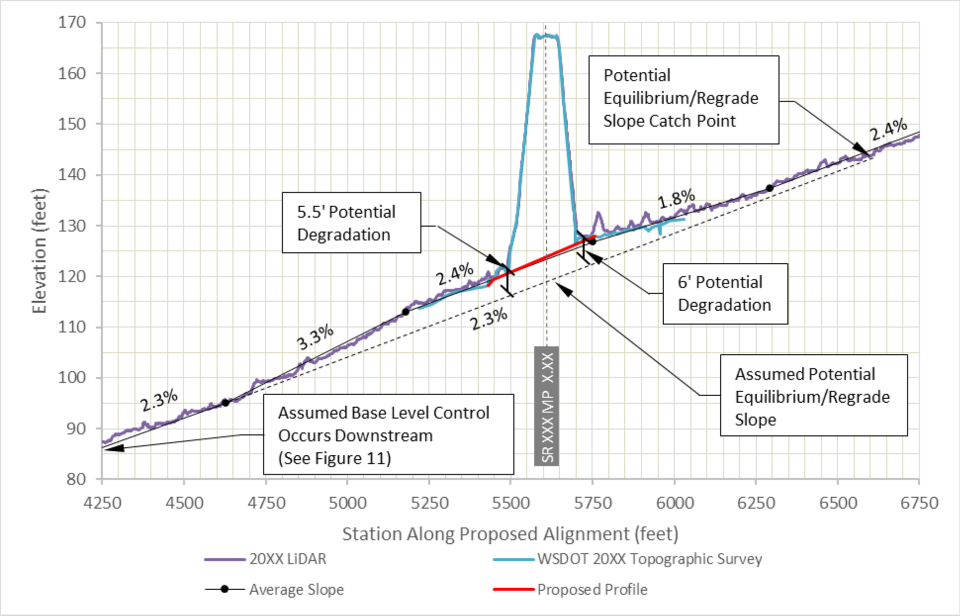
*See future scour certification

Purpose:

- Document scour analysis and assumptions

Key Items:

- Scour training/certification in development
- Total Scour
  - Lateral migration
  - Long-term degradation
  - Contraction scour
  - Local scour

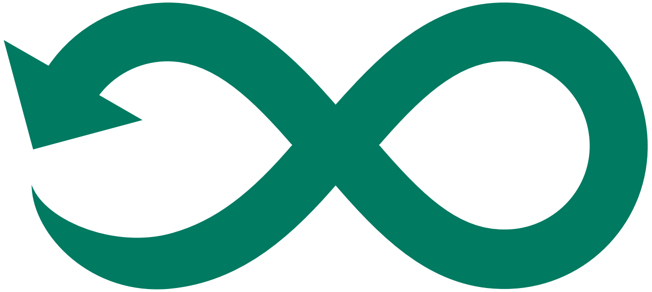


Lessons Learned:

- **Follow the template!**
- Iterative, interdisciplinary process

7 Scour Analysis

- Iterative scour analysis process
  - PHD uses MHO/SFZ
  - Intermediate SFZ Analysis (if not known at PHD)
  - FHD uses final configuration
- Key terminology (refer to HM glossary)
  - Scour Design Flood
  - Scour Check Flood
  - Total Scour
- FHWA Hydraulic Toolbox required



7.1 Lateral Migration

- With respect to structural elements
- PHD
  - Primarily assumed “not-low” unless detailed geotechnical data supports assessment of no lateral migration anticipated
- FHD
  - See template bullet list for lateral migration variable and evaluations required
- Future HM updates

7.1 Lateral Migration

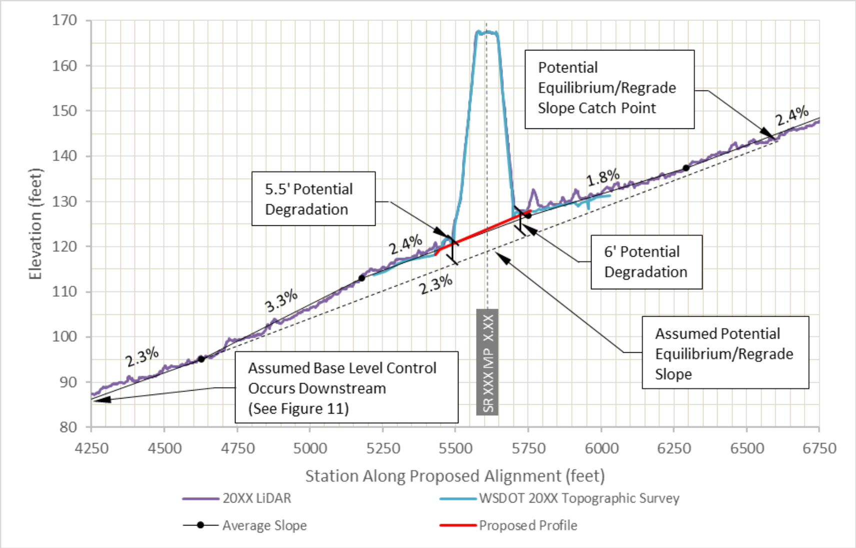
Describe lateral migration risk within the project reach and at the crossing, at minimum based on the variables and evaluations below:

- *The presence of non-erodible soils based on available geotechnical data. This can be accomplished through geotechnical bore logs, hand augers, or other approved soil investigation methods.*
- *The evaluation of historical/existing conditions vs expected future conditions with the proposed stream design. Primarily, the analysis will evaluate what the expected lateral migration will be in the future based on how the stream may adjust over the life of the structure. This evaluation shall refer to Section 2.7.4 and 7.2, which includes the determination of whether the site is considered aggrading or degrading and how will that change in future conditions as the stream develops its natural equilibrium gradient.*
- *The evaluation of the dynamic physical process of stream sinuosity and channel meandering capabilities in consideration of the proposed design. The information from this evaluation is used to predict the streams migration pattern based on the proposed design.*
- *The evaluation of the existing and proposed hydraulic models and the evaluation of the potential effects of the shear stress and velocity of the stream in consideration of the proposed design and how it relates to the expected future condition of the stream. This information is used to predict the streams scour and bank erosion potential with the proposed design and assess changes in stream characteristics between existing and proposed conditions.*
- *If a scour countermeasure (i.e., rock revetment) is required to protect against lateral migration, conduct a geometric evaluation of where the stream may move laterally and determine angles of attack of the stream in relation to the various infrastructure components. This evaluation is to determine the spatial extents of scour protection needed based on the potential for lateral migration.*

At the PHD stage, the risk to lateral migration in relation to the structure is assumed to occur (i.e., not a low risk) unless detailed geotechnical data (i.e., competent bedrock, geotechnical evaluation for soil erodibility, stream power vs. soil erodibility, etc.) is available to support the assessment of no lateral migration being anticipated over the life (75+ years) of the proposed structure(s).

7.2 Long-term Degradation

- Aggradation not included in total scour
- Document
  - Methodology used
  - Identification and justification for base level control determination
- Geotechnical data may reduce long-term degradation



7.3 Contraction Scour

7.3 Contraction Scour

Describe type of contraction scour (e.g., clear-water or live-bed) and how much contraction scour is expected for the scour design flood and scour check flood. Use the results of the hydraulic (Section 5.4) analysis and proposed geometry based on the recommended minimum hydraulic opening or structure free zone or final structure

- PHD – utilizes MHO
- Potential update if SFZ identified different than MHO
- FHD – final structure

7.4 Local Scour

- PHD, SFZ, FHD
- Determine appropriate components of total scour and evaluate
  - Pier scour
  - Abutment scour
  - Bend scour
  - Wall scour
  - Etc.

7.4 Local Scour

Describe type and amount of local scour (e.g., pier scour, bend scour, abutment scour, etc.) for the scour design flood and scour check flood. Use the results of the hydraulic analysis (Section 5.4) and proposed geometry based on the recommended minimum hydraulic opening or structure free zone or final structure

Examples of various local scour components are provided below. ***Designer needs to determine the most appropriate types of scour at the crossing and correctly apply equations applicable to the site.***

7.5 Total Scour

- Document scour at each specific infrastructure component
- Migration potential – scour relative to thalweg
- No migration potential – scour relative to ground at base of infrastructure component

Table 17: Scour analysis summary (Author to provide additional tables for various infrastructure components. Coordinate with Geotechnical and Structural Engineer to make sure all locations where total scour is needed are provided.)

Calculated Scour Components and Total Scour for SR X NAME Creek		
	Scour design flood	**Scour check flood**
Long-term degradation (ft)	X.X	X.X
Contraction scour (ft)	X.X	X.X
Local scour (ft)[a]	X.X	X.X
Total depth of scour (ft)[b]	X.X	X.X

a. *Author to provide additional rows explaining what components of local scour (e.g., pier, wall, bend, abutment, etc.) are included.*
b. *For channels that are anticipated to laterally migrate, depth of total scour should be applied to the thalweg elevation of the proposed channel to determine the total scour elevation at each infrastructure component (e.g., structure, walls, roadway embankments, scour countermeasure, etc.). If risk of lateral migration is low over design life of the infrastructure component, use existing ground elevations at base of infrastructure component.*

8 Scour Countermeasures

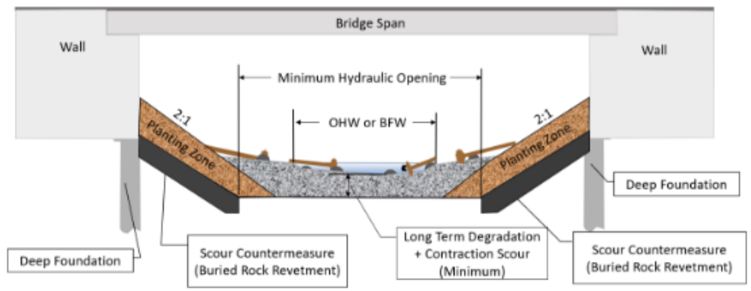
Purpose:

- Determine need for scour countermeasures
- Design calculations and extents

Key Items:

- PHD
  - Anticipated need or not
  - Approximate extents
- FHD
  - Design following HEC-23
  - FHWA Hydraulic Toolbox calculations

Figure 7-9 Scour Countermeasure Design for Water Crossing Structures with Deep Foundation and No Calculated Abutment Scour



Lessons Learned:

- Coordinate with HQ Hydraulics
  - LWM key pieces within structure
  - Informs SFZ determination

9 Summary

Table 18: Report summary

Stream crossing category	Element	Value	Report location
Habitat gain	Total length	XXXX LF	2.1 Site Description
Bankfull width	Reference reach found?	Yes/No	2.7.1 Reference Reach Selection
	Design BFW	X.X ft	2.7.2 Channel Geometry
	Concurrence BFW	X.X ft	2.7.2 Channel Geometry
Floodplain utilization ratio (FUR)	Flood-prone width	X.X ft	2.7.2.1 Floodplain Utilization Ratio
	Average FUR	X.X (add two values if different for US/DS)	2.7.2.1 Floodplain Utilization Ratio
Channel morphology	Existing	See link	2.7.2 Channel Geometry
	Proposed	See link	4.3.2 Channel Complexity
Hydrology/design flows	100 yr flow	XX cfs	3 Hydrology and Peak Flow Estimates
	2080 100 yr flow	XX cfs	3 Hydrology and Peak Flow Estimates
	2080 100 yr used for design	Y/N (elaborate if used for width but not freeboard, etc.)	3 Hydrology and Peak Flow Estimates
	Dry channel in summer	Yes/No	3 Hydrology and Peak Flow Estimates
Channel geometry	Existing	See link	2.7.2 Channel Geometry
	Proposed	See link	4.1.1 Channel Planform and Shape
Channel slope/gradient	Existing culvert	X.X%	2.6.2 Existing Conditions
	Reference reach	X.X%	2.7.1 Reference Reach Selection
	Proposed	X.XX%	4.1.3 Channel Gradient
Hydraulic width	Existing	X ft	2.6.2 Existing Conditions
	Proposed	XX ft	4.2.2 Hydraulic Width
	Added for climate resilience	Yes/No	4.2.2 Hydraulic Width
Vertical clearance	Required freeboard	X.X ft	4.2.3 Vertical Clearance
	Required freeboard applied to 100 yr or 2080 100 yr	100 yr/2080 100 yr	4.2.3 Vertical Clearance
	Maintenance clearance	Recommended/Required X ft	4.2.3 Vertical Clearance
	Low chord elevation	See link	4.2.3 Vertical Clearance
Crossing length	Existing	X.X ft	2.6.2 Existing Conditions
	Proposed	X.X ft	4.2.4 Hydraulic Length
Structure type	Recommendation	Yes/No	4.2.6 Structure Type
	Type		4.2.6 Structure Type
Substrate	Existing	See link	2.7.3 Sediment
	Proposed	See link	4.3.1 Bed Material
	Coarser than existing?	Yes/No	4.3.1 Bed Material
Channel complexity	LWM for bank stability	Yes/No	4.3.2 Channel Complexity
	LWM for habitat	Yes/No	4.3.2 Channel Complexity
	LWM within structure	Yes/No	4.3.2 Channel Complexity
	Meander bars	#	4.3.2 Channel Complexity
	Boulder clusters	#	4.3.2 Channel Complexity
	Coarse bands	#	4.3.2 Channel Complexity
	Mobile wood	Yes/No	4.3.2 Channel Complexity
Floodplain continuity	FEMA mapped floodplain	Yes/No	6 Floodplain Evaluation
	Lateral migration	Yes/No	2.7.5 Channel Migration
	Floodplain changes?	Yes/No	6 Floodplain Evaluation
Scour	Analysis	See link	7 Scour Analysis
	Scour countermeasures	Yes/No/Determined at FHD	8 Scour Countermeasures
Channel degradation	Potential?	Range	7.2 Long-term Aggradation/Degradation of the Channel Bed
Channel degradation	Allowed?	Yes/No	7.2 Long-term Aggradation/Degradation of the Channel Bed

References

References

These are suggested reference and are not inclusive of all reference that may or may not be used. Add and remove references as appropriate for each individual PHD.

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Appendices

- Do not delete unused appendices, simply label as “not used”
- Add additional appendices to the end if needed

Appendices

Do not revise appendices lettering, so we can keep consistent between PHDs. If an appendix is not used simply add a note to the fly sheet that it was not used or is not applicable to this crossing. Add additional appendices below standard list if needed.

Appendix A: FEMA Floodplain Map

Appendix B: Hydraulic Field Report Form

Appendix C: Streambed Material Sizing Calculations

Appendix D: Stream Plan Sheets, Profile, Details

Appendix E: Manning's Calculations

Appendix F: Large Woody Material Calculations

Appendix G: Future Projections for Climate-Adapted Culvert Design

Appendix H: SRH-2D Model Results

Appendix I: SRH-2D Model Stability and Continuity

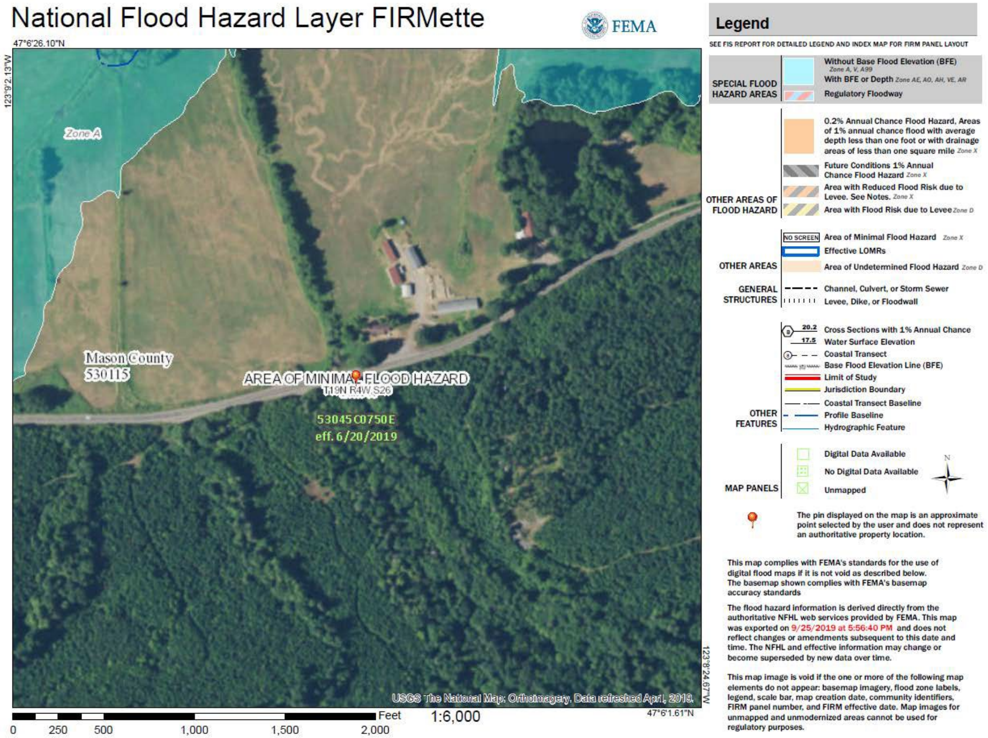
Appendix J: Reach Assessment (This is only used if a Reach Assessment already exists and has been validated by the hydraulic/hydrology staff to include as an Appendix)

Appendix K: Scour Calculations

Appendix L: Floodplain Analysis (FHD ONLY)

Appendix M: Scour Countermeasure Calculations (FHD ONLY)

Appendix A: FEMA Floodplain Map



Appendix B: Hydraulic Field Report Form

WSDOT Hydraulics Section

Site Visit 2 Field Report

Project Name:	Project Number:	
Project Office:	Date:	
Stream Name:	Time of Arrival:	
WDFW ID Number:	Tributary to:	Time of Departure:
State Route/MP:	Township/Range/Section/ ¼ Section:	Weather:
County:	Purpose of Site Visit:	Prepared By:
		WRIA:

Meeting Location:

Attendance List:

Name	Organization	Role

Observations:
Describe measurements, locations, known history, summarize on site discussion.

Reference Reach:
Describe location, known history, summarize on site discussion, appropriateness, bankfull measurement, geomorphic pattern, slope.

Bankfull Width & Bankfull Depth:
Describe who was involved, extents collection occurred within.

Data Collection:
Describe site conditions, channel geomorphology (shape, spacing of features, etc), habitat type and location, flow splits, LWM location and quantity, etc. Provide a sketch showing location of data collected.

Pebble Counts:
Describe location of pebble counts if available.

Photos:
Any relevant photographs placed here with descriptions.

WSDOT Hydraulics Section

Project Complexity Field Form

Prepared By:	Page: 1
Project Name:	Date:
Stream Name:	WDFW ID Number:
Tributary to:	State Route/MP:

Site Visit Type:

Anticipated Level of Complexity:
Low ☐ Medium: ☐ High: ☐
Additional Notes:

In Water Work Window:

General Instructions:
The following elements of projects should be discussed before the production of a Preliminary Hydraulic Design by members of WSDOT and WDFW to identify the level of complexity for each site, and corresponding communication and review. While certain elements may be categorized as indicators of a low/medium/high complexity project, these are only suggestions, and newly acquired information may change the level of complexity during a project. The ultimate documentation category for a given site is up to both WSDOT and WDFW, considering both site characteristics and synergistic effects.

Discuss the following elements as they apply to the project. Rank each element as low, medium, or high in complexity. The assigned level of complexity determines the appropriate agreed upon review from WDFW (*see accompanying document*, *coming soon*). Ultimately, WSDOT needs to acquire an HPA from WDFW for fish passage projects and the agreed upon communication and review of project elements will contribute to efficiencies in the permitting process.

Category	Project Elements	Levels of Complexity			Follow up/Observations
		Low	Med	High	
ign ofile, bed mix)	Channel realignment				
	Stream grading extents				
	Expected stream movement				

WSDOT Hydraulics Section

Site Visit 3 Concurrence Form

Project Name:	Prepared By:
	Date:
Stream Name:	WDFW ID Number:
Tributary to:	State Route/MP:

Bankfull Measurements:

Location	Width	Include in Average?

Additional Notes:

Average Bankfull Width: ______________ **Concurrence Reached:** Yes: ☐ No: ☐

Reference Reach Location and Morphology:

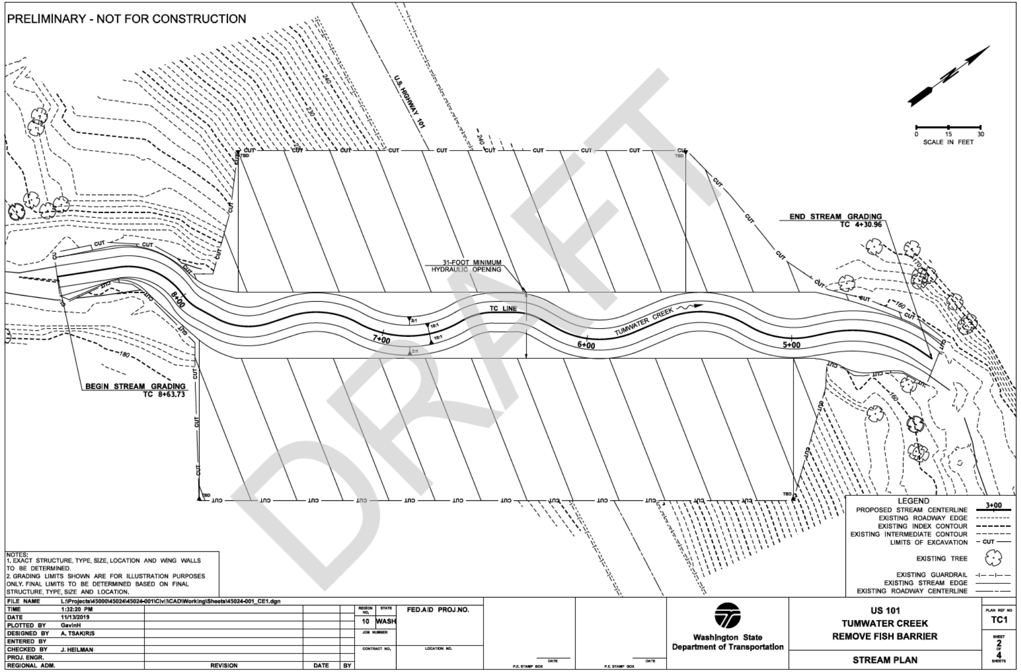
Reference Reach Morphology: ______________ **Concurrence Reached:** Yes: ☐ No: ☐

Habitat Connectivity:
Habitat Connectivity Memo: Received or In Process ☐ Requested ☐ Not Requested ☐
Additional Notes:

Additional Information Requested by Comanagers:

Appendix C: Streambed Material Sizing Calculations

Appendix D: Stream Plan Sheets, Profile, Details



Appendix E: Manning's Calculations

Table 4A-2 Manning's Roughness Coefficients for Stream Channels

Stream Channels	Manning's n
Minor streams (surface width at flood stage less than 100 feet):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030-0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035-0.05
c. Some weeds, light brush on banks	0.035-0.05
d. Some weeds, heavy brush on banks	0.05-0.07
e. Some weeds, dense willows on banks	0.06-0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by 0.01–0.02	
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e above 0.01–0.02	
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04-0.05
b. Bottom of cobbles, with large boulders	0.05-0.07
Floodplains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030-0.035
b. High grass	0.035-0.05
2. Cultivated areas:	
a. No crop	0.03-0.04
b. Mature row crops	0.035-0.045
c. Mature field crops	0.04-0.05
3. Heavy weeds, scattered brush	0.05-0.07
4. Light brush and trees:	
a. Winter	0.05-0.06
b. Summer	0.06-0.08
5. Medium to dense brush:	
a. Winter	0.07-0.11
b. Summer	0.10-0.16
6. Dense willows, summer, not bent over by current	0.15-0.20
7. Cleared land with tree stumps, 100 to 150 per acre:	
a. No sprouts	0.04-0.05
b. With heavy growth of sprouts	0.06-0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10-0.12
b. Flood depth reaches branches	0.12-0.16

Appendix F: Large Woody Material Calculations

WSDOT Large Woody Material for stream restoration metrics calculator

State Route# & MP	*SR 515 MP 3.97*		Key piece volume	*1.310*	*yd^3*
Stream name	*Panther Creek*		Key piece/ft	*0.0335*	*per ft stream*
length of regrade[a]	*414*	*ft*	Total wood vol./ft	*0.3948*	*yd^3/ft stream*
Bankfull width	*9.5*	*ft*	Total LWM[c] pieces/ft stream	*0.1159*	*per ft stream*
Habitat zone[b]	*Western WA*				

Log type	Diameter at midpoint (ft)	Length(ft)[d]	Volume (yd^3/log)[d]	Rootwad?	Qualifies as key piece?	No. LWM pieces	Total wood volume (yd^3)
A	2.00	30	3.49	yes	yes	11	38.40
B	1.50	25	1.64	yes	yes	15	24.54
C	1.50	20	1.31	yes	no	13	17.02
D	1	20	0.58	yes	no	16	9.31
E	1.0	6	0.17	yes	no	13	2.27
F			0.00				0.00
G			0.00				0.00
H			0.00				0.00
I			0.00				0.00
J			0.00				0.00
K			0.00				0.00
L			0.00				0.00
M			0.00				0.00
N			0.00				0.00
O			0.00				0.00
P			0.00				0.00

	No. of key pieces	Total No. of LWM pieces	Total LWM volume (yd^3)
Design	26	68	91.5
Targets	**14**	**48**	**163.4**
	surplus	surplus	deficit

Appendix G: Future Projections for Climate-Adapted Culvert Design

Future Projections for Climate-Adapted Culvert Design

Project Name: SR515MP3.97 PantherCr 997645

Stream Name: Panther Creek

Drainage Area: 467 ac

Projected mean percent change in bankfull flow:

2040s: 14.3%

2080s: 19.8%

Projected mean percent change in bankfull width:

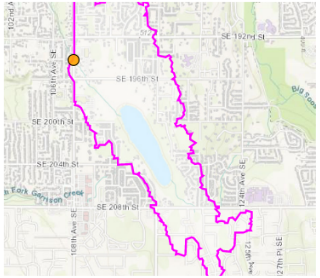
2040s: 6.9%

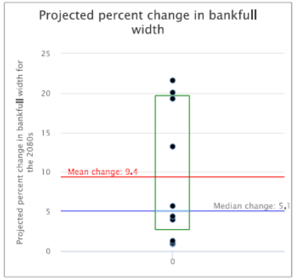
2080s: 9.4%

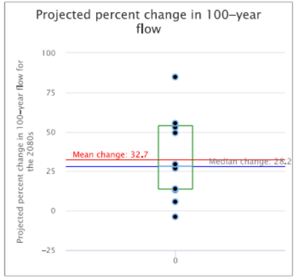
Projected mean percent change in 100-year flood:

2040s: 26.6%

2080s: 32.7%



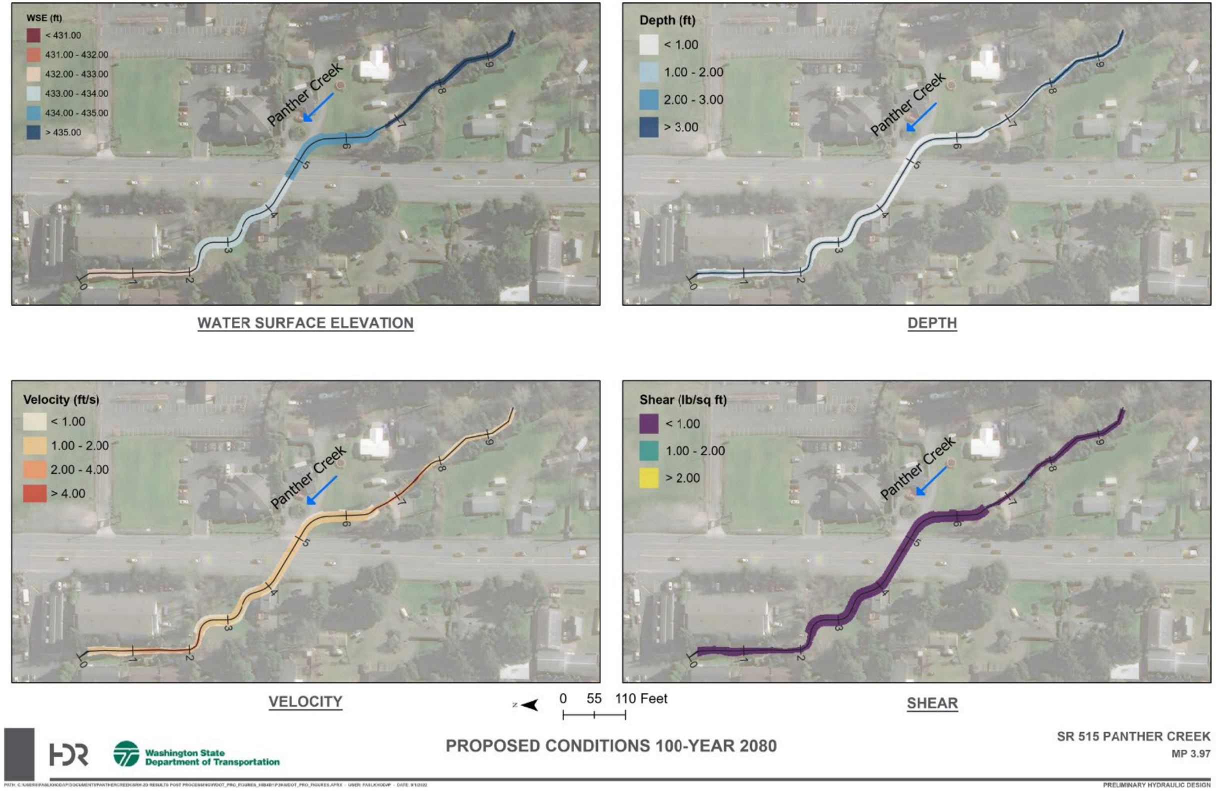




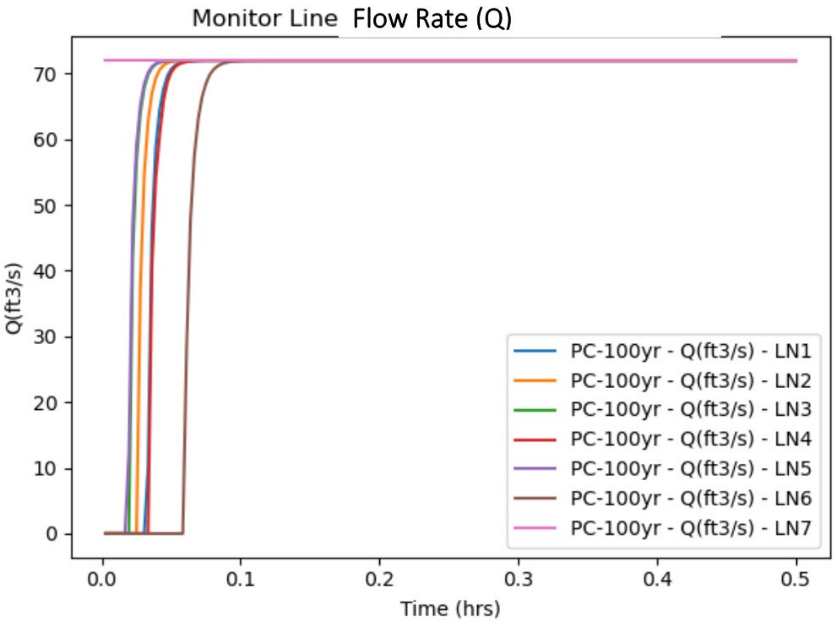
Black dots are projections from 10 separate models

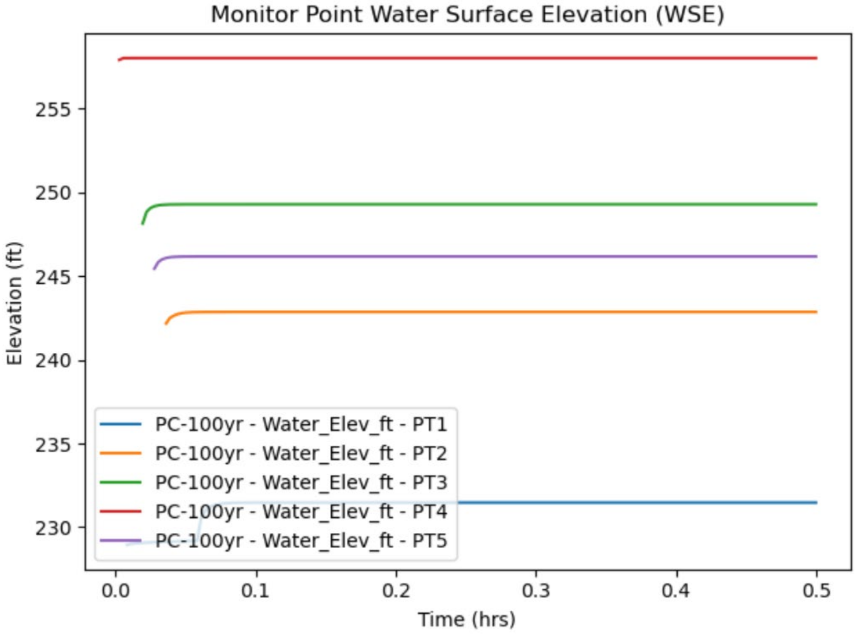
The Washington Department of Fish and Wildlife makes no guarantee concerning the data's content, accuracy, precision, or completeness. WDFW makes no warranty of fitness for a particular purpose and assumes no liability for the data represented here.

Appendix H: SRH-2D Model Results



Appendix I: SRH-2D Model Stability and Continuity





Appendix J: Reach Assessment

Site and Reach Assessment
Chico Creek At SR 3

Work Order MS 5404

Robert W. Schanz, Hydrologist
Jim Park, Hydrologist
WSDOT Environmental Services
Watershed Management Program

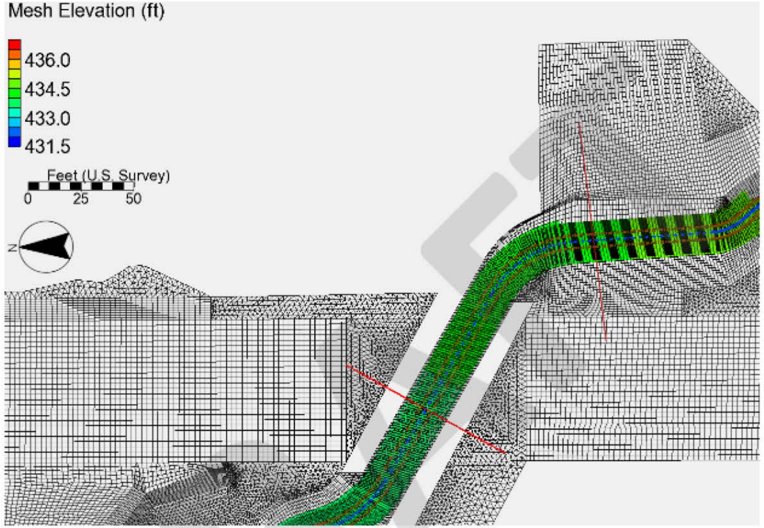
May 2006

Washington State Department of Transportation
Environmental and Engineering Service Center
Environmental Services Office

Appendix K: Scour Calculations

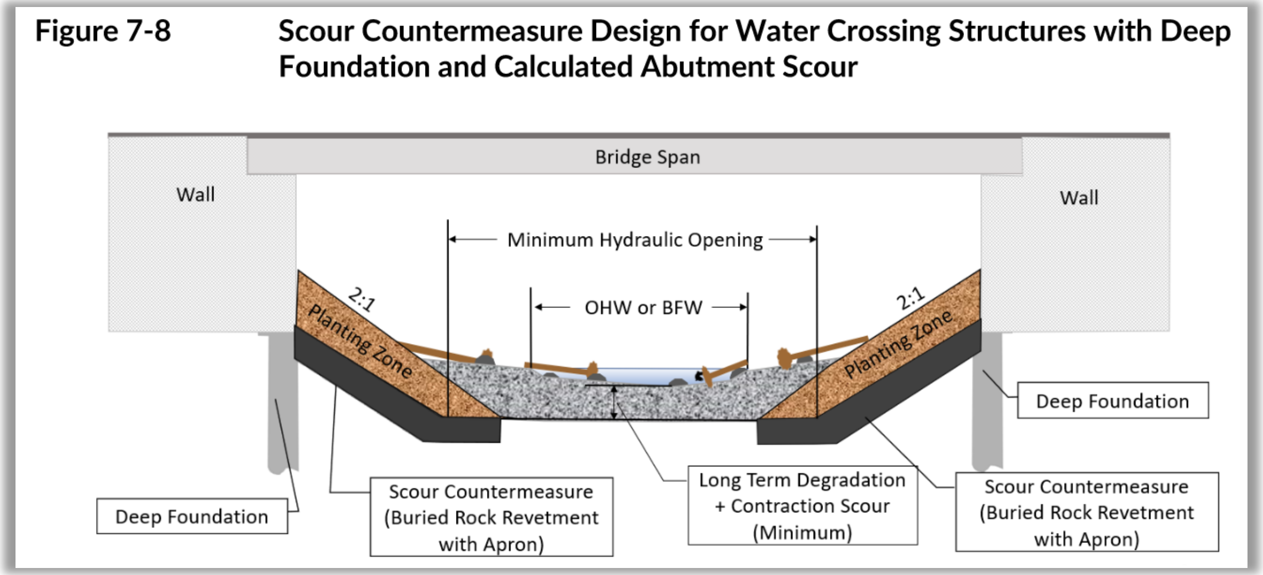
Scour Design / Check Flood Event Hydraulic Toolbox Contraction Scour Computation		
Parameter	value	Units
Input Parameters		
Average Depth Upstream of Contraction	1.51	ft
D50	0.06	mm
Average Velocity Upstream	1.65	ft/s
Results of Scour Condition		
Critical velocity above which bed material of size D and smaller will be transported	4.68	ft/s
Contraction Scour Condition	Clear Water	
Live Bed & Clear Water Input Parameters		
Temperature of Water	60	F
Slope of Energy Grade Line at Approach Section	0.004	ft/ft
Discharge in Contracted Section	15.39	cfs
Discharge Upstream that is Transporting Sediment	14.94	cfs
Width in Contracted Section	6	ft
Width Upstream that is Transporting Sediment	6.01	ft
Depth Prior to Scour in Contracted Section	1.51	ft
Unit Weight of Water	62.4	lb/ft^3
Unit Weight of Sediment	165	lb/ft^3
Results of Clear Water Method		
Diameter of the smallest nontransportable particle in the bed material	0.075	ft
Average Depth in Contracted Section after Scour	0.58	ft
Scour Depth	-0.93	ft
Recommendations		
Recommended Scour Depth	-0.93	ft

Scour Design / Check Flood Event Hydraulic Toolbox Abutment Scour Computation		
Parameter	value	Units
Input Parameters		
Scour Condition	Compute	
Scour Condition Location	Type a (Main Channel)	
Abutment Type	Vertical-Wall Abutment	
Unit Discharge, Upstream in Main Channel (q1)	2.49	cfs/ft
Discharge in Constricted Area (q2)	2.57	cfs/ft
D50	0.06	mm
Upstream Flow Depth	1.51	ft
Flow Depth prior to Scour	1.8	ft
Results of Live Bed Method		
q2 / q1	1.03	
Average Velocity Upstream	1.65	ft/s
Critical velocity above which bed material of size D and smaller will be transported	4.68	ft/s
Scour Condition	Live Bed	
Scour Condition	a (Main Channel)	
Amplification Factor	1.39	
Flow Depth including Contraction Scour	0.63	ft
Maximum Flow Depth including Abutment Scour	1.38	ft
Scour Hole Depth	-0.42	ft



Appendix L: Floodplain Analysis (FHD ONLY)

Appendix M: Scour Countermeasure Calculations (FHD ONLY)



PHD/FHD Checklist

- Use checklist to assist in guiding content of each section
  - **Still use Hydraulics Manual!!!**
- Upload files to WSDOT PWise
  - Final PHD
  - Final FHD
- Good tool for QC of reports

General Format

- ☐ Table of Contents, Figures, and Tables updated
- ☐ All Figures that require a North Arrow, Flow Arrow, and Scale Bar have them
- ☐ All Figure numbers have been updated in the text
- ☐ All Table numbers have been updated in the text
- ☐ No bookmark errors
- ☐ All highlighted text deleted
- ☐ Footers updated
- ☐ Draft watermark
- ☐ PDF created with bookmarks of headings, so reader can quickly jump between sections

Cover Page

- ☐ SR/MP/Creek Title Correct
- ☐ Cover photograph shows water in the creek channel
- ☐ Names updated
- ☐ Lower right corner title/date/etc. updated
- ☐ Lower left corner submittal type selected from drop down
- ☐ FPT number for all authors (Julie Heilman's is FTP20-00157)

1 Introduction

- ☐ WDFW ID number correct
- ☐ Milepost and State Route correct
- ☐ WSDOT region correct
- ☐ LF habitat gain listed
- ☐ Brief description of what design method was used and why
- ☐ General location described
- ☐ Existing structure type, length, dia./width described
- ☐ Minimum hydraulic opening stated
- ☐ Any design deviations are described
- ☐ Any structure recommendations described or stated that there are none
- ☐ Vicinity Map included

Summary of Key Items

- Created to document design decisions and justification
- **Follow the template!**
- **Use the Hydraulic Manual!!!**
  - PHD/FHD template and checklist do not take the place of official guidance documents

Q&A