Washington State Department of Transportation

Memorandum

April 27, 2022

TO: WSDOT Project Development Engineers

FROM: Mark Gaines, Development Division Director

SUBJECT: Project Delivery Memo #22-01 – Vertical Clearance for Water Crossing Bridges and Buried Structures

The purpose of this memo is to provide revised guidance for vertical clearance for water crossing bridges and buried structures.

Background

Design Instructions - Vertical Clearance Considerations was updated in January 2022. The revision to the guidance changed the location where the Maintenance Clearance dimension is measured, which caused a discrepancy with Design Manual chapter 720.03(5)(b) Minimum Clearance for New Structures, iv Water Crossing Structures. The current Design Manual guidance defines the measurement location at the thalweg of the stream. The location has been moved as described in the following revised Design Manual guidance:

720.03 Bridge Site Design Elements
720.03(5) Vertical Clearance
720.03(5)(b) Minimum Clearance for New Structures
iv Water Crossing Structures

Maintenance Clearance is the distance from the ~~Thalweg (or line of the lowest streambed elevation within the watercourse)~~ highest ground elevation within the horizontal limits of the Hydraulic Width to the bottom spanning member. The State Hydraulics Engineer determines the Hydraulic Width, and it is documented in the P/FHD. Providing Maintenance Clearance beyond the minimum Freeboard is beneficial for required monitoring and inspections, as well as any maintenance activities that may be required during the life of the structure. Generally, these activities include staff walking through the culvert, taking measurements and photographs, but could also involve the use of machinery within the structure limits.

For each water crossing location, evaluate and document the type of activities that will be conducted in collaboration with Region Maintenance, Bridge Preservation, ESO/Stream Restoration Biologists, and other key stakeholders. Additionally, site specific considerations must be evaluated in order to determine the appropriate Maintenance Clearance. See the attached *Design Instructions - Vertical Clearance Considerations* for additional information and considerations when determining the preferred vertical clearance.

In general, when no large objects are placed beneath the structure, use 6 feet ~~from the Thalweg to the bottom spanning member~~ as the initial Maintenance Clearance target. However, it is desired to provide as much vertical clearance as feasible. Large objects, including boulders and large woody debris, under or inside water crossing structures are not allowed unless approved by the State Hydraulics Engineer. When large objects are approved to be placed beneath the structure, use 10 feet as the minimum Maintenance Clearance. However, it is desirable to provide as much vertical clearance as feasible.

The ARA for Development approves vertical clearance where greater than or Equal to Freeboard and does not otherwise require a Design Analysis.

Direction to Designers

Apply the revised guidance on all active projects that have not obtained Design Approval/Conceptual Design Approval. If using this revised Design Manual guidance adversely affects the project delivery, take one of the following actions:

- For structures with no large objects, document the reason(s) the project did not provide the 6-foot target in the Design Documentation Package (DDP).
- For structures that have been approved to place boulders and/or large woody debris under or inside the structure, coordinate the decision with the State Hydraulics Engineer, Region Maintenance, Bridge Preservation, and the Assistant State Design Engineer. Document the reason(s) the project did not provide the 10-foot minimum Maintenance Clearance in a Design Analysis.

For design-build projects, Maintenance Clearance must be evaluated by the design team and incorporated into Chapter 2.30 of the Request for Proposal (RFP) prior to being published.

Questions

If you need assistance using this guidance, please contact your Assistant State Design Engineer.

MG:dm

cc: Ahmer Nizam, ESO Director
Kim Mueller, ESO Fish Passage Delivery Manager
Bijan Khaleghi, State Bridge Design Engineer
Bob Dyer, HQ Construction Office

Attachment: Design Instructions – Vertical Clearance Considerations

Title

Vertical Clearance Considerations for Bridges and Buried Structures for Water Crossings

Purpose

To provide information and guidance for designers on how to determine vertical clearance.

Background

All water crossing structures require inspection, monitoring, and potential maintenance activities during their life cycle.

- The streambed channel within Fish bearing water crossing structures is periodically monitored to ensure fish passage
    - Water crossings in the Federal Culvert Injunction area require streambed channel monitoring at least three times within the first 5 years of correction, and then once every 10 years in perpetuity to ensure fish passage. Some sites may require modifications post construction if determined to be a fish barrier following a correction.
- WDFW Hydraulic Project Approval (HPA) permits require streambed channel monitoring on two-three occasions within the first 2 years after the water crossing structure is constructed to ensure it is performing as expected.
- WSDOT Bridge Preservation performs structural integrity inspections every 2 years for all structures with spans ≥8 feet. Note, these inspections are federally mandated for all structures with a Structural Clear Span ≥20 feet.

There are two elements that must be considered while determining the appropriate vertical clearance under bridges and inside buried structures. The first is Hydraulic Design Flood Freeboard (Freeboard), and the second is Maintenance Clearance. Both terms are defined in the Definitions section below.

Freeboard is related to the hydraulic capacity of the structure and is required by state and federal guidance. Typically, all bridges and buried structures are required to have a minimum of 1-3 feet of freeboard above the Hydraulic Design Flood Elevation. The State Hydraulics Engineer determines the Freeboard, and it is documented in the Preliminary/Final Hydraulic Design Report (P/FHD). Approval from the State Hydraulics Engineer is required for Freeboard less than what is documented in the P/FHD.

Guidance

Direction to Designers

Providing Maintenance Clearance beyond the minimum Freeboard is beneficial for required monitoring and inspections, as well as any maintenance activities that may be required during the life of the structure. Generally, these activities include staff walking through the culvert, taking measurements and photographs, but could also involve the use of machinery within the structure limits. Evaluate and document the type of activities that will be conducted in collaboration with Region Maintenance, Bridge Preservation, ESO/Stream Restoration Biologists, and other key stakeholders.

For design-build projects, Maintenance Clearance must be evaluated by the design team and incorporated into Chapter 2.30 of the Request for Proposal (RFP) prior to being published.

Maintenance Clearance Target

Each water crossing location has site specific considerations that must be evaluated in order to determine the appropriate Maintenance Clearance. Provide as much clearance beyond the minimum Freeboard called out in the Preliminary/Final Hydraulic Design Report (P/FHD) as feasible.

Use 6 feet from the highest ground elevation within the horizontal limits of the Hydraulic Width to the Controlling Top Elevation (CTE) as the initial Maintenance Clearance target. This initial target has been found to provide reasonable access for inspection, monitoring, and maintenance staff. 10 feet minimum vertical clearance is required for machinery access and operation. Large objects, including boulders and large woody debris, under or inside water crossing structures are not allowed unless approved by the State Hydraulics Engineer. When large objects are approved to be placed beneath the structure, use 10 feet as the minimum Maintenance Clearance.

It is good practice to evaluate the list of Considerations below with Region Maintenance and the Bridge Preservation Office when determining the appropriate Maintenance Clearance.

Considerations

- ✓ For buried structures, evaluate the embankment depth over the structure in order to increase the Maintenance Clearance without raising the roadway profile. In most cases it likely will not be feasible to raise the roadway profile, but there may be exceptions such as a requirement for providing minimum Freeboard or, the stream is located below a sag curve, etc.
- ✓ At some locations wildlife connectivity and/or clearance indicative of a bridge due to commitments to Tribes and WDFW regarding structure type may also need to be considered, discuss with Region Environmental Office.
- ✓ Consider minimum fill requirements over the buried structure. For concrete structures, if the fill depth is less than 2 feet, measured from the top of slab to the roadway surface, the top slab may become the driving surface, thus triggering structural design requirements. Contact the Bridge Office for a determination. For metal plate structures, minimum fill depths may control as required by the design specification.
- ✓ Consider fill depth needed over buried structure to allow for standard guardrail post installation. There may be a balance between maximizing the Maintenance Clearance and allowing for the use of standard guardrail.
- ✓ Consider overall structure height. It is good practice to check with industry suppliers in order to understand the costs associated with increases in structure height. If the Maintenance Clearance can be provided without exceeding typical forming system maximum height the additional cost may be negligible.
- ✓ Consider the overall length of the structure. Longer structures increase the risk for potential monitoring and maintenance, and access is difficult if there is insufficient height.
- ✓ Consider constructability for placing the streambed material. Often the streambed material must be placed inside the structure prior to placing the overhead part of the buried structure and backfilling if there is not enough vertical clearance. This may require a longer roadway closure and may add risk during the closure.
- ✓ Consider delivery of the precast sections. There may be height restrictions along the delivery route.
- ✓ Consider placement of precast sections. For constrained locations evaluate appropriate space for crane set up, delivery of the structure sections, and crane picking operation to place the sections.
- ✓ **Minimum SFZ Width**: Owing to the subjective nature of establishing the width of the structure over the stream beyond the minimum required for Hydraulic Width, such as for wildlife connectivity, habitat, or the minimum to be considered a “bridge”, the minimum SFZ Width is always established by the WSDOT Engineer before publishing the RFP. This ensures WSDOT will get the SFZ width we need and also establishes a level playing field among Proposers. The minimum SFZ width can never be less than the Hydraulic Width. The minimum SFZ Width may be greater than the Hydraulic Width when the WSDOT Engineer wants the Design-Builder’s design to provide for wildlife connectivity, additional habitat, additional width to be a “bridge”, or for other contextual considerations.

- ✓ **Minimum SFZ Height** is established by the WSDOT Engineer before publishing the RFP.
  - For crossings that WSDOT will accept either a bridge or a buried structure, establishing the minimum SFZ Height is a two-step process. The first step is to determine which generates the highest CTE – the flood freeboard or maintenance clearance? The second step is to determine whether this elevation plus superstructure thickness will require the roadway profile to be raised? If the roadway profile need not be raised, the Minimum SFZ height is the difference between the CTE and the minimum ground elevation within the horizontal limits of the Hydraulic Width. On the other hand, if the profile needs to be raised, HQ Hydraulics should be consulted to evaluate whether or not a reduction in flood freeboard and/or maintenance clearance can be accommodated in order to avoid or minimize increasing the roadway profile. The SFZ Height in the RFP should reflect the decision from this conversation. It is incumbent on the WSDOT Engineer to know whether or not the SFZ Height will require roadway to be raised or not so the Technical Requirements of the RFP can address acceptable sight distance and rates of change in the profile.
  - For crossings that WDOT will accept nothing other than a bridge, the SFZ height will usually be the estimated vertical difference between the bottom of the superstructure and the highest ground elevation inside the Hydraulic Width. However, this should never be less than minimum SFZ Height determined from the bullet above.

Approvals

The Region ARA for Development (or delegate) has the final approval for Maintenance Clearance. As previously mentioned, it is good practice to consult Region Maintenance and the Bridge Preservation Office when evaluating Maintenance Clearance.

Documentation

Decisions regarding Maintenance Clearance shall be documented in the Basis of Design (BOD), Design Parameters Worksheet, or a design decision and included in the Design Documentation Package (DDP). The documentation should include conclusions for the aforementioned considerations, and concurrence from the approval authority.

Definitions

Average 100 Year Stream Slope Under Structure (A100SS) – The slope calculated by dividing the difference in elevation of the 100-year stream flow MRI water surface elevation between the extreme ends of the measurement of Hydraulic Length, by the Hydraulic Length.

Bearing of Stream – The imaginary line that meets all of the following: (1) equidistant between the Structure walls (or abutments) to the left and right of the stream, and (2) at the A100SS slope, and (3) at the 100-year stream flow MRI water surface elevation. This line is irrespective of the location of the thalweg or any sinuosity in the stream bed.

Hydraulic Width – A horizontal distance measured perpendicular to the Bearing of Stream, between the nearest face of the Structure to the left of the stream and the nearest face of the Structure to the right of the stream. Hydraulic Width is determined by the State Hydraulics Engineer and is documented in the P/FHD.

Design Flood – The discharge that is selected as the basis for the design or evaluation of a hydraulic structure including a hydraulic design flood, scour design flood, and scour check flood.

Hydraulic Design Flood Freeboard (Freeboard) – The minimum dimension from the Hydraulic Design Flood Elevation to the Controlling Top Elevation (CTE) as defined by the State Hydraulics Engineer.

Controlling Bottom Elevation (CBE) – An imaginary surface the represents the bottom boundary of the Structure Free Zone (SFZ).

Controlling Top Elevation (CTE) – An imaginary surface that represents the top boundary of the Structure Free Zone (SFZ).

Maintenance Clearance – At any given cross section of the SFZ, Maintenance Clearance is a vertical dimension added to the highest ground elevation within the horizontal limits of the Hydraulic Width.

Structure Free Zone (SFZ) – An imaginary prism that represents the minimum boundary within which no part of the fish passage structure shall be allowed.

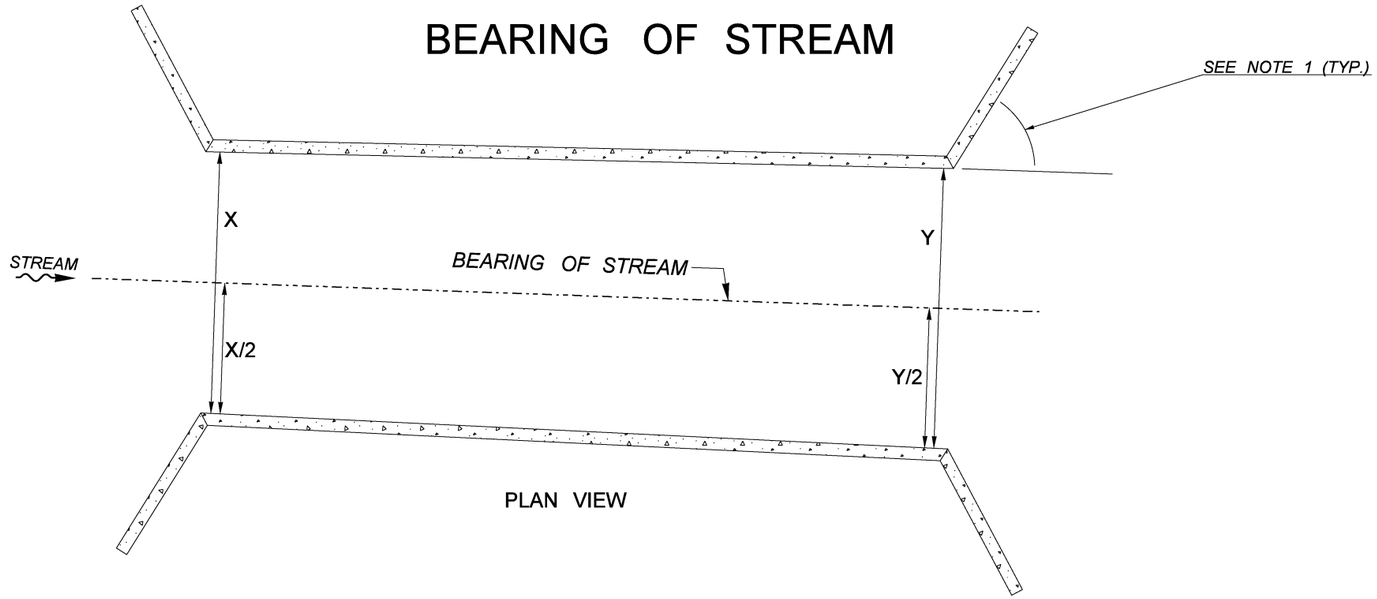
Structure Free Zone (SFZ) Width – A horizontal distance measured perpendicular to the Bearing of Stream, between the nearest face of the Structure to the left of the stream and the nearest face of the Structure to the right of the stream but includes additional width beyond the Hydraulic Width to address contextual considerations.

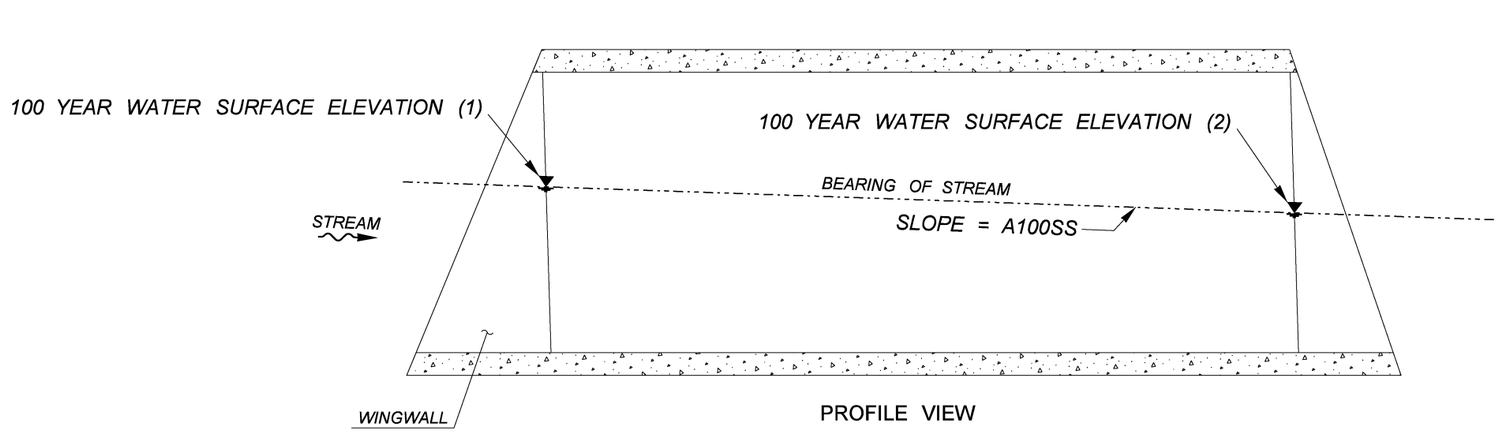
Structure Free Zone Height – Dimension measured from the highest ground elevation within the horizontal limits of the Hydraulic Width to the CTE and is defined by the highest elevation established by Freeboard, Maintenance Clearance, or any other dimension to address contextual considerations.

Attachments

Exhibit 1
Exhibit 2
Exhibit 3

Exhibit 1





NOTES:

1. WALLS SKEWED AT ANGLES LESS THAN 60 DEGREES MEASURED FROM A LINE PARALLEL TO THE BEARING OF THE STREAM, SHALL BE INCLUDED IN THE HYDRAULIC LENGTH CALCULATION. REFER TO SFZ2 FOR ADDITIONAL INFORMATION.

$$A100SS = \frac{(100\ YR\ WATER\ SURFACE\ ELEV\ 2) - (100\ YR\ WATER\ SURFACE\ ELEV\ 1)}{HYDRAULIC\ LENGTH\ (SEE\ SFZ2)}$$

STRUCTURE FREE ZONE DEFINITIONS EXHIBIT

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DESIGNED BY	S. CROSIER						
ENTERED BY	S. CROSIER						
CHECKED BY	K. WILCOX				CONTRACT NO.		LOCATION NO.
PROJ. ENGR.	B. ELLIOTT						
REGIONAL ADM.	J. WYNANDS	REVISION	DATE	BY			

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

SR 108/US 101
MASON/THURSTON CO FISH BARRIERS - REMOVE FISH BARRIERS

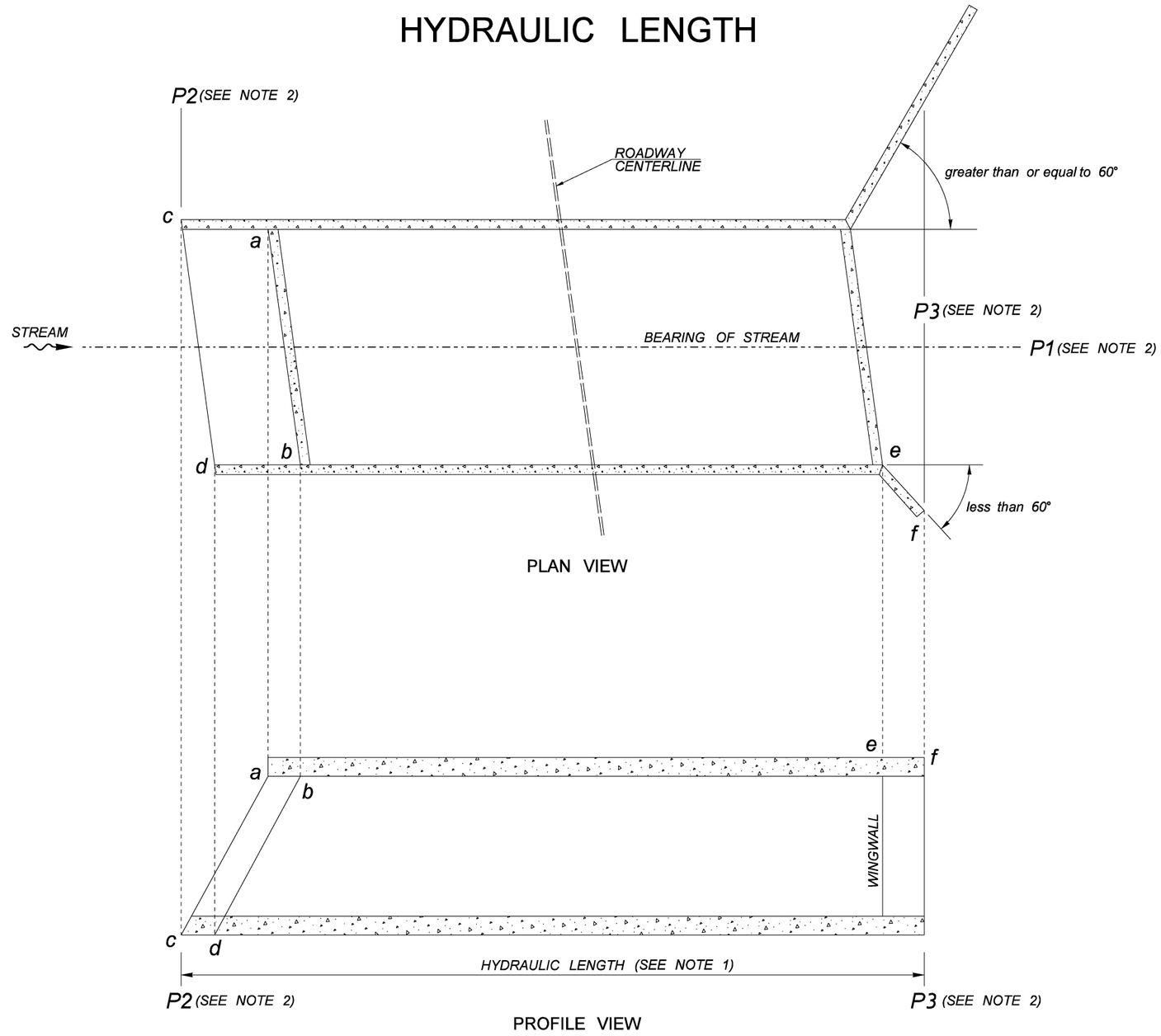
BEARING OF STREAM / A100SS

PLAN REF NO **SFZ1**

SHEET 1 OF 3 SHEETS

Exhibit 2

HYDRAULIC LENGTH



NOTES:

1. HYDRAULIC LENGTH IS MEASURED HORIZONTALLY.
2. LET P1 BE A VERTICAL PLANE CONTAINING THE BEARING OF STREAM. LET P2 BE A VERTICAL PLANE, PERPENDICULAR TO P1, AND PASSING THROUGH THE POINT ON THE STRUCTURE THAT IS FURTHER-MOST UPSTREAM (NOT INCLUDING WING WALLS THAT ARE AT A HORIZONTAL SKEW ANGLE OF 60 DEGREES OR GREATER FROM THE BEARING OF STREAM). LET P3 BE A VERTICAL PLANE, PERPENDICULAR TO P1, AND PASSING THROUGH THE POINT ON THE STRUCTURE THAT IS FURTHER-MOST DOWNSTREAM (NOT INCLUDING WING WALLS THAT ARE AT A HORIZONTAL SKEW ANGLE OF 60 DEGREES OR GREATER FROM THE BEARING OF STREAM).

STRUCTURE FREE ZONE DEFINITIONS EXHIBIT

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DESIGNED BY	S. CROSIER				CONTRACT NO.		LOCATION NO.		HYDRAULIC LENGTH
ENTERED BY	S. CROSIER								
CHECKED BY	K. WILCOX								
PROJ. ENGR.	B. ELLIOTT								
REGIONAL ADM.	J. WYNANDS	REVISION	DATE	BY					

Exhibit 3

NOTES:

1. **CTE = CONTROLLING TOP ELEVATION**

2. **CBE = CONTROLLING BOTTOM ELEVATION**

3. **FILLETS SHALL BE OUTSIDE SFZ PER DETAIL 1 UNLESS:**

   A_{F1} = AREA OF FILLET 1

   A_{F2} = AREA OF FILLET 2

   $\sum A_F = A_{F1} + A_{F2}$

   IF: $\sum A_F \leq 2\%$ (SFZ W x SFZ H)

   AND A_F IS ABOVE BOTH

   A) **THE ELEVATION CALCULATED AS THE HYDRAULIC DESIGN FLOOD ELEVATION + HYDRAULIC DESIGN FLOOD FREEBOARD**

   B) **THE ELEVATION CALCULATED AS THE HIGHEST GROUND ELEVATION WITHIN THE HORIZONTAL LIMITS OF THE HYDRAULIC WIDTH + MAINTENANCE CLEARANCE**

   THEN: FILLETS MAY BE INSIDE THE SFZ

4. **MEASURE SFZ HEIGHT FROM THE HIGHEST GROUND ELEVATION WITHIN THE HORIZONTAL LIMITS OF THE HYDRAULIC WIDTH. SEE TECHNICAL REQUIREMENTS TABLE 2.30-B *STRUCTURE AND CHANNEL DESIGN CHARACTERISTICS* FOR EXCEPTIONS.**

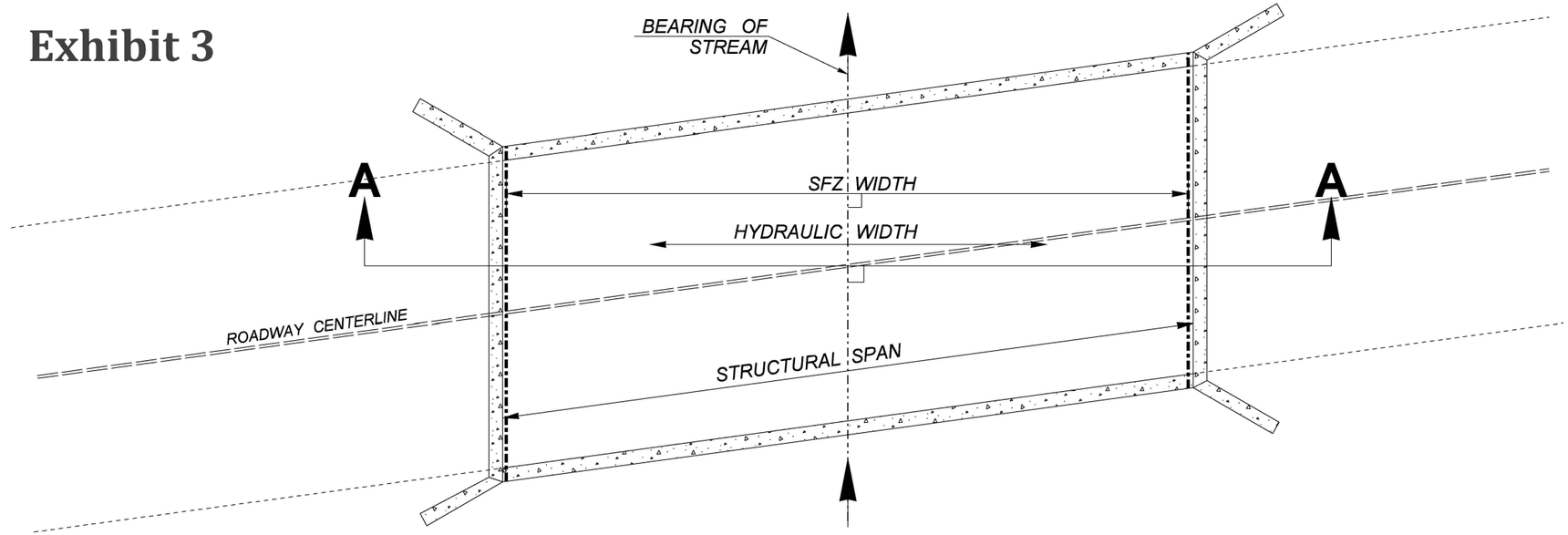
5. ***CONTROLLING BOTTOM ELEVATION (CBE)* - AN IMAGINARY SURFACE THAT REPRESENTS THE BOTTOM BOUNDARY OF THE STRUCTURE FREE ZONE (SFZ) AT ANY VERTICAL CROSS SECTION OF THE SFZ TAKEN AT A HORIZONTAL ANGLE OF 90 DEGREES TO THE BEARING OF STREAM, THE CBE SHALL BE A HORIZONTAL LINE LOCATED:**

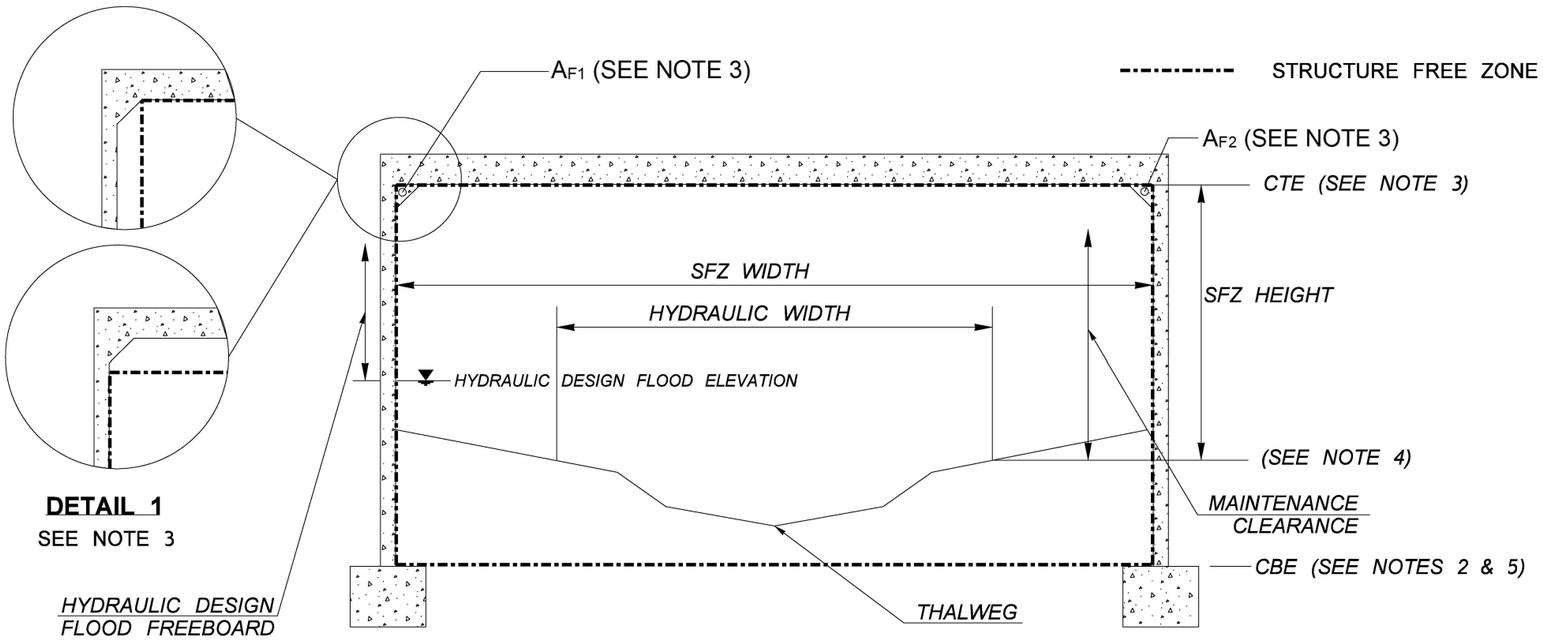
   ***FOR BOTTOMLESS STRUCTURES*, SUCH AS THREE SIDED BURIED STRUCTURES, METAL STRUCTURAL PLATE ARCHES AND BRIDGES:**

   WHEN ANY PART OF ANY FOOTING EXTENDS HORIZONTALLY UNDER THE VERTICAL SHADOW OF THE HYDRAULIC WIDTH, THE CBE SHALL BE AT LEAST TWO FEET BELOW THE ELEVATION OF SCOUR FOR THE SCOUR CHECK FLOOD.

   WHEN NO PART OF ANY FOOTING EXTENDS HORIZONTALLY UNDER THE VERTICAL SHADOW OF THE HYDRAULIC WIDTH THE CBE SHALL BE AT THE ELEVATION OF SCOUR FOR THE SCOUR CHECK FLOOD OR LOWER.

   ***FOR BURIED STRUCTURES WITH A BOTTOM*, SUCH AS A FOUR-SIDED BURIED STRUCTURE OR A CIRCULAR PIPE, THE CBE SHALL BE AT LEAST TWO FEET BELOW THE ELEVATION OF SCOUR FOR THE SCOUR CHECK FLOOD.**





STRUCTURE FREE ZONE

SECTION A-A

STRUCTURE FREE ZONE DEFINITIONS EXHIBIT

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REGIONAL ADM.	J. WYNANDS	REVISION	DATE	BY			

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

SR 108/US 101
MASON/THURSTON CO FISH BARRIERS - REMOVE FISH BARRIERS

CTE, CBE, SFZ WIDTH & SFZ HEIGHT

PLAN REF NO **SFZ3**

SHEET 3 OF 3 SHEETS