



WSDOT

Scour Workshop

Module 7

Contraction Scour

May 31st, 2023

Scott Hogan

Senior Hydraulic Engineer FHWA Resource Center



Current Duties

- Training
- Technical Support
- Technology Development and Deployment



Background and Experience

- 10 years at FHWA Resource Center
- 7 years at Central Federal Lands Hydraulics Team Lead
- 14 years consulting engineering



Education

- B.S. Civil Engineering (Colorado State University)
- M.S. Hydraulics (Colorado State University)



Personal Interests

- Hiking
- Camping
- Fishing and Hunting
- Cycling
- DIY Home Improvement

Casey Kramer

Principal River Engineer Natural Waters, LLC



Current Duties

- Owner of Natural Waters, LLC
- WSDOT HQ staff augmentation team assisting State Hydraulics Engineer



Background and Experience

- Previous WSDOT State Hydraulic Engineer
- Private sector hydraulics and river engineering consultant
- Research River Engineer



Education

- B.S. Civil Engineering (Washington State University)
- M.S. River Engineering (University of Iowa – Iowa Institute of Hydraulic Research)



Personal Interests

- Spending time with family
- Rivers
- Dirt biking, Fishing, Camping, and Coaching/Watching Sports

Contraction Scour Overview

- Types of contraction scour
- Summary for how to compute contraction scour
- Steps to compute contraction scour



Image Source: Casey Kramer

Types of Contraction Scour

- **Clear-water** – No transport of bed material sediment from upstream. The area of the contracted section increases until the velocity of the flow is equal to the critical velocity of the bed material
- **Live-bed** – Bed material from the riverbed upstream is transported into the crossing

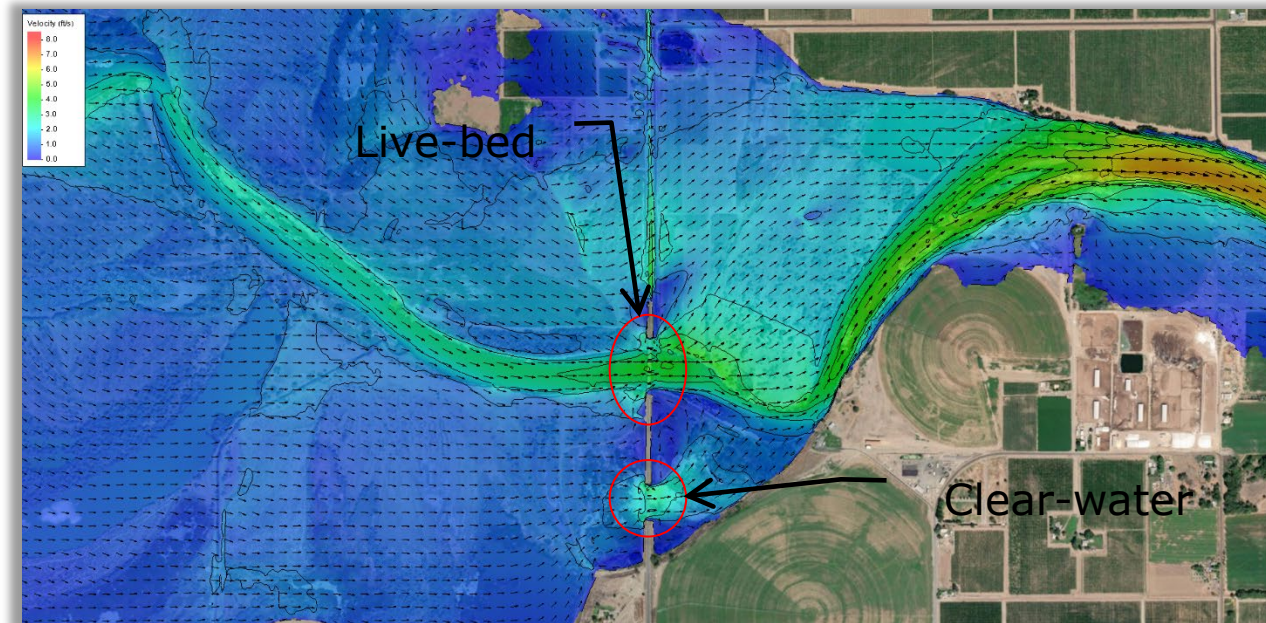


Image Source: Casey Kramer

Contraction Scour – Clear-water or Live-Bed

- Compare the average velocity (V_1) and the critical velocity (V_c) for bed material transport at the approach section
 - If $V_1 > V_c \rightarrow$ live-bed is most likely
 - If $V_1 < V_c \rightarrow$ clear-water is most likely
- Compute clear-water scour using the bed material gradation (D_{50}) at the water crossing
- Always compute contraction scour for live-bed and clear-water scour conditions

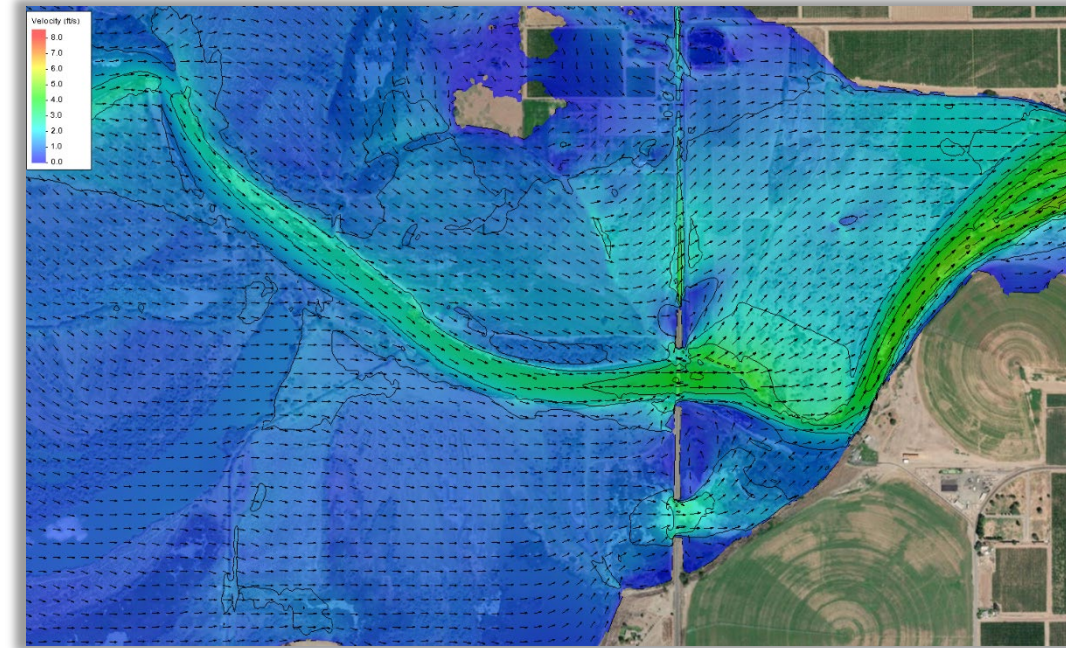


Image Source: Casey Kramer

How to Compute Contraction Scour

- **Approach Section location:**
 - Upstream of where overbank flow is diverted into the main channel
 - Width represents the flow that would likely transport sediment:
 - Toe to toe (of slopes) or between tops of banks
 - Field observations (e.g., sediment being mobilized, vegetation, etc.)
 - Critical velocity or shear for incipient motion
 - Avoid locally higher velocity locations, as they result in underestimating contraction scour

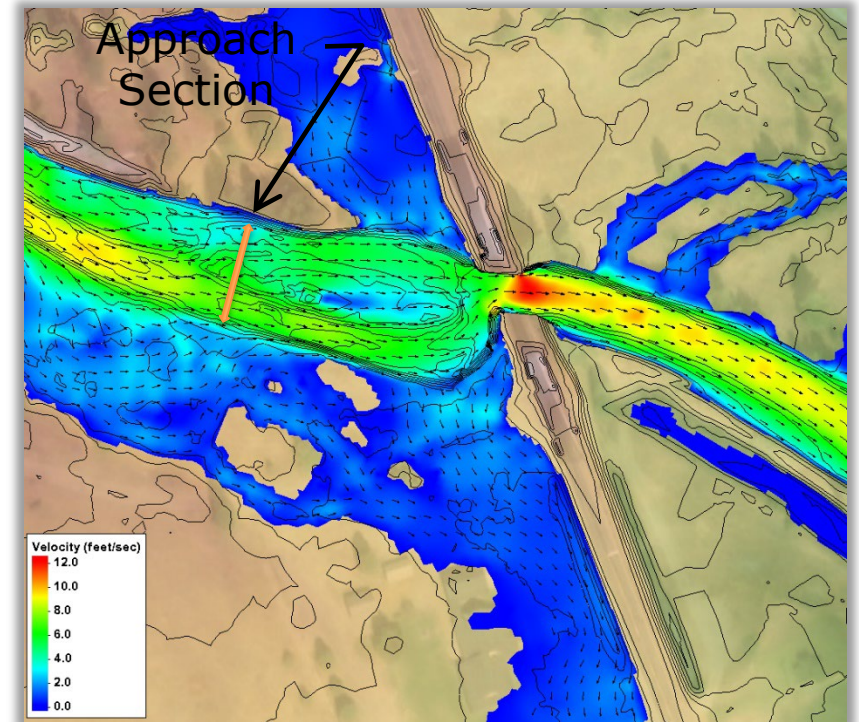


Image Source: Casey Kramer

How to Compute Contraction Scour

- **Contracted Section location:**
 - Where flow is most contracted through the bridge
 - Width should be consistent with the approach section reference (i.e., toe to toe (of slopes) or between tops of banks)
 - Width should exclude effective width of piers
 - Width needs to be adjusted for skew

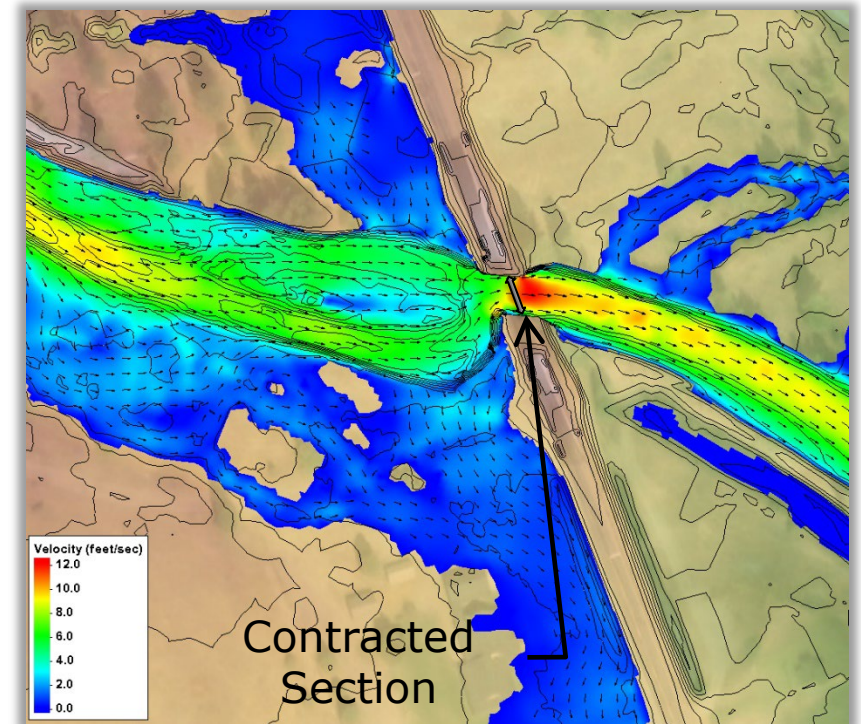


Image Source: Casey Kramer

Main Channel vs Overbank Contraction Scour

- If the main channel can migrate to either abutment, the main channel computed contraction scour is applied to the entire opening width
- Main channel contraction scour is likely live-bed scour, but clear-water scour may occur
- Overbank contraction scour is not common for most WSDOT fish passage projects. When it does occur, it is predominantly clear-water scour when channel is assessed to be stable and the overbanks are vegetated (i.e., secondary and relief structures)



Image Source: Casey Kramer

Contraction Scour

- The following provides an example for computing contraction scour for a PHD
- Key assumptions:
 - The structure type, size and location has not been determined
 - Contraction scour is determined at the selected contracted section location.
 - Per the WSDOT H_HD template other total scour tables may be necessary to perform scour analysis at appropriate locations
 - Channel profile and geometry is typical through the crossing, therefore flow depths are assumed to be uniform.
 - Applying depths of scour at locations other than the location of the selected contraction scour arc needs to be assessed carefully

Contraction Scour

- The hydraulic engineer of record determines appropriate total scour elevations that are commensurate with the site and acceptable level of risk in coordination with WSDOT
- Ultimate goal is to determine scour elevations at each infrastructure component being designed. Coordination **MUST** happen with the project, geotechnical, and bridge and structures offices to determine appropriate scour elevations to be used for design as the design progresses
- The intent of the next series of slides is to show an example for how contraction scour should be calculated but does not go into detail of all scenarios and analyses required to develop total scour. Completion of NHI Course 135046 and the FHWA scour workshop is required for more details on computing total scour

Contraction Scour

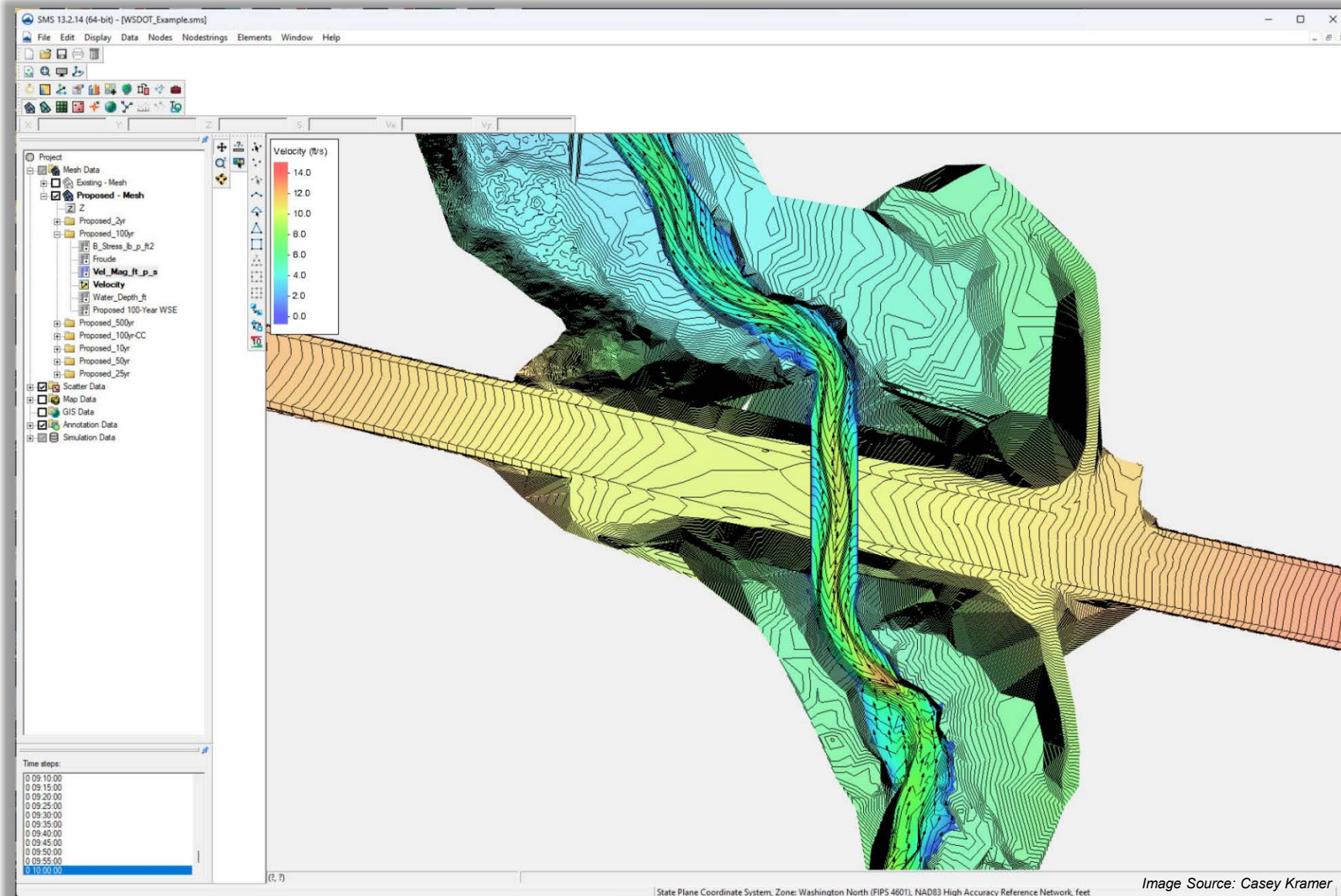
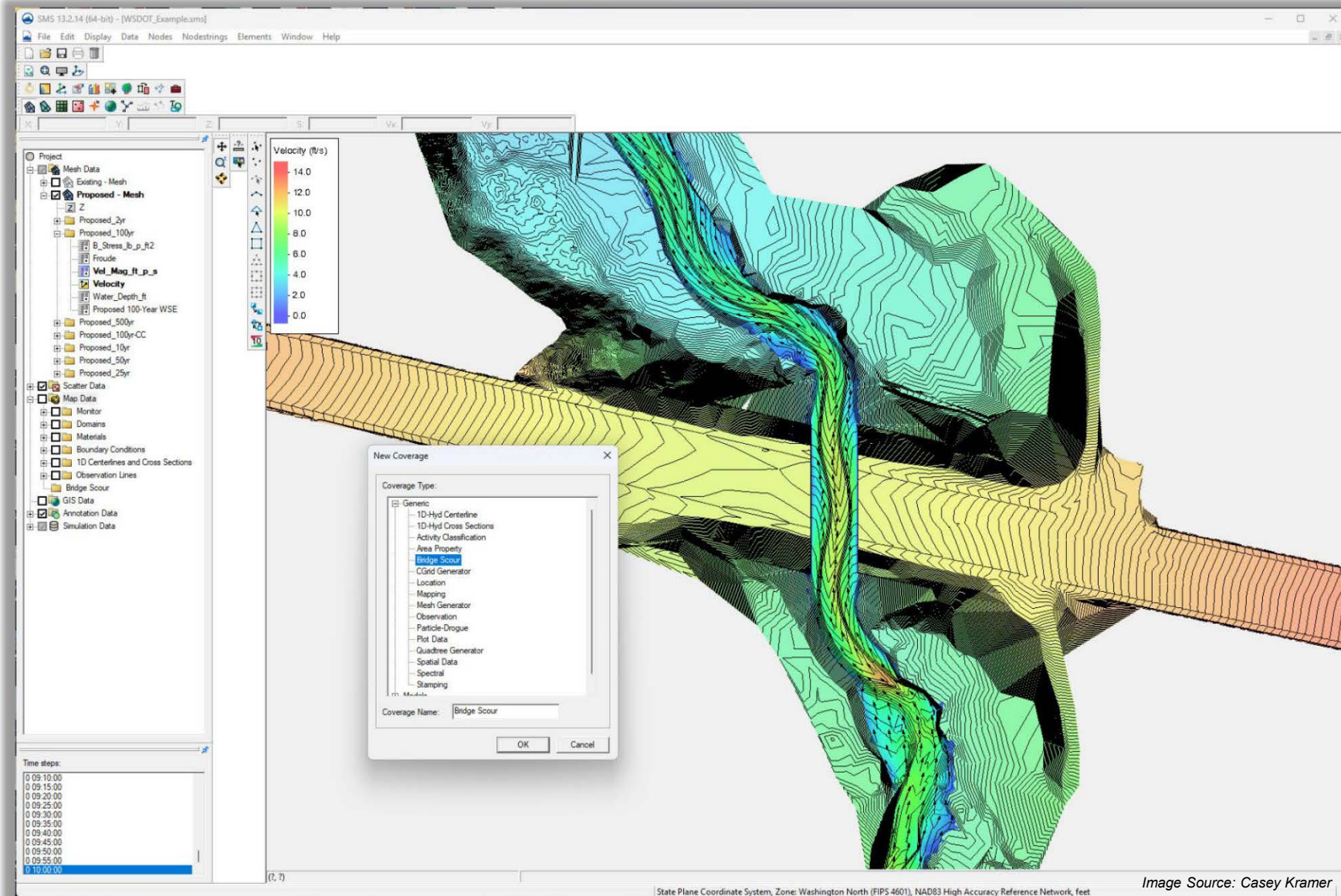
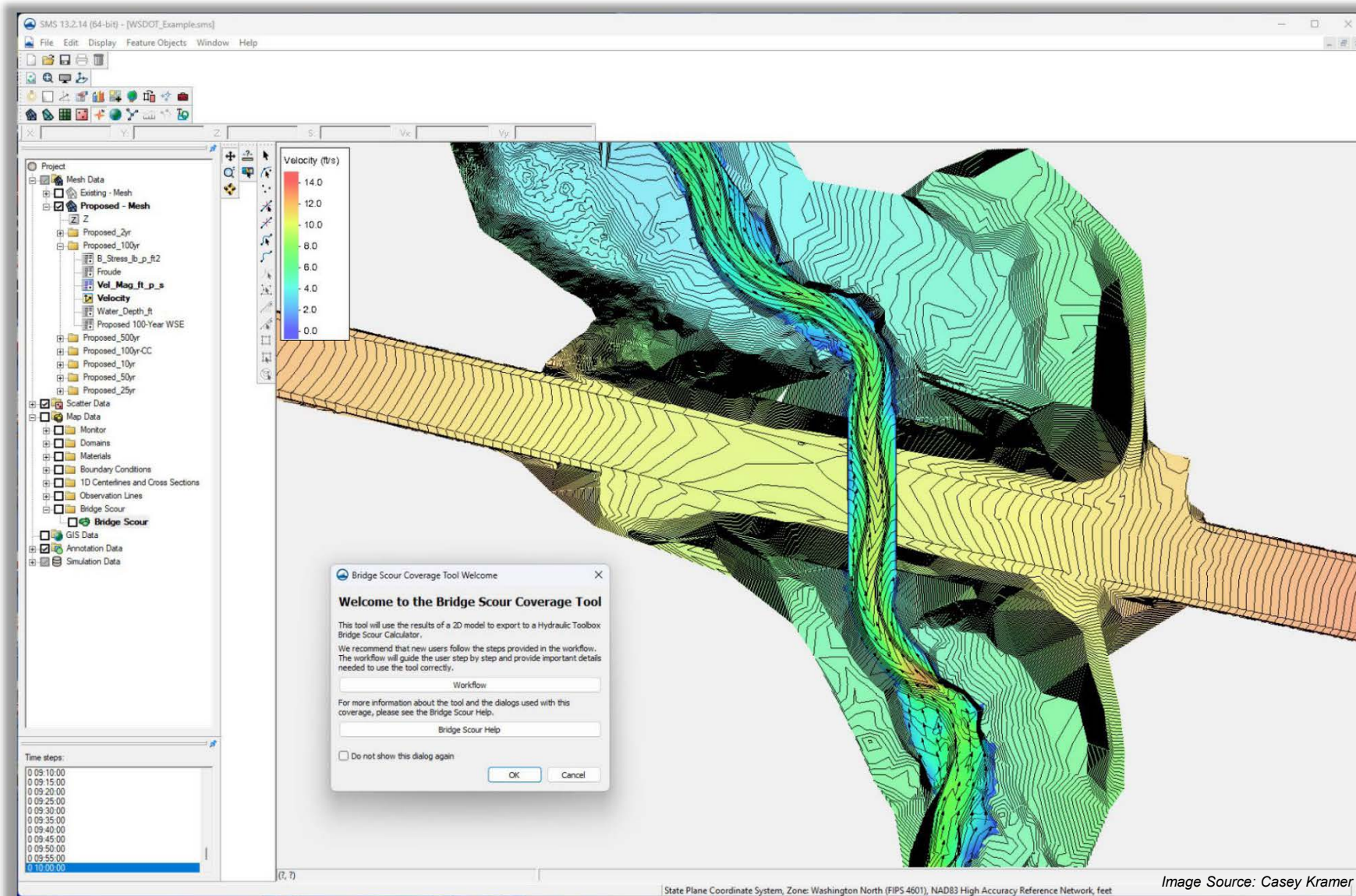


Image Source: Casey Kramer

Contraction Scour



Contraction Scour



Contraction Scour

The screenshot displays the SMS 13.2.14 (64-bit) - [WSDOT_Example.sma] interface. The main window shows a 3D model of a bridge structure with a velocity field overlay. A color scale legend for Velocity (ft/s) is visible, ranging from 0.0 (blue) to 14.0 (red). The 'Bridge Scour Coverage Properties' dialog box is open, showing the following settings:

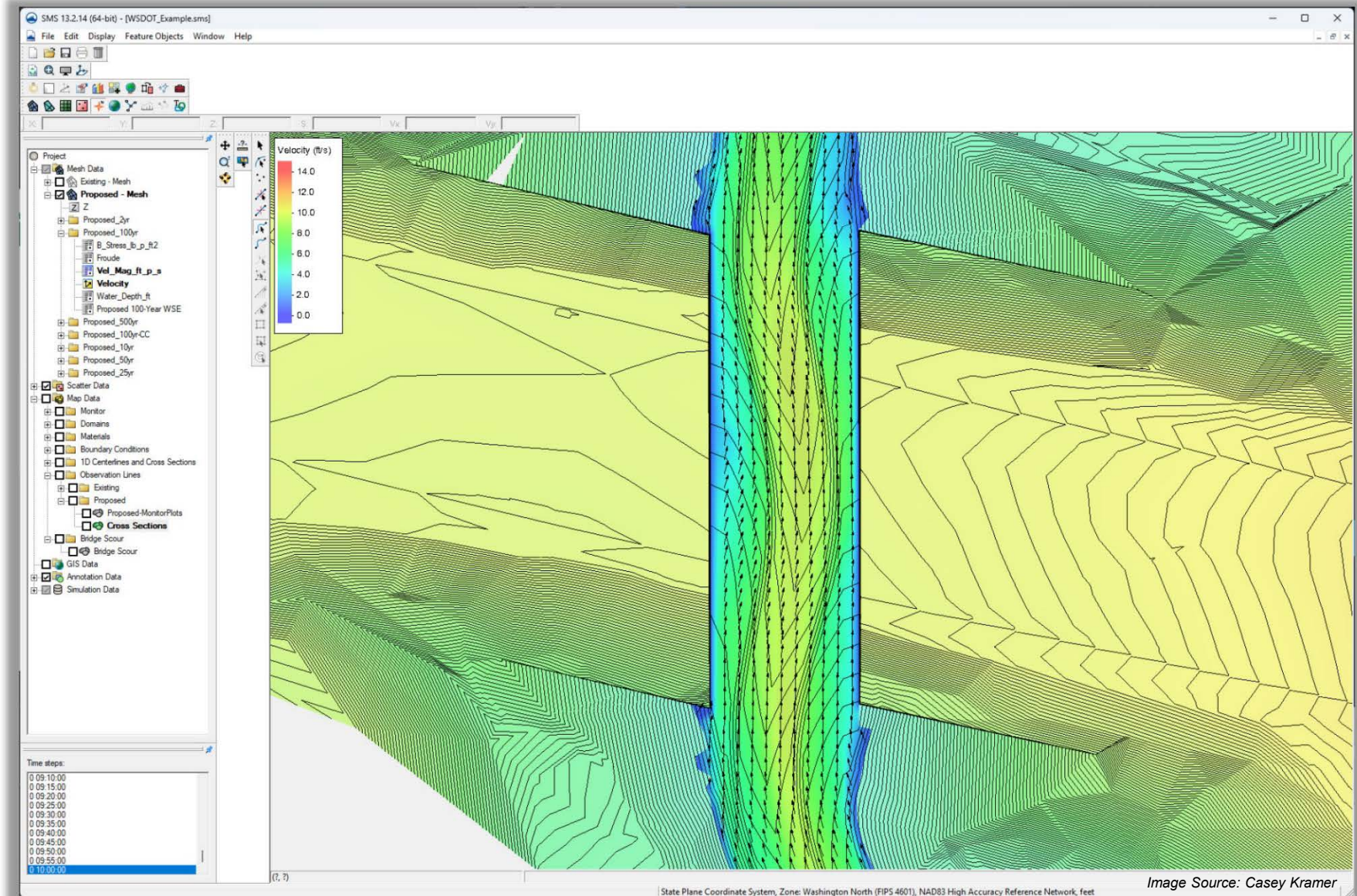
- Input:** Define Soil Gradation...
- Mesh:** Existing - Mesh
- Scenarios:** (Empty list)
- Bridge Deck:** Select... (none selected), Auto compute bridge starting station on export, Specify bridge starting station: 0, Compute...
- Upstream offset for pier hydraulics:** 0 ft (From contracted arc. Leave 0.0 for max pier length.)
- Model Specifications:** Contraction Scour Variable Extraction Approach: Bank Width Ratios, NCHRP Abutment Scour Condition: Scour Condition a (Main Channel) (Left and Right)
- Output:** Browse... .hyd, Export Hydraulic Toolbox File, Launch Hydraulic Toolbox
- Utilities:** Edit Default Options..., Delete Generated Arcs
- Buttons:** Help..., OK, Cancel

Time steps: 0 09:10:00, 0 09:15:00, 0 09:20:00, 0 09:25:00, 0 09:30:00, 0 09:35:00, 0 09:40:00, 0 09:45:00, 0 09:50:00, 0 09:55:00, 0 10:00:00

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

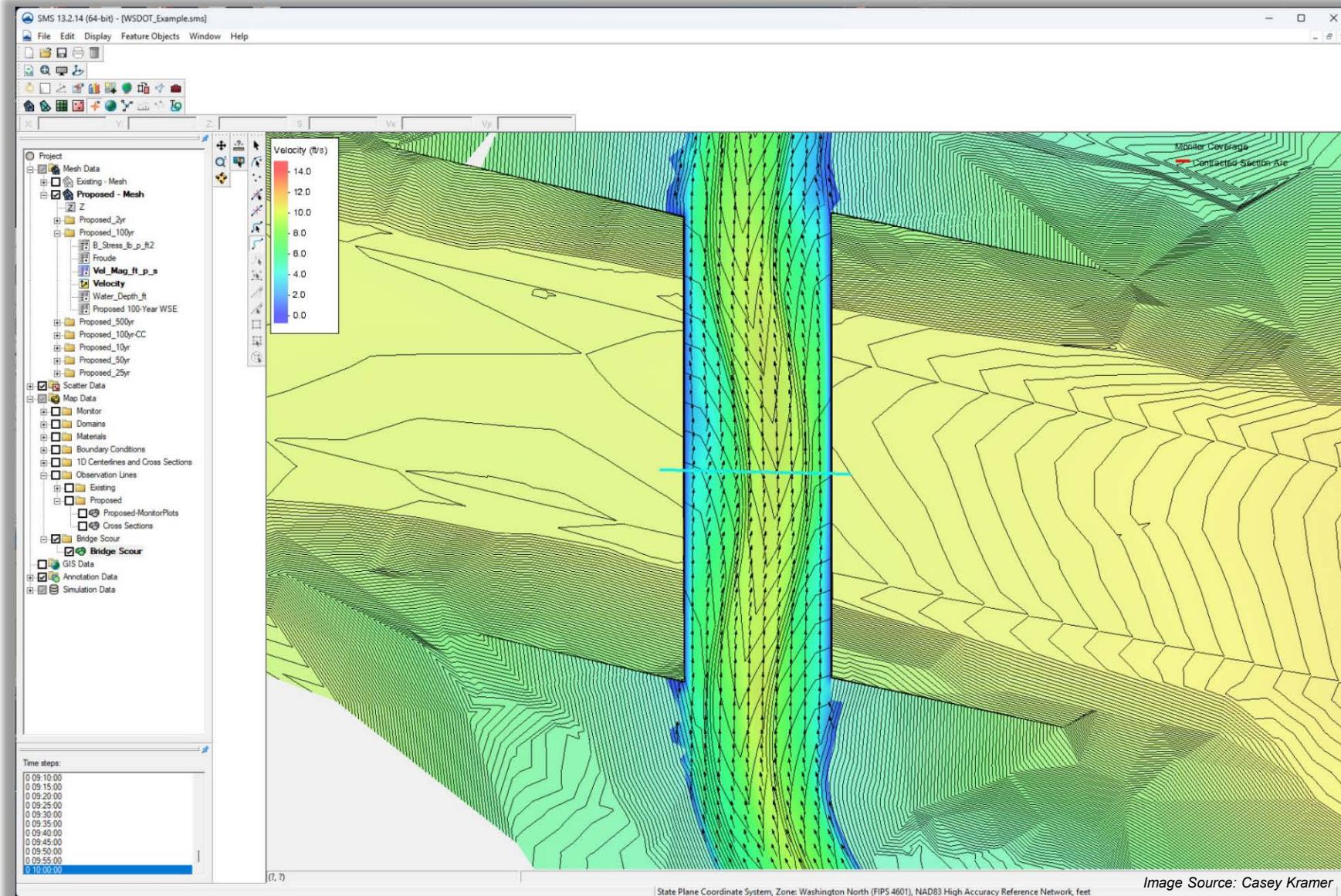
Contraction Scour



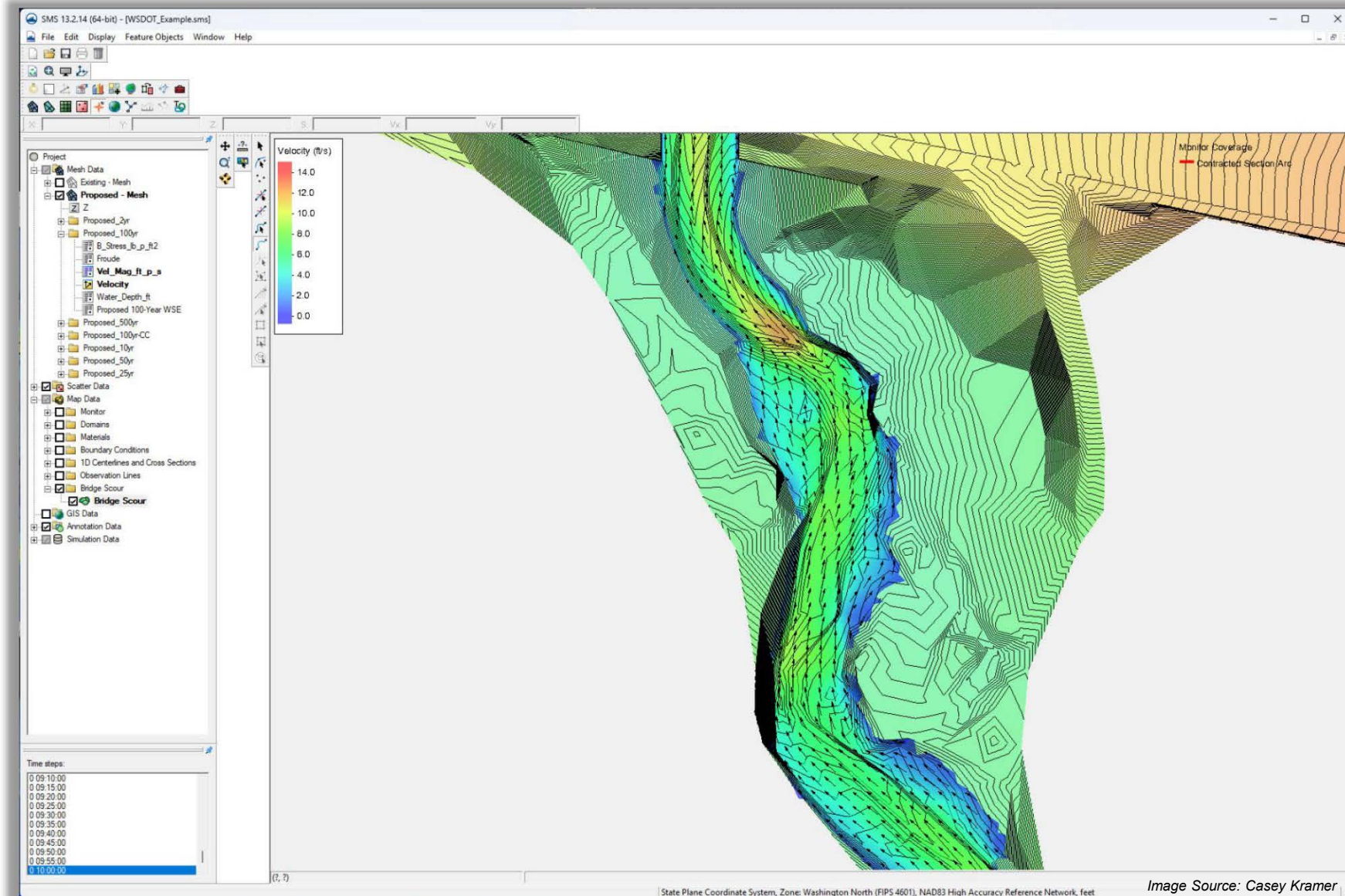
State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

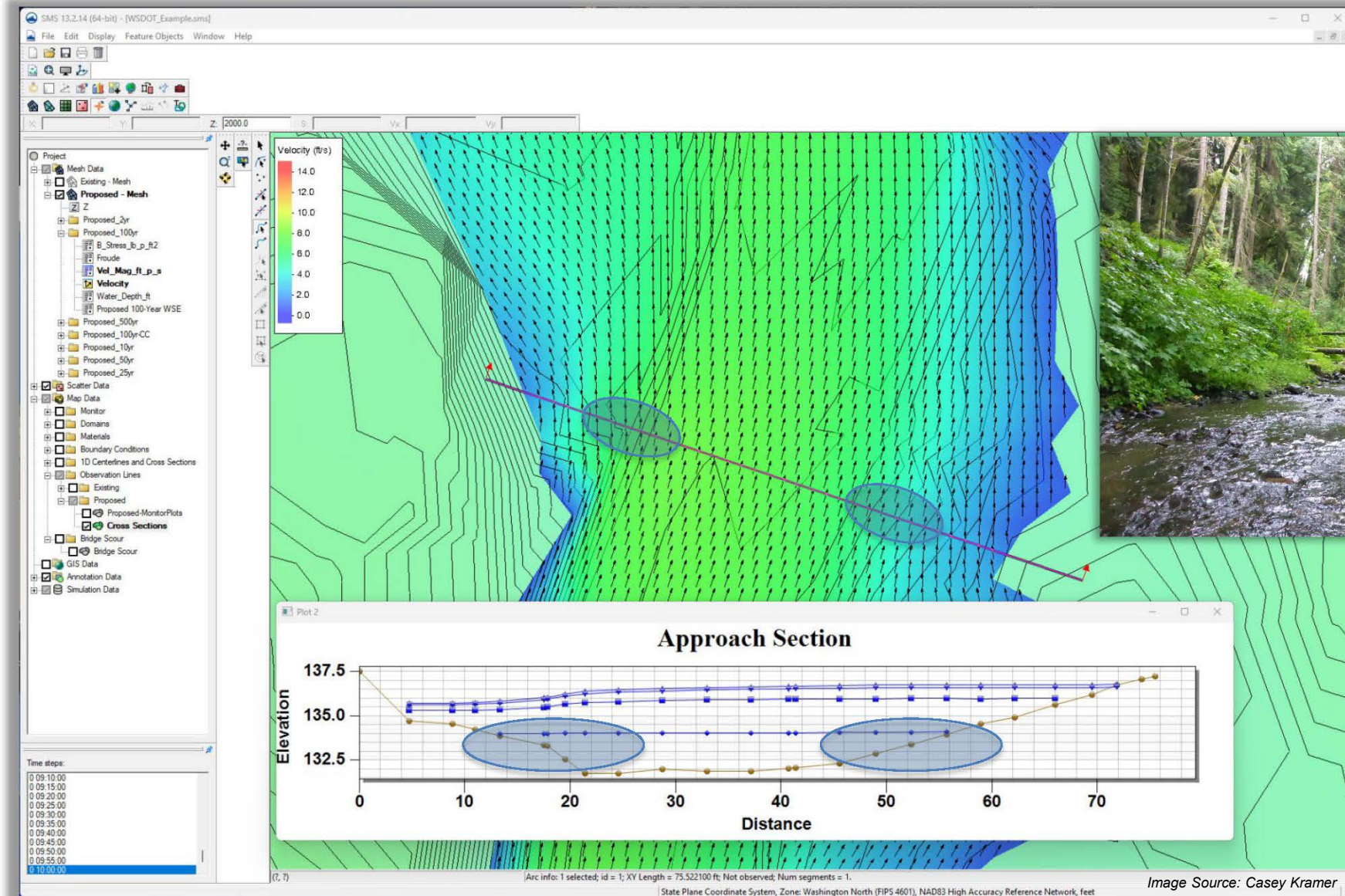
Contraction Scour



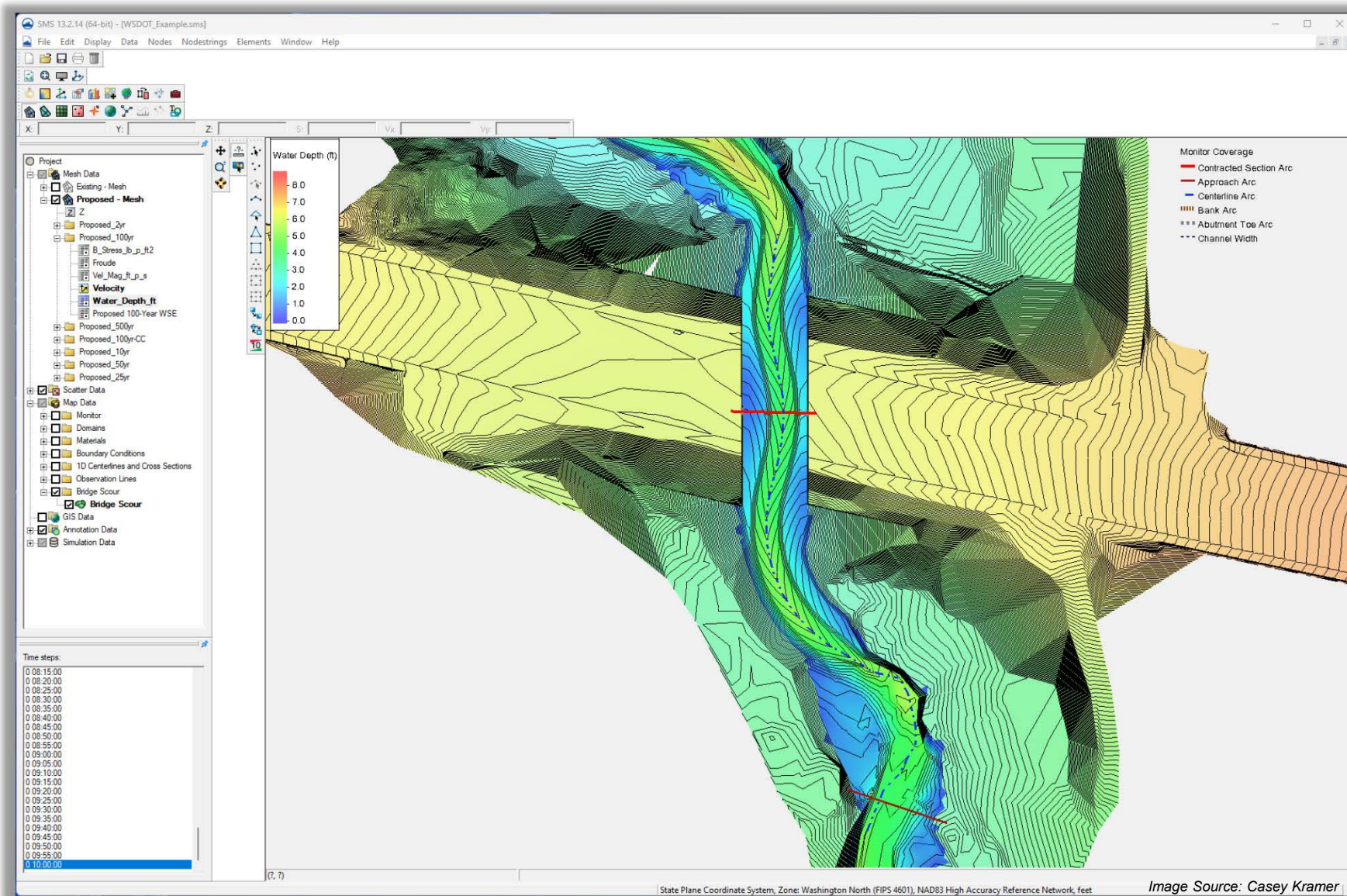
Contraction Scour



Contraction Scour



Contraction Scour



Contraction Scour

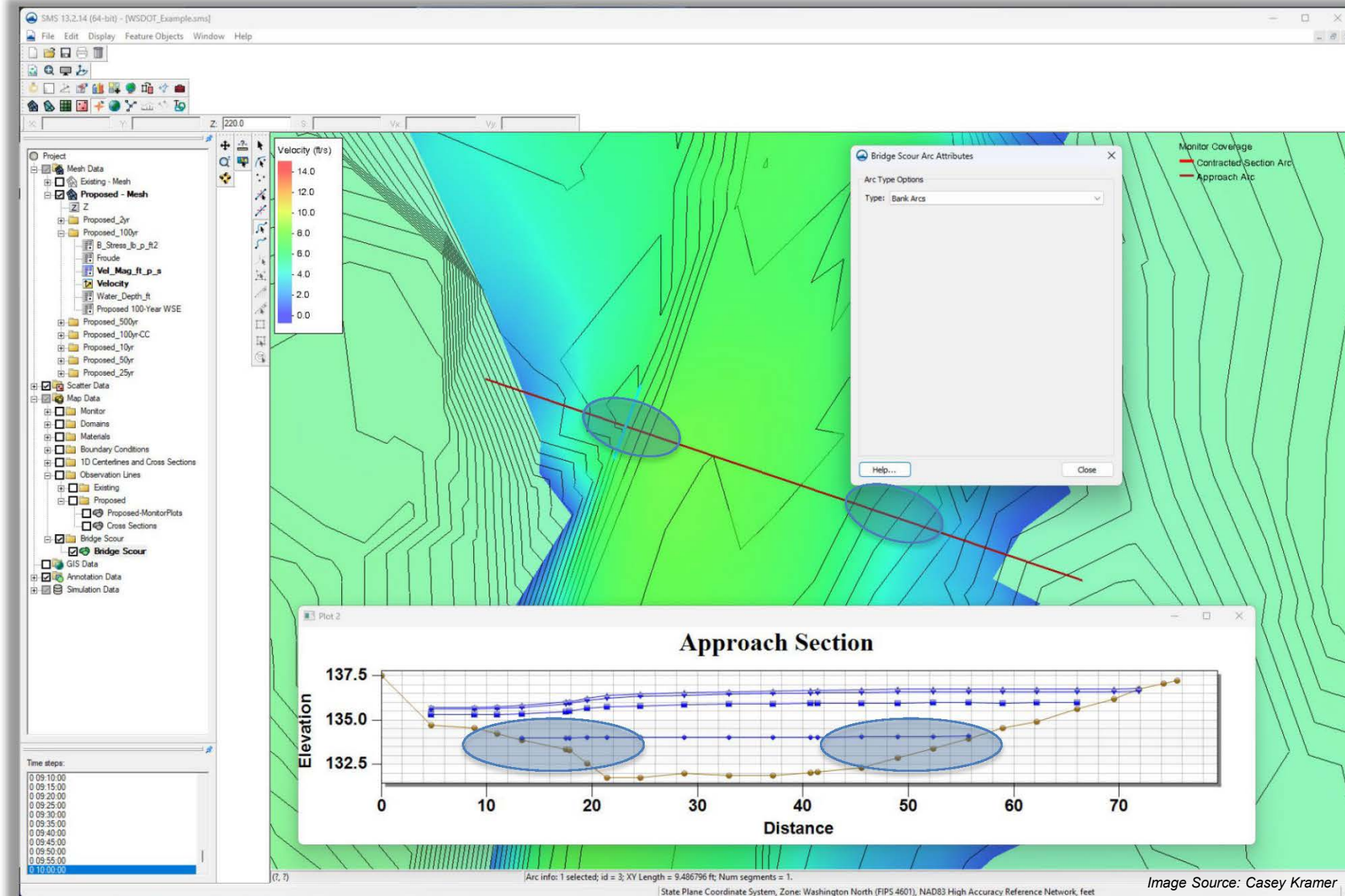
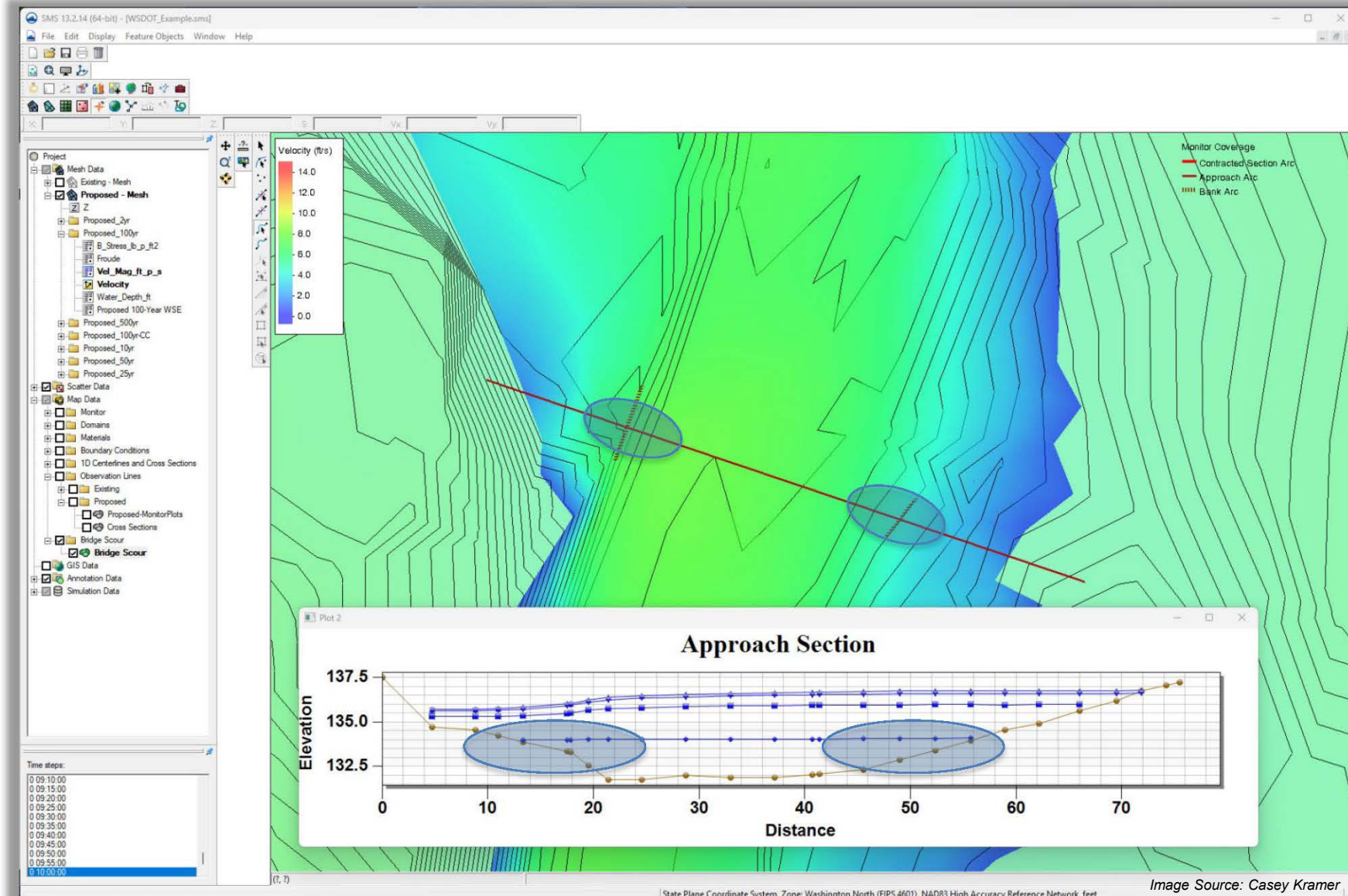


Image Source: Casey Kramer

Contraction Scour



State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

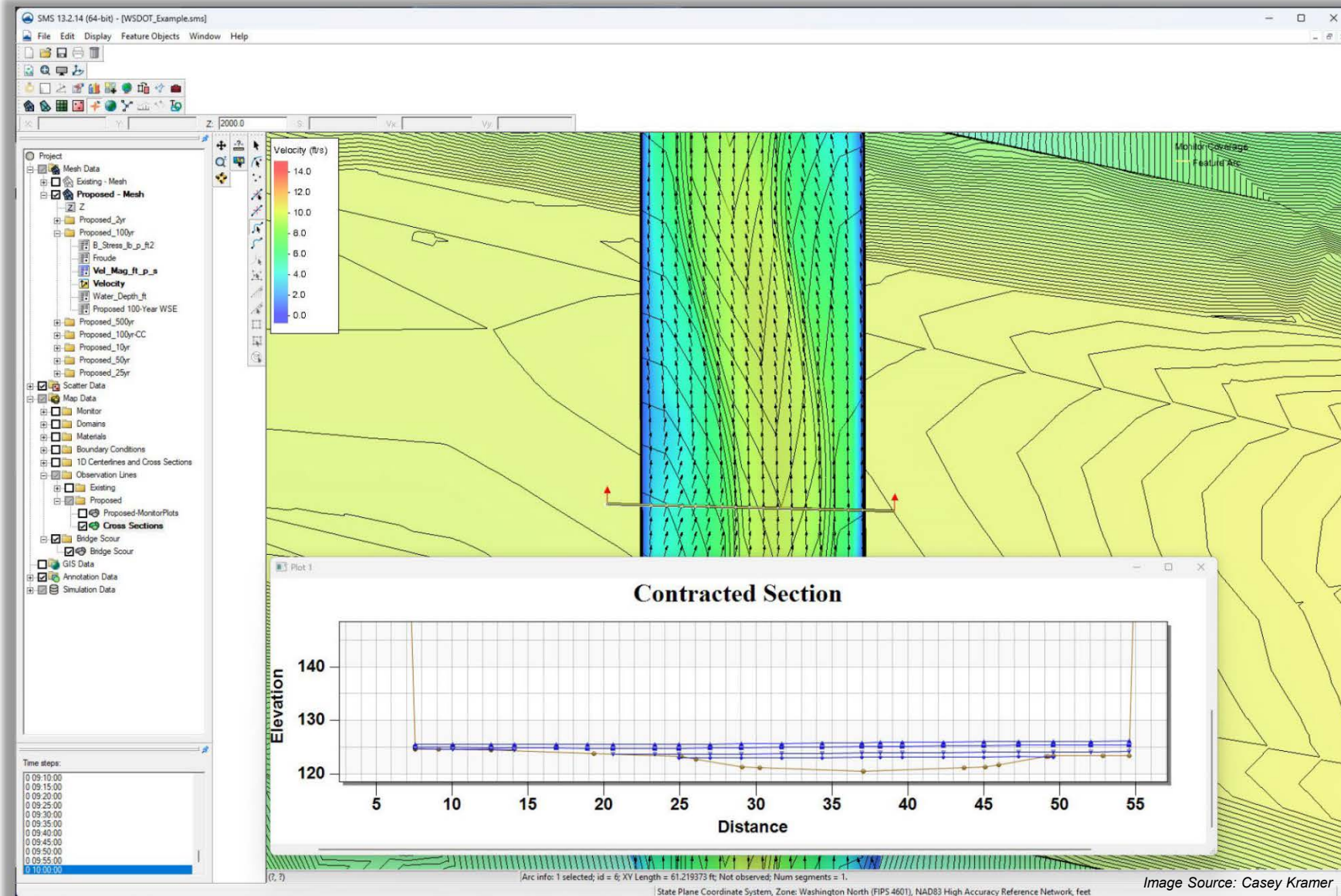


Image Source: Casey Kramer

Contraction Scour

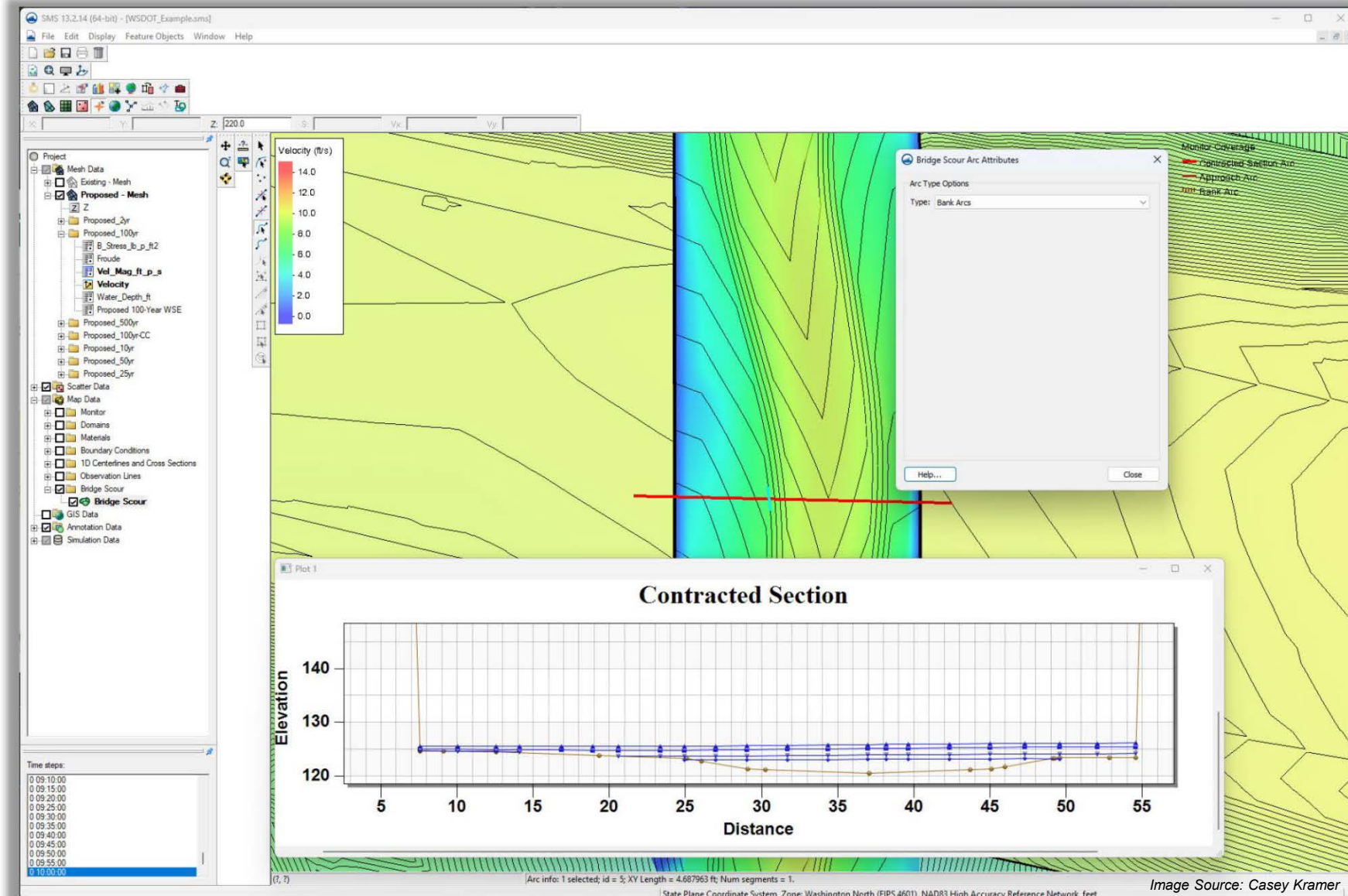
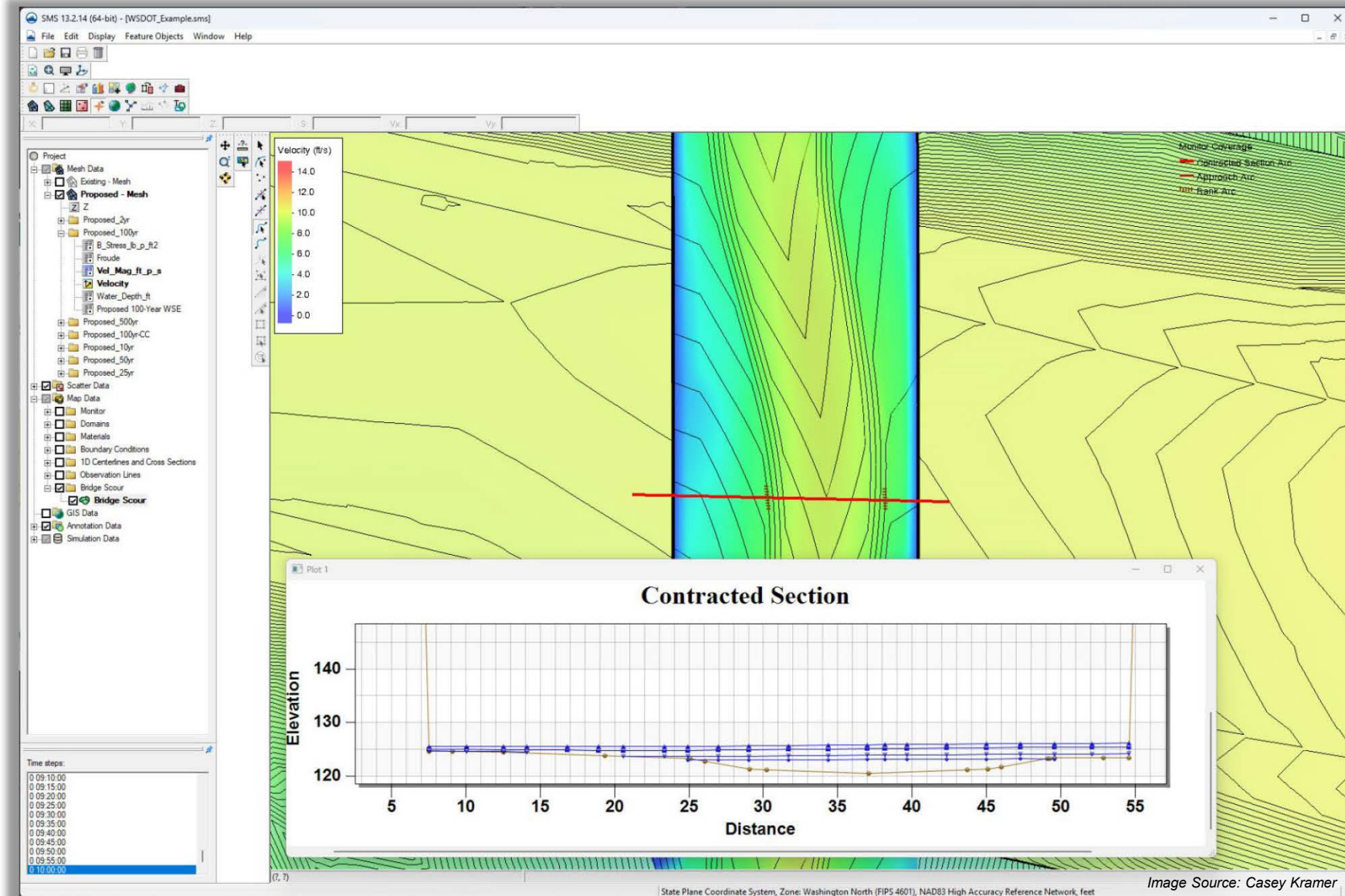


Image Source: Casey Kramer

Contraction Scour



State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

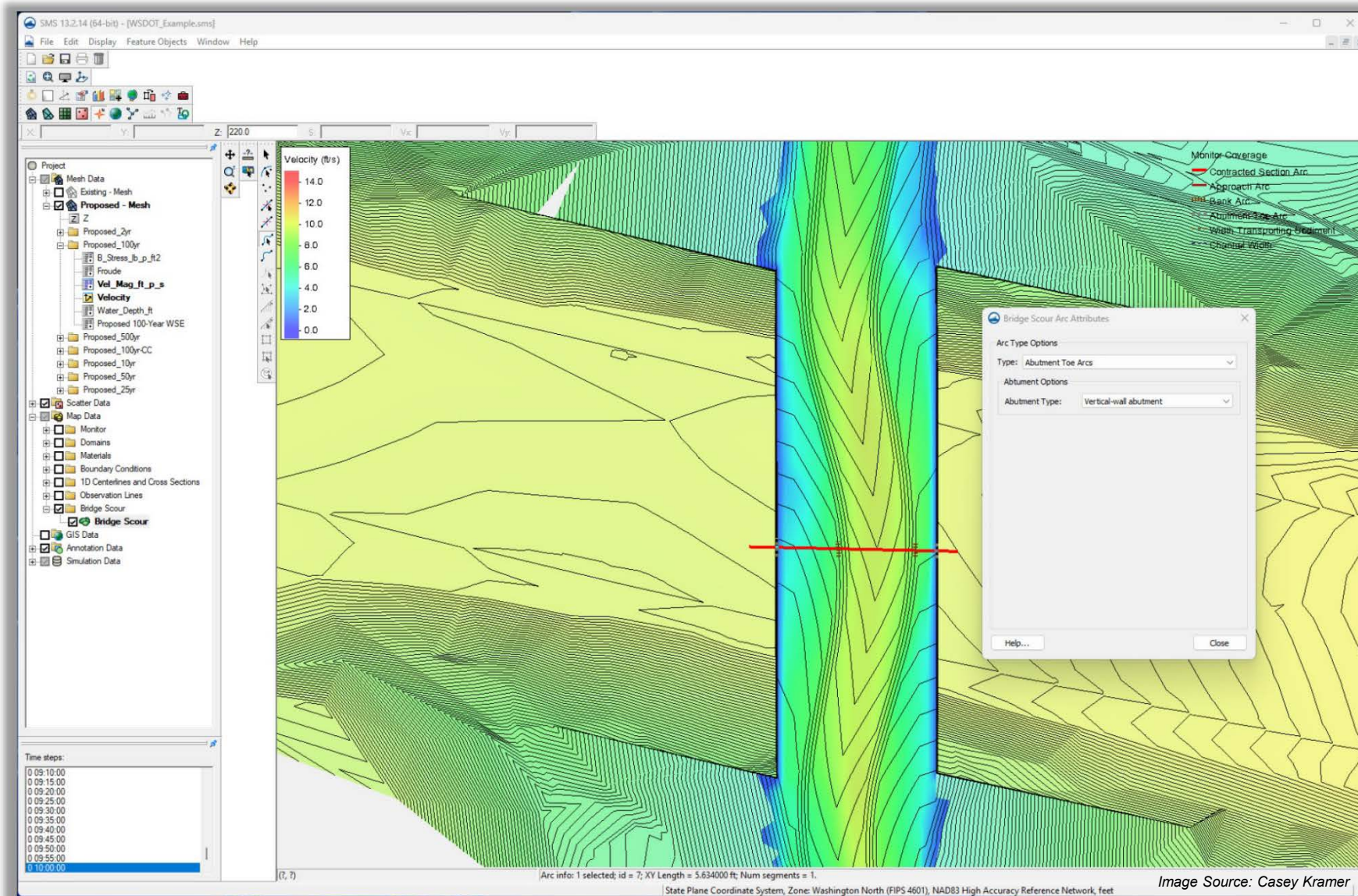


Image Source: Casey Kramer

Contraction Scour

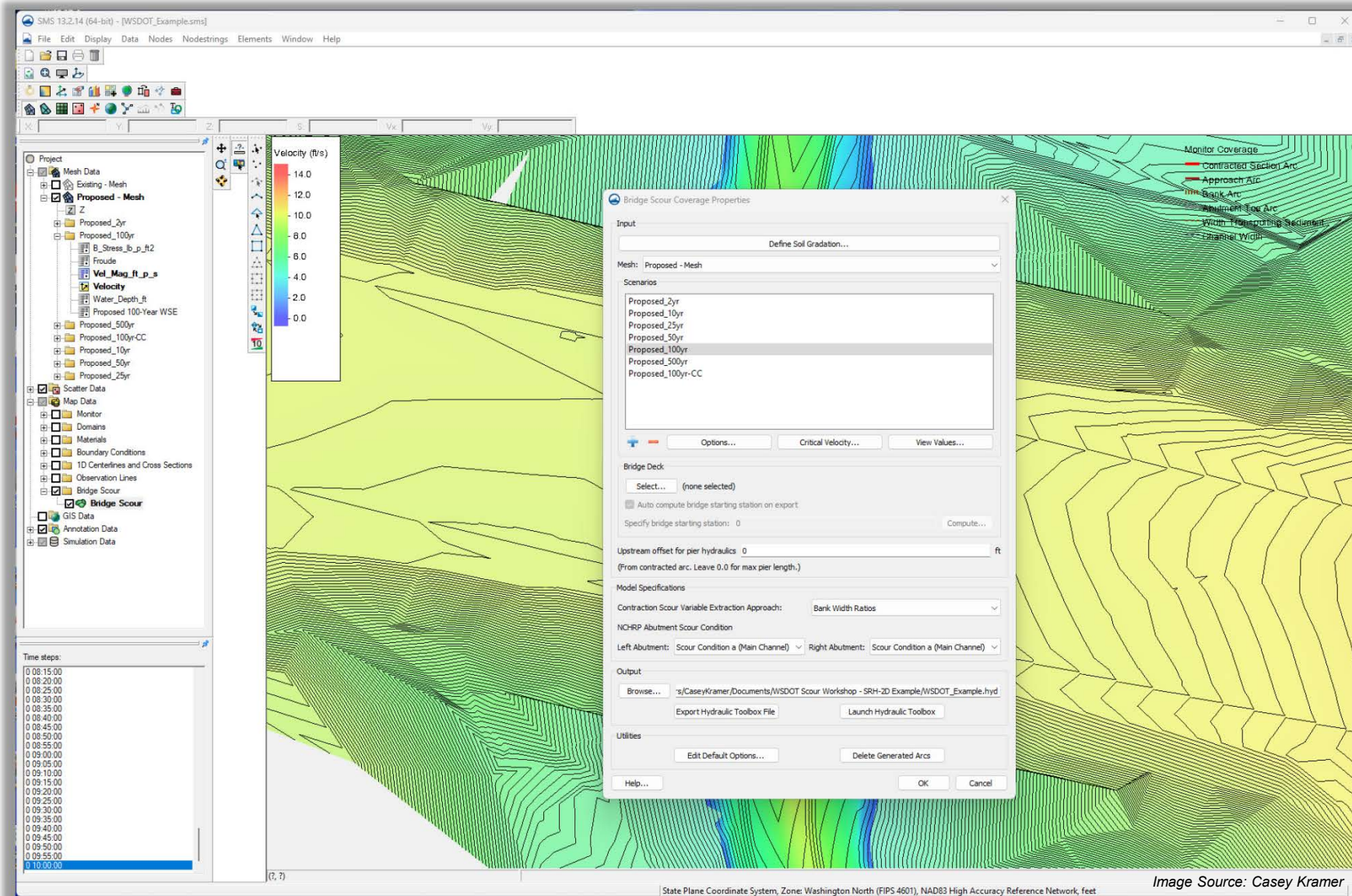


Image Source: Casey Kramer

Contraction Scour

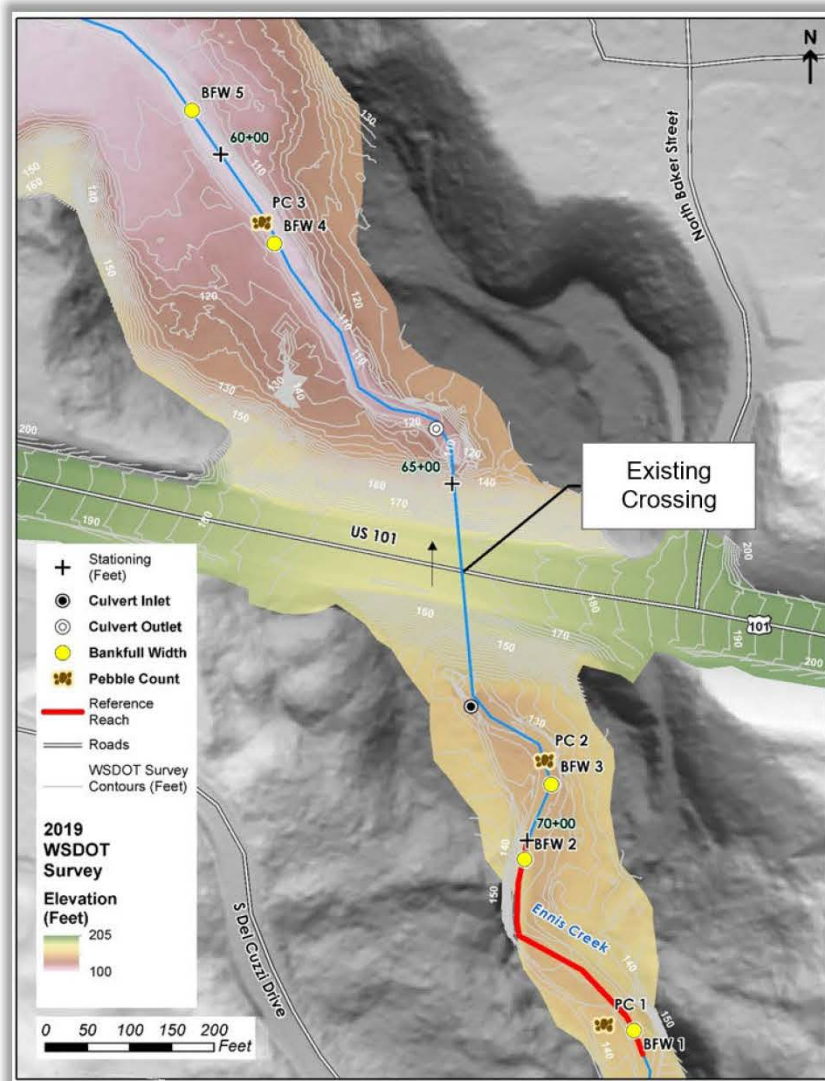


Image Source: WSDOT

Wolman Pebble Counts

Particle Percent Smaller Than	Pebble Count 1, Particle Diameter (Inches) ^a	Pebble Count 2, Particle Diameter (Inches) ^b	Pebble Count 3, Particle Diameter (Inches) ^c
D ₁₆	1.5	1.3	1.6
D ₅₀	3.0	3.1	4.3
D ₈₄	6.9	5.9	12.8
D ₁₀₀	19.7	17.7	39.4

a. Pebble Count 1 taken about 500 feet upstream of culvert in riffle of active channel.
 b. Pebble Count 2 taken about 110 feet upstream of culvert at cobble bar.
 c. Pebble Count 3 taken about 300 feet downstream of culvert in active channel where alluvial cover was present.

Contraction Scour

The screenshot displays the SMS 13.2.14 (64-bit) - [WSDOT_Example.sms] interface. The main window shows a hydraulic model with velocity contours ranging from 0.0 to 14.0 ft/s. Two dialog boxes are open over the model:

Bridge Scour Coverage Properties

- Input: Define Soil Gradation...
- Mesh: Proposed - Mesh
- Scenarios: (Empty list)
- Options... Critical Velocity... View Values...
- Bridge Deck: Select... (none selected)
- Auto compute bridge starting station on export
- Specify bridge starting station: 0
- Upstream offset for pier hydraulics: 0 ft
- Model Specifications: Contraction Scour Variable Extraction Approach: Bank Width Ratios
- NCHRP Abutment Scour Condition: Left Abutment: Scour Condition a (Main Channel), Right Abutment: Scour Condition a (Main Channel)
- Output: Browse... .hyd
- Export Hydraulic Toolbox File Launch Hydraulic Toolbox
- Utilities: Edit Default Options... Delete Generated Arcs
- Help...

Bridge Scour Soil Gradation

Number of Points: 4

	Sediment Particle Diameter (ft)	Percent Passing (0.0-1.0)
1	0.125	.16
2	0.25	.5
3	0.575	.84
4	1.64	1

Legend: Monitor Coverage, Contracted Section Arc, Approach Arc

Time steps: 0 09:10:00, 0 09:15:00, 0 09:20:00, 0 09:25:00, 0 09:30:00, 0 09:35:00, 0 09:40:00, 0 09:45:00, 0 09:50:00, 0 09:55:00, 0 10:00:00

[Arc info: 1 selected; id = 2; XY Length = 75.522125 ft; Num segments = 1.]

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

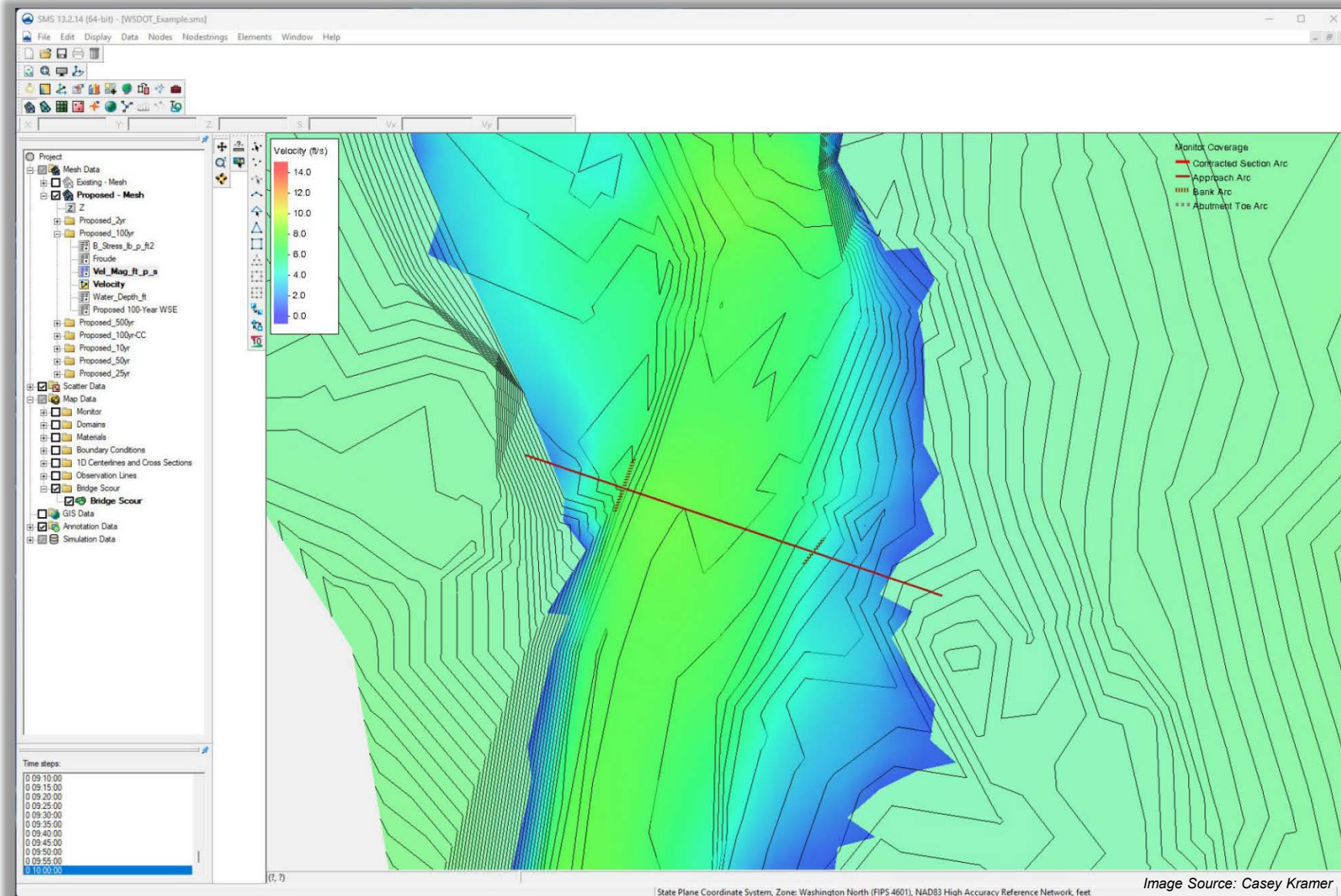
The screenshot displays the SMS 13.2.14 (64-bit) - [WSDOT_Example.sms] interface. The main window shows a hydraulic model with a velocity contour plot. A legend on the right indicates 'Monitor Coverage' with 'Contracted Section Arc' and 'Approach Arc'. A 'Velocity (ft/s)' legend on the left shows a color scale from 0.0 (blue) to 14.0 (red). The 'Bridge Scour Coverage Properties' dialog box is open, showing 'Proposed - Mesh' as the mesh and a list of scenarios including 'Proposed_2yr', 'Proposed_10yr', 'Proposed_25yr', 'Proposed_50yr', 'Proposed_100yr', and 'Proposed_100yr-CC'. The 'Edit Bridge Scour Scenario' dialog box is also open, showing 'Proposed_100yr' as the scenario name and various input parameters like 'Water Surface Elevations', 'Water Depth', 'Water Velocity', 'Shear Stress', and 'Time Step'. The 'Output' section of the 'Bridge Scour Coverage Properties' dialog shows a file name ending in '.hyd' and buttons for 'Export Hydraulic Toolbox File' and 'Launch Hydraulic Toolbox'. The 'Utilities' section includes 'Edit Default Options...' and 'Delete Generated Arcs'. The 'Time steps' panel at the bottom left shows a list of time intervals from 0:09:10:00 to 0:10:00:00. The status bar at the bottom indicates 'Arc info: 1 selected; id = 2; XY Length = 75.522125 ft; Num segments = 1.' and 'State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet'. The image source is cited as 'Image Source: Casey Kramer'.

Contraction Scour

The screenshot displays the SMS 13.2.14 (64-bit) - [WSDOT_Example.sms] interface. The main window shows a hydraulic model with velocity contours. A legend on the right indicates: Monitor Coverage, Contracted Section Arc (red line), Approach Arc (orange line), Bank Arc (yellow line), and Abutment Toe Arc (dotted line). A velocity scale on the left ranges from 0.0 to 14.0 ft/s. Two dialog boxes are open: 'Bridge Scour Coverage Properties' and 'Bridge Scour Scenario Critical Velocity'. The 'Bridge Scour Coverage Properties' dialog has a red circle around the 'Critical Velocity...' button. The 'Bridge Scour Scenario Critical Velocity' dialog shows 'D50 Gradation Computation Results' with 'Override Critical Velocity Computations' unchecked and 'Critical velocity for sediment in approach section: 8.74013 ft/s'. The 'Bridge Deck' section is set to 'none selected'. The 'Model Specifications' section shows 'Contraction Scour Variable Extraction Approach: Bank Width Ratios'. The 'Output' section shows 'Browse... .hyd'. The 'Utilities' section has 'Edit Default Options...' and 'Delete Generated Arcs' buttons. The 'Time steps' list at the bottom left shows a range from 0:09:10:00 to 0:10:00:00. The status bar at the bottom indicates 'State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet'.

Image Source: Casey Kramer

Contraction Scour



State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

The screenshot displays the SMS 13.2.14 (64-bit) - [WSDOT_Example.sms] interface. The main window shows a topographic map with a velocity overlay. A legend on the right indicates 'Monitor Coverage' with symbols for Contracted Section Arc, Approach Arc, Bank Arc, Abutment Toe Arc, and Channel Width. A 'Velocity (ft/s)' color scale ranges from 0.0 (blue) to 14.0 (red). Two dialog boxes are open: 'Bridge Scour Coverage Properties' and 'View Values'. The 'View Values' dialog displays hydraulic parameters for both approach and contracted sections.

Bridge Scour Coverage Properties

Input: Define Soil Gradation...

Mesh: Proposed - Mesh

Scenarios:

- Proposed_2yr
- Proposed_10yr
- Proposed_25yr
- Proposed_50yr
- Proposed_100yr
- Proposed_500yr
- Proposed_100yr-CC

Bridge Deck:

Select... (none selected)

Auto compute bridge starting station on export

Specify bridge starting station: 0 Compute...

Upstream offset for pier hydraulics: 0 ft (From contracted arc. Leave 0.0 for max pier length.)

Model Specifications:

Contraction Scour Variable Extraction Approach: Bank Width Ratios

NCHRP Abutment Scour Condition

Left Abutment: Scour Condition a (Main Channel) Right Abutment: Scour Condition a (Main Channel)

Output:

Browse... .hyd

Export Hydraulic Toolbox File Launch Hydraulic Toolbox

Utilities:

Edit Default Options... Delete Generated Arcs

Help... OK Cancel

View Values

APPROACH SECTION HYDRAULIC PARAMETERS:

Entire approach cross section:

Energy grade line slope at the approach section (ft/ft)	0.0348463
Total flow in the approach section (cfs)	1054.37
Total flow area of the approach section (ft ²)	163.367
Total wetted perimeter of the approach section (ft)	61.9831

Main channel (approach):

Approach section left bank station (ft)	17.709
Approach section right bank station (ft)	52.1215
Approach section main channel width (ft)	34.4125
Approach section main channel flow (cfs)	925.289
Approach section main channel flow area (ft ²)	127.097
Approach section main channel wetted perimeter (ft)	34.612
Approach section main channel hydraulic radius (ft)	3.67205
Approach section main channel hydraulic depth (ft) (used for average depth upstream of contraction)	3.69334
Approach section main channel maximum depth (ft)	4.04756
Approach section main channel unit discharge (cfs/ft)	26.8881
Approach section main channel average velocity (ft/s)	7.28017
Approach section critical velocity (ft/s)	8.74013

Left overbank (approach; Used for overbank contraction scour calculations):

Left overbank station (ft):	17.709
Left overbank average flow depth (ft):	1.21274
Left overbank average velocity (ft/s):	5.22495
Left overbank flow width (ft):	12.993
Left overbank flow (cfs):	82.3306
Left overbank unit discharge (cfs/ft):	6.33652

Right overbank (approach; Used for overbank contraction scour calculations):

Right overbank station (ft):	52.1215
Right overbank average flow depth (ft):	2.12396
Right overbank average velocity (ft/s):	2.92759
Right overbank flow width (ft):	13.8618
Right overbank flow (cfs):	86.1936
Right overbank unit discharge (cfs/ft):	6.21808

CONTRACTED SECTION HYDRAULIC PARAMETERS:

OK

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

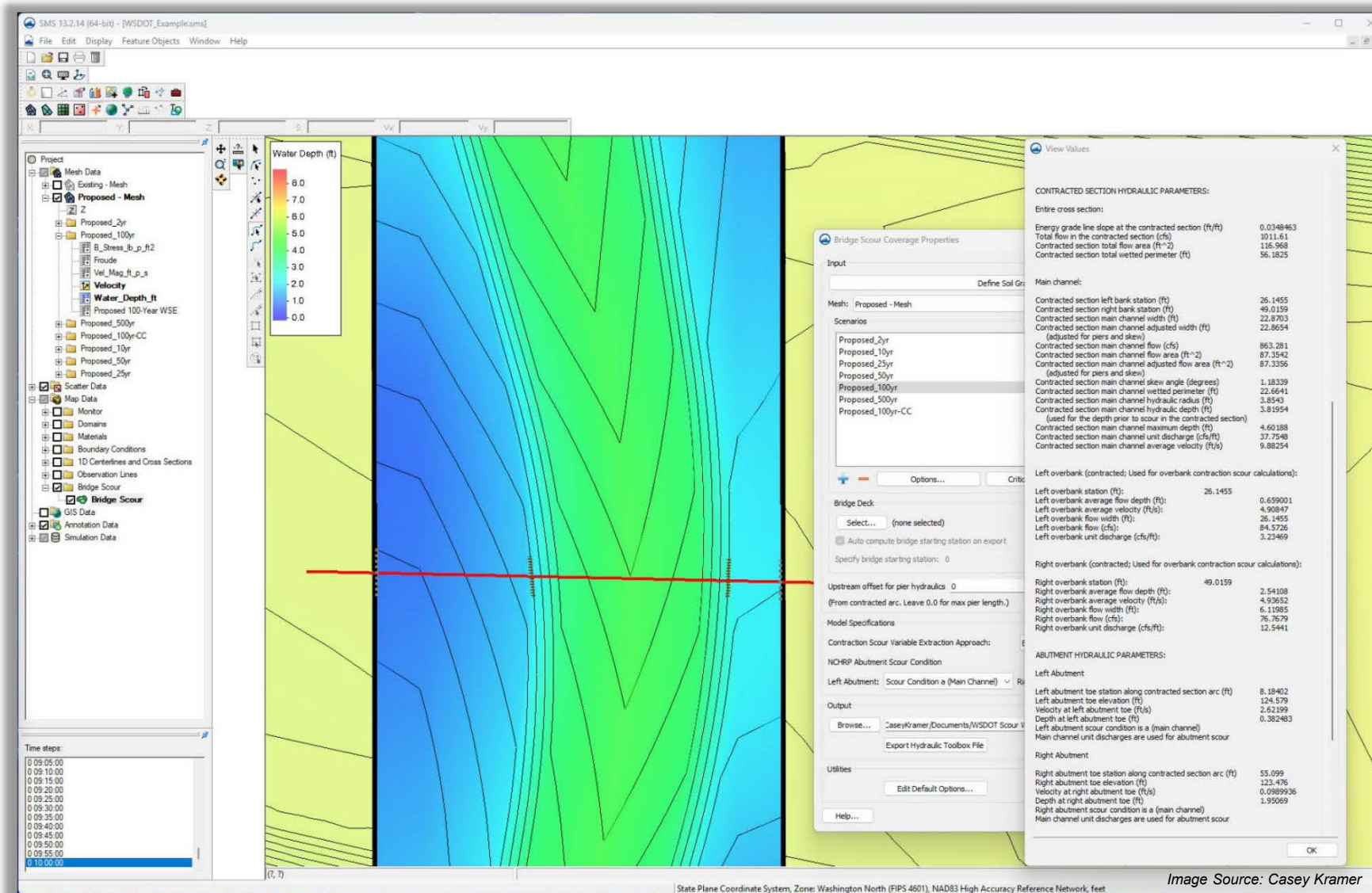


Image Source: Casey Kramer

Contraction Scour

The screenshot displays the SMS 13.2.14 (64-bit) - [WSDOT_Example.sms] interface. The main window shows a contour plot of water depth (ft) with a color scale from 0.0 (blue) to 8.0 (red). A red line indicates the bridge location. The left sidebar shows the Project tree with 'Bridge Scour' selected. The right sidebar shows the Bridge Scour Coverage Properties dialog box, which is open. The dialog box has several sections: Input (Define Soil Gradation...), Mesh (Proposed - Mesh), Scenarios (Proposed_2yr, Proposed_10yr, Proposed_25yr, Proposed_50yr, Proposed_100yr, Proposed_500yr, Proposed_100yr-CC), Bridge Deck (Select... (none selected), Auto compute bridge starting station on export, Specify bridge starting station: 0, Compute...), Model Specifications (Contraction Scour Variable Extraction Approach: Bank Width Ratios, NCHRP Abutment Scour Condition, Left Abutment: Scour Condition a (Main Channel), Right Abutment: Scour Condition a (Main Channel)), Output (Browse..., Export Hydraulic Toolbox File, Launch Hydraulic Toolbox), and Utilities (Edit Default Options..., Delete Generated Arcs). The 'Browse...' and 'Export Hydraulic Toolbox File' buttons are circled in red. The bottom status bar shows 'State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet'.

Water Depth (ft)

Project

- Mesh Data
 - Existing - Mesh
 - Proposed - Mesh
 - Proposed_2yr
 - Proposed_100yr
 - B_Stress_b_p_ft2
 - Froude
 - Vel_Mag_ft_p_s
 - Velocity
 - Water_Depth_ft
 - Proposed 100-Year WSE
 - Proposed_500yr
 - Proposed_100yr-CC
 - Proposed_10yr
 - Proposed_50yr
 - Proposed_25yr

- Scatter Data
- Map Data
- Monitor
- Domains
- Materials
- Boundary Conditions
- 1D Centerlines and Cross Sections
- Observation Lines
- Bridge Scour
 - Bridge Scour
 - Bridge Scour
- GIS Data
- Annotation Data
- Simulation Data

Time steps:

- 0 09:05:00
- 0 09:10:00
- 0 09:15:00
- 0 09:20:00
- 0 09:25:00
- 0 09:30:00
- 0 09:35:00
- 0 09:40:00
- 0 09:45:00
- 0 09:50:00
- 0 09:55:00
- 0 10:00:00

Bridge Scour Coverage Properties

Input

Define Soil Gradation...

Mesh: Proposed - Mesh

Scenarios

- Proposed_2yr
- Proposed_10yr
- Proposed_25yr
- Proposed_50yr
- Proposed_100yr
- Proposed_500yr
- Proposed_100yr-CC

Options... Critical Velocity... View Values...

Bridge Deck

Select... (none selected)

Auto compute bridge starting station on export

Specify bridge starting station: 0 Compute...

Upstream offset for pier hydraulics: 0 ft

(From contracted arc. Leave 0.0 for max pier length.)

Model Specifications

Contraction Scour Variable Extraction Approach: Bank Width Ratios

NCHRP Abutment Scour Condition

Left Abutment: Scour Condition a (Main Channel) Right Abutment: Scour Condition a (Main Channel)

Output

Browse... W:\Casey\Kramer\Documents\WSDOT Scour Workshop - SRH-2D Example\WSDOT_Example.hyd

Export Hydraulic Toolbox File Launch Hydraulic Toolbox

Utilities

Edit Default Options... Delete Generated Arcs

Help... OK Cancel

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

The screenshot shows the SMS 13.2.14 (64-bit) - [WSDOT_Example.msx] interface. The main window displays a map with a color-coded water depth overlay. A 'Hydraulic Toolbox' window is open, and a 'Bridge Scour Coverage Properties' dialog box is also visible, with the 'Launch Hydraulic Toolbox' button circled in red.

Water Depth (ft) Legend:

- 8.0
- 7.0
- 6.0
- 5.0
- 4.0
- 3.0
- 2.0
- 1.0
- 0.0

Bridge Scour Coverage Properties Dialog:

- Input: Define Soil Gradation...
- Mesh: Proposed - Mesh
- Scenarios: Proposed_2yr, Proposed_10yr, Proposed_25yr, Proposed_50yr, Proposed_100yr, Proposed_500yr, Proposed_100yr-CC
- Options... Critical Velocity... View Values...
- Bridge Deck: Select... (none selected)
- Auto compute bridge starting station on export
- Specify bridge starting stations: 0 Compute...
- Upstream offset for pier hydraulics: 0 ft (From contracted arc. Leave 0.0 for max pier length.)
- Model Specifications: Contraction Scour Variable Extraction Approach: Bank Width Ratios
- NCHRP Abutment Scour Condition: Left Abutment: Scour Condition a (Main Channel) Right Abutment: Scour Condition a (Main Channel)
- Output: Browse... s:\CaseyKramer\Documents\WSDOT Scour Workshop - SRH-2D Example\WSDOT_Example.hyd Export Hydraulic Toolbox File **Launch Hydraulic Toolbox**
- Utilities: Edit Default Options... Delete Generated Arcs
- Help... OK Cancel

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

Bridge Scour Analysis

Parameter Value Units Notes

Enable Scour Plot Options

To plot scour components add specified bridge geometry and cross section information

Import Geometry from HEC-RAS File

Multiple Scenarios

Scenario Proposed_100yr

Long Term Degradation

Create New Scenario

Delete Current Scenario

Contraction Scour

Define Contraction Scour Parameters

Left Bank Station

Define Left Overbank Contraction Scour Parameters

Right Bank Station

Define Right Overbank Contraction Scour Parameters

Bridge Cross-Section & Geometry

Cross-Section Name

Define Cross-Section Under Bridge

Define WSE prior to Bridge

Bridge Name

Define Bridge Deck Geometry

Approach Cross-Section

Approach Cross-Section Name

Define Approach Cross-Section

Local Scour at Piers

Local Scour at Abutments

Left Abutment

Bridge Scour Summary Table

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	3.69	ft	
D50	76.200000	mm	0.2 mm is the lower limit for ...
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	8.75	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge	17.709	cfs	
Bottom Width	1.25	ft	
Depth Prior to Scour	1.10	ft	
Temperature	1.50		
Slope of Energy Grade Line	1.10		
Discharge in Contracted Section	1.10	cfs	
Discharge Upstream of Contraction	1.10	cfs	
Width in Contracted Section	1.10	ft	
Width Upstream of Contraction	1.10	ft	
Depth Prior to Scour	1.10	ft	
Unit Weight of Sediment	1.10	pcf	
Unit Weight of Water	1.10	pcf	
Results of Scour			
Average Velocity Upstream	7.28	ft/s	
Diameter of Particle	0.075	ft	
Average Depth of Scour	0.70	ft	Negative values imply 'zero' ...
Scour Depth	0.70	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	2.3732	lb/ft ²	
Shear Required for Movement of D50 Particle	1.0003	lb/ft ²	
Recommendations			
Recommended Scour Depth	0.07	ft	Negative values imply 'zero' ...

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Image Source: Casey Kramer

Contraction Scour

Bridge Scour Analysis

Parameter | Value | Units | Notes

Check boxes for scour components to be computed

Enable Scour Plot Options

To plot scour components add specified bridge geometry and cross section information

Import Geometry from HEC-RAS File

Multiple Scenarios

Scenario: Proposed_100yr

Scenario Name:

Create New Scenario

Delete Current Scenario

Long Term Degradation

Contraction Scour

Define Contraction Scour Parameters

Left Bank Station:

Define Left Overbank Contraction Scour Parameters

Right Bank Station:

Define Right Overbank Contraction Scour Parameters

Bridge Cross-Section & Geometry

Cross-Section Name:

Define Cross-Section under Bridge

Define WSE prior to Bridge

Bridge Name:

Define Bridge Deck Geometry

Approach Cross-Section:

Approach Cross-Section Name:

Define Approach Cross-Section

Local Scour at Piers

Local Scour at Abutments

Left Abutment:

Bridge Scour Summary Table

Contraction Scour

Computation Method: Clear-Water and Live-Bed Scour

Parameter | Value | Units | Notes

Input Parameters

Average Depth Upstream of Contraction: 3.69 ft

D50: 76.200000 mm (0.2 mm is the lower limit for ...)

Average Velocity Upstream: 7.28 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and s...: 8.75 ft/s

Contraction Scour Condition: Clear Water

Clear Water Input Parameters

Discharge in Contracted Section: 863.28 cfs

Bottom Width in Contracted Section: 22.87 ft (Width should exclude pier wi...)

Depth Prior to Scour in Contracted Section: 3.82 ft

Live Bed & Clear Water Input Parameters

Temperature of Water: 60.00 °F

Slope of Energy Grade Line at Approach Section: 0.034846 ft/ft

Discharge in Contracted Section: 863.28 cfs

Discharge Upstream that is Transporting Sediment: 924.25 cfs

Width in Contracted Section: 22.87 ft (Remove widths occupied by ...)

Width Upstream that is Transporting Sediment: 54.41 ft

Depth Prior to Scour in Contracted Section: 3.82 ft

Unit Weight of Water: 62.40 lb/ft³

Unit Weight of Sediment: 165.00 lb/ft³

Results of Clear Water Method

Diameter of the smallest nontransportable particle in the b...: 95.250000 mm

Average Depth in Contracted Section after Scour: 3.89 ft

Scour Depth: 0.07 ft (Negative values imply 'zero' ...)

Results of Live Bed Method

k1: 0.640000

Shear Velocity: 2.04 ft/s

Fall Velocity: 1.64 ft/s

Average Depth in Contracted Section after Scour: 4.52 ft

Scour Depth: 0.70 ft (Negative values imply 'zero' ...)

Shear Applied to Bed by Live-Bed Scour: 2.3732 lb/ft²

Shear Required for Movement of D50 Particle: 1.0003 lb/ft²

Recommendations

Recommended Scour Depth: 0.07 ft (Negative values imply 'zero' ...)

View Values

Main channel (approach):

Approach section left bank station (ft): 17.709

Approach section right bank station (ft): 52.1215

Approach section main channel width (ft): 34.4125

Approach section main channel flow (cfs): 925.289

Approach section main channel flow area (ft²): 127.097

Approach section main channel wetted perimeter (ft): 34.612

Approach section main channel hydraulic radius (ft): 3.67205

Approach section main channel hydraulic depth (ft) (used for average depth upstream of contraction): 3.69334

Approach section main channel maximum depth (ft): 4.04756

Approach section main channel unit discharge (cfs/ft): 26.8881

Approach section main channel average velocity (ft/s): 7.28017

Approach section critical velocity (ft/s): 8.74013

Left overbank (approach; Used for overbank contraction scour calculations):

Left overbank station (ft): 17.709

Left overbank average flow depth (ft): 1.21274

Left overbank average velocity (ft/s): 5.22495

Left overbank flow width (ft): 12.993

Left overbank flow (cfs): 82.3306

Left overbank unit discharge (cfs/ft): 6.33652

Right overbank (approach; Used for overbank contraction scour calculations):

Right overbank station (ft): 52.1215

Right overbank average flow depth (ft): 2.12296

Right overbank average velocity (ft/s): 2.92759

Right overbank flow width (ft): 13.8618

Right overbank flow (cfs): 86.1536

Right overbank unit discharge (cfs/ft): 6.21808

CONTRACTED SECTION HYDRAULIC PARAMETERS:

Entire cross-section:

Energy grade line slope at the contracted section (ft/ft): 0.0348463

Total flow in the contracted section (cfs): 1011.61

Contracted section total flow area (ft²): 116.968

Contracted section total wetted perimeter (ft): 56.1825

Main channel:

Contracted section left bank station (ft): 26.1455

Contracted section right bank station (ft): 49.0159

Contracted section main channel width (ft): 22.8703

Contracted section main channel adjusted width (ft) (adjusted for piers and skew): 22.8654

Contracted section main channel flow (cfs): 863.281

Contracted section main channel flow area (ft²): 87.3542

Contracted section main channel adjusted flow area (ft²) (adjusted for piers and skew): 87.3356

Contracted section main channel skew angle (degrees): 1.18339

Contracted section main channel wetted perimeter (ft): 22.6641

Contracted section main channel hydraulic radius (ft): 3.8543

Contracted section main channel hydraulic depth (ft) (used for the depth prior to scour in the contracted section): 3.81954

Contracted section main channel maximum depth (ft): 4.60188

Contracted section main channel unit discharge (cfs/ft): 37.7548

Contracted section main channel average velocity (ft/s): 9.88254

Image Source: Casey Kramer

State Plane Coordinate System, Zone: Washington North (FIPS 4601), NAD83 High Accuracy Reference Network, feet

Contraction Scour

Contraction Scour
Computation Method: Clear-Water and Live-Bed Scour

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	3.69	ft	
D50	76.200000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	7.28	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	8.75	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	863.28	cfs	
Bottom Width in Contracted Section	22.87	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	3.82	ft	
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	F	
Slope of Energy Grade Line at Approach Section	0.034846	ft/ft	
Discharge in Contracted Section	863.28	cfs	
Discharge Upstream that is Transporting Sediment	925.29	cfs	
Width in Contracted Section	22.87	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	34.41	ft	
Depth Prior to Scour in Contracted Section	3.82	ft	
Unit Weight of Water	62.40	lb/ft ³	
Unit Weight of Sediment	165.00	lb/ft ³	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	95.250000	mm	
Average Depth in Contracted Section after Scour	3.89	ft	
Scour Depth	0.07	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.640000		
Shear Velocity	2.04	ft/s	
Fall Velocity	1.64	ft/s	
Average Depth in Contracted Section after Scour	4.52	ft	
Scour Depth	0.70	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	2.3732	lb/ft ²	
Shear Required for Movement of D50 Particle	1.0003	lb/ft ²	
Recommendations			
Recommended Scour Depth	0.07	ft	Negative values imply 'zero' ...

View Values	
Main channel (approach):	
Approach section left bank station (ft)	17.709
Approach section right bank station (ft)	52.1215
Approach section main channel width (ft)	34.4125
Approach section main channel flow (cfs)	925.289
Approach section main channel flow area (ft ²)	127.097
Approach section main channel wetted perimeter (ft)	34.612
Approach section main channel hydraulic radius (ft)	3.67205
Approach section main channel hydraulic depth (ft)	3.69334
(used for average depth upstream of contraction)	
Approach section main channel maximum depth (ft)	4.04756
Approach section main channel unit discharge (cfs/ft)	26.8881
Approach section main channel average velocity (ft/s)	7.28017
Approach section critical velocity (ft/s)	8.74013
Left overbank (approach; Used for overbank contraction scour calculations):	
Left overbank station (ft):	17.709
Left overbank average flow depth (ft):	1.21274
Left overbank average velocity (ft/s):	5.22495
Left overbank flow width (ft):	12.993
Left overbank flow (cfs):	82.3306
Left overbank unit discharge (cfs/ft):	6.33652
Right overbank (approach; Used for overbank contraction scour calculations):	
Right overbank station (ft):	52.1215
Right overbank average flow depth (ft):	2.12396
Right overbank average velocity (ft/s):	2.92759
Right overbank flow width (ft):	13.8618
Right overbank flow (cfs):	86.1936
Right overbank unit discharge (cfs/ft):	6.21808
CONTRACTED SECTION HYDRAULIC PARAMETERS:	
Entire cross section:	
Energy grade line slope at the contracted section (ft/ft)	0.0348463
Total flow in the contracted section (cfs)	1011.61
Contracted section total flow area (ft ²)	116.968
Contracted section total wetted perimeter (ft)	56.1825
Main channel:	
Contracted section left bank station (ft)	26.1455
Contracted section right bank station (ft)	49.0159
Contracted section main channel width (ft)	22.8703
Contracted section main channel adjusted width (ft)	22.8634
(adjusted for piers and skew)	
Contracted section main channel flow (cfs)	863.281
Contracted section main channel flow area (ft ²)	87.3542
Contracted section main channel adjusted flow area (ft ²)	87.3356
(adjusted for piers and skew)	
Contracted section main channel skew angle (degrees)	1.18339
Contracted section main channel wetted perimeter (ft)	22.6641
Contracted section main channel hydraulic radius (ft)	3.8543
Contracted section main channel hydraulic depth (ft)	3.81954
(used for the depth prior to scour in the contracted section)	
Contracted section main channel maximum depth (ft)	4.60188
Contracted section main channel unit discharge (cfs/ft)	37.7548
Contracted section main channel average velocity (ft/s)	9.88254

Image Source: Casey Kramer

Contraction Scour

Approach Section Pebble Count D₅₀

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	3.69	ft	
D50	76.200000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	7.28	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	8.75	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	863.28	cfs	
Bottom Width in Contracted Section	22.87	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	3.82	ft	
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.034846	ft/ft	
Discharge in Contracted Section	863.28	cfs	
Discharge Upstream that is Transporting Sediment	925.29	cfs	
Width in Contracted Section	22.87	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	34.41	ft	
Depth Prior to Scour in Contracted Section	3.82	ft	
Unit Weight of Water	62.40	lb/ft ³	
Unit Weight of Sediment	165.00	lb/ft ³	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	95.250000	mm	
Average Depth in Contracted Section after Scour	3.89	ft	
Scour Depth	0.07	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.640000		
Shear Velocity	2.04	ft/s	
Fall Velocity	1.64	ft/s	
Average Depth in Contracted Section after Scour	4.52	ft	
Scour Depth	0.70	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	2.3732	lb/ft ²	
Shear Required for Movement of D50 Particle	1.0003	lb/ft ²	
Recommendations			
Recommended Scour Depth	0.07	ft	Negative values imply 'zero' ...

Design Mix D₅₀

Parameter	Value	Units	Notes
Input Parameters			
Average Depth Upstream of Contraction	3.69	ft	
D50	88.900000	mm	0.2 mm is the lower limit for ...
Average Velocity Upstream	7.28	ft/s	
Results of Scour Condition			
Critical velocity above which bed material of size D and s...	9.21	ft/s	
Contraction Scour Condition	Clear Water		
Clear Water Input Parameters			
Discharge in Contracted Section	863.28	cfs	
Bottom Width in Contracted Section	22.87	ft	Width should exclude pier wi...
Depth Prior to Scour in Contracted Section	3.82	ft	
Live Bed & Clear Water Input Parameters			
Temperature of Water	60.00	°F	
Slope of Energy Grade Line at Approach Section	0.034846	ft/ft	
Discharge in Contracted Section	863.28	cfs	
Discharge Upstream that is Transporting Sediment	925.29	cfs	
Width in Contracted Section	22.87	ft	Remove widths occupied by ...
Width Upstream that is Transporting Sediment	34.41	ft	
Depth Prior to Scour in Contracted Section	3.82	ft	
Unit Weight of Water	62.40	lb/ft ³	
Unit Weight of Sediment	165.00	lb/ft ³	
Results of Clear Water Method			
Diameter of the smallest nontransportable particle in the b...	111.125000	mm	
Average Depth in Contracted Section after Scour	3.72	ft	
Scour Depth	-0.09	ft	Negative values imply 'zero' ...
Results of Live Bed Method			
k1	0.640000		
Shear Velocity	2.04	ft/s	
Fall Velocity	1.64	ft/s	
Average Depth in Contracted Section after Scour	4.52	ft	
Scour Depth	0.70	ft	Negative values imply 'zero' ...
Shear Applied to Bed by Live-Bed Scour	2.4983	lb/ft ²	
Shear Required for Movement of D50 Particle	1.1671	lb/ft ²	
Recommendations			
Recommended Scour Depth	-0.09	ft	Negative values imply 'zero' ...

Particle Percent Smaller Than	Bathurst Calculated 100-Year Particle Diameter (Inches)	Proposed Streambed Gradation (Inches)
D ₁₆	1.1	0.5
D ₅₀	3.6	3.5
D ₈₄	9.1	11.8
D ₁₀₀	22.7	18.0

Contraction Scour

To Demonstrate Requirement of All Flows Up To Scour Design Flood and Scour Check Flood **ONLY**

Parameter	Proposed_2yr	Proposed_10yr	Proposed_25yr	Proposed_50yr	Proposed_100yr	Proposed_500yr	Proposed_100yr-CC	Units	Notes
Scenario	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Contraction Scour									
Selected Contraction Computation Method	Clear-Water...	Clear-Water ...	Clear-Water ...	Clear-Water ...	Clear-Water a...	Clear-Water an...	Clear-Water and Li...		Clear-Water and Live-Bed Scour
Applied Contraction Scour Depth	0.00	0.00	0.00	0.00	0.00	0.16	0.10	ft	
Clear Water Contraction Scour Depth	-0.37	-0.30	-0.24	-0.17	-0.09	0.16	0.10	ft	Item bolded is the governing contraction scour for scenario
Live Bed Contraction Scour Depth	0.61	0.77	0.73	0.71	0.70	0.71	0.71	ft	Item bolded is the governing contraction scour for scenario

Depths of Scour are Determined at PHD as Structure Type, Size and Location has not Been Determined

Total Scour Elevation at Each Infrastructure Component is Determined by Interdisciplinary Team as Design Progresses