

Oct 20, 2025 10:23:19am - User: gossymierbachin
N:\PROJECTS\1827 RED PLAINS PROFESSIONAL, INC\24-000194 SHOALWATER BAY TRIBE RELOCATION MASTER PLAN\PHASE 03 - RETAINING WALL STRUCTURAL DESIGN\STRUCTURAL WALL SECTIONS\NORTH COVE\DWG\1010225 NORTH COVE RETAINING WALLING

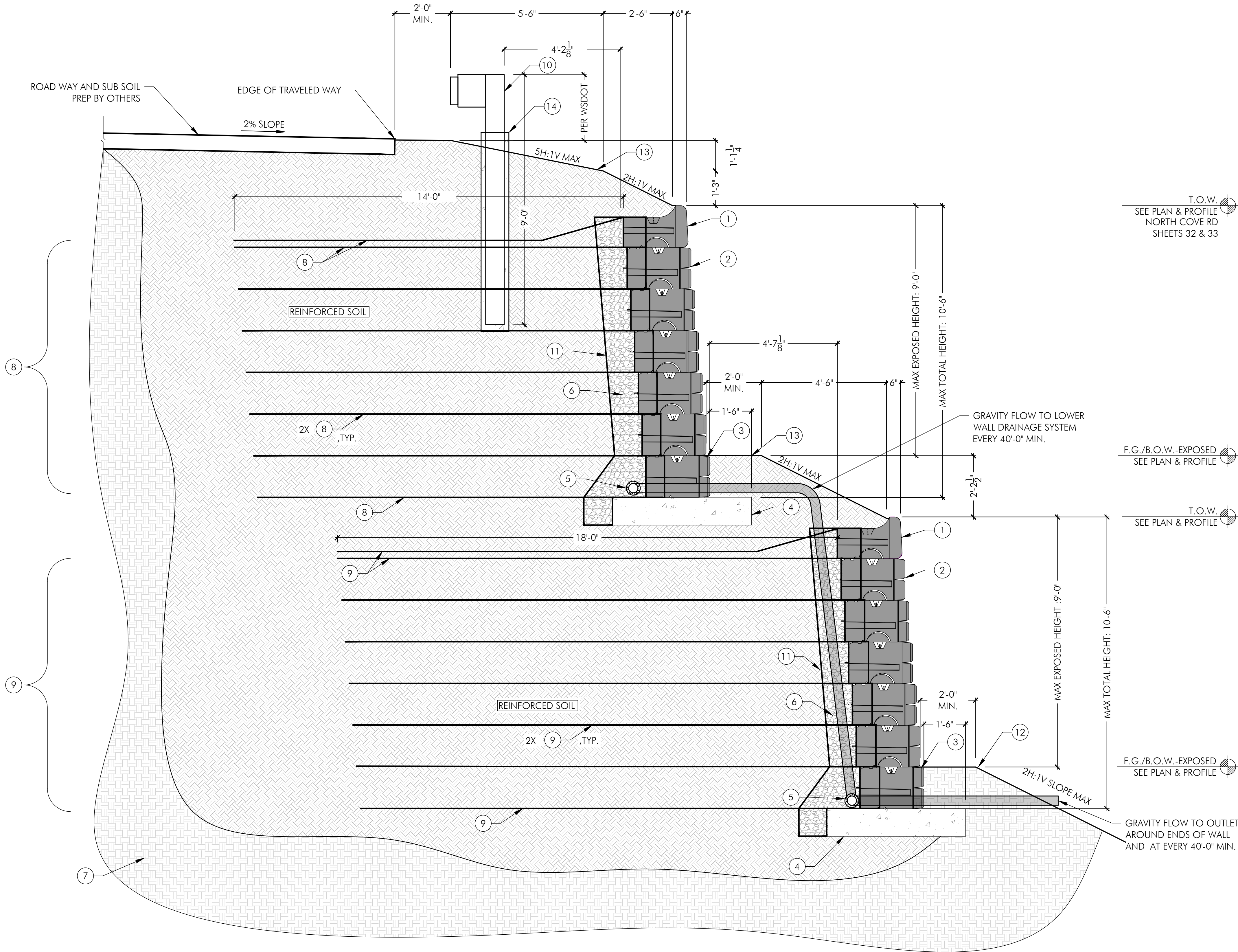
LEGEND

- 1 TOP BLOCK 28 PC PER REDI ROCK
- 2 BLOCK 28 PC PER REDI ROCK
- 3 BOTTOM BLOCK 28 PC PER REDI ROCK
- 4 CONCRETE LEVELING PAD: 5'-0" x 1'-0"
- 5 4" PERFORATED DRAINAGE TILE
WRAP DRAINAGE TILE IN 3/4" DRAIN ROCK
& FILTER FABRIC & WEEP DRAIN OPTION DETAIL S2.0
- 6 3/4" CRUSHED ROCK, UNIT DRAINAGE MATERIAL
1'-0" DEPTH BEHIND WALL, MIN. REF. GEOTECH
- 7 UNDISTURBED NATIVE SOILS
- 8 GEO GRID REINFORCING: MIRAGRID 10XT
- 9 GEO GRID REINFORCING: MIRAGRID 20XT
- 10 BEAM GUARD RAIL-TYPE 31
(WSDOT C20.10-09-TIMBER & WSDOT C-1b)
- 11 NON-WOVEN GEOTEXTILE FABRIC
- 12 FINISHED GRADE
- 13 F.G. NOT DESIGNED FOR PEDESTRIAN USE/ACCESS
- 14 PRE-ENGINEERED WSDOT BEAM GUARDRAIL ANCHOR
(WSDOT C-23.70-01)
POST AND BEAM GUARD RAIL DETAIL S2.0

PLAN NOTES:

- 1. BLOCK STANDARD SETBACK:
 - 1.1. STANDARD: 1 5/8", TYP. 5" BATTER ON WALL
- 2. MOVE BLOCKS FORWARD DURING INSTALLATION TO ENGAGE SHEAR KNOBS (TYPICAL).
- 3. FOOTING TRENCH TO EXTEND A MINIMUM DISTANCE OF 9" FROM THE EDGE OF THE BLOCK. CONTRACTOR TO PLACE GEOTEXTILE FABRIC ON THE SUB-GRADE PRIOR TO PLACING THE STRUCTURAL FILL TO MINIMIZE THE MIGRATION OF FINES INTO THE STRUCTURAL FILL.
- 4. FILL MATERIAL PLACED BEHIND THE WALL SHOULD CONSIST OF FREE DRAINING GRANULAR MATERIAL, REF. GEOTECHNICAL REPORT.
- 5. RE:GEOTECHNICAL REPORT FOR SITE PREPARATION AND GRADING.
- 6. ONLY USE STRIPS OF MIRAGRID GEOGRID THAT HAVE BEEN FACTORY CUT AND ARE CERTIFIED FOR WIDTH AND STRENGTHS BY TENCATE.
- 7. EXTEND GEOTEXTILE OVER DRAIN STONE AND BELOW SURFACE MATERIALS
- 8. INSTALL WALL PER BLOCK MANUFACTURER RECOMMENDATIONS.
- 9. GEOTECHNICAL PARAMETERS:
 - 9.1. ULTIMATE BEARING CAPACITY: 2000 PSF
- 10. FILL VERTICAL CORE SLOT AND WEDGE BETWEEN ADJACENT BLOCKS WITH DRAINAGE AGGREGATE (TYPICAL)
- 11. 12" WIDE STRIP OF GEOGRID WRAPPED THROUGH BLOCK AND EXTENDING FULL LENGTH (L) BACK INTO REINFORCED FILL ZONE (TYPICAL)
- 12. LOADING CONDITIONS:
 - 12.1. SEISMIC: KH = 0.23 (3" OF MOVEMENT DURING EARTHQUAKE EVENT)
 - 12.2. SURCHARGE = 250 PSF
 - 12.3. VEHICULAR GUARD RAIL, 1000 LB PER POST
- 13. LOADING SCENARIOS
 - 13.1. SURCHARGE ONLY
 - 13.2. SEISMIC ONLY
 - 13.3. VEHICULAR IMPACT ON GUARD RAIL
- 14. TO ADJUST WALL HEIGHT MAINTAIN TOP OF WALL AND REMOVE 2ND BLOCK FROM BOTTOM OF WALL, INSTALL IN COORDINATION WITH REDI ROCK INSTALLATION GUIDE.

CIVIL REF:REDPLAINS PROFESSIONAL INC.
NORTH COVE BEACH ACCESS RD
WALL PLAN & PROFILE
PROJ. 60260
SHEET 32 & 33
WALL 1 STA : 30+29 TO STA:33+70
WALL 2 STA:39+56 TO STA:43+75

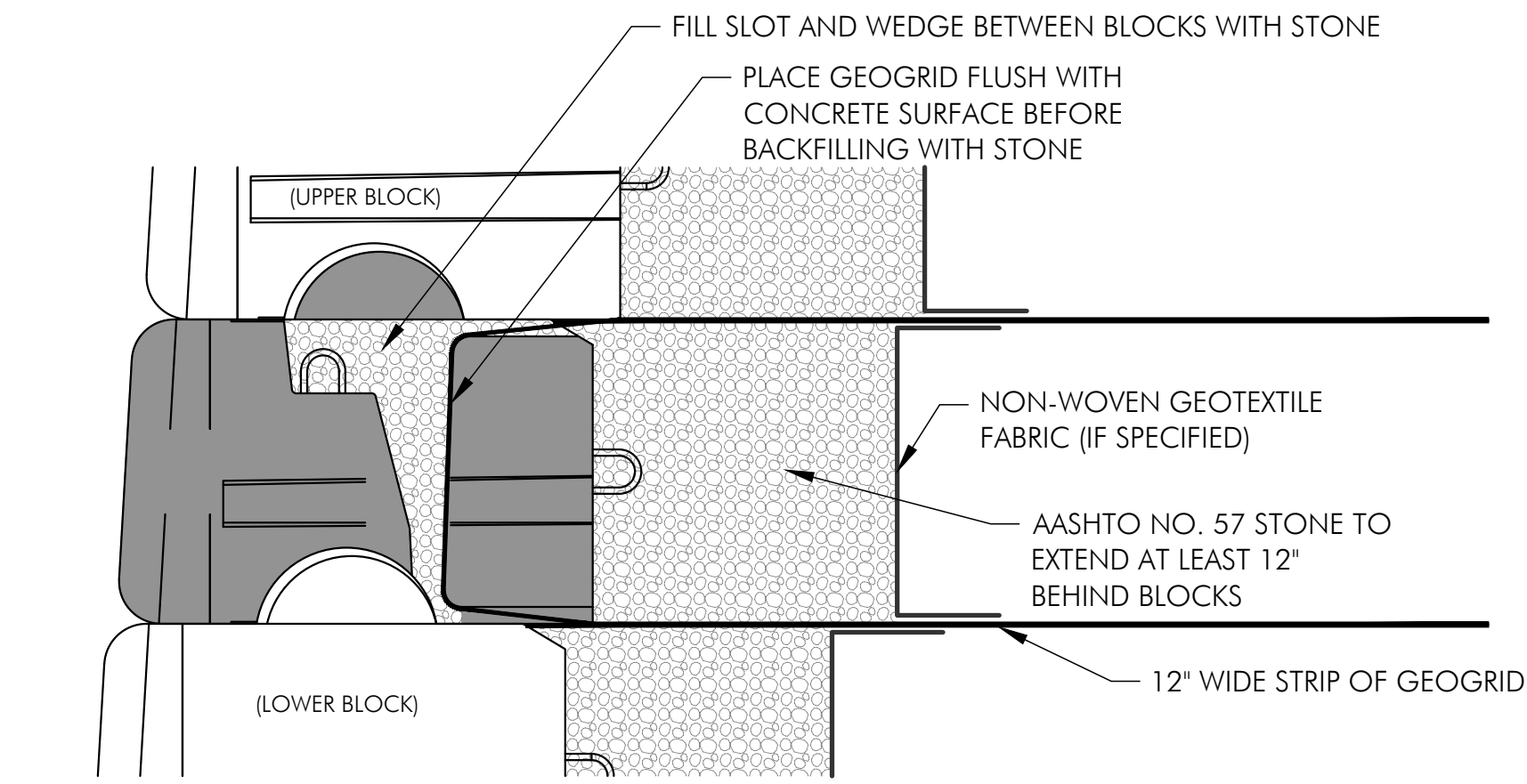


RETAINING WALL ELEVATION

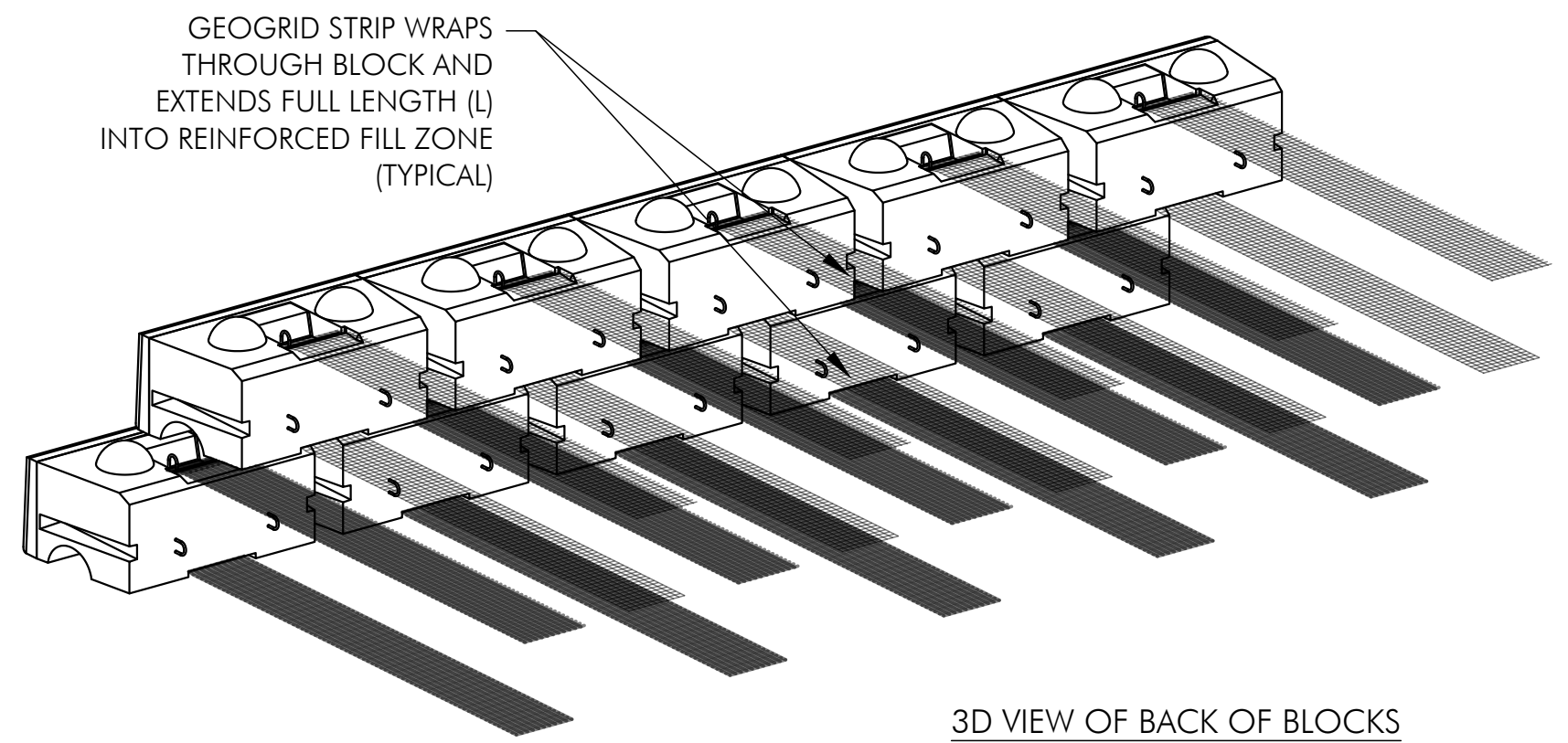
SCALE: 1/2" = 1'-0"

BY					
DATE					
REVISIONS					
SCJ ALLIANCE CONSULTING SERVICES 400 NORTH MAIN STREET, GUNNISON, CO 81230 SCJALLIANCE.COM					
SHEET TITLE: NORTH COVE ROAD RETAINING WALL-MAXIMUM WALL HEIGHT		PROJECT NAME: SHOALWATER BAY TRIBE RELOCATION TOKELAND, WA			
DESIGNER: CAM					
DRAWN BY: CAM					
APPROVED BY: CAM					
DRAWING: PERMIT					
DATE: 10-16-25					
JOB NO: 24-000194					
DRAWING NO:					
S1.0					
01 OF 02					

Oct 20, 2025 10:16:55am - User: gossymierbachin
N:\PROJECTS\1827 RED PLANS PROFESSIONAL, INC\24-000194 SHOALWATER BAY TRIBE RELOCATION MASTER PLAN\PHASE 03 - RETAINING WALL STRUCTURAL DESIGN\STRUCTURAL WALL SECTIONS\NORTH COVE\DWG\10102025 DETAILS RETAINING WALL.DWG

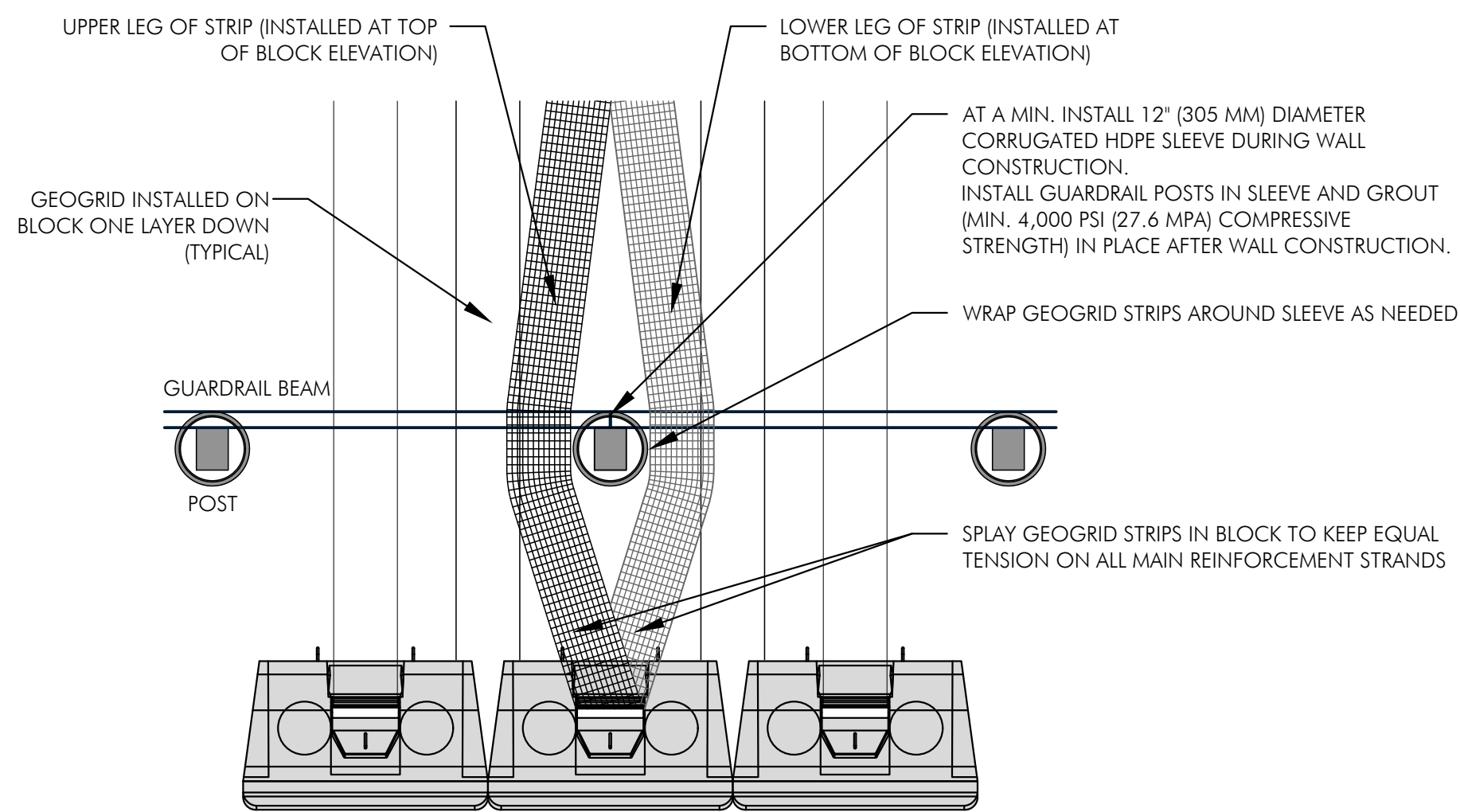


SECTION VIEW THROUGH BLOCKS
NO SCALE

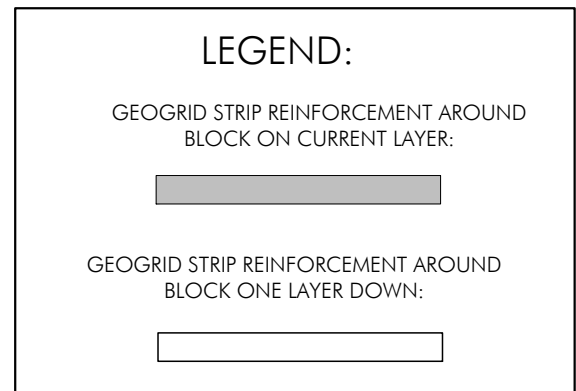
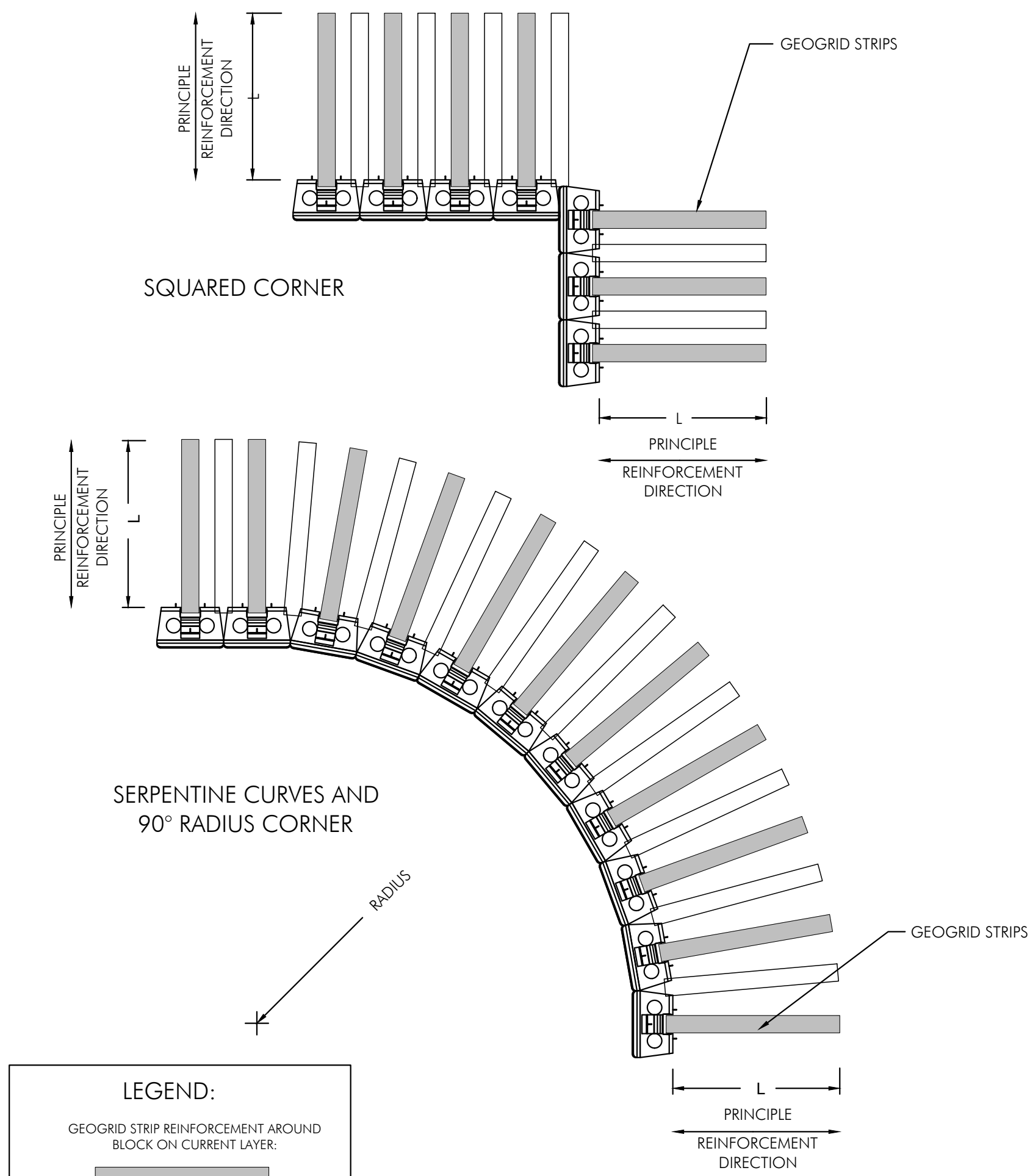


3D VIEW OF BACK OF BLOCKS
NO SCALE

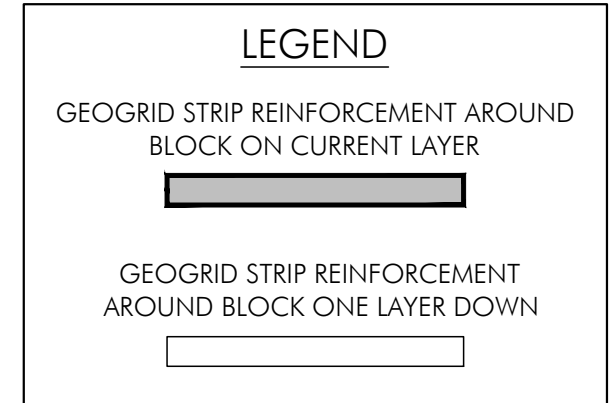
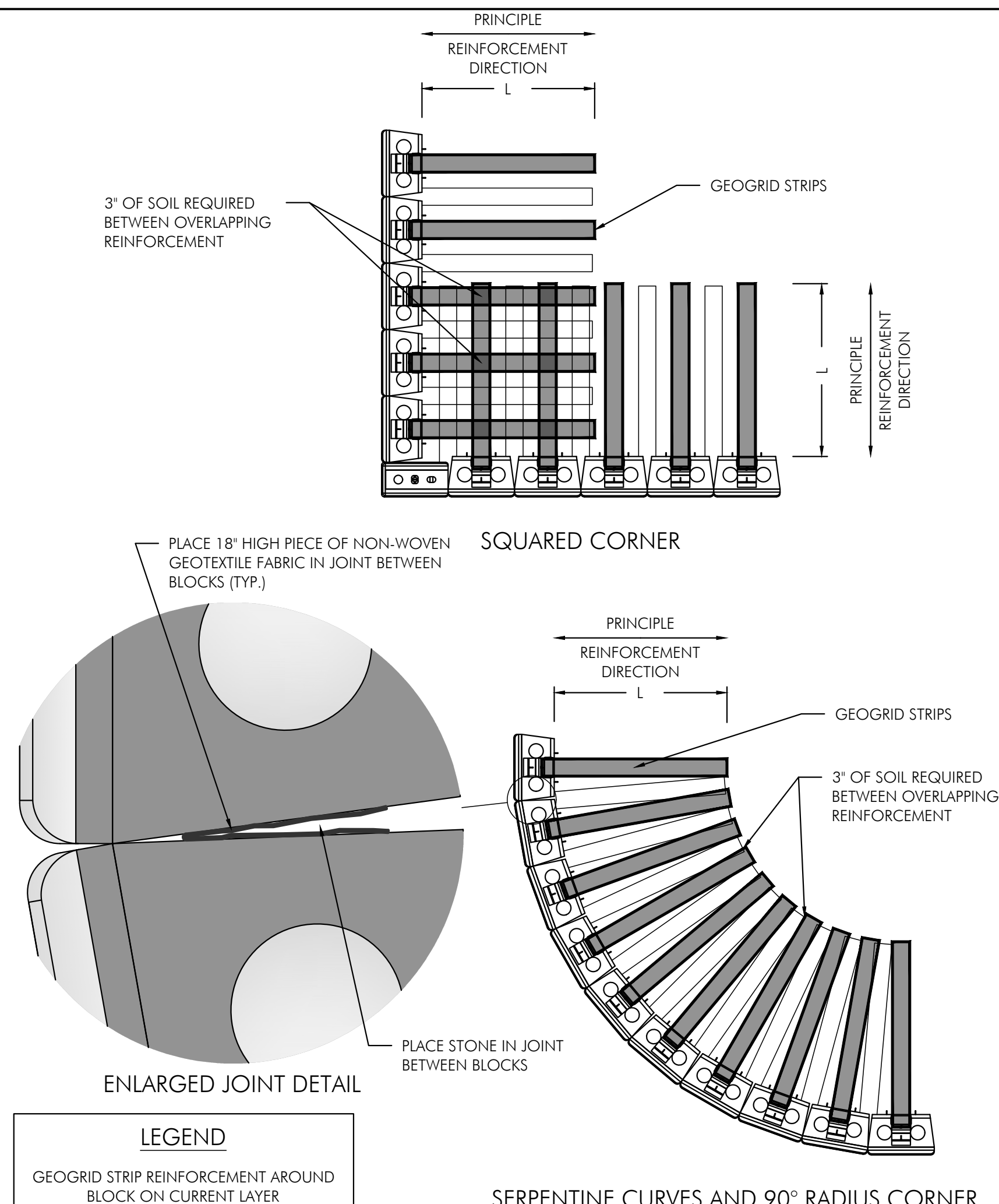
POSITIVE CONNECTION (PC) DETAILS
N.T.S.



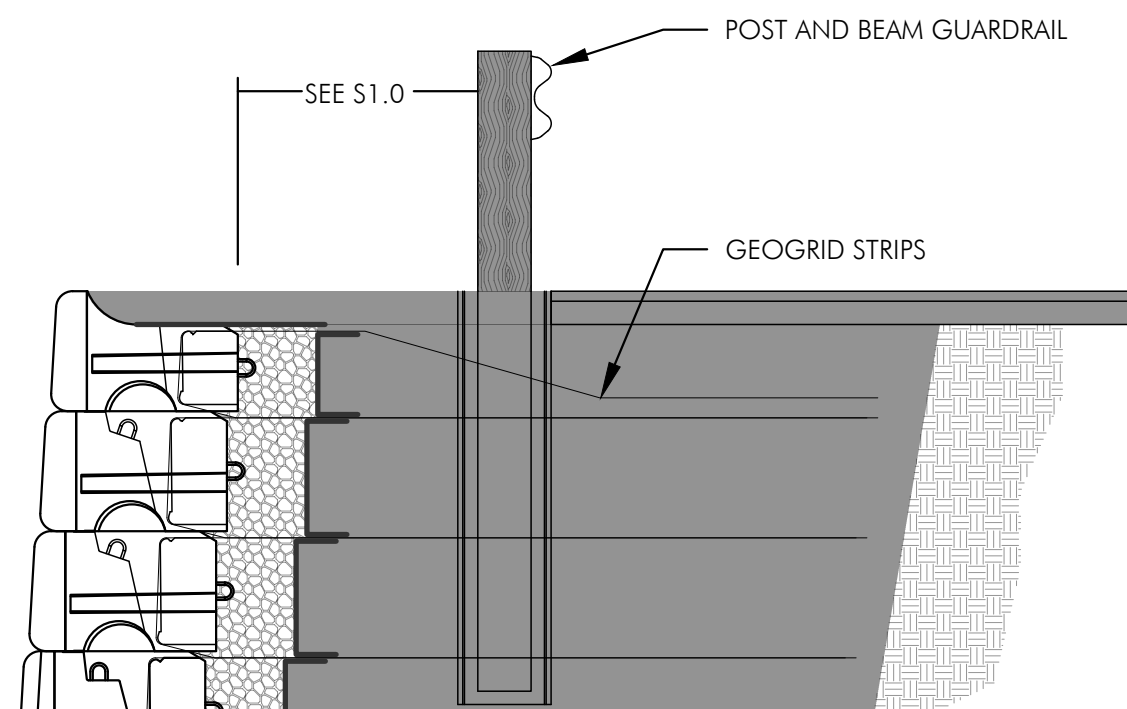
TOP VIEW
POST AND BEAM GUARDRAIL
N.T.S.



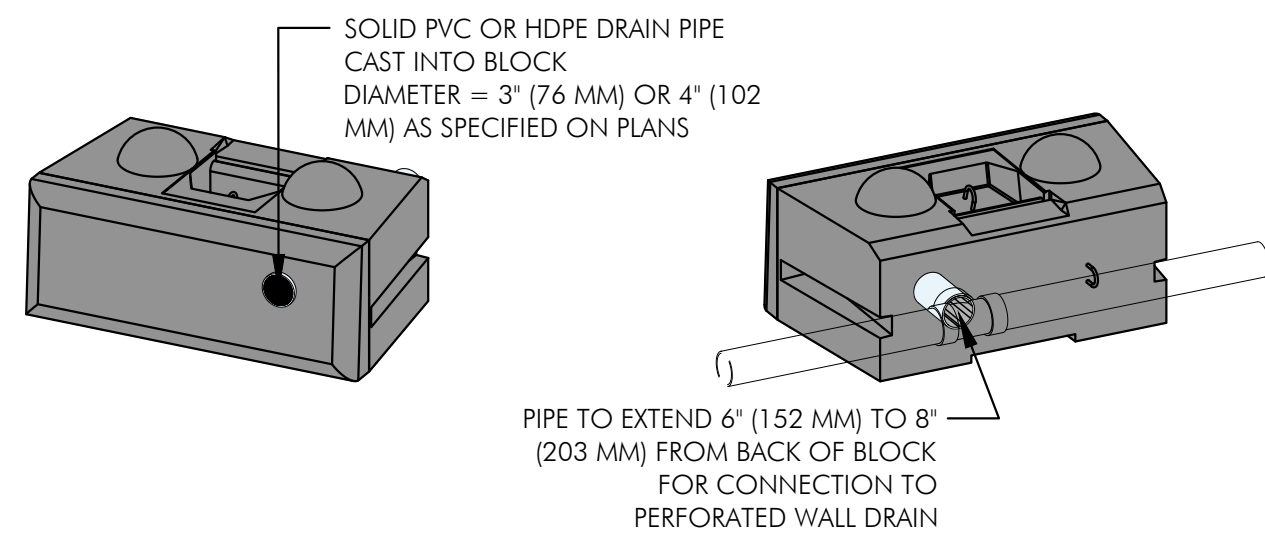
REINFORCEMENT PLACEMENT FOR CONCAVE CORNERS



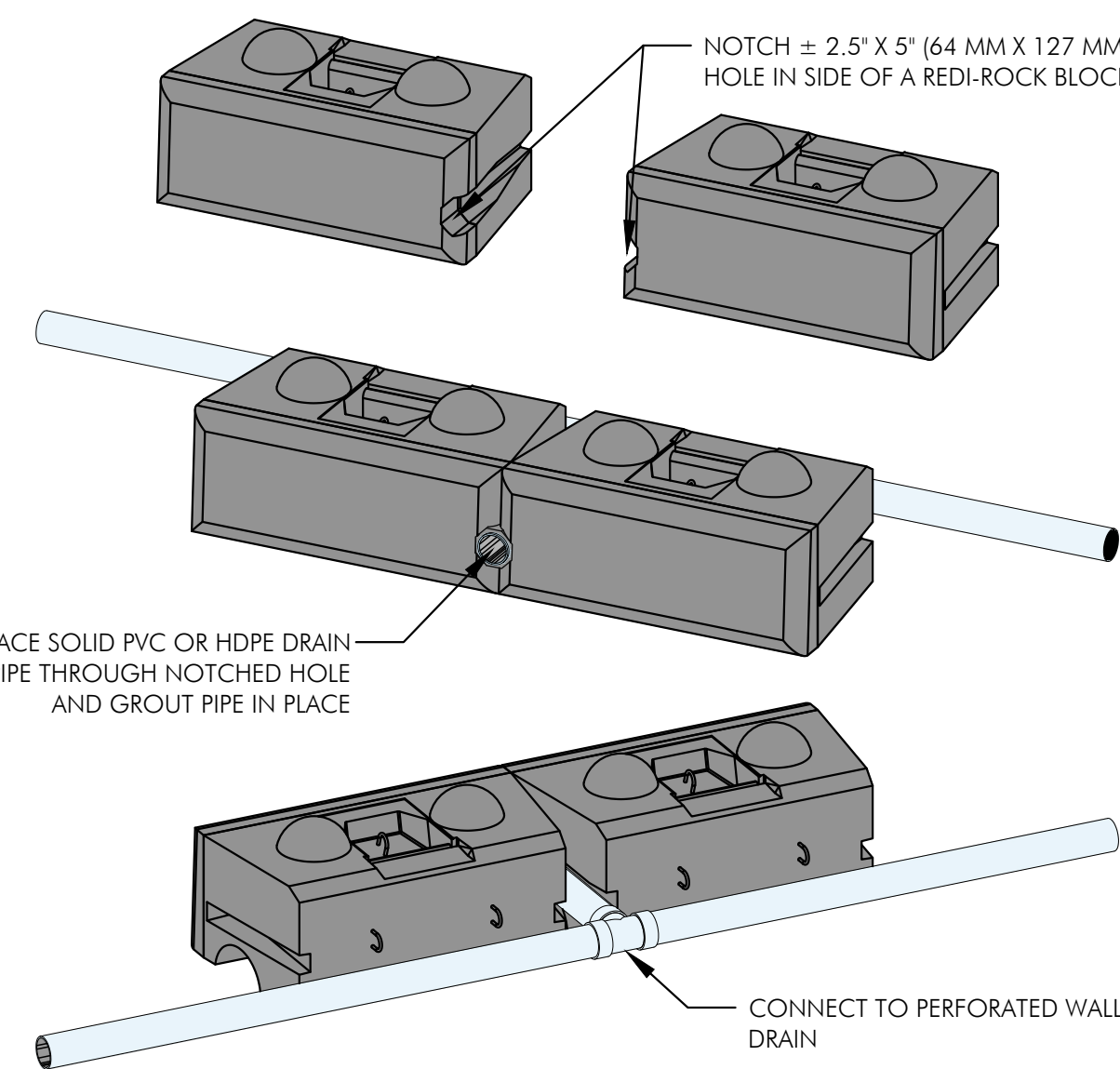
REINFORCEMENT PLACEMENT FOR CONVEX CORNERS



SECTION VIEW



CUSTOM PIPE CAST INTO BLOCK



FIELD INSTALLED PIPE

WEEP DRAIN OPTIONS DETAIL

BY	
DATE	
REVISIONS	
▲	

SCJ ALLIANCE
CONSULTING SERVICES
400 NORTH MAIN STREET, GUNNISON, CO 81230
SCJALLIANCE.COM

NORTH COVE ROAD MFG. GEO GRID DETAILS (TYP.)	SHOALWATER BAY TRIBE RELOCATION TOKELAND, WA
SHEET TITLE:	PROJECT NAME:
DESIGNER: CAM	APPROVED BY: CAM
DRAWN BY: CAM	DRAWING: PERMIT
DATE: 10-16-25	JOB NO: 24-000194
DRAWING NO:	S2.0
	02 OF 02

Culvert Basis of Design Memorandum



DRAFT TECHNICAL MEMORANDUM

TO: Red Plains Professionals, Inc.

FROM: Thomas J. Mathis, PE, PH
Landau Associates, Inc.

DATE: May 14, 2026

RE: **Hydraulic Basis of Design, Stream 6 Culvert Replacement**
RAISE Loop Project
Tokeland, WA
Project No. 2443003.010

Landau Associates, Inc has prepared this technical memorandum to document the hydraulic basis of design for the replacement of culvert CD-4 that conveys Stream 6 under North Cove Beach Road. The replacement crossing is advanced as an 8-foot-diameter circular culvert with 2.4 feet of blocked depth to accommodate streambed material throughout the barrel. The design objective is to improve fish passage by enhancing channel continuity through the crossing and providing a constructed streambed within the culvert. The proposed culvert must also convey the modeled design flows without roadway overtopping or hydraulic failure. The project vicinity is shown on Figure 1, site setting on Figure 2, and mapped stream context on Figure 3.

EXISTING CROSSING

The existing CD-4 crossing is a single 3-foot-diameter circular corrugated metal pipe with a headwall inlet and a perched condition at the outlet. The perched culvert outlet is a barrier for resident fish, preventing passage through the culvert. The existing culvert length is 78.3 feet, with upstream and downstream invert elevations of 54.78 feet and 51.92 feet respectively.

PROPOSED CROSSING DESIGN

The proposed CD-4 replacement is a single 8-foot-diameter circular culvert, modeled as a corrugated metal pipe with a mitered inlet conforming to the fill slope. The culvert is 140 feet long, with 2.4 feet of blocked depth representing streambed material placed within the barrel. The blocked depth is 30 percent of the culvert diameter, leaving an effective vertical hydraulic opening of approximately 5.6 feet above the constructed bed. The proposed conditions are shown in the design sheets provided on Figure 4.

The proposed upstream invert elevation is 55.23 feet, and the downstream invert elevation is 51.82 feet. Based on the 3.41-foot invert drop over 140 feet, the proposed culvert slope is 0.0243 feet per foot (ft/ft).

The proposed crossing satisfies the project objective of improving fish passage by carrying a constructed streambed through the culvert while substantially increasing the hydraulic opening relative to the existing 3-foot pipe. However, the design does provide 5.6 feet of modeled vertical clearance above the constructed bed; where a 6-foot debris-access clearance criterion is applied, it should be documented as a project-specific design departure.

GEOMORPHIC BASIS

The Stream 6 crossing lies in a low-gradient, heavily vegetated valley bottom where bankfull indicators are diffuse and difficult to trace with confidence. The channel flows through an emergent and scrub/shrub palustrine wetland immediately upstream of the culvert. Based on current field observations, bankfull width in the immediate reach ranges from about 42 to 64 inches, and a working average bankfull width of 48 inches (4 feet) is carried forward for preliminary stream-simulation scaling, including the crossing-width check, internal low-flow channel layout, and scour-prism geometry. National Marine Fisheries Service (NMFS) notes that stream-simulation design may require modification where geomorphic features such as bankfull width cannot be confidently predicted, including settings affected by upstream wetland or ponded conditions.

Observed bed material differs across the existing crossing. Current project information describes the upstream bed as predominantly fine sediment, while the downstream bed contains a higher proportion of gravel and minor cobble. That contrast is interpreted as evidence that the existing culvert and associated upstream backwater conditions have altered local sediment storage and transport. The proposed design should therefore treat the present upstream fines as a disturbed condition, not as the sole reference for the reconstructed bed inside the new crossing.

NMFS requires that fill materials within a stream simulation crossing be similar in size composition to the natural bed materials adjacent to the road crossing and that the designer demonstrate the constructed bed will remain stable over time. Consistent with that requirement, the proposed crossing consists of a constructed bed and low-flow channel scaled from the working bankfull width, with bed material selected from the adjacent reach conditions judged to best represent the transport reach rather than the ponded fines immediately upstream of the existing culvert. Irregular bankline rock or similar margin treatments may be used to form stable margins and add channel complexity.

On a preliminary basis, the proposed streambed shall consist of an overall blend of approximately 60 percent Streambed Fine Sediment meeting Washington State Department of Transportation 2026 Standard Specifications Division 9 Sec. 9-03.11(2), 30 percent Streambed Sediment meeting Sec. 9-03.11(1), and 10 percent 4-inch Streambed Cobbles meeting Sec. 9-03.11(4), by volume. Within the active low-flow/scour prism, the target blend should be finer, consisting of approximately 70 percent Streambed Fine Sediment and 30 percent Streambed Sediment; outside that prism, the lateral roughness bands should be comparatively coarser, consisting of approximately 40 percent Streambed Fine Sediment, 45 percent Streambed Sediment, and 15 percent 4-inch Streambed Cobbles. A minor quantity of Streambed Sand meeting Sec. 9-03.11(3) may be added during final gradation development as needed to fill interstitial voids and maintain surface low-flow continuity (i.e., to avoid hyporheic flow).

HYDRAULIC MODELING APPROACH

The current hydraulic evaluation is based on a US Army Corps of Engineers Hydrologic Engineer Center's River Analysis System (HEC-RAS) 6.4.1 steady-flow model for existing and proposed conditions. The model includes one culvert, 23 cross sections, and mixed-flow computations.

The design flows used to evaluate the crossing are:

Recurrence Interval	Flow
2-year	36.03 cubic feet per second (cfs)
10-year	50.03 cfs
100-year	87.34 cfs

These flows are applied at the upstream cross-section for both existing and proposed model plans. The proposed-condition model uses normal-depth boundary conditions with an upstream slope of 0.021 ft/ft and a downstream slope of 0.022 ft/ft.

The model was used to evaluate the existing crossing and the proposed 8-foot culvert under the 2-year, 10-year, and 100-year flows. The proposed culvert is modeled at River Station (RS) 1375.13. The model includes outlet-control culvert calculations for the 2-year, 10-year, and 100-year events.

Existing Conditions Results

The plan view schematic for the existing conditions model are shown on Figure 5. Existing conditions results show outlet control for the modeled storm events (Figure 6). Culvert velocities are relatively high, ranging from 7.40 to 12.36 feet per second (ft/s) at the upstream end and from 9.89 to 12.36 ft/s at the downstream end across the 2-year through 100-year events. The modeled hydraulic depths and velocities for the existing conditions model are shown on Figures 7 and 8. Results for each cross section under existing conditions are provided in Attachment 1. The model also reports supercritical flow at the existing culvert, including hydraulic jumps at the outlet for the 2-year and 10-year events and critical-depth limitations for the 100-year event. A complete summary report of the model results is provided in Attachment 2.

These results are consistent with a hydraulically constricted existing crossing. The replacement design is therefore intended to reduce the hydraulic restriction, provide streambed continuity through the structure, and improve long-term passage of water, sediment, and debris. The model-predicted streambed shear results are shown on Figure 9.

Proposed Conditions Results

The proposed 8-foot diameter culvert has an upstream invert elevation is 55.23 feet, a downstream invert elevation is 51.82 feet, and is 140 feet long, resulting in a slope of 0.0243 ft/ft. The modeling results demonstrate that the proposed 8-foot culvert conveys the 2-year, 10-year, and 100-year events through the culvert without modeled roadway overtopping. Figure 10 shows the schematic for the hydraulic model and proposed crossing. The minimum elevation for weir flow is 78.97 feet, while the

100-year upstream water-surface elevation is 69.36 feet, leaving approximately 9.6 feet between the modeled 100-year upstream water surface and the onset of roadway weir flow. The predicted water surface elevations for the proposed conditions are shown on Figure 11. The results for each cross section under the proposed conditions are provided in Attachment 3 and the complete results summary is provided in Attachment 4.

The proposed culvert remains under outlet control for all modeled events. Modeled culvert velocities are summarized below:

Event	Flow	Upstream Culvert Velocity	Downstream Culvert Velocity	Culvert Control
2-year	36.03 cfs	1.40 ft/s	5.28 ft/s	Outlet
10-year	50.03 cfs	1.56 ft/s	5.87 ft/s	Outlet
100-year	87.34 cfs	2.32 ft/s	7.06 ft/s	Outlet

The 100-year model reports a culvert full-flow length of 107.44 feet, with a normal depth of 5.60 feet and a critical depth of 1.59 feet. HEC-RAS notes that the normal depth exceeds the culvert height and assumes normal depth equal to the culvert height; in this context, that note reflects the effective modeled hydraulic opening above the 2.4-foot blocked bed. These conditions are shown on Figure 12 and 13.

The proposed-condition results indicate that the culvert has adequate hydraulic capacity for the modeled 100-year event. Final design should confirm that the constructed bed gradation, bed retention strategy, inlet transition, and outlet transition remain consistent with the assumptions represented by the high bottom roughness and blocked-depth model setup. The model-predicted streambed shear stress is shown on Figure 14.

CONSTRUCTION AND LONG-TERM PERFORMANCE

Construction should be performed within the applicable in-stream work window. Consistent with NMFS road-crossing guidance, the crossing should be installed only under dewatered conditions and with project-specific sediment-control and flow-routing measures in place before work begins. Construction disturbance within the channel and riparian area should be kept to the minimum needed to complete the installation. If temporary pumping is required, the diversion setup should include a compliant fish screen and any construction wastewater should be disposed of upland where it will not drain directly to the stream. After construction, the work area and riparian corridor should be restored with native, locally adapted riparian vegetation.

Under NMFS guidance, post-construction review includes three elements: verifying that the culvert was installed in accordance with the design and construction procedures, measuring hydraulic conditions to determine whether the crossing is performing as intended, and performing a biological assessment where warranted by site conditions and agency requirements. For this project, the evaluation focuses on the specific issues identified in this memorandum, including as-built embedment, continuity of the constructed bed and low-flow channel, inlet and outlet transition grades, and whether the hydraulic-jump concern identified in the preliminary HEC-RAS results persists under field conditions.

Long-term operation and maintenance should include inspection at least annually over the life of the culvert, with any failures or deficiencies corrected promptly. During the storm season, timely inspection and debris removal will be needed to keep the crossing passing water, sediment, and debris. Because this project is advancing a long culvert instead of a bridge and the preliminary model flags the inlet transition as the main unresolved hydraulic issue, the inspection program should pay particular attention to debris accumulation, bed stability within the barrel, and changes at the inlet and outlet that could create a new barrier condition.

BASIS OF DESIGN CONCLUSIONS

CD-4 replacement design is an 8-foot-diameter circular culvert with 2.4 feet of constructed streambed material. The proposed culvert is modeled as a 140-foot-long corrugated metal pipe with a mitered inlet, upstream invert elevation of 55.23 feet, downstream invert elevation of 51.82 feet, and outlet-control performance under the modeled 2-year, 10-year, and 100-year events.

The proposed-condition HEC-RAS results indicate that the culvert conveys the modeled 100-year flow of 87.34 cfs without roadway overtopping. The modeled 100-year upstream water-surface elevation is 69.36 feet, compared with a minimum weir-flow elevation of 78.97 feet. The proposed design substantially increases the hydraulic opening relative to the existing 3-foot culvert and provides for a constructed streambed through the crossing.

CLOSING

The proposed 8-foot-diameter culvert with 2.4 feet of streambed material is the hydraulic design carried forward for CD-4. Based on the updated HEC-RAS results, the design provides adequate modeled capacity for the 2-year, 10-year, and 100-year flows and avoids roadway overtopping during the 100-year event. The final design specifications should include a focus on constructability, streambed stability, inlet and outlet transitions, and clear documentation of any project-specific departures from applicable stream-crossing guidance.

LANDAU ASSOCIATES, INC.

Thomas J. Mathis, PE, PH
Senior Engineer

TJM/BMB/tmh
[P:\2443\003\010\R\HYDRAULIC BOD\STREAM 6 CULVERT BOD MEMO_BB.DOCX]

FIGURES

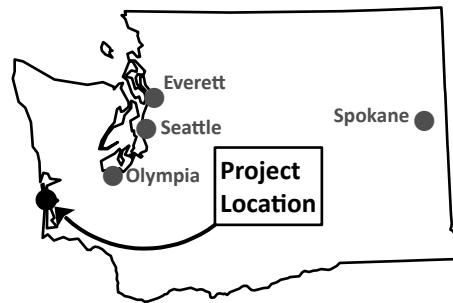
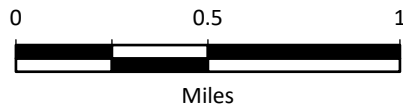
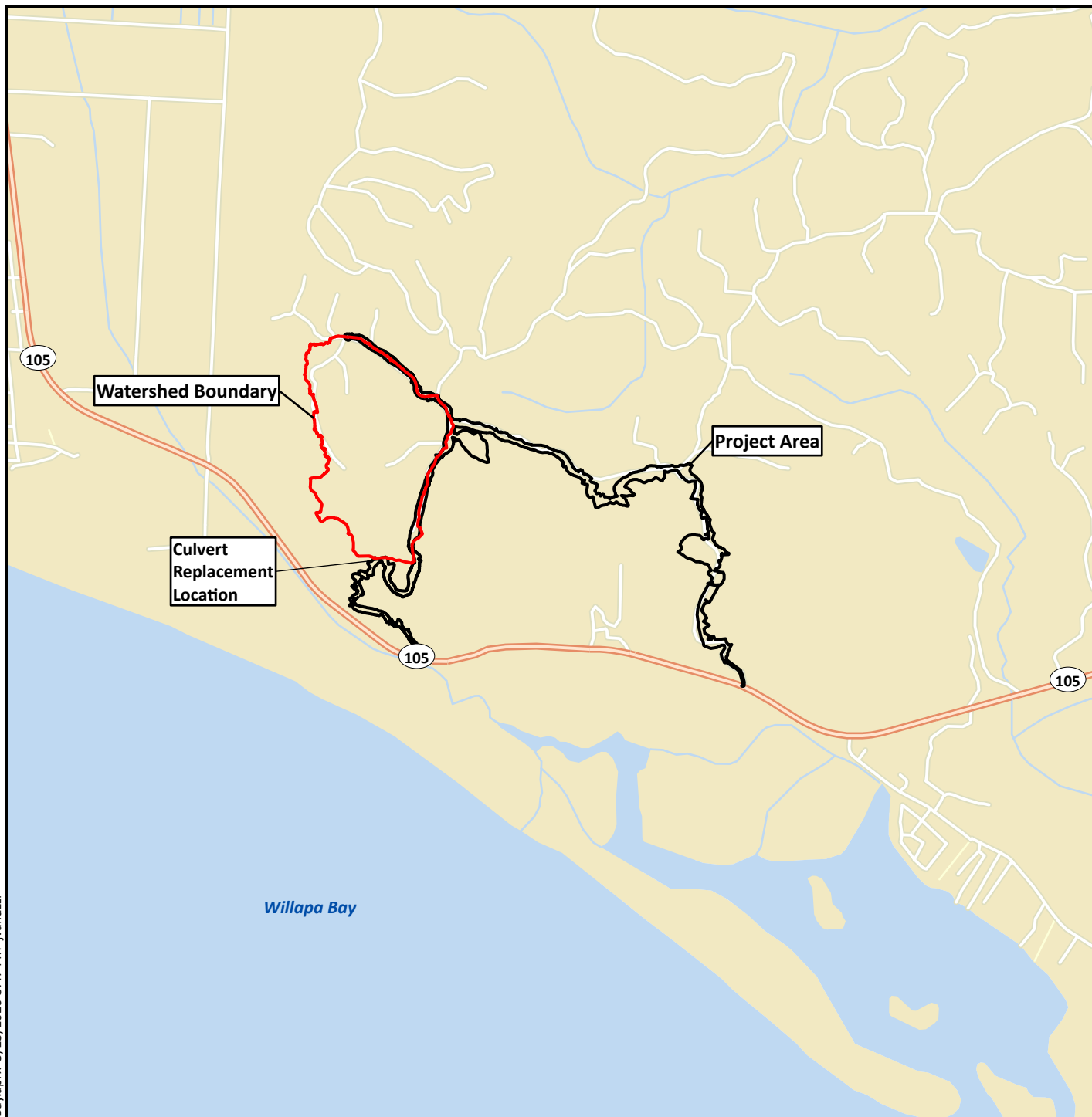
Figure 1. Vicinity Map
Figure 2. Aerial Photo and Project Area Map

- Figure 3. WADNR Stream Map
- Figure 4. Proposed Culvert Design Plan and Profile View
- Figure 5. Model Plan View – Existing Conditions
- Figure 6. Profile Plot – Existing Conditions
- Figure 7. Hydraulic Depth – Existing Conditions
- Figure 8. Velocity Plot – Existing Conditions
- Figure 9. Shear Plot – Existing Conditions
- Figure 10. Model Plan View – Proposed Conditions
- Figure 11. Profile Plot – Proposed Conditions
- Figure 12. Hydraulic Depth – Proposed Conditions
- Figure 13. Velocity Plot – Proposed Conditions
- Figure 14. Shear Plot – Proposed Conditions

ATTACHMENTS

- Attachment 1. Cross Section Results: Existing Conditions
- Attachment 2. Model Output Report – Existing Conditions
- Attachment 3. Cross Section Results: Proposed Conditions
- Attachment 4. Model Output Report – Proposed Conditions

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Data Source: Esri.



Legend

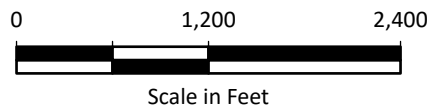
-  Project Area
-  Watershed Boundary

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: WADNR; Google Earth Pro.

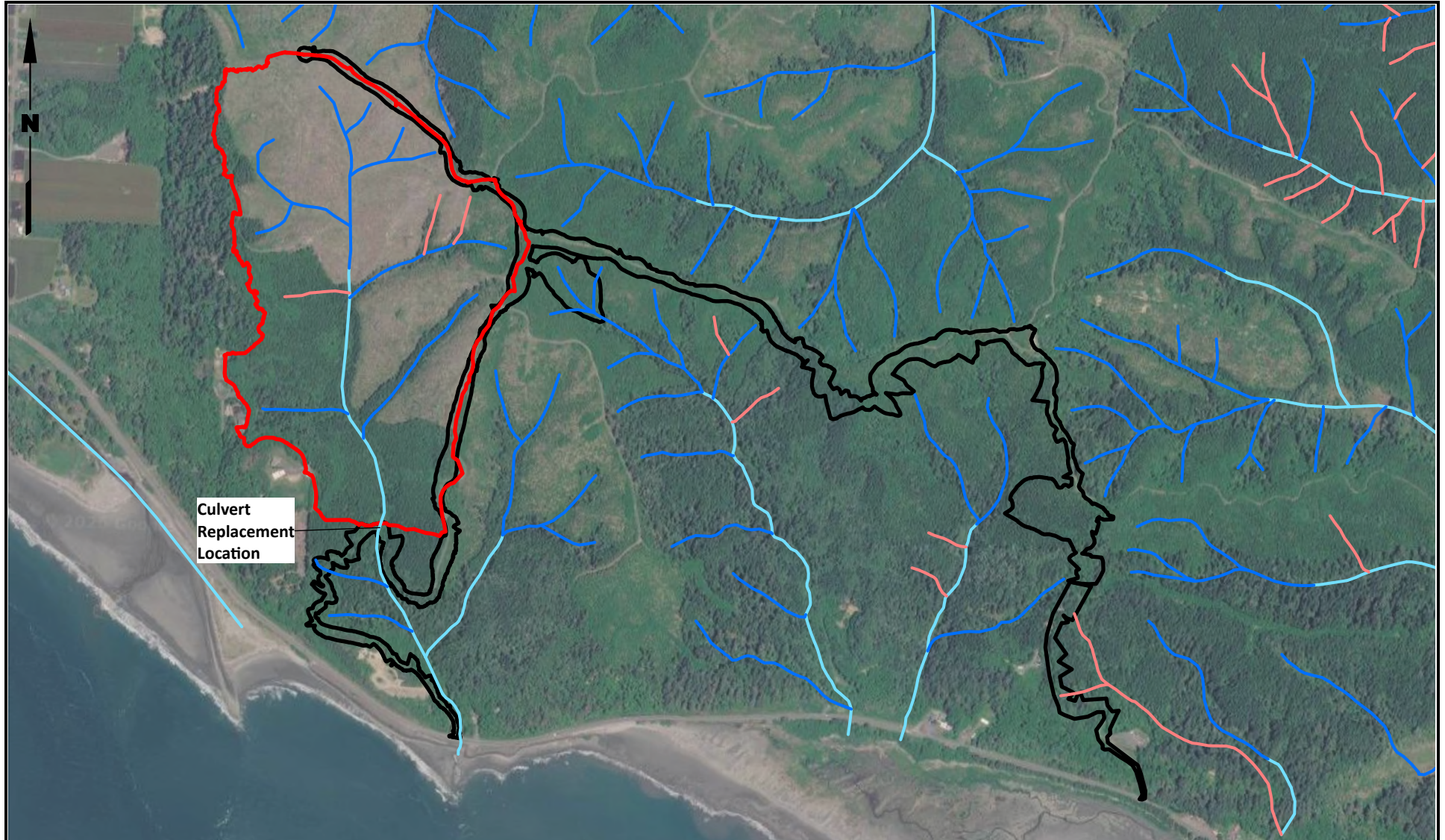
LANDAU
ASSOCIATES



RAISE Loop Project
Hydraulic Basis of Design
Tokeland, Washington

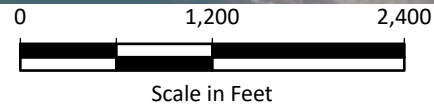
Aerial Photo and Project Area

Figure
2



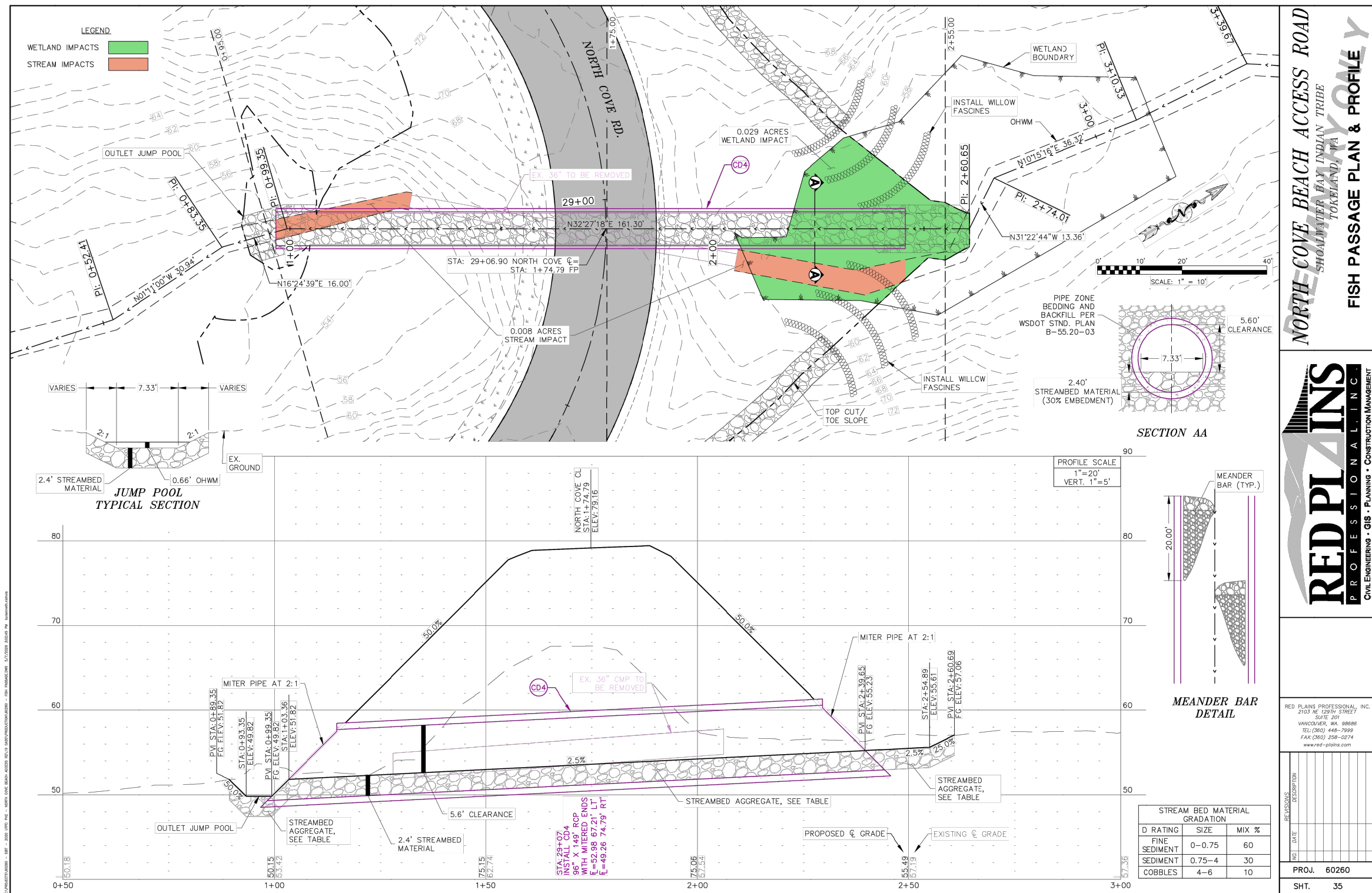
Legend

- Project Area
- Watershed Boundary
- Fish-Bearing Stream
- Non Fish-Bearing Stream
- Unknown Stream



Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: Red Plains Professional, Inc., 2026

RAISE Loop Project
Hydraulic Basis of Design
Tokeland, Washington

Design Plan-Profile View

Figure
4