
ENGINEERING APPENDIX

STARRUCCA CREEK SUSQUEHANNA COUNTY, PENNSYLVANIA CONTINUING AUTHORITIES PROGRAM SECTION 14, EMERGENCY STREAMBANK STABILIZATION

APPENDIX C

March 2026



U.S. Army Corps of Engineers
North Atlantic Division - Baltimore District
In partnership with the Pennsylvania Department of Transportation

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C-1 Purpose and Scope

Streambank erosion is threatening a segment of the PA SR-1005 transportation corridor adjacent to Starrucca Creek. Section 14 of the Continuing Authorities Program (CAP) authorizes the U.S. Army Corps of Engineers (USACE) to carry out projects that protect public infrastructure and facilities that face an imminent risk of damage or failure due to natural streambank erosion.

This appendix, prepared in support of a CAP Section 14 project, is intended to summarize the engineering understanding of site conditions driving instability, describe the feasibility-level concept for the tentatively selected stabilization approach, and identify key data needs and design analyses to be completed during PED to advance the recommended plan to an implementable design. The project is being carried out in coordination with the Pennsylvania Department of Transportation (PennDOT), which is serving as the non-Federal sponsor for this study.

C-2. Project Setting and Conditions

The project is located in the Thompson Township, Susquehanna County, Pennsylvania, along SR 1005 between the boroughs of Thompson and Starrucca (Figure 1). The area along SR 1005 that is experiencing streambank erosion extends from approximately Segment 0100 Offset 1365 to Segment 0100 Offset 1680 on the left shoulder adjacent to the right bank of Starrucca Creek. SR 1005 carries approximately 174 vehicles per day, including about 17 trucks. SR 1005 is classified as a Rural Major Collector by PennDOT with a speed limit of 35 mph. Starrucca Creek is a tributary to the Susquehanna River and is approximately 18.1 miles long, with a total drainage area of about 52 square miles. The project is located in the upper watershed with a drainage area of 9.1 square miles contributing to the site.

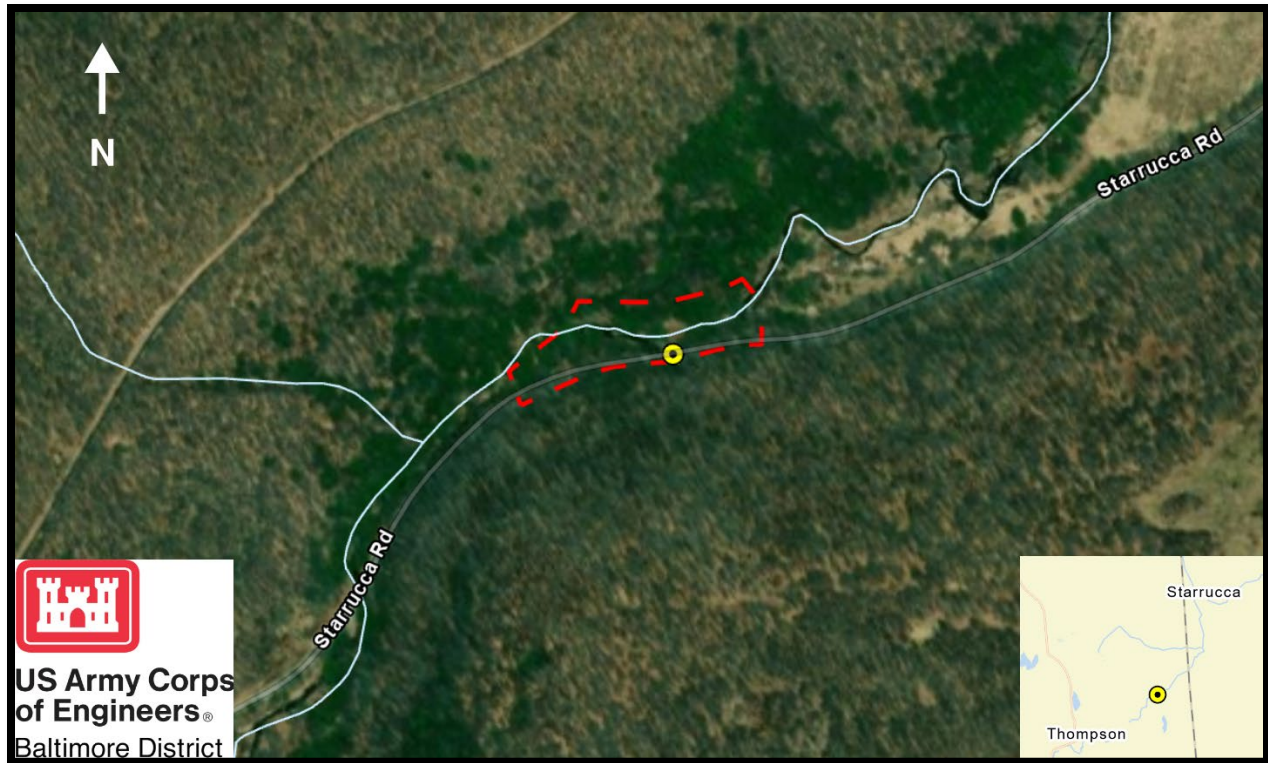


Figure 1: Study Area Map

C-2.1 Existing Conditions

Existing site conditions were assessed based on PDT member site visits, review of available information, and a topographic survey conducted by PennDOT. SR 1005 Segment 0100 is a two-lane, two-way undivided roadway with a 19-to-22-foot paved width and a bituminous asphalt surface. The roadway is benched along a hillside, where the left shoulder drops at a slope steeper than 1H:1V towards Starrucca Creek with approximately 10 to 20 feet of relief, while the right shoulder drains to a roadside ditch; beyond the ditch, the ground rises at an approximate 1.1H:1V slope to about El. 1760 roughly 1,600 feet south of SR 1005. The majority of PA SR-1005 is superelevated towards the right shoulder ditch, where drainage is carried to either an 18-inch culvert to the east or a 24-inch culvert to the west; however, in the area of concern the roadway is superelevated towards Starrucca Creek. In this area, the left lane pavement is exhibiting edge deterioration with longitudinal and stress cracking due to ongoing erosion along the left shoulder. Additionally, the eroding left shoulder has eliminated the deflection pad required for the guide rail to deflect as designed and caused the guide rail to tilt (Figure 2).

The observed distress is being driven by continued stream migration toward SR 1005. In this reach, the SR 1005 alignment is generally parallel to Starrucca Creek, with a steep, wooded embankment dropping from the roadway edge to the stream. The

embankment between SR 1005 and Starrucca Creek is steeper than 1H:1V in some areas, with dry hand-stacked stone retaining wall approximately 3-4 foot tall and 30 foot in length 6 feet from edge of road (Figure 3). Existing conditions indicate that sediment deposition has formed a gravel bar on the left bank opposite the roadway, which has progressively influenced the low-flow and high-flow alignment. As the active flow path has shifted laterally, the bank adjacent to SR 1005 has been exposed to sustained hydraulic attack, resulting in increased erosive forces at the roadway embankment toe and progressive loss of shoulder support (Figure 4).

An existing overhead telecommunications line runs along the left shoulder of SR 1005; however, upstream of the eroded embankment, the line diverges from the roadway and shifts onto the adjacent tract. Near the eroded embankment, the line generally follows the north side of Starrucca Creek's base-flow channel, with one pole located within the stream.



Figure 2: Pavement distress and tilted guide rail photo



Figure 3: Steep embankment and stone wall photo



Figure 4: Gravel bar and stream at embankment toe photo

C 2-2 Objectives

The following feasibility-phase engineering objectives will guide development of the recommended plan for the Starrucca project:

- Address the primary driver of instability by removing sediment buildup that has caused Starrucca Creek to shift laterally toward SR 1005 and reestablish a stable channel away from the roadway.
- Provide a stabilization configuration and features that will halt, or substantially reduce, future streambank retreat adjacent to the roadway.
- Restore a stable embankment foundation beneath the roadway prism and reestablish adequate deflection capacity for the guide rail system.
- Develop a stabilization plan that is constructible, maintainable, and minimizes roadway risk while avoiding unacceptable adverse impacts and limiting the project footprint where practicable.

C-3 Survey and Mapping

To support evaluation of existing conditions and development of feasibility-level concepts, the non-Federal sponsor completed a topographic survey of the project area and established a control framework that can be carried forward into PED. Project coordinates and elevations for the survey were established using the horizontal and vertical control described below.

Horizontal project coordinates are referenced to the Pennsylvania State Plane Coordinate System, North Zone (FIPS 3701), NAD83(2011), using the PA North Zone 3701 coordinate plane. Horizontal control was established using KeyNet VRS network RTK, with TP 50 set via VRS and TP 51 verified through multiple RTK observations. Additional control points (TP 52 through TP 58) were established by a Trimble S5 Robotic total station grid traverse, with an RTK tie performed at TP 57 to provide an independent check on the traverse solution. All horizontal observations and control are reported on the Pennsylvania State Plane grid, and the average combined factor for the grid traverse was 1.00007438. The associated control coordinates and elevations for TP 50 through TP 58, including the RTK tie at TP 57, are summarized in Table 1.

Vertical control was established from a PennDOT survey monument disk located on the bridge over Starrucca Creek and stamped "12-57-1005-3." Elevations are reported in NAVD88, with the benchmark NAVD88 elevation of 1434.623 ft obtained using an NCAT conversion from the published NGVD29 elevation of 1435.110 ft.

Project Control Points (TP 50–TP 58)				
Point	Northing	Easting	Elevation	Code
50	629481.0117	2583563.6502	1432.78	IP W/ CAP
51	629673.1642	2583668.8658	1428.03	MAG
52	629986.1614	2583912.3290	1424.16	IP W/ CAP
53	630113.7996	2584078.3177	1422.00	IP W/ CAP
54	630248.4782	2584388.1088	1417.60	IP W/ CAP
55	630254.5654	2584649.7760	1421.20	IP W/ CAP
56	630317.9385	2584823.2784	1421.44	IP W/ CAP
57	630302.2492	2585044.8136	1417.37	IP W/ CAP
57 RTK	630302.2775	2585044.7629	(Traverse Tie-In)	
58	630400.0860	2585256.2785	1413.83	IP W/ CAP

**Table 1: Survey Control Points and Coordinates
(NAD83(2011) / PA North 3701; NAVD88)**

C-4 Geotechnical Considerations

During the feasibility-phase site visit, the PDT geotechnical engineer inspected the existing roadway embankment slope and the dry hand-stacked stone wall along the creek-side shoulder. The initial field assessment was that the wall appeared to be stable and could potentially remain in place, provided that the tree growing from the base was removed in a manner that minimized disturbance of the wall’s foundation. Conceptually, the intent was to remove the above-grade trunk and manage the root mass conservatively, leaving the stump/root zone in place rather than grubbing and undermining the wall, to reduce the likelihood of locally destabilizing the existing masonry through loss of confinement or inadvertent excavation at the toe.

As the design progressed from reconnaissance to survey-based geometry, it became clear that the project features extend beyond a typical “bank armor” repair and must also function as a roadway embankment reconstruction. Survey review indicated that the shoulder would need to be widened to restore an adequate deflection pad for the guide rail system, and that the vertical relief between the roadway and the stream in portions of the reach can approach approximately 20 feet and slopes less than 1H:1V. These factors increase the consequence of deformation and stability typical of embankment widenings and fills constructed on sloping ground. PennDOT geotechnical guidance emphasizes that embankment construction and widening recommendations should explicitly address details for placing embankment on sloping ground and widening existing embankments, as well as the potential need other foundation preparation measures.

Accordingly, the feasibility-level concept for Alternative 2a was refined to rely on construction of bonding (merge) benches cut into competent existing material, rather than relying on the dry-stacked wall and an unbenched cut slope interface as the primary means of support. Benching provides a positive geometric “lock” between new embankment materials and the existing slope and reduces the potential for sliding along the contact between the new fill/rock mass and the pre-existing ground surface. This approach aligns with PennDOT’s embankment widening criteria that recognize benching of the existing embankment prior to fill placement as a key condition for lower-risk widening scenarios.

C - 5. Alternative Designs

C-5.1 Alternative Design Considerations

Based on the identified failure mechanisms, site constraints, and feasibility-phase objectives, stabilization alternatives were developed and evaluated to identify a practicable recommended plan. The alternatives developed were conceptual solutions based on widely used practices for streambank stabilization. The alternatives are described in this section and include stream realignment with a sloped riprap embankment and bench (Alternative 2a), stream realignment with a riprap embankment incorporating a cambered stone toe-wall (Alternative 2b), and relocation of SR 1005 (Alternative 1). For each alternative, rough order of magnitude quantities and construction cost were developed; summarized in Table 2. These quantities and costs are intended to support comparative screening at the feasibility level and will be refined during PED as survey, right-of-way limits, and final hydrologic/hydraulic parameters are refined. Conceptual typical cross sections for Alternatives 2a and 2b are provided on Exhibits C-1 and C-2, respectively.

Alternative	Total Costs
Alternative 1	\$4,057,000
Alternative 2a	\$3,288,000
Alternative 2b	\$4,008,000

Table 2: Cost for Alternative Plans

C-5.1.1 Alternative 1 – Relocation of SR 1005

This alternative was evaluated during the Federal Interest Determination phase and is presented in the FID submittal dated 23 October 2023. This alternative consists of shifting the roadway alignment away from the creek to reduce long-term exposure of the

roadway to stream migration. Conceptually, this includes construction of a new roadway along a shifted roadway alignment, tie-ins to the existing roadway, drainage modifications, and roadway demolition of the abandoned roadway segment. Additionally, the roadway shift towards the hillside would require acquisition of land and substantial earthwork to achieve a new alignment and roadway prism, including associated grading and potential retaining measures. This alternative is retained herein for comparative purposes relative to measures that may be implemented under CAP Section 14.

C -5.1.2 Alternative 2a – Starrucca Creek Channel Modification and Streambank Stabilization Utilizing Rip-rap

This alternative stabilizes the roadway shoulder with a layered rock riprap embankment and a constructed bench, with a stream realignment, that helps guide the active flow away from SR 1005. This alternative would restore the shoulder and foundation beneath the roadway prism by constructing a layered PennDOT Class R-3 and R-5 rock riprap filled embankment sloped at 2H:1V. The base layer of the embankment would be constructed with a keyed toe of PennDOT Class R-7 riprap and extend up to the 100-year water surface elevation. The rock filled embankment would be constructed on a stable slope cut and underlaid with geotextile filter. The sloped riprap embankment would extend approximately 270 feet and consist of riprap with a D_{50} ranging from 3 to 18 inches (consistent with the specified PennDOT riprap classes). The existing guide rail and one lane of traffic would need to be removed and reconstructed. At the base of the slope, a 10 foot wide bench would be constructed at the bank full elevation to reduce localized scour potential near the toe and to provide a more stable transition between the armored bank and the active channel. The gravel bar would be removed to realign the stream to its historical alignment and the stream banks and bed would be reinforced with a nominal 18-inch layer of PennDOT Class R-5 underlaid with a geotextile filter. The conceptual typical cross section for Alternative 2a is shown on Exhibit C-1.

C -5.1.3 Alternative 2b – Starrucca Creek Channel Modification and Streambank Stabilization Utilizing Rip-Rap and Retaining Wall

Alternative 2b stabilizes the roadway shoulder with a layered rock riprap embankment similar to 2a but incorporates a cambered stone wall element at the base to reduce the lateral footprint required for construction. This alternative would restore the shoulder and foundation beneath the roadway prism by constructing a layered PennDOT Class R-3 and R-5 rock riprap filled embankment sloped at 2H:1V with a 1H:3V cambered

stone wall at the base starting at the 100-year water surface elevation down to the scour depth. The riprap embankment with cambered stone wall would extend approximately 200 feet and consist of riprap with a D_{50} of 3 to 9 inches and large stone boulders with the longest dimension at least 72 inches, and at least 50 percent of the volume of the stone having a least dimension of 24 inches. The least dimension of the stone shall be greater than 33 percent of the longest dimension. Stone for stone fill shall be approved, hard, cut or blasted, with stackable faces. The gravel bar will be removed to realign the stream to its historical alignment and the stream banks and bed would be reinforced with a nominal 18-inch layer of PennDOT Class R-5 underlaid with a geotextile filter. Relative to Alternative 2a, this concept achieves a similar hydraulic intent, redirecting the active flow away from the roadway, while substituting a structural toe configuration for the full-width bench to reduce the lateral construction footprint. The conceptual typical cross section for Alternative 2b is shown on Exhibit C-2.

C-5.2 Alternatives Evaluation and Selection

The alternatives were evaluated for their ability to address the observed instability mechanisms at SR 1005, reduce near-term risk to the roadway prism and roadside safety features, and provide a constructible and maintainable configuration that can be implemented within the anticipated constraints of right-of-way, permitting, and construction access. In addition to technical performance, comparative feasibility factors considered during screening included anticipated footprint, relative construction complexity and traffic control implications, and rough order of magnitude cost (Table 2).

Alternative 1 (relocation of SR 1005) was examined during the FID phase and was screened out from further development for this CAP 14 action because it introduces a substantially larger real estate and environmental footprint than a targeted stabilization measure at the site. Although shifting the roadway away from the creek can reduce long-term exposure to bank migration if sufficient setback is achieved, the alternative would require new alignment construction, extensive earthwork, and likely protracted coordination for right-of-way acquisition and permitting. The associated schedule and cost burden would be disproportionate to the focused nature of the documented instability at the project reach, and it would not provide the timely risk reduction needed given the active erosion condition. Consistent with the feasibility-level comparison, the roadway relocation alternative also carried the highest rough order of magnitude cost estimate (Table 2: \$4.6M).

Alternatives 2a and 2b both directly address the primary instability driver at the site by removing the gravel bar accumulation and realigning the active channel away from the roadway-side bank, while providing robust armoring and reconstruction of the embankment supporting the roadway shoulder. The principal distinction between the two concepts is the means by which toe stability and scour resistance are provided at the base of the armored slope. Alternative 2a accomplishes this through a sloped riprap embankment with a constructed bench at the bank full elevation, which broadens the

section and reduces the potential for localized toe scour and undermining. This approach relies on conventional grading and stone placement methods, provides a straightforward transition between the stabilized bank and the active channel, and is generally favorable for constructability and long-term maintenance. The tradeoff is that Alternative 2a requires sufficient lateral space to construct the 2H:1V slope and bench while maintaining roadway functionality and accommodating the required reconstruction of the guide rail and shoulder. Based on the feasibility-level estimate, Alternative 2a also represents the lowest rough order of magnitude cost.

Alternative 2b was developed to reduce the lateral footprint by replacing the full-width bench configuration with a cambered stone toe-wall element at the base of the embankment. Where right-of-way constraints, adjacent features, or geometric limitations restrict the available width for grading, the toe-wall concept can be advantageous by achieving comparable bank protection within a narrower section. Although the concept was developed using common streambank stabilization approaches and a generally conventional structural geometry and stone material, the proposed section would also function as a roadway embankment support element rather than solely a bank armor system. As a result, additional internal stabilization or reinforcement measures, such as geosynthetic reinforced soil (GRS), select backfill zones, or other engineered reinforcement and drainage details, may be required to ensure the section provides adequate load-carrying capacity and deformation control for the roadway prism and associated roadside features. The potential need for these additional structural elements, in combination with more demanding foundation preparation, tighter placement tolerances, and heightened reliance on toe and transition performance under scour conditions, increases construction complexity and performance sensitivity relative to Alternative 2a. Collectively, these factors increase construction risk and would be expected to increase cost relative to a purely armored slope with bench; consistent with the feasibility-level comparison, Alternative 2b carries a higher rough order of magnitude cost.

Based on the comparative evaluation, Alternative 2a was selected as the preferred alternative. Alternative 2a provides direct, durable mitigation of the observed erosion and embankment loss mechanism through channel realignment and a robust riprap embankment with a bench that reduces toe scour susceptibility, while remaining comparatively straightforward to construct and maintain. It also achieves the lowest rough order of magnitude cost among the action alternatives considered and avoids the expanded real estate and coordination burden associated with relocating SR 1005.

C -6. Recommended Design Concept

The Recommended Design Concept is a combined streambank protection and roadway-embankment restoration design intended to arrest active erosion on the Starrucca Creek right bank adjacent to SR 1005, reestablish a stable roadway prism at the outside edge of pavement, and restore roadside safety performance at the guiderail line by rebuilding the shoulder/deflection area that has been lost. The recommended plan is illustrated on Exhibits C-3 through C-5, including the detailed typical section (Exhibit C-3), plan view layout (Exhibit C-4), and design cross sections (Exhibit C-5).

The recommended design concept restores the SR 1005 left 9-foot travel lane with a 2-foot shoulder and guiderail near the outside edge. The roadway edge is reconstructed using PennDOT No. 2A subbase at the shoulder/embankment interface to reestablish the roadway prism and provide a stable platform foundation beneath the shoulder. Rebuilding the outside shoulder and its supporting embankment reestablishes the functional mass needed for the rail system to perform as intended.

The recommended design concept includes benching of the existing degraded embankment to create a stable cut face and a bonding interface for the reconstructed rockfill/armored embankment, with a minimum bench width and step height equivalent to a 1.5H:1V slope cut. This benching is a standard PennDOT “merge benching” practice used to prevent sliding along the old/new interface by creating mechanical interlock and improving compaction and bonding of new fill to existing slope materials.

The armored embankment is configured as a riprap-lined revetment on an approximate 2H:1V slope. The recommended design concept uses a zoned riprap system to match constructability and anticipated hydraulic demand, with larger stone at the most hydraulically stressed locations and smaller stone where demands are lower and interface with the roadway prism is required. Specifically, the typical section will use PennDOT Class R-3 riprap in the upper zone beneath/adjacent to the shoulder restoration, PennDOT Class R-5 riprap across the mid-slope, and PennDOT Class R-7 riprap at the toe, where near-bank velocities, turbulence, and local scour potential are expected to be highest.

The PennDOT Class R-7 riprap armor height is shown extending to approximately 1.5 feet above the 100-year water surface elevation (WSE_{100}) to provide a practical freeboard margin above the design flood elevation for turbulence, localized acceleration, and uncertainty inherent to feasibility-level hydraulics. Additionally, the recommended design concept incorporates an embedded toe key with an embedment depth of 4 feet and a toe base width of 8 feet minimum. This embedded toe is intended to prevent unraveling, slope flattening, and progressive loss of the section due to toe undermining during large events and post-event drawdown. At the slope/stream interface, the design includes an approximately 10-foot-wide bench armored with PennDOT Class R-5 riprap to resist local bed reworking near the toe and provide a

durable, constructible transition between the stabilized bank and the streambed. The concept realigns the channel by removing and regrading the gravel bar to move flow away from the roadway-side bank and back to the historical alignment.

A PennDOT geotextile (Class 4, Type A) is shown beneath the riprap and at designated interfaces to function as a separator and filter, preventing migration of embankment fines into riprap voids while allowing seepage relief through the armor. Geotextile selection is consistent with PennDOT Publication 408 requirements, including Section 735 (Geotextiles) and the applicability identified in Section 850 (Rock Lining) Table 850.2(a)2, which allows Class 4, Type A geotextile for riprap placement up to PennDOT Class R-8. Placement and overlaps will follow PennDOT Section 212 (Geotextiles). PennDOT specifications provide both material applicability and placement requirements for geotextile used for layer separation and erosion control, including surface preparation, overlap requirements, and placement of cover material by back-dumping and spreading to prevent damage or tensioning of the fabric.

At feasibility level, riprap class zoning was guided using PennDOT permissible shear stress and permissible velocity criteria for channel linings. PennDOT Publication 584 (Drainage Manual) provides allowable unit shear stresses for riprap linings by class, including R-3 = 1.0 lb/ft², R-5 = 3.0 lb/ft², and R-7 = 5.0 lb/ft², along with permissible velocities. The summary results from a HEC-RAS model of Starrucca creek, the velocity is approximately between 6-7 feet per second for the 100-year event with a max shear stress of approximately 5.0 lb/ft² at a cross section near the proposed revetment.

C -7. Preconstruction Engineering and Design (PED) Considerations

During PED, the feasibility-level Recommended Design Concept will be advanced to a biddable PS&E package by reducing the key technical uncertainties and by translating the concept into PennDOT standard construction details, specifications, and project-specific inspection/QC requirements. PED should, at a minimum, confirm survey and mapping needs, lock the hydraulic and geotechnical design bases, and translate the concept into buildable staging, access, and traffic control requirements.

The non-Federal sponsor completed a topographic survey of the project area and established a control framework that can be carried forward into PED; however, the PED team should confirm that all work, including temporary access, work areas, and spoil/stockpile areas, fit within existing ROW or that temporary easements are defined, acquired, and mapped.

At feasibility, the riprap zoning/freeboard concept was guided using permissible shear stress/velocity screening and HEC-RAS results. PED should lock the hydraulic design basis by verifying the WSE₁₀₀ at the revetment and tie-ins and confirming that extending

the R-7 armor to ~1.5 ft above WSE_{100} remains appropriate once the final hydraulics are run using final geometry, roughness assumptions, and boundary conditions. Additionally, PED should confirm the channel realignment and define any required grade control or transitions at the upstream and downstream tie-ins, including any bed/bank transition treatments needed to prevent knickpoints, local scour at ends, or adverse headcutting that could undermine the revetment limits.

Because the Recommended Plan relies on benching into an existing, degraded roadway embankment and constructing an armored rockfill section that must remain stable under flood drawdown and traffic loading, PED should include exploration to characterize existing embankment materials and thickness, identify unsuitable/erodible layers at the toe and within the slope, evaluate groundwater/seepage conditions that could drive piping or wet-slope instability behind the revetment, and confirm bed/bank materials in the toe-key excavation zone. During PED, the geotechnical design will confirm geotextile survivability for the anticipated riprap size and placement methods; if more severe installation conditions are expected, the geotextile will be upgraded.

Because the project purpose includes restoring the guiderail deflection/backup area, the final plans should confirm guiderail offset, length-of-need, end treatment type, and grading behind/around the rail consistent with PennDOT roadside design expectations for crashworthy terminals and anchorage.

The Recommended Plan will require temporary construction access to both banks of Starrucca Creek to support gravel bar removal and channel grading. A temporary ramp and access route, with a stabilized construction entrance, should be detailed in the E&S plan to prevent tracking and sediment export, including stabilization at access points and prompt removal of sediment deposited on SR 1005. A temporary stream crossing will be needed to access the left bank for gravel bar excavation and channel work; during PED the crossing type should be selected and fully detailed, including approaches, and inspection/maintenance requirements.

The Recommended Plan will require temporary construction access to both banks of Starrucca Creek to support gravel bar removal and channel grading. A temporary ramp and access route, with a stabilized construction entrance, should be detailed in the E&S plan to prevent tracking and sediment export, including stabilization at access points and prompt removal of sediment deposited on SR 1005. A temporary stream crossing will be needed to access the left bank for gravel bar excavation and channel work; during PED the crossing type should be selected and fully detailed, including approaches, and inspection/maintenance requirements. A construction staging/laydown plan is required and should be incorporated into the E&S drawings and specifications. Two areas have been identified, a temporary area near the stream (usable only during active construction hours or if approvals/permit conditions allow extended use), and a primary staging area on/near the roadway prism.

Because the work includes gravel bar removal and channel grading, PED should include a practicable in-channel isolation and flow-management approach, using cofferdams and/or pump-around diversion, with clear sequencing, monitoring requirements, and contingency actions for rising flows. The PED package should clearly define a staged approach consistent with the plan intent to re-align flow away from the roadway bank and then construct the armored embankment/bench system. At feasibility, the following preliminary construction sequencing was developed:

- Stage 1 – Left bank isolation and channel preparation - Install initial E&S controls and access features; construct the temporary crossing/ramp; then install a cofferdam to isolate the left bank and establish dry or low-velocity working conditions. During this stage, remove/regrade the gravel bar and rough-grade the new/realigned channel alignment.
- Stage 2 – Right bank isolation, flow diversion, and embankment construction - Shift cofferdam/isolation to protect the right bank work zone and divert flow into the newly graded alignment. Construct the roadway embankment restoration including the benched excavation/backfill sequence, installation of geotextile, and placement of riprap layers and toe/bench armoring as detailed.
- Stage 3 – Restoration and demobilization - Remove temporary diversion features and the stream crossing as soon as practicable; stabilize all disturbed areas; and complete roadway/shoulder and guide rail restoration.

Consistent with CAP 14 constructability practices used on similar roadway embankment stabilization projects, PED should specify short, sequential excavation/backfill increments and require immediate placement of separation/filter materials and stone after exposing the embankment cut face, rather than leaving long open excavations. Final design should convert the benching concept into buildable limits that maintain slope stability and minimize exposure of unsupported cuts.

Because construction will occur immediately adjacent to SR 1005 and will require heavy equipment operation, hauling, and intermittent removal/restoration of roadway-side elements, PED should include a traffic control plan that supports full roadway closure during the in-channel work and embankment reconstruction. The traffic plan should address detour signing, maintenance of safe access for emergency response, and work zone device visibility/maintenance requirements consistent with PennDOT construction specifications for traffic accommodation and detours. The low traffic volumes documented for SR 1005 support feasibility of a closure/detour approach, but PED should still coordinate detour routing with PennDOT District, local responders, and the municipality.

C -8. References

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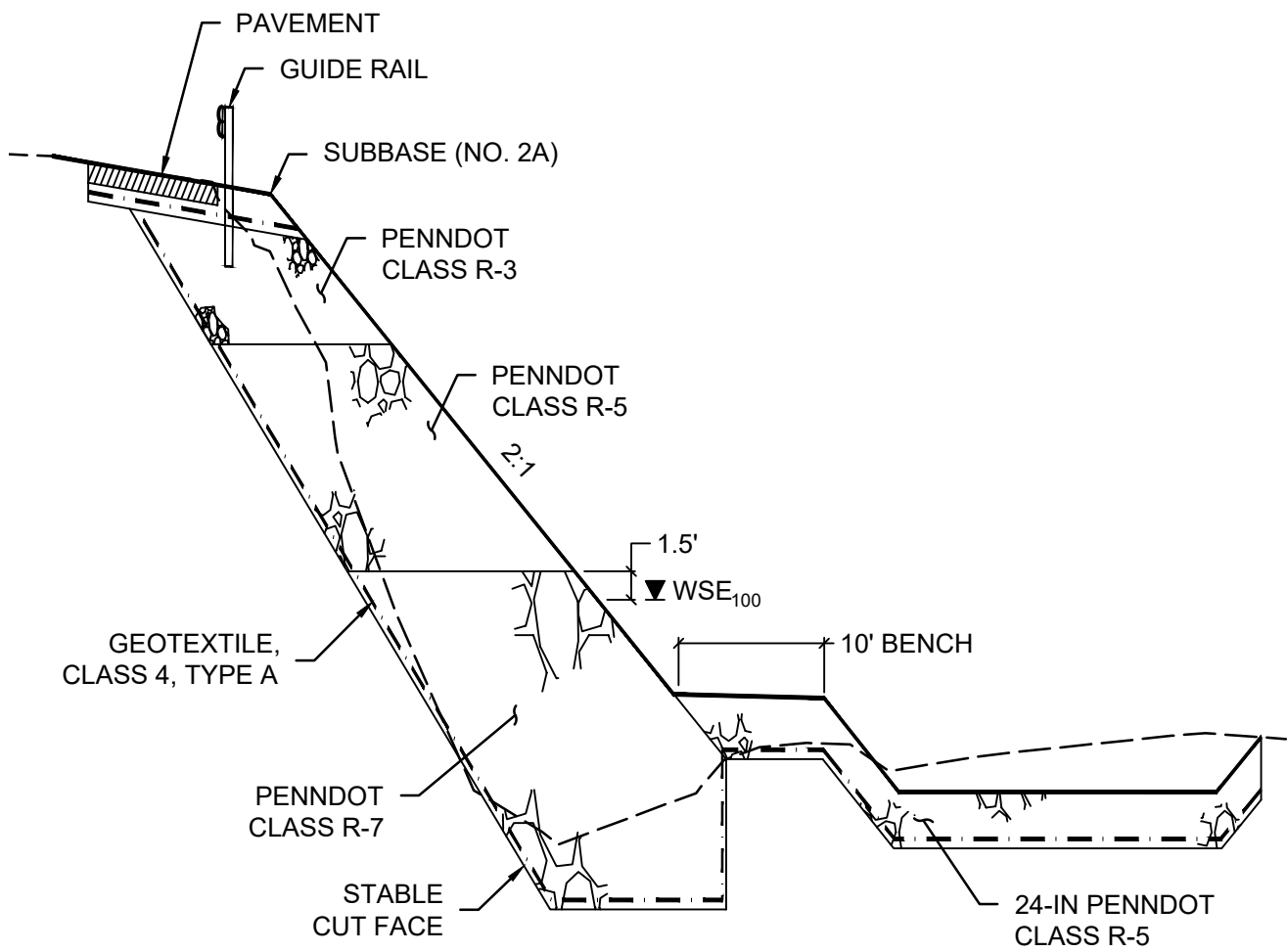
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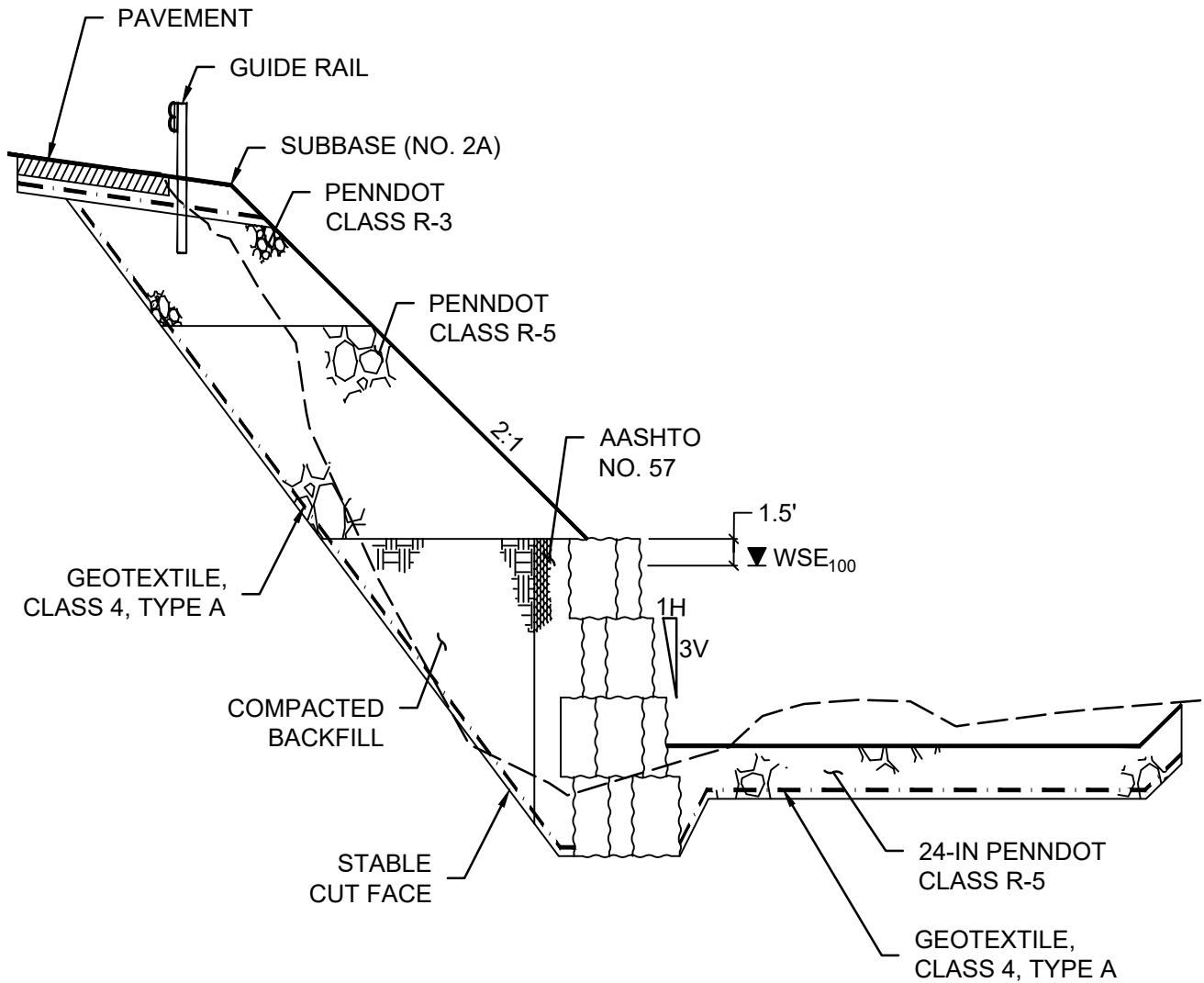
**US Army Corps
of Engineers**

ALTERNATIVE 2A: CONCEPTUAL TYPICAL CROSS SECTION

CONTINUING AUTHORITIES PROGRAM SECTION 14
 PA SR 1005 - STARRUCCA CREEK
 STREAMBANK AND EMBANKMENT
 PROTECTION OF PUBLIC FACILITIES
 SUSQUEHANNA COUNTY PENNSYLVANIA

EXHIBIT:

C-1



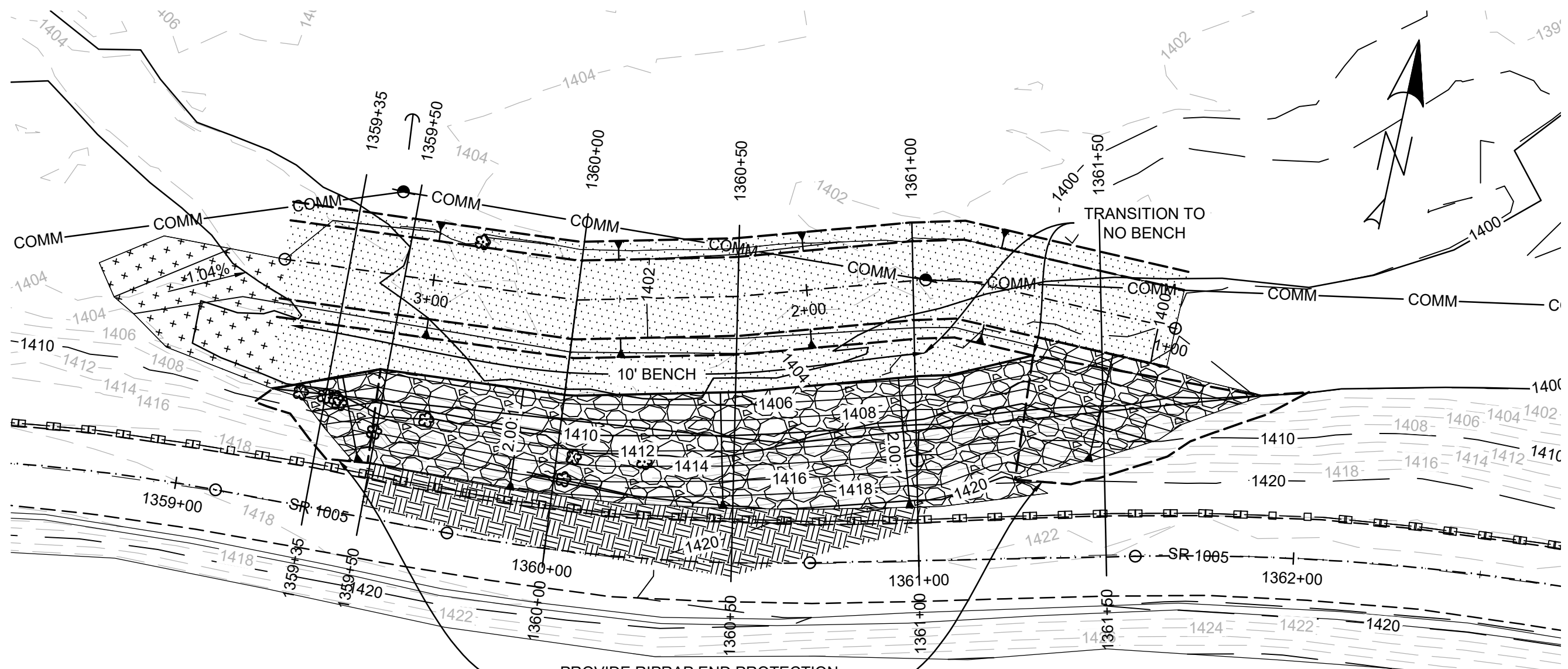
**US Army Corps
of Engineers**

ALTERNATIVE 2B: CONCEPTUAL TYPICAL CROSS SECTION

CONTINUING AUTHORITIES PROGRAM SECTION 14
 PA SR 1005 - STARRUCCA CREEK
 STREAMBANK AND EMBANKMENT
 PROTECTION OF PUBLIC FACILITIES
 SUSQUEHANNA COUNTY PENNSYLVANIA


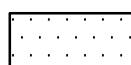

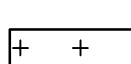
EXHIBIT:

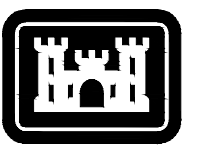
C-2



PROVIDE RIPRAP END PROTECTION AND TIE-INS IN ACCORDANCE WITH EM 1110-2-1601 TO PREVENT FLANKING.

LEGEND

-  ROCKFILL SLOPE
-  STONE STABILIZED STREAM
-  ROADWAY RECONSTRUCTION
-  REGRADED SWALE AREA

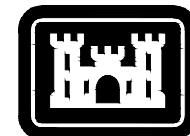


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 SUSQUEHANNA COUNTY PENNSYLVANIA

U.S. ARMY CORPS OF ENGINEERS
 BALTIMORE DISTRICT
 RECOMMENDED PLAN:
 PLAN VIEW

EXHIBIT:
C-4



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CONTINUING AUTHORITIES PROGRAM SECTION 14

PA SR 1005 - STARRUCCA CREEK
STREAMBANK AND EMBANKMENT
PROTECTION OF PUBLIC FACILITIES

SUSQUEHANNA COUNTY PENNSYLVANIA

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

RECOMMENDED PLAN:
DESIGN CROSS SECTIONS

EXHIBIT:

C-5

