



***BRIDGE ON ROUTE 3
OVER RAPPAHANNOCK RIVER
(ROBERT O. NORRIS JR. BRIDGE)***

Middlesex and Lancaster Counties, Virginia

***CONCEPT STUDY FOR
SUPERSTRUCTURE REPLACEMENT***

EXECUTIVE SUMMARY

September 2017

PREPARED BY
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Roanoke, Virginia

PREPARED FOR
Virginia Department of Transportation

Executive Summary

The Robert O. Norris Jr. Bridge carries Route 3 over the Rappahannock River between Middlesex and Lancaster counties. As the structure enters its seventh decade of service, the Virginia Department of Transportation has initiated planning for future requirements to address physical and functional deficiencies in the structure. As a part of the planning process, the Department commissioned AECOM to study concept alternatives for replacing the bridge superstructure as a bridge rehabilitation alternative. The superstructure alternatives were contrasted with several total bridge replacement alternatives.

This report summarizes the development of concept alternatives for superstructure replacement and presents the results of a comprehensive evaluation of these alternatives. The scope of this study includes development and evaluation of potential alternative concepts for replacement of the bridge superstructure, based on several criteria and considerations as outlined in Section 2, and considering several structure types as reviewed in Section 3.

The Route 3 Bridge, also known regionally as the Norris Bridge, was constructed in 1957 and carries an average daily traffic of 8,208 vehicles per weekday and 6,326 vehicles per weekend day. The Norris Bridge is 9,985-feet long with a bridge deck width of 23-feet curb-to-curb and 26-feet out-to-out. Its channel span provides 110-foot vertical and 300-foot horizontal clearance for marine navigation.

Preliminary evaluation of the existing approach and channel span piers indicates that the existing piers may be reused with some strengthening and modifications. The condition of the existing piers in the beam and girder spans is unfavorable for supporting a replacement superstructure, so this study also considers the complete replacement of these piers.

The overhead electric utility currently supported by the existing bridge will require temporary relocation during construction of any superstructure replacement. Consideration of supporting the electrical line through under-deck conduits is included in all alternative concepts. Impacts to natural and cultural resources will require coordination with regulatory agencies. The environmental impacts of each superstructure replacement alternative are considered reasonably similar for comparison purposes. Impacts to navigation clearance over the river will require coordination with U.S. Coast Guard.

Due to the lack of an acceptable detour route, impacts to traffic during construction presents a significant challenge to the project. The scale of a superstructure replacement project and lack of functional detour prompted consideration of rapid replacement construction methods, of which several alternatives are evaluated as outlined in Section 4. This evaluation concluded that the preferred construction method for rapid replacement includes construction of the new superstructure on temporary foundations located on an alignment offset immediately adjacent to the existing. Once the bridge superstructure construction is complete on the offset alignment, traffic may be moved to the new deck by use of temporary diversion ramps at each end of the bridge. This enables an extended schedule for deconstruction of the old bridge and modification of the existing piers before slide in.



The Department's previous project to replace the superstructure of the U.S. Route 17 Bridge over York River (known as the George P. Coleman Memorial Bridge) in 1996 provides some perspective for rapid replacement options. The Coleman Bridge is a swing span bridge adjacent to the Yorktown National Park, site of the final battle of the American Revolution. With the substructure in good condition, replacement of the Coleman Bridge superstructure with another swing span configuration was chosen to minimize impacts on this adjacent historic resource and maintain access for naval and commercial marine traffic. The project scope was prepared to allow two 12-day road closures. The contractor eventually elected to float out sections of the old bridge and float in sections of the new bridge on construction barges. The new Coleman Bridge spans are configured with the same configuration of joints and span interfaces as the old spans. This configuration permitted effective reuse of the complex barge support towers for both deconstruction of the original bridge and construction of the new superstructure.

In contrast to the Coleman Bridge, the Norris Bridge has no movable spans and it is approximately three times longer. The vehicular traffic on the Norris Bridge is much lower, there is no naval or significant commercial marine traffic on the Rappahannock River, and there are no sensitive historical resources nearby the project site. The Norris Bridge includes spans of varying configuration and elevation, with pinned hangers in most spans, which results in less efficient construction sequence and precludes cost-effective reuse of the complex barge support towers required for float in operations.

Among a variety of superstructure replacement concepts initially considered, seven superstructure replacement alternatives were developed and evaluated. These alternatives are described in detail in Section 5 of this report. These alternatives were developed to provide a desirable structure width, but in order to minimize project costs, the minimum structure width required by VDOT Structure and Bridge geometric criteria is used. The two most feasible superstructure replacement alternatives are summarized below, followed by a table which summarizes the conceptual cost estimate data for each alternative.

Alternative D1 provides for rapid replacement of the superstructure using the construction methods noted above, to reduce the duration of road closure to a few weeks and minimize the impacts to users. The curb-to-curb width is established as 30 feet in all spans. The beam and girder spans are replaced with prestressed concrete girders on new substructure. The approach and channel spans are replaced with continuous steel deck truss spans, which are fracture critical. This alternative assumes that the navigation channel vertical clearance may be reduced to 75 feet, which requires U.S. Coast Guard approval.

The costs summarized in the table below indicate that the use of rapid replacement construction methods at the Norris Bridge increase the construction costs by a significant proportion. This is exacerbated by the unfavorable subsurface conditions and the high cost of the temporary foundation construction. This cost increase is proportional to the cost premium experienced for the construction methods used for the rapid replacement of the Coleman Bridge.



Alternative F provides replacement of the superstructure using more conventional construction methods for the least cost. Conventional construction requires that the bridge be closed to traffic for the duration of construction of approximately 4 years. The curb-to-curb width is 30 feet in all spans. The beam and girder spans are replaced with prestressed concrete girders on new substructure. The superstructure of the approach and channel spans is replaced with continuous steel plate girders in all spans except the navigation span, where a networked steel tied arch with a post-tensioned concrete tie is employed. Modifications to the existing piers are more extensive for this alternative but the superstructure is not fracture critical. This alternative assumes that the navigation channel vertical clearance may be reduced to 75 feet, which requires U.S. Coast Guard approval. At the time of this report, USCG coordination is ongoing, but if the vertical clearance cannot be reduced, the cost of Alternative F will increase by approximately \$2M.

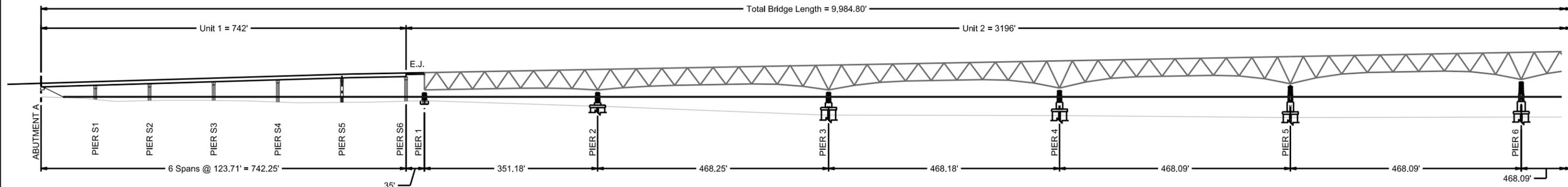
Given the high priority to minimize impacts to traffic during construction, and the high cost of completing a superstructure replacement project with rapid replacement construction methods, it is evident that complete replacement of the bridge on a new alignment should also be evaluated for comparison with the superstructure replacement alternatives. For comparative purposes, this report develops and evaluates several total bridge replacement alternatives. The most cost-effective complete replacement alternative is summarized below.

Alternative 7A provides for construction of a new bridge on a new alignment, approximately 100 to 200 feet upstream from the existing bridge, with a curb-to-curb width of 32 feet. The superstructure type consists of prestressed concrete girders and steel plate girders supporting a concrete deck. This alternative assumes that the navigation channel vertical clearance may be reduced to 75 feet, which requires U.S. Coast Guard approval. At the time of this report, USCG coordination is ongoing, but if the vertical clearance cannot be reduced, the cost of Alternative 7A will increase by approximately \$2M. By constructing on a new alignment, the impacts to traffic during construction would be minimal compared with other alternatives.

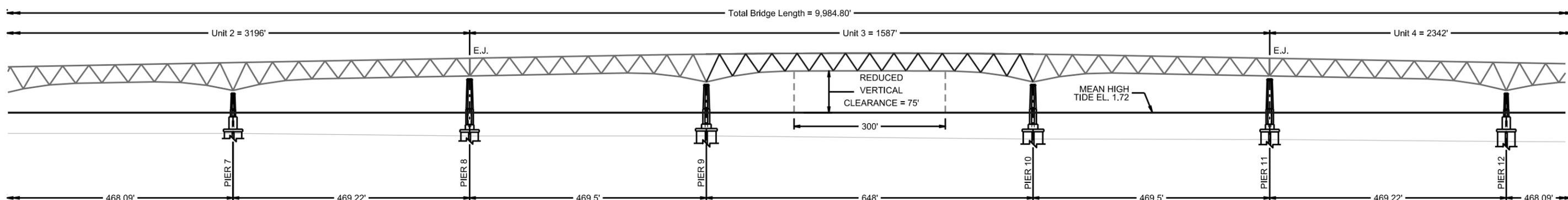
Conceptual Cost Estimates for Alternatives

Component	Superstructure Replacement Alternative D1	Superstructure Replacement Alternative F	Total Replacement Alternative 7A
Bridge Superstructure	\$71	\$108	\$53
Bridge Substructure	\$19	\$27	\$98
General Items	\$15	\$17	\$21
Temporary Works for Rapid Replacement	\$148	-	-
Contingency	\$51	\$30	\$26
Project Development & Administration	\$46	\$54	\$60
Total Cost (present day \$)	\$349M	\$237M	\$258M
Fracture Critical Structure	Yes	No	No
Road Closed to Traffic	15 days	4 years	Not required

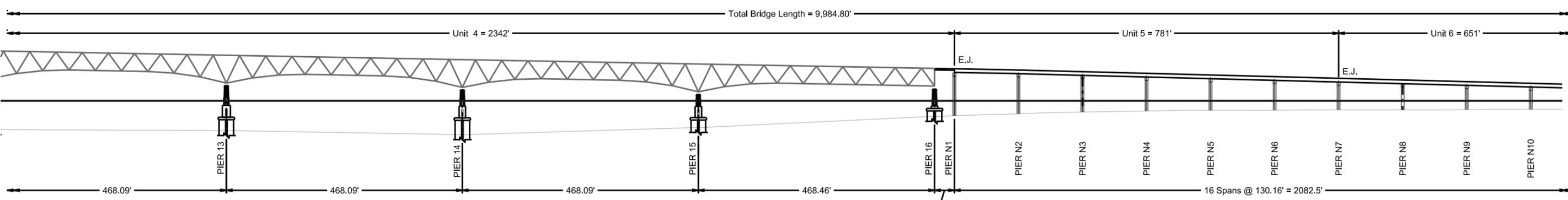
In conclusion, **Alternative 7A** for complete bridge replacement on a new upstream alignment results in a longer service life with less maintenance costs than the alternatives that reuse significant portions of the existing substructure with a new replacement superstructure. This alternative is also considered to offer the most optimal balance of costs and user impacts during construction.



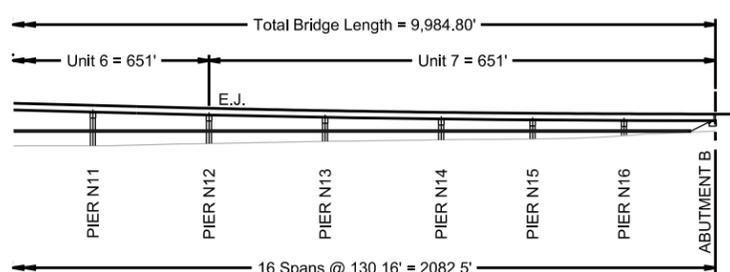
ELEVATION - ABUTMENT A THRU PIER 6



ELEVATION - PIERS 7 THRU 12



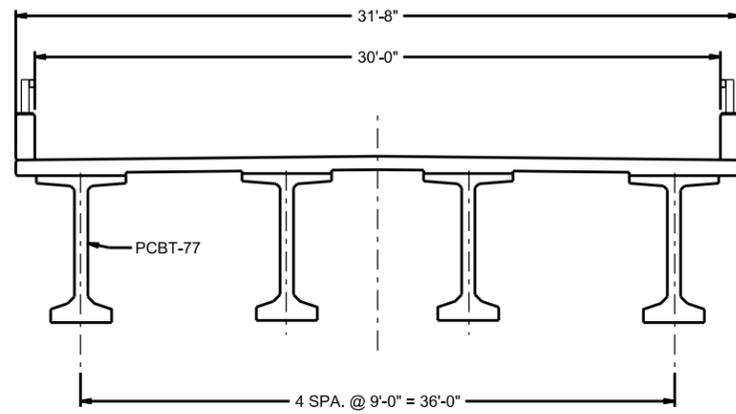
ELEVATION - PIERS 13 THRU N10



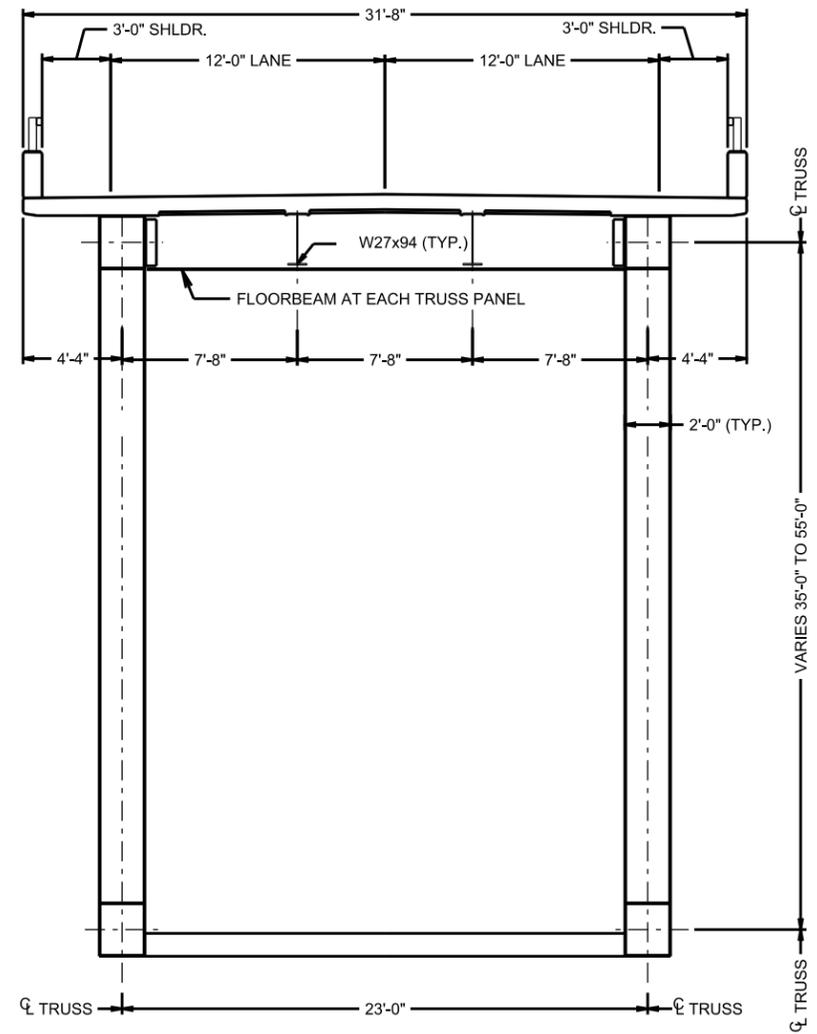
ELEVATION - PIER N11 THRU ABUTMENT B

- ALTERNATIVE KEY FEATURES**
- + Curb-Curb Width = 30 feet (3 ft shoulders)
 - + Complete replacement of existing beam and girder spans
 - + Superstructure replacement in truss spans using deck truss spans
 - + Fracture Critical
 - + Vertical Navigation Clearance = 75 feet
 - + Only short-term closure to traffic
 - + Total Cost = \$349M

<p>NORRIS BRIDGE OVER RAPPAHANNOCK RIVER SUPERSTRUCTURE REPLACEMENT CONCEPT STUDY</p>	
<p>PROPOSED ELEVATION ALTERNATIVE D1</p>	<p>DRAWING 5-12</p>

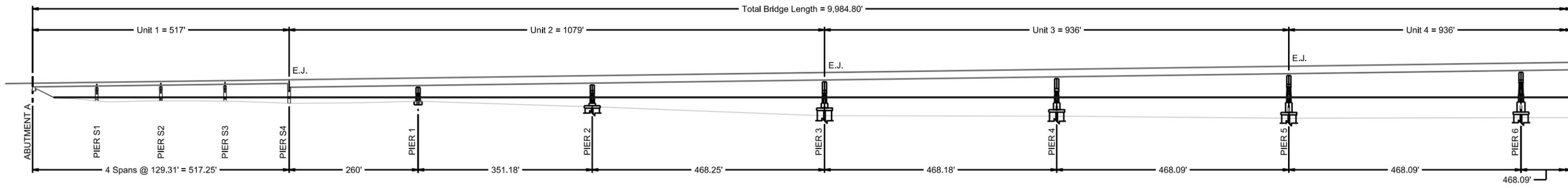


TYPICAL SECTION - BEAM & GIRDER UNITS

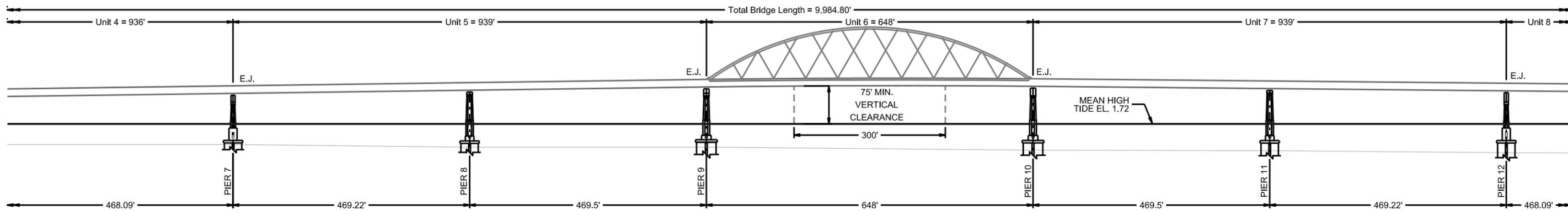


TYPICAL SECTION - DECK TRUSS
APPROACH & CHANNEL SPAN UNITS

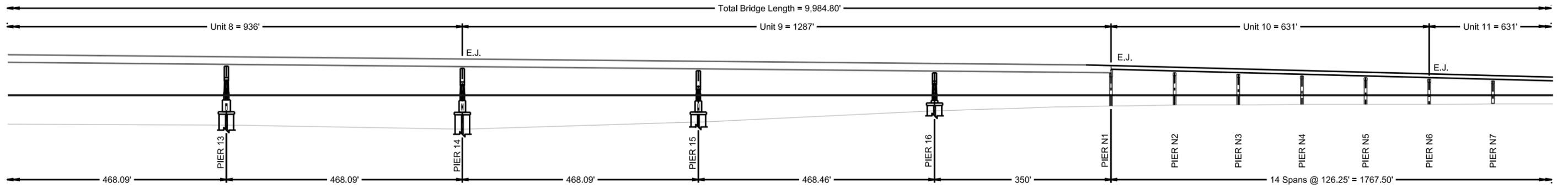
NORRIS BRIDGE OVER RAPPAHANNOCK RIVER SUPERSTRUCTURE REPLACEMENT CONCEPT STUDY	
PROPOSED DETAILS ALTERNATIVE D1	DRAWING 5-13



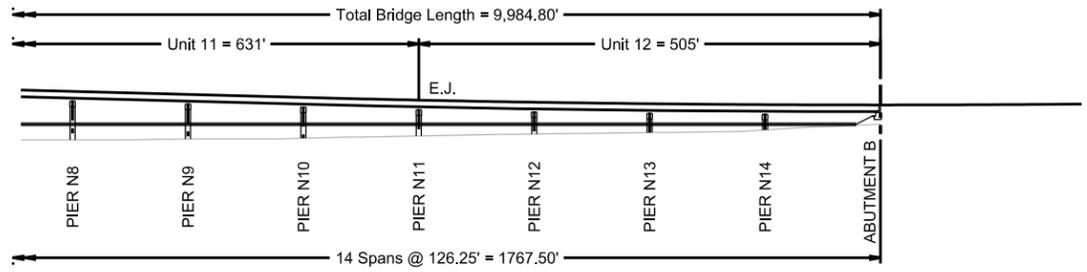
ELEVATION - ABUTMENT A THRU PIER 6



ELEVATION - PIERS 7 THRU 12



ELEVATION - PIERS 13 THRU N7



ELEVATION - PIER N8 THRU ABUTMENT B

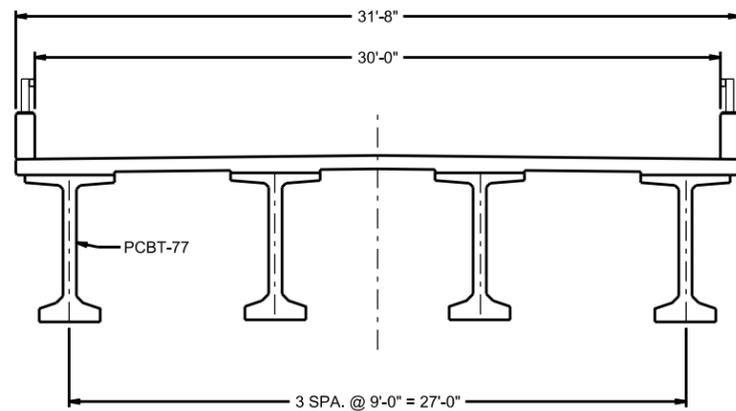
ALTERNATIVE KEY FEATURES

- + Curb-Curb Width = 30 feet (3 ft shoulders)
- + Complete replacement of existing beam and girder spans
- + Superstructure replacement in truss spans using steel girder spans, with arch span over channel
- + Not Fracture Critical
- + Vertical Navigation Clearance = 75 feet
- + Closed to traffic for duration of construction (4 years)
- + Total Cost = \$237M

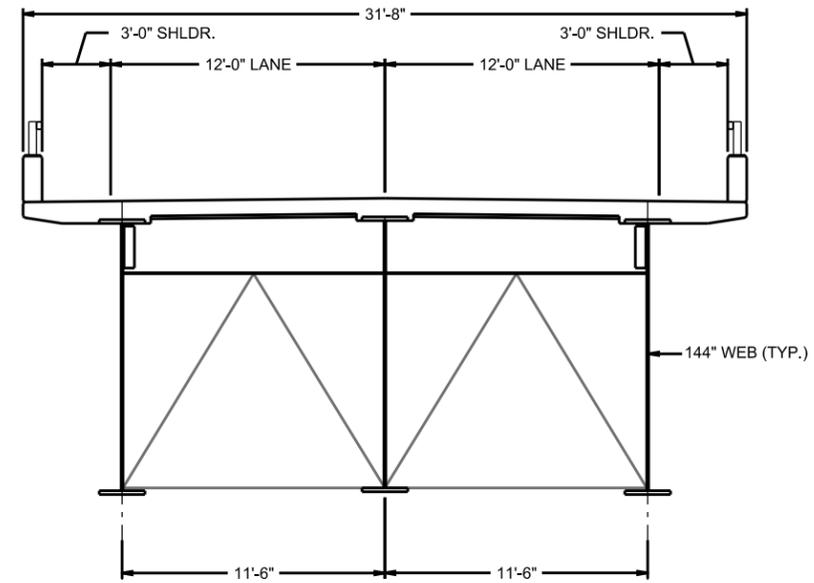
NORRIS BRIDGE OVER RAPPAHANNOCK RIVER
SUPERSTRUCTURE REPLACEMENT CONCEPT STUDY

PROPOSED ELEVATION
ALTERNATIVE F

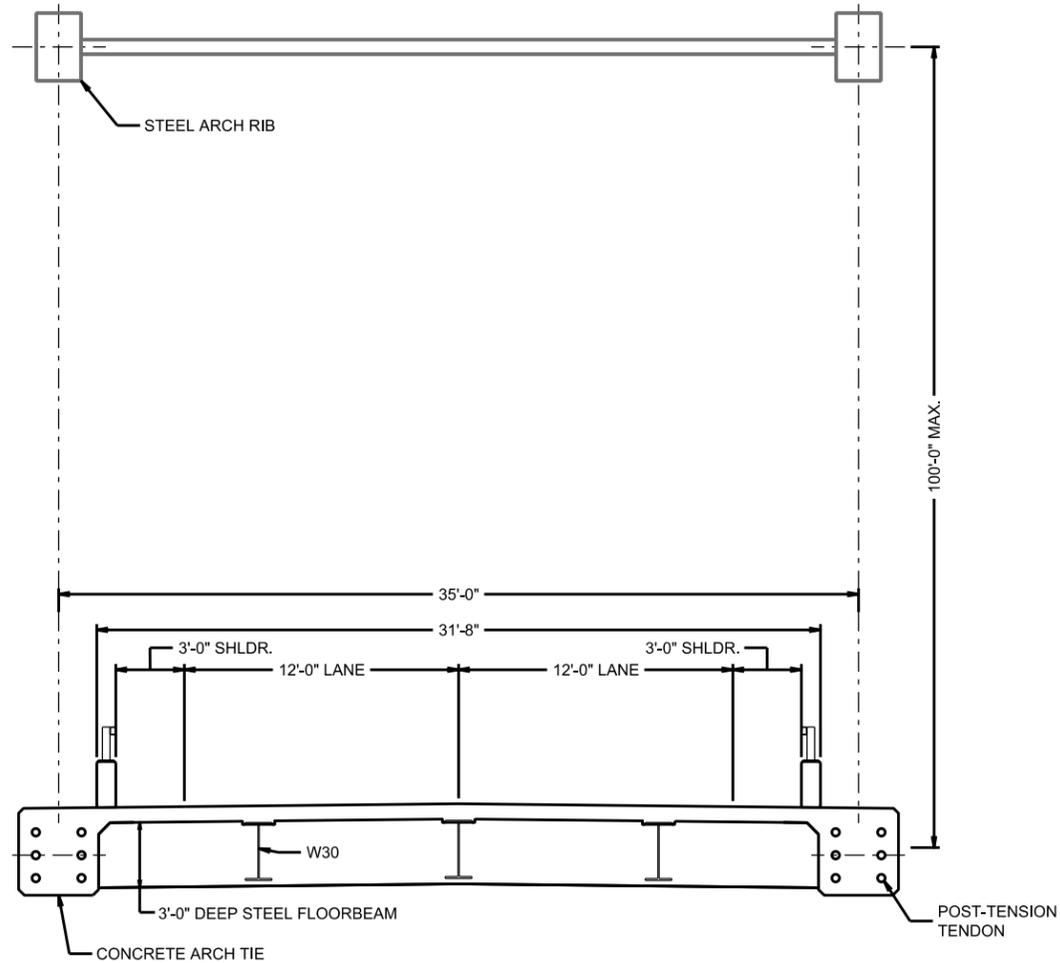
DRAWING
5-14



TYPICAL SECTION - BEAM & GIRDER UNITS

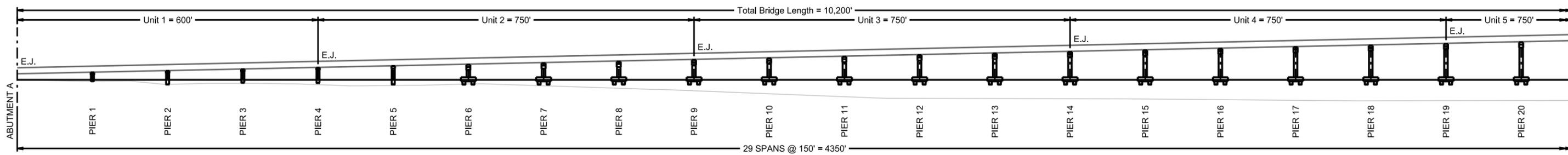


TYPICAL SECTION - STEEL PLATE GIRDER APPROACH UNITS

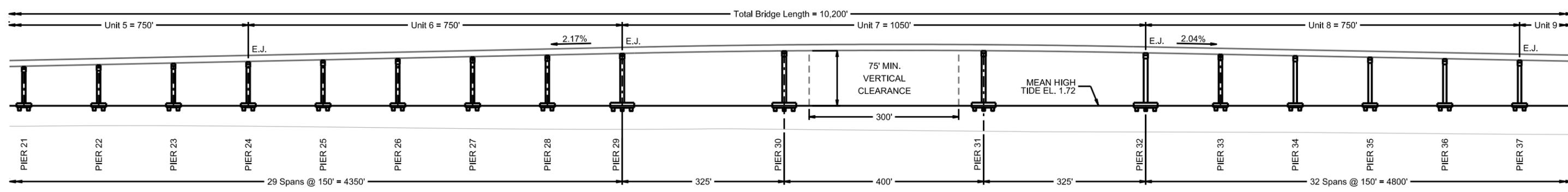


TYPICAL SECTION - TIED ARCH CHANNEL SPAN UNIT

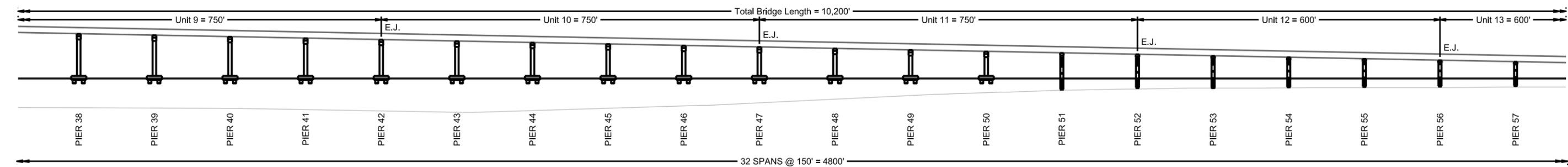
NORRIS BRIDGE OVER RAPPAHANNOCK RIVER SUPERSTRUCTURE REPLACEMENT CONCEPT STUDY	
PROPOSED DETAILS ALTERNATIVE F	DRAWING 5-15



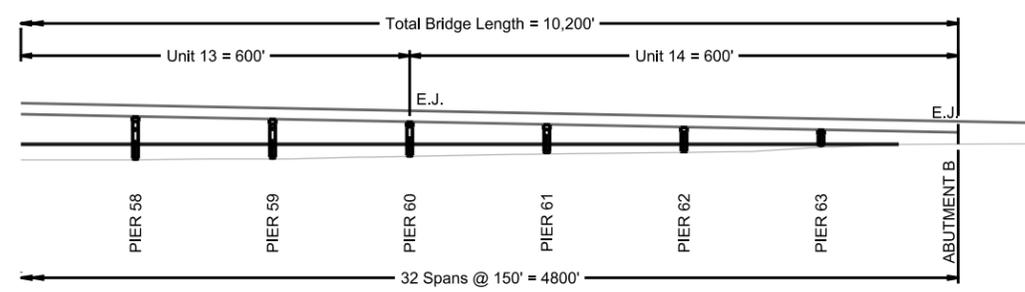
ELEVATION - ABUTMENT A THRU PIER 20



ELEVATION - PIERS 21 THRU 37



ELEVATION - PIERS 38 THRU 57



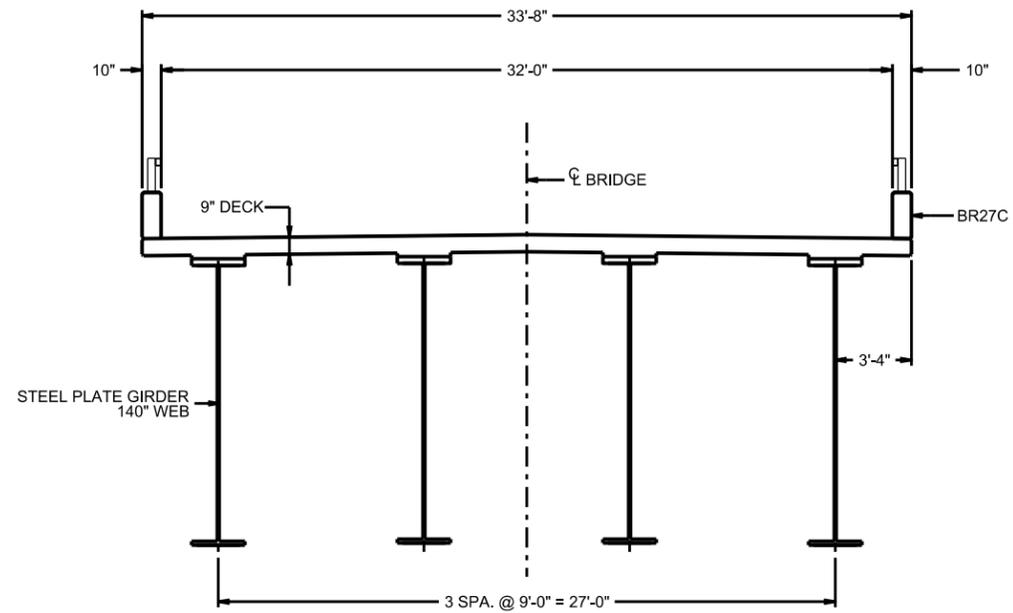
ELEVATION - PIER 58 THRU ABUTMENT B

- ALTERNATIVE KEY FEATURES**
- + Curb-Curb Width = 32 feet (4 ft shoulders)
 - + Complete replacement bridge on new upstream alignment
 - + Superstructure of prestressed and steel girders
 - + Not Fracture Critical
 - + Vertical Navigation Clearance = 75 feet
 - + Minimal disruption to traffic
 - + Total Cost = \$258M

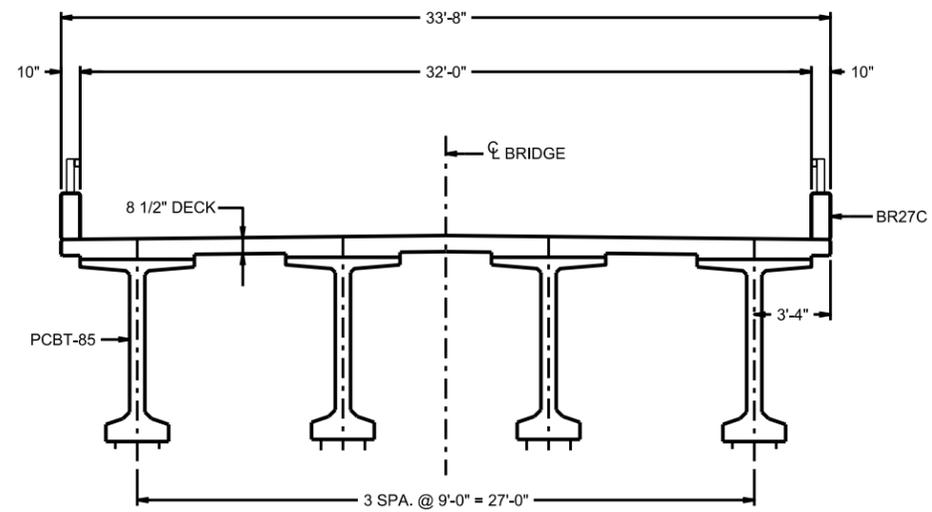
NORRIS BRIDGE OVER RAPPAHANNOCK RIVER
SUPERSTRUCTURE REPLACEMENT CONCEPT STUDY

PROPOSED ELEVATION
REPLACEMENT OPTION 7A

DRAWING
6-11



TYPICAL SECTION - 325' & 400'
CHANNEL SPANS UNIT



TYPICAL SECTION - 150'
APPROACH UNITS

NORRIS BRIDGE OVER RAPPAHANNOCK RIVER SUPERSTRUCTURE REPLACEMENT CONCEPT STUDY	
TYPICAL SECTIONS REPLACEMENT OPTION 7A	DRAWING 6-12