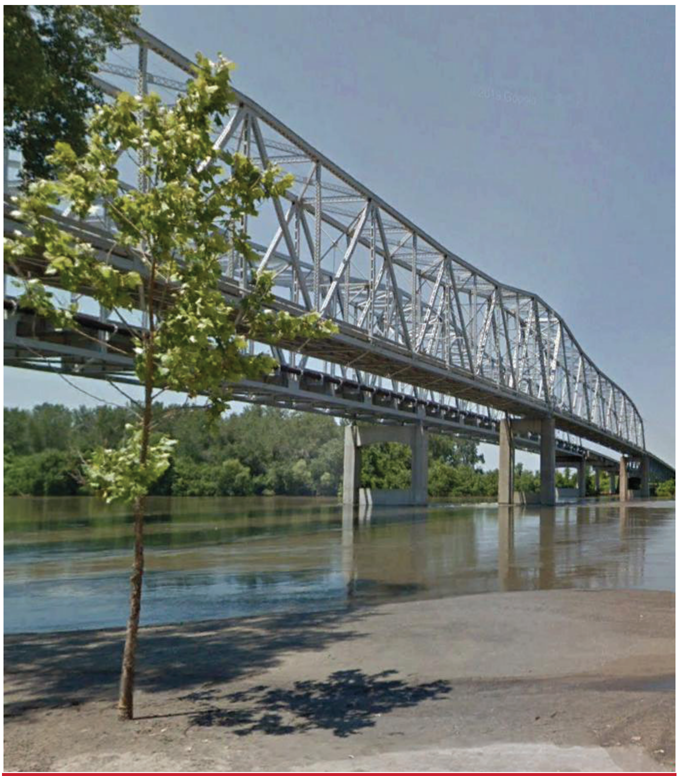

Final Feasibility Study Report

Superstructure Widening/Replacement or Complete Bridge Replacement of NB Rte. 291 over Missouri River

Jackson County

Bridge No. L0568

October 13, 2020

Prepared for:
Missouri Department of Transportation
Project No. J4P3471

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1 General

1.1 Bridge Description

Route 291 over the Missouri River comprises two parallel bridges for northbound (NB) and southbound (SB) traffic. The subject of this study is the NB bridge - L0568. Information is provided below for the SB bridge - A4757, as pertains to this study.

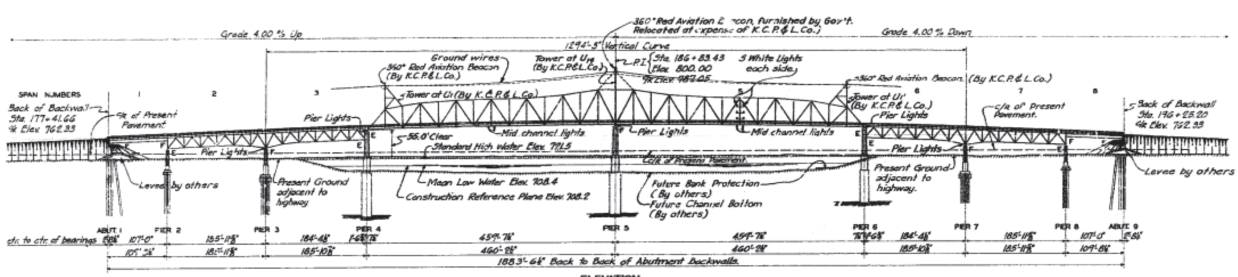
Northbound Rte. 291 – Bridge L0568

The NB lanes are carried on the original bridge, which was completed in 1949 and rehabilitated in 1984, 1986, 1995, 2001 and 2009. Repainting the bridge was included in the 2001 rehabilitation plans, but no painting note on the bridge was observed.

The roadway is 24 feet wide and is striped for two 11-foot lanes. The bridge is an 8-span structure, with approximate span lengths of 107’-185’-185’-460’-460’-185’-185’-107’. Both end spans are steel two-girder systems, with steel floorbeams supporting the concrete deck. Spans 2-3 and 3-4 are carried on a continuous, two-span steel deck truss. Spans 6-7 and 7-8 are carried on a similar continuous, two-span steel deck truss. Spans 4-5 and 5-6 are carried on a continuous, two-span steel thru-truss. Steel floorbeams and stringers support the concrete deck in all truss spans. The deck and barriers were replaced as part of the 2001 rehabilitation.

Concrete spill-through abutments are founded on concrete footings and piles driven to bedrock. Piers 2, 3, 7 and 8 are rectangular concrete columns with full-height web walls, supported on concrete footings and piles driven to bedrock. Piers 4 and 6 are rectangular concrete columns with partial-height web walls and intermediate and upper bearing beams, supported on a concrete pedestal on two round, concrete-filled caissons extending to bedrock. Pier 5 is rectangular concrete columns with a partial-height web wall, supported on a concrete pedestal above a rectangular concrete-filled caisson extending to bedrock.

Figure 1-1. Elevation of Northbound Bridge

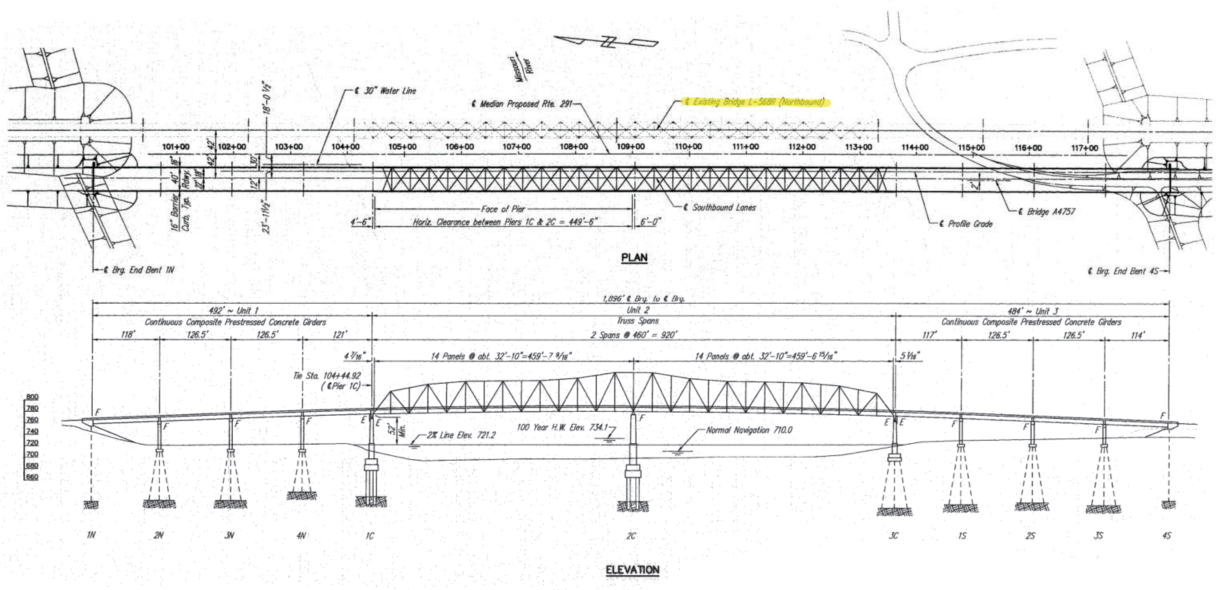


Southbound Rte. 291 – Bridge A4757

The SB bridge is a 10-span structure, with approximate span lengths of 117’-126’-126’-117’-460’-460’-121’-126’-126’-118’. The roadway is 40 feet wide, with 6-foot inside shoulder, two 12-foot lanes, and 10-foot outside shoulder. Clear distance between existing NB and SB structures is approximately 46 feet.

The main river unit is also a continuous, two-span steel thru-truss, with low chord elevation approximately 3 feet below low chord of the northbound bridge. The river piers of the SB bridge are offset approximately 34 feet to the south from the river piers of the NB bridge, aligning with the skew of the Missouri river. The approach units of the SB bridge have one more span than the NB bridge, therefore several of the approach piers are not aligned.

Figure 1-2. Plan and Elevation of Southbound Bridge

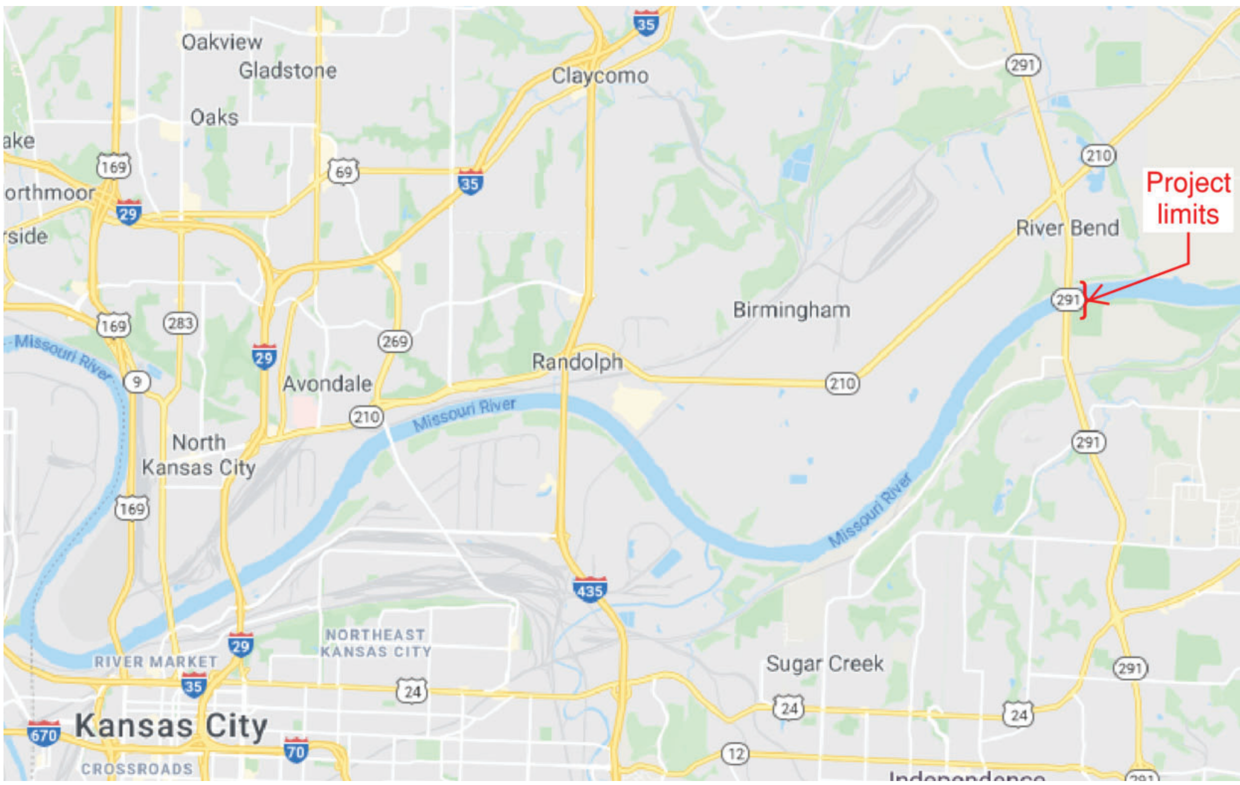


1.2 Location Map and Aerial Image

The bridge, also known as the Liberty Bend Bridge, is located on Route 291 between Sugar Creek, MO and Independence, MO, northeast of Kansas City, MO, as shown in Figure 1-3.

The marked navigation channel, shown in Figure 1-4. Project Aerial Image, runs between the northern set of river piers – NB piers 5 and 6, and SB piers 1C and 2C.

Figure 1-3. Project Location



Map from Google Maps.

Figure 1-4. Project Aerial Image

Image from Google Earth. Navigation channel and lights included in a kml file, loaded into Google Earth, obtained from US Army Corps of Engineers, Kansas City District website.

1.3 Project Scope and Goals

The scope of this project is to provide a conceptual level feasibility study that considers superstructure widening/replacement and complete bridge replacement for NB Rte. 291 (bridge L0568). The project includes four tasks:

1. Condition assessment and field visit – a site visit to conduct visual observation of the bridge condition, review of available bridge records, and condition assessment of the substructure elements in order to determine suitably of reuse and modification
2. Superstructure widening and replacement – determine maximum widening that is feasible while using the existing foundations, and level of substructure rehabilitation needed
3. Complete bridge replacement – conceptual level layout of new bridge that accommodates additional roadway width
4. Feasibility study report – a summary of the analysis, evaluation of the replacement alternatives, and best-value recommendation

The goal of the study is to provide a recommendation for the best-value alternative based on many factors, including:

- Estimated construction cost comparison
- Estimated life of the structure
- Environmental constraints/issues
- Operational improvements
- Durability
- Return on investment

It should be noted that the analysis used to estimate the scope and costs of the various alternatives, and to make broad recommendations in this report, is conceptual in nature. Many simplifying assumptions were made and extrapolations used to meet the goals of the study, while remaining within the scope and budget limitations of the project.

2 Condition Assessment and Field Visit

Field Visit Report Summary and Initial Recommendations

A field visit was conducted at the beginning of the study. Per the scope, the field visit was conducted by visual observation from the ground, for the purpose of assessing the general condition of the bridge. A report of the field visit and condition assessment was submitted under separate cover, dated April 3, 2020. A summary of preliminary recommendations from that field visit report is provided below.

1. Main river piers 4, 5, and 6 were observed to have previous repairs and further delaminations in the columns and tie beams. The recommendation is to remove the columns and tie beams down to the top of the pedestal wall, and rebuild these portions.
2. Approach piers 2, 3, 7, and 8 also have previous repairs and delaminations in the exposed upper portion of columns, web wall and cap. The pedestal wall and approximately half of the columns are completely buried underground; therefore the recommendation is to remove the top of pier to 2 to 3 feet below the existing construction joint, and rebuild these portions to the elevation required.
3. The existing end bents are recommended to be abandoned, replaced with new integral end bents on steel piles, and located to clear the existing structure.

Channel Scour

Scour and hydraulic analyses were not part of the project scope. It was noted from the reports of USGS bathymetric surveys executed in 2010, 2011, and 2015 that a significant scour hole is present around SB pier 2C and NB pier 5. The hole depth near NB pier 5 fluctuated between elevation 660 and 675, which is generally 25’ to 40’ below the 1946 design ground line. See Appendix A for the plot of bathymetric survey results.

3 Superstructure Widening and Replacement

The first portion of the project was a study of a replacement of the existing superstructure, including deck, barriers, expansion joints, steel girders, deck trusses, thru-truss, and bearings, with a new, potentially-widened superstructure supported on the existing substructure.

The conceptual replacement superstructure consists of composite steel girders in the main spans to match the existing substructure. Steel plate girder units and prestressed concrete girder units were considered for the approach spans.

3.1 Selected Options

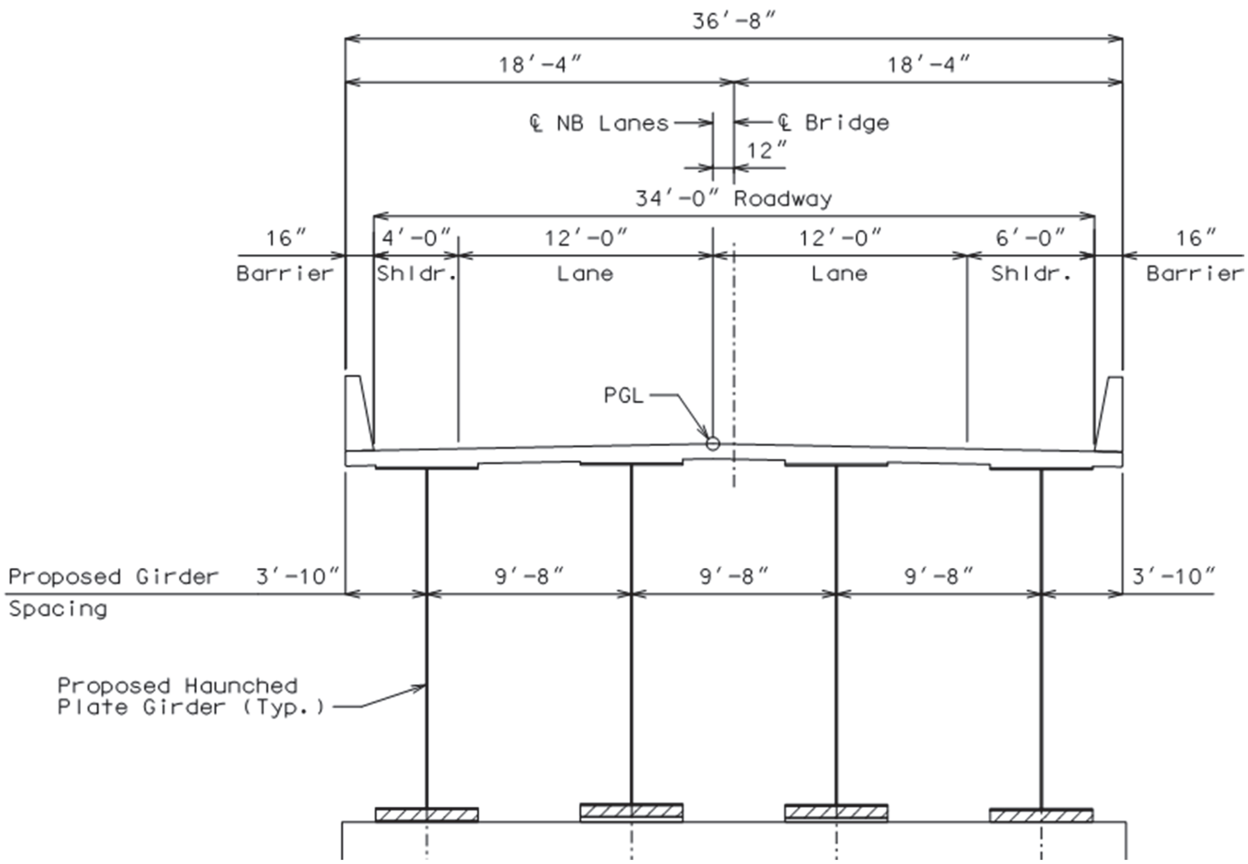
Traffic handling during construction will consist of head-to-head, one-lane NB and SB traffic on the SB bridge. As such, construction on the NB bridge will not require staging.

The roadway profile was developed to locate the low chord of the new girder with the same minimum vertical clearance as the existing low chord of the thru-truss. The vertical curve tangents are increased from existing 4% to 4.87%. This results in a 14’ profile raise near center of the bridge, and approximately 880’ of roadway and embankment work beyond both the south and north proposed end bents.

Typical Section

The initial consideration for determining a possible new deck width is the dimensions of the existing piers. The center-to-center dimension of the columns of Piers 4, 5, and 6 is 29’-0”, which is also the centerline of bearing dimension of the trusses. Locating the exterior plate girders coincident to these dimensions allows for a 4-girder cross-section, with 4-foot inside shoulder, two 12-foot lanes, and 6-foot outside shoulder, as shown in Figure 3-1.

Figure 3-1. Typical Section for Superstructure Widening



Span Arrangement

Two span arrangement options were considered for the main unit crossing the river. The first was a 2-span, composite, haunched plate girder from Pier 4 to Pier 6. The span lengths are 460.21'-460.21' to the centerlines of the existing piers. The plate girder haunches from 11'-6" web at the ends to 16'-0" web at Pier 5. The 16'-0" depth allows for inspection of the girders from a snooper truck on the bridge deck. This arrangement most closely resembles the existing spans and the locations of expansion joints on Piers 4 and 6, therefore distribution of vertical and longitudinal loads to the foundations in the unit will be similar to that of the existing bridge.

The approach spans for the first option can be arranged as a 3-span, parallel-flange plate girder unit or a 4-span, continuous prestressed girder unit on each side of the main unit. The plate girder unit has the benefit of matching, or slightly offsetting, the existing approach Piers 2, 3, 7 and 8 of the NB bridge. The prestressed girder unit has the benefit of aligning piers with those of the SB bridge, which will improve hydraulic efficiency of the combined structures.

The second option for span arrangement of the main unit is a 4-span, composite, haunched plate girder. The spans are 300'-460.21'-460.21'-300'. The two interior spans utilize the existing foundations at Piers 4, 5, and 6. The two exterior spans will land on new expansion piers offset inward from existing Piers 2 and 8, thus eliminating Piers 3 and 7. The exterior:interior span ratio of this unit is 1:1.5, which will produce a significantly more efficient plate girder than the 2-span option. Additionally, superstructure loads on Pier 5 should be reduced, and this unit is expected to aid in distributing longitudinal load (specifically barge impact) to multiple piers. The converse effect is that superstructure loads will increase on existing Piers 4 and 6, which will increase the bearing stress on these caissons.

The approach spans for the second option are 192' single-span, parallel-flange plate girder units on each side of the main unit.

3.2 Superstructure Design

Per the scope, the analysis, design, and capacity checks are by the AASHTO LRFD 7th Edition and Interims, and the MoDOT Engineering Policy Guide (EPG).

A preliminary design of the continuous plate girders for both options was completed, in order to obtain accurate superstructure design loading for the substructure analysis and fabrication weights. The line-girder software, STLBRIDGE, was used for preliminary design of all steel plate girders.

The steel girders were proportioned based on flexure, shear, fatigue and live load deflection. The following are some additional parametric assumptions used in the preliminary girder designs:

- 8.5" concrete slab, composite throughout
- Future wearing surface allowance = 35 psf
- Utility load = 15 plf
- Designed for 12' Design Lanes
- Normal weight concrete in deck and barriers for 2-span option = 150 pcf
- Lightweight concrete in deck and barriers for 4-span option = 110 pcf
- 15% of total weight of girder system assumed for other steel details (splices, studs, lateral bracing)
- Weathering steel with 50 ksi webs and 70 ksi flanges

Girder sizes for the prestressed concrete girder units were selected from available span charts in the EPG.

3.3 Substructure Analysis

3.3.1 Analysis Methodology

The piers of the existing NB bridge are of two types, caisson foundation or steel pile foundation. The caisson foundation piers were analyzed as spread footings, with capacity checks for foundation sliding, uplift and bearing, and structural flexure and shear. Pile foundation piers are checked for pile uplift, compression, and combined compression and flexure, with concrete sections checked for flexure and shear.

All piers were analyzed with applicable Strength and Extreme Event II load cases. For this project, Extreme Event II is vessel collision loading. In lieu of a complete analysis, barge loadings were based on loading used in the design of two lower Missouri River bridges that HDR has been involved with recently: Boone Bridge (Rte 364) and Washington Bridge (Rte 47). There are several design barge/tug configurations, with the two governing configurations used for collision load in this study, shown below:

1. Design Hopper Barge (Empty): 35' bow width x 195' long (200 ton/2'draft)
   a. Applied to all piers at 100-yr flood elevation
   b. Applied as a drift barge moving at river velocity, assumed at flood velocity of 8 feet/second
2. Design Oversize Tank Barge Tow: 1 Barge Wide, 2 barges long, with tug (9600 ton)
   a. Applied at 2% water line, to directly impact Pier 5 only; other piers receive load by longitudinal distribution through bearings and superstructure
   b. Applied as a powered barge, traveling downstream, at typical vessel transit speed of 11.37 feet/second (8.0 mph) (D-S powered barge)
   c. Additional load case of barge traveling upstream, at transit speed of 8.23 feet/second (typical transit speed minus 3.5 feet/second normal river velocity) (U-S powered barge)

Vessel collision forces are calculated parallel and perpendicular to the channel flow, in accordance with AASHTO LRFD, and applied to pier models as separate cases in each direction.

The additional upstream powered barge tow was considered after initial analysis showed the downstream case to be very critical. Considering the location of the SB Pier 2C immediately upstream and in-line with NB Pier 5, the probability of Pier 5 receiving a direct hit of this magnitude is low. Conversely, with no protection by fenders or dolphins, Pier 5 is vulnerable to a powered barge directly impacting in the upstream direction, although the transit speed for this case can be reduced.

Models of stand-alone piers were created in LARSA4D, which comprise the existing foundation elements and proposed new substructure elements, as applicable. All loads were input and load combinations specified in the LARSA4D model.

The following are basic assumptions that were included in the analysis:

- Bridge importance classification = Critical
- Concrete strength for existing elements f'c = 3,500 psi (provided on NB plans)
- Yield strength of existing reinforcing steel fy = 33,000 psi
- Yield strength of existing H-pile fy = 33,000 psi
- Weight and stiffness of seal course included in model
- Buoyancy included in the analysis
- Assume scour to elevations shown in recent bathymetric surveys of the bridge
- Soil properties from boring logs on existing plans

Geotechnical data from the existing SB bridge plans was used to develop allowable foundation end bearing resistance values for the caissons at Piers 4, 5 and 6. The only geotechnical information provided in the existing NB bridge plans is the logs of the auger borings. The SB bridge plans include boring logs, Standard Penetration Test blowcounts, recovery lengths and losses, and select Rock Quality Designation measurements and unconfined compression tests. Based on review of the stratigraphy and rock core data, an assumption was made that the geotechnical data of the SB bridge can be applied to the NB bridge. Calculated resistance values are shown in Table 3-1.

Table 3-1. Bearing Resistance

Load Case	Nominal Bearing Resistance	Load Factor	Factored Bearing Resistance
Strength	89 ksf	0.45	40 ksf
Extreme Event	89 ksf	1.0	89 ksf

Soil-structure interaction was also investigated for different elevations of scour at Piers 4, 5, and 6. LPile, a software program that analyzes stress and deformation of foundation elements under vertical and lateral loading, was used to determine the resistance that can be expected from the soil profile. Initial load responses from the LARSA4D model at the top of foundation elements were input into LPile. Depending on the stiffness of the foundation element in the direction of loading, significant soil resistance can be mobilized, thus reducing the effective moment and shear in the foundation element itself. These LPile results were used to modify the moment and shear values from the LARSA4D analysis. One specific design assumption used in the LPile analysis is that the large caissons of Piers 4, 5, and 6 cannot freely rotate at the bedrock interface; therefore rotation restraint was imparted in the LPile analysis.

3.3.2 Main Unit Pier 5

The existing foundation of Pier 5 is comprised of a 12.5’ x 44’ x 30’ tall pedestal wall on top of a 20’ x 50’ x 80’ tall rectangular caisson. The caisson is embedded less than 2 feet into bedrock. Both the pedestal wall and caisson are under-reinforced per current LRFD specifications.

A LARSA4D model of a stand-alone pier was created, consisting of the existing caissons, existing pedestal wall, new columns, new tie beam and new cap. Initial analysis of Pier 5, using a 2-span main superstructure unit, showed that the pier had high bearing stress for all cases and became unstable in Extreme Event cases. Therefore the following sets of variables were investigated to determine what measures are needed to obtain satisfactory performance of the existing river pier foundations:

- Soil-structure interaction for two channel elevations
  - elevation 670’ - representing the current condition
  - elevation 690’ - representing condition after scour mitigation is implemented
- Longitudinal distribution of loads

  - considering only Pier 5 as a fixed pier, therefore longitudinal load concentrated on this pier
  - considering a more uniform distribution of load to all piers within the unit, through use of isolation bearings at Piers 4, 5, and 6
- Length of main river unit
  - 2-span unit, Pier 5 is the only interior pier
  - 4-span unit, such that Piers 4 and 6 are also interior piers, potentially reducing vertical loading on Pier 5

Results for bearing stress at the base of the caisson are shown in Table 3-2, given as calculated bearing stress and demand/capacity ratio (D/C). Results for flexure and shear capacity of the caisson and for foundation sliding and overturning are shown in Table 3-3, given as D/C ratios.

Bearing stress was calculated using axial load and bi-axial bending moment on the caisson. Because the caisson is bearing on rock, potential for lift-off of one or more corners of the caisson had to be considered when the eccentricity of loading was outside the middle third of the caisson dimension. For several cases of the downstream powered barge, eccentricity of the moment exceeded the middle third in one or both axes; therefore the linear equations for bearing stress do not accurately provide the effective bearing stress. A more rigorous non-linear analysis is needed to determine bearing stress for these cases, which was beyond the scope of this project. As such, Extreme Event II bearing stress is reported for the empty barge and upstream powered barge cases.

Table 3-2. Pier 5 Bearing Stress Check

Analysis Case	Channel elevation 670’ (existing condition)		Channel elevation 690’ (after scour mitigation)	
	Strength load cases	Extreme Event II load cases	Strength load cases	Extreme Event II load cases
Factored bearing resistance	40 ksf	89 ksf	40 ksf	89 ksf
2-span Main unit				
	(bearing stress, demand/capacity)			
Fixed Pier 5 – full longitudinal load	52 ksf, 1.3	78 ksf, 0.88 U-S powered barge [1]	46 ksf, 1.15	72 ksf, 0.81 U-S powered barge [1]
Distributed longitudinal load	42 ksf, 1.05	77 ksf, 0.87 U-S powered barge [1]	39 ksf, 0.98	72 ksf, 0.81 U-S powered barge [1]
4-span Main unit				
Fixed Pier 5 – full longitudinal load	n/a [2]	n/a [2]	n/a [2]	n/a [2]
Distributed longitudinal load	40 ksf, 1.0	64 ksf, 0.72 U-S powered barge [1]	37 ksf, 0.93	51 ksf, 0.57 U-S powered barge [1]

(1) Highest result from the empty barge and U-S powered barge is reported, as noted. Refer to discussion on bearing stress for D-S powered barge.

(2) In the 4-span Main unit, Piers 3, 4, & 5 are all fixed. As such, the case of Fixed Pier 5, which assumes Piers 3 & 5 as expansion, does not apply.

Table 3-3. Pier 5 Capacity Checks for Caisson

Design Check		Strength load cases (channel elev 670')	Extreme Event II load cases (channel elev 670')
		(demand/capacity)	(demand/capacity)
2-span Main unit			
Flexure	Fixed Pier 5 – full longitudinal load	0.44	1.26 D-S powered barge 0.78 U-S powered barge
Flexure	Distributed longitudinal load	0.16	0.94 D-S powered barge 0.46 U-S powered barge
Shear		0.07	0.31
Sliding		0.09	0.45
Overturning		none	none [1]
4-span Main unit			
Flexure	Fixed Pier 5 – full longitudinal load	n/a [2]	n/a [2]
Flexure	Distributed longitudinal load	0.28	1.07 D-S powered barge 0.78 U-S powered barge
Shear		0.06	0.31
Sliding		0.10	0.49
Overturning		none	none [1]

(1) Refer to discussion on bearing stress for D-S powered barge

(2) In the 4-span Main unit, Piers 3, 4, & 5 are all fixed. As such, the case of Fixed Pier 5, which assumes Piers 3 & 5 as expansion, does not apply.

Several observations are made when comparing the impact of the sets of variables on the analysis results:

- Existing channel elevation 670' shows that the distributed longitudinal load, Strength bearing cases, for both 2-span and 4-span Main units, are right at or slightly over allowable. This could be improved when a complete geotechnical evaluation is conducted, possibly resulting in a higher allowable bearing stress.
- Channel elevation 690' produces lower bearing stress for all cases, with the only D/C exceeding 1.0 for a fixed pier case.
- The fixed Pier 5 analysis shows Strength bearing stress and Extreme Event flexure are not satisfactory. Distributing the longitudinal load, either by isolation bearing or using a 4-span unit, improves performance.

3.3.3 Main Unit Piers 4 and 6

The existing foundation of Piers 4 and 6 comprise a 12.5' x 44' x 30' tall pedestal wall on top of two 18' diameter by 80' tall circular caissons. The caissons are embedded less than 2 feet into bedrock. Like Pier 5, both the pedestal wall and caissons are under-reinforced per current LRFD specifications.

The analysis of Piers 4 and 6 was conducted similarly to that of Pier 5. A LARSA4D model of a stand-alone pier was created, consisting of the existing caissons, existing pedestal wall, new columns, new tie beam and new cap. Analysis of Piers 4 and 6 used similar set of variables for longitudinal load distribution and length of main unit, but the only channel elevation considered was 695', since the entire caisson is shown to be beneath the channel surface in the recent bathymetric surveys.

Results for bearing stress at the base of the caisson are shown in Table 3-4, given as calculated bearing stress and demand/capacity ratio (D/C). Results for flexure and shear capacity of the caisson and for foundation sliding and overturning are shown in Table 3-5, given as D/C ratios.

Table 3-4. Piers 4 & 6 Bearing Stress Check

Analysis Case	Channel elevation 695' (existing condition)	
	Strength load cases	Extreme Event II load cases
Factored bearing resistance	40 ksf	89 ksf
2-span Main unit		
	bearing stress / (demand/capacity) ratio	
Expansion pier – full longitudinal load on pier 5	35 ksf / 0.88	61 ksf, 0.69
Distributed longitudinal load	35 ksf, 0.88	55 ksf, 0.62
4-span Main unit		
Expansion pier – full longitudinal load on pier 5	n/a [1]	n/a [1]
Distributed longitudinal load	42 ksf, 1.05	58 ksf, 0.65

(1) In the 4-span Main unit, Piers 3, 4, & 5 are all fixed. As such, the case of Fixed Pier 5, which assumes Piers 3 & 5 as expansion, does not apply.

Table 3-5. Piers 4 & 6 Capacity Checks for Caisson

Design Check		Strength load cases	Extreme Event II load cases
		(demand/capacity)	(demand/capacity)
2-span Main unit			
Flexure	Expansion pier – full longitudinal load on pier 5	0.29	1.04 - bottom of caisson
Flexure	Distributed longitudinal load	0.40	1.02 – bottom of caisson
Shear		0.07	0.23
Sliding		0.09	0.34
Overturning		none	none
4-span Main unit			
Flexure	Expansion pier – full longitudinal load on pier 5	n/a [1]	n/a [1]
Flexure	Distributed longitudinal load	0.75	0.99 – bottom of caisson
Shear		0.10	0.23
Sliding		0.10	0.27
Overturning		none	none

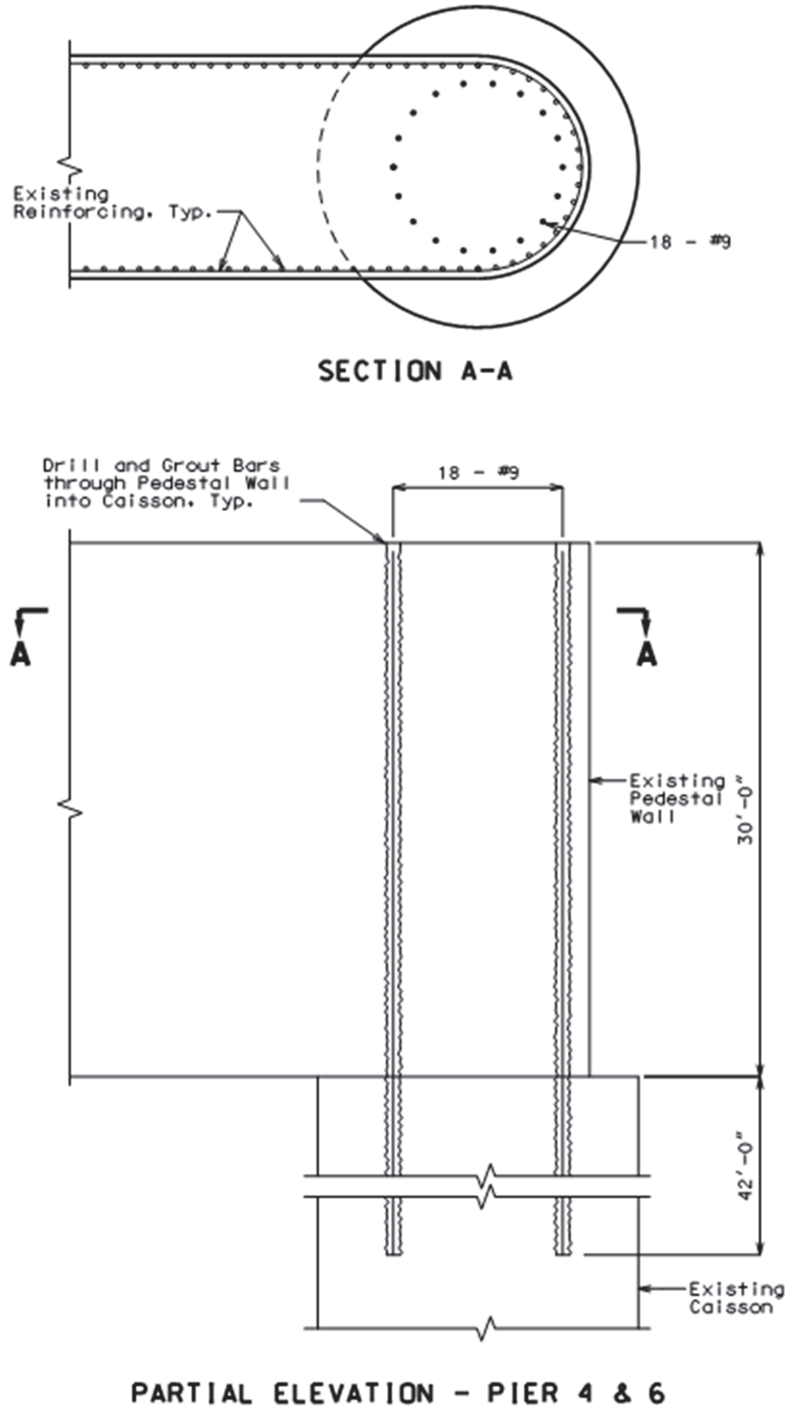
(1) In the 4-span Main unit, Piers 3, 4, & 5 are all fixed. As such, the case of Fixed Pier 5, which assumes Piers 3 & 5 as expansion, does not apply.

The top of the circular caissons was found to have inadequate tensile capacity for the uplift forces, due to the low amount of reinforcing steel in the section. In order to increase the tensile capacity, a retrofit consisting of drilling and grouting new reinforcing bars into the caissons is proposed. Drilling would be completed from the top of the pedestal wall for accessibility, and the new reinforcing bars would be installed through the pedestal wall and into the top of the caissons. Refer to Figure 3-2 for proposed retrofit concept.

Observations on the results of analysis for Piers 4 and 6 are these:

- The 4-span unit has higher vertical and overturning load than the 2-span span unit, which increases the Strength bearing stress above allowable.
- Flexure at the bottom of the caisson is at or slightly over capacity, although this can possibly be improved with a more rigorous soil-structure interaction analysis.
- In all cases, tensile capacity for uplift at the top of caisson is not satisfactory, and requires a retrofit to increase the amount of reinforcement to resist uplift.

Figure 3-2. Piers 4 & 6 Caisson Retrofit



3.3.4 Approach Unit Piers 2, 3, 7, and 8

Approach Piers 3 and 7 consist of 54 - 12x53 H-piles beneath a seal course, an 18' x 36' x 4.5' tall footing, and 26.5' x 8.25' x 18.5' tall pedestal wall. The existing columns and web wall are partially underground, with existing ground line approximately 11' from top of pedestal wall. The footing and pedestal are under-reinforced per current LRFD specifications. The seal course is unreinforced.

Approach Piers 2 and 8, are similar in configuration but smaller than Piers 3 and 7, consisting of 28 - 12x53 H-piles beneath a seal course, a 16' x 30' x 4' tall footing, and 26' x 7' x 8' tall pedestal wall. The existing columns and web wall are partially underground, with existing ground line approximately 11' from top of pedestal wall. The footing and pedestal are under-reinforced per current LRFD specifications. The seal course is unreinforced.

The analyses of Piers 3 & 7 and Piers 2 & 8 were conducted similarly. A LARSA4D model of a stand-alone pier was created, consisting of the existing seal course, existing footing, existing pedestal wall, existing columns and web wall, and new columns, new tie beam and new cap. The model was fixed for rotation and translation at the bottom of the seal course. The moment, axial and shear forces at this fixed support were then used to calculate forces in piles based on moment arm of the pile group.

The approach piers were checked for Strength and Extreme Event II, with empty drift barge only. It is important to note that the top of Piers 3 and 7 were raised approximately 29 feet from the top of the existing piers, due to the proposed profile raise. The top of Piers 2 and 8 was raised approximately 17 feet. These increases in pier height significantly increase the lateral overturning load on the piers from the vehicle, braking, and wind load cases, which translates into much higher axial tension and compression loads on the H-pile configurations than was in the original design.

Results of capacity checks for the H-piles and concrete pedestal wall for Piers 3 and 7 are provided in Table 3-6. Results for Piers 2 and 8 are provided in Table 3-7.

Table 3-6. Piers 3 & 7 Capacity Checks

Design Check	Strength load cases	Extreme Event II load cases
	(demand/capacity)	(demand/capacity)
H-pile		
Tension	0.74	0.40
Axial compression only	0.98	0.97
Flexure w/ axial compression	>>1.0	>>1.0
Concrete pedestal wall		
Flexure	0.55	>>1.0
Shear	0.62	0.56

Table 3-7. Piers 2 & 8 Capacity Checks

Design Check	Strength load cases	Extreme Event II load cases
	(demand/capacity)	(demand/capacity)
H-pile		
Tension	0.74	0.92
Axial compression only	1.16	1.47
Flexure w/ axial compression	>>1.0	>>1.0
Concrete pedestal wall		
Flexure	0.49	>>1.0
Shear	0.74	0.67

The conclusion of the approach pier analyses is that none of the existing Piers 2, 3, 7, and 8 are suitable for re-use, due to the small footprint of the H-pile foundations and the significantly higher overturning loads that are calculated for the larger superstructure needed for widening and replacement.

3.4 Scour Hole Mitigation

The proposed scour mitigation consists of a layer of Class VIII riprap placed to elevation 690, over a layer of sand-filled filter bags. The remainder of the scour hole volume is filled with granular fill.

Refer to General Plan and Elevation provided in Appendix B for the preliminary extents of scour mitigation, which were used for cost estimation. The proposed extents of rirprap and filter bags is based on limited data and it is recommended that further analysis and design be completed during final design to properly proportion the scour mitigation. During design, contraction scour, bend scour, dune scour, and long term degradation or aggradation should be accounted for in developing the appropriate counter measure. In addition, the analysis should review the interaction of the SB and NB piers and scour along with a more detailed estimation of debris loading on the pier.

3.5 Estimated Cost and Remaining Life

The estimated cost of a superstructure widening and replacement, including the roadway costs is **$28.1M**, as shown in Table 3-8. An estimated **$1.2M** was included as a maintenance or life cycle cost for a presumptive scope on the order of a one-time latex-modified overlay, slab repair and expansion joint adjustment assumed during the 50 year service life.

Costs presented in Table 3-8 are for the 2-span Main unit option with prestressed girder approaches, which is the least cost of the superstructure replacement options considered.

A complete detailed cost estimate can be found in Appendix D.

Table 3-8. Estimated Cost of Superstructure Widening and Replacement

Item	Estimated Cost
Main Unit	$11.295 M
Approach Units	$4.858 M
Other Bridge	$1.574 M
Existing Bridge Removal	$3.307 M
Scour Mitigation	$3.625 M
Roadway	$1.591 M
Mobilization	$1.838 M
TOTAL PROJECT COST [2]	**$28.088 M**
Anticipated Service Life	50 years
Project Cost per Year of Service Life	$561,800
Life Cycle Cost [1]	$1.254 M
TOTAL LIFE CYCLE COST [2]	**$29.342 M**
Life Cycle Cost per Year of Service Life	$586,800

(1) Life Cycle Cost assumes a latex-modified overlay, slab repair and expansion joint adjustment at Year 25 of service life.
(2) Cost provided in FY 2020 dollars.

4 Complete Bridge Replacement

The second portion of the project was determining a conceptual layout for a complete bridge replacement that provides additional roadway width.

4.1 Location and Layout Options

Similar to the widening options, traffic handling during construction will consist of head-to-head, one-lane NB and SB traffic on the SB bridge. This will accommodate an on-alignment bridge replacement. An on-alignment bridge replacement is recommended to reduce the coordination effort needed in obtaining right-of-way and permits from owners and agencies adjacent to the bridge.

The span arrangement for the new superstructure had to take into account the navigation channel on the north side of the river. The existing horizontal clearance of approximately 397’ is governed by NB Pier 5 and SB Pier 1C. New pier foundations will need a minimum offset of 30’ to clear the existing foundations. A shift of the existing 460’ span to the north or south by 30’ reduces the horizontal clearance. Therefore, the proposed layout places new piers outside of the navigation channel that is bracketed by existing Piers 5 and 6, for a span over the navigational channel of 520’. This is pushing the maximum span length for a plate girder structure but it is still a reasonable and feasible alternative.

The roadway profile was developed to locate the low chord of the new girder with same minimum vertical clearance as the existing low chord of the thru-truss. The vertical curve tangents are increased from existing 4% to 5%. This results in a 19’ profile raise near the center of the bridge, and approximately 1,180’ of roadway and embankment work beyond the south proposed end bent and 1,340’ beyond the north proposed end bent.

4.2 New Bridge Type, Size, and Layout

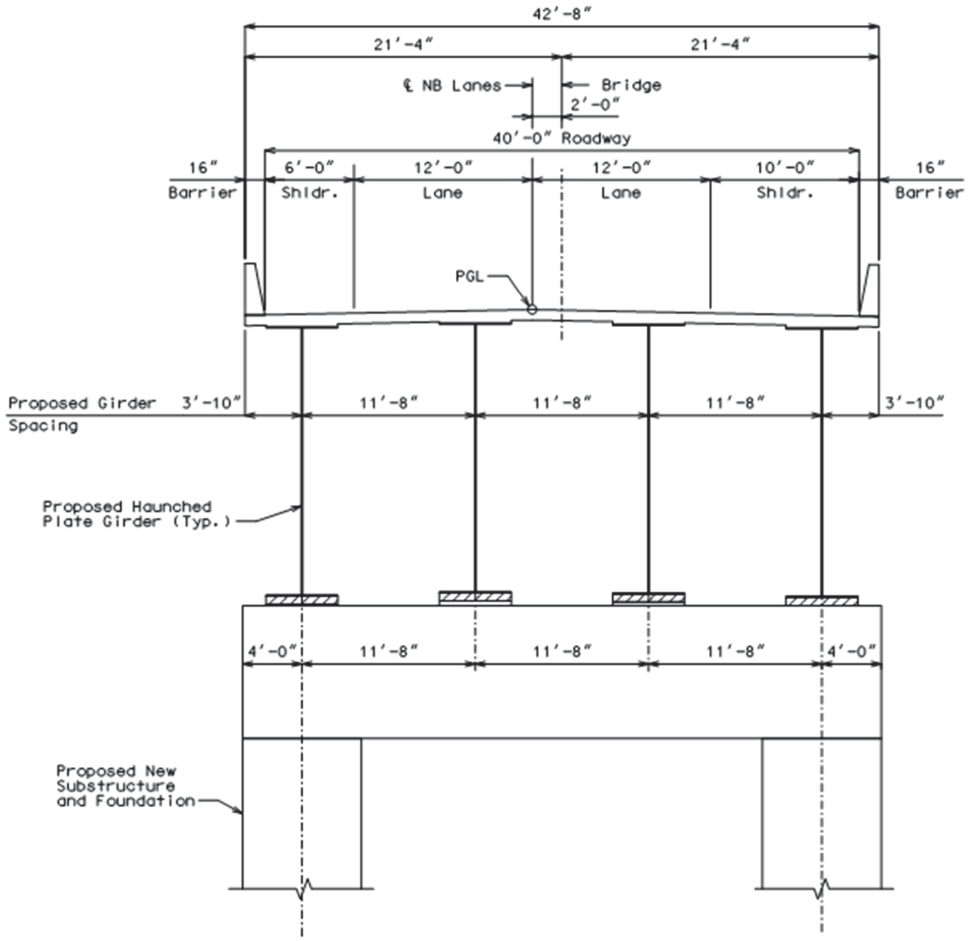
Superstructure

As discussed above, the span over the navigation channel is 520’, therefore a symmetric 3-span, 400’-520’-400’ haunched, composite plate girder was selected for the main unit. A 2-span 520’-520’ girder would be a very inefficient design, prohibitively deep, and comparatively expensive on a per-foot basis. A 4-span girder unit is not necessary for crossing the river and would add cost for steel fabrication. The 3-span unit provides the optimal balance of design considerations and cost. The steel girders in the 3-span unit were preliminarily sized using a line-girder analysis for estimating purposes.

Approach spans are prestressed concrete girder units. The north approach is a single 62’ span Type 3 girder, and the south approach is a 4-span 145’-123’-123’-123’ continuous NU53 unit. The south spans are arranged to have new piers align with the existing SB Piers 1S, 2S, and 3S, which will improve the hydraulic efficiency from the existing condition where the NB and SB piers are not aligned.

The roadway is 40 feet wide, consisting of 6-foot inside shoulder, two 12-foot lanes, and 10-foot outside shoulder, as shown in Figure 4-1.

Figure 4-1. Typical Section for Bridge Replacement



See Appendix C for the General Plan and Elevation and Typical Sections of the complete bridge replacement option.

Substructure

Integral end bents, founded on steel piles, are located behind the existing abutments. Approach piers are rectangular (to match the SB bridge) multi-column, founded on either steel piles or drilled shafts. Main unit piers are rectangular (to match the SB bridge) 2-column, founded on two 12' drilled shafts socketed into rock. The river Piers 4-6 will also have partial concrete web walls or tie beams for vessel collision resistance. All substructure dimensions were estimated based on prior experience and bridge detailing of similar size and types of bridges constructed over the Missouri River. Detailed analysis and design of the substructure was not completed.

Scour Hole Mitigation

Scour mitigation is also recommended for the complete replacement option, using the same limits as discussed in Section 3.4. This will be the optimum time to remediate the scour hole around the existing SB pier and armor the channel around the future NB pier, since crews and equipment are already mobilized in the river and hydraulic and environmental permits are in place. Refer to General Plan and Elevation provided in Appendix C for the proposed extents of scour mitigation.

4.3 Estimated Cost and Design Bridge Life

The estimated cost of a new bridge constructed on-alignment, including the roadway costs is **$40.2M**, as shown in Table 4-1. An estimated **$2.9M** was included as a maintenance or life cycle cost for a presumptive scope on the order of a latex-modified overlay, slab repair and expansion joint adjustment, assumed to be executed twice during the 100 year service life, and a one-time full deck and expansion joint replacement.

The design life of bridges designed for the current AASHTO LRFD specifications is 75 years, but a major river bridge designed to modern standard should be designed and expected to last for **100 years**.

A complete detailed cost estimate can be found in Appendix E.

Table 4-1. Estimated Cost of Bridge Replacement

Item	Estimated Cost
Main Unit	$24.901 M
Approach Units	$2.863 M
Other Bridge	$1.579 M
Existing Bridge Removal	$2.010 M
Scour Mitigation	$3.625 M
Roadway	$2.555 M
Mobilization	$2.627 M
TOTAL PROJECT COST [2]	**$40.160 M**
Anticipated Service Life	100 years
Project Cost per Year of Service Life	$401,600
Life Cycle Cost [1]	$6.570 M
TOTAL LIFE CYCLE COST [2]	**$46.730 M**
Life Cycle Cost per Year of Service Life	$467,300

(1) Life Cycle Cost assumes a latex-modified overlay, slab repair and expansion joint adjustment at Years 25 & 75 of service life, and full deck and expansion joint replacement at Year 50.

(2) Cost provided in FY 2020 dollars.

5 Recommendations

Table 5-1 compares the construction cost, service life, cost per year of service and construction duration of the two studied alternatives:

1. Superstructure widening and replacement
2. Complete bridge replacement

The costs are in FY2020 dollars and do not include cost of engineering, environmental studies and permitting. These estimates do include associated roadway, traffic control and mobilization costs. All of the options will require routine maintenance and repairs throughout the life of the structure; the frequency, level and cost of these were not considered here for comparison.

Table 5-1. Comparison of Alternatives: Construction Cost, Service Life and Schedule

Alternative	Estimated Construction Cost [1]	Service Life	Estimated Life Cycle Cost [1] / Year of Service Life	Construction Duration
Superstructure Replacement	$28.088 M	50 years +/-	$586,800	2 years
Bridge Replacement	$40.160 M	100 years +/-	$467,300	3 years

(1) Cost provided in FY2020 dollars

Based on the cost per year of service life, the best-value option is the full Bridge Replacement. Based on least first cost, the Superstructure Replacement alternative would be recommended. Therefore, HDR's recommendation depends on MoDOT's needs and funding availability.

The Superstructure Replacement alternative could be permitted, designed and constructed much sooner. Delivery would take an estimated 18 months for permitting and design and 2 years of construction. If design were initiated in January 2021, a fall/winter 2022 letting could be achieved, with construction beginning in 2023 and completing by December 2024. The existing bridge would be demolished in 2023.

Design and permitting of the on-alignment Bridge Replacement alternative could be completed in an estimated 30 months, which includes an additional 12 months allocated for right-of-way acquisition and more challenging permitting efforts as compared to the Superstructure Replacement alternative. If design were initiated in January 2021, a fall/winter 2023 letting could be achieved, with construction beginning in 2024 and completing by December 2026. The existing bridge would be demolished in 2024.

If the existing bridge can be maintained until 2024 and funding is available sufficient to construct the replacement bridge, HDR's recommendation is to design and construct the new Bridge Replacement. However, if funding is constrained but sufficiently available to construct the Superstructure Replacement alternative and/or the existing bridge cannot remain in service without major rehabilitation until 2024, HDR's recommendation is to design and construct the Superstructure Replacement alternative.

6 References

Huizinga, R. J. Bathymetric Surveys at Highway Bridges Crossing the Missouri River in Kansas City, Missouri, using a Multibeam Echo Sounder, 2010: U.S. Geological Survey Scientific Investigations Report 2010-5207, 61 p.

Huizinga, R. J. Bathymetric and Velocimetric Surveys at Highway Bridges Crossing the Missouri River near Kansas City, Missouri, June 2-4, 2015: U.S. Geological Survey Scientific Investigations Report 2016-5061, 93 p.

Appendix A. Bathymetric Survey plot

The following plot is extracted from the report of the 2015 bathymetric survey conducted at bridge L0568.

Results of Bathymetric and Velocimetric Surveys   61

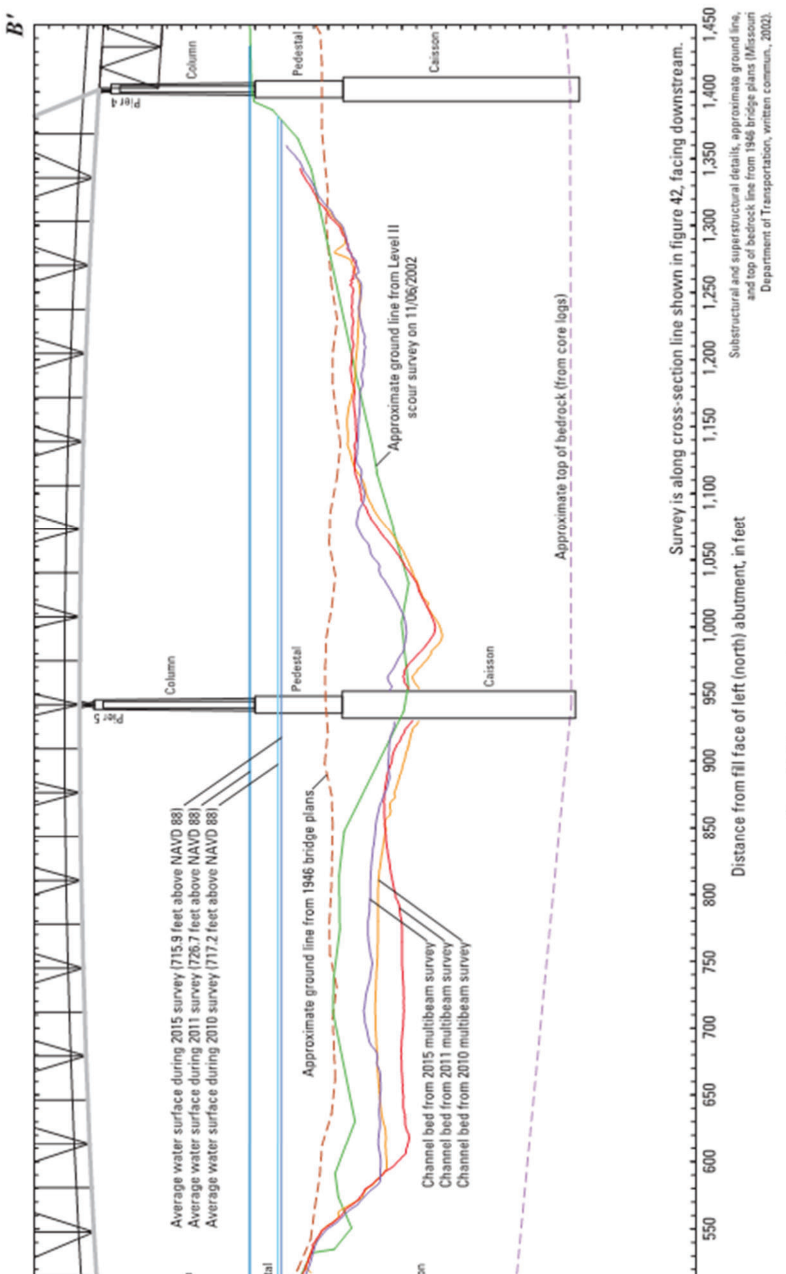
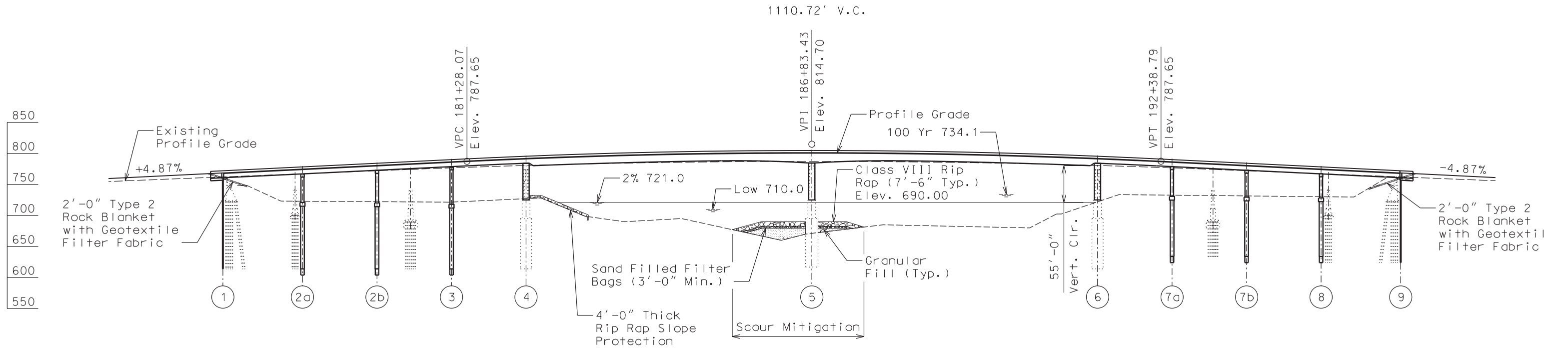
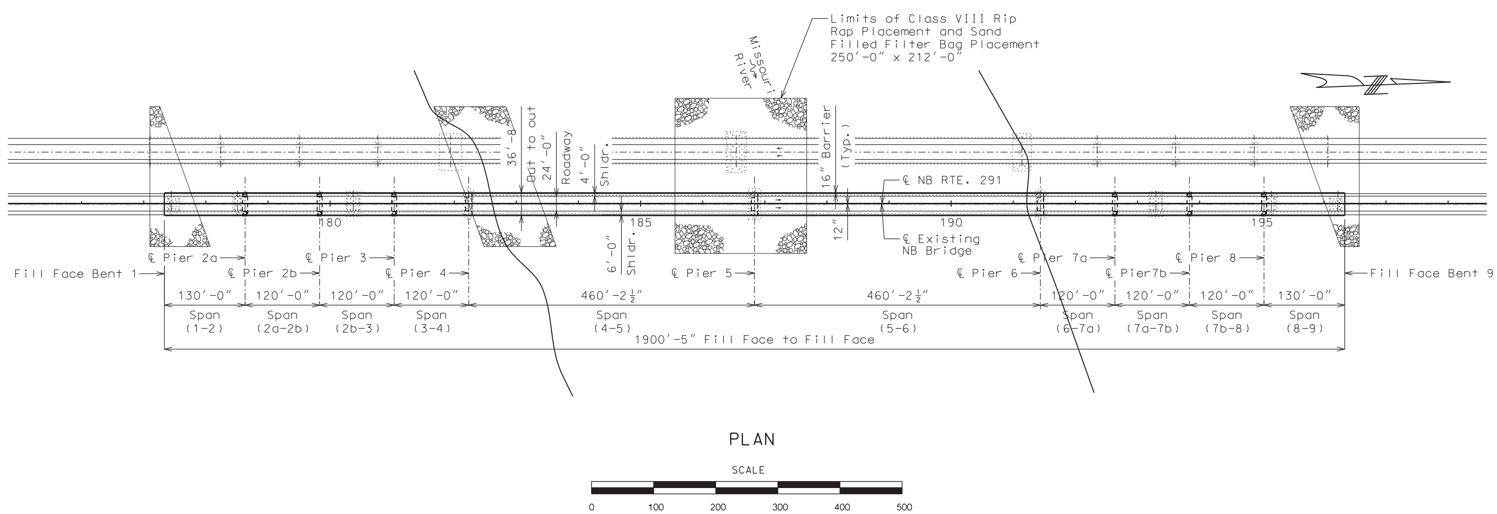


Figure 45. Key features, substructural and superstructural details, and surveyed channel bed of structure L0568 on State Highway 291 crossing the Missouri River near Kansas City, Missouri.

Appendix B. Superstructure Widening and Replacement – Plan and Elevation and Typical Sections



ELEVATION



PLAN

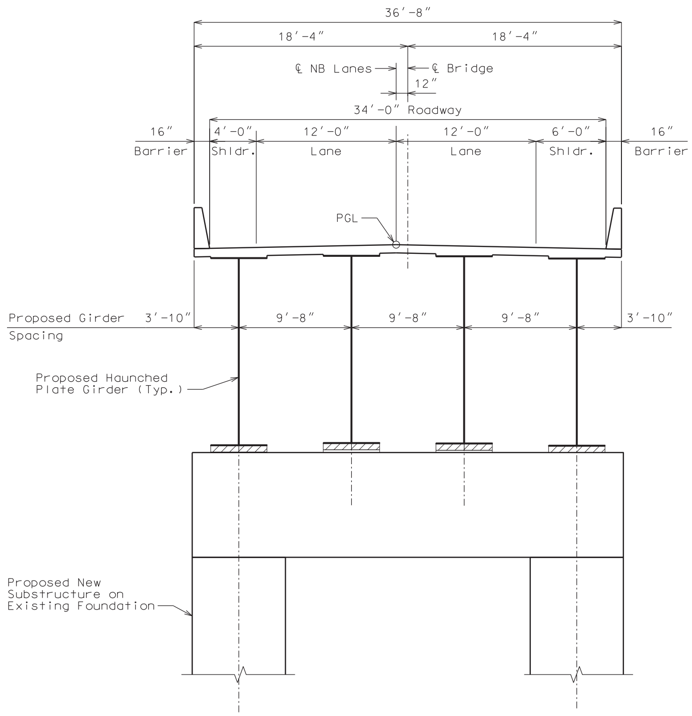
GENERAL PLAN & ELEVATION
SUPERSTRUCTURE WIDENING AND REPLACEMENT

DATE PREPARED	8/11/2020
ROUTE 291N	STATE MO
DISTRICT KC	SHEET NO.
COUNTY	JACKSON
JOB NO.	J4P3471
CONTRACT ID.	
PROJECT NO.	
BRIDGE NO.	L0568

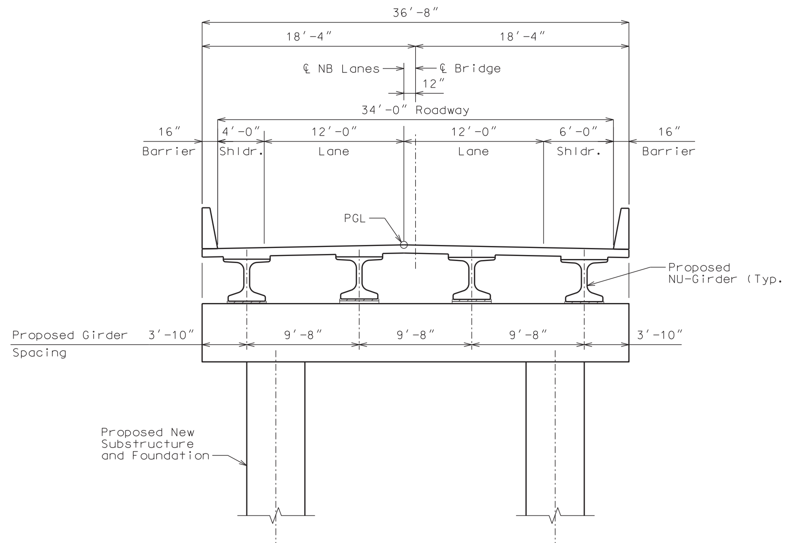
DATE	DESCRIPTION

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
105 WEST CAPITOL
JEFFERSON CITY, MO 65102
1-888-ASK-MODOT (1-888-275-6636)

HDR Engineering, Inc.
401 S. 18th Street
Suite 300
St. Louis, MO 63103-2267
314-425-8300
Certificate of Authority: 000856



TYPICAL SECTION
MAIN UNIT - SPANS 4 & 5



TYPICAL SECTION
APPROACH UNITS - SPANS 1-3 & 6-8

TYPICAL SECTIONS
SUPERSTRUCTURE WIDENING AND REPLACEMENT

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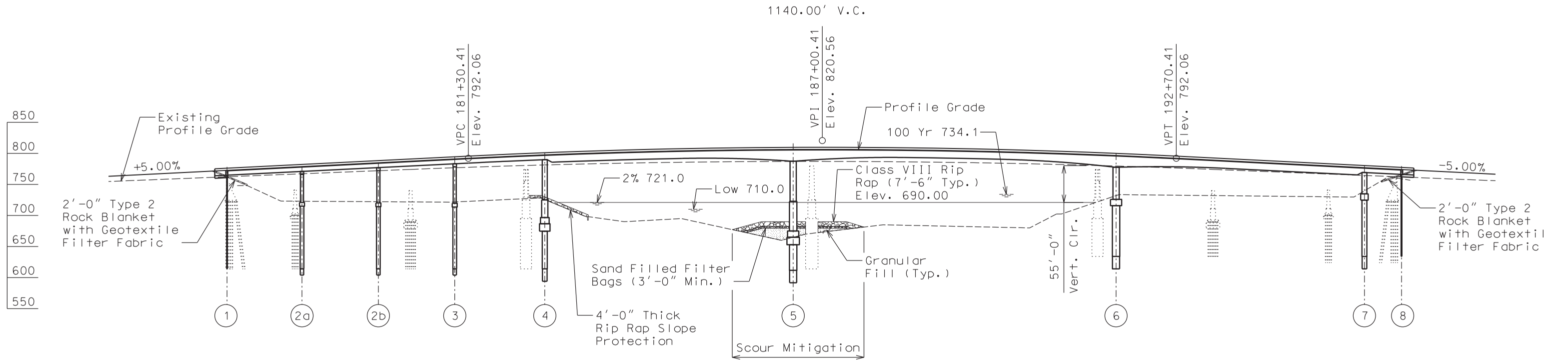
MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
105 WEST CAPITOL
JEFFERSON CITY, MO 65102
1-888-ASK-MODOT (1-888-275-6636)

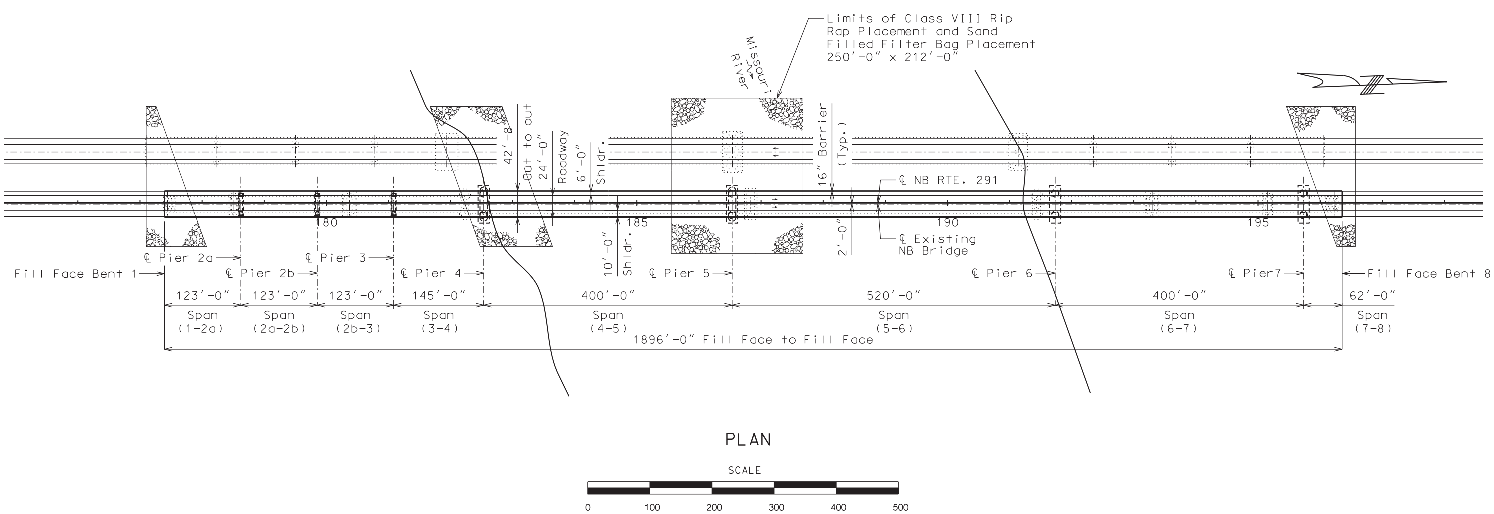
DATE	DESCRIPTION

DATE PREPARED	8/11/2020
ROUTE	291N
STATE	MO
DISTRICT	KC
SHEET NO.	
COUNTY	JACKSON
JOB NO.	J4P3471
CONTRACT ID.	
PROJECT NO.	
BRIDGE NO.	L0568

Appendix C. Complete Bridge Replacement – Plan and Elevation and Typical Sections



ELEVATION



PLAN

GENERAL PLAN & ELEVATION
BRIDGE REPLACEMENT

DATE PREPARED	8/11/2020
ROUTE	291N
STATE	MO
DISTRICT	KC
SHEET NO.	
COUNTY	JACKSON
JOB NO.	J4P3471
CONTRACT ID.	
PROJECT NO.	
BRIDGE NO.	L0568

DATE	DESCRIPTION

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
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JEFFERSON CITY, MO 65102
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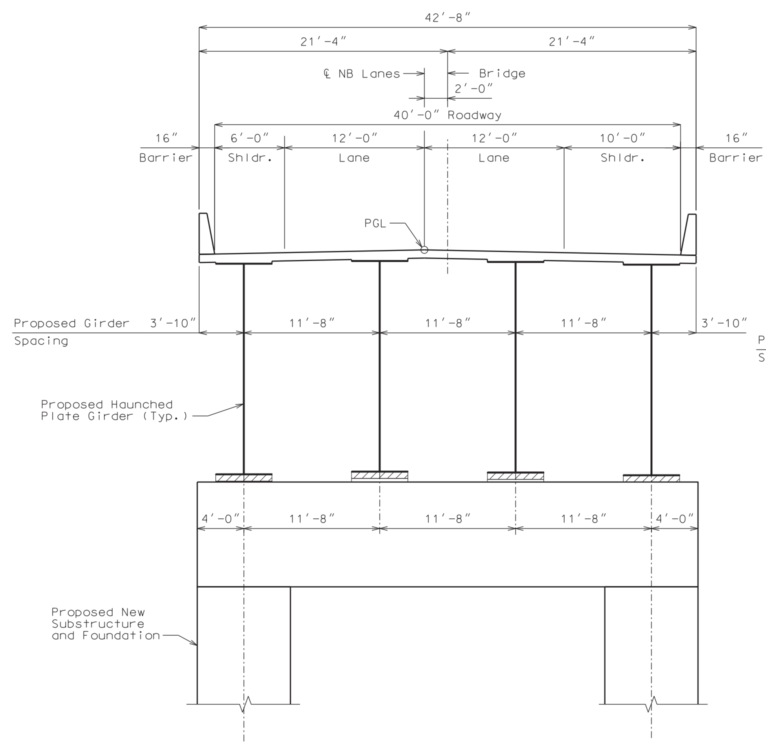
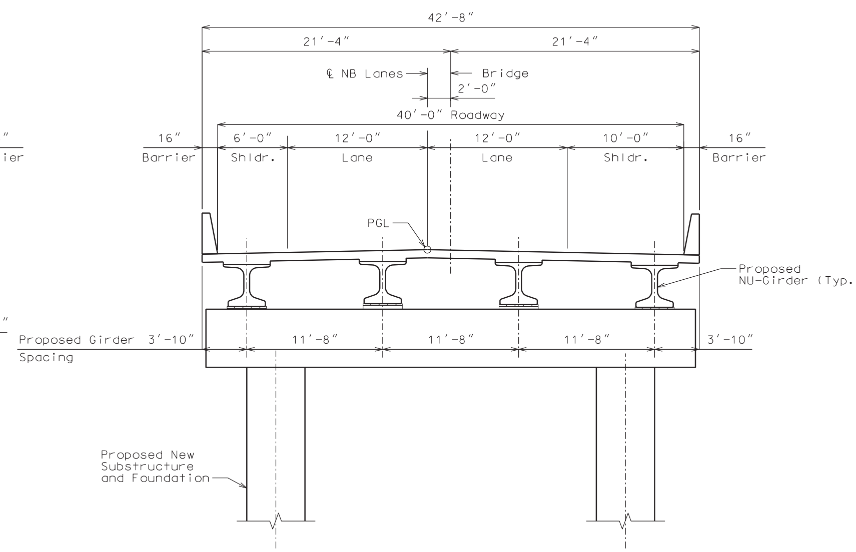


TYPICAL SECTION
MAIN UNIT - SPANS 4-6



TYPICAL SECTION
APPROACH UNITS - SPANS 1-3 & 7

TYPICAL SECTION
BRIDGE REPLACEMENT

DATE PREPARED	
8/11/2020	
ROUTE 291N	STATE MO
DISTRICT KC	SHEET NO.
COUNTY JACKSON	
JOB NO. J4P3471	
CONTRACT ID.	
PROJECT NO.	
BRIDGE NO. L0568	

DATE	DESCRIPTION

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
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JEFFERSON CITY, MO 65102
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Appendix D. Cost Estimate for Superstructure Widening and Replacement

Cost Estimate - By Item

Superstructure Widening and Replacement

Unit 1: 4-Span (130'-120'-120'-120') NU 43-Girder Option
Unit 2: 2-Span (460'-460') Haunched Steel Plate Girder Option
Unit 3: 4-Span (120'-120'-120'-130') NU 43-Girder Option

Project Construction Cost

Costs are provided in FY2020 dollars.

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Class B Concrete (Substr)	Cu. Yd.	1,229.3		$800	$983,440
Slab on Steel	Sq. Yd.		3,750	$260	$975,000
Misc. Concrete Repair, Drill & Grout Rebar	Ea.	72		$2,000	$144,000
Reinforcing Steel (Bridges)	Lbs.	184,400		$1.40	$258,160
Fab. Structural Steel	Lb.		4,762,180	$1.75	$8,333,815
Modular Expansion Joint	Lin. Ft.		75	$4,000	$300,000
Isolation Bearings	Ea.		12	$25,000	$300,000
				Main Unit =	**$11,295,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Class 1 Excavation	Cu. Yd.	805		$50	$40,250
Drilled Shafts (6'-0")	Lin. Ft.	1,080.0		$900	$972,000
Rock Sockets (5'-6")	Lin. Ft.	120.0		$900	$108,000
Video Camera Inspection	Ea.	12		$640	$7,680
Foundation Inspection Holes	Lin. Ft.	252.0		$112	$28,224
Sonic Logging Testing	Ea.	12		$1,800	$21,600
Class B Concrete (Substr)	Cu. Yd.	1,136.8		$800	$909,440
Slab on Concrete NU-Girder	Sq. Yd.		3,992	$315	$1,257,480
NU 43, NU-Girder	Lin. Ft.		3,920	$250	$980,000
Reinforcing Steel (Bridges)	Lbs.	321,910		$1.40	$450,674
Steel Intermediate Diaphragm	Ea.		48	$1,000	$48,000
Lam. Neo. Brg. Pad (Tapered)	Ea.		56	$325	$18,200
Lam. Neo. Brg. Pad Assembly	Ea.		8	$2,000	$16,000
				Approach Units =	**$4,858,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Class 1 Excavation	Cu. Yd.	110		$50	$5,500
Bridge Approach Slab (Major Road)	Sq. Yd.		163	$230	$37,490
Water Transportation for Engineer	Lump Sum		1	$10,000	$10,000
Galvanized Structural Steel Pile (14")	Lin. Ft.	1,320		$65	$85,800
Dynamic Pile Testing	Ea.	12		$2,500	$30,000
Pile Point Reinforcement	Ea.	12		$125	$1,500
Class B Concrete (Substr)	Cu. Yd.	40.9		$800	$32,720
Barrier Curb (Type D)	Lin. Ft.		3,881	$87	$337,647
Conduit System	Lin. Ft.		3,802	$45	$171,090
Slab Drain	Ea.		40	$340	$13,600
Vertical Drain at End Bents	Lin. Ft.	157		$45	$7,065
Misc (Class VIII Rip Rap)	Cu. Yd.	3,815		$100	$381,500
Navigation Lighting System	Lump Sum		1	$150,000	$150,000
Clearance Gauge	Lump Sum		1	$10,000	$10,000
Misc. bridge	Lump Sum	1		$300,000	$300,000
				Other Bridge =	**$1,574,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Partial Removal of Substructure Concrete	Cu. Yd.	4,604		$500	$2,302,000
Removal of Existing Superstructure (Steel)	Sq. Ft.		50,234	$20	$1,004,680
				Ex. Bridge Removal =	**$3,307,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Misc (Class VIII Rip Rap)	Cu. Yd.	10,003		$100	$1,000,300
Misc (Sand Filled Filter Bags)	Cu. Yd.	3,964		$400	$1,585,600
Misc (Granular Fill Material)	Cu. Yd.	10,932		$95	$1,038,540
				Scour Mitigation =	**$3,625,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Pavement	Sq. Yd.		4,709	$65	$306,085
Shoulder	Sq. Yd.		3,140	$45	$141,300
Aggregate Base	Sq. Yd.		3,532	$12	$42,384
Embankment	Cu. Yd.		29,106	$10	$291,060
Traffic Control	Lump sum		1	$600,000	$600,000
MGS Guardrail	Lin. Ft.		3,532	$25	$88,300
MGS Bridge Approach Transition	Ea.		4	$2,533	$10,132
Type A Crashworthy End Terminal	Ea.		4	$2,613	$10,452
Furnishing Type 2 Rock Blanket	Cu. Yd.	1,470		$43	$63,210
Placing Type 2 Rock Blanket	Cu. Yd.	1,470		$21	$30,870
Permanent Erosion Control Geotextile	Sq. Yd.	2,200		$3.15	$6,930
				Roadway Cost =	**$1,591,000**

Mobilization Cost =	**$1,838,000**

Total Project Construction Cost = $28,088,000

Life Cycle Costs

Costs are provided in FY2020 dollars.

Consists of slab repair, expansion joint adjustment, and latex-modified overlay
Include all repairs at **Year 25**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Latex Modified Concrete Wearing Surface	Sq. Yd.	7,743		$100	$774,300
Repairing Concrete Deck (Half-Soling)	Sq. Ft.	10,500		$35	$367,500
Full Depth Repair	Sq. Ft.	1,400		$80	$112,000

Total Life Cycle Cost = $1,254,000

Appendix E. Cost Estimate for Complete Bridge Replacement

Cost Estimate - By Item

Full Bridge Replacement

Unit 1: 4-Span (123'-123'-123'-145') NU 53-Girder Option
Unit 2: 3-Span (400'-520'-400') Haunched Steel Plate Girder Option
Unit 3: 1-Span (62') Type 3 I-Girder Option

Project Construction Cost

Costs are provided in FY2020 dollars.

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Class 1 Excavation	Cu. Yd.	1,540		$50	$77,000
Class 2 Excavation	Cu. Yd.	2,350		$60	$141,000
Cofferdams (Major River)	Ea.	3		$1,000,000	$3,000,000
Drilled Shafts (8'-0")	Lin. Ft.	302.0		$1,300	$392,600
Drilled Shafts (12'-0")	Lin. Ft.	254.0		$2,200	$558,800
Rock Sockets (7'-6")	Lin. Ft.	40.0		$1,450	$58,000
Rock Sockets (11'-6")	Lin. Ft.	80.0		$2,100	$168,000
Video Camera Inspection	Ea.	8		$640	$5,120
Foundation Inspection Holes	Lin. Ft.	272.0		$112	$30,464
Sonic Logging Testing	Ea.	8		$1,800	$14,400
Class B Concrete (Substr)	Cu. Yd.	4,913.8		$800	$3,931,040
Seal Concrete	Cu. Yd.	1,621.3		$300	$486,390
Slab on Steel	Sq. Yd.		6,258	$260	$1,627,080
Reinforcing Steel (Bridges)	Lbs.	1,136,950		$1.40	$1,591,730
Fab. Structural Steel	Lb.		6,748,240	$1.75	$11,809,420
Modular Expansion Joint	Lin. Ft.		90	$4,000	$360,000
Inspection Platform	Sq. Ft.		5,120	$80	$409,632
POT Bearings	Ea.		16	$15,000	$240,000
				Main Unit =	**$24,901,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Class 1 Excavation	Cu. Yd.	440		$50	$22,000
Drilled Shafts (6'-0")	Lin. Ft.	600.0		$900	$540,000
Rock Sockets (5'-6")	Lin. Ft.	60.0		$900	$54,000
Video Camera Inspection	Ea.	6		$640	$3,840
Foundation Inspection Holes	Lin. Ft.	126.0		$112	$14,112
Sonic Logging Testing	Ea.	6		$1,800	$10,800
Class B Concrete (Substr)	Cu. Yd.	630.1		$800	$504,080
Slab on Concrete I-Girder &NU-Girder	Sq. Yd.		2,731	$315	$860,265
Type 3, I-Girder	Lin. Ft.		310	$175	$54,250
NU 53, NU-Girder	Lin. Ft.		2,056	$240	$493,440
Reinforcing Steel (Bridges)	Lbs.	177,790		$1.40	$248,906
Steel Intermediate Diaphragm	Ea.		28	$1,000	$28,000
Lam. Neo. Brg. Pad (Tapered)	Ea.		33	$325	$10,725
Lam. Neo. Brg. Pad Assembly	Ea.		9	$2,000	$18,000
				Approach Units =	**$2,863,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Class 1 Excavation	Cu. Yd.	110		$50	$5,500
Bridge Approach Slab (Major Road)	Sq. Yd.		190	$230	$43,700
Water Transportation for Engineer	Lump Sum		1	$10,000	$10,000
Galvanized Structural Steel Pile (14")	Lin. Ft.	1,320		$65	$85,800
Dynamic Pile Testing	Ea.	12		$2,500	$30,000
Pile Point Reinforcement	Ea.	12		$125	$1,500
Class B Concrete (Substr)	Cu. Yd.	40.9		$800	$32,720
Barrier Curb (Type D)	Lin. Ft.		3,872	$87	$336,864
Conduit System	Lin. Ft.		3,792	$45	$170,640
Slab Drain	Ea.		38	$340	$12,920
Vertical Drain at End Bents	Lin. Ft.	157		$45	$7,065
Misc (Class VIII Rip Rap)	Cu. Yd.	3,815		$100	$381,500
Navigation Lighting System	Lump Sum		1	$150,000	$150,000
Clearance Gauge	Lump Sum		1	$10,000	$10,000
Misc. bridge	Lump Sum	1		$300,000	$300,000
				Other Bridge =	**$1,579,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Removal of Bridges	Sq. Ft.	50,235		$40	$2,009,400
				Ex. Bridge Removal =	**$2,010,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Misc (Class VIII Rip Rap)	Cu. Yd.	10,003		$100	$1,000,300
Misc (Sand Filled Filter Bags)	Cu. Yd.	3,964		$400	$1,585,600
Misc (Granular Fill Material)	Cu. Yd.	10,932		$95	$1,038,540
				Scour Mitigation =	**$3,625,000**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Pavement	Sq. Yd.		6,707	$65	$435,955
Shoulder	Sq. Yd.		4,471	$45	$201,195
Aggregate Base	Sq. Yd.		5,030	$12	$60,360
Embankment	Cu. Yd.		75,445	$10	$754,450
Traffic Control	Lump sum		1	$800,000	$800,000
MGS Guardrail	Lin. Ft.		5,030	$25	$125,750
MGS Bridge Approach Transition	Ea.		4	$2,533	$10,132
Type A Crashworthy End Terminal	Ea.		4	$2,613	$10,452
Furnishing Type 2 Rock Blanket	Cu. Yd.	2,350		$43	$101,050
Placing Type 2 Rock Blanket	Cu. Yd.	2,350		$21	$49,350
Permanent Erosion Control Geotextile	Sq. Yd.	1,760		$3.15	$5,544
				Roadway Cost =	**$2,555,000**

Mobilization Cost =	**$2,627,000**

Total Project Construction Cost = $40,160,000

Life Cycle Costs

Costs are provided in FY2020 dollars.

Consists of slab repair, expansion joint adjustment, and latex-modified overlay
Include all repairs at **Year 25** and **Year 75**

Item	*Unit*	*Substr.*	*Superstr.*	*Unit Cost*	*Total Cost*
Latex Modified Concrete Wearing Surface	Sq. Yd.		8,989	$100	$898,900
Repairing Concrete Deck (Half-Soling)	Sq. Ft.		12,150	$35	$425,250
Full Depth Repair	Sq. Ft.		1,650	$80	$132,000
				Subtotal (1x) =	$1,456,150
				Subtotal (2x) =	$2,912,300

Consists of deck and expansion joint replacement
Include at **Year 50**

Removal of Existing Bridge Decks - Composite	Sq. Ft.		80,950	$10	$809,500
Slab on Steel	Sq. Yd.		6,258	$260	$1,627,080
Slab on Concrete I-Girder &NU-Girder	Sq. Yd.		2,731	$315	$860,265
Modular Expansion Joint	Lin. Ft.		90	$4,000	$360,000
				Subtotal (1x) =	$3,656,845

Total Life Cycle Cost = $6,570,000