MEMORANDUM

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FROM: Todd Lang, HDR

DATE: March 4, 2013 – Final

RE: Red Wing Bridge Project - Bridge 9040 New Structure Alternatives

PURPOSE AND BACKGROUND

MnDOT initiated the Red Wing Bridge Project in January 2012. The project includes the US 63 (Eisenhower) Bridge 9040 over the Mississippi River and the US 63 Bridge 9103 over US 61, as well as the highway connections to US 61, Minnesota TH 58, and approach roadways in the State of Wisconsin. The Eisenhower Bridge carries US 63 across the river from Red Wing and connects to the state of Wisconsin. The bridge provides the only regional crossing of the river for over 30 miles upstream or downstream for several communities on both the Wisconsin and Minnesota sides of the river.

As documented in the project's Purpose and Need Statement, the primary purpose of the project is to provide a structurally sound crossing of the Mississippi River and US 61. Secondarily, the project will study future capacity needs and the accommodation of pedestrian/bicycle traffic across the Mississippi River and US 61.

This memorandum documents the initial screening of new bridge alternative structure types that could be built parallel to the rehabilitated existing Bridge 9040 as the second half of a four-lane crossing, or in place of the existing Bridge 9040 as a new two-lane or four-lane bridge. It documents initial screening, with the intent to provide information sufficient to narrow the number of the alternatives under consideration. A more detailed study of the remaining alternatives will be undertaken in the next phase.

GENERAL DESIGN CONSIDERATIONS

Structure Limits and Alignment

All of the proposed bridge alternates discussed in this memo will be on or near the existing alignment of Bridge 9040. The south abutment is proposed to be located in line with the existing south abutment. For the purposes of this first screening, it has been assumed that the north abutment will also be aligned with the existing north abutment. This produces an overall mainline bridge length of approximately 1,625 feet for all alternatives studied during this phase. During the subsequent phases of this study, shortening the bridge by approximately 90' at the north end will be investigated for potential efficiencies; however, the results of that investigation will not affect this initial screening.

The main unit of the existing bridge is comprised of a three-span continuous through truss with spans of 216'-432'-217'with the 432' main span being over the main channel of the Mississippi River. At the north end of the main unit there are six steel girder approach spans of 125'-150'-150'-150'-125'-60' for a total of 760'. See Figure 1 on the following page for an aerial view of the existing bridge layout.

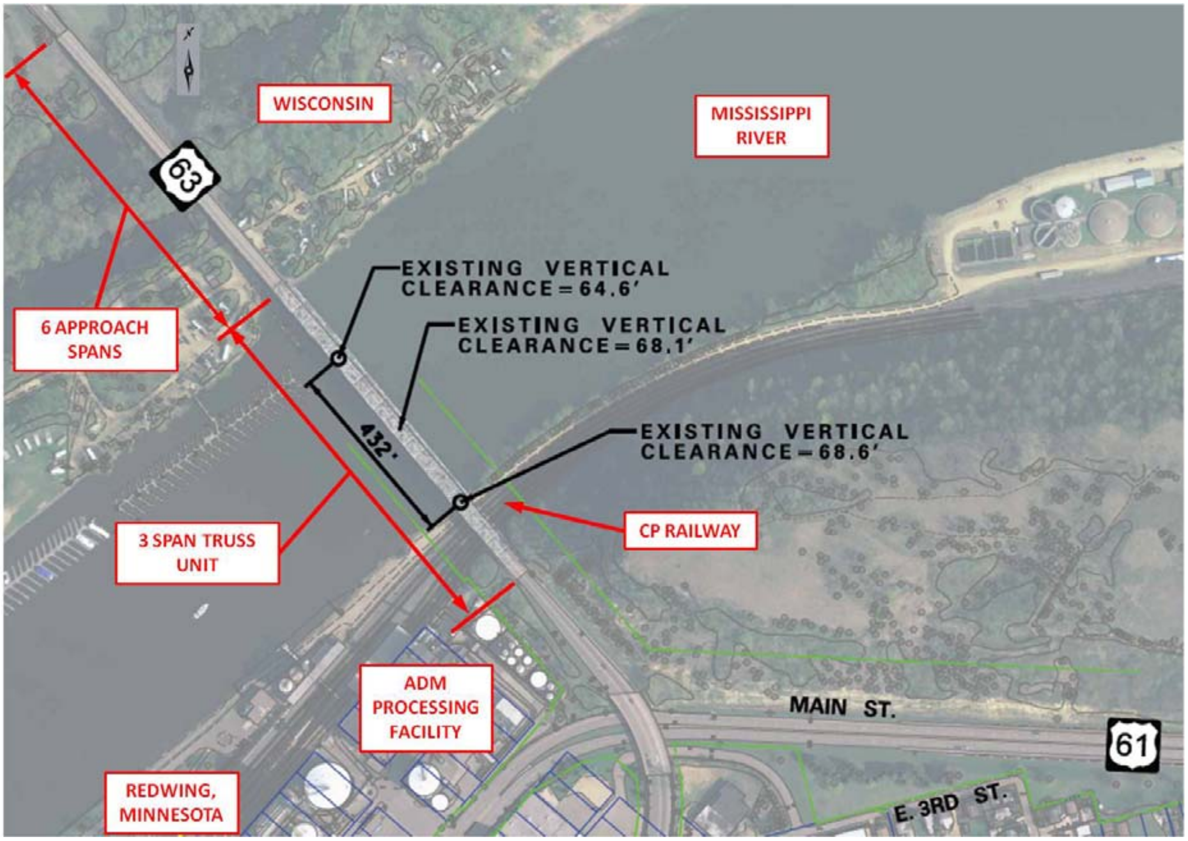


FIGURE 1 – BRIDGE LAYOUT

Grade

Existing Bridge 9040 has approximately a 4% grade rising up to the bridge from both the Minnesota and Wisconsin approach roadways. The southernmost 930' of the existing bridge is in a 1,300' long vertical curve that starts approximately 370' south of the south abutment. Preliminary geometric studies indicate that the starting station and length of the vertical curve, and the grade coming out of the vertical curve can be adjusted such that the profile grade in the main span can be raised by a maximum of approximately 10' while maintaining the 4% approach grade. Due to geometric constraints south of the bridge, it is desirable to maintain the 4% grade coming onto the bridge, but depending on decisions regarding Bridge 9103 some potential structure types may require a grade increase to 5%.

The existing bridge truss spans have a structure depth from profile grade to low steel of approximately 4.1'. Preliminary coordination with the United States Coast Guard (USCG) has indicated that the vertical and horizontal navigational clearances for any new bridges or parallel structures will have to match the existing 432' main span. Therefore, any increase in structure depth in the main span will have to be accommodated by a grade increase.

Typical Sections

The existing bridge has a 30' clear roadway width between curbs, 2'-6" wide raised curbs on both sides of the road and 1'-2" wide concrete parapets on the outsides for a total out-to-out deck width of 37'-4" (see Figure 2 at the end of this memo). If the existing bridge is rehabilitated and a new two-lane bridge is constructed parallel to it, the existing bridge will become a two-lane northbound bridge with two 12' lanes, a 4’ inside shoulder, a 6’ outside shoulder and two 1’-8” wide concrete barriers to retain its 37’-4” deck width. The new structure would have a similar configuration carrying two southbound lanes but would include a 12’ wide trail that would be separated from the traffic by a 1’-6” wide barrier. The barrier on the outside of the trail would be 1’-2” wide for a total deck width of 50’-4” (see Figure 3 at the end of this memo). The clear distance between the outside of the rehabilitated existing truss and the new parallel structure will need to be a minimum of 10’ to provide inspection access between the structures and to provide clearance between adjacent substructure units for the new and existing bridges.

If it is determined that the existing truss will not be rehabilitated, it will be replaced by a new two-lane bridge constructed parallel to the existing bridge or a four-lane bridge. A new two-lane bridge will have a cross section similar to the new parallel structure described above but as a two-way structure, it will likely require 10’ shoulders on both sides leading to a total deck width of 60’-4” (see Figure 4 at the end of this memo). The 10’ shoulder requirement will be confirmed in later studies. A new four-lane bridge with two lanes in each direction would have 4’ inside and 6’ outside shoulders, a 12’ wide trail, and depending on the structure type and construction staging could have as narrow as a 1’-9” wide median barrier between opposing inside shoulders (see Figure 5 at the end of this memo).

Barn Bluff is located just to the east of the existing structure on the Minnesota approach and is on the National Register of Historic Places (NRHP). To avoid impacting Barn Bluff, the eastern limits of the selected structure alternative and approach roadway cannot move any further east than the eastern limits of the current bridge. There is an ADM facility that is approximately 82’ west of the western limits of the existing bridge that would be costly to impact, and alternative development will therefore focus on avoiding or minimizing impacts to ADM. Given the above limits and that the existing structure is approximately 42’ out-to-out of structure, the selected alternative will need to have a total section width of less than 124’.

Vertical Clearance

As mentioned previously, the USCG has indicated that the existing navigational clearances must be maintained for any new structures. This includes the existing 64.5’ above normal pool in the main river span.

In addition to the Mississippi River, the existing bridge crosses over Canadian Pacific Railways (CPR) and the Island Campground and Marina. The southernmost span, Span 1, crosses six sets of CPR tracks with an existing vertical clearance of approximately 51’. This is much greater than the 23’-0” required by AREMA so railroad clearance should not have any effect on the allowable structure depths of the alternatives. Likewise, the existing vertical clearance above the Island Campground and Marina in Spans 4 and 5 is over 40’ and will not impact the structure types studied.

Horizontal Clearance

Horizontal clearance from the centerline of the CPR tracks to the face of piers shall be a minimum of 25’ to preclude the use of crash walls. Should an alternate place piers between 12 and 25 feet, crash walls will be required in accordance with AREMA. No clearance shall be less than 12 feet. The alternatives in this memo all maintain a minimum of 25 feet from piers to the centerline of tracks to match the existing horizontal clearance. It should be noted that the existing Pier 1 is located within the CPR right-of-way and therefore any new pier constructed for a parallel bridge located adjacent to Pier 1 will also be on CPR right-of-way.

Horizontal clearance for the Mississippi River navigation channel is dictated by the USCG, and varies along the river. As noted previously, the USCG has indicated that the main river span will need to remain

432’ or greater. If a new pier is built to align with the existing Pier 2 it will likely have impacts on the location of some of Island Marina’s boat slips.

With the tight horizontal clearances to Pier 1 between the CPR tracks and the Mississippi River, Pier 1 will be lined up with the existing Pier 1 in all of the alternatives in this memo. Also, Pier 2 has been aligned with existing Pier 2 in almost all alternatives to minimize the span length of the main river span and to avoid hydraulic impacts. In addition, all piers within the river’s floodplain should be aligned with the existing piers to minimize the hydraulic impacts. Although the clearance between the existing bridge and the ADM facility to the west is limited, there will be enough room to construct these piers (see Figures 7 and 8 at the end of this memo).

Aesthetics

The existing truss is visible from many properties that are on or eligible for the NRHP, and is a prominent piece of the City’s skyline. As such, the appearance of the new structure alternatives will be important. How the alternatives fit with the surroundings and in the case of a parallel structure, how they fit with the existing truss will be evaluated in the next phase of the replacement alternatives study.

Maintenance of Traffic

The existing US 63 crossing at Red Wing is the only crossing for over 30 miles upstream or downstream. The bridge is used by commuters, commercial vehicles and recreational vehicles, and emergency service vehicles to travel between communities on opposite sides of the Mississippi River everyday. The 60 mile detour created by any closure of the crossing will have a great impact on this traffic and emergency response time.

Any specific impacts on maintenance of traffic that need to be considered for the different alternates will be discussed in detail for that alternate later in this report.

SPAN ARRANGEMENT STUDY ALTERNATES

Based on the capabilities of various bridge types and experience on similar major projects, the following alternate structure types for the main river span were considered:

Alternate 1 – Tied Arch

Alternate 2 – Simple Span Truss

Alternate 3 – Three-Span Continuous Truss

Alternate 4 – Extradosed Bridge

Alternate 5 – Cable-Stayed Bridge

Alternate 6 – Concrete Segmental Box Girders

Alternate 7 – Steel Box Girders

In the sections that follow, these seven structure types are presented and discussed. Following these sections is a discussion of the selection of the most appropriate approach units for each of these alternates.

ALTERNATE 1 – TIED ARCH

The proposed structure for Alternate 1 is a tied arch. The main span length of 432’-0” bridges the current navigation channel of the Mississippi River. The arch rise would be approximately 75’above the roadway, yielding a span-to-rise ratio of 6, which provides an efficient and geometrically proportional structure. The arches could be vertical or could be a basket-handle, and if vertical using free standing arches instead of bracing could be investigated. The tie girder is suspended from the arch rib by suspenders. The suspenders could run vertically in a conventional tied arch or diagonally in a pattern of diamond-shapes forming a network tied arch. See Figure 6 at the end of this memo for an elevation view of a network tied arch.

The tie girders are primarily tension members that resist the thrust of the arch rib. They would be located outside of the bridge deck at about the same elevation as the bridge's floor system. These members are critical elements that must be designed to be fatigue and fracture resistant per MnDOT practice, including a redundant system to prevent failure of the tied arch system. Several alternative means of achieving redundancy have been investigated and used on recent projects, such as the Lowry Avenue Bridge in Minneapolis and the Hastings Bridge. These include; 1) designing the tie girders to withstand a complete fracture of either one web or one flange without yielding the remaining section, thereby allowing sufficient time to identify the issue and make repairs (the webs and flanges are connected by a bolted connection, which eliminates potential crack propagation between the web and flange plates of the ties) or a second redundant tie girder would be provided, 2) post-tensioning the steel tie girder to eliminate tension in the member, 3) designing the tie girders to consist of a post tensioned concrete girder with tension carried by the tendons and provisions for adding future tendons if needed, thus eliminating many of the fatigue and fracture issues of a traditional steel tension tie.

As mentioned above, the arch suspenders are attached between the arch rib and tie girder, and could be either vertical or diagonal. The use of diagonal suspenders in a network tied arch has been found to be more efficient than the conventional vertical suspenders; however the diagonal pattern of the suspenders can make inspection access difficult.

The floor system for a tied arch would be made up of steel floorbeams and stringers. The floorbeams would be located at the locations where the suspenders attach to the tie girder and would run transverse to the roadway. Stringers would span between floorbeams, run parallel to the roadway and would support a concrete deck. The arch and tie girder are the primary load carrying system and are outside and generally above the deck, yielding a shallow structure depth from the profile grade to the low member elevation. How shallow the structure depth is will depend on how the stringers are connected to the floorbeams. The stringers can either be framed into the floorbeams or stacked on top of them. If they are framed-in, this structure type would only require a 2' grade raise but if they are stacked it would increase to approximately 5'. Because there are advantages and disadvantages to each type of floor system, this should be investigated in greater detail if this structure type is studied further.

Construction

Two possible methods of construction are envisioned for the tied arch. The two methods include cantilevered arch erection with the use of backstays, and a float-in construction sequence. The use of falsework to support the structure in the navigation channel would not be practical at this site due to the expected width of navigation channel required during the construction process, and the expense of falsework and falsework protection in the river.

Cantilevered erection is performed by supporting the arch ribs with backstays during construction. The backstays attach through towers to temporary anchor blocks behind the river piers and connect to the arch ribs at critical locations to support the dead load of the arch rib and construction loads. Following the completion of the arch rib construction, the arch ribs and backstays support the tie girders during erection. The floor system is constructed after the tie girder erection is complete and the suspenders are installed.

Cantilevered arch erection is an efficient method of construction. The construction engineering required is of moderate complexity, and the cost of the erection temporary works is offset by reduced construction time. Also, cantilevered arch erection is a common method of erection and should not preclude erectors from bidding on the project.

The erection of the arch for a float-in scheme is performed off-site. It requires the use of staging areas that are located nearby and have access to the river. The river bridge arch ribs, tie girders, suspenders, floorbeams, rib bracing, and tie bracing are assembled on falsework. The off-site location provides the erector with safer working conditions and minimal temporary works at the final project site. After the arch erection is complete, the structure is floated to the project site and lifted or lowered into place atop the river pier bearings. Once the arch is in place, the stringers and deck forms are installed, and the deck is placed. Float-in erection allows the structural steel for the main span to be assembled while the substructure and approach span construction is also performed. This sequence can reduce the construction time for the project. Construction engineering is limited to the design of the falsework used to support the arch members during erection and the jacking system used to set the bridge in the final position. The major drawback is the transportation of the completed structure to the project site and lifting the completed structure into the final position. This specialized form of erection could preclude some erectors from bidding on the construction project. However, the float-in method has previously been used for the truss at Wabasha, MN, and the tied arches at Hastings and LaCrosse, WI.

Future Inspection, Maintenance and Expansion

Inspection access to the floor system and tied arch would be provided by an Under Bridge Inspection Vehicle (UBIV). As mentioned earlier, the use of a network tied arch would make moving the arm of the UBIV in and out of the suspenders more difficult than a conventional tied arch. Access to the arch, including the suspender connections to the arch, would be by manlifts that would be positioned on the bridge deck.

Future maintenance of the structure includes periodic inspections, repainting, deck replacement, and future wearing surface application. The geometric constraints of the arch make widening the deck for additional lanes in the future not feasible unless accommodations are made in the original design to facilitate the addition of a third arch at a later date. This would require that the arch that would become the middle arch in the future, be designed from the beginning to a higher capacity than the outside arches. Adding a separate, second arch bridge parallel to the first could also be considered but is not likely to be feasible due to the narrow constraints between ADM and Barn Bluff.

Deck replacement is feasible while maintaining traffic. Approximately one half of the bridge deck is replaced while maintaining traffic on the other side of the bridge. Once half the deck is completed, the traffic is shifted to complete the other half.

Aesthetics

Conventional Tied Arch bridges are both powerful and elegant. The upward curve of the arch ribs gives the sense of the bridge flowing away from the roadway below. The minimal structural elements extending above the bridge deck grant an unrestricted view while looking from the roadway to the landscape beyond the bridge. Also, the suspender cables provide minimal interference to the observer from either up or down stream and traffic traversing the bridge.

If used as a parallel structure with the existing rehabilitated truss left in place, a tied arch would likely fit well with the existing structure. Both an arch and the existing truss are above deck steel superstructures with fairly shallow floor systems and a more classical appearance. At its high point the arch would extend about 75’ above the roadway which compares fairly well to the existing truss bridge which extends about 50’ above the roadway, and is still over 100’ lower than the top of Barn Bluff.

ALTERNATE 2 – SIMPLE SPAN TRUSS

Alternate 2 is a simple span through truss consisting of total length of 432’. The truss is a variable depth Pratt truss. The depth of the truss increases from the portals to the centerline of the bridge where it will be approximately 70’ above the deck. Similar to the tied arch alternate the entire deck section will be inside the trusses. An elevation view of this structure type is shown in Figure 9 at the end of this memo.

The chord members and compression diagonals would be box-shaped sections. The tension diagonals would likely be fabricated I-sections. A steel truss is a non-redundant structure with fracture critical members. Therefore, the truss tension members which would be the lower chord members and some of the diagonals would have to be designed to incorporate redundancy into the design and/or precompression will need to be introduced to keep them out of tension. The incorporation of redundant systems would be required by MnDOT policy and practice. If this alternative is carried forward for more detailed studies, acceptable methods of providing redundancy will need to be studied in greater detail. It likely will also be a significant structural engineering challenge to develop a detail satisfactory to the designer and owners.

The floor system for a truss will be similar to that described above for the tied arch alternate. The floorbeams will be located at every truss joint and the stringers will span between floorbeams. The structure depth from the profile grade to the low member elevation for this alternate is fairly shallow. Similar to the tied arch, the floor system for a truss can be framed-in or stacked. Therefore the required grade raise for this alternate will be either 2’ or 5’ depending on the floor system selected.

Construction

Two methods of construction are feasible for the simple span truss and include cantilevered construction with falsework in the river or float-in construction.

The use of falsework in the river will depend on the minimum navigation channel required by the Coast Guard during construction and may not be feasible. After the trusses and floorbeams are erected, the stringers and deck would be installed to complete the construction. This method of construction is moderately complex with moderate construction engineering required. Using temporary falsework in the river and protection of the temporary falsework will increase the cost of this option.

The assembly of the truss for a float-in scheme is performed off-site. The entire span including both trusses, floorbeams, top and bottom lateral bracing and sway frames is erected on temporary falsework. Performing this work off-site provides safer and more controlled working conditions and eliminates falsework in the navigation channel. Stringers and deck forms could also be placed off-site. However, to limit total weight of the float-in pick, it is assumed that they would be installed after the truss unit is placed on the piers. The completed truss is floated into position and lifted onto the river piers. In a variation of this type of construction the temporary falsework that the truss is assembled on is built at a higher elevation than the piers. This allows the truss to be lowered into place by taking on water in the barges once the truss is positioned over the piers, eliminating the need to lift the truss. The truss at Wabasha, MN was constructed by lowering it into place in this manner.

After the truss is in its final position, the stringers and deck are installed to complete construction. A float-in scheme minimizes construction time by permitting work on the substructure and approach spans to occur concurrently with the main span construction. Construction engineering includes designing falsework during erection and a lifting scheme for final placement. However, the float-in scheme could also be a drawback as this type of construction may reduce the number of contractors who bid on the project.

Future Inspection, Maintenance and Expansion

Inspection access for the floor system and lower chords would be obtained by using an UBIV. Access to the top chord, diagonals and top lateral bracing would be by climbing or from a manlift located on the deck.

Simple span truss structures are typically considered to be non-redundant. The bottom chord tension members are highly loaded and considered to be fracture critical. These members must be designed, detailed and fabricated according to the fracture critical guide specifications. However, the increased cost of designing to these specifications is partially offset by the reduction in material costs and decreased maintenance costs for a closed member. Even with the addition of redundant systems for tension members noted earlier, it is expected inspection time and effort would continue to be higher than other structure types.

Future maintenance for the simple span truss alternate includes periodic inspections, painting, deck replacement and wearing surface application. Inspecting and painting trusses is a significant maintenance cost due to the number of members that comprise the structure. Maximizing panel lengths reduces the number of members. Additional measures to prevent corrosion include drain holes in the web of inclined I-sections and detailing to prevent ponding.

Deck replacement is feasible while maintaining traffic. Utilizing phased construction, half the deck would be removed while keeping traffic on the other half. Traffic would be switched to the new deck and the other half replaced. Future roadway widening is not possible given the truss configuration unless accommodations are made in the original design to facilitate the addition of a third truss at a later date. This would require that the truss that would become the middle truss in the future, be designed from the beginning to a higher capacity than the outside trusses. Adding a separate, second truss bridge parallel to the first could also be considered but is not likely to be feasible due to the narrow constraints between ADM and Barn Bluff.

Aesthetics

The top chord of a simple span truss has a pleasing arched appearance. However, the lengths of the diagonals toward the center of the bridge could yield a slender, almost spindly appearance. Because sway frames are necessary for stability, the bridge could impart a sense of confinement.

If used as a parallel structure with the existing rehabilitated truss left in place, a simple span truss would fit well with the existing structure. The height of the new truss would be slightly taller than the existing truss since it is a simple span as compared to the existing continuous truss.

ALTERNATE 3 – THREE-SPAN CONTINUOUS TRUSS

Alternate 3 is a three-span continuous through truss with span lengths of 216’-432’-217’, for a total length of approximately 865’. A possible configuration would be a Warren truss. The use of a Warren truss with or without verticals can be studied in greater detail in later studies. Likewise the use of a constant depth or variable depth truss should be studied. The use of a constant depth without verticals would likely be the most economical and have the cleanest appearance, however a variable depth truss with verticals would most closely match the existing bridge. An elevation view of a variable depth truss with verticals can be found in Figure 10 at the end of this memo.

The chord members and compression diagonals would be box-shaped sections. The tension diagonals would likely be fabricated I-sections. A steel truss is a non-redundant structure with fracture critical members. Therefore the truss tension members, which would be the tension chord members and some of the diagonals, would have to be designed to incorporate redundancy into the design and/or precompression will need to be introduced to keep them out of tension. As noted earlier, this would be required by MnDOT policy and practice. With the three-span truss alternate being continuous over the interior piers, it may be possible to take advantage of the continuity in a three-dimensional design and reduce the number of non-redundant members. The use of double members or post-tensioning could also be used to address redundancy issues in this type of structure.

The floor system for this alternate will be similar to the simple span truss. Likewise, the grade raise required for this alternate will be 2' or 5' depending on whether the stringers are framed into the floorbeams or stacked on top of them.

Construction

Erection of a continuous truss requires falsework for the end spans only, leaving the full navigation channel open to barge traffic. This may require construction of falsework over the CPR tracks, but due to the extra clearance that is currently provided, this is not anticipated to be a problem. Erection would begin by placing the first few panels of the end spans nearest to the interior piers between the pier and falsework. It is likely that these panels could be erected partially or in their entirety on the ground and lifted into place. The next panels of the middle and end spans would be erected using balanced cantilever construction. Cantilevered construction of the center span would continue past this point by placing counterweights or tie-downs in the end spans. After closure of the middle span, the final panels of each end span would be completed. These panels would be erected last to permit dropping of the ends of the truss to facilitate closure at the center of the bridge at the proper geometry. Once the trusses and floorbeams are in place, the stringers and deck would complete construction.

The balanced cantilever construction method is relatively straightforward. Similar erection methods have been successfully used in the past. The ease and speed of construction is correlated to the number of members and connections that must be made. The number of connections could be minimized by eliminating truss verticals and using a diamond pattern for the top lateral bracing.

Construction complexity and the numbers of constructors available to bid on this structure type would be similar to the simple span truss alternate.

Future Inspection, Maintenance and Expansion

Inspection access for the floor system and lower chords would be obtained by using an UBIV. The elimination of verticals would make access easier by enlarging the openings through which the arm of the UBIV would have to be directed. Access to the top chord, diagonals and top lateral bracing would be by climbing or from a manlift located on the deck.

There is not general agreement as to whether a continuous truss structure can be considered to be redundant. Heavily loaded tension members are usually considered to be fracture critical. The continuity and three-dimensional behavior of the structure would be analyzed to determine which tension members are truly fracture critical. As noted earlier, redundant systems would need to be added to those members in the design.

Future maintenance for the variable depth continuous truss alternate includes periodic inspections, painting, deck replacement and wearing surface application. Painting trusses is a significant maintenance cost due to the number of members. Eliminating verticals and maximizing panel lengths would reduce the number of members. Additional measures to prevent corrosion would be similar to the simple span truss. The elimination of fatigue prone details will help keep future maintenance needs reasonable.

Similar to Alternates 1 & 2, deck replacement while maintaining traffic would be feasible for this alternate. However, future widening of the structure to accommodate additional lanes of traffic would not be practical unless designed for in the original design.

Aesthetics

A variable depth three-span continuous through truss is believed to be generally aesthetically pleasing. The elimination of verticals and top sway bracing could create a simple, open appearance not always achieved in truss bridges. The relative slenderness of the diagonals provides a fairly unrestricted view from the bridge.

If used as a parallel structure with the existing rehabilitated truss left in place, a variable depth truss with verticals could be used to match the existing bridge as closely as possible in shape and size which means that it would extend approximately 50’ above the deck.

ALTERNATE 4 – EXTRADOSED BRIDGE

The extradosed alternate is a three-span cable supported structure with span lengths of 216’-432’-217’, with approximately 50’ tall towers above the deck and two vertical planes of cables. Due to the cable stay supports, the extradosed spans will result in a constant depth of superstructure, or variable depth out to the first stay, that combines post-tensioned concrete box girders with relatively low-angle cable stays.

The floor system for an extradosed bridge would be similar to a concrete segmental bridge (see Alternate 6) but shallower for a given span length due to the contribution of the cables. It is estimated that the structure depth from profile grade to low member for this alternate would be about 14’ which would require a 10’ grade raise above existing. A preliminary profile for the 10’ grade raise is shown in Figure 15 at the end of this memo.

The grade raise introduces a separation in elevation between the existing roadway and the proposed that requires construction of wall systems between roadways. This would add complication to the construction staging and add cost to the project, as compared to other alternates.

An elevation view of this alternative is shown in Figure 11 at the end of this memo.

Construction

Special procedures are required to construct cable supported structures. Currently, only one extradosed bridge has been built in the United States, which is the Pearl Harbor Memorial Bridge in New Haven, CT. The method of construction utilized for this project was cast-in-place, utilizing form travelers in balanced cantilever. Several others are currently under design in the US including the St. Croix River Crossing, with many having been built in other parts of the world. Construction of the main tower foundations would follow similar procedures as the other alternates. Superstructure erection would begin with a short starter piece (pier segment) supported on brackets or falsework at the main tower. Then, each segment of the structure would be cast-in-place (if form travelers were utilized) by the balanced cantilever method, with the permanent stay cables being installed at about 20’ spacing. An alternative to casting the segments in place with form travelers would be to use precast segments; however, given the size of the structure it is likely that less than 100 segments would be required and that precasting the segments would not be cost effective. Regardless of whether the segments are precast or cast-in-place, balanced cantilever erection does not require falsework and keeps the navigation channel free of major obstructions.

Wind tunnel testing should be performed during final design to determine the aerodynamic characteristics of the bridge, both during erection and in the completed state.

Local contractors have limited experience with cable supported structures and would likely need to supplement their current staff if they are the successful bidder. They have done this on past projects involving segmental construction, so it is not a barrier to the structure type, simply an added item in comparison to girder, truss or arch bridges.

Future Inspection, Maintenance and Expansion

For this structure the cables and cable anchorages are the primary maintenance concern. Cable corrosion problems in early cable-stayed bridges have been addressed through the use of multi-level protective sheathing, and cables in newer bridges have demonstrated superior longevity. However, to facilitate any unforeseen cable or anchorage rehabilitation, all anchorages would be detailed to allow for removal and replacement under traffic. Details that are fatigue resistant and internally redundant would be used wherever possible and the structure would be designed such that the loss of one cable would not cause a collapse (non-fracture critical). One maintenance issue with cable supported bridges in cold climates has been ice forming on the cables and falling onto the roadway.

It is anticipated that full deck replacement would not be necessary due to transverse and longitudinal post-tensioning maintaining compression in the deck, using a protective overlay or increased cover, and possible use of stainless steel reinforcement in the deck, if MnDOT and WisDOT concur. Any overlay could simply be removed and replaced without removal of the structural deck. Widening of this structure may not be feasible due to the cable planes and the tower legs. However, the initial design could be performed to include accommodating the addition of a second plane of cables in the eastern towers at a later date. This would allow a third line of towers to be built and the original eastern towers would become the middle towers between the two directions of traffic. Time dependent changes such as creep and shrinkage, and cable elongation would need to be considered in this design.

For inspection, manlifts would be used to inspect the towers and cables. Cables may make using an UBIV difficult. In that case, a suspended walkway may be needed for inspection of the underside of the deck. Navigational clearances and coordination would need to be considered in the design of a suspended walkway.

Aesthetics

The extradosed alternate would be a signature bridge. The tower and superstructure shape selection would provide an opportunity to produce a unique and visually appealing structure. The towers for this structure type would extend approximately 50' above the roadway which is similar to the height that the existing truss extends above the roadway.

If used as a parallel structure with the existing rehabilitated truss left in place, the modern appearance of the extradosed alternate would be in contrast to the existing bridge. Also, the required grade raise for this structure type requires a roadway 10' above the existing roadway on the truss. That elevation difference would have definite visual implications with the extradosed span creating a visual barrier upstream for motorists on the truss span. From the City of Red Wing, the extradosed span would visually block viewing the lower portion of the truss bridge. These issues would need to be vetted in the next phase of alternative evaluations.

ALTERNATE 5 – CABLE-STAYED BRIDGE

The cable-stayed alternate is a two-span structure with lengths of 612'-612'. The tower(s) will be over 300' tall and could have one, two, three or four vertical planes of cables. The cable spacing at deck level is between 28' and 30' which is within the typical range for a cable stayed bridge. A variety of tower shapes are suitable for this span length including, single, double, H-shape, diamond and inverted Y. The cable arrangements are typically parallel, fan or semi-fan. The superstructure deck systems are typically either composite or trapezoidal box sections. The composite deck system is comprised of edge girders, floor beams and concrete deck panels. Trapezoidal box superstructures can be concrete (either cast-in-place or precast) or steel (with cast-in-place decks). The superstructure depths for the deck systems are typically 5' to 10' for the composite and trapezoidal box sections, respectively. Therefore, it is anticipated that this alternate would only require a profile grade raise of about 1' to 6'. An elevation view of the cable-stayed alternate is shown in Figure 12 at the end of this memo. This alternative would be the only alternative to move Pier 2 completely out of the normal pool river channel.

Past projects have identified the tall towers and cables required for this structure type to be potential problems for migratory birds flying in the Mississippi River valley. If this structure type is advanced, the negative impacts of potential bird strikes will need to be evaluated.

Construction

Special procedures are required to construct cable-stayed bridges. However, a number of such bridges have been successfully built in the United States and Canada since 1975, and the construction technology is well developed. Construction of the main tower foundations would follow similar procedures as the other alternates. Superstructure erection would begin with a short starter piece supported on falsework or brackets at the main tower. Then, each segment of the deck would be erected by the balanced cantilever method, with the permanent stay cables being installed at the completion of each segment. The balanced cantilever erection does not require falsework and keeps the navigation channel free of major obstructions.

Wind tunnel testing should be performed during final design to determine the aerodynamic characteristics of the bridge, both during erection and in the completed state. Fairings on the outside of the longitudinal edge girders and/or wind bracing (for the composite section) may be required in order to ensure aerodynamic stability.

Similar to the extradosed bridge, local contractors have limited experience with cable supported structures and would likely need to supplement their current staff if they are the successful bidder.

Future Inspection, Maintenance and Expansion

For this structure, the stay cables and anchorages are the primary maintenance concern. Cable corrosion problems in early cable-stayed bridges have been addressed through the use of multi-level protective sheathing, and cables in newer bridges have demonstrated superior longevity. However, to facilitate any unforeseen cable or anchorage rehabilitation, all anchorages would be detailed to allow for removal and replacement. Details that are fatigue resistant and internally redundant would be used wherever possible and the structure will be designed such that the loss of one cable would not cause a collapse (non-fracture critical). One maintenance issue with cable-stayed bridges in cold climates has been ice forming on the cables and falling onto the roadway. Also, tall cable-stayed bridge towers typically require lightning protection.

It is anticipated that full deck replacement would not be necessary due to transverse and longitudinal post-tensioning maintaining compression in the deck, and a protective overlay being used. The overlay could simply be removed and replaced without removal of the structural deck. Also, widening of this structure would not be feasible due to the cable planes and the tower legs unless future widening is considered and designed for in the initial design.

For inspection, there are manlifts available that can reach over 200 ft vertically from the deck level. Also, ladder or stair systems are typically provided inside the tower. Thus, direct access to the tower head cable anchorages would be possible. Cables anchored to the exterior of the superstructure may make using an UBIV difficult. In which case, a suspended walkway may be needed for inspection of the underside of the deck. Navigational clearances and coordination would need to be considered in the design of a suspended walkway.

Aesthetics

The cable-stayed alternate is the tallest and most impressive of the structure types studied; it would be a signature bridge. The superstructure and tower shape, and cable pattern selection provide an opportunity to produce a unique and visually appealing structure.

If used as a parallel structure with the existing rehabilitated truss left in place, this alternate's tall tower and modern appearance would provide the largest contrast to the existing bridge. With a tower that would extend over 240' above the roadway and a cable pattern that extends over 1200', this structure would be highly visible and would dominate the viewshed from Red Wing.

ALTERNATE 6 – CONCRETE SEGMENTAL BOX GIRDERS

Alternate 6 is a three-span variable depth continuous concrete segmental box girder bridge with span lengths of 216'-432'-217', for a total length of approximately 865'. The required structure depth below deck for this alternate would be the deepest of all of the alternates. Typically the shallowest concrete segmental bridges have a depth of about 1/25th of the span length over the pier. Therefore for a 432' span, the depth should be a minimum of over 17' and a grade raise of more than 13'would be necessary for this structure. A preliminary profile grade has been developed to accomplish this grade raise. The preliminary profile grade and an elevation view of this alternate are shown on Figures 13 and 14 at the end of this memo. A cross section for this alternative would be similar to the cross section for Alternative 7 (see Figure 17).

Providing this grade raise would have several impacts. First, the grade of the Minnesota approach would need to be increased from 4% to 5%, and if the grade of the Wisconsin approach is held to 4%, the project limits would extend several hundred feet further to the north before the new profile could be tied into the existing grades. Also, this grade would require the use of retaining walls at both approaches to accommodate the difference in elevations between the new and existing profiles. These retaining walls may be temporary or permanent depending on whether or not the existing truss is rehabilitated and left in place.

For the two-lane options, the cross section for this structure type would be made up of one trapezoidal-shaped concrete box with wings. The four-lane option would require two boxes. Given the size of this bridge, the concrete segments would likely be cast-in-place, although precast could be an option. However even a four-lane bridge would only require about 170 segments, which is typically too few to be cost effective for a precast option.

Construction

This alternate could be constructed without placing falsework in the main Mississippi River channel by using the balanced cantilever method of construction. Construction would start at the two main river piers and work outward. The box girders would be placed alternately between the river side of the pier and the shore side, thereby minimizing the amount of unbalanced loads being placed on the pier during construction. This could be done by pouring alternating cast-in-place segments with the use of form travelers or by lifting alternating precast segments into place.

Local contractors have experience with segmental bridges and the latest project at Dresbach, Minnesota had multiple bidders. The structure type does not appear to be an issue for bidders.

Future Inspection, Maintenance and Expansion

Inspection access for the outside of the concrete boxes would be obtained by using an UBIV. With no superstructure members above the deck, the underside of this alternate would be easier to inspect with an UBIV than all of the previous alternates. However, this structure type would also require that the inside of the concrete boxes be inspected. Access to the inside of the boxes would be gained through access hatches located at the ends of the concrete segmental spans. Lighting and electrical outlets would need to be provided inside the concrete box at regular intervals along the bridge to facilitate inspection.

Future maintenance for the concrete segmental box alternate includes periodic inspections and wearing surface application. Future maintenance needs for this alternate should typically be less than many of the previously described steel alternates because it will not need to be repainted.

It is anticipated that full deck replacement will not be necessary due to transverse and longitudinal post-tensioning, possible use of stainless reinforcing in the deck, and added cover or use of a 2” overlay. The overlay could simply be removed and replaced without removal of the structural deck. Future widening of the structure to accommodate additional lanes of traffic would not be possible without construction of a separate substructure and superstructure.

Aesthetics

The concrete segmental box girder alternate’s shape is very clean and unobtrusive. Because this structure type does not have any superstructure elements above the deck it would provide an open view of the Mississippi River and the City of Red Wing from the bridge.

If used as a parallel structure with the existing rehabilitated truss left in place, its modern appearance would provide a contrast to the existing bridge. Also, the required grade raise for this structure type would look visually out of place next to the existing truss on the existing grade, and the concrete box would form a visual barrier between the existing truss and downtown Red Wing, as described in the Extradosed Alternate. This difference in grades would also introduce staging and construction challenges, and could cause issues from the deck of the existing bridge being in the shadows of the new concrete box for part of the day.

ALTERNATE 7 – STEEL BOX GIRDERS

Alternate 7 is a three-span continuous haunched steel box girder bridge with span lengths of 216’-432’-342’, for a total length of approximately 990’. With the second span being twice as long as the first span, the uplift at the south abutment in this span arrangement would need to be further evaluated and accounted for in the design. Ideally the span ratio between the second and first span would be similar to the ratio between the second and third span, but this is not feasible due to the desire to not move the first pier away from the bank and out into the Mississippi River navigational channel.

The required structure depth for the steel box girder alternate would be about 14’ over the piers. That means that this structure type would require a grade raise of around 10’. The 10’ grade raise required for this alternative would have many of the same issues as the 14’ grade raise for Alternate 6 but they would not be as great and a 4% grade could be maintained on the Minnesota approach. A preliminary profile grade has been developed to accomplish the 10’ grade raise. The preliminary profile grade and an elevation view of this alternate are shown on Figures 15 and 16 at the end of this memo. Also, a cross section showing the steel box alternate constructed next to the existing truss is shown on Figure 17.

Construction

This alternate could be constructed without placing falsework in the main Mississippi River channel by erecting field segments from cranes on land and on barges. Compared to the other alternates listed above, the continuous steel box girder alternate would require the least specialized equipment and erection procedures to construct.

Future Inspection, Maintenance and Expansion

Inspection access for the girders and underside of the deck would be obtained by using an UBIV. With no superstructure members above the deck, the underside of this alternate would be easier to inspect with an UBIV than Alternates 1-5. This structure type would also require that the inside of the steel boxes be inspected. Access to the inside of the boxes would be gained through access hatches located at the ends of the spans. Lighting and electrical outlets would need to be provided inside the steel box at regular intervals along the bridge to facilitate inspection.

Future maintenance for the steel box girder alternate includes periodic inspections, painting, deck replacement and wearing surface application. Deck replacement could be accomplished a half at a time while maintaining traffic on the other half. If an odd number of boxes in the cross section are designed, then accommodations for future re-decking may require special design of diaphragms and bracing. Future widening of this structure to accommodate additional lanes of traffic could be accomplished by adding additional girder lines and new additional substructures in the future.

Aesthetics

The steel box girder alternate would be a very typical looking structure. With this structure type not having any superstructure elements above the deck, it would provide a more open view of the Mississippi River and the City of Red Wing than Alternates 1-5.

If used as a parallel structure with the existing rehabilitated truss left in place, the required grade raise for this structure type would have all of the same construction challenges and visual impacts as the extradosed and concrete segmental alternates.

APPROACH UNITS

Approach Unit Material Selection

Depending on the structure type selected for the main river bridge, there often are aesthetic reasons to employ the same primary material in the approach spans that is used for the main spans. This may or may not lead to some overall cost savings for the project depending on constructability, substructure costs and other economic factors. Therefore for the approach spans, both concrete prestressed girders and steel plate girders will be studied and evaluated based on costs, aesthetics and other factors. In addition, if steel box girders are used for the main spans they may be viable for the approach spans as well.

Span Balance for Steel Approach Spans

Depending on whether or not the existing north approach spans are being removed, there are different span arrangements that are being studied for the new north approach spans. If the existing north approach spans are to remain, there are aesthetic and hydraulic reasons to line up the new piers with the existing piers. For single main span alternatives such as an arch or a simple span truss this would lead to a four span layout of 217’-275’-300’-185’ for the north approach. This layout is reasonable but is not ideally balanced for the steel beams to be as efficient as possible.

If the existing north approach spans are to be removed or it is determined that the new piers do not need to line up with the existing piers in the approach spans, then a better balanced span layout would be 217’-272’-272’-216’.

For the alternatives that have a three-span main river unit such as the continuous truss and the extradosed, the options for steel approach spans would be similar to those described above but would be one span shorter. If the piers need to line up with the existing piers, the approach span layout would be 275’-300’-185’. But if they do not have to line up, spans of 235’-290’-235’ would be more economical.

These options will both be studied so that a decision can be made with regard to the need to line up the new and existing piers in the north approach.

Spans for Concrete Approach Spans

Span layouts for using prestressed concrete beams for the north approach will be studied in a similar manner to the steel spans described above. Because the prestressed beams would not be designed continuous, efficient span ratios are not an issue, however the use of equal beam lengths in multiple spans should lead to some savings in fabrication. Therefore, two different alternate layouts for each structure type will be studied; one that lines up the proposed piers with the existing piers and one that optimizes span lengths.

For the single main span alternates, the concrete approach span layout to line up with existing piers will be 109’-109’-125’-150’-150’-150’-125’-60’. Note that this layout will require one more pier than currently exists because prestressed girders are not readily available for the 217’ span length. If the new piers do not have to line up with the existing piers then the layout would be seven spans at about 140’ each.

For the alternatives that have a three-span main river unit such as the continuous truss and the extradosed, the options for concrete approach spans would be similar to those described above but would be two spans shorter. If the piers need to line up with the existing piers, the approach span layout would be 125’-150’-150’-150’-125’-60’, but if they do not have to line up, using five spans at about 152’ each would be more economical. For Alternate 6, the concrete segmental box girders, it may be cost-effective to use concrete box girders in the approach spans as well.

COSTS

As discussed earlier, at this stage of the project development several different cross sections that all have different widths are still being studied. Therefore a cost comparison based on the estimated cost per square foot and anticipated lengths of the main spans and approach spans will be the basis of comparing the construction costs of the different structure types under consideration. The approach spans for all of the alternatives are assumed to cost $275 per square foot in 2012 dollars. This is higher than typical bridges but has been increased due to the poor soils on the Wisconsin approach side of the river and because the piers for the approaches will be relatively tall. Based on direction from MnDOT, an inflation factor of 1.33 has been used to inflate all of the 2012 costs to the 2018 letting year. The costs in the table on the following page are estimated for the bridge construction only and do not include any roadway costs.

Structure Alternate	Main Span(s) Length	Approach Spans Length *	Main Span Sq. Ft. Cost (2012)	Weighted Average Sq. Ft. Cost (2012)	Weighted Average Sq. Ft. Cost (2018)
Tied Arch	432’	1193’	$750	$401	$533
Simple Span Truss	432’	1193’	$750	$401	$533
Three-Span Continuous Truss	864’	761’	$750	$528	$702
Extradosed Bridge	864’	761’	$850	$581	$773
Cable-Stayed Bridge	1224’	401’	$800	$670	$891
Concrete Segmental Box Girders	1625’	0’	$350	$350	$466
Steel Box Girders	1625’	0’	$325	$325	$432

***** All approach spans assumed to cost $275 per square foot in 2012 dollars

Using the estimated square foot costs above with the three different bridge widths under consideration and adding in the approximate approach roadway costs, contingencies and 20% for Engineering and Administration, the table on the following page provides a comparison of the total project costs excluding right-of-way for the different structure type alternatives. The approach roadway costs include both the Minnesota and the Wisconsin approaches. For estimating purposes the higher cost option of replacing Bridge 9103 and building a button-hook approach with a slip ramp on the Minnesota approach has been assumed.

TOTAL PROJECT COSTS INCLUDING APPROACH ROADWAY (EXCLUDING RIGHT-OF-WAY)

Structure Alternate	Total Costs for a 50'-4" Wide Bridge (with Cost of Truss Rehab included)	Total Costs for a 60'-4" Wide, 2-Lane Bridge	Total Costs for a 86'-1" Wide, 4-Lane Bridge
Tied Arch	$74M to $84M ($111M to $121M)	$84M to $97M	$115M to $133M
Simple Span Truss	$75M to $86M ($112M to $122M)	$86M to $98M	$117M to $135M
Three-Span Continuous Truss	$92M to $106M ($129M to $143M)	$106M to $123M	$146M to $170M
Extradosed Bridge	$101M to $110M ($138M to $147M)	$117M to $128M	$162M to $177M
Cable-Stayed Bridge	$113M to $124M ($150M to $160M)	$132M to $144M	$182M to $200M
Concrete Segmental Box Girders	$69M to $74M ($105M to $111M)	$78M to $85M	$106M to $115M
Steel Box Girders	$63M to $72M ($100M to $109M)	$72M to $82M	$97M to $111M

- Includes Approach Roadway costs for Minnesota and Wisconsin approach, excluding right-of-way
- Approach costs assume the higher cost option of replacing Bridge 9103 and building a button-hook approach with a slip ramp
- Costs include 20% for Engineering and Administration
- The 50'-4" Wide Bridge would only be built if used as part of a pair of bridges, therefore shoulder widths assume one way traffic
- The 60'-4" Wide Bridge assumes two way traffic and therefore assumes 10' shoulders on each side
- Bridge costs include a range for contingencies to reflect material cost volatility, unknowns based on the preliminary level of design that has been done to date, staging complexity and construction complexity

EVALUATION MATRIX

The evaluation matrix on the following page compares the seven potential structure types based on their grade raise requirements, future maintenance and inspection requirements, aesthetic impacts, the complexity of their construction, their fracture critical issues, ability to accommodate future expansion and their estimated initial construction cost. The information below is based on the discussions in the previous sections of this memo. The table provides a comparison of the alternatives in each category by ranking them "Low", "Medium" or "High". In all categories the "Low" ranking is the most desirable either because it has lower requirements or lower impacts or lower complexities.

EVALUATION MATRIX

Structure Alternate	Grade Raise Required	Future Maintenance and Inspection Requirements	Aesthetic Impacts	Constructability Complexity	Redundancy and Fracture Critical Issues	Difficulty of Future Expansion	Other Considerations	Construction Cost per Sq. Ft. (2018)
Tied Arch	Low – 2' +/- (Framed-in Stringers) 5' +/- (Stacked)	Medium – Requires future painting. Inspection will require special expertise.	Low – Looks somewhat similar to existing bridge.	Medium – Bridge could be built in pieces using temporary supports, or built off-site and moved into place.	Medium – Tie girder will require special design similar to Hastings Bridge.	Medium – Original design would have to account for future addition of third arch.		Medium - $534
Simple Span Truss	Low – 2' +/- (Framed-in Stringers) 5' +/- (Stacked)	High – Requires future painting. Inspection will be costly.	Low – Looks similar to existing bridge.	Medium – Bridge could be built in pieces using temporary supports, or built off-site and moved into place.	High – Lower chord, tension diagonals and verticals will require special design.	Medium – Original design would have to account for future addition of third truss.		Medium - $534
Three-Span Continuous Truss	Low – 2' +/- (Framed-in Stringers) 5' +/- (Stacked)	High – Requires future painting. Inspection will be costly.	Low – Looks most like existing bridge.	Medium – Balanced cantilever construction of fairly light pieces.	Medium to High – Will be similar to Simple Span Truss but continuous spans will provide some additional load paths.	Medium – Original design would have to account for future addition of third truss.		Medium to High - $702
Extradosed Bridge	Medium to High – 10' +/-	Medium – Inspection of cables and anchorages will require some special expertise.	High – Towers and grade raise will have visual impact. More modern appearance.	High – Least common structure type. Only one extradosed currently in US. Staging challenges with the required grade raise.	Low – Concrete segments are precompressed and cables are redundant at each location.	Medium to High – Original design would have to account for future addition of a third tower.	The higher grade raise requirements could add time and complexity to the construction staging and maintenance of traffic.	High - $773
Cable-Stayed Bridge	Low – 1' +/- (Composite Deck) 6' +/- (Trapezoidal Box)	Medium – Inspection of cables and anchorages will require some special expertise.	High – 300' tall towers and modern looking cables will have the greatest visual impact.	High –300' tall towers and installing cables will require special equipment & expertise.	Low – floor system contains multiple members or is precompressed, and cables are redundant at each location.	High – Designing cable planes and tower legs for future expansion would need to be considered in the initial design.	There may be environmental impacts due to the possible issues with migratory bird strikes with the tall towers and cables.	High - $891
Concrete Segmental Box Girders	High – 13' +/-	Low – Concrete box girders require little maintenance and will be fairly easy to inspect.	High – 13' Grade raise will cause a visual impact.	Medium – This type of construction has become more common. Staging challenges with the required grade raise.	Low – Concrete segments are precompressed and multiple girder lines provide redundancy.	Low – Additional box girders could be constructed to add additional lanes at a future date.	The higher grade raise requirements could add time and complexity to the construction staging and maintenance of traffic.	Low - $465
Steel Box Girders	Medium to High – 10' +/-	Medium – Requires future painting, but will be fairly easy to inspect.	Medium to High – 10' Grade raise will cause a visual impact.	Medium – Most common type of construction of all of the alternatives. There will be staging challenges with the required grade raise.	Low – Multiple girder lines provide redundancy.	Low – Additional box girders could be constructed to add additional lanes at a future date.	The higher grade raise requirements could add time and complexity to the construction staging and maintenance of traffic.	Low - $432

RECOMMENDATIONS

Based on the discussions and evaluation matrix above, the following recommendations are being made for each of the seven structure type alternates.

Alternate 1 – Tied Arch: The tied arch did not rank "High" in any of the evaluation categories. It is a good fit with the project site both aesthetically and geometrically and can be a cost effective solution in the required span length range. For these reasons it is recommended that the tied arch be carried forward to the next phase of study to be investigated in greater detail.

Alternate 2 – Simple Span Truss: The simple span truss ranked "High" in Future Maintenance and Inspection, and Fracture Critical Issues. It will look similar and be similar in cost to the tied arch, however there are not established design and detailing methods to address the redundancy and fracture critical issues of the simple span truss like there are for the tied arch. Therefore, it is recommended that the simple span truss be dismissed from future investigations.

Alternate 3 – Three-Span Continuous Truss: The three-span continuous truss ranked "High" in the Future Maintenance and Inspection category, and "Medium to High" in Fracture Critical Issues and Cost. It is the best fit aesthetically with the existing bridge and can be a cost effective solution in this span range. Being a truss, this alternate has some of the same redundancy and fracture critical issues as the simple span truss. Because it is continuous over Piers 1 and 2 there may be opportunities to design redundant load paths into the structure but MnDOT procedures for doing this have not been established. For these reasons it is recommended that the three-span continuous truss be dismissed from future investigations.

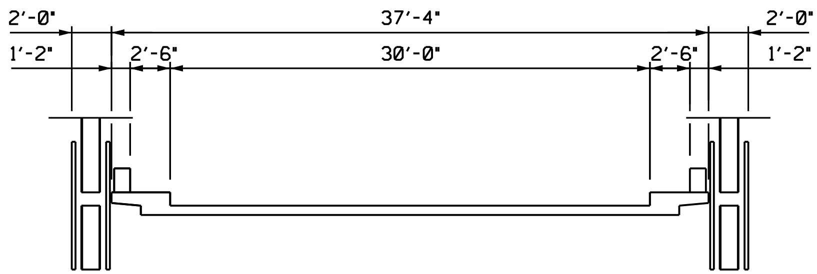
Alternate 4 – Extradosed Bridge: The extradosed bridge ranked "High" in Aesthetic Impacts and Constructability Complexity, and "Medium to High" in Difficulty of Future Expansion. It is also one of the more expensive alternates and requires more of a grade raise than the first three alternates. Therefore, it is recommended that the extradosed bridge be dismissed from further study.

Alternate 5 – Cable-Stayed Bridge: The cable-stayed alternate ranked "High" in Aesthetic Impacts, Constructability Complexity, and Difficulty of Future Expansion. It is the most expensive alternate and would have the greatest visual impact on the downtown Red Wing viewshed. Therefore, it is recommended that the cable-stayed bridge be dismissed from further study.

Alternate 6 – Concrete Segmental Box Girders: The concrete segmental box girder alternate only ranked "High" in the Aesthetic Impacts category. It is also one of the least expensive alternatives and has the least Future Maintenance and Inspection Requirements. Even though it requires the largest grade raise, it is recommended that this alternate be studied further due to its low maintenance requirements and low initial construction cost.

Alternate 7 – Steel Box Girders: The steel box girder alternate did not rank "High" in any of the evaluation categories. It will require a greater grade raise than several of the alternates but it is still estimated to be the least expensive alternative. Therefore it is recommended that the steel box girder alternate be carried forward to the next phase of study to be investigated in greater detail.

Attachments



EXISTING BRIDGE CROSS SECTION

HDR Engineering, Inc.	RED WING BRIDGE	DES: / DR: / CHK: / CHK:	BRIDGE NO. 9040
	FIGURE 2 - EXISTING BRIDGE		

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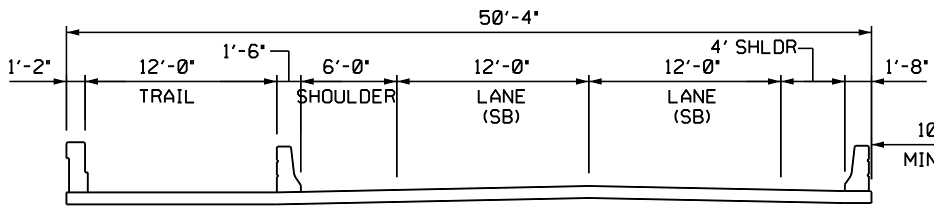
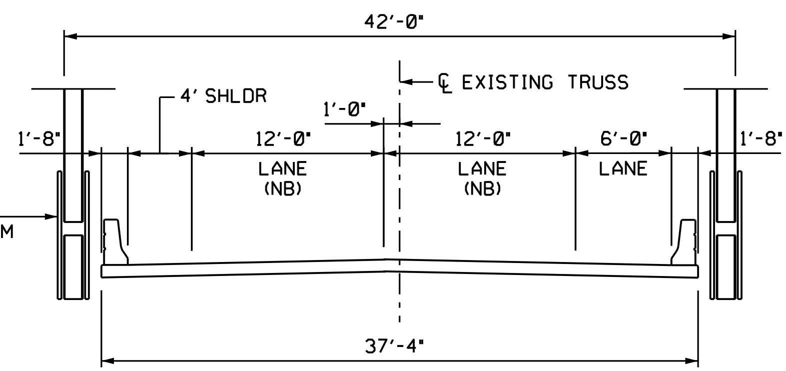


NEW TWO-LANE BRIDGE



EXISTING BRIDGE

HDR
HDR Engineering, Inc.

RED WING BRIDGE

FIGURE 3 - REHABILITATE EXISTING WITH NEW TWO-LANE

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CHK: CHK:

BRIDGE NO.
9040

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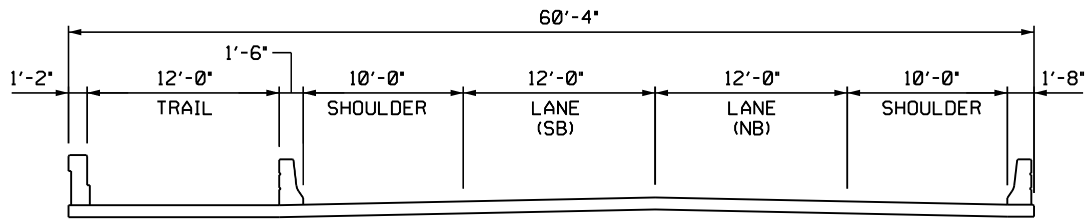
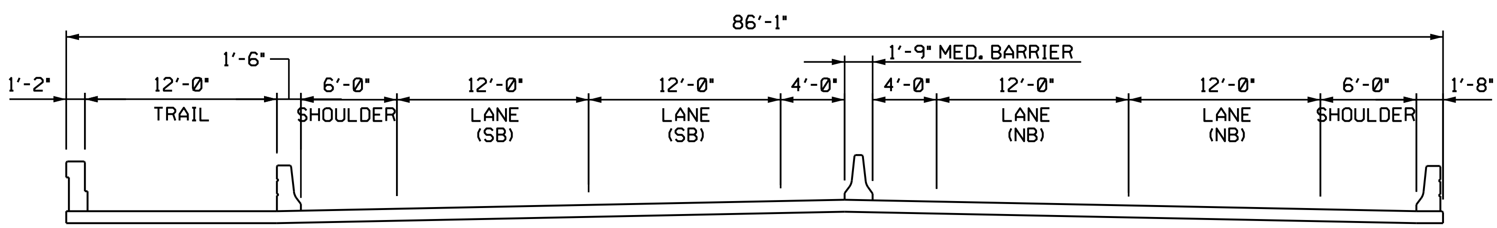


NEW TWO-LANE BRIDGE

HDR Engineering, Inc.

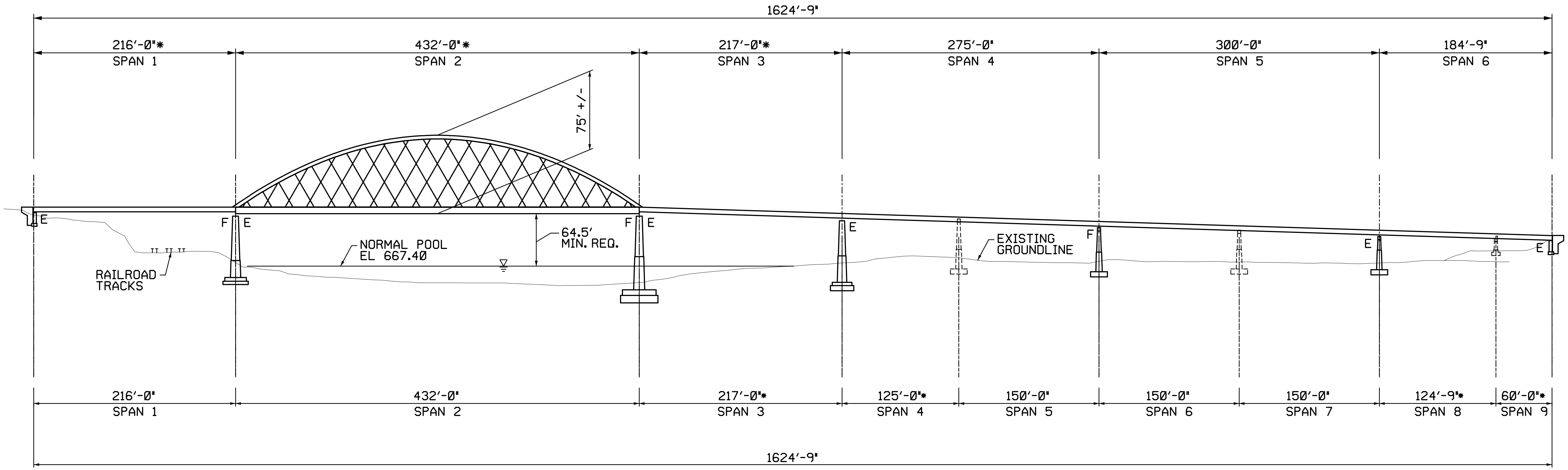
RED WING BRIDGE	DES:	DR:	BRIDGE NO.
	CHK:	CHK:	
FIGURE 4 - NEW TWO-LANE			9040



NEW FOUR-LANE BRIDGE

HDR Engineering, Inc.	RED WING BRIDGE	DES: DR: CHK: CHK:	BRIDGE NO. 9040
	FIGURE 5 - NEW FOUR-LANE		

NEW SPANS



EXISTING SPANS

* SEE NOTE 2

ELEVATION

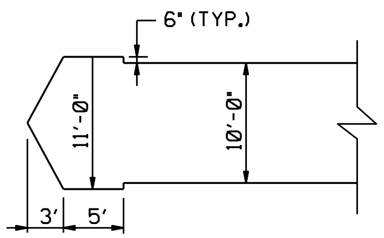
NOTES:

1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.

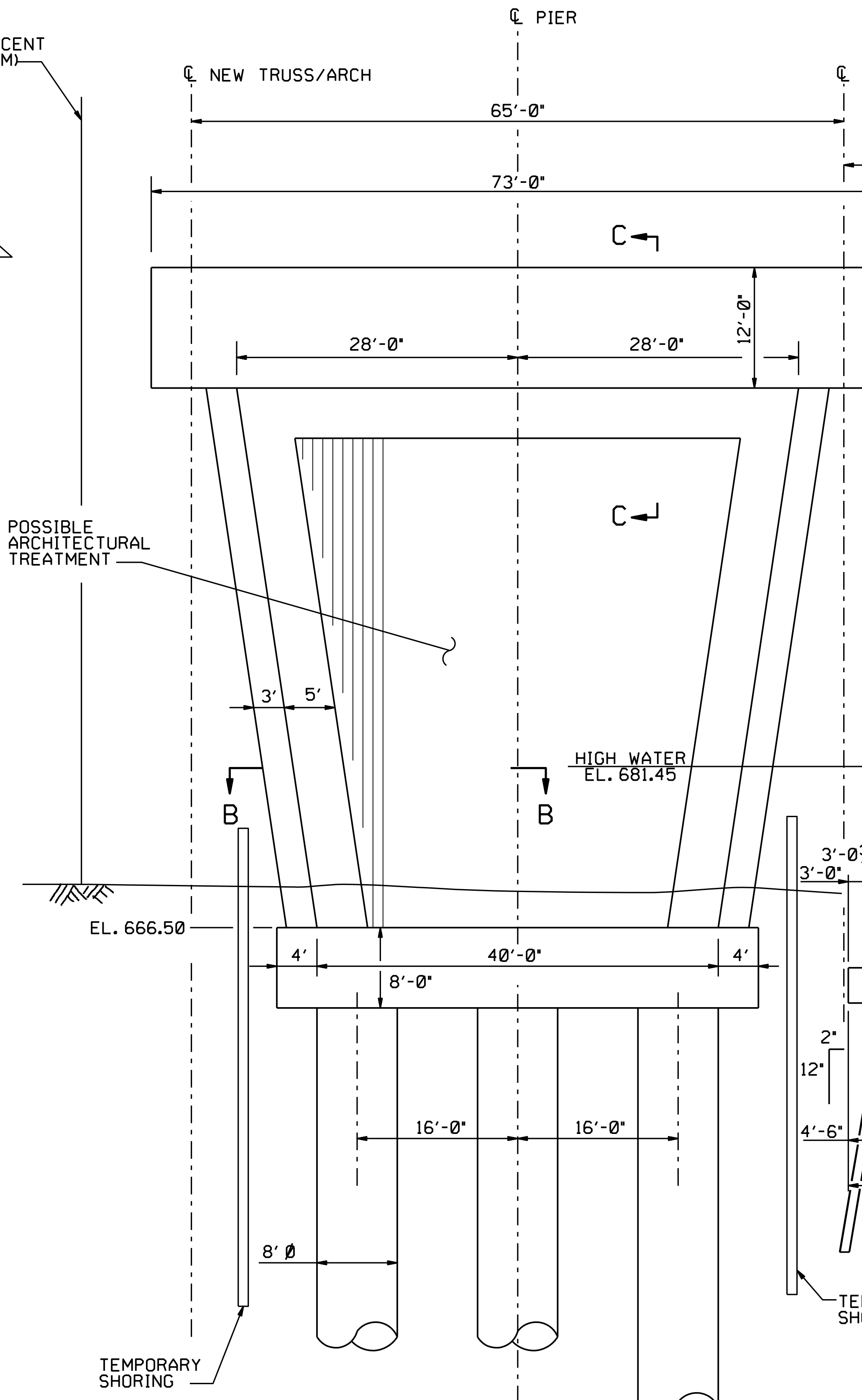
Main Unit - Network Tied Arch (432')
S. Approach - Simple Span Plate Girder (216')
N. Approach - 4-Span Plate Girder (217'-275'-300'-185')

Notes:
Option if new piers should be aligned with existing piers for some reason, i.e. hydraulic.

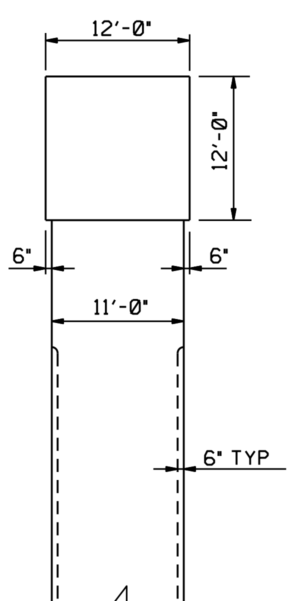
HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - NETWORK TIED ARCH	DES: / CHK:	DR: / CHK:	BRIDGE NO.
		FIGURE 6		9040



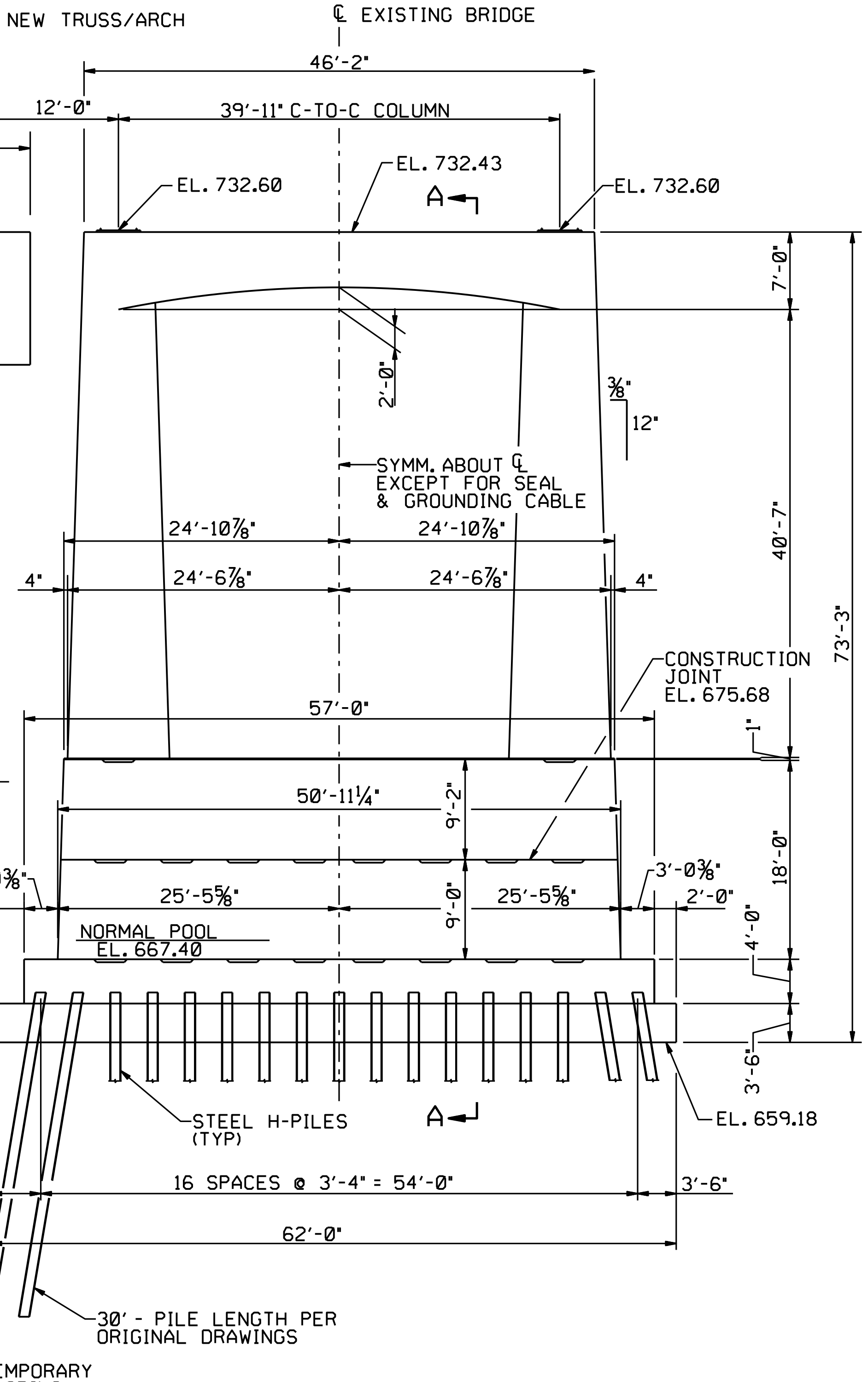
SECTION B-B
SCALE 1/8"=1'-0"



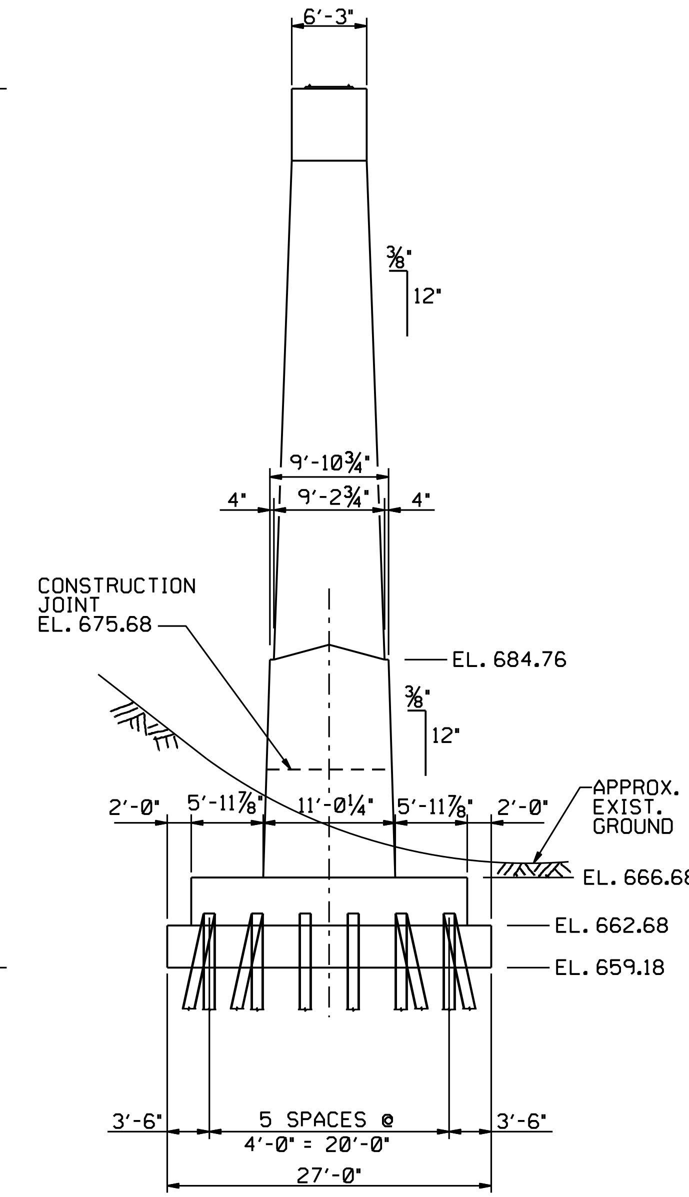
PROPOSED PIER 1 ELEVATION
SCALE 1/8"=1'-0"



SECTION C-C
SCALE 1/8"=1'-0"



EXISTING PIER 1 ELEVATION
SCALE 1/8"=1'-0"

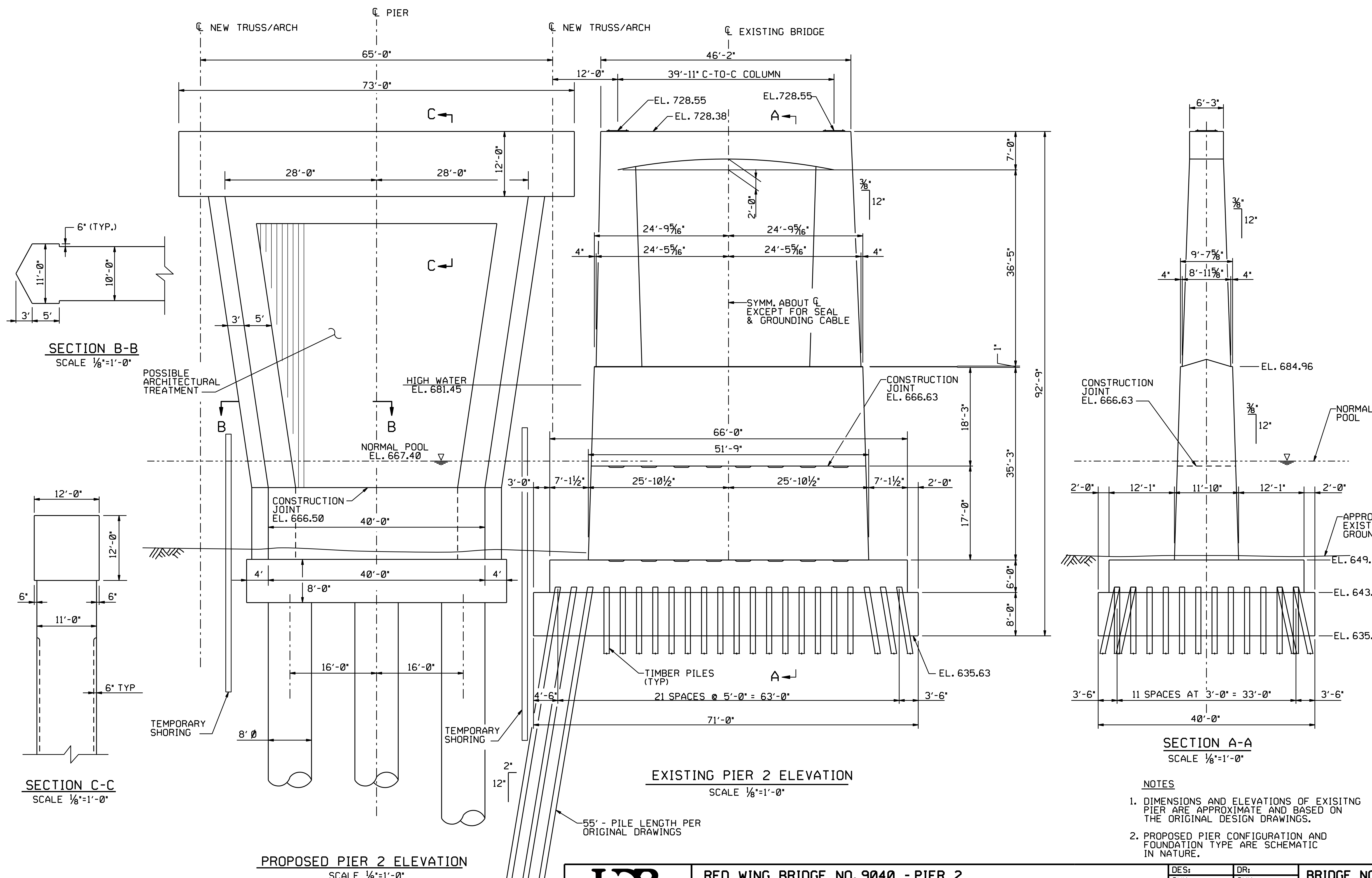


SECTION A-A
SCALE 1/8"=1'-0"

NOTES

1. DIMENSIONS AND ELEVATIONS OF EXISITNG PIER ARE APPROXIMATE AND BASED ON THE ORIGINAL DESIGN DRAWINGS.
2. PROPOSED PIER CONFIGURATION AND FOUNDATION TYPE ARE SCHEMATIC IN NATURE.

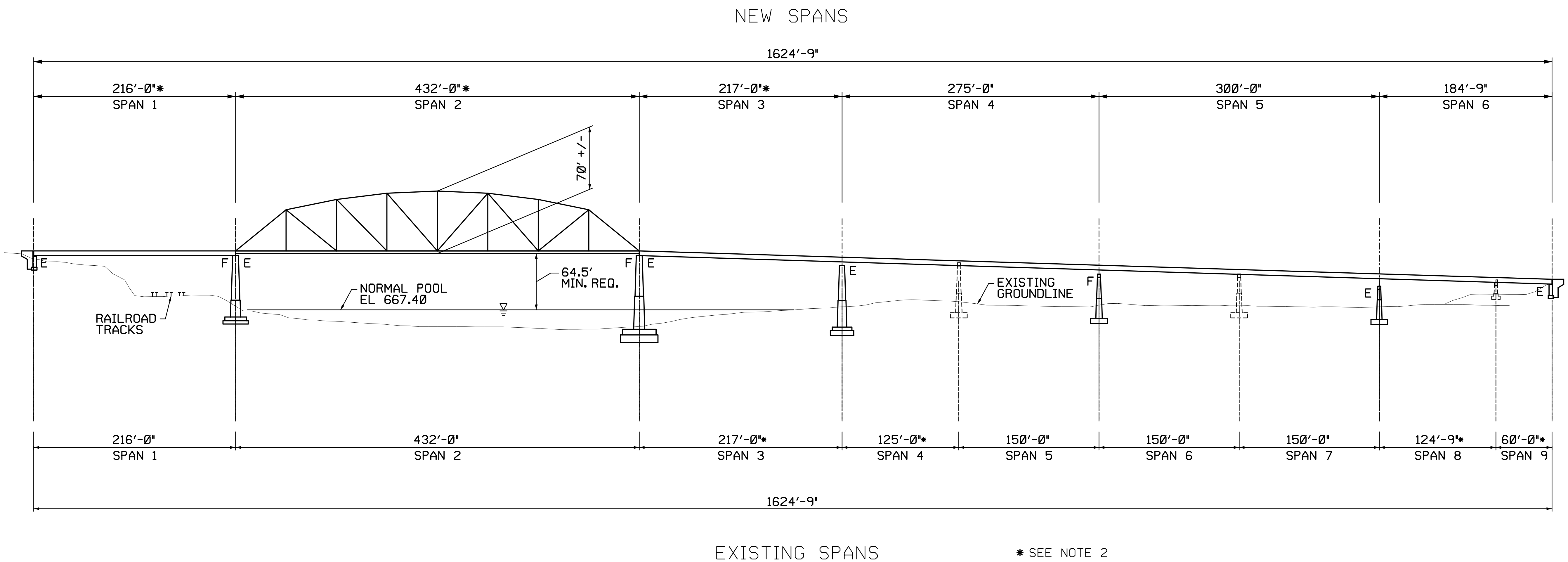
HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - PIER 1	DES: / CHK:	DR: / CHK:	BRIDGE NO. 9040
		FIGURE 7		



NOTES

1. DIMENSIONS AND ELEVATIONS OF EXISITNG PIER ARE APPROXIMATE AND BASED ON THE ORIGINAL DESIGN DRAWINGS.
2. PROPOSED PIER CONFIGURATION AND FOUNDATION TYPE ARE SCHEMATIC IN NATURE.

HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - PIER 2	DES: / DR: / CHK: / CHK:	BRIDGE NO. 9040
		FIGURE 8	



* SEE NOTE 2

ELEVATION

NOTES:

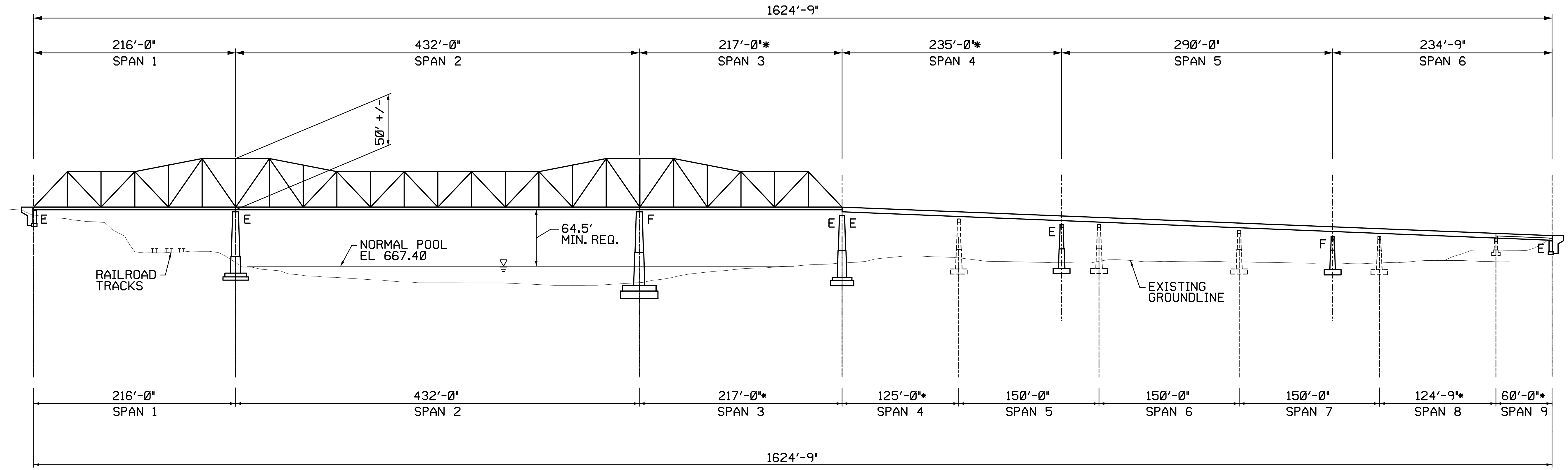
1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.

Main Unit - Simple Span Truss (432')
S. Approach - Simple Span Plate Girder (216')
N. Approach - 4-Span Plate Girder (217'-275'-300'-185')

Notes:
Option if new piers should be aligned with existing piers for some reason, i.e. hydraulic.

HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - SIMPLE SPAN TRUSS	DES: DR: CHK: CHK:	BRIDGE NO.
		FIGURE 9	9040

NEW SPANS



EXISTING SPANS

* SEE NOTE 2

ELEVATION

NOTES:

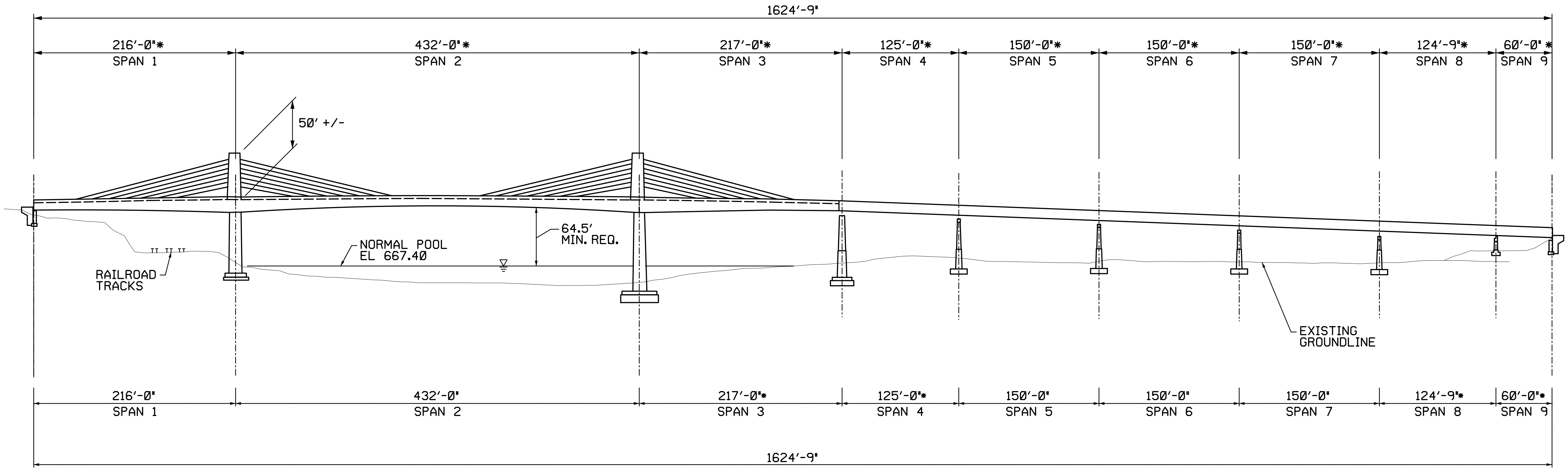
1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.

Main Unit - 3-Span Truss (216'-432'-216') - Similar to original
S. Approach - None
N. Approach - 3-Span Plate Girder (235'-290'-235')

Notes:
New north piers have good clearance from existing piers.
North approach could be shortened by 87' if geotech issues are addressed. If so, 3-span approach could be (204'-265'-204').

HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - THREE-SPAN CONTINUOUS TRUSS	DES:	DR:	BRIDGE NO.
		CHK:	CHK:	9040
		FIGURE 10		

NEW SPANS



EXISTING SPANS

* SEE NOTE 2

ELEVATION

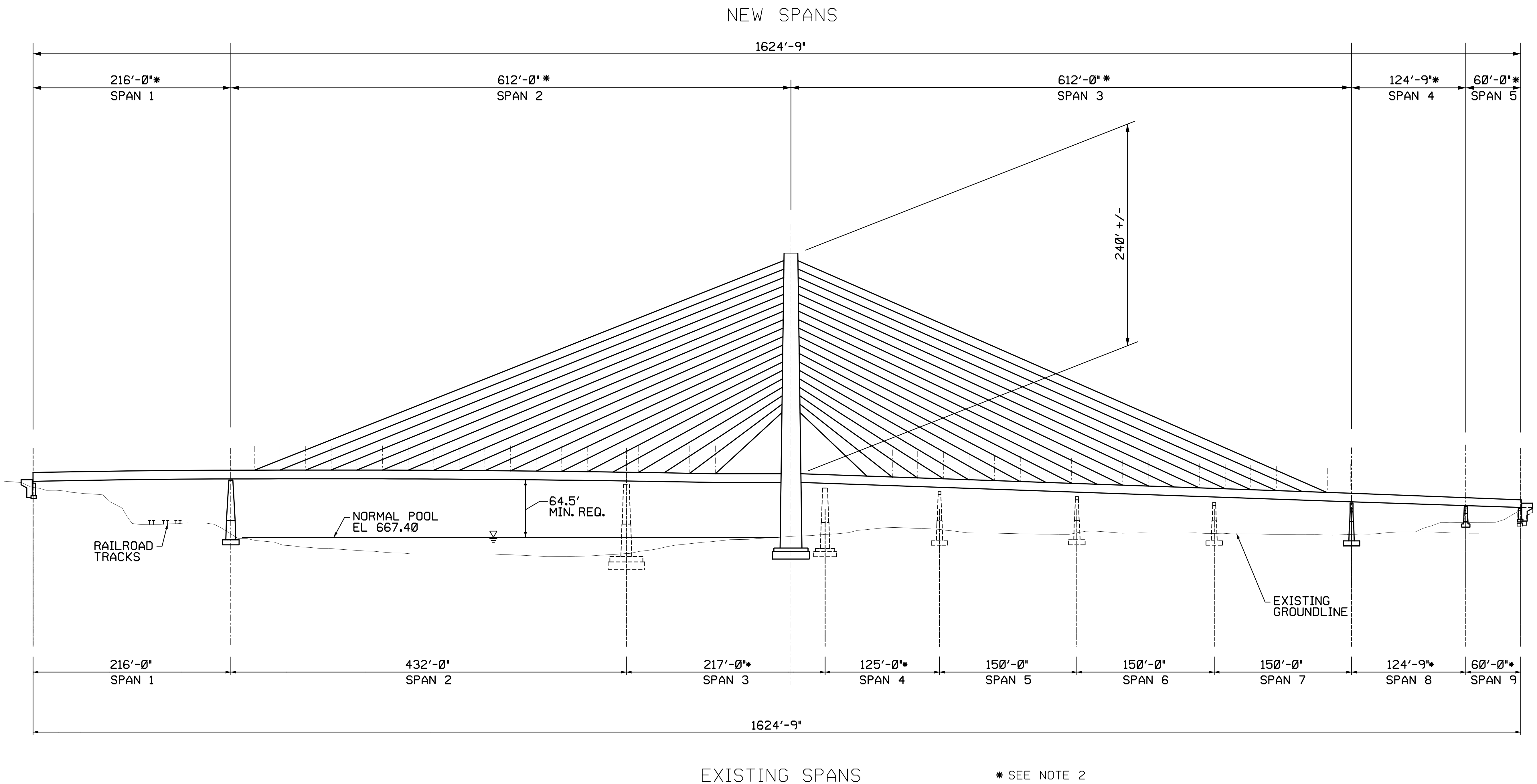
NOTES:

1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.
4. P/S BEAM DETAILS AND FIXITIES TO BE DETERMINED
5. REQUIRES 10' +/- GRADE RAISE IN SPAN 2

Main Unit - 3-Span Extradosed (216'-432'-217')
S. Approach - None
N. Approach - 6-Span P/S Beam (125'-3 at 150'-124.75'-60')

Notes:
New north piers line up with existing piers.
North approach could be shortened by 87' if geotech issues are addressed.

HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - EXTRADOSED	DES:	DR:	BRIDGE NO.
		CHK:	CHK:	
		FIGURE 11		9040



ELEVATION

NOTES:

1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.
4. P/S BEAM DETAILS AND FIXITIES TO BE DETERMINED

Main Unit - 2-Span Cable-Stayed (612'-612')
S. Approach - Simple Plan Plate Girder (216')
N. Approach - 2-Span P/S Beam (124.75'-60')

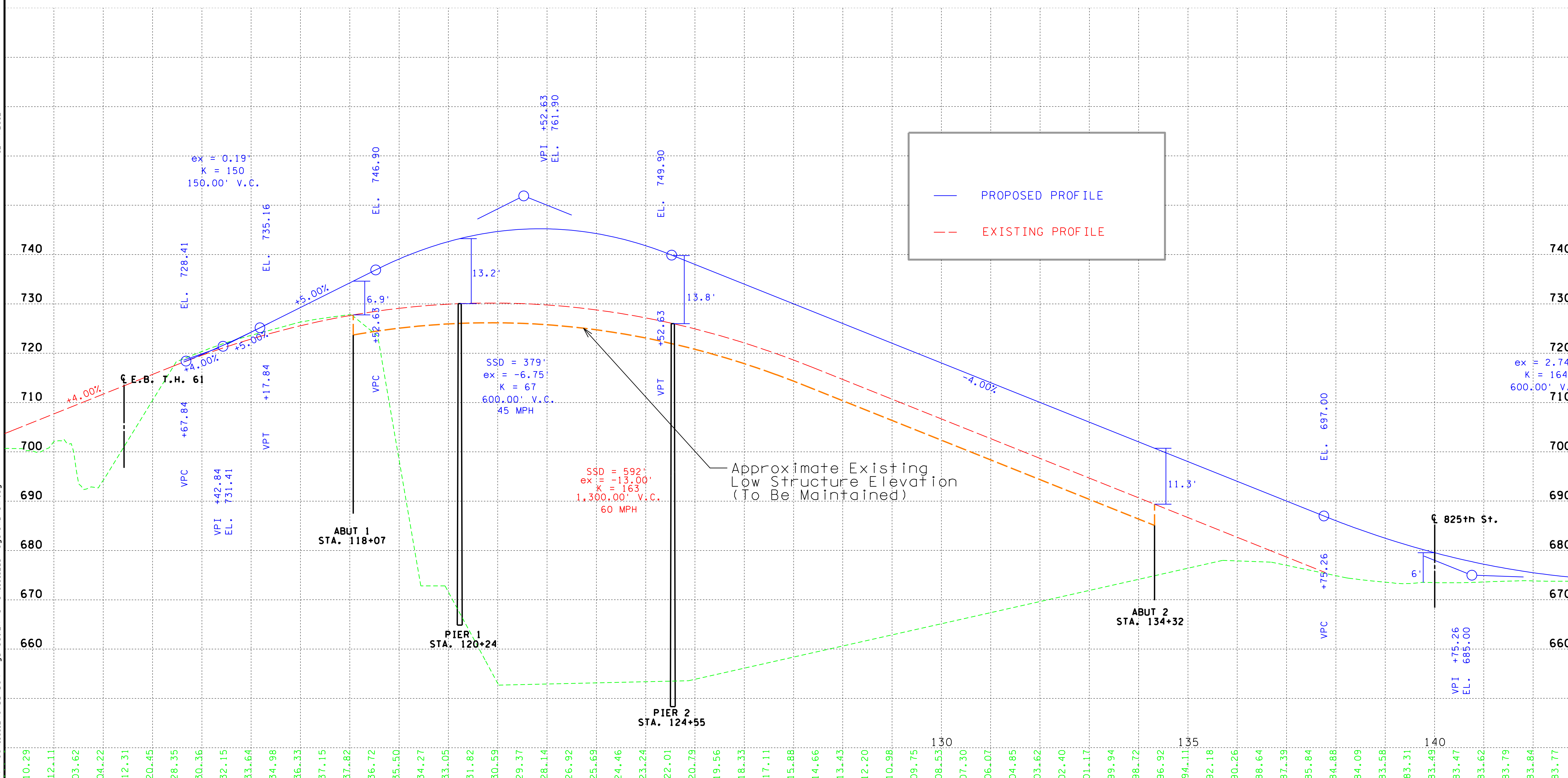
Notes:
New north piers line up with existing piers.
North approach could be shortened by 87' if geotech issues are addressed.

HDR Engineering, Inc.	RED WING BRIDGE NO. 9040 - CABLE-STAYED	DES: DR: CHK: CHK:	BRIDGE NO.
		FIGURE 12	9040

$USER$ $TIME$ $DATE$ $PLOTR$ PEN_TBL DGN

13' Profile Increase with 9103 Rehab

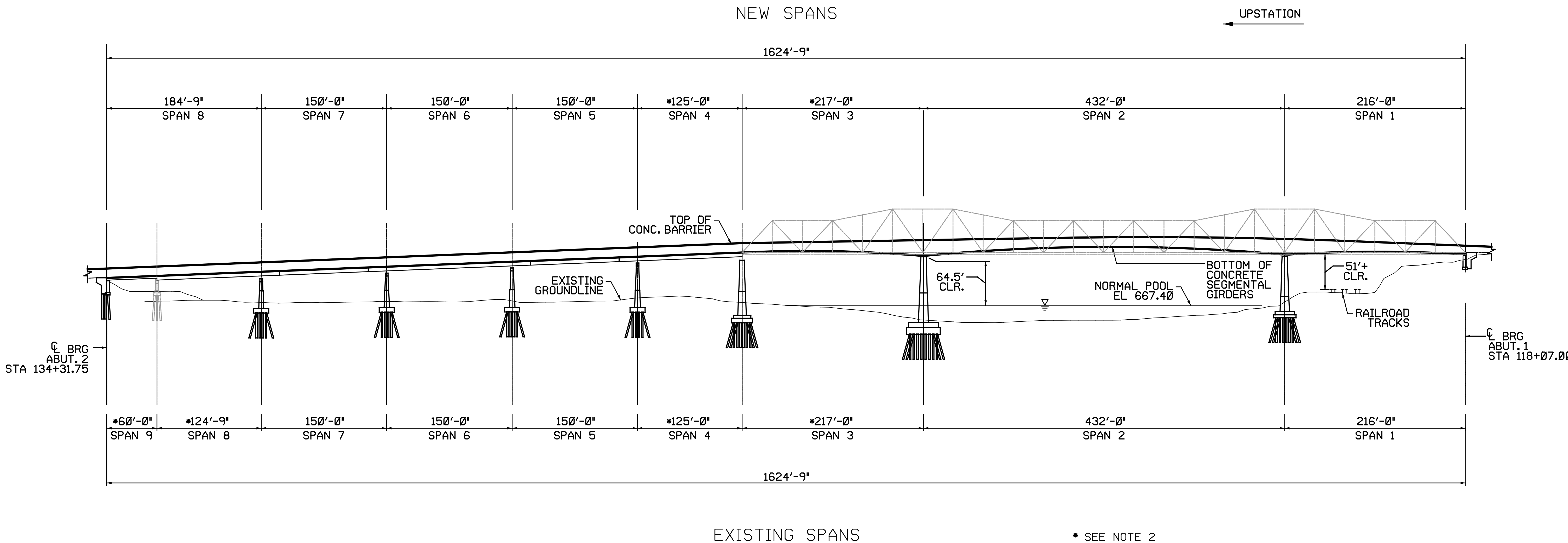
"Draft"



FILE NO. 119112	TH 63 / TH 61	TH 63 PROFILE
DATE: 12/7/2012	RED WING, MINNESOTA	WITH CONCRETE SEGMENTAL BOX

SEH · Minnesota Department of Transportation · Red Wing Bridge Project

Figure 13



* SEE NOTE 2

ELEVATION
(LOOKING EAST/DOWNSTREAM)

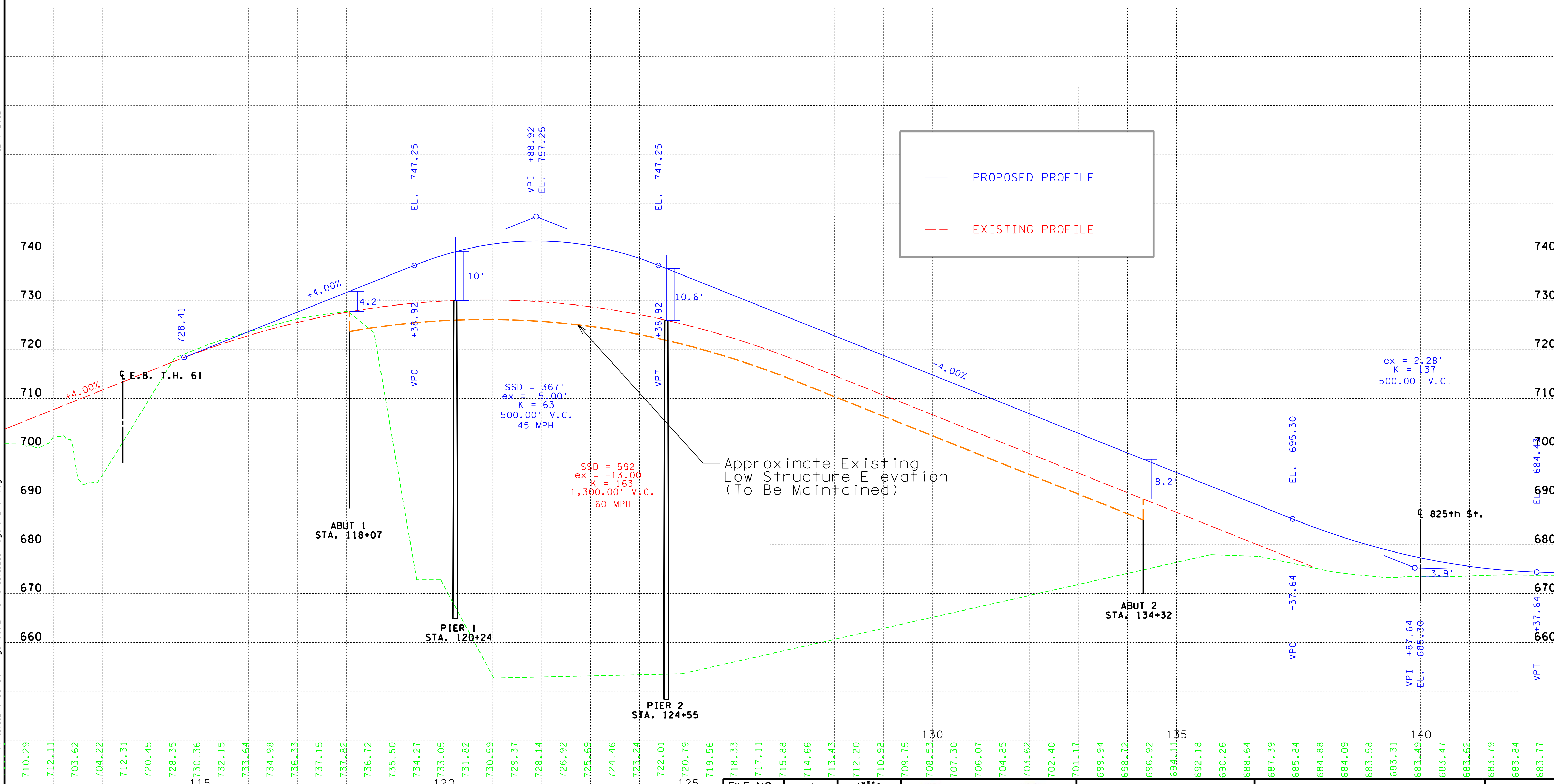
NOTES:

1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.

HDR Engineering, Inc.	RED WING BRIDGE - REHABILITATED EXISTING BRIDGE WITH CONCRETE SEGMENTAL	DES: / CHK: / DR: / CHK:	BRIDGE NO. 9040
		FIGURE 14	

10' Profile Increase with 9103 Rehab

"Draft"



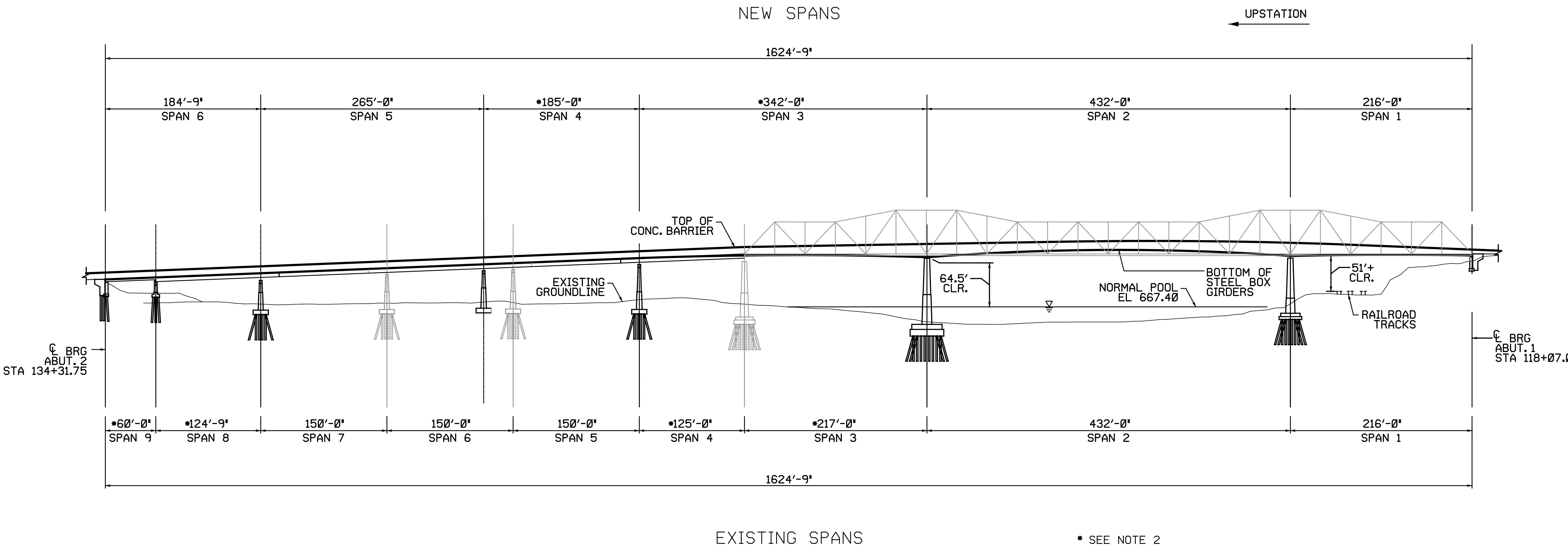
FILE NO. 119112
DATE: 12/6/2012

SEH

TH 63 / TH 61
RED WING, MINNESOTA

TH 63 PROFILE WITH STEEL BOX GIRDER

Figure 15



ELEVATION
(LOOKING EAST/DOWNSTREAM)

NOTES:

1. TOP OF ROCK NOT SHOWN.
2. SPANS MEASURED CENTER TO CENTER OF PIERS.
3. FOUNDATION TYPES FOR NEW SUBSTRUCTURE UNITS TO BE DETERMINED.

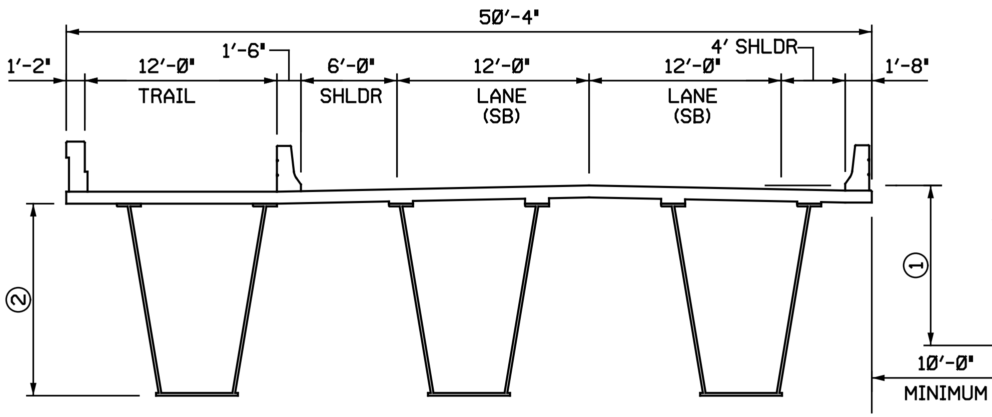
HDR Engineering, Inc.

RED WING BRIDGE - REHABILITATED EXISTING BRIDGE WITH STEEL BOX GIRDERS

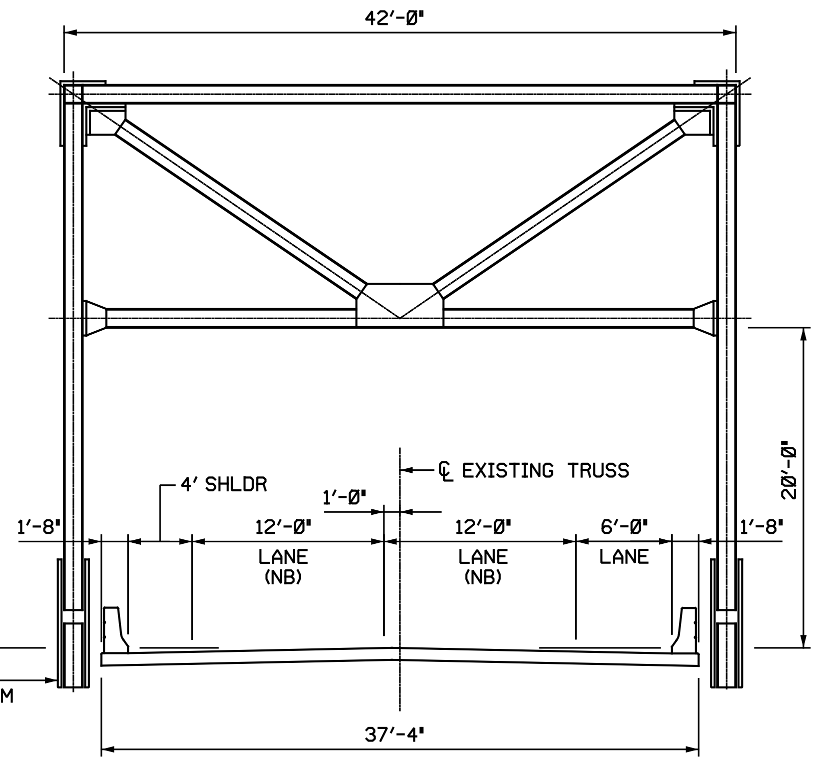
DES: | DR: | CHK: | CHK:

FIGURE 16

BRIDGE NO. 9040



NEW TWO-LANE BRIDGE



EXISTING BRIDGE AFTER REHABILITATION

NOTES

① DIFFERENCE WILL VARY ALONG THE BRIDGE:
SOUTH ABUTMENT = 4.2' +/-
MAIN SPAN = 10' MINIMUM
NORTH ABUTMENT = 8.2' +/-
10'-0" SHOWN

② DEPTH WILL VARY ALONG GIRDER: 7'-0" MINIMUM TO
12'-0" MAXIMUM AT PIERS 1 AND 2.
12'-0" SHOWN

HDR Engineering, Inc.	RED WING BRIDGE	DES: / CHK:	DR: / CHK:	BRIDGE NO.
	FIGURE 17 - REHABILITATE EXISTING WITH NEW TWO-LANE STEEL BOX GIRDER			9040

#USER# #TIME# #DATE# #PLOTR# #PEN_TBL# #DGN#