

Bridge 9103 Rehabilitation Study Final Report Red Wing, Minnesota

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Prepared by
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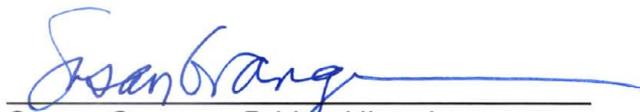
I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.



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I hereby certify that I meet the Secretary of the Interior's Professional Qualifications for History and Architectural History (36 CFR part 81).



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EXECUTIVE SUMMARY

The Bridge 9103 Rehabilitation Study is being conducted to explore alternatives for the rehabilitation of Bridge 9103 at the junction of TH 63 and TH 61 in Red Wing, Minnesota. The bridge is eligible for the National Register of Historic Places. A principal goal of the study is to identify alternatives that rehabilitate the bridge for continued use on-site in a manner consistent with the Secretary of the Interior's Standards for the Treatment for Historic Properties.

The bridge was completed in 1960 to serve as the southern approach to the Eisenhower Bridge (Bridge 9040) over the Mississippi River, as well as to carry TH 63 over TH 61 and over an access road that serves the parking area of the Red Wing Shoe Company's Main and Potter Street facility. Both TH 63 and TH 61 are on the National Highway System and classified as principal arterial routes.

Bridge 9103 is a 211'-long, continuous concrete slab span with an adjacent 220' southern approach roadway. The bridge and southern approach were designed and built together, and the boundaries of the National Register-eligible property include both. The property is eligible for the National Register under Criterion C for engineering significance and exceptional aesthetic qualities.

Bridge 9103's overall condition is fair. However, on the bottom surface of the concrete slab there are substantial areas of delaminated and deteriorating concrete concentrated near the longitudinal construction joint along the centerline of the bridge. There are numerous spalls in Spans 2, 3, 4, and 5. Areas where spalls are 2" deep or greater comprise more than 5% of the underside. In some areas, spalling and delamination are so deep that the bottom longitudinal reinforcing steel is no longer bonded to the concrete. This is evident at 8 to 10 longitudinal bars in each of Spans 2, 3, 4, and 5 along most of their length. Although 8 to 10 bars comprise only 5% to 6% of the total longitudinal bars, the affected bars are concentrated within a design strip width. Testing indicates a high level of chloride content throughout the slab, which suggests additional reinforcing steel has begun to corrode or will begin to do so in the foreseeable future.

The bridge is not currently posted and is safely carrying normal traffic. However, deterioration of the concrete superstructure threatens the ability to maintain adequate load capacity. Posting the bridge to prohibit heavy loads would hinder the increasing number of heavy commercial haulers who use the Mississippi River crossing at Red Wing for the transport of agricultural and industrial materials and other freight.

Bridge 9103 meets some modern design criteria. Vertical profile and horizontal curve geometrics are more than adequate for the 30 mph posted speed limit (35 mph design speed), and the bridge meets lane and shoulder width requirements. However, the historic railing's strength (crashworthiness) falls below MnDOT BPIR and MnDOT Bridge Design Manual standards, and the bridge is not universally accessible. On TH 61 beneath the bridge, horizontal clearance is significantly more narrow than MnDOT standards, which is a potential safety concern, and vertical clearance is several inches lower than MnDOT standards, which causes the diversion of some oversize loads onto other routes.

Four alternatives for the rehabilitation of Bridge 9103 were identified and opportunities to create hybrid alternatives were explored. The four alternatives were assessed against a set of

evaluation criteria, most of which were derived from the Red Wing Bridge Project's Purpose and Need. Detailed cost estimates were developed.

All four alternatives would increase load capacity. Alternatives 1 and 2, which differ only in the use of an inner TL-2 rail, would meet the Secretary of the Interior's Rehabilitation Standards. Alternatives 3 and 4, which propose to replace the bridge's concrete slab superstructure, would not meet the Standards and would diminish the property's historic integrity to the point that it is no longer eligible for the National Register. Alternatives 2, 3, and 4 would improve traffic safety, a secondary need, with railings that meet TL-2 crash test requirements, while Alternative 1's rail would remain below standards. (Alternative 4 would also meet criteria for rail height and opening size.) All four alternatives would meet ADA requirements. Alternative 4 would increase traffic capacity, a secondary need, by accommodating a four-lane rather than two-lane roadway. None of the alternatives would improve horizontal clearance on TH 61. Alternatives 1, 2, and 3 could improve vertical clearance if an optional lowering of the TH 61 roadway is included. No improvement of vertical clearance is possible with Alternative 4. Horizontal and vertical clearance are other considerations in the Purpose and Need statement.

Alternatives 1 and 2 each have a service life of 10 to 15 years, which could be increased to about 20 years if optional cathodic protection is included. Alternatives 3 and 4 each have a service life of about 60 years. Service life is defined as the number of years before significant rehabilitation would be required; significant rehabilitation is defined as work that requires hiring a contractor but excludes mill and overlay which is considered expected maintenance within a bridge's service life.

There is a risk under Alternatives 1 and 2 that unforeseen deterioration of the slab may be identified during construction, complicating construction staging and threatening maintenance of traffic on TH 63, which is a secondary need. Alternative 3 is the most complicated of the four to construct. Alternative 4 is the only alternative that would require additional right-of-way; it would require acquisition of approximately four parcels with two likely relocations.

The rehabilitation study committee recommends that Alternatives 1 and 2 are viable alternatives for the rehabilitation of Bridge 9103. Each has two optional work items: passive cathodic protection of the concrete slab, and lowering TH 61 by about 10" to improve vertical clearance. The committee recommends that Alternatives 3 and 4 are not viable because they would not meet the Secretary of the Interior's Standards for the Treatment for Historic Properties and would diminish Bridge 9103's historic integrity to the point that it is no longer eligible for the National Register. These two alternatives would create an adverse effect under Section 106 of the National Historic Preservation Act and likely constitute "use" of historic properties under Section 4(f) of the Transportation Act of 1966.

1.0 INTRODUCTION

The Minnesota Department of Transportation (MnDOT), in partnership with the Wisconsin Department of Transportation, is studying options to rehabilitate or replace two bridges in Red Wing, Minnesota: the Eisenhower Bridge (Bridge 9040), which carries TH 63 over the Mississippi River between Red Wing and Pierce County, Wisconsin, and Bridge 9103, which serves as the southern approach to the Eisenhower Bridge and carries TH 63 over TH 61 and over an access road that serves the parking area of the Red Wing Shoe Company's Main and Potter Street facility. Both bridges were opened for traffic in 1960.

One of the two bridges, Bridge 9103, is eligible for the National Register of Historic Places. The boundaries of the National Register-eligible property (Figure 3) include both Bridge 9103 and an adjacent southern approach roadway with which it was comprehensively designed and built (see historic plans in Appendix B). Per National Register guidelines, the boundaries include the entire resource and its grounds (or the surrounding land historically associated with the resource - in this case the area within MnDOT right-of-way).

This rehabilitation study is being conducted to explore alternatives for the rehabilitation of Bridge 9103, and in particular to investigate whether the bridge can be rehabilitated in a manner consistent with the Secretary of the Interior's Standards for the Treatment for Historic Properties. According to MnDOT's Management Plan for Historic Bridges (2006), the preferred option for the treatment of a historic bridge is rehabilitation for continued vehicular use on-site, with the rehabilitation following the Secretary of the Interior's Standards.

This study is being conducted within the framework of two laws that offer a measure of protection to historic properties, Section 106 of the National Historic Preservation Act of 1966 and Section 4(f) of the Transportation Act of 1966. Section 106 requires that federally-funded projects take historic properties into consideration during planning and implementation. Under Section 4(f) of the Transportation Act of 1966, a federally-funded transportation project cannot "use" a historic property unless there is no prudent and feasible alternative to the use and the undertaking includes all possible planning to minimize harm to the property resulting from the use. Both laws define historic properties as those listed on, or eligible for, the National Register of Historic Places.

The study is also being conducted within the context of a Section 106 Programmatic Agreement (PA) on Pre-1956 Historic Bridges in Minnesota signed by MnDOT, the Federal Highway Administration (FHWA), and other signatories in 2008. The PA encourages historic bridge rehabilitation projects to explore context-sensitive solutions during project planning, including the use of tools such as design exceptions, when practical, to help preserve a bridge's historic integrity. The PA does not currently apply to bridges such as Bridge 9103 that were built after 1955, but it is being amended to do so. In the meantime, MnDOT is proceeding with the treatment of post-1955 bridges as if the PA amendment has been completed.

The rehabilitation study committee is comprised of staff from FHWA; MnDOT (including District 6, the Bridge Office, and the Office of Environmental Stewardship); SEH, Inc. (prime consultant for the Red Wing Bridge Project); HDR Engineering, Inc. (bridge engineering subconsultant); and Gemini Research (bridge historian consultant). The committee met in 2012 and 2013.



Figure 1. Location of Bridge 9103 in Red Wing, Minnesota.

2.0 PROJECT PURPOSE AND NEED

The Red Wing Bridge Project includes two bridges, the Eisenhower Bridge over the Mississippi River (Bridge 9040) and its approach bridge, Bridge 9103. The Eisenhower Bridge provides the only regional crossing of the river for approximately 30 miles upstream or downstream. Completed in 1960, the Eisenhower Bridge is a two-lane, continuous steel through-truss bridge. Bridge 9103, also completed in 1960, is 350' south of Bridge 9040 with no roadway accesses between them (Figure 1). TH 63 and TH 61 are both on the National Highway System and classified as principal urban arterial routes. The 2012 AADT (annual average daily traffic) for both bridges is 12,000.

The Red Wing Bridge Project's Purpose and Need Statement is included in Appendix A. The document's summary Purpose Statement reads as follows:

The primary purpose of the project is to provide a structurally sound bridge crossing of the Mississippi River Main Channel at Red Wing, Minnesota and a structurally sound crossing of US 61. In addition, the project needs to maintain the connection between

the Red Wing, Minnesota and Wisconsin highway systems located on Trenton Island, and provide adequate capacity to safely accommodate future transportation needs within the design life of the bridges, while maintaining traffic to the maximum extent possible during construction.

Primary purposes of the Project are to provide structurally sound crossings of the Mississippi River and TH 61.

Secondary needs are the need to maintain the continuity of TH 63; the need to maintain TH 63's connections to TH 61 and TH 58; the need for adequate capacity, acceptable traffic operations, and safe design; the need for maximum maintenance of traffic; the need for access to Trenton Island (Wisconsin); and the need to maintain or improve pedestrian/bicycle facilities.

Other considerations include structural redundancy (Bridge 9040), geometrics, economic development, parking, and regulatory requirements. The regulatory requirements include directives such as Section 106 of the National Historic Preservation Act, Section 4(f) of the Transportation Act, the US Coast Guard's maintenance of the Mississippi River navigational channel, and Section 404 of the Clean Water Act.

See Appendix A for the full Purpose and Need statement.

3.0 BRIDGE BACKGROUND AND SIGNIFICANCE

3.1 Bridge 9103

Bridge 9103 was completed in 1960 to serve as the approach bridge for the Eisenhower Bridge (Bridge 9040), which crosses the Mississippi River. The same designers and builders worked on both bridges.

Bridge 9103 is a 211'-long continuous concrete slab span with an adjacent 220' southern approach roadway. Together the bridge and southern approach curve nearly 90-degrees from Red Wing's Third Street to the river crossing, lift traffic up to the elevation of the river bridge, and separate TH 63 and TH 61 at a new junction that was created by the 1960 project (Figures 1, 2, and 19).

Bridge 9103 and its southern approach are significant from both an engineering and aesthetic standpoint. The bridge's unusually long curved form and the combined property's Modernist design and ornamental railing achieved the project's engineering goals and at the same provided a handsome approach to a major Mississippi River crossing and a gateway to downtown Red Wing.

The river bridge (Bridge 9040) was built to replace a deteriorating 1895 truss bridge that state and local officials had been planning to replace since before World War II. The new bridge was dedicated by sitting President Dwight D. Eisenhower in October 1960. It was originally called the Hiawatha Bridge but renamed the Eisenhower Bridge soon after the President's visit.

West of downtown Red Wing, TH 61 had been realigned and widened in 1951-1953. Two years later, in 1955, the legislature approved Minnesota's share of funding of the \$3.4 million Eisenhower Bridge project. The contract for designing the new river crossing was awarded to Alfred Benesch and Associates of Chicago in the spring of 1956. On the marshy Wisconsin side of the river, the 2-mile-long project would require 1½ miles of fill and several minor spans.

Initial grading for the two bridges and associated realignments began in April 1958. The river bridge was under construction by that fall. The state highway department's project engineer was William C. Merritt. Industrial Construction of Minneapolis was the contractor for the entire project. The improvements were controversial – 85 houses in East Red Wing had to be razed or moved, and the project required alteration of Barn Bluff, the 325'-tall island mesa that was Red Wing's best-known landmark and a place of cultural significance for centuries. On Barn Bluff's west flank, massive amounts of earth were removed (and hauled to Trenton Island for fill). A monumental public stairway up the side of the bluff was demolished. In May of 1959 a huge piece of Barn Bluff's towering "Indian head" formation tumbled to the ground, damaging boxcars and a nearby industrial facility and ending hopes that the formation could remain in place above the south end of the new river bridge.



Figure 2. This aerial view from October 1960 shows newly-completed Bridges 9103 and 9040, as well as construction scars on the west flank of Barn Bluff. TH 61 under the bridge is not yet complete (Minnesota Historical Society photo by the St. Paul Dispatch).

Both Bridge 9103 and Bridge 9040 were designed by Alfred Benesch and Associates of Chicago. (H. B. Schultz was the designing engineer.) Benesch and Associates was founded in 1946 by World War II veteran Alfred Benesch. The company initially worked in the Midwest and Northeast providing engineering services for factories, office towers, and public buildings. In the

early 1950s Benesch began to design highway and railroad bridges. The Benesch firm designed several notable bridges that still stand in Chicago including a 4,000'-long 42-span plate-girder built in the mid-1950s as part of Chicago's Skyway Toll Bridge system, and seven truss bridges completed in 1964-1970. In the 1960s-1980s, Benesch and Associates was engineer for several well-known residential skyscrapers on Lake Michigan in downtown Chicago (Randall 1999). Alfred Benesch retired in 1971. The company is still based in Chicago.

Bridge 9103 and Bridge 9040 and associated highway improvements were built as part of an overarching, postwar initiative to widen and improve TH 61 between La Crescent and St. Paul. TH 61 was a major artery between Chicago and the Twin Cities that carried heavy commercial traffic. It was also a popular tourist route with stunning views of the Mississippi River and its bluffs. In addition to the two 1960 bridges and associated realignments, other TH 61 improvements of the period included reconstructing TH 61 in West Red Wing (1951-1953), a new bridge at Hastings (1951), survey for a four-lane from Red Wing to La Crosse (1952), a major bypass of downtown Winona (let in 1952), and completion of the last four-lane segments between St. Paul and Hastings (1958). In the 1950s Congress also approved planning funds for the Great River Road, a proposed scenic route along the Mississippi River from New Orleans on the Gulf Coast to the river's headwaters in northern Minnesota. The Great River Road had been in the planning stages since the 1930s and was predicted to increase recreational traffic on TH 61 in Minnesota.

National Register Eligibility

Bridge 9103 is eligible for the National Register under Criterion C (design and construction) in the area of Engineering. The bridge was determined eligible for the National Register as part of a statewide evaluation of post-1955 highway bridges conducted in 2010 by Mead and Hunt for MnDOT. Both Bridge 9103 and its southern approach roadway are included within the boundary of the eligible property (Figure 3).

Bridge 9103's National Register eligibility is based on two principal factors:

Engineering Significance. Bridge 9103 is the only horizontally-curved, continuous concrete slab bridge from the period 1955-1970 standing in Minnesota. In addition, the horizontal curve of 14 degrees is the greatest curvature for any extant bridge in Minnesota from the period. At 211' long, Bridge 9103 is also exceptionally long for its type. According to Mead and Hunt, the bridge's unusual curvature and length demonstrate "the complex design issues the engineers faced to meet the site challenges and road requirements for a bridge at this location."

Exceptional Aesthetic Qualities. Bridge 9103 is one of only four bridges identified in the post-1955 statewide bridge study that are eligible for the National Register for "high artistic value." The bridge and its southern approach were given special aesthetic consideration because of proximity to the new Eisenhower Bridge and to downtown Red Wing.

Bridge 9103 and its southern approach are essentially unaltered. The property retains strong historic integrity in all seven categories cited in National Register eligibility criteria: location, design, setting, materials, workmanship, feeling, and association. The level of significance is State and the period of significance is the year of construction, 1960.

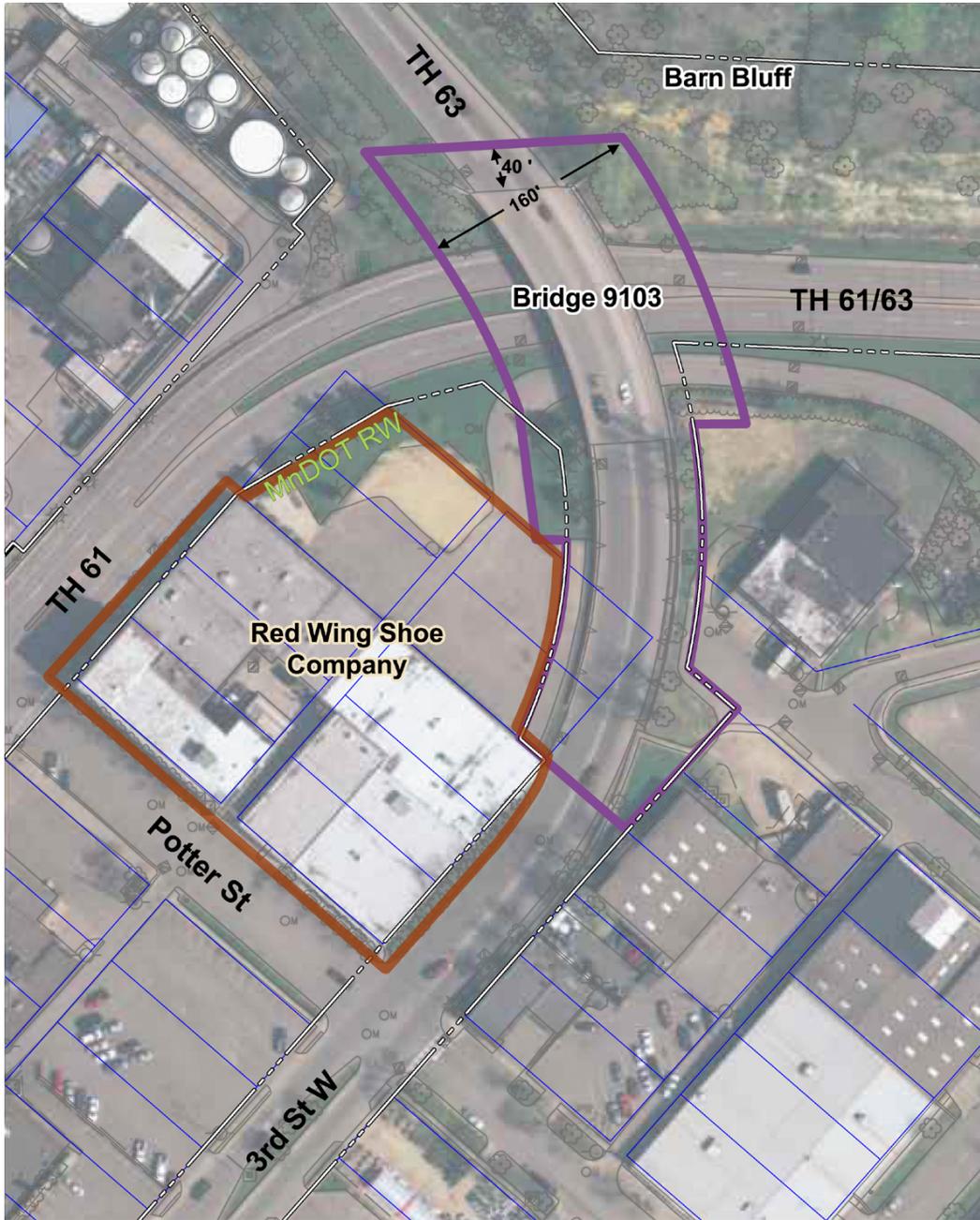


Figure 3. The purple line indicates the boundary of the National Register-eligible property. Bridge 9103 is also part of the Highway 61 (Great River Road) Historic District. Barn Bluff and the Red Wing Shoe Company are historic properties immediately adjacent to Bridge 9103 (Gemini Research drawing).

3.2 Other Historic Properties

Bridge 9103 is a Contributing element in a linear historic district – called Highway 61 (Great River Road) – and immediately adjacent to two other historic properties, Barn Bluff and the Red Wing Shoe Company (see map in Appendix N).

Highway 61 (Great River Road) Historic District. TH 61 between St. Paul and La Crosse was recommended eligible for the National Register in 2009. The road is eligible under Criterion A (broad patterns of history) in the area of Transportation. Historic roads are treated as linear historic districts by the National Register program. The portion within the Red Wing city limits is known as the Red Wing Segment (GD-RWC-1448). Bridge 9103 (GD-RWC-1387) is a Contributing element within the linear historic district.

Barn Bluff (GD-RWC-280), now a 73-acre city park, was listed on the National Register in 1990 (Figures 4 and 19). It is one of the best-known natural features on the Mississippi River between La Crescent and St. Paul and is significant to both Euro-American and native cultures. The National Register boundary follows the bluff's 740' contour line. In 2011 Gemini Research recommended that the National Register boundary was too small and should be expanded to follow the current city park limits. This line is the MnDOT right-of-way line near the northeastern end of Bridge 9103.

Red Wing Shoe Company (GD-RWC-019), built in five stages in 1905-1954, is eligible for the National Register under Criterion A (broad patterns of history) in the area of Industry. The company has been a leading Red Wing employer since its establishment in 1905. The recommended period of significance of 1905-1965 begins when the first phase of the factory was built, and ends in 1965 when the company built a second plant in the Burnside neighborhood of Red Wing, ending this facility's role as the company's sole factory. The boundary of the National Register-eligible property includes the factory and its east parking area (Figure 3).

There are two other historic properties located within 1½ blocks of Bridge 9103: the CMSTPP Railroad Historic District (GD-RWC-1371) at the river's edge, and the Red Wing Commercial Historic District (GD-RWC-1451), which begins one lot west of the intersection of TH 61 (Main Street) and Potter Street. The Eisenhower Bridge (Bridge 9040) over the Mississippi is not eligible for the National Register.

There are no archaeological concerns within Bridge 9103's existing footprint. Any ground-disturbing work outside of the existing footprint could have potential impacts to archaeology, but they are unknown at this time. The Phase I archaeological survey for the Red Wing Bridge Project started in fall 2012 and will resume in spring 2013.

4.0 BRIDGE DESCRIPTION & CHARACTER-DEFINING FEATURES

4.1 Geometrics and Bridge Configuration

Bridge 9103, completed in 1960, is located at the junction of TH 63 and TH 61, about 350' south of Bridge 9040 (the Eisenhower Bridge) which crosses the Mississippi River at the base of Red Wing's highest summit, Barn Bluff.

Bridge 9103 is a curving, five-span, continuous concrete slab on a 14-degree curve. The slab serves as both superstructure and deck. (See Appendix B for original plans and Appendix L for photos taken soon after completion.) The bridge has an overall structural length of 211', measured along the centerline of the roadway. The longest span is 47'6". Connected to the south end is a 220'-long curving approach roadway that is supported on retained fill with cast-in-place concrete retaining walls. Outlines and other imprints from the construction forms are visible on the walls' surface (Figure 6). The bridge and approach were designed as a single project. The bridge deck slab and piers create a strong Modernist form, while the railings represent a transition away from the Art Deco-influences of the 1930s and 1940s and into modern design.



Figure 4. Bridge 9103 and its southern approach with Barn Bluff to the north. The first 220' of railing mark the southern approach; the car in the center of the photo is just leaving the bridge.

The out-to-out slab width of Bridge 9103, and of the corresponding approach roadway, is 62'6". On both structures this distance includes a superelevated 52'-wide roadway, a 2'6" raised sidewalk on the west side, and a 5' raised sidewalk on the east side. The 52'-wide roadway consists of two 12'-wide lanes and two 14'-wide shoulders. On the bridge and southern

approach, TH 63 functions as a two-lane roadway, while south of the approach, southbound TH 63 widens from one to two lanes.

Beneath the bridge, TH 61 consists of two 12' lanes in each direction with an adjacent a 24'-wide service drive under Span 2. This drive provides sole access to the parking area of the Red Wing Shoe Company's Main and Potter Street facility. There are no pedestrian facilities on TH 61 beneath the bridge. On southbound TH 61, the inside shoulder is 0' wide and the outside shoulder is about 2' wide (basically the gutter pan). On northbound TH 61, the inside shoulder is 0' wide and the outside shoulder is about 4' wide. (The northbound outside shoulder varies; it is less than 4' wide south of the bridge and more than 4' wide north of the bridge.) Bridge 9103's horizontal clearance does not meet design criteria in the MnDOT Bridge Preservation, Improvement and Replacement Guidelines (BPIR) and the MnDOT Bridge Design Manual (see Section 6.0).

Both TH 63 and TH 61 are on the National Highway System and classified as principal urban arterial routes. Therefore, the appropriate design speed for these highways is 35 mph. The posted speed limit is 30 mph on both TH 63 over the bridge and TH 61 under the bridge.

Bridge 9103 is located on a constant 4% vertical grade and a 14-degree horizontal curve. The bridge contains a variable superelevation with a maximum slope of 4%. Both the vertical and horizontal curve geometrics on top of the bridge are adequate for a 35-mph design speed.

Segments of steel w-beam guardrail extend north from the west bridge railing, and south (after a pedestrian opening of 4') from the southern approach's west railing. Beneath the bridge, a concrete traffic barrier topped with a black metal railing has been added to the north edge of TH 61 northbound. The barrier and rail extend west to Potter Street.

The bridge superstructure consists of a five-span parabolically-haunched continuous concrete slab that varies in thickness from 18½" at midspan to 27" over the piers. The slab has a longitudinal construction joint along the centerline that is visible on the underside. The main reinforcing in the slab runs longitudinally along the curve. It is made up of #8 bars (in the bottom of the slab) and #8 or #10 bars (in the top of the slab over the piers). The transverse reinforcing is made up of #4 bars in the top of the slab and #5 bars in the bottom of the slab (see original bridge plans in Appendix B). The bars are uncoated (i.e., do not have a protective coating against corrosion). The span lengths are 34', 42', 42', 45'6", and 47'6", measured along the centerline of the roadway. The bottom surface of the slab retains outlines and other imprints from the original construction forms (Figure 5; see also inspection photos in Appendix E). Along the bridge fascia is a distinctive curved coping that continues along the approach roadway retaining walls (Figure 7).

The latest MnDOT inspection report notes that Bridge 9103 has a minimum vertical clearance of 15.5' over TH 61 southbound, 16.4' over TH 61 northbound, and 14.7' over the service drive to the Red Wing Shoe Company parking area. The vertical clearance over TH 61 does not meet design criteria in the MnDOT BPIR and the MnDOT Bridge Design Manual for clearance over a principal arterial. The clearance over the service drive meets the standards in those documents (see Section 6.0).

Bridge 9103's substructure includes four piers, each comprised of five rectangular columns on square spread footings (Figure 5). The outer ends of the exterior columns are rounded beneath the bridge fascia. The exterior columns have overall dimensions of 2'6" by 4'. The interior columns are 2' by 3' in rectangular cross section. The pier caps are 3'6" tall with rounded ends that are flush with the rounded ends of the exterior columns. The piers retain outlines and other imprints from the original construction forms (Figure 5).



Figure 5. The continuous concrete slab and distinctive piers, facing north.

The south abutment consists of a high parapet abutment supported on a spread footing keyed into rock, while the north abutment consists of a low parapet abutment with the stem bearing directly on rock. The south abutment has retaining walls that are part of the southern approach roadway, while the north abutment has flared wings on either side. The abutment slopes are protected by square precast concrete blocks (Figure 7).

The bridge has expansion bearings at both abutments and at Piers 1 and 4, and fixed bearings at Piers 2 and 3. A total of 12 equally-spaced bearing devices are present at each substructure unit.

The bridge was originally built with open joints at each end of the deck slab covered with 3/4" steel plates in the roadway sections and 3/8" steel plates in the raised sidewalk sections. In 1978 the open joints were replaced with the strip seal joints that are in place today. At the same time, a 2 1/2" low-slump concrete overlay was added to the top of the slab. The slab had been originally covered with a bituminous overlay that served the same purpose.

The southern approach roadway is supported on earth fill that is retained by a pair of smooth cast-in-place concrete retaining walls along which the bridge coping and railing extend (Figure

6). The retaining walls have approximately 1' of exposed height near the south end, about 8' in the middle, and about 6' of exposed height near the bridge's south abutment. For a majority of the length the exposed height of the retaining walls varies between 5' and 8' to follow the existing terrain. The driving surface of the approach is bituminous.

The ornamental railing is continuous on both the bridge and southern approach. Made of galvanized steel, the railing has 39"-tall posts with Art Deco-inspired fluting that arches to form a shallow point at the top of each post. The railing panels are about 8'2" long with rectangular handrails and an alternating pattern of slender vertical members. The bridge railing is a version of a standard Minnesota Highway Department design used elsewhere in Red Wing on portions of TH 61 that were rebuilt in the 1950s. Bridge 9103's railing differs slightly from other versions. For example, remnants of railing west of downtown (1951-1953) have round rather than rectangular handrails, and rail panels that are attached to the outsides of the posts rather than being inset. TH 61's Hastings Bridge (completed in 1951, now being replaced) has a railing similar to that of Bridge 9103 but with posts that have flat rather than pointed tops. The bridge railing does not meet modern design criteria for crashworthiness and rail height, and does not meet some standards for rail opening size (see Section 6.0). The historic rail has a transverse load capacity of 5.4 kip (ASD) or 9.8 kip (LRFD). (For comparison, a Test Level 1 or TL-1 rail has a 13.5 kip transverse load capacity (LRFD) and a TL-2 rail has a 27.0 kip transverse load capacity (LRFD); see Section 6.0.)



Figure 6. West retaining wall on the southern approach, facing northeast. The edge of the Red Wing Shoe Company parking area is in the foreground.

Seven lights are within the National Register-eligible property boundary. (There are a few similar lights just outside of the boundary.) The lamp standards have a fairly typical, slender, design, with cobra-head fixtures. Two of the seven lights are located directly on the bridge and southern approach; both are integrated into the east railing (see Photo 15 in Appendix D). Five of the seven lights are adjacent to the bridge and approach. (The five are on southbound TH 63 off the north end of the bridge; northbound TH 63 off the southern approach; northbound TH 61 both west and east of the bridge; and southbound TH 61 west of the bridge.) All seven lights are believed to be in their original positions, per historic photos (Appendix L). The two standards on the bridge are original and the other five are replacements that resemble the originals. All seven cobra-head fixtures are replacements that resemble the originals.

The most visually substantive landscaping within the historic property is a group of mature spruce trees on the grassy slope west of the bridge's south abutment (Figure 7). Historic photos suggest they were planted in the 1970s or later. Also within the boundary of the National Register-eligible property is a line of recently-planted deciduous and evergreen shrubs that curves along the southern approach's east retaining wall.

Bridge 9103 and its southern approach retain historic integrity. Changes have been minor and include: replacement of the bridge deck joints, a low-slump concrete overlay on the bridge (the overlay was originally bituminous), replacement of bituminous on the southern approach roadway, replacement of five streetlights close to the bridge, and the addition of a concrete barrier topped by a black railing on the north edge of TH 61 northbound (from the bridge west to Potter Street).

4.2 Character-Defining Features

Character-defining features are prominent or distinctive qualities or elements of a historic property that contribute significantly to its physical character and historic integrity and significance. Bridge 9103's character-defining features include, but are not limited to:

- the 211'-long, 14-degree-curved, continuous concrete slab
- the 220'-long southern approach roadway, comprehensively designed and built with the bridge
- the elements that contribute to the property's Mid-Century Modern design and other aspects of its aesthetics. These elements include:
 - a long, continuous curved form created by the bridge superstructure and southern approach
 - smooth concrete surfaces that emphasize the lean, sculptural design
 - a slim deck slab formed with shallow haunched arches over each bay which maximize vertical clearance while making the slab appear slender and light
 - the approach roadway's smooth vertical retaining walls
 - elegant curved coping along the bridge fascia and approach walls which emphasizes the long horizontal curve and visually slims the deck slab
 - distinctive piers, comprised of five evenly-spaced columns, that resemble flat panels with rectilinear cut-outs; the pier ends are rounded to match the curved coping and to smoothly meet the shallow arches of the haunched slab

- o a continuous ornamental railing on both bridge and southern approach that emphasizes the length and shape of the horizontal curve; the railing's gray unpainted surface and slender members create a light, open, almost translucent effect when viewed from some angles
- the bridge's dramatic setting at the base of Barn Bluff and adjacent to the Eisenhower Bridge and downtown Red Wing



Figure 7. Bridge 9103's west railing, curved coping, and haunched deck slab over rounded piers, facing southeast.

5.0 CONDITION ANALYSIS

5.1 Overall Condition

The most recent routine NBIS (National Bridge Inspection Standards) inspection of Bridge 9103 was performed by MnDOT on September 15, 2011. The Structure Inventory Report and Bridge Inspection Report from that inspection can be found in Appendix C. HDR engineers performed additional inspection work at the bridge site on April 12th, May 16th, and June 26th, and November 7th, 2012. HDR's site visits have been led by Nick Sovell, PE, who has 23 years of bridge design and inspection experience, and is a MnDOT-Certified Bridge Inspection Team Leader. Photographs from HDR's site visits can be found in Appendix E and a map of inspection findings is in Appendix G. In addition, MnDOT took concrete cores at several locations throughout the bridge in 2011 to measure chloride content, performed infrared

thermography on the bridge on July 12, 2012, and performed destructive testing on August 13, 2012 (see the findings in Appendices F, H, and I).

The overall condition of the bridge is fair. The underside of the continuous concrete slab has areas of spalling and exposed reinforcing bars. Several of the exposed bars have section losses between 24% and 44%. One of the longitudinal bars in Span 3 and one of the longitudinal bars in Span 4 have completely corroded through and several feet of the bars are completely gone. Several of the transverse bars have sections from approximately 1' to 3' in length that are completely missing. Chloride testing indicates a high level of chloride content in the slab. Detailed results of the inspection and testing work are discussed in the following sections.

5.2 Deck Overlay, Joints, Bearings, Sidewalks, Lights, and Railing

Deck Overlay

When the bridge was originally constructed, the concrete slab had a 2" bituminous wearing surface on it. The bituminous surface would have done very little to prevent chlorides from salt applications from reaching the top of the concrete deck. The 2½" low-slump concrete overlay currently on the bridge structure was installed in 1978 to replace the 2" bituminous wearing surface. The purpose of the low-slump overlay is to provide a layer of protection over the structural concrete slab to slow the ingress of chlorides. Map cracking of the overlay surface is present throughout the bridge and there are structural cracks with delamination in the northbound lane of Spans 2 and 5. MnDOT records show that approximately 4400 linear feet of cracks were sealed in 2008.

See the condition of the concrete slab under 5.3 Superstructure Condition below.

Joints

The strip seal joints on both ends of the bridge appear to be in satisfactory condition. The seals are full of dirt and debris, but there are no signs of leakage. The paving block at the north abutment has several longitudinal cracks across its length and there is settled and cracked bituminous approach pavement at both ends of the bridge.

Bearings

From the most recent MnDOT inspection report, the fixed bearings at Piers 2 and 3 are in satisfactory condition with little or no deterioration.

All 12 expansion bearings at each abutment have masonry plates with active corrosion and minor section loss. Two of the 12 expansion bearing masonry plates at Pier 1 have active corrosion with minor section loss, while all 12 expansion bearings at Pier 4 are in satisfactory condition.

Sidewalks

There is map cracking and small pop-outs throughout the curbs and sidewalks on both the bridge and the southern approach roadway. There is settlement of the approach curb and sidewalk at the south end of the bridge. With no accessible ramps or tactile paving and a west sidewalk that is only 2'6" wide, the sidewalks along TH 63 do not meet ADA standards (see Section 6.0). There are no sidewalks below the bridge.

Lights

The bridge and its southern approach each have one light integrated into the east railing. The lamp standards are original and the cobra fixtures closely resemble the original fixtures. The lights are in fair condition.

Railing

The galvanizing on the ornamental rail on both the bridge and the southern approach is breaking down on all steel surfaces with light areas of corrosion showing. The rails have been struck by vehicles in several locations. Damage to rails or spindles was noted at nearly 20 different locations. One or more spindles have been damaged at least 5 places on the east rail and at least 13 places on the west rail where the adjacent sidewalk is only 2'6" wide. The bridge railing does not meet modern design criteria for crashworthiness and rail height, and does not meet some standards for rail opening size (see Section 6.0).

5.3 Superstructure Condition

According to the most recent MnDOT inspection report for Bridge 9103, the deck and superstructure both have NBIS condition ratings of 5, which designate fair condition. The top of the deck contains a 2½" low-slump concrete overlay that was installed in 1978. Map cracking of the overlay surface is present throughout the bridge. Also, there are structural cracks with delamination in the northbound lane of Spans 2, 4 and 5. Based on field observations, these cracks appear to go completely through the depth of the slab.

There are two spalls and a scrape on the western side of the slab over southbound TH 61 that appear to have been caused by impacts from high-load vehicles traveling on southbound TH 61 under the bridge.

On the bottom of the slab there are areas of delaminated and deteriorating concrete at the longitudinal construction joint along the centerline of the bridge. The entire length of longitudinal construction joint on the underside of the slab is leaching. There are numerous spalls in Spans 2, 3, 4, and 5. Areas where the spalls are 2" deep or greater amount to more than 5% of the underside of the deck. None of the exposed reinforcing bars have any corrosion protection. All of the existing reinforcing in the slab is comprised of uncoated steel bars, rather than the epoxy-coated bars that would be used under current construction practices. Exposed rebar on the bottom of the slab has been repaired with epoxy in the past, but this epoxy has worn off and the rebar continues to deteriorate. In addition to the leaching at the centerline joint, the outside edges of the slab also have numerous cracks with leaching and efflorescence.

In some areas, the spalling and delamination of the concrete on the underside of the slab are so deep that the bottom reinforcing steel running parallel to TH 63 (longitudinal) is no longer bonded to the concrete. This is evident at 8 to 10 longitudinal bars in each of Spans 2, 3, 4, and 5 along most of their length. This steel is the main reinforcing steel in the middle of the spans. It is corroded and section loss has occurred all the way around many of the bars (Figure 8). Although 8 to 10 bars comprise only 5% to 6% of the total longitudinal bars, the affected bars are concentrated within a design strip width. Two exposed reinforcing bars that were completely debonded from the concrete were measured and found to have a remaining

diameter of approximately $\frac{3}{4}$ ". These bars were originally 1" in diameter, which equates to a 44% loss in cross sectional area. (See Section 7.0; see also Page 4 of Appendix G.)

All of the areas of cracks, spalling and delamination have been mapped on a plan view of the bridge on Sheet 1 and 3 in Appendix G. All of the exposed reinforcing steel and the remaining diameter of several exposed bars have been recorded on Sheet 2 in Appendix G. The mapping of the areas of spalling and delamination was accomplished by visual inspection and by sounding the entire underside of the slab with a hammer from a bucket truck. When areas of sound concrete are hit with a hammer they make a solid "ping" sound while delaminated concrete makes a hollow "clunk" sound.



Figure 8. Exposed and debonded reinforcing in Span 3.

In addition to the sounding performed by HDR, MnDOT verified the areas of delamination by performing infrared thermography on the underside of the concrete slab on July 12, 2012. The results from this work can be found in Appendix H. In general, the infrared thermography verified the areas of delamination identified by the sounding and did not find any additional areas of deterioration.

MnDOT also obtained four concrete cores from the slab of Bridge 9103 which were processed at MnDOT's Office of Materials Laboratory. The results of this testing are summarized in the BR #9103 Slab Span Chloride Content Test Results Report, dated November 7, 2011, which is included in Appendix F. The purpose of the cores was to measure the presence of chlorides within the concrete slab as an indicator of possible corrosion of the reinforcing steel and the general condition of the slab. All four cores showed high chloride content throughout the depth of the cores. The chloride content threshold at which corrosion is likely to begin in the reinforcing steel is dependant on several factors including chemical composition of the concrete, the water-to-cement ratio used in the concrete, and the environment to which the concrete has been exposed. Commonly-used values for the threshold chloride content at which corrosion of reinforcement begins are as low as 350 ppmCl and are estimated at 700 ppmCl as the high end. Every chloride content value in the four cores, with the exception of eight values in the middle of Core 1 and one value in Core 2, exceeds 700 ppmCl. The content in the upper two inches of

the bridge deck (the area of the low-slump overlay) ranged from 1500 to 5500 ppm. Readings at depths of 2" to 24" were frequently in the 1500 to 3900 ppm range, far in excess of accepted thresholds for corrosion.

The November 2011 chloride content testing report did not assign a specific value to section loss, which is reasonable given the information available. The amount and rate of corrosion of reinforcing steel is dependent on the ratio of the corroded area to the uncorroded area, which cannot be determined without physically inspecting the steel. However, the report does include a general statement indicating, "it is reasonable to suspect advanced degradation of the reinforcing steel throughout the slab," which is supported by the results of the chloride content test. Once degradation of the reinforcing steel has begun, it cannot be reversed but can only be arrested. While the actual section loss in the reinforcing bars that were not exposed cannot be quantified, the conclusion of the MnDOT chloride content tests are valid regarding possible degradation throughout the slab. In addition, based on measured chloride content, it is reasonable to assume that, in the future, new corrosion will initiate and existing corrosion will propagate.

Lastly, on August 13, 2012, destructive testing was performed by MnDOT at six locations on the underside of the bridge. The six locations for testing were selected because they were near the areas of cracking and spalling but slightly outside of them. These locations represent areas that were suspected as possible areas of corrosion and deterioration initiation. The testing involved chipping out an area of concrete that was approximately 1' x 1', and exposing one or two reinforcing bars. In all six locations the concrete was found to be sound, and little or no corrosion was found on the exposed reinforcing bars. Photographs and field notes from this testing can be found in Appendix I.

In addition to the testing and inspection work that has already been done, several additional testing methods were considered to gain additional information about the condition of the bridge. The use of Ground Penetrating Radar (GPR) was discussed and considered, but based on MnDOT's past experience with the technology and the capability of GPR, the results would be limited to identification of possible voids or delaminations. The chloride testing results, infrared thermography, and reinforcing bar section losses already measured provide quality information for the assessment of this bridge and GPR data would not add to that information.

Drilling concrete cores through reinforcing bars at several locations was considered so that section losses could be measured in additional reinforcing bars that were not exposed due to spalling. Taking further cores would be invasive and it was decided by MnDOT that the limited additional information gained from taking these cores would not justify the damage that would be done.

Summary of Superstructure Condition

While the condition of the concrete superstructure is rated as fair, deterioration of the slab threatens the ability to maintain adequate load capacity. The load capacity of the bridge is discussed in detail in Section 7.0. The underside of the slab has large areas of spalling and exposed reinforcing steel, concentrated near the longitudinal construction joint along the centerline of the bridge. These areas range from less than 2% in Span 1 to about 9% in Span 4. There are structural cracks with delamination in the northbound lane of Spans 2, 4 and 5. Based on field observations, these cracks appear to go completely through the depth of the

slab. Section losses in the main reinforcing steel were measured between 24% and 44% in many locations along the structure. One of the longitudinal bars in Span 3 and one of the longitudinal bars in Span 4 have completely corroded through and several feet of the bars are completely gone. Several of the transverse bars have sections from approximately 1' to 3' in length that are completely missing.

Nearly all of the chloride content measurements taken in the four concrete cores were higher than the anticipated threshold for corrosion initiation. The cores were taken at locations throughout the slab, not just near the centerline joint, so it can be concluded that corrosion of the reinforcing steel may be initiated in areas that have not yet spalled off. In six locations on the underside of the slab, near existing spalled areas, destructive testing found sound concrete and the reinforcing bars that were exposed were found to have little or no corrosion.

5.4 Substructure Condition

Based on visual inspections, the substructure of Bridge 9103 has an NBIS condition rating of 5, which designates fair condition. The pier columns generally exhibit superficial to minor map cracking. The pier caps generally have minor random cracks at both ends, with superficial cracking on both sides, and scattered rust on the bottom of the caps due to exposed rebar chairs.

The abutments have vertical cracks with some leaching in the front face. Both abutments also have areas of delaminated concrete on the front face, which measure approximately 8 square feet and 70 square feet for the south and north abutments, respectively. The south abutment has spalled areas that measure approximately 12 square feet, and the north abutment has random and horizontal cracking that measures approximately 35' in length. Typical examples of the deterioration found on both abutments are shown in Figure 9. The slope paving in front of the North Abutment has several areas of severe settlement, up to 12" in depth. According to inspection records, the settlement and erosion at the north abutment began at least five years ago but it is unclear if it has stabilized or getting worse.



Figure 9. Spalled and delaminated concrete on the north abutment.

5.5 Southern Approach Roadway

The cast-in-place retaining walls that support the southern approach roadway on retained fill are supported on spread footings. They are in generally good condition with some hairline vertical cracks. The hairline vertical cracks are typically spaced at 10' or more with the exception of the first 40' of the west wall where the crack spacing varies from 2' to 5'. There are minor corner spalls at three of the vertical joints but they are all 3" x 4" or less in size and less than 3' long. See Figure 10 for typical cracks and spalls.

The galvanizing on the ornamental rail is breaking down on all steel surfaces with light areas of corrosion showing. Like the railing on the bridge itself, the current rail does not meet most modern design criteria (see Section 6.0).



Figure 10. Typical spalls and cracks in the approach retaining walls.

The sidewalks along the southern approach roadway are also cast-in-place concrete. Like those on the bridge, they do not meet ADA standards (see Section 6.0). The sidewalks contain map cracking and small pop-outs. There is settlement of the sidewalk and curb where the approach roadway meets the south end of the bridge.

The driving surface of the southern approach is bituminous pavement. The pavement contains map cracking and is settling where it meets the south end of the bridge.

6.0 REHABILITATION ALTERNATIVES EVALUATION CRITERIA

Most of the criteria used to compare and evaluate alternatives for the rehabilitation of Bridge 9103 are based on the Red Wing Bridge Project's Purpose and Need statement (see Appendix A). Some are based on design criteria specified by the MnDOT Bridge Preservation, Improvement and Replacement Guidelines (BPIR), the MnDOT Bridge Design Manual, and AASHTO LRFD Bridge Design Specifications. Construction costs and the estimated service life for each alternative are also considered.

The evaluation criteria are listed below. The alternatives' ability to meet the criteria is described in Section 8.0 and summarized in the matrix in Section 9.0.

Primary Needs

Provide structurally sound crossing of the Mississippi River. The rehabilitation alternatives are judged on their ability to maintain connectivity to Bridge 9040. (Certain changes to Bridge 9103 such as modifying its vertical profile would impact the function of Bridge 9040.)

Provide structurally sound crossing of TH 61. Per guidance from the MnDOT Bridge Office, an inventory rating factor of 0.9, based on LRFR, is the lower limit used to identify "structurally sound" members that do not require any strengthening or replacement. The 0.9 limit is based on the MnDOT BPIR. In Table G-1 of the BPIR under Column 4 (Minimum Criteria for Bridge Improvements), an HS-18 inventory load rating is required. Accepting an HS-18 inventory rating for the standard HS-20 truck represents a 10% reduction from full capacity. This equates to a 0.9 rating factor based on LRFR.

Secondary Needs

Maintain continuity of TH 63. Ability to maintain the continuity of TH 63, part of the National Highway System and an important regional route serving increasing numbers of heavy commercial haulers and other traffic.

Maintain TH 63's connections to TH 61 and TH 58. Ability to maintain connections with TH 61, also part of the National Highway System, and TH 58.

Provide adequate capacity, acceptable traffic operations, and safe design. Ability to provide adequate capacity for the design year 2042 estimated AADT of 15,600. (The estimated ADT for 2018, the proposed year of construction, is 12,700.) Both TH 63 and TH 61 are principal arterial routes.

Rail strength. Safe design includes the crashworthiness of the bridge railing. Bridge 9103's historic rail has a transverse load capacity of 5.4 kip (ASD) or 9.8 kip (LRFD) and meets no modern design standards. For comparison, a Test Level 1 or TL-1 rail has a 13.5 kip transverse load capacity (LRFD) and a TL-2 rail has a 27.0 kip transverse load capacity (LRFD). A TL-2 railing is crash-tested for vehicles traveling 45 mph (formerly expressed as 70 km/h or 43.5 mph), and a TL-1 railing is tested for vehicles traveling 30 mph (formerly expressed as 50 km/h or 31.1 mph).

Bridge 9103's historic railing must contain both vehicles and pedestrians, and is therefore considered a combination rail. According to the MnDOT Bridge Design Manual, for a combination rail mounted on a raised sidewalk where the design speed is 40 mph or less, the railing is required to meet TL-2 standards in accordance with the AASHTO LRFD Bridge Design Specifications (Section 13.7.2) and NCHRP 350. The MnDOT BPIR contain some guidance for rail criteria to be used on rehabilitation projects. The BPIR specifies a 10-kip (ASD) transverse load capacity if the design speed is less than 30 mph. The design speed on TH 63 is 35 mph so the neither the lower capacity referenced in the BPIR or the TL-1

standard could be used without a design exception. (As explained above, the existing historic rail does not meet either of these standards.)

It is likely that Bridge 9103 will carry increasing amounts of heavy commercial truck traffic in the future. Silica (frac) sand mining is increasing in the region, for example, and sand mined in Wisconsin may be hauled to potential processing plants and shipping locations in Red Wing. In addition, rising fuel prices have resulted in more heavy commercial traffic using the Mississippi River crossing at Red Wing, including Bridge 9103, as the trucks travel from the I-94 area in Wisconsin to Rochester, Minnesota, and vicinity.

Maximum maintenance of traffic. Each alternative is judged on its ability to maintain traffic during construction. Full closure of TH 63 would require a maximum detour of approximately 65 miles (about 1½ hours). Since traffic using the crossing is generated from various locations around the region, the average detoured trip length is assumed to be approximately to 2/3 of that. This is based on data from the 2005 and 2010 Red Wing Bridge Origin-Destination and Traffic Circulation Studies. Both full closure of TH 61 and reduction in vertical clearance due to construction falsework would require a local detour using CSAH 21 (Flower Valley Road) and TH 58. (Trucks unable to meet the vertical clearance height restriction would experience a CSAH 21 detour which, while not lengthy, has serious operational difficulties including additional four-way stops and traffic lights, tight downtown turns which require semi-trucks to encroach into opposing lanes, and heavy traffic on Plum (TH 58) and adjacent streets.)

Maintain access to Trenton Island. Maintaining connectivity to Bridge 9040 would maintain access to Trenton Island.

Maintain or improve pedestrian/bicycle facilities. **Pedestrian facilities** on public rights-of-way are required to be universally accessible per Section 504 of the Rehabilitation Act of 1973 and Title II of the Americans with Disabilities Act of 1990 (ADA). MnDOT's Strategic Plan and the Statewide Transportation Plan recognize accessibility as an integral part of the State's transportation networks. ADA-compliant sidewalks must be 5' wide, a distance that can be reduced to 3' if 5' x 5' passing areas are provided every 200'. The ADA standard for maximum profile grade is 5% and the maximum allowed cross slope is 2.08%. Under MnDOT guidelines (PROWAG 2005), projects must provide ADA-compliant curb ramps with detectable warnings and proper cross slope, running slope, and landings.

On top of Bridge 9103 and the southern approach there are two raised sidewalks, 2'6" wide on the west and 5' wide on the east. The west sidewalk does not meet ADA width requirements. Neither sidewalk has accessible ramps or tactile paving. The profile grades and cross slopes meet ADA standards.

Bridge 9103's sidewalks are aligned with two 2'6" raised sidewalks on Bridge 9040. If changes to Bridge 9040 include improved pedestrian facilities, which is likely, then Bridge 9103's facilities would need to accommodate more users.

On TH 63 beneath Bridge 9103 there are no pedestrian accommodations.

Bicycle facilities. By state law, MnDOT has substantial authority and responsibility for accommodating and encouraging safe bicycling. Minnesota Statute Chapter 174.01, Subd. 2 (14), which creates the Department of Transportation, specifically refers to bicycle transportation as part of the state's transportation system's goals "to promote and increase bicycling as an energy-efficient, nonpolluting, and healthful transportation alternative." MnDOT policies and design guidance for bike facilities are contained in the Minnesota Bikeway Facility Design Manual. In Table 4-1 of the manual for the Bridge 9103's traffic speed and ADT the suggested bikeway design is a 6' bike lane or 8' paved shoulder.

On top of the bridge, bicycles travel on TH 63's outside paved shoulders which are 12' wide. Below the bridge, bicycles use TH 61's outside shoulders which are about 2' wide (basically the gutter pan) on southbound TH 61 and about 4' wide on northbound TH 61. (The northbound outside shoulder varies; it is less than 4' wide south of the bridge and more than 4' wide north of the bridge.)

Bicycle use in the vicinity of Bridge 9103 is expected to increase. Red Wing is a popular bike destination and part of three interconnected trail systems in the region, described below. The three trails are linked to an expanding local trail system within the City of Red Wing.

The Mississippi River Trail (MRT) follows the Mississippi from its source in northern Minnesota to the Gulf of Mexico. It is the only US Bicycle Route in Minnesota. On the Minnesota side of the river, the MRT uses TH 61 except in central Red Wing where local streets are used, thereby avoiding the TH 63/TH 61 junction and Bridge 9103. (The city's long-range plans include a riverfront trail that would eventually carry the MRT under the south end of Bridge 9040 and on the north side of Barn Bluff.) On the Wisconsin side of the river, a unit of the MRT uses Wisconsin Highway 35, which is about 2½ miles north of Bridge 9040. Cyclists on the Wisconsin side often cross Bridges 9040 and 9103 to visit Red Wing, as do participants in the popular Tour de Pepin that circles Lake Pepin on parts of the MRT. While Bridges 9040 and 9103 are not officially part of the MRT, they provide the primary link between the MRT in each state.

The Cannon Valley Regional Trail meets the MRT west of downtown Red Wing near County Road 1 (west of Hay Creek). The popular trail follows the Cannon River for 19 miles between its endpoints: Red Wing on the east and Cannon Falls on the west.

The Goodhue Pioneer State Trail meets the MRT and the Cannon Valley Trail west of downtown Red Wing (near Hay Creek). Still under development, the Goodhue Pioneer Trail will eventually link Red Wing with communities to the southwest such as Zumbrota, as well as connecting with the Douglas State Trail which leads to Rochester.

Other Considerations

Structural redundancy. Not applicable; Bridge 9103 has no fracture critical members.

Geometrics. The set of rules that governs **vertical clearance** is the MnDOT Bridge Design Manual. In addition, the MnDOT BPIR contains some guidance for vertical clearance criteria in rehabilitation projects. Table G-1 of the BPIR states that if a project is using federal funds then the vertical clearance requirements should meet Column 5 of the table

(see footnote “*”). The required vertical clearance for principal arterials is 16.33' (16'4") for new construction and 16.0' for rehabilitation projects. Specified vertical clearance over local roads in an urban setting is 14.5' (14'6").

Bridge 9103 currently provides 15.5' (15'6") over TH 61 southbound, 16.4' (16'5") over TH 61 northbound, and 14.7' (about 14'8") over the service drive in Span 2 that leads to the Red Wing Shoe Company's parking lot.

According to the MnDOT Freight Office, approximately two to three new oversize load permits per week are denied between mid-May and mid-November. Statistics are not available on the number of oversize haulers who avoid TH 61 through Red Wing because of the restriction and therefore detour to I-90, for example. The denied loads are in the 15'6" range, with 6 additional inches needed for tolerance. There are fewer applicants during the winter months. The loads are primarily construction equipment and large boats. Bridge 9103 is the only bridge on TH 61 between I-90 on the south and I-94 and TH 52 on the north that has these vertical clearance restrictions. All other bridges between these points can accommodate oversize permit loads.

Horizontal clearance. The source for design criteria governing horizontal clearance on TH 61 is the MnDOT Bridge Design Manual. The MnDOT BPIR also contains some guidance for horizontal clearance criteria for rehabilitation projects. According to Section 2.1.3 of the MnDOT Bridge Design Manual, the horizontal clearance should be 5'-6" on the left and 10' on the right. Table G-1 of the BPIR states that the horizontal clearance for a one-way principal arterial should be 4' on the left and 10' on the right.

Horizontal clearance on TH 61 below the bridge does not meet the above guidelines. On southbound TH 61, the inside shoulder is 0' wide and the outside shoulder is about 2' wide (basically the gutter pan). On northbound TH 61 the inside shoulder is 0' wide and the outside shoulder is about 4' wide. (The northbound outside shoulder varies; it is less than 4' wide south of the bridge and more than 4' wide north of the bridge.) One result of the existing horizontal clearance is that large vehicles traveling under the bridge tend to shy away from the closest pier and track into the adjacent travel lane.

Rail height and opening size. Railing height and the size of railing openings are considered as part of the geometrics criterion. Applicable rules for the height and opening size of pedestrian rails come from the MnDOT Bridge Design Manual (Section 13.2.2) and AASHTO LRFD Bridge Design Specifications (Section 13.8). The specifications make no distinction between new rails and existing rails.

The existing rail is 39" tall. (The height is measured from the top of the walkway to the top of the highest horizontal rail component.) The standard in both the MnDOT Bridge Design Manual and AASHTO LRFD Bridge Design Specifications is 42". The existing railing has openings that are 4½" to 5½" wide. The MnDOT Bridge Design Manual specifies that openings below 27" block a 4" sphere and openings above 27" block a 6" sphere. The AASHTO LRFD Bridge Design Specifications state that openings below 27" should block a 6" sphere and openings above 27" should block an 8" sphere.

If changes to the river crossing (Bridge 9040) include improved pedestrian facilities, which is likely, then Bridge 9103's facilities, if not improved, would be inadequate and need to accommodate more users.

Economic development. Each alternative is judged on its ability to maintain or improve economic development – particularly in downtown Red Wing – by maintaining or improving traffic operations (e.g., downtown congestion).

Parking. Each alternative is judged on ability to maintain or improve downtown parking.

Regulatory requirements: Section 106. Alternatives are evaluated on their ability to avoid an adverse effect to historic properties under Section 106 of the National Historic Preservation Act of 1966. The Act defines historic properties as properties listed on, or eligible for, the National Register of Historic Places.

Under Section 106, a project is deemed to have an adverse effect if it proposes to “alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register, in a manner that would diminish the integrity of the property’s location, design, setting, materials, workmanship, feeling, or association.” The Act also states that, to avoid an adverse effect, the “alteration of a [historic] property, including restoration, rehabilitation, repair, maintenance, stabilization” must be “consistent with the Secretary of the Interior’s Standards for the Treatment of Historic Properties (36 CFR part 68) and applicable guidelines.” In addition, a project must avoid diminishing the integrity of other historic properties (e.g., other historic properties in the vicinity).

Regulatory requirements: Section 4(f). Alternatives are judged on their ability to avoid Section 4(f) “use” of certain properties. Under Section 4(f) of the Transportation Act of 1966, a federally-funded project cannot use a park or recreation land, wildlife or waterfowl refuge, or historic site unless there is no prudent and feasible alternative to the use, and the undertaking includes all possible planning to minimize harm to the property resulting from the use. Section 4(f) implementation generally references Section 106 (see above) for identifying historic properties and assessing potential effect.

FHWA’s Section 4(f) policy on historic bridges indicates that a proposed project will use a historic bridge if it impairs the historic integrity of the bridge either through demolition or through rehabilitation that adversely affects the bridge’s historic integrity. Rehabilitation of a historic bridge should preserve its historic integrity “to the greatest extent possible, consistent with unavoidable transportation needs, safety, and load requirements.” To avoid adversely affecting historic integrity, the rehabilitation should be consistent with the Secretary of the Interior’s Standards. Project planning must include identification of feasible and prudent alternatives that meet Purpose and Need, avoid using Section 4(f) properties, and explore all possible ways to minimize harm resulting from use.

Regulatory requirements: navigational channel. Certain changes to Bridge 9103 (e.g., alteration of vertical profile) could have implications for Bridge 9040 and its relationship with the Mississippi River navigational channel.

Regulatory requirements: stormwater management. Alternatives are judged on ability to meet stormwater management practices required by Section 404 of the Clean Water Act.

Social, Economic, and Environmental Issues

Right-of-way impacts. Alternative are evaluated on right-of-way acquisition (i.e., the number of parcels and structures acquired), on the number of relocations, on temporary easements during construction, and on other potential right-of-way impacts.

Property access. Alternatives are judged on ability to maintain access to nearby properties during construction, and ability to maintain permanent access after the rehabilitation. The service drive in Span 2 provides sole access to the parking area of the Red Wing Shoe Company's Main and Potter Street facility.

Other environmental impacts (contaminated properties, Threatened and Endangered Species, etc.). The potential for additional environmental impacts is considered.

Cost

Construction cost estimate. Initial construction costs are provided for each rehabilitation alternative in 2018 dollars.

Cost estimates were generated using today's prices and adding 15% for miscellaneous minor items that have not been quantified yet and 33% for inflation. When a range is shown, the lower limit of the range does not contain any contingencies and the upper limit includes a contingency based on the given alternative.

Life cycle costs include the cost of the 2018 rehabilitation project plus anticipated future maintenance and repair costs. They do not contain any increases for contingencies. The costs for future work are discounted back to construction year 2018 by using the MnDOT prescribed Real Discount Rate of 2.5%. Costs for minor maintenance and bi-annual inspections are not included.

Service life. Service life is estimated for each alternative. Service life is defined as the number of years before significant rehabilitation would be required. Significant rehabilitation is defined as work that is more invasive (and usually requires hiring a contractor) such as full-depth repairs and deck replacement; it excludes mill and overlay which is considered expected maintenance within a bridge's service life.

7.0 REHABILITATION LOAD RATING ANALYSIS

The inventory load rating factor (RFinv) is the ratio of the structural capacity of a bridge divided by the forces that are applied from traffic loads on a regular basis. Load ratings for the existing bridge were performed using the Virtis Bridge Load Rating software from AASHTOWare. Following MnDOT's current policies, the Load and Resistance Factor Rating (LRFR) methodology was used to compute the inventory rating factors (RFinv). An RFinv of 1.0 or greater is desired. The Load Factor Rating (LFR) methodology was used to check if any postings or permit restrictions were required.

The methodology was applied using three different levels of condition deterioration and section loss to produce a sensitivity analysis of the bridge's load rating based on its existing condition. The three condition level assumptions are described in the following paragraphs and the results from all three of them are summarized in the two tables below. (See details in Appendix J.) One table contains LFR results and the other contains LRFR results. The methodology that Virtis uses to load rate a continuous concrete slab such as this bridge, analyzes a strip width along the length of the bridge. Applying the equations from Section 4.6.2.3 of the AASHTO LRFD Bridge Design Specifications, it was calculated that the design strip width for this bridge is 6.25' wide per wheel load. For each condition level that was analyzed, it was assumed that condition applied uniformly across the width of the design strip.

Condition Code 5, No Losses. This condition represents the upper bound of the bridge's load rating and only applies to those areas of the bridge where it is certain no section loss of the reinforcing steel has taken place. In the most recent MnDOT inspection report for this bridge, the deck and superstructure were given NBIS condition ratings of 5 ("Fair" condition). According to Section 6A.4.2.3 of the AASHTO Manual for Bridge Evaluation (MBE), a Fair condition requires that a Condition Factor of 0.95 be used when rating the bridge using LRFR. In a similar manner, Section 15.4 of the MnDOT LRFD Bridge Design Manual states that members that have condition rating of 5 require a capacity reduction factor of 0.95 to be used when rating the bridge using LFR. Because the bridge is a concrete slab, a LRFR System Factor of 1.00 was used for all of the condition levels.

Loss of 1/8" of Diameter on Longitudinal Reinforcing Bars. The main reinforcing in the middle of each span of this bridge is made up of #8 (originally 1"-diameter) reinforcing bars that run parallel to the roadway in the bottom of the slab. Based on field inspections performed by HDR, there are at least 12 locations where the existing #8 bars are completely exposed because the existing concrete has spalled off, and the remaining section of the reinforcing bar is 7/8" in diameter or less. This condition level analyzes the load rating based on the remaining reinforcing steel at these locations.

Loss of 1/4" of Diameter on Longitudinal Reinforcing Bars. Based on field inspections performed by HDR, there are at least 3 locations where the existing #8 bars are completely exposed because the existing concrete has spalled off, and the remaining section of the reinforcing bar is 3/4" in diameter or less. This condition level analyzes the load rating as the bars continue to deteriorate and the section losses reach a level where the average losses in all of the bars within a 6.25'-wide design strip are equal to 1/4" in diameter.

Table 1. LFR Load Rating Results

	LRFR Condition Factor, ϕ_c	LRFR System Factor, ϕ_s	Section Losses in Analysis	LRFR RFinv	LRFR RF for Legal Loads
NBIS Condition Code = 5 (Fair)	0.95	1.00	None	1.04	1.42
7/8" Dia. remains on #8 bars (24% Section Loss)	0.95	1.00	1/16" all around	0.92	1.36
3/4" Dia. remains on #8 bars (44% Section Loss)	0.95	1.00	1/8" all around	0.59	0.88

Table 2. LRFR Load Rating Results

	Section Losses in Analysis	LFR Capacity Reduction	LFR RFinv	LFR RF for Legal Loads	LFR Analysis - Posting Req'd.?	LFR Analysis - Permit Restriction?
NBIS Condition Code = 5 (Fair)	None	0.95	1.00	1.49	No	No
7/8" Dia. remains on #8 bars (24% Section Loss)	1/16" all around	0.95	0.88	1.30	No	No
3/4" Dia. remains on #8 bars (44% Section Loss)	1/8" all around	0.95	0.55	0.82	Yes	Yes

From the tables above it can be seen that the RFinv is greater than or equal to 1.0 only in the areas of the bridge where no section loss of the reinforcing steel has taken place. Once the main reinforcing bars have deteriorated down to an average of 7/8" diameter remaining in a 6.25'-wide design strip, the RFinv is computed to be about 0.9 (0.88 using LFR and 0.92 using LRFR). An RFinv of 0.9 is MnDOT's typical threshold for requiring strengthening or repairing members. When the deterioration of the reinforcing bars exceeds 24%, the RFinv will fall below 0.9.

The bridge slab area along the centerline of the bridge has delaminated concrete, deep spalls, and exposed and corroded reinforcing bars. Many of bars in this area and some outside of the center section of the bridge have 24% section loss or greater. When load ratings were calculated assuming this amount of section loss in a 6.25' design strip width, the LRFR inventory load rating factor computed was 0.92.

There are also areas along the centerline that have up to 44% section loss in some of the reinforcing bars. When load ratings were calculated assuming this amount of section loss in a 6.25' design strip width, the LRFR inventory load rating factor computed was 0.59.

When the actual section losses measured in June 2012 are used, the remaining reinforcing section area in a 6.25'-wide design strip at the midspan of Span 4 is calculated to be 86.7%, or 13.3% section loss (see Page 4 in Appendix G). This level of section loss equates to an inventory load rating factor (RFinv) for Bridge 9103 of approximately 0.95. As previously noted, it is desirable for the RFinv to be greater than 1.0.

Although the RFinv is less than 1.0, Bridge 9103 does not currently require load posting and is safely carrying normal traffic. However, as the section losses in the bottom reinforcing steel continue to increase, this will need to be re-evaluated annually. If the average section losses in the longitudinal bottom bars exceed 24% (1/8" of deterioration) in a 6.25'-wide design strip, the inventory rating factor would become less than the MnDOT threshold of 0.9 minimum. Repairs such as replacing deteriorated or missing bars would then be required to restore the load rating and avoid posting. (Posting the bridge would interfere with the transport of heavy freight critical to the region's agricultural, industrial, and commercial sectors; see Section 6.0.)

8.0 REHABILITATION ALTERNATIVES

Scenarios Not Discussed Herein

The rehabilitation study team considered several scenarios for Bridge 9103 that are not discussed in this report. They include:

- preserving Bridge 9103 on-site but bypassing it. The option was considered infeasible because there is not sufficient distance to bypass Bridge 9103 and keep the river crossing at the approximately location of Bridge 9040.
- relocating Bridge 9103 and rehabilitating it for less-demanding use on a new site. This was considered infeasible because of the bridge's length and continuous concrete slab construction.
- not rehabilitating Bridge 9103, but simply maintaining it (in its continued role as the approach to the river crossing). Although the bridge is not currently posted, further corrosion of the reinforcing steel will lead to the need for posting in the near future if repairs are not made. (Posting has important implications because the bridge is part of an important regional route serving increasing numbers of heavy commercial haulers.) Rehabilitation Alternative 1, described below, represents the minimal amount of repair needed to address Bridge 9103's deterioration including chloride content, spalling, and section loss in the reinforcing steel.
- rehabilitating Bridge 9103 to serve as the approach for one of a pair of two-lane river crossing bridges. The option was considered infeasible because there is not sufficient room to build a second approach bridge to the other bridge in a potential pair. Bridge 9103 could not be used to carry TH 63's two northbound lanes because there is not adequate distance between the river bridge and the Red Wing Shoe Company building to build a southbound bridge to the west of Bridge 9103 and get the horizontal alignment tied back into Third Street. Bridge 9103 could not be used to carry TH 63's two southbound lanes because

there is not adequate distance between Bridge 9103 and Barn Bluff to build the northbound lanes to the east of Bridge 9103.

Scenarios Considered But Not Fully Developed

As the team developed the details of the four rehabilitation alternatives documented in this report, additional concepts were considered but set aside or not fully developed, usually because they were determined infeasible from an engineering standpoint, or did not meet the Secretary of the Interior's Standards for Rehabilitation, or both. These ideas are briefly described in Section 8.6 below.

Four Rehabilitation Alternatives

Four alternatives for the rehabilitation of Bridge 9103 were developed and are described below. The work tasks associated with each alternative are summarized in Table 3.

Table 3. Summary of Rehabilitation Alternatives Work Tasks

COMPONENT	WORK TASKS	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4
		Replace Approx. 10'-15' Strip	Replace Approx. 10'-15' Strip and Add Inner Rail	Full Deck Replacement	Widen to Four Lanes
SLAB	Replace approx 10'-15' strip in-kind	X	X		
	Replace slab in-kind			X	
	Replace with wider slab				X
	Patch spalls	X	X		
	Repair cracks	X	X		
	Replace joints	X	X	X	X
	Replace deck overlay	X	X	X	X
RAIL	Restore historic rail	X	X	X	
	Add inner TL-2 rail		X	X	
	Replace historic rail with new TL-2 rail				X
	Install guardrail end terminals	X	X	X	X
LIGHTS	Restore two lights at railing	X	X	X	
	Replace two lights at railing				X
SIDEWALKS	Widen west to 5' (east is already 5')	X			
	Widen both to 6' (5' clear)		X	X	
	Extend west sidewalk to 3rd and Potter	X	X	X	
	Replace sidewalks with one 10' trail (west side only; goes to 3rd and Potter)				X
	Add ADA ramps and tactile paving	X	X	X	X
ABUTMENTS AND PIERS	Patch spalls	X	X	X	X
	Repair slope paving	X	X	X	X
	Widen abutments, piers, slope paving				X
APPROACH ROADWAY	Seal retaining wall cracks	X	X	X	
	Replace approach panel	X	X	X	X
	Widen approach				X
SERVICE DRIVE	Lower elevation				X
CATHODIC PROTECTION		OPTION	OPTION		
LOWER TH 61		OPTION	OPTION	OPTION	X

Where “Cathodic Protection” and “Lower TH 61” are shown as an OPTION on the table, these work tasks could be added to the alternative but would not have to be. In Alternative 4, where “Lower TH 61” is shown with an “X,” it is not optional and must be included in the alternative.

8.1 Rehabilitation Alternative 1 – Replace Approximately 10' to 15' Strip

8.1.1 Description

Alternative 1 involves the least amount of work that can be done to the bridge while addressing the project's primary needs. The alternative would replace in-kind a longitudinal center strip of the concrete slab to mitigate the most serious deterioration and spalling of the deck slab and section loss in the bottom reinforcing. The alternative would restore the historic pedestrian railing, in addition to other repair work. It would maintain the load rating and provide some extension of the service life of the bridge, but would not provide any geometric improvements.

As shown in Table 3, Alternative 1's major work items include replacing an approximately 10'- to 15'-wide strip of the concrete slab and restoring the historic railing and two lights. The alternative also includes minor work items such as patching spalls in the slab, epoxy injecting minor cracks in the slab, replacing deck expansion joints, replacing the concrete deck overlay, patching spalls on the piers and abutments, repairing the slope paving, repairing the approach retaining walls and approach panel, and adding crashworthy end terminals to the guardrail. The west sidewalk would be widened to 5' and a new sidewalk would be built from the southern approach's west sidewalk to the corner of Third and Potter Streets.

There are two optional work items under Alternative 1: passive cathodic protection of the concrete slab and lowering the elevation of TH 61 by about 10" to improve vertical clearance.

Deck Slab

For a girder bridge with a reinforced concrete deck (deck and girder bridge), the dead load of the deck and traffic loads are carried by the deck over a span of 4' to 6' to the nearest girder, and the girder system is the primary load-carrying member of the bridge. Unsound or deteriorated sections of the deck of a girder bridge, such as a 4' by 4' section, can be removed and replaced with new concrete and reinforcing. Removal and replacement of the deck can be readily done by supporting forms from the girders. Such a repair generally does not adversely impact the other bridge components such as girders and adjacent sound deck.

A reinforced concrete slab bridge such as Bridge 9103, however, performs quite a bit differently than a deck and girder bridge. The slab itself carries all of the dead load plus traffic loads longitudinally along the bridge to the supports (piers and abutments), making the slab the primary structural member. When Bridge 9103 was originally constructed, falsework was built across TH 61 to support the forms, reinforcing steel, and concrete slab pour while the concrete hardened. The falsework was then released and pulled down from the underside of the slab and the slab supported itself. The reinforcing steel and concrete were placed under stress as they began holding up the self-weight of the bridge without the aid of the shoring. While the slab spans from pier to pier, any narrow section of the slab that is loaded by a truck tire is aided by the adjacent sections of the slab in carrying load. The slab acts as a monolithic member.

In contrast to the deck on a deck and girder bridge, a 4' by 4' deteriorated portion of a concrete slab span bridge cannot simply be cut out and replaced. Such an action would adversely impact the adjacent sections of slab. The continuity of the slab span from pier to pier would be broken, forcing the adjacent spans to pick up load as it is redistributed. This would cause the positive moments in the midspans of the spans adjacent to the removal to increase because the

dead load from the span that was removed would no longer be counteracting their dead load. The adjacent remaining sections of the slab on either side of the removal would also pick up additional load. This additional dead load would reduce the reserve capacity of those sections to carry live loads, resulting in a diminished live load rating capacity for the bridge.

To properly replace a deteriorated section of a reinforced concrete slab bridge, the span and adjacent spans must once again have falsework shoring installed below the slab. The slab would then need to be jacked up to transfer the dead weight of the slab to the falsework. Once the slab is unloaded, the deteriorated section could be removed and recast. When the falsework is lowered, this new section of the slab would then share the load of the bridge as intended in the original design. During construction operations, the falsework would reduce the bridge's existing vertical clearance by 1' to 2' while the new section of slab is being constructed.

Alternative 1 would replace in-kind the portion of the concrete slab that is most deteriorated, an approximately 10'-15' constant-width strip along the entire length of the bridge (Figures 11 and 12). The final required width would be determined in Final Design. (Final Design could include more nondestructive testing to refine the strip dimensions.) The strip to be replaced would be located along the existing longitudinal construction joint. The upper bound width of approximately 15' was determined by using the maximum distance that the spall along the centerline joint extends away from the joint based on the field inspections, which is approximately 5'. The lap length of a #5 reinforcing bar (the size of the transverse bars) was then added to the 5' to allow for the new transverse bars to be lapped onto sound existing reinforcement that would be cleaned, straightened, and left in place to extend from the existing concrete into the new concrete, and then the distance was rounded up to the nearest 6". The lap length of the transverse reinforcing was calculated using AASHTO equations and found to be approximately 25". The transverse reinforcing also needs to be lapped in accordance with AASHTO to distribute load between the existing and new concrete slab as the design strip width methodology assumes. This resulted in removal limits that extend 7'6" on each side of the joint, or about 15' total. It has been determined that two-way traffic can be maintained on TH 63 if the width of removal is limited to about 15' (Figure 12). However, lanes would be reduced to 11' and the shoulders to 2', which is less than typical standards, and the contractor's workers would be required to operate in a narrow work zone that has live traffic on both sides. The lower bound width of approximately 10' was determined by assuming that the widest area of deterioration in Span 3 is small enough that it could be repaired outside of the constant width strip and that the repair would not be symmetrical about the centerline joint (Figure 11).

As part of this study, several possible strip widths were considered. The recommendation of approximately 10' to 15' was based on the desire to minimize the loss of historic fabric, as well as factors such as those described above. Various strip widths were evaluated for consistency with the Secretary of the Interior's Standards, and it was determined that removal and replacement in-kind of slightly more or less than a strip 10' to 15' wide would not significantly affect the property's historic integrity. Removing a strip wider than 15' would not be well-supported by engineering evidence because the current limits of observed deterioration do not extend outside of this limit. Because of the structural behavior of continuous concrete slabs, it was determined that the use of falsework, which would reduce the vertical clearance on TH 61 during construction, would be required even for a replacement strip narrower than the recommended 10' to 15'.

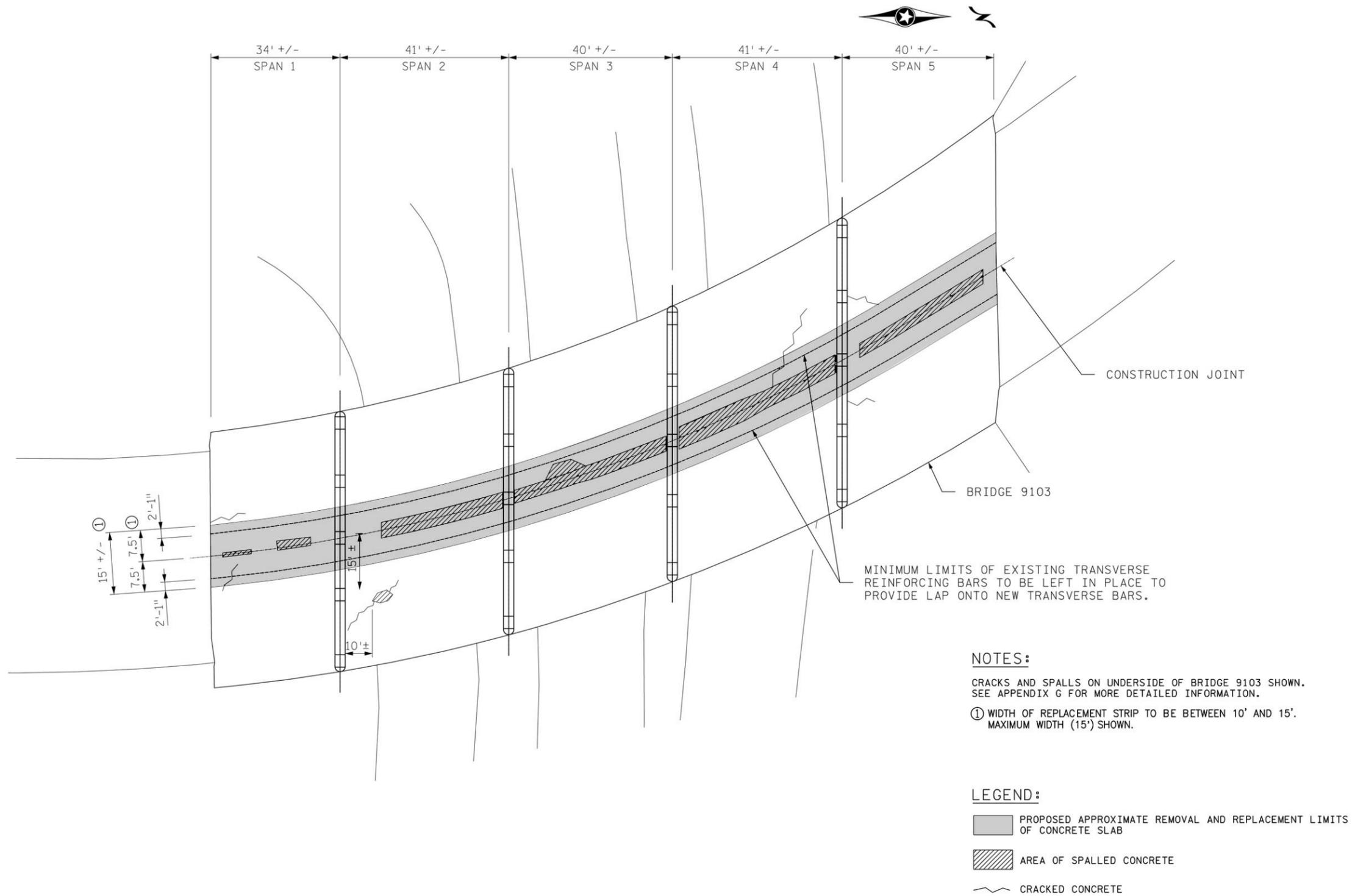


Figure 11. Plan view showing existing cracking and spalling of concrete slab on underside of Bridge 9103 and the approximate limits of removal and replacement for Alternatives 1 and 2 (HDR drawing).

It is recommended that the replaced strip be a constant width for several reasons. The first is based on how the continuous concrete slab functions, as described above. If the removed strip is wider in one span than in an adjacent span, the redistribution of loads would cause the dead load being carried by the adjacent span to be greater than was originally intended. Secondly, a constant-width strip helps maintain the continuity of the reinforcing bars. Varying the width would cause the cut line for the removal to cross the longitudinal reinforcing steel, potentially at sharp angles. This would make it very difficult or not possible to lap onto existing longitudinal bars. Construction would be complicated and time consuming for the contractor, requiring field-cutting of numerous reinforcement bars to fit varying widths and lengths of deck replacement. Although using a variable-width strip would remove slightly less material, all of the construction operations (i.e., concrete removals, erecting falsework, forming, reinforcement placement, and finishing the concrete) would still be required regardless of the removal width at any particular location. There would not be any time savings, and, in fact, constantly varying the width would delay the construction crew as they would have to continually stop and assess the limits of removal. The inefficiencies would offset any savings from decreased quantities of concrete and reinforcing.

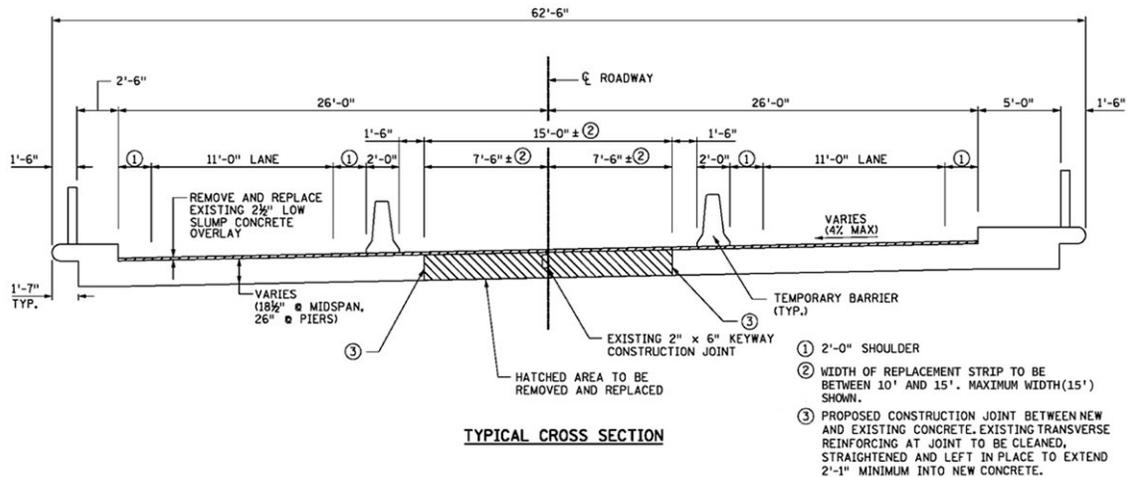


Figure 12. Approximate concrete slab removal and replacement limits for Alternatives 1 and 2 with possible lane configuration for maintaining traffic (HDR drawing).

In addition to replacement of the center 10'- to 15'-wide strip, Alternative 1 would patch spalled areas of the slab outside of the removal limits and epoxy inject all cracks. Expansion joints at the ends of the deck would be replaced with new strip seal joints. The map cracking and chloride content in the slab's overlay (noted in Sections 5.2 and 5.3) has reduced the overlay's effectiveness in protecting the structural concrete slab from the ingress of chlorides, therefore the deck's 2½" low-slump concrete overlay would be replaced on the entire width of the bridge. A MnDOT-approved crashworthy end terminal would be added to the bridge approach guardrail.

Adding Cathodic Protection (Optional)

Adding passive Cathodic Protection (CP) to the concrete slab is an option under Alternative 1. As noted above, a new overlay will improve the protection of the structural slab from the ingress of additional chlorides. A CP system will

electrochemically protect the reinforcing steel from the chlorides that already exist in the structural slab. CP would be installed after the low-slump concrete overlay has been removed and after the central 10'- to 15'-wide strip of the slab has been replaced and additional areas of deteriorated concrete have been patched and sealed. The recommended type of CP is a galvanic system, a type that does not require an external power source to provide an impressed current. On the bottom of the slab, threaded rods would be embedded into the slab where they would connect with the bottom reinforcing bars. The rods would be spaced about 15' apart in a grid pattern and their ends would project slightly. The bottom surface of the slab would be lightly sandblasted and cleaned of sand and dust with pressurized air. A zinc mesh plate, about 4" x 4" square, would be bolted to the end of each threaded rod. The lower slab surface would then be arc-sprayed with an activated zinc coating (Figure 13). The coating would be between 0.01" and 0.02" thick and grayish-white in color. It would have a glint or metallic sheen from the zinc. The coating and mesh plates would be visible on the lower surface of the slab.

On the top of the slab, the process to mill away the overlay would also remove an approximately 1"-thick layer of the existing concrete slab to expose the reinforcing steel. Sacrificial zinc anodes up to 7.5' long would be embedded longitudinally about 1' to 2' apart where they would make contact with the reinforcing steel (Figure 13). The final required spacing would be determined in detailed design. A new concrete overlay would then be placed over the anodes.



Figure 13. Cathodic protection: arc-spraying a zinc coating (left) and embedding sacrificial anodes in the top of a slab (right).

It is important to note that CP would not reduce the chloride content in the concrete slab or reverse corrosion or section loss, but would instead create a measure of electro-chemical protection for the reinforcing steel because the sacrificial zinc anodes would corrode instead. The sacrificial zinc anodes will need to be replaced in the future as their effectiveness is reduced. Thermally sprayed zinc anodes have been used to effectively mitigate chloride-induced corrosion of reinforcing steel by the Oregon Department of

Transportation since 1992 for several historic reinforced concrete bridges in marine coastal areas. Based on Oregon's experience and manufacturer's recommendations, it would be necessary to renew the sprayed-on cathodic protection at about 15- to 20-year intervals by lightly sandblasting to remove the zinc coating and arc-spraying to apply a new coat. Likewise, the zinc anodes embedded in the top of the slab below the low-slump concrete overlay will need to be replaced every 30 years when the overlay is replaced. (For more information about Cathodic Protection see Appendix K.)

Railing and Sidewalks

Alternative 1 would restore the historic pedestrian railing on both the bridge and the southern approach. Vehicle damage to the railing would be repaired, requiring that some of the railing's bent elements be replaced in-kind. After repairs have been made, the railing would be sandblasted and re-galvanized before being reinstalled in its original position.

This alternative would require obtaining a design exception for railing strength or crashworthiness (see Table 4). The historic rail has a transverse load capacity of 5.4 kip (ASD) or 9.8 kip (LRFD) and meets no design standard including TL-1, which must have a minimum transverse load capacity of 13.5 kip (LRFD). According to the AASHTO LRFD Bridge Design Specifications (Section 13.7.2), TL-1 railings are acceptable for "very low volume, low speed local streets" and have a test speed of 30 mph. TL-1 would not be appropriate for a trunk highway with 12,000 AADT and a design speed of 35 mph. According to the MnDOT Bridge Design Manual, for a combination rail mounted on a raised sidewalk where the design speed is 40 mph or less, the railing is required to meet TL-2 crash test standards in accordance with the AASHTO Specifications and NCHRP Report 350. A railing meeting TL-2 is crash-tested for vehicles traveling 45 mph (formerly expressed as 70 km/h or 43.5 mph), and has a transverse load capacity of 27.0 kip (LRFD). Despite a low accident history, the MnDOT Bridge Office does not consider a design exception to be an acceptable remedy to the historic railing's insufficient crash load capacity because the potential would remain for a vehicle to crash through the railing and fall to the roadway below.

Alternative 1 would require obtaining a design exception for railing height and opening size (see Table 4). The existing rail is 39" tall, whereas the standard in both the MnDOT Bridge Design Manual and AASHTO LRFD Bridge Design Specifications is 42". While there is a potential safety concern for pedestrians walking adjacent to a railing that doesn't meet MnDOT specifications for height, given the National Register eligibility of the bridge, the fact that the sidewalks are not heavily traveled, and the fact that the historic rail is only slightly below the criteria, a design exception may be appropriate.

The existing railing has openings that are 4½" to 5½" wide, which do not meet MnDOT standards but do meet AASHTO standards (see Section 6.0). Given the National Register eligibility of the bridge, the fact that the sidewalks are not heavily traveled, and the fact that the openings meet AASHTO standards, a design exception may be appropriate.

See Sections 8.6.4 through 8.6.7 for the unsuccessful exploration of concepts to improve the historic rail's strength, height, and opening size in ways that would meet the Secretary of the Interior's Rehabilitation Standards.

Alternative 1 would widen the west sidewalk on both the bridge and southern approach from 2'6" to 5' wide to better accommodate pedestrians and meet ADA requirements. The east sidewalk is already 5' wide. The west sidewalk currently ends at the south end of the southern approach. An ADA-compliant ramp would likely be built to tie this sidewalk to the Red Wing Shoe Company parking area. (The grass in Photo 13 in Appendix D marks the approximate location of the ramp; the parking area is in the left half of the photo.) In addition, a new 5' sidewalk would be built from the south end of the southern approach on the west side of TH 63 down to the corner of Third and Potter Streets (Figure 3). The new sidewalk would curve around the east corner of the Red Wing Shoe Company building and continue inside (immediately west of) the street trees near the building (Photo 18 in Appendix D). The curb ramp at Third and Potter Streets (near the woman in Photo 18) would be replaced with a ramp that meets current ADA standards. The east sidewalk on the bridge and southern approach (Figure 4) already extends southward to the corner of Third and Potter Streets (Photo 17 in Appendix D). Tactile paving would be added where needed.

Abutments, Piers, and Horizontal Clearance

Alternative 1 would patch areas of spalled concrete on the abutments and piers. The slope paving would be repaired by removing broken or settled concrete blocks, filling in eroded areas under the slope paving, and replacing the concrete blocks. Paving blocks that are broken or missing would be replaced in-kind. Horizontal clearance on TH 61 could not be improved without moving the bridge piers, which would threaten the bridge's historic integrity and result in significant cost; a design exception would be required (see Table 4).

Vertical Clearance

Alternative 1 would not change existing vertical clearance over TH 61 and would require a design exception (see Table 4) unless the option of lowering TH 61 were included. (See Lowering TH 61 (Optional) below.) Clearance is currently 15.5' (15'6") over TH 61 southbound and 16.4' (16'5") over TH 61 northbound. The applicable MnDOT BPIR standard is 16.0' for rehabilitation and 16.33' (16'4") for new construction. See Section 6.0 for the standards and implications of the existing condition.

Lowering TH 61 (Optional)

Lowering the elevation of TH 61 about 10" to improve vertical clearance is an option under Alternative 1. Although TH 61 would only need to be lowered by 4" to meet the 16.0' clearance standard in the MnDOT BPIR that is applicable to Alternatives 1 and 2, it is recommended that TH 61 be lowered to obtain 16.33' (16'4") clearance, which is the MnDOT BPIR standard for new construction, so Bridge 9103 is no longer a choke point along the TH 61 corridor (see Section 6.0).

When lowering the TH 61 roadway, care will be required so the bridge footings are not damaged. The elevations of the existing pier footings have been reviewed and they currently have enough cover to maintain a minimum of 4'6" above the bottom of footing even after TH 61 is lowered 10". Lowering the roadway would have to be accomplished one lane at a time to maintain traffic on TH 61. The required change in grade is less than 1' so it is not anticipated that any shoring would be required. However, the contractor's workers would have to operate in a narrow work zone next to live traffic.

Southern Approach Roadway

On the southern approach roadway, Alternative 1 would restore the pedestrian railing. Minor repairs to the southern approach would include sealing vertical cracks in the concrete retaining walls. To correct roadway settlement at the end of the bridge, the roadway approach panel would be reconstructed and the pavement replaced. For sidewalks, see Railings and Sidewalks above.

Lights

There are two lights on the bridge and southern approach, both integrated into the east railing. These lights would be removed, restored, and reinstalled in their original positions.

Preliminary planning for the Red Wing Bridge Project has not yet identified lighting needs. It is likely that a bridge rehabilitation project could alter the existing lighting scheme without compromising the property's historic integrity if the proposed lighting is simple and unobtrusive in design and the MnDOT Cultural Resources Unit is consulted during planning.

8.1.2 Risks

The condition of the concrete and reinforcing steel at the removal limits of the approximately 10'- to 15'-wide strip cannot be fully known until the removal has taken place. Additional nondestructive testing could be undertaken during Final Design, especially if testing technology continues to advance and become more accurate. (A regular inspection schedule will also be maintained by MnDOT in the interim.) Given the high chloride content found throughout the depth of four different cores taken from the concrete slab and the use of uncoated reinforcing bars in the original construction, it can be expected that additional corrosion initiation and propagation will continue between the time of the 2012 inspections and a proposed 2018 construction date. If consistently good concrete and reinforcing are not found along the removal limits, it may be necessary to remove material in an area wider than the center 10' to 15' strip. Additional removals could eliminate the ability to maintain TH 63 traffic in both directions as well as increase the duration of construction.

While the approximately 10'- to 15'-wide strip is being removed and replaced, the contractor would be working with live traffic on both sides of the work zone, which would make the construction more hazardous than typical construction operations. If unanticipated additional removals are required, the already-minimal work area for construction would be reduced and the duration of construction would likely be increased.

There is also the likelihood that new, additional spalling will take place outside of the central strip replaced under Alternative 1. As stated, it is likely that the reinforcing steel in areas outside of the 10' to 15' removal limits has begun or will begin to corrode, which may lead to additional spalling. If the cathodic protection option is included with this alternate, corrosion of the steel could be delayed. While the CP system would inhibit the corrosion process, its effectiveness will vary dependent on the ability to establish and maintain electrical connectivity between the reinforcement and anode, and moisture and chloride content at the rebar location. Additional spalling would be a maintenance and safety concern and would require additional repairs to the

slab. Spalling of concrete from the bottom of bridge decks can be a problem; there have been several documented cases of concrete falling on vehicles and causing damage and injury.

Finally, it is likely that full-depth repairs to additional portions of the slab will be required within 10 to 15 years of this rehabilitation project (see Service Life below). As described above, it is anticipated that corrosion of the reinforcing steel will begin or is taking place outside of the approximately 10' to 15' center strip, given the uncoated rebar and the slab's high chloride content (measured throughout the depth of cores from four locations). While the cathodic protection option would slow the process, there are limits to the method as described above. It is possible that further full-depth strip removals such as the 10' to 15' strip proposed under Alternative 1 will be needed in 10 to 15 years. There is a risk that replacement of additional portions of the slab may not meet the Secretary of the Interior's Rehabilitation Standards due to the cumulative effect of changes to the property and loss of an unacceptable amount of historic fabric.

8.1.3 Service Life

Alternative 1 would replace the area of the concrete slab that appears to be in the worst condition and raise the load rating of the bridge. However, given high chloride content in the slab and the use of uncoated reinforcing bars in the original construction, it is likely that additional corrosion of the reinforcing steel in the slab outside of the 10' to 15' center strip has begun or will begin in the foreseeable future. As described in Section 8.1.2, it is anticipated that additional full-depth patching and repairs to the slab will be required within 10 to 15 years of this rehabilitation project, based on MnDOT's previous experience with bridges built in this era. For example, the TH 52 Lafayette Bridge and the TH 61 Hastings Bridge are both undergoing replacement, but the decks on these bridges have had measured delamination over time even though they have undergone deck repairs in their history. The I-694 bridges in Oakdale were in need of and underwent deck replacement in 2010, even though deck repairs were made in the early 1990s. The I-394 Bridge in Minneapolis (Bridge 27831) near Dunwoody Institute was in need of and underwent deck replacement in 2007, even though deck repairs were made in the late 1980s. The Wisconsin Department of Transportation (WisDOT) has indicated that they have had similar experience with several repair projects on concrete slab span bridges. Three examples are discussed in detail in an email from WisDOT that appears in Appendix P.

Although rehabilitation projects such as the work that comprises Alternative 1 can gain additional bridge life and assist in keeping historic bridges in service, service life as defined in the rehabilitation alternatives evaluation criteria (see Section 6.0) refers to the number of years before significant rehabilitation would be required. Important in estimating service life for this alternative is the fact that Bridge 9103 has historically been heavily salted during bad weather. The practice will likely continue because of the bridge's curved, downhill geometry as TH 63 comes into the city of Red Wing. Although Alternative 1 will include a new overlay, years of heavy salting will continue to increase the chloride content in the concrete slab which will lead to additional deterioration.

An additional factor that was considered when estimating the service life of 10 to 15 years for Alternative 1 was the potential for the "halo effect" or "ring corrosion" after recommended repairs are constructed. Deterioration typically occurs because of chlorides present in a concrete slab. The casting of new concrete against existing concrete that contains chlorides can trigger a "halo

effect” whereby the old concrete and steel reinforcement on the periphery of the repaired area experience accelerated corrosion and damage due to the abrupt difference in corrosion potential between the new and existing concrete. This often occurs within a few years of the repair (Clemena and Jackson 2000). In discussions with MnDOT bridge inspection and construction staff, it was noted that they have seen this occur on Minnesota bridges after repairs have been completed. (MnDOT bridge staff also noted that, for a nonhistoric slab bridge in Bridge 9103’s condition, MnDOT would typically replace the entire slab because substantial additional repairs would continue to be needed.)

If the option of using cathodic protection is included with this alternate, the time until additional full-depth repairs are required could be increased and the extent of the repairs reduced. However, the zinc coating on the bottom of slab would require replacement in about 20 years, and the concrete overlay on top of the slab and the anodes beneath the overlay would require replacement in about 30 years.

8.1.4 Cost Estimates

The estimated initial construction costs for Alternative 1 and its options are as follows:

Alternative 1	\$ 935,000 - \$ 1,170,000
Cathodic Protection (CP) Option	\$ 1,090,000 - \$ 1,360,000
Alternative 1 with CP Option	\$ 2,025,000 - \$ 2,530,000
Lowering TH 61 Option	\$ 665,000
Alternative 1 with Lowering TH 61 Option	\$ 1,600,000 - \$ 1,835,000
Alternative 1 with both options	\$ 2,690,000 - \$ 3,195,000

The lower limit of the range shown does not include any contingencies. The upper limit includes 25% for contingencies. This percentage was estimated assuming 15% for material cost volatility and the possibility of increased deterioration between now and construction in 2018, and is based on the level of detailed design completed to date. The additional 10% was added to account for the risk associated with the unknowns that may be uncovered during the partial removal of the slab.

Costs are in construction year 2018 dollars and do not include engineering or construction administration. Costs for new bridge approach panels, retaining wall repairs, and sidewalk improvements off the bridge are included, but costs for any other approach roadway work are not. See Appendix O for cost estimate details.

Life cycle costs for keeping the bridge structurally sound for the next 100 years were also estimated. The following assumptions about required future major maintenance activities were used:

Alternative 1	Slab patching and repairs every 10 years
	Deck mill and overlay every 30 years
Alternative 1 with CP	Reapply zinc coating to slab bottom every 20 years
	Replace zinc anodes in top of slab every 30 years
	Deck mill and overlay every 30 years

Estimated life cycle costs for Alternative 1 and its options are as follows:

Alternative 1	\$ 1,145,000
Alternative 1 with Cathodic Protection Option	\$ 2,785,000
Alternative 1 with Lowering TH 61 Option	\$ 1,810,000
Alternative 1 with both options	\$ 3,450,000

Life cycle costs include the cost of the 2018 rehabilitation project plus anticipated future maintenance and repair costs. Life cycle costs do not include any contingencies. The costs for future work are discounted back to construction year 2018 by using the MnDOT prescribed Real Discount Rate of 2.5%. Costs for minor maintenance and bi-annual inspections are not included. See Appendix O for cost estimate details.

8.1.5 Compatibility With the Secretary of the Interior’s Standards for Rehabilitation

See Appendix M for the Secretary of the Interior’s (SOI) Standards for Rehabilitation.

The in-kind replacement of an approximately 10'- to 15'-wide section of the bridge slab (the final width to be determined in Final Design) would alter one of the bridge’s most important character-defining features, but it is anticipated that the change would meet the Rehabilitation Standards. While Standard 6 directs that historic elements be repaired rather than replaced, the SOI Rehabilitation Guidelines allow “limited replacement in-kind” of “extensively deteriorated or missing parts of features” in some circumstances. Although Alternative 1 would replace up to about 24% of the slab width (approximately 15' of a 62.5'-wide slab), the width of the 10' to 15' strip is as conservative as possible per SOI Rehabilitation Guidelines. The replacement concrete would not be visible on top of the bridge where the driving surface would be covered by a concrete overlay. It would be visible on the bottom of the superelevated slab (Figure 5), although portions of the bottom of the slab are somewhat shadowed, reducing the visual impact. The replacement material would closely resemble the original construction material. (The principal differences are that modern steel rebar is epoxy-coated against corrosion, and modern concrete is less permeable than the concrete used in 1960.) The surface of the new concrete would be textured and colored to match the original as closely as possible. Replacement of a central strip would mean a change from the slab’s original, single, centerline construction joint to a pair of construction joints symmetrically placed 7.5' out from the centerline. While this would constitute an alteration, the change would be primarily visual. The original joint is not a particularly significant component of the slab (e.g., not distinctive or innovative from an engineering or design standpoint), but instead is the result of standard construction practice and is typical for bridges of this type.

The use of low-slump concrete for the deck overlay, rather than the original bituminous, is a fairly minor change that would meet the Standards. Similarly, the sidewalk and guardrail changes proposed under Alternative 1 would increase safety and accessibility while being visually unobtrusive.

The rest of Alternative 1’s work items would repair or restore deteriorated historic elements and extend the life of the historic property. They would preserve historic character and distinctive features (Standards 2 and 5) and would generally repair, rather than replace, deteriorated

elements (Standard 6). The proposed methods would not damage historic materials in accordance with Standard 7, which states that repair methods “will be undertaken using the gentlest means possible” and that “treatments that cause damage to historic materials will not be used.”

Cathodic protection of the slab is an option under Alternative 1. On the upper slab surface beneath the overlay, an approximately 1"-thick layer of the concrete slab would be milled off so anodes could be embedded to make contact with the rebar (Figure 13). The surface would then be covered with a new concrete overlay. A different style of anode – short threaded rods – would be embedded perpendicularly into the bottom surface of the slab in a 15' grid and 4"-square zinc mesh plates would be attached to the ends of the rods. The bottom surface of the slab would then be lightly sandblasted. The entire bottom surface would next be covered with a gray-white, paintlike coating that has a metallic glint.

Bridge 9103's lower surface is visually prominent from some angles because of the structure's superelevation (Figure 5). Views of the surface are somewhat obscured, however, by shadows and by the structure's tilt. Adding zinc plates and short rods to the bottom of the slab would introduce a gridwork of studs to the relatively smooth surface. Sandblasting the surface would change the texture of the raw concrete, which was meant to be exposed and has characteristic patterns left by the original formwork. Sandblasting would also remove the patina of aging including surface irregularities and discoloration. The arch-sprayed zinc would give the surface a smooth, uniform, paintlike coating that is several shades lighter than the existing concrete and has a metallic glint. While the glint would fade with time and the surface would get grayer and dirtier, the cathodic protection would need to be renewed every 15 to 20 years with additional sandblasting and recoating, just as the treatment was getting less obvious. While some sources suggest that cathodic protection is “reversible,” in reality the original texture and patina of the bridge's historic concrete could not be recovered. It is recommended that the cathodic protection proposed under Alternative 1 would diminish the historic integrity of the property but stop short of an adverse effect. If applied to more parts of Bridge 9103 than the bottom of the slab, the change would likely not meet the Standards.

Lowering TH 61 beneath the bridge is also an option under Alternative 1. The roadway would be lowered about 10". It is anticipated that the change would not cause a substantial visual effect given the large scale of the bridge, southern approach, and associated highways. The alteration would not diminish the property's historic integrity in any other significant way, and would meet the Rehabilitation Standards.

Other Historic Properties

Bridge 9103 is a Contributing element within the Red Wing Segment of a linear historic district – the Highway 61 (Great River Road) Historic District – which is eligible for the National Register. Alternative 1 would not adversely affect the historic integrity of the district because the proposed changes to the bridge would meet the Secretary the Interior's Standards. Further, Bridge 9103 represents a small component of the district, which is many miles long.

Alternative 1 would have no adverse effect on the historic integrity of Barn Bluff, which is listed on the National Register.

Alternative 1 would have no adverse effect on the historic integrity of the Red Wing Shoe Company, which is eligible for the National Register. The recommended boundary of the National Register-eligible property extends to the existing Third Street curbline (Figure 3). Within this boundary, a new sidewalk would be built around the eastern corner of the building and inside the street trees against the eastern facade. Historically (i.e., within the Shoe Company's period of significance), there was a sidewalk in the same location that was evidently removed circa 1960. The sidewalk change would be fairly minor and visually unobtrusive. The street trees would remain in place.

Alternative 1's proposed changes to Bridge 9103 would not affect the setting or viewshed of any other historic properties in Red Wing.

Summary

In summary, it is anticipated that Alternative 1, with its options, would meet the Secretary of the Interior's Standards for Rehabilitation. The proposed work would result in some change to Bridge 9103's integrity of design, materials, workmanship, feeling, and association, and no change to its integrity of location and setting. The property's historic character would generally be preserved per Section 106. No other historic properties would be adversely affected. It is anticipated that Alternative 1 is not likely to constitute "use" of historic properties under Section 4(f).

8.1.6 Alternative 1's Ability to Meet Purpose and Need

Alternative 1's ability to meet the project Purpose and Need is summarized below. See also the Evaluation Matrix in Section 9.0.

Primary Needs

Alternative 1 would meet the primary needs of maintaining connectivity to the Mississippi River crossing and providing a structurally sound crossing of TH 61. The inventory load rating factor of the bridge would be improved to 1.04 which is greater than the minimum desired rating factor of 1.00 (see details in Appendix J). The alternative would improve the service life of the bridge by replacing the most deteriorated portions of the concrete slab and replacing the concrete overlay to improve protection against future chloride intrusion. In 10 to 15 years the bridge would require additional rehabilitation, which would include more full-depth repairs of the slab. If cathodic protection is added, the service life would be improved but the zinc coating would need replacement in 15 to 20 years and the anodes in the top of the slab would need replacement in 30 years. As noted in Section 8.1.3 above, the extent of these rehabilitations on a cycle of 10 to 15 years can be expected to be significant as reinforcement deterioration continues.

Secondary Needs

Alternative 1 would meet the secondary needs of maintaining the continuity of TH 63, maintaining TH 63's connections with TH 61 and TH 58, and maintaining access to Trenton Island.

The alternative would not improve the bridge's capacity in terms of traffic volume, or its role in traffic operations, but would maintain the status quo. Traffic safety would be maintained but not improved, although crashworthy end terminals would be added to the guardrail. The bridge

railing would not meet strength standards (including the lowest level of crashworthiness, TL-1). Despite a low accident history, the MnDOT Bridge Office does not consider a design exception to be an acceptable remedy to the railing's insufficient crash load capacity because the potential would remain for a vehicle to crash through the railing and fall to the roadway below.

The alternative maintains traffic to the maximum extent possible. By limiting deck slab replacement to an approximately 10'- to 15'-wide strip (the final width to be determined in Final Design), the alternative allows two-way traffic on TH 63 to remain open during construction. The work could be accomplished in one construction stage and is expected to last about 8 to 10 weeks. However, as noted in Section 8.1.2 above, there is a risk that additional removal beyond the 10' to 15' strip may be needed, thereby disrupting the ability to maintain TH 63 traffic in both directions, reducing the already-minimal construction work area, and increasing the duration of construction.

On TH 61, occasional short-term closures may be required for falsework construction but they would not be expected to last long. Vertical clearance on TH 61, however, would be reduced by 1' to 2' for approximately 4 to 6 weeks while falsework was in place. Trucks unable to meet the height restriction would be required to detour on TH 58 and CSAH 21 (Flower Valley Road). While the detour would only add about three miles to the trip, it is expected that detouring trucks (both northbound and southbound) would experience additional delays because of operational challenges. The detour would include two additional four-way-stop intersections and two additional traffic signals, as well as requiring the trucks to turn at a third downtown signal (Main and Plum Streets) where the current alignment is straight. Turning at Main and Plum Street is difficult for semi-trucks because of the tight radius, and they generally encroach into opposing traffic lanes which increases congestion and potentially affects traffic and pedestrian safety. The detour would increase the number of large trucks on Plum Street, which already experiences heavy traffic, thereby exacerbating congestion on Plum and adjacent streets downtown. (See Section 6.0 for additional information on trucks denied access to TH 61 under Bridge 9103 because of vertical clearance.)

Adding the cathodic protection option to Alternative 1 should not affect the construction schedule because the work could be done while other operations are taking place. However, cathodic protection would introduce the need for some additional temporary lane closures on TH 61 while the bottom of the slab is being worked on.

Adding the Lowering TH 61 Option to this alternative would not affect the overall construction schedule because it could be done during bridge repair operations. However it would require that southbound TH 61 be reduced from two lanes to one lane for approximately 2 to 4 weeks.

Alternative 1 would improve pedestrian facilities by widening the 2'6"-wide west sidewalk to an ADA-compliant 5' (the east sidewalk is already 5'), adding a sidewalk southward to Third and Potter Streets, and adding ADA-compliant ramps and tactile paving. Pedestrian accommodations would not be added to TH 61. Bicyclists would continue to use the TH 63 and TH 61 shoulders.

Other Considerations

Unless the option of lowering TH 61 beneath the bridge is included, a design exception would be required for vertical clearance. No improvement in horizontal clearance for TH 61 is

proposed under Alternative 1 and a design exception would be required. Design exceptions would also be required for the pedestrian railing's height and the size of the rail openings (see Table 4).

The alternative would have no effect on the bridge's ability to maintain or improve economic development or maintain or improve downtown parking.

Alternative 1 would meet the Secretary of the Interior's Standards for Rehabilitation and would not diminish the historic integrity of adjacent historic properties (including archaeological resources). There would be no adverse effect under Section 106. There would be no use of protected resources under Section 4(f).

The alternative would have no effect on the navigational channel. Section 404 water quality requirements would be met.

Social, Economic, and Environmental Issues

No parcels of property would be acquired. Two temporary easements during construction are anticipated. They are not expected to require any relocations.

Access to the parking lot of the Red Wing Shoe Company's Main and Potter Street facility would be affected during construction. The only entrance to the parking lot is via the service drive in Span 2, and the complex's only loading dock is on the northeast facade (Figure 3). The service drive would be occasionally closed for short periods of time while the falsework shoring for slab repairs was being erected. Vertical clearance for the service drive would be reduced by 1' to 2' for about 4 to 6 weeks while the falsework was in place. Vertical clearance over the drive is currently 14.7' (about 14'8"). The loading dock needs to be accessed each day by UPS trucks, which require 13'10" clearance, and about once per month by semi-trucks, which require 14' clearance, for essential deliveries and product shipment.

There are expected to be no other environmental impacts under this alternative.

8.2 Rehabilitation Alternative 2 – Replace Approximately 10' to 15' Strip and Add Inner Rail

8.2.1 Description

Alternative 2 is similar to Alternative 1 except that an inner TL-2 railing would be added. Alternative 2 would replace in-kind a longitudinal center strip of the slab and restore the pedestrian railing and two lights, in addition to other repair work. It would maintain the load rating and provide some extension of the service life of the bridge, as well as traffic safety, but would not provide any geometric improvements.

As shown in Table 3, Alternative 2's major work items include replacing an approximately 10'- to 15'-wide strip of the slab, restoring the historic railing and two lights, and adding an inner TL-2 railing. Alternative 2's minor work items are similar to those under Alternative 1: patching spalls in the slab, epoxy injecting minor cracks in the slab, replacing deck expansion joints, replacing the low-slump concrete overlay, patching spalls on the piers and abutments, repairing the slope paving, repairing the approach retaining walls and approach panel, and adding crashworthy end

terminals to the guardrail. In addition, both sidewalks would be widened to 6' to accommodate the new inner railing and provide 5' of clear walkway. A new sidewalk would be built from the southern approach's west sidewalk to the corner of Third and Potter Streets.

There are two optional work items under Alternative 2: passive cathodic protection of the concrete slab and lowering the elevation of TH 61 by about 10" to improve vertical clearance.

Deck Slab

Alternative 2 would replace in-kind the portion of the concrete slab that is most deteriorated, an approximately 10' to 15' constant-width strip along the slab's longitudinal construction joint for the entire length of the bridge (Figures 11 and 12). The final required width will be determined in Final Design. See Deck Slab under Alternative 1 (Section 8.1.1) for details.

Like Alternative 1, this alternative would also patch spalled areas of the slab outside of the approximately 10'- to 15'-wide center strip, epoxy inject all cracks, replace expansion joints at the ends of the concrete deck, and replace the low-slump concrete wearing surface.

Adding Cathodic Protection (Optional)

Adding passive Cathodic Protection to the concrete slab is an option under Alternative 2. See Deck Slab under Alternative 1 (Section 8.1.1) for details.

Railing and Sidewalks

Alternative 2 would restore the historic pedestrian railing on both the bridge and southern approach. It would require design exceptions for railing height and opening size (Table 4). See Railing and Sidewalks under Alternative 1 (Section 8.1.1) for details.

See also Sections 8.6.4 through 8.6.7 for the unsuccessful exploration of concepts to improve the historic rail's strength, height, and opening size in ways that would meet the Secretary of the Interior's Rehabilitation Standards.

Alternative 2 would add an inner TL-2 railing on the inside edge of the raised sidewalk on both the bridge and the southern roadway approach. (See Section 6.0, as well as Railing and Sidewalks under Alternative 1 (Section 8.1.1), for information on rail strength.) The proposed inner rail has been used on the National Register-listed Taft Bridge in Washington, DC, and on other historic bridges. It consists of two horizontal steel members attached to curb-mounted steel posts. The inner rail would be about 17" tall measured from the top of the sidewalk (Figures 14 through 17).

Bridge Rail Guide 2005 - Steel Tube Bridge Rails Attached to Top of Deck

Washington, DC Historic Bridge Rail Retrofit (Curb Mount)

Height:
27"

Cost per linear foot:
\$—

Test level:
TL-2

Utilized in:
Washington, DC

Contact:
Robert McNeely
District Dept of Transportation
1403 W Street, NW
Washington, DC 20009
(202) 438-7770



Figure 14. Inner TL-2 rail used in Washington, DC. This information, included in FHWA's 2005 Bridge Rail Guide, shows the rail mounted on the Taft Bridge on Connecticut Avenue in Washington, which is listed on the National Register.

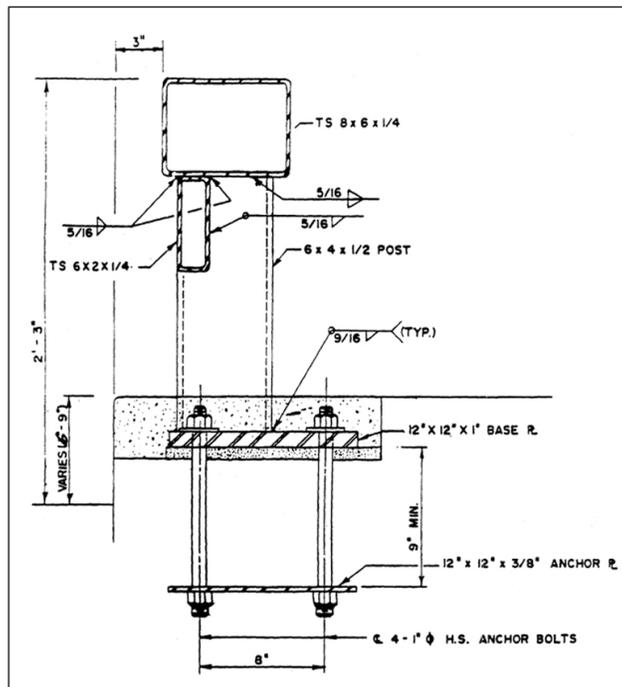


Figure 15. Construction details for the Washington, DC, inner TL-2 rail from FHWA's 2005 Bridge Rail Guide.



Figure 16. Bridge 9103 “before” the addition of the proposed inner TL-2 railing.



Figure 17. Photo mock-up of Bridge 9103 “after” the proposed inner rail (Gemini Research).

On both bridge and southern approach, Alternative 2 would also widen the west sidewalk from 2'6" to 6' and the east sidewalk from 5' to 6'. The widening would be needed to accommodate the inner rail, provide an ADA-compliant 5' walkway, and visually separate the new inner railing from the historic railing to help mitigate the visual effect of the change (Figures 16 and 17).

Alternative 2 would likely add an ADA-compliant ramp at the south end of the southern approach (on the west side of TH 63) to connect the west sidewalk with the Red Wing Shoes parking area. It would also add a new 5' sidewalk from the south end of the southern approach down to the corner of Third and Potter Streets (where there would be another ADA-compliant ramp). Tactile paving would be added. See Railing and Sidewalks under Alternative 1 (Section 8.1.1) for details.

Abutments, Piers, and Horizontal Clearance

Alternative 2 would repair the abutments and piers by patching spalled concrete and repairing slope paving. See Abutments and Piers under Alternative 1 (Section 8.1.1) for details. Horizontal clearance on TH 61 could not be improved without moving the bridge piers, which would threaten the bridge's historic integrity and result in significant cost; a design exception would be required (see Table 4).

Vertical Clearance

Alternative 2 would not change existing vertical clearance over TH 61 and would require a design exception (see Table 4) unless the option of lowering TH 61 were included. (See Lowering TH 61 (Optional) below.) Clearance is currently 15.5' (15'6") over TH 61 southbound and 16.4' (16'5") over TH 61 northbound. The applicable MnDOT BPIR standard is 16.0' for rehabilitation and 16.33' (16'4") for new construction. See Section 6.0 for the standards and implications of the existing condition.

Lowering TH 61 (Optional)

Lowering the elevation of TH 61 about 10" to improve vertical clearance is an option under Alternative 2. See Vertical Clearance under Alternative 1 (Section 8.1.1) for details.

Southern Approach Roadway

On the southern approach roadway, Alternative 2 would restore the pedestrian railing and add the same inner TL-2 railing used on the bridge itself. The west sidewalk would be widened from 2'6" to 6' and the east sidewalk from 5' to 6' to accommodate the inner rail, provide a 5' clear walkway, and visually separate the new inner railing from the historic railing. For more on sidewalk changes, see Railing and Sidewalks above.

Minor repairs to the southern approach would include sealing the vertical cracks in the concrete retaining walls. To correct roadway settlement at the end of the bridge, the roadway approach panel would be reconstructed and the pavement replaced.

Lights

The two lights on the bridge and southern approach would be restored. See Lights under Alternative 1 (Section 8.1.1) for details, as well as for a recommendation on future lighting changes.

8.2.2 Risks

The condition of the concrete and reinforcing steel at the removal limits of the approximately 10'- to 15'-wide strip cannot be fully known until the removal has taken place. Additional nondestructive testing could be undertaken during Final Design, especially if testing technology continues to advance and become more accurate. (A regular inspection schedule will also be maintained by MnDOT in the interim.) Given the high chloride content found throughout the depth of four different cores taken from the concrete slab and the use of uncoated reinforcing bars in the original construction, it can be expected that additional corrosion initiation and propagation will continue between the time of the 2012 inspections and a proposed 2018 construction date. If consistently good concrete and reinforcing are not found along the removal limits, it may be necessary to remove material in an area wider than the center 10' to 15' strip. Additional removals could eliminate the ability to maintain TH 63 traffic in both directions as well as increase the duration of construction.

While the approximately 10'- to 15'-wide strip is being removed and replaced, the contractor would be working with live traffic on both sides of the work zone, which would make the construction more hazardous than typical construction operations. If unanticipated additional removals are required, the already-minimal work area for construction would be reduced and the duration of construction would likely be increased.

There is also the likelihood that new, additional spalling will take place outside of the central strip replaced under Alternative 2. As stated, it is likely that the reinforcing steel in areas outside of the 10' to 15' removal limits has begun or will begin to corrode, which may lead to additional spalling. If the cathodic protection option is included with this alternate, corrosion of the steel could be delayed. While the CP system would inhibit the corrosion process, its effectiveness will vary dependent on the ability to establish and maintain electrical connectivity between the reinforcement and anode, and moisture and chloride content at the rebar location. Additional spalling would be a maintenance and safety concern and would require additional repairs to the slab. Spalling of concrete from the bottom of bridge decks can be a problem; there have been several documented cases of concrete falling on vehicles and causing damage and injury.

Finally, it is likely that full-depth repairs to additional portions of the slab will be required within 10 to 15 years of this rehabilitation project (see Service Life below). As described above, it is anticipated that corrosion of the reinforcing steel will begin or is taking place outside of the approximately 10' to 15' strip given the uncoated rebar and the slab's high chloride content (measured throughout the depth of cores from four locations). While the cathodic protection option would slow the process, there are limits to the method as described above. It is possible that further full-depth strip removals such as the 10' to 15' strip proposed under Alternative 2 will be needed in 10 to 15 years. There is a risk that replacement of additional portions of the slab may not meet the Secretary of the Interior's Rehabilitation Standards due to the cumulative effect of changes to the property and loss of an unacceptable amount of historic fabric.

8.2.3 Service Life

Alternative 2 would replace the area of the concrete slab that appears to be in the worst condition and raise the load rating of the bridge. However, given high chloride content in the slab and the use of uncoated reinforcing bars in the original construction, it is likely that additional corrosion of the reinforcing steel in the slab outside of the central 10' to 15' has begun or will begin in the foreseeable future. As described in Section 8.1.2, it is anticipated that additional full-depth patching and repairs to the slab will be required within 10 to 15 years of this rehabilitation project, based on MnDOT's previous experience with bridges built in this era. For example, the TH 52 Lafayette Bridge and the TH 61 Hastings Bridge are both undergoing replacement, but the decks on these bridges have had measured delamination over time even though they have undergone deck repairs in their history. The I-694 bridges in Oakdale were in need of and underwent deck replacement in 2010, even though deck repairs were made in the early 1990s. The I-394 Bridge in Minneapolis (Bridge 27831) near Dunwoody Institute was in need of and underwent deck replacement in 2007, even though deck repairs were made in the late 1980s. The Wisconsin Department of Transportation (WisDOT) has indicated that they have had similar experience with several repair projects on concrete slab span bridges. Three examples are discussed in detail in an email from WisDOT that appears in Appendix P.

Although rehabilitation projects such as the work that comprises Alternative 2 can gain additional bridge life and assist in keeping historic bridges in service, service life as defined in the rehabilitation alternatives evaluation criteria (see Section 6.0) refers to the number of years before significant rehabilitation would be required. Important in estimating service life for this alternative is the fact that Bridge 9103 has historically been heavily salted during bad weather. The practice will likely continue because of the bridge's curved, downhill geometry as TH 63 comes into the city of Red Wing. Although Alternative 2 will include a new overlay, years of heavy salting will continue to increase the chloride content in the concrete slab which will lead to additional deterioration.

An additional factor that was considered when estimating the service life of 10 to 15 years for Alternative 2 was the potential for the "halo effect" or "ring corrosion" after recommended repairs are constructed. Deterioration typically occurs because of chlorides present in a concrete slab. The casting of new concrete against existing concrete that contains chlorides can trigger a "halo effect" whereby the old concrete and steel reinforcement on the periphery of the repaired area experience accelerated corrosion and damage due to the abrupt difference in corrosion potential between the new and existing concrete. This often occurs within a few years of the repair (Clemena and Jackson 2000). In discussions with MnDOT bridge inspection and construction staff, it was noted that they have seen this occur on Minnesota bridges after repairs have been completed. (MnDOT bridge staff also noted that, for a nonhistoric slab bridge in Bridge 9103's condition, MnDOT would typically replace the entire slab because substantial additional repairs would continue to be needed.)

If the option of using cathodic protection is included with this alternate, the time until additional full-depth repairs are required could be increased and the extent of the repairs reduced. However, the zinc coating on the bottom of slab would require replacement in about 20 years, and the concrete overlay on top of the slab and the anodes beneath the overlay would require replacement in about 30 years.

8.2.4 Cost Estimates

The estimated initial construction costs for Alternative 2 and its options are as follows:

Alternative 2	\$ 1,075,000 - \$ 1,345,000
Cathodic Protection (CP) Option	\$ 1,090,000 - \$ 1,360,000
Alternative 2 with CP Option	\$ 2,165,000 - \$ 2,705,000
Lowering TH 61 Option	\$ 665,000
Alternative 2 with Lowering TH 61 Option	\$ 1,740,000 - \$ 2,010,000
Alternative 2 with both options	\$ 2,830,000 - \$ 3,370,000

The lower limit of the range shown does not include any contingencies. The upper limit includes 25% for contingencies. This percentage was estimated assuming 15% for material cost volatility and the possibility of increased deterioration between now and construction in 2018, and is based on the level of detailed design completed to date. The additional 10% was added to account for the risk associated with the unknowns that may be uncovered during the partial removal of the slab.

Costs are in construction year 2018 dollars and do not include engineering or construction administration. Costs for new bridge approach panels, retaining wall repairs, and sidewalk improvements off the bridge are included, but costs for any other approach roadway work are not. See Appendix O for cost estimate details.

Life cycle costs for keeping the bridge structurally sound for the next 100 years were also estimated. The following assumptions about required future major maintenance activities were used:

Alternative 2	Slab patching and repairs every 10 years
	Deck mill and overlay every 30 years
Alternative 2 with CP	Reapply zinc coating to slab bottom every 20 years
	Replace zinc anodes in top of slab every 30 years
	Deck mill and overlay every 30 years

Estimated life cycle costs for Alternative 2 and its options are as follows:

Alternative 2	\$ 1,285,000
Alternative 2 with Cathodic Protection Option	\$ 2,925,000
Alternative 2 with Lowering TH 61 Option	\$ 1,950,000
Alternative 2 with both options	\$ 3,590,000

Life cycle costs include the cost of the 2018 rehabilitation project plus anticipated future maintenance and repair costs. Life cycle costs do not include any contingencies. The costs for future work are discounted back to construction year 2018 by using the MnDOT prescribed Real Discount Rate of 2.5%. Costs for minor maintenance and bi-annual inspections are not included. See Appendix O for cost estimate details.

8.2.5 Compatibility With the Secretary of the Interior's Standards for Rehabilitation

See Appendix M for the Secretary of the Interior's (SOI) Standards for Rehabilitation.

The in-kind replacement of an approximately 10'- to 15'-wide section of the bridge slab (the final width to be determined in Final Design) would alter one of the bridge's most important character-defining features, but it is anticipated that the change would meet the Rehabilitation Standards. While Standard 6 directs that historic elements be repaired rather than replaced, the SOI Rehabilitation Guidelines allow "limited replacement in-kind" of "extensively deteriorated or missing parts of features" in some circumstances. Although Alternative 2 would replace up to about 24% of the slab width (approximately 15' of a 62.5'-wide slab), the size of the strip is as conservative as possible per SOI Rehabilitation Guidelines. The replacement concrete would not be visible on top of the bridge where the driving surface would be covered by a concrete overlay. It would be visible on the bottom of the superelevated slab (Figure 5), although portions of the bottom of the slab are somewhat shadowed, reducing the visual impact. The replacement material would closely resemble the original construction material. (The principal differences are that modern steel rebar is epoxy-coated against corrosion, and modern concrete is less permeable than the concrete used in 1960.) The surface of the new concrete would be textured and colored to match the original as closely as possible. Replacement of a central strip would mean a change from the slab's original, single, centerline construction joint to a pair of construction joints symmetrically placed 7.5' out from the centerline. While this would constitute an alteration, the change would be primarily visual. The original joint is not a particularly significant component of the slab (e.g., not distinctive or innovative from an engineering or design standpoint), but instead is the result of standard construction practice and is typical for bridges of this type.

Alternative 2 proposes to add an inner TL-2 railing to both the bridge and southern approach, an action considered a health and safety upgrade in terms of the SOI Standards and Guidelines. The sidewalks would be widened so they met ADA standards with 5' of clear walkway between the historic and new railing (Figures 14 and 17). The new railing, which has been used on historic bridges in Washington, DC, is compatible in size, scale, and proportion to the historic railing and does not visually overwhelm it. It would be physically separated and clearly differentiated from the historic railing so that an observer would be able to understand and experience the historic design while at the same time readily perceiving (and able to visually isolate) the alteration. Adding the inner railing would meet Standard 9, which states that new additions should "not destroy historic materials, features, and spatial relationships that characterize the property" and that the new work should be visually compatible with the historic materials or features and yet differentiated from them. Under the topic "Health and Safety Considerations," the SOI Rehabilitation Guidelines advise that "particular care must be taken not to obscure, radically change, damage, or destroy character-defining features in the process" of meeting health and safety requirements. The proposed inner rail is consistent with this recommendation.

The use of low-slump concrete for the deck overlay, rather than the original bituminous, is a fairly minor change that would meet the Standards. The guardrail changes proposed under Alternative 2 would increase safety while being visually unobtrusive.

The rest of Alternative 2's work items would repair or restore deteriorated historic elements and extend the life of the historic property. They would preserve historic character and distinctive features (Standards 2 and 5) and would generally repair, rather than replace, deteriorated elements (Standard 6). The proposed methods would not damage historic materials in accordance with Standard 7, which states that repair methods "will be undertaken using the gentlest means possible" and that "treatments that cause damage to historic materials will not be used."

Cathodic protection of the slab is an option under Alternative 2. On the upper slab surface beneath the overlay, an approximately 1"-thick layer of the concrete slab would be milled off so anodes could be embedded to make contact with the rebar (Figure 13). The surface would then be covered with a new concrete overlay. A different style of anode – short threaded rods – would be embedded perpendicularly into the bottom surface of the slab in a 15' grid and 4"-square zinc mesh plates would be attached to the ends of the rods. The bottom surface of the slab would then be lightly sandblasted. The entire bottom surface would next be covered with a gray-white, paintlike coating that has a metallic glint.

Bridge 9103's lower surface is visually prominent from some angles because of the structure's superelevation (Figure 5). Views of the surface are somewhat obscured, however, by shadows and by the structure's tilt. Adding zinc plates and short rods to the bottom of the slab would introduce a gridwork of studs to the relatively smooth surface. Sandblasting the surface would change the texture of the raw concrete, which was meant to be exposed and has characteristic patterns left by the original formwork. Sandblasting would also remove the patina of aging including surface irregularities and discoloration. The arch-sprayed zinc would give the surface a smooth, uniform, paintlike coating that is several shades lighter than the existing concrete and has a metallic glint. While the glint would fade with time and the surface would get grayer and dirtier, the cathodic protection would need to be renewed every 15 to 20 years with additional sandblasting and recoating, just as the treatment was getting less obvious. While some sources suggest that cathodic protection is "reversible," in reality the original texture and patina of the bridge's historic concrete could not be recovered. It is recommended that the cathodic protection proposed under Alternative 2 would diminish the historic integrity of the property but stop short of an adverse effect. If applied to more parts of Bridge 9103, the change would likely not meet the Standards.

Lowering TH 61 beneath the bridge is also an option under Alternative 2. The roadway would be lowered about 10". It is anticipated that the change would not cause a substantial visual effect given the large scale of the bridge, southern approach, and associated highways. The alteration would not diminish the property's historic integrity in any other significant way, and would meet the Rehabilitation Standards.

Other Historic Properties

Bridge 9103 is a Contributing element within the Red Wing Segment of a linear historic district – the Highway 61 (Great River Road) Historic District – which is eligible for the National Register. Alternative 2 would not adversely affect the historic integrity of the district because the proposed changes to the bridge would meet the Secretary the Interior's Standards. Further, Bridge 9103 represents a small component of the district, which is many miles long.

Alternative 2 would have no adverse effect on the historic integrity of Barn Bluff, which is listed on the National Register.

Alternative 2 would have no adverse effect on the historic integrity of the Red Wing Shoe Company, which is eligible for the National Register. The recommended boundary of the National Register-eligible property extends to the existing Third Street curbline (Figure 3). Within this boundary, a new sidewalk would be built around the eastern corner of the building and inside the street trees against the eastern facade. Historically (i.e., within the Shoe Company's period of significance), there was a sidewalk in the same location that was evidently removed circa 1960. The sidewalk change would be fairly minor and visually unobtrusive. The street trees would remain in place.

Alternative 2's proposed changes to Bridge 9103 would not affect the setting or viewshed of any other historic properties in Red Wing.

Summary

In summary, it is anticipated that Alternative 2, with its options, would meet the Secretary of the Interior's Standards for Rehabilitation. The proposed work would result in some change to Bridge 9103's integrity of design, materials, workmanship, feeling, and association, and no change to its integrity of location and setting. The property's historic character would generally be preserved per Section 106. No other historic properties would be adversely affected. It is anticipated that Alternative 2 is not likely to constitute "use" of historic properties under Section 4(f).

8.2.6 Alternative 2's Ability to Meet Purpose and Need

Alternative 2's ability to meet the project Purpose and Need is summarized below. See also the Evaluation Matrix in Section 9.0.

Primary Needs

Alternative 2 would meet the primary needs of maintaining connectivity to the Mississippi River crossing and providing a structurally sound crossing of TH 61. The inventory load rating factor of the bridge would be improved to 1.04 which is greater than the minimum desired rating factor of 1.00 (see details in Appendix J). This alternative would improve the service life of the bridge by replacing the most deteriorated portions of the concrete slab and replacing the concrete overlay to improve protection against future chloride intrusion. In 10 to 15 years the bridge would require additional rehabilitation, which would include more full-depth repairs of the slab. If cathodic protection is added, the service life would be improved but the zinc coating would need replacement in 15 to 20 years and the anodes in the top of the slab would need replacement in 30 years. As noted in Section 8.2.3 above, the extent of these rehabilitations on a cycle of 10 to 15 years can be expected to be significant as reinforcement deterioration continues.

Secondary Needs

Alternative 2 would meet the secondary needs of maintaining the continuity of TH 63, maintaining TH 63's connections with TH 61 and TH 58, and maintaining access to Trenton Island.

The alternative would not improve the bridge's capacity in terms of traffic volume, or its role in traffic operations, but would maintain the status quo. Alternative 2 would improve traffic safety by adding an inner TL-2 railing. New guardrail would have crashworthy end terminals.

The alternative maintains traffic to the maximum extent possible. By limiting deck slab replacement to an approximately 10' to 15' strip (the final width to be determined in Final Design), the alternative allows two-way traffic on TH 63 to remain open during construction. The work could be accomplished in one construction stage and is expected to last about 8 to 10 weeks. However, as noted in Section 8.2.2 above, there is a risk that additional removal beyond the approximately 10'- to 15'-wide strip may be needed, thereby disrupting the ability to maintain TH 63 traffic in both directions, reducing the already-minimal construction work area, and increasing the duration of construction.

On TH 61, occasional short-term closures may be required for falsework construction but they would not be expected to last long. Vertical clearance on TH 61, however, would be reduced by 1' to 2' for approximately 4 to 6 weeks while the falsework was in place. Tall trucks would be required to detour on TH 58 and CSAH 21 (Flower Valley Road). The detour's challenges are described under Secondary Needs in Section 8.1.6 (Alternative 1) above.

Adding the cathodic protection option to this alternative should not affect the construction schedule because this work could be done while other operations are taking place. However, cathodic protection would introduce the need for some additional temporary lane closures on TH 61 while the bottom of the slab is being worked on.

Adding the Lowering TH 61 Option to this alternative would not affect the overall construction schedule because it could be done during bridge repair operations. However it would require that southbound TH 61 be reduced from two lanes to one lane for approximately 2 to 4 weeks.

Alternative 2 would improve pedestrian facilities by widening the sidewalks, adding a sidewalk southward to Third and Potter Streets, and adding ADA ramps and tactile paving. After construction, both west and east sidewalks on the bridge and southern approach would provide a 5' walkway between the historic and new TL-2 railings. Pedestrian accommodations would not be added to TH 61. Bicyclists would continue to use the TH 63 and TH 61 shoulders.

Other Considerations

Unless the option of lowering TH 61 beneath the bridge is included, a design exception would be required for vertical clearance. No improvement in horizontal clearance for TH 61 is proposed under Alternative 2 and a design exception would be required. Design exceptions would also be required for the pedestrian railing's height and the size of the rail openings (see Table 4).

The alternative would have no effect on the bridge's ability to maintain or improve economic development or maintain or improve downtown parking.

Under Alternative 2, the bridge rehabilitation would meet the Secretary of the Interior's Standards for Rehabilitation and would not diminish the historic integrity of adjacent historic

properties (including archaeological resources). There would be no adverse effect under Section 106. There would be no use of protected resources under Section 4(f).

The alternative would have no effect on the navigational channel. Section 404 water quality requirements would be met.

Social, Economic, and Environmental Issues

No parcels of property would be acquired. Two temporary easements during construction are anticipated. They are not expected to require any relocations.

Access to the parking lot of the Red Wing Shoe Company's Main and Potter Street facility would be affected during construction. The only entrance to the parking lot is via the service drive in Span 2, and the complex's only loading dock is on the northeast facade (Figure 3). The service drive would be occasionally closed for short periods of time while the falsework shoring for slab repairs was being erected. Vertical clearance for the service drive would be reduced by 1' to 2' for about 4 to 6 weeks while the falsework was in place. Vertical clearance over the drive is currently 14.7' (about 14'8"). The loading dock needs to be accessed each day by UPS trucks, which require 13'10" clearance, and about once per month by semi-trucks, which require 14' clearance, for essential deliveries and product shipment.

There are expected to be no other environmental impacts under this alternative.

8.3 Rehabilitation Alternative 3 – Full Slab Replacement

8.3.1 Description

Alternative 3 would fully replace the bridge slab in-kind to mitigate its deteriorating condition, rather than replacing a central strip as proposed under Alternatives 1 and 2. Like Alternative 2, this alternative would add an inner TL-2 railing. It would restore the historic pedestrian railing and two lights, in addition to other repair work. The alternative would improve the load rating and service life of the bridge, as well as traffic safety, but would not provide any geometric improvements.

As shown in Table 3, Alternative 3's major work items include replacing the concrete slab in-kind, restoring the historic railing and two lights, and adding an inner TL-2 railing. Minor work items would include replacing deck joints, patching spalls on the piers and abutments, repairing the slope paving, repairing the approach retaining walls and approach panel, and adding crashworthy end terminals to the guardrail. In addition, both sidewalks would be widened to 6' to accommodate the new inner railing and provide ADA-compliant 5' of clear walkway. A new sidewalk would be built from the southern approach's west sidewalk to the corner of Third and Potter Streets.

There is one optional work item under Alternative 3: lowering the elevation of TH 61 about 10" to improve vertical clearance.

Deck Slab

Alternative 3 involves replacing the entire continuous concrete slab superstructure in-kind. The replacement superstructure – including its curved coping detail and shallow span arches – would be designed, detailed, and constructed to match the existing slab as closely as possible in design, color, texture, and, materials. It would be designed to visually blend with the southern approach (including its concrete coping and retaining walls), which would be retained.

In contrast to replacing an approximately 10'- to 15'-wide center strip of the slab, a full slab replacement would completely eliminate the issue of chloride concentration and reinforcing steel deterioration. Rather than simply slowing the continued deterioration, a full slab replacement would restore the concrete slab to new condition.

The construction of a full slab replacement would need to be accomplished in three stages to keep enough deck width in service to maintain two-way traffic on TH 63 during construction operations. Being constructed in three stages makes this alternative the most complicated of the four to construct. Bridge falsework shoring would be required below the slab along its entire length during slab removal and replacement. The falsework would likely reduce the bridge's vertical clearance by 2' to 3' while the new slab was being constructed.

Railing and Sidewalks

Alternative 3 would restore the existing pedestrian railing on both the bridge and southern approach. A design exception would be required for the height and opening size of the pedestrian railing (Table 4). See Railing and Sidewalks under Alternative 1 for details.

See also Sections 8.6.4 through 8.6.7 for the unsuccessful exploration of concepts to improve the historic rail's strength, height, and opening size in ways that would meet the Secretary of the Interior's Rehabilitation Standards.

Alternative 3 would add an inner TL-2 railing to both the bridge and southern approach (Figures 14 and 15). See Railing under Alternative 2 for details.

When the bridge slab is replaced, the west sidewalk would be widened from 2'6" to 6' and the east sidewalk from 5' to 6' to accommodate the inner rail, provide a 5' clear walkway per ADA standards, and visually separate the new inner railing from the historic railing to help mitigate the visual change.

Alternative 3 would likely add an ADA-compliant ramp at the south end of the southern approach (on the west side of TH 63) to connect the west sidewalk with the Red Wing Shoes parking area. It would also add a new 5' sidewalk from the south end of the southern approach down to the corner of Third and Potter Streets (where there would be another ADA-compliant ramp). Tactile paving would be added where needed. See Railing and Sidewalks under Alternative 1 for details.

Abutments, Piers, and Horizontal Clearance

Alternative 3 would repair the abutments and piers by patching spalled concrete and repairing slope paving. See "Abutments, Piers, and Horizontal Clearance" under Alternative 1 for details. Horizontal clearance on TH 61 could not be improved without moving the bridge piers, which

would threaten the bridge's historic integrity and result in significant cost; a design exception would be required (see Table 4).

Vertical Clearance

Alternative 3 would not change existing vertical clearance over TH 61 and would require a design exception (see Table 4) unless the option of lowering TH 61 were included. (See Lowering TH 61 (Optional) below.) Clearance is currently 15.5' (15'6") over TH 61 southbound and 16.4' (16'5") over TH 61 northbound. The applicable MnDOT BPIR standard is 16.0' for rehabilitation and 16.33' (16'4") for new construction. See Section 6.0 for the standards and implications of the existing condition.

Lowering TH 61 (Optional)

Lowering the elevation of TH 61 about 10" to improve vertical clearance is an option under Alternative 3. See Vertical Clearance under Alternative 1 for details.

Southern Approach Roadway

On the southern approach roadway, Alternative 3 would restore the pedestrian railing and add the same inner TL-2 railing used on the bridge itself. The west sidewalk would be widened from 2'6" to 6' and the east sidewalk from 5' to 6' to accommodate the inner rail, provide a 5' clear walkway, and visually separate the new inner railing from the historic railing. For more on sidewalk changes, see Railings and Sidewalks above.

Minor repairs to the southern approach would include sealing the vertical cracks and patching the spalls in the concrete retaining walls. To correct roadway settlement at the end of the bridge, the roadway approach panel would be reconstructed and the pavement replaced.

Lights

The two lights on the bridge and southern approach would be restored. See Lights under Alternative 1 for details, as well as for a recommendation on future lighting changes.

8.3.2 Risks

Alternative 3 is the most complicated of the four alternatives to construct because three construction stages would be needed. Construction work would occur next to live traffic for an estimated 6 to 8 months, with one of the stages requiring the contractor to work with live traffic on both sides of the work zone. Alternative 3 has relatively low risk that unforeseen factors will be identified during construction.

8.3.3 Service Life

Alternative 3 would replace the concrete slab and raise the load rating of the bridge. With regular routine maintenance and a new concrete overlay after about 30 years, the bridge could be expected to remain in service for at least 60 years before any major rehabilitation work is required. The 60-year service life estimate is based on the substructures, which are original construction that would be repaired in 2018. The superstructure slab is expected to provide 75-100 years of service, consistent with other new decks that utilize coated reinforcing bars, less permeable concretes, and overlays.

8.3.4 Cost Estimates

The estimated initial construction costs for Alternative 3 and its option are as follows:

Alternative 3	\$ 1,780,000 - \$2,045,000
Lowering TH 61 Option	\$ 665,000
Alternative 3 with Lowering TH 61 Option	\$ 2,445,000 - \$2,710,000

The lower limit of the range shown does not include any contingencies. The upper limit includes 15% for contingencies such as material cost volatility and the possibility of increased deterioration between now and construction in 2018, and is based on the level of detailed design completed to date.

Costs are in construction year 2018 dollars and do not include engineering or construction administration. Costs for new bridge approach panels, retaining wall repairs, and sidewalk improvements off of the bridge are included, but costs for any other approach roadway work are not. See Appendix O for cost estimate details.

Life cycle costs for keeping the bridge structurally sound for the next 100 years were also estimated. The following assumptions about required future major maintenance activities were used:

Alternative 3	Deck mill and overlay every 30 years
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Estimated life cycle costs for Alternative 3 and its option are as follows:

Alternative 3	\$ 1,830,000
Alternative 3 with Lowering TH 61 Option	\$ 2,495,000

Life cycle costs include the cost of the 2018 rehabilitation project plus anticipated future maintenance and repair costs. Life cycle costs do not include any contingencies. The costs for future work are discounted back to construction year 2018 by using the MnDOT prescribed Real Discount Rate of 2.5%. Costs for minor maintenance and bi-annual inspections are not included. See Appendix O for cost estimate details.

8.3.5 Compatibility With the Secretary of the Interior's Standards for Rehabilitation

See Appendix M for the Secretary of the Interior's (SOI) Standards for Rehabilitation.

Alternative 3 proposes to fully replace Bridge 9103's superstructure slab to mitigate deterioration. The slab would be replaced in-kind and, with the exception of slightly-widened sidewalks, the new superstructure would match the historic slab as closely as possible. The historic railing and two adjacent lights would be restored and reinstalled in original positions on the new slab.

Bridge 9103's continuous concrete slab is one of its most distinctive elements and an essential part of its National Register eligibility. At first glance, replacing the slab in-kind might be

considered consistent with the Rehabilitation Standards. Standard 6, for example, states that “Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will [i.e., must] be substantiated by documentary and physical evidence.”

The SOI Rehabilitation Guidelines state that repairs should be as conservative as possible, but that the “limited replacement in-kind” of “extensively deteriorated or missing parts of features when there are surviving prototypes” can be considered. The Guidelines explain:

Following repair in the hierarchy, Rehabilitation guidance is provided for replacing an entire character-defining feature with new material because the level of deterioration or damage of materials precludes repair (e.g., an exterior cornice; an interior staircase; or a complete porch or storefront). If the essential form and detailing are still evident so that the physical evidence can be used to re-establish the feature as an integral part of the rehabilitation, then its replacement is appropriate. Like the guidance for repair, the preferred option is always replacement of the entire feature in-kind, that is, with the same material. . . . It should be noted that, while the National Park Service guidelines recommend the replacement of an entire character-defining feature that is extensively deteriorated, they never recommend removal and replacement with new material of a feature that – although damaged or deteriorated – could reasonably be repaired and thus preserved.

The Guidelines include recommendations and examples to help interpret the Standards. Under the category “Masonry” (which includes reinforced concrete), the Guidelines provide 51 recommendations. Under “Recommended,” they include, for example:

Recommended: “Cutting damaged concrete back to remove the source of deterioration (often corrosion on metal reinforcement bars).”

Recommended : “Repairing masonry features by patching, piecing-in, or consolidating the masonry using recognized preservation methods. Repair may also include the limited replacement in-kind – or with compatible substitute material – of those extensively deteriorated or missing parts of masonry features when there are surviving prototypes such as terra-cotta brackets or stone balusters.”

Recommended: “Replacing in-kind an entire masonry feature that is too deteriorated to repair – if the overall form and detailing are still evident – using the physical evidence as a model to reproduce the feature. Examples can include large sections of a wall, a cornice, balustrade, column, or stairway.”

Under “Not Recommended,” they include, for example:

Not Recommended: “Replacing an entire masonry feature such as a cornice or balustrade when repair of the masonry and limited replacement of deteriorated or missing parts are appropriate.”

Not Recommended: “Replacing or rebuilding a major portion of exterior masonry walls that could be repaired so that, as a result, the building is no longer historic and is essentially new construction.”

Full replacement of Bridge 9103’s slab would be inconsistent with the above guidance. The action would require replacement of 54% of the property’s historic concrete (calculated by adding up slab, piers, abutments, footings, and southern approach retaining walls). The SOI Rehabilitation Guidelines’ use of the word “limited” in phrases such as “limited replacement in-kind” and “limited replacement of deteriorated or missing parts” suggests that replacement of historic fabric on the scale proposed under Alternative 3 is not intended and would not meet the Standards.

The elements that the Guidelines use to illustrate replacement recommendations are all small or limited in scale: cornice, staircase, porch, storefront, brackets, balusters, column, wall section. Replacement of an entire masonry feature of substantial size is never mentioned.

Replacement of Bridge 9103’s entire slab would result in a property that has entered the realm of reconstruction, rather than being an authentic historic property that retains integrity. The slab replacement would be inconsistent with Standards 2 and 5, which emphasize retention and preservation of distinctive materials and features. While Standard 6 allows the in-kind replacement of a distinctive feature if it is too deteriorated to repair, replacement on a scale proposed under Alternative 3 is not supported.

Considered separately from the slab replacement, Alternative 3’s other work tasks (e.g., adding the inner TL-2 railing and various repair and maintenance items) would likely meet the Rehabilitation Standards, as described in Sections 8.1.5 and 8.2.5. Lowering TH 61, an option under Alternative 3, would meet the Rehabilitation Standards if considered separately from slab replacement (see Sections 8.1.5 and 8.2.5).

Other Historic Properties

Bridge 9103 is a Contributing element within the Red Wing Segment of a linear historic district – the Highway 61 (Great River Road) Historic District – which is eligible for the National Register. The proposed changes to Bridge 9103 would not meet the Secretary the Interior’s Standards and would alter one of the district’s Contributing elements. However, because Bridge 9103 represents a small component of the many-mile-long historic district, the district’s overall historic integrity would not be significantly diminished.

Alternative 3 would have no adverse effect on the historic integrity of Barn Bluff, which is listed on the National Register.

Alternative 3 would have no adverse effect on the historic integrity of the Red Wing Shoe Company, which is eligible for the National Register. The recommended boundary of the National Register-eligible property extends to the existing Third Street curblin (Figure 3). Within this boundary, a new sidewalk would be built around the eastern corner of the building and inside the street trees against the eastern facade. Historically (i.e., within the Shoe Company’s period of significance), there was a sidewalk in the same location that was evidently removed circa 1960. The sidewalk change would be fairly minor and visually unobtrusive. The street trees would remain in place.

Alternative 3's proposed changes to Bridge 9103 would not affect the setting or viewshed of any other historic properties in Red Wing.

Summary

In summary, it is anticipated that Alternative 3 would not meet the Secretary of the Interior's Standards for Rehabilitation. The proposed work would result in substantial change to Bridge 9103's integrity of materials, workmanship, feeling, and association; some change to integrity of design; and no change to its integrity of location and setting. The alterations would adversely affect the property's historic character per Section 106. (No other historic properties would be adversely affected.) It is recommended that Bridge 9103 would no longer be eligible for the National Register after the change. Alternative 3 would likely constitute "use" of the historic property under Section 4(f).

8.3.6 Alternative 3's Ability to Meet Purpose and Need

Alternative 3's ability to meet the project Purpose and Need is summarized below. See also the Evaluation Matrix in Section 9.0.

Primary Needs

Alternative 3 would meet the primary needs of maintaining connectivity to the Mississippi River crossing and providing a structurally sound crossing of TH 61. The inventory load rating factor of the bridge would be improved to greater than the minimum desired rating factor of 1.00 (see details in Appendix J), and the service life of the bridge would be increased to at least 60 years.

Secondary Needs

The alternative would meet the secondary needs of maintaining the continuity of TH 63, maintaining TH 63's connections with TH 61 and TH 58, and maintaining access to Trenton Island.

The alternative would not improve the bridge's capacity in terms of traffic volume, or its role in traffic operations, but would maintain the status quo. Alternative 3 would improve traffic safety by adding an inner TL-2 railing. New guardrail would have crashworthy end terminals.

The alternative maintains traffic to the greatest extent possible. By constructing Alternative 3 in three stages, two-way traffic could be maintained on TH 63. Construction work would occur next to live traffic for an estimated 6 to 8 months. The contractor would be required to work with live traffic on both sides of the work zone during one of the construction stages.

On TH 61, occasional short-term closures may be required for falsework construction but they would not be expected to last long. Vertical clearance on TH 61, however, would be reduced by 2' to 3' for approximately 10 to 14 weeks while the falsework was in place. Tall trucks would be required to detour on TH 58 and CSAH 21 (Flower Valley Road). The detour's challenges are described under Secondary Needs in Section 8.1.6 (Alternative 1) above.

Adding the Lowering TH 61 Option to this alternative would not affect the overall construction schedule because it could be done during bridge repair operations. However it would require that southbound TH 61 be reduced from two lanes to one lane for approximately 2 to 4 weeks.

Alternative 3 would improve pedestrian facilities by widening the sidewalks, adding a sidewalk southward to Third and Potter Streets, and adding two ADA ramps. After construction, both west and east sidewalks on the bridge and southern approach would provide a 5' walkway between the historic and new TL-2 railings. Pedestrian accommodations would not be added to TH 61. Bicyclists would continue to use the TH 63 and TH 61 shoulders.

Other Considerations

Unless the option of lowering TH 61 beneath the bridge is included, a design exception would be required for vertical clearance. No improvement in horizontal clearance for TH 61 is proposed under Alternative 3 and a design exception would be required. Design exceptions would also be required for the pedestrian railing's height and the size of the rail openings (see Table 4).

The alternative would have no effect on the bridge's ability to maintain or improve economic development or maintain or improve downtown parking.

Alternative 3 would constitute an adverse effect under Section 106 and would likely constitute use of a historic property under Section 4(f). The bridge rehabilitation would not meet the Secretary of the Interior's Standards for Rehabilitation, primarily because of the large amount of historic fabric that would be removed, including the character-defining superstructure slab. It is recommended that the bridge would no longer be eligible for the National Register. The alternative would not diminish the historic integrity of adjacent historic properties (including archaeological resources).

Alternative 3 would have no effect on the navigational channel. Section 404 water quality requirements would be met.

Social, Economic, and Environmental Issues

No parcels of property would be acquired. Two temporary easements during construction are anticipated. They are not expected to require any relocations.

Access to the parking lot of the Red Wing Shoe Company's Main and Potter Street facility would be affected during construction. The only entrance to the parking lot is via the service drive in Span 2, and the complex's only loading dock is on the northeast facade (Figure 3). The service drive would be occasionally closed for short periods of time while the falsework shoring for slab repairs was being erected. Vertical clearance for the service drive would be reduced by 2' to 3' for about 10 to 14 weeks while the falsework was in place. Vertical clearance over the drive is currently 14.7' (about 14'8"). The loading dock needs to be accessed each day by UPS trucks, which require 13'10" clearance, and about once per month by semi-trucks, which require 14' clearance, for essential deliveries and product shipment.

There are expected to be no other environmental impacts under this alternative.

8.4 Rehabilitation Alternative 4 – Widen to Four Lanes

8.4.1 Description

The study team explored the option of rehabilitating Bridge 9103 to accommodate a four-lane river crossing since alternatives for Bridge 9040 (which Bridge 9103 approaches) include both two- and four-lane scenarios. Carrying four lanes on TH 63 addresses the secondary need of providing adequate traffic capacity now and in the foreseeable future. A wider Bridge 9103, which Alternative 4 proposes, could serve as the approach for either a new four-lane river bridge or for a pair of two-lane river bridges. Rehabilitating Bridge 9103 to serve as the approach for *one* of a pair of two-lane river bridges, with a second approach bridge needed for the second bridge in the pair, was determined infeasible (see the top of Section 8.0).

Alternative 4 would replace Bridge 9103's slab with a wider slab to mitigate deterioration and accommodate four lanes of traffic. (Widening, rather than replacing, the slab was determined impractical; see Section 8.6.9.) The replacement slab would be designed to accommodate a 78'-wide roadway that would consist of 4-12' lanes, 2' inside shoulders, 6' outside shoulders, a 4' raised center median, and a 10' raised trail on the west side only (Figure 18). Alternative 4 would replace the historic railing with a new TL-2 railing mounted near the outside edge of the slab. The alternative would improve the bridge's capacity, load rating, and service life, as well as improving traffic safety and providing geometric improvements.

As shown in Table 3, Alternative 4's major work items would include replacing the concrete superstructure with a new slab that extends approximately 18.5' farther to the west than the current slab, and correspondingly widening the piers, abutments, and slope paving. The southern approach roadway would be reconstructed so it was wider, had a new horizontal alignment, and had two new retaining walls. The historic rail on both bridge and southern approach would be replaced with a new TL-2 rail, and the two lights integrated into the historic railing would be replaced. The elevation of both TH 61 and the service drive (in Span 2) would be lowered to maintain vertical clearance beneath the superelevated superstructure. Minor work items would include patching spalls on the piers and abutments, repairing slope paving, and adding crashworthy end terminals to the guardrail. Instead of two sidewalks, the new slab would have a raised 10'-wide pedestrian/bicycle trail on the west side only; the trail would extend southward to Third and Potter Streets.

Deck Slab

Alternative 4 involves replacing the entire continuous concrete superstructure with a wider slab to accommodate a four-lane roadway. The existing superstructure is 62'6" wide, while the new slab would be approximately 81' wide (measured outside to outside). To line up with a potential four-lane river bridge, the new slab would extend about 18.5' farther west than the current slab, but be positioned the same as the current slab on the east side. Although wider, the replacement slab would be designed and detailed to match the existing slab in appearance as closely as possible.

The construction of this full slab replacement would need to be accomplished in two stages to keep enough deck width in service to maintain two-way traffic on TH 63 during construction. Because of the additional width, the slab could be constructed one-half at a time using relatively common two-staged construction. Bridge falsework shoring would be required below the slab

along its entire length during slab removal and replacement. The falsework will likely reduce the bridge's vertical clearance by 2' to 3' while the new slab is being constructed.

Creating a wider bridge and southern approach would require slightly reducing the size of the Red Wing Shoe Company parking area (see Southern Roadway Approach below). Mature spruce trees immediately west of the south abutment would be removed.

Railings and Sidewalks

Alternative 4 would replace the historic railing with a new TL-2 railing (its design to be determined in the future) on both the bridge and southern approach. The rail would be tall enough to meet design criteria for a bicycle trail.

Instead of two sidewalks, the new slab would have a raised 10'-wide pedestrian/bicycle trail on the west side only. The trail would extend southward from the bridge and approach to the corner of Third and Potter Streets. ADA-compliant ramps and tactile paving would be added.

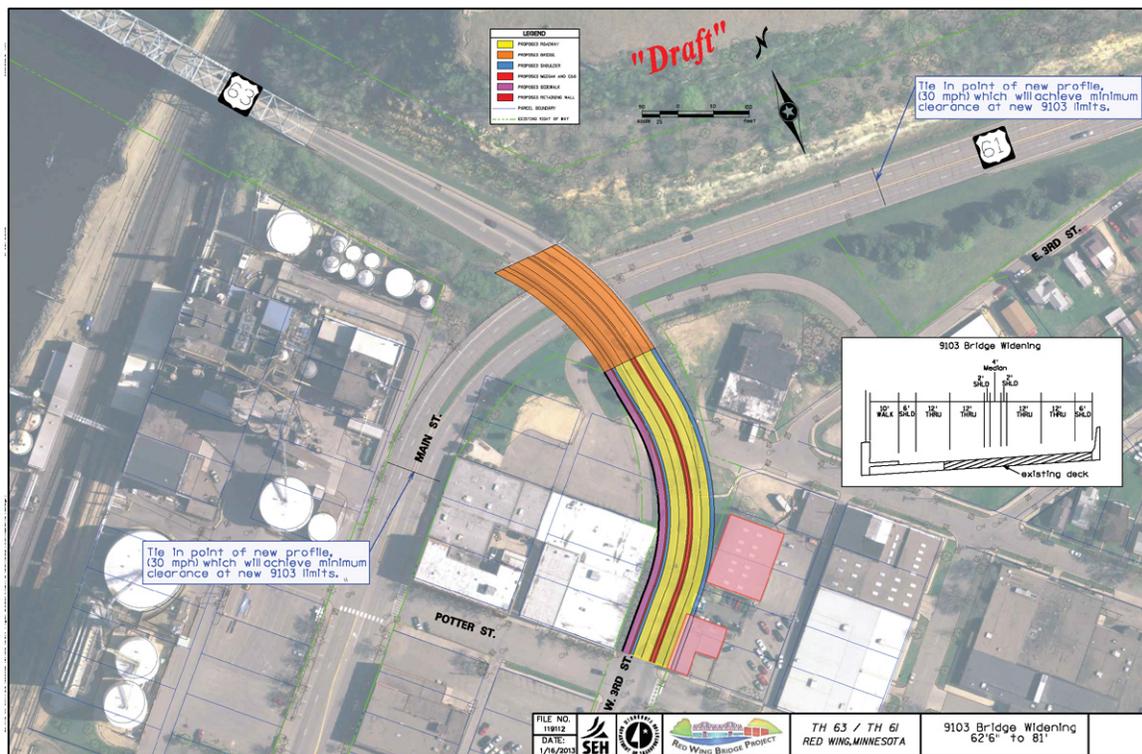


Figure 18. Alternative 4 would widen Bridge 9103 and the southern approach to accommodate a four-lane road (SEH drawing).

Abutments, Piers, and Horizontal Clearance

Alternative 4 would widen the abutments and piers about 18.5' to the west to support the new wider slab. Spalls in the existing portions of the abutments and piers would be repaired. The slope paving would also be extended to the west, and the existing slope paving repaired. Horizontal clearance on TH 61 could not be improved without moving the bridge piers, which

would threaten the bridge's historic integrity and result in significant cost; a design exception would be required (see Table 4).

Vertical Clearance

Because Bridge 9103's superstructure is superelevated, the elevation of TH 61 would need to be lowered about 1' under Alternative 4 to maintain existing vertical clearance beneath a wider slab. A design exception would still be required for vertical clearance because it would not meet current MnDOT standards (see Table 4). Clearance is currently 15.5' (15'6") over TH 61 southbound and 16.4' (16'5") over TH 61 northbound. The applicable MnDOT BPIR standard is 16.0' for rehabilitation and 16.33' (16'4") for new construction. See Section 6.0 for the standards and implications of the existing condition.

The elevation of the service drive to the Red Wing Shoe Company's parking area would also need to be lowered – about 6" – to continue to meet the MnDOT vertical clearance standard of 14'6" over a local street in an urban setting (see Section 6.0).

Southern Approach Roadway

Alternative 4 would reconstruct the southern approach roadway to align with the widened bridge. The new approach would be wider and have a different horizontal alignment than the original. The approach's retaining walls would be removed and new walls constructed that would resemble the original walls.

A widened southern approach would require reducing the size of the Red Wing Shoe Company parking area (Figure 18). The eastern edge of the lot, which is within MnDOT right-of-way, would be removed to accommodate the approach. Additional right-of-way would not be required at this location.

The southern approach's historic railing would be replaced by a new TL-2 railing. The approach's raised sidewalks would be removed. On the western side there would be a new 10'-wide, raised pedestrian/bike trail. The trail would extend southward from the end of the approach to the corner of Third and Potter Streets. ADA-compliant ramps and tactile paving would be added.

Lights

The two lights on the bridge and southern approach would be replaced with new lights (style to be determined; preliminary planning for the Red Wing Bridge Project has not yet identified lighting needs).

8.4.2 Risks

Alternative 4 has relatively low risk that unforeseen factors will be identified during construction. The alternative would require standard two-stage construction. The contractor would be working with live traffic on one side of the work zone.

8.4.3 Service Life

Alternative 4 would replace the concrete slab and raise the load rating of the bridge. With regular routine maintenance and a new concrete overlay after about 30 years, the bridge could be expected to remain in service for at least 60 years before any major rehabilitation work is required. The 60-year service life estimate is based on the substructures, which are original construction that would be repaired in 2018. The superstructure slab is expected to provide 75-100 years of service, consistent with other new decks that utilize coated reinforcing bars, less permeable concretes, and overlays.

8.4.4 Cost Estimates

The estimated initial construction cost for Alternative 4 is:

Alternative 4	\$ 3,015,000 - \$ 3,345,000
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The lower limit of the range shown does not include any contingencies. The upper limit includes 15% for contingencies such as material cost volatility and the possibility of increased deterioration between now and construction in 2018, and is based on the level of detailed design completed to date.

Costs are in construction year 2018 dollars and do not include engineering, construction administration, or right-of-way acquisition. Costs include new bridge approach panels and retaining walls, but no other bridge approach roadway improvements because the limits of these improvements are beyond the scope of this study. See Appendix O for cost estimate details.

Life cycle costs for keeping the bridge structurally sound for the next 100 years were also estimated. The following assumptions about required future major maintenance activities were used:

Alternative 4	Deck mill and overlay every 30 years
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Estimated life cycle costs for Alternative 4 are as follows:

Alternative 4	\$ 3,065,000
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Life cycle costs include the cost of the 2018 rehabilitation project plus anticipated future maintenance and repair costs. Life cycle costs do not include any contingencies. The costs for future work are discounted back to construction year 2018 by using the MnDOT prescribed Real Discount Rate of 2.5%. Costs for minor maintenance and bi-annual inspections are not included. See Appendix O for cost estimate details.

8.4.5 Compatibility With the Secretary of the Interior's Standards for Rehabilitation

See Appendix M for the Secretary of the Interior's (SOI) Standards for Rehabilitation.

Alternative 4 proposes to replace Bridge 9103's slab with a new superstructure that is about one-third wider than the original slab. The historic piers, abutments, and slope paving would be enlarged to the west to accommodate the new slab. TH 61 would be lowered about 1' beneath the bridge.

The southern approach roadway would also be altered. The approach would be widened and its horizontal alignment modified so a widened TH 63 would avoid impacting the eastern corner of the National Register-eligible Red Wing Shoe Company building (Figures 3 and 18). The southern approach's historic retaining walls would be removed and replaced with new walls.

The historic railing on both the bridge and southern approach would be replaced with a new TL-2 railing of undetermined design. The two historic lights on the bridge and approach would be replaced with new lights of undetermined design. Mature spruce trees immediately west of the spot where the southern approach meets the bridge would be removed.

Alternative 4's proposed work items would not meet the Secretary of the Interior's Standards. A substantial part of the bridge's historic fabric would be lost and numerous character-defining features would be altered.

Other Historic Properties

Bridge 9103 is a Contributing element within the Red Wing Segment of a linear historic district – the Highway 61 (Great River Road) Historic District – which is eligible for the National Register. The proposed changes to the bridge would not meet the Secretary the Interior's Standards and would alter one of the district's Contributing elements. However, because Bridge 9103 represents a small component of the many-mile-long historic district, the district's overall historic integrity would not be significantly diminished.

Alternative 4 would change the setting of Barn Bluff, which is listed on the National Register. Under this alternative Bridge 9103 and its approach – located south of the western flank of the bluff (Figures 4 and 19) – would be widened by about one-third and would carry four rather than two lanes of traffic as well as a 10'-wide trail. Because the change would occur to an element that is already a modern intrusion in Barn Bluff's setting, and because the bridge would be widened away from the bluff rather than moving closer toward it, it is recommended that the widening of Bridge 9103 proposed under Alternative 4 would not be a change substantial enough to significantly diminish the property's historic integrity. (The assessment of other effects to Barn Bluff from the Red Wing Bridge Project are beyond the scope of this bridge rehabilitation study.)

Alternative 4 would also change the setting of the Red Wing Shoe Company, which is eligible for the National Register. The recommended boundary of the National Register-eligible property extends to the existing Third Street curblin (Figure 3). Under this alternative, Bridge 9103 and its approach north and northeast of the property would be widened by about one-third and would carry four, rather than two, lanes of traffic as well as a 10' trail. A narrow slice of the eastern side of the Shoe Company's parking area would be removed. The slice to be removed is on MnDOT right-of-way (Figure 6) and outside the boundary of the National Register-eligible property. The right-of-way would not expand at this location. In another setting change, Third Street immediately east of the Shoe Company would be widened by about 50% and would carry more lanes of traffic and a 10' trail. The trail would be east of the existing Third Street curblin,

whose alignment would not change, and the mature street trees immediately west of the curb would remain in place. Finally, both buildings across the street to the east of the Shoe Company would likely be demolished.



Figure 19. Barn Bluff in 1960 with new and old alignments of TH 63 (Minnesota Historical Society photo by the St. Paul Pioneer Press).

It is anticipated that the described setting changes would not be substantial enough to significantly diminish the Red Wing Shoe Company's historic integrity. The factory was built within, and would remain within, a downtown setting with an urban street grid predominant to the south and west. The factory would remain adjacent to a modern bridge and highway (Bridge 9103 and TH 63) that became part of the Shoe Company's setting within the property's National Register period of significance of 1905-1965. The changes in setting proposed under Alternative 4 would not substantially alter the property's ability to convey its historic character and significance. Integrity of location, design, materials, workmanship, feeling, and association would be retained. Stewardship of the property would not likely be affected.

Alternative 4's proposed changes to Bridge 9103 would not affect the setting or viewshed of any other historic properties in Red Wing. However, assessing changes in traffic volume and pattern resulting from the change from two to four lanes on the bridge and on Third Street are beyond the scope of this rehabilitation study and will be addressed in the NEPA process.

Summary

In summary, it is anticipated that Alternative 4 would not meet the Secretary of the Interior's Standards for Rehabilitation. The proposed work would result in substantial change to Bridge

9103's integrity of design, materials, workmanship, feeling, and association; but no change to its integrity of location and setting. The alterations would adversely effect Bridge 9103's historic character per Section 106. (No other historic properties would be adversely affected.) It is recommended that Bridge 9103 would no longer be eligible for the National Register after the change. Alternative 4 would likely constitute "use" of the historic property under Section 4(f).

8.4.6 Alternative 4's Ability to Meet Purpose and Need

Alternative 4's ability to meet the project Purpose and Need is summarized below. See also the Evaluation Matrix in Section 9.0.

Primary Needs

Alternative 4 would meet the primary needs of maintaining connectivity to the Mississippi River crossing and providing a structurally sound crossing of TH 61. The inventory load rating factor of the bridge would be improved to greater than the minimum desired rating factor of 1.00 (see details in Appendix J), and the service life of the bridge would be increased to at least 60 years.

Secondary Needs

The alternative would meet the secondary needs of maintaining the continuity of TH 63, maintaining TH 63's connections with TH 61 and TH 58, and maintaining access to Trenton Island.

The alternative would improve the bridge's capacity in terms of traffic volume by widening it from a two-lane to a four-lane bridge.

Alternative 4 would improve traffic safety by replacing the historic railing (which does not meet current standards for strength) with a new TL-2 railing. In addition, new guardrail would have crashworthy end terminals.

The alternative maintains traffic to the greatest extent possible. By constructing Alternative 4 in two stages, two-way traffic could be maintained on TH 63. Because of the additional slab width in this alternative, the slab could be constructed one-half at a time using relatively common two-stage construction. This alternative would require the contractor to work with live traffic on one side of the work zone. Slab construction would be expected to last up to 4 to 5 months.

On TH 61, occasional short-term closures may be required for falsework construction but they would not be expected to last long. Vertical clearance on TH 61, however, would be reduced by 2' to 3' for approximately 6 to 10 weeks while the falsework was in place. Tall trucks would be required to detour on TH 58 and CSAH 21 (Flower Valley Road). The detour's challenges are described under Secondary Needs in Section 8.1.6 (Alternative 1) above.

The process of lowering TH 61 would also require that both directions of TH 61 be reduced from two lanes to one lane for approximately 2 to 4 weeks.

Alternative 4 would improve pedestrian/bicycle facilities by replacing the existing raised sidewalks on the bridge and southern approach with a raised 10'-wide trail on the west side

only. The trail would extend to Third and Potter Streets. ADA-compliant ramps and tactile paving would be added where needed.

Other Considerations

Bridge geometrics would be somewhat improved because of replacement of the historic railing with a new railing that meets MnDOT standards for height and opening size. No improvement in horizontal clearance for TH 61 is proposed under Alternative 4 and a design exception would be required. A design exception would also be required for vertical clearance (see Table 4).

Because Bridge 9103 and Third Street would carry four rather than two lanes of traffic, the alternative has the potential to increase downtown congestion, which may hinder economic development. The increase from two to four lanes may also result in a reduction in downtown parking.

Alternative 4 would constitute an adverse effect under Section 106 and would likely constitute use of a historic property under Section 4(f). The bridge rehabilitation would not meet the Secretary of the Interior's Standards for Rehabilitation, primarily because of the extensive removal and alteration of character-defining features. It is recommended that the bridge would no longer be eligible for the National Register. The historic integrity of other historic properties (see 8.4.5 above) would not be significantly diminished. However, construction would occur outside of the existing footprint of the bridge and its southern approach; potential archaeological impacts are unknown pending an archaeological survey.

Alternative 4 would have no effect on the navigational channel. Section 404 water quality requirements would be met.

Social, Economic, and Environmental Issues

Alternative 4 would require the acquisition of approximately four parcels, including two warehouses, on the east side of Third Street (shaded in pink on Figure 18). (Increasing the right-of-way on the east side of Third Street, rather than on the west side, avoids impacts to the Red Wing Shoe Company, which is eligible for the National Register.) Acquisition of the two warehouses would likely result in two relocations. The parking lot between the two warehouses (see Figure 18) is owned by the same owner as the southwestern warehouse. The northeastern warehouse is the western part of a complex that includes the parking lot and buildings east of the northeastern warehouse.

Access to the parking lot of the Red Wing Shoe Company's Main and Potter Street facility would be affected during construction. The only entrance to the parking lot is via the service drive in Span 2, and the complex's only loading dock is on the northeast facade (Figure 3). The service drive would be occasionally closed for short periods of time while the falsework shoring for slab repairs was being erected. Vertical clearance for the service drive would be reduced by 2' to 3' for about 6 to 10 weeks while the falsework was in place. Vertical clearance over the drive is currently 14.7' (about 14'8"). The loading dock needs to be accessed each day by UPS trucks, which require 13'10" clearance, and about once per month by semi-trucks, which require 14' clearance, for essential deliveries and product shipment.

Access to the Red Wing Shoes parking area would also be affected by the process of lowering the elevation of the service drive to continue to meet MnDOT's vertical clearance standard (see Table 4). This is necessary because vertical clearance would be permanently reduced by widening the superelevated slab. The service drive could be lowered one lane at a time so access to the parking area is maintained.

The Red Wing Shoe Company parking area would also be slightly but permanently reduced in size because of the widened bridge and southern approach. The part of the parking area to be removed is at its eastern edge and is within MnDOT right-of-way. The right-of-way would not need to expand at the parking area.

Alternative 4 is expected to require four temporary easements during construction.

There are expected to be no other environmental impacts under this alternative.

8.5 Relationship to Design Standards

Table 4. Relationship to Design Standards

See Section 6.0 for information on the standards referenced.

		EXISTING CONDITION	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4
DESIGN EXCEPTIONS						
RAILING STRENGTH		5.4 kip transverse load capacity (ASD); 9.8 kip transverse load capacity (LRFD)	MnDOT BPIR or MnDOT Design Manual	MnDOT BPIR or MnDOT Design Manual	TL-2	TL-2
		Standards MnDOT BPIR: 10 kip transverse load (ASD) MnDOT Br Design Manual and AASHTO LRFD Br Design Specs: TL-2 which is 27.0 kip transverse load (LRFD)	No change	Historic rail plus new inner TL-2	Historic rail plus new inner TL-2	New TL-2 rail
		Alternative proposes	Yes	No	No	No
		Exception needed?	Yes	No	No	No
RAILING HEIGHT		39"	MnDOT Br Design Manual: 42" AASHTO LRFD Br Design Specs: 42"			
		Standards MnDOT Br Design Manual: 42" AASHTO LRFD Br Design Specs: 42"	No change	No change	No change	New TL-2 rail (at least 4'6" tall for bikes)
		Alternative proposes	Yes	Yes	Yes	No
		Exception needed?	Yes	Yes	Yes	No
RAILING OPENING SIZE		4 1/2" to 5 1/2"	MnDOT Br Design Manual: 4" below 27" and 6" above 27"; AASHTO Br Design Specs: 6" below 27" and 8" above 27"			
		Standards MnDOT Br Design Manual: 4" below 27" and 6" above 27"; AASHTO Br Design Specs: 6" below 27" and 8" above 27"	No change	No change	No change	New TL-2 rail (meeting standards)
		Alternative proposes	Yes	Yes	Yes	No
		Exception needed?	Yes	Yes	Yes	No
VERTICAL CLEARANCE		15.5' over TH 61 SB 16.4' over TH 61 NB 14.7' over service drive	MnDOT BPIR: varies over principal arterial; 14.5' over local street	16.0' needed	16.33' needed	16.33' needed
		Standards MnDOT BPIR: varies over principal arterial; 14.5' over local street	No change unless Lower TH 61 Option included, then 16.4'	No change unless Lower TH 61 Option included, then 16.4'	No change unless Lower TH 61 Option included, then 16.4'	No change
		Alternative proposes	Yes, unless Lower TH 61 Option included	Yes, unless Lower TH 61 Option included	Yes, unless Lower TH 61 Option included	Yes
		Exception needed?	Yes	Yes	Yes	Yes
HORIZONTAL CLEARANCE		TH 61 SB 0' left, 2' right TH 61 NB 0' left, ~4' right	MnDOT Br Design Manual: 5.5' left, 10' right MnDOT BPIR: 4' left, 10' right			
		Standards MnDOT Br Design Manual: 5.5' left, 10' right MnDOT BPIR: 4' left, 10' right	No change	No change	No change	No change
		Alternative proposes	Yes	Yes	Yes	Yes
		Exception needed?	Yes	Yes	Yes	Yes
OTHER DESIGN ELEMENTS						
PEDESTRIAN FACILITIES AND ACCESSIBILITY STANDARDS		TH 63: west sidewalk, 2'-6", east 5', grade and cross slope okay, no ramps or tactile paving TH 61: no ped facilities	ADA: 5' sidewalk, 5% grade, 2.08% cross slope; ramps, tactile paving	TH 63: 5' walks with ramps and tactile paving; meets ADA TH 61: no change	TH 63: 5' walks with ramps and tactile paving; meets ADA TH 61: no change	TH 63: raised 10' ped/bike trail west side only, ramps, tactile paving; meets ADA TH 61: no change
		Standards ADA: 5' sidewalk, 5% grade, 2.08% cross slope; ramps, tactile paving	TH 63: 5' walks with ramps and tactile paving; meets ADA TH 61: no change	TH 63: 5' walks with ramps and tactile paving; meets ADA TH 61: no change	TH 63: 5' walks with ramps and tactile paving; meets ADA TH 61: no change	TH 63: raised 10' ped/bike trail west side only TH 61: no change
BICYCLE FACILITIES		TH 63: bikes on 12' paved shoulders TH 61: bikes on 2' and ~4' paved shoulders	MnDOT: 6' bike lane or 8' paved shoulder	TH 63: no change TH 61: no change	TH 63: no change TH 61: no change	TH 63: raised 10' ped/bike trail west side only TH 61: no change
		Standards MnDOT: 6' bike lane or 8' paved shoulder	TH 63: no change TH 61: no change	TH 63: no change TH 61: no change	TH 63: no change TH 61: no change	TH 63: raised 10' ped/bike trail west side only TH 61: no change

8.6 Rehabilitation Options Considered But Not Fully Developed

Described below are rehabilitation options that were considered during the development of the alternatives but not fully developed, generally because they were infeasible from an engineering standpoint or did not meet the Secretary of the Interior's (SOI) Standards for Rehabilitation, or both.

8.6.1 Cathodic Protection Alone

Using Cathodic Protection alone to mitigate chloride saturation of the deck slab was explored but determined not to be a viable alternative given the slab's advanced state of deterioration. Cathodic protection is described in some detail in Appendix K.

Bridge 9103 exhibits a significant amount of corrosion on the underside of the slab. The deterioration is particularly significant along the longitudinal slab joint, but is also present to varying degrees elsewhere on the slab.

Chloride concentrations were found to be high throughout the slab area and elevated from the surface to the bottom of the 9"- to 24"-deep core samples. Typically, high chloride concentrations are contained in the upper 1"-2" of a deck slab near the top reinforcing mat.

Given the state of the bridge slab, cathodic protection does not provide a long-term solution for the bridge. Cathodic protection cannot reverse the corrosion and loss of reinforcing steel section that has occurred, nor can it restore the lost live load capacity of the bridge. Cathodic protection would not remove the capacity reduction factors from the rating analysis, so the structural capacity of the bridge would not be significantly improved using this method alone.

A cathodic protection system has a finite life and would need replacement in 15 to 20 years. The effectiveness of cathodic protection for Bridge 9103 may also be negatively impacted by the fact that corrosion in the steel reinforcing grid has deteriorated contact between the bars and there may be insufficient contact to maintain electrical continuity in places.

8.6.2 Electrochemical Chloride Extraction

Using Electrochemical Chloride Extraction (ECE) to mitigate chloride saturation in the slab was also explored. Electrochemical chloride extraction is described in some detail in Appendix K.

ECE was determined to not be a viable alternative for Bridge 9103 given the issues outlined below:

- ECE systems can remove chlorides in the top several inches of a typical 8" bridge slab. Bridge 9103, however, is a continuous slab of 18½" thickness at midspan, haunched to 26" at the piers. The chlorides present lower in the 18½" to 26" depth will not be extracted. The lower reinforcing must carry the bridge slab self-weight and live loads in the midspan regions, and is thus a critical component. The midspan region is one of the most highly-stressed areas of a concrete slab bridge and ECE will not benefit this steel.

- Similar to cathodic protection, ECE does not restore section loss that has already occurred in the reinforcing steel
- Bridge 9103 would need to be closed for up to 8 weeks for the ECE installation and operation (at odds with one of the Red Wing Bridge Project's Secondary Needs). Similar to cathodic protection, the ECE process has a limited life and must be repeated every 10 to 15 years, which would result in several multiple-week detours during the remaining service life of the bridge.
- A level surface is the most desirable for installation of an ECE system. The ECE system requires the anode be kept wet in an electrolyte bath over the entire upper slab surface. In the case of Bridge 9103 the grade is significant at 4%, and is additionally complicated by a superelevation of up to 0.04 ft/ft. With the significant elevation differences in the deck slab, it would be difficult to install a system and end dams to maintain the electrolyte over the entire area without extraordinary construction, such as numerous terraced dams and separate ECE systems.

8.6.3 Deck Slab Patching

Deck slab patching is done to remove and replace deteriorated concrete in a deck slab to extend service life, but is generally not a permanent repair. Deterioration typically occurs due to chlorides present in a concrete slab. The casting of new concrete against existing concrete that contains chlorides can trigger "ring corrosion" where the old concrete and reinforcement on the periphery of the patched area will experience accelerated corrosion and damage, often within a few years of the repair (Clemena and Jackson 2000). There may be some smaller areas where patching is a possible solution for Bridge 9103, but the large areas of concrete spalls and corroded reinforcing along the existing centerline longitudinal joint are too great for patching to be a viable solution. In addition, most of the visible areas of deterioration are on the underside of the slab. Performing removal and patching operations overhead could prove to be more labor-intensive and time-consuming than removal of a full-depth strip. Overhead patches have a history of eventual failure, causing the concrete to fall to the roadway below. These are a safety issue for the owner.

8.6.4 Adding Members to the Existing Railing to Improve Strength and Geometrics

The rehabilitation study team explored adding steel members to the existing railing on both the bridge and southern approach to increase rail strength and height, and reduce opening size.

The option was eventually eliminated after no design could be identified that would not significantly alter the historic railing – a key component of the property's significant aesthetics. The proposed alterations would be in a highly-visible location and would not meet SOI Rehabilitation Standard 9 (changes should "not destroy historic materials, features, and spatial relationships that characterize the property"). The work would also be inconsistent with the SOI Rehabilitation Guidelines, which do not recommend "Altering, damaging, or destroying character-defining spaces, features, and finishes while making modifications to a building or site to comply with safety codes," or "Making changes to historic [properties] without first exploring

equivalent health and safety systems, methods, or devices that may be less damaging to historic spaces, features, and finishes.”

8.6.5 Mounting the Existing Railing on a 6” Concrete Parapet to Improve Height

The study team explored placing the existing railing, on both the bridge and southern approach, on a 6”-tall concrete parapet so the railing system would meet MnDOT and AASHTO height standards for pedestrian railings. After the alteration, the railing posts, which are 10’ apart, would meet TL-2 strength standards. However, the horizontal rails and vertical pickets would not meet strength standards and a design exception would still be required. The size of the railing openings would not be altered; they would continue to meet AASHTO standards but not MnDOT standards (see Section 6).

The proposed parapet would be a continuous concrete structure 6” tall by 12” wide. Two possible locations were explored. The first placed the parapet so the railing would remain at its current location: the centerline of the railing currently rises from a point 12” inside the outermost edge of the curved concrete coping (Figure 7). The second option was to place the parapet so the centerline of the railing would rise 12” farther to the inside. It was hoped that shifting the parapet to the inside might help maintain the distinctive, sculptural line of the coping.

It was ultimately determined that a 6” parapet in either location would significantly alter critical aspects of the bridge design including the slim Modernist deck slab (which would be visually thickened by the parapet); the shape and line of the curved coping (including its important planar upper surface); and the coping’s spatial relationship with the bridge railing. The proposed change would affect a distinctive and highly-visible part of the bridge and would not be consistent with SOI Rehabilitation Standard 9 (i.e., alterations should “not destroy historic materials, features, and spatial relationships that characterize the property”). The alteration would also be inconsistent with the SOI Rehabilitation Guidelines which do not recommend “Altering, damaging, or destroying character-defining spaces, features, and finishes while making modifications to a building or site to comply with safety codes,” or “Making changes to historic [properties] without first exploring equivalent health and safety systems, methods, or devices that may be less damaging to historic spaces, features, and finishes.”

8.6.6 Mounting the Railing on a 28” Concrete Parapet to Meet Strength and Geometric Standards

The team briefly explored the option of placing the existing railing, on both the bridge and southern approach, on a 28”-tall poured concrete parapet so the railing system would meet TL-2 strength standards. After the alteration, the railing would also meet MnDOT and AASHTO standards for height and opening size (see Section 6.0). The parapet would be a continuous concrete structure 28” tall and 12” wide. Two locations were considered. Because the 28” parapet would be a more radical change than the 6” parapet (see above), it was dropped from consideration for the same reasons the 6” parapet was eliminated.

8.6.7 Replacing the Existing Railing with a Custom Railing That Meets Design Standards

The team explored the option of replacing the existing railing, on both the bridge and southern approach, with a custom-designed railing that meets MnDOT standards for strength, height, and opening size (see Section 6.0) and replicates the existing railing as closely as possible. No design could be identified that did not differ significantly from the existing railing (see, for example, Figure 20).

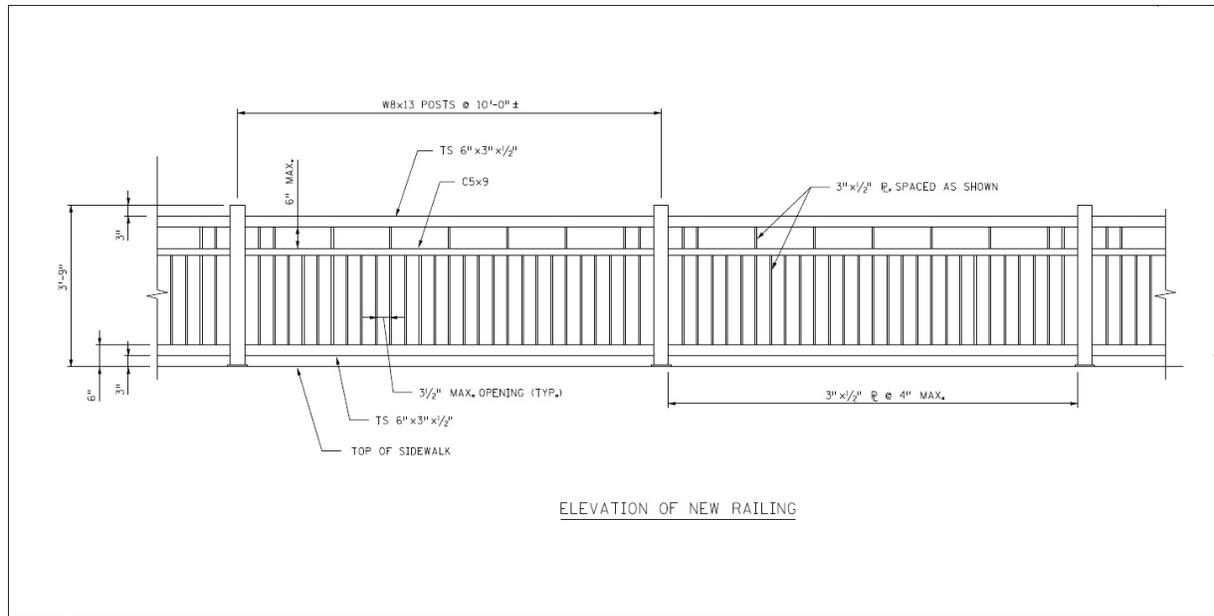


Figure 20. Potential custom-designed railing that meets MnDOT standards for strength, height, and opening size and replicates the existing railing as closely as possible. Its use on Bridge 9103 would not meet the Secretary of the Interior's Standards for Rehabilitation (HDR drawing).

The proposed change would be in a highly-visible location and seriously diminish the historic integrity of the bridge. The loss of the original railing would not meet SOI Rehabilitation Standards 2 and 5, which emphasize retaining and preserving important, distinctive elements. The change would not be reversible, which is inconsistent with Standard 10. Like other railing changes described above, the work would be inconsistent with the SOI Rehabilitation Guidelines which do not recommend “Altering, damaging, or destroying character-defining spaces, features, and finishes while making modifications to a building or site to comply with safety codes,” or “Making changes to historic [properties] without first exploring equivalent health and safety systems, methods, or devices that may be less damaging to historic spaces, features, and finishes.”

8.6.8 Raising the Bridge Slab to Increase Vertical Clearance

The study team explored the possibility of raising the bridge slab or superstructure by approximately 10" to improve vertical clearance in Alternative 3, which proposes to fully replace the slab (see Section 8.3.1). Under this scenario, the height of the pier caps (the upper part of each pier) would be increased from the existing 3'6" to about 4'4". The abutments would be correspondingly altered, as would the southern approach, whose roadway, sidewalk, coping, and concrete retaining walls align with those of the bridge.

The option was dropped from consideration because the alterations would substantially diminish the historic property's integrity of design. The changes would alter shapes and proportions essential to the bridge's aesthetics including the design of the slim Modernist slab and the visual relationship between slab and piers (Figure 7). The change would not meet the Secretary of the Interior's Rehabilitation Standards 2, 5, 9, and 10.

8.6.9 Widening Rather Than Replacing Existing Slab to Accommodate Four Lanes

To accommodate a 78'-wide roadway with four lanes of traffic, the possibility of widening the existing slab, rather than replacing it as proposed in Alternative 4, was considered. The deteriorated approximately 10'- to 15'-wide strip down the center of the slab would still need to be replaced. The option was dropped from consideration because the cost of widening the existing slab and replacing the central 10' to 15' would be similar to the cost of replacement, yet issues of chloride concentration and deteriorating reinforcing steel would remain in the portions of the historic slab that were retained. The service life would be shorter than if the slab were replaced, and additional patching and repairs to areas of the slab outside the approximately 10' to 15' center strip would still be required within 10 to 15 years. It was also determined the change would not meet the Secretary of the Interior's Rehabilitation Standards, including Standards 2, 5, 9, and 10.

8.6.10 Rehabilitating Bridge 9103 to Accommodate One of a Pair of River Crossing Bridges

Creating a pair of bridges at the river crossing is one of the proposed alternatives for Bridge 9040. Rehabilitating Bridge 9103 to serve as the approach for one of a pair of two-lane river bridges was considered by the rehabilitation study team. The option was determined infeasible because of Bridge 9103's horizontal alignment and close proximity to the river crossing.

Bridge 9103 could not be used to carry TH 63's two northbound lanes because there is not adequate distance between the river bridge and the Red Wing Shoe Company building to build a southbound bridge west of Bridge 9103 and tie the horizontal alignment back into Third Street.

Bridge 9103 could not be used to carry TH 63's two southbound lanes because there is not adequate distance between Bridge 9103 and Barn Bluff to build the northbound lanes to the east of Bridge 9103.

9.0 REHABILITATION ALTERNATIVES EVALUATION MATRIX

Bridge 9103 Rehabilitation Alternatives Evaluation Matrix - August 2013

EVALUATION CRITERIA	See this report's Table 4 for information on the standards referenced below	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4
		Replace Approx. 10'-15' Strip	Replace Approx. 10'-15' Strip and Add Inner Rail	Full Slab Replacement	Widen to Four Lanes
PRIMARY NEEDS					
Structurally sound crossing of the Mississippi River	Ability to maintain connectivity to Bridge 9040	No effect	No effect	No effect	No effect
Structurally sound crossing of US 61	Ability to meet structural requirements	Repaired concrete slab, Inv Rating Factor > 1.00	Repaired concrete slab, Inv Rating Factor > 1.00	Replaced concrete slab, Inv Rating Factor > 1.00	Replaced concrete slab, Inv Rating Factor > 1.00
SECONDARY NEEDS					
Continuity of US 63	Ability to maintain continuity	Yes	Yes	Yes	Yes
US 63 connection to US 61 and TH 58	Ability to maintain connections	Yes	Yes	Yes	Yes
Adequate capacity, acceptable traffic operations, safe design	Ability to provide adequate capacity for design year 2042 estimated AADT of 15,600	No improvement	No improvement	No improvement	Capacity improved from 2 to 4 Lanes
	Ability to maintain acceptable operations	Yes	Yes	Yes	Yes
	Ability to maintain or improve traffic safety	Maintained	Improved - inner TL-2 rail added	Improved - inner TL-2 rail added	Improved - rail replaced with TL-2 rail
	Ability to meet current standards for bridge rail crashworthiness	Does not meet TL-2 standards 9.8 kip transverse load capacity (LRFD); see Table 4	Meets TL-2 standards 27.0 kip transverse load capacity (LRFD); see Table 4	Meets TL-2 standards 27.0 kip transverse load capacity (LRFD); see Table 4	Meets TL-2 standards 27.0 kip transverse load capacity (LRFD); see Table 4
Maximum maintenance of traffic	Duration of full closure of US 63	Negligible	Negligible	Negligible	Negligible
	Duration of full closure of US 61	Negligible	Negligible	Negligible	Negligible
	Duration US 61's vertical clearance is reduced	4 to 6 weeks	4 to 6 weeks	10 to 14 weeks	6 to 10 weeks
	Complexity of construction staging	One stage but work zone between 2-way live traffic	One stage but work zone between 2-way live traffic	Three stages required, all next to live traffic	Conventional two-stage construction
	Risk of unforeseen factors affecting traffic maintenance	Risk that removal limits increase during construction	Risk that removal limits increase during construction	Low Risk	Low Risk
Access to Trenton Island	Ability to maintain connectivity to Bridge 9040	No effect	No effect	No effect	No effect
Maintain or improve pedestrian/bicycle facilities	Ability to maintain or improve pedestrian/bicycle facilities (see also Geometrics)	Improved for TH 63 peds - sidewalks widened, extended to 3rd and Potter, ADA ramps added; no improvement on TH 61	Improved for TH 63 peds - sidewalks widened, extended to 3rd and Potter, ADA ramps added; no improvement on TH 61	Improved for TH 63 peds - sidewalks widened, extended to 3rd and Potter, ADA ramps added; no improvement on TH 61	Improved for TH 63 peds and bikes - sidewalks replaced with one 10' trail to 3rd and Potter with ADA ramps; no improvement on TH 61
OTHER CONSIDERATIONS					
Structural redundancy	Not applicable to Bridge 9103	n/a	n/a	n/a	n/a
Geometrics	Meet current design standards - vertical clearance	Only with Lowering TH 61 Option; see Table 4	Only with Lowering TH 61 Option; see Table 4	Only with Lowering TH 61 Option; see Table 4	No - see Table 4
	Meet current design standards - horizontal clearance	No - see Table 4			
	Meet current design standards -pedestrian rail height	No - 3" low see Table 4	No - 3" low see Table 4	No - 3" low see Table 4	Yes see Table 4
	Meet current design standards - pedestrian rail opening size	Meets AASHTO, not MnDOT; see Table 4	Meets AASHTO, not MnDOT; see Table 4	Meets AASHTO, not MnDOT; see Table 4	Meets both; see Table 4
Economic development	Ability to maintain or improve economic development	No effect	No effect	No effect	Potential congestion increase due to 4-lane traffic
Parking	Ability to maintain or improve downtown parking	No effect	No effect	No effect	Potential parking loss due to 4-lane traffic
Regulatory Requirements:					
Section 106 compliance - Bridge 9103	Ability to meet the SOI's Standards for Rehabilitation	No adverse effect - meets SOI Rehab Standards	No adverse effect - meets SOI Rehab Standards	Adverse effect - does not meet SOI Standards, property would be ineligible for NRHP	Adverse effect - does not meet SOI Standards, property would be ineligible for NRHP
Section 106 compliance - Other historic properties	Effect on Highway 61 (Great Riv Rd) Historic District	No adverse effect	No adverse effect	No adverse effect	No adverse effect
	Effect on Barn Bluff	No adverse effect	No adverse effect	No adverse effect	No adverse effect
	Effect on Red Wing Shoe Company	No adverse effect	No adverse effect	No adverse effect	No adverse effect
Section 4(f) compliance	Section 4(f) impacts	No Section 4(f) use	No Section 4(f) use	Section 4(f) use TBD	Section 4(f) use TBD
Navigational channel	Effect on maintenance of channel	No effect	No effect	No effect	No effect
Section 404 water quality requirements	Ability to meet required stormwater management practices	Yes	Yes	Yes	Yes
SOCIAL, ECONOMIC AND ENVIRONMENTAL ISSUES					
Right-of-way impacts	Number of parcels acquired	None	None	None	4
	Number of structures acquired	None	None	None	2
	Number of relocations	None	None	None	2
	Number of temporary easements	2	2	2	4
Property access	Ability to maintain access to nearby properties during construction	Vertical clearance for RW Shoes access road reduced for 4 to 6 weeks	Vertical clearance for RW Shoes access road reduced for 4 to 6 weeks	Vertical clearance for RW Shoes access road reduced for 10 to 14 weeks	Vertical clearance for RW Shoes access road reduced for 6 to 10 weeks
	Ability to maintain permanent access to nearby properties	Access maintained	Access maintained	Access maintained	Access maintained
Other environmental impacts	Ability to minimize other environmental impacts	No impacts	No impacts	No impacts	No impacts
COST					
Construction Cost Estimate	Base alternative	\$ 935,000 - \$ 1,170,000	\$ 1,075,000 - \$ 1,345,000	\$ 1,780,000 - \$ 2,045,000	\$ 3,015,000 - \$ 3,345,000
	Alternative with Cathodic Protection (CP) Option	\$ 2,025,000 - \$ 2,530,000	\$ 2,165,000 - \$ 2,705,000	n/a	n/a
	Alternative with Lowering TH 61 Option	\$ 1,600,000 - \$ 1,835,000	\$ 1,740,000 - \$ 2,010,000	\$ 2,445,000 - \$ 2,710,000	n/a
	Alternative with both options	\$ 2,690,000 - \$ 3,195,000	\$ 2,830,000 - \$ 3,370,000	n/a	n/a
Service Life	Number of years until significant rehabilitation required	10 to 15 years, increased to 20 with CP Option	10 to 15 years, increased to 20 with CP Option	60 years	60 years

10.0 RECOMMENDATIONS/CONCLUSION

Bridge 9103, completed in 1960 and eligible for the National Register of Historic Places, serves as the approach for Bridge 9040 over the Mississippi River and carries TH 63 over TH 61. Both roads are on the National Highway System.

Bridge 9103's inventory load rating factor (RFinv) is approximately 0.95, below the desired factor of 1.0. The bridge does not currently require load posting and is safely carrying normal traffic. However, while the bridge's overall condition is listed as fair, the concrete superstructure is deteriorating and threatens the ability to maintain adequate load capacity. Posting the bridge to prohibit heavy loads would hinder the increasing number of large commercial haulers who use the Mississippi River crossing at Red Wing for the transport of agricultural and industrial materials and other freight.

Bridge 9103 meets some modern design criteria including vertical profile, horizontal curve geometrics, and lane and shoulder width. However, the historic railing's crashworthiness falls below MnDOT BPIR and MnDOT Bridge Design Manual standards, and the bridge is not universally accessible. Horizontal clearance for TH 61 is significantly more narrow than MnDOT standards, a potential safety concern, and vertical clearance is several inches lower than MnDOT standards, causing the diversion of some oversize loads onto other routes.

A rehabilitation study committee comprised of staff from FHWA, MnDOT, SEH, HDR Engineering, and Gemini Research met in 2012 and 2013 to develop alternatives for the rehabilitation of the bridge, particularly seeking alternatives that would meet the Secretary of the Interior's Standards for the Treatment of Historic Properties and comply with Section 106 of the National Historic Preservation Act and Section 4(f) of the Transportation Act of 1966.

Four alternatives were identified and opportunities to create hybrid alternatives were explored. The four alternatives were assessed against a set of evaluation criteria, most of which were derived from the Red Wing Bridge Project's Purpose and Need.

All four alternatives would increase load capacity. Alternatives 1 and 2, which differ only in the use of an inner TL-2 rail, would meet the Secretary of the Interior's Rehabilitation Standards. Alternatives 3 and 4, which propose to replace the bridge's concrete slab superstructure, would not meet the Standards and would diminish the property's historic integrity to the point that it is no longer eligible for the National Register. Alternatives 2, 3, and 4 would improve traffic safety, a secondary need, with railings that meet TL-2 crash test requirements, while Alternative 1's rail would remain below standards. (Alternative 4 would also meet criteria for rail height and opening size.) All four alternatives would meet ADA requirements. Alternative 4 would increase traffic capacity, a secondary need, by accommodating a four-lane rather than two-lane roadway. None of the alternatives would improve horizontal clearance on TH 61. Alternatives 1, 2, and 3 could improve vertical clearance if an optional lowering of the TH 61 roadway is included. No improvement of vertical clearance is possible with Alternative 4. Horizontal and vertical clearance are other considerations in the Purpose and Need statement.

Alternatives 1 and 2 each have a service life of 10 to 15 years, which could be increased to about 20 years if optional cathodic protection is included. Alternatives 3 and 4 each have a service life of about 60 years. Service life is defined as the number of years before significant

rehabilitation would be required; significant rehabilitation is defined as work that requires hiring a contractor but excludes mill and overlay which is expected maintenance within a bridge's service life.

Alternatives 1 and 2 have the risk that unforeseen deterioration of the slab may be identified during construction, complicating construction staging and threatening maintenance of traffic on TH 63, which is a secondary need. Alternative 3 is the most complicated of the four to construct. Alternative 4 is the only alternative that would require additional right-of-way; it would require acquisition of about four parcels with two likely relocations.

The rehabilitation study committee recommends that Alternatives 1 and 2 are viable alternatives for the rehabilitation of Bridge 9103. Each has two optional work items: passive cathodic protection of the concrete slab, and lowering TH 61 by about 10" to improve vertical clearance. The committee recommends that Alternatives 3 and 4 are not viable because they would not meet the Secretary of the Interior's Standards for the Treatment for Historic Properties and would diminish Bridge 9103's historic integrity to the point that it is no longer eligible for the National Register. These two alternatives would create an adverse effect under Section 106 of the National Historic Preservation Act and likely constitute "use" of historic properties under Section 4(f) of the Transportation Act of 1966.

11.0 REFERENCES

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