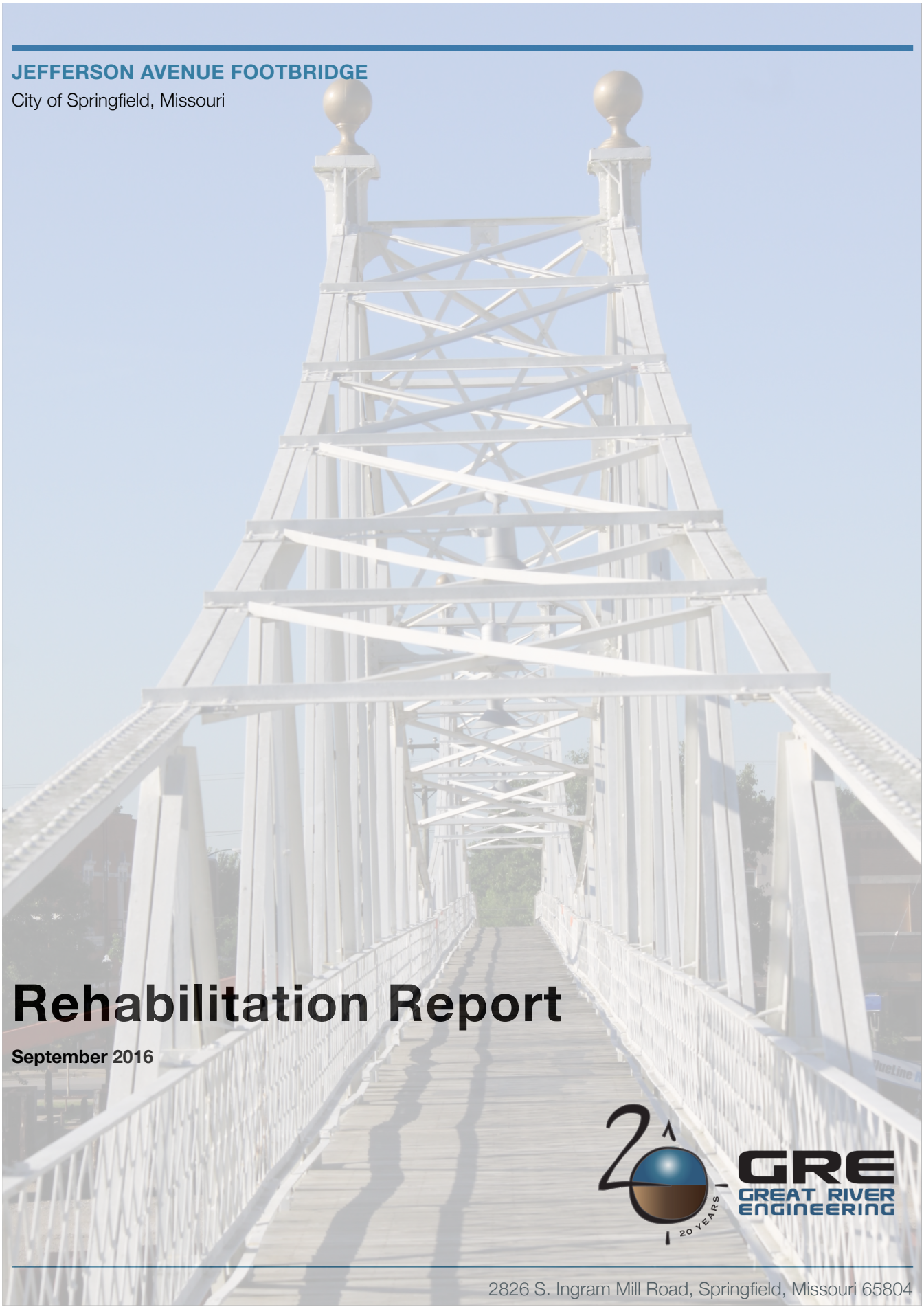


JEFFERSON AVENUE FOOTBRIDGE

City of Springfield, Missouri

Rehabilitation Report

September 2016

GREAT RIVER ENGINEERING

2826 S. Ingram Mill Road, Springfield, Missouri 65804

EXECUTIVE SUMMARY

Springfield's historic footbridge was closed March 1, 2016 after an inspection revealed corrosion and steel loss in the north support column. Public Works hired Great River Engineering to conduct an initial evaluation for safety. While the bridge was not in imminent danger, it was deemed in the best interest of the public to close the bridge to conduct a full evaluation and determine repair options.

ABOUT THE JEFFERSON AVENUE FOOTBRIDGE

The Jefferson Avenue Footbridge was built in 1902 and is on the National Register of Historic Places. The 562-foot-long bridge allows pedestrians to cross 13 tracks of the Burlington Northern rail yard from Chase Street to Commercial Street and has done so for 114 years.

The footbridge underwent restoration in 2002, in time for its centennial celebration. The City of Springfield partnered with the Commercial Club to obtain federal transportation enhancement grants and Community Development Block Grant funding to conduct the repairs. In addition to the rehabilitation work on the footbridge, a gathering place plaza was created adjacent to the bridge. The rehabilitation work was conducted in 2001 and 2002 at a cost of just over $518,000.

EVALUATION PROCESS & FINDINGS

The structural evaluation of the footbridge was conducted in four phases:

PHASE 1: Observation – Field Inspection

Information was collected on the bridge and its individual members, including verifying the dimensions, corrosion of the steel, alignment and deformation.

PHASE 2: Qualitative Evaluation

Based on information from the Observation phase, we identified the criticality of the conditions, created by corrosion, alignment and deformation and the changes that would affect the performance of each member.

PHASE 3: Quantitative Evaluation

The structural evaluation included computation of the loads applied to each member and the capacity of that member to carry the load.

The data was prepared by analyzing the bridge in accordance with guidelines set by the American Association of State Highway Transportation Officials (AASHTO) as well as the American Institute of Steel Construction. The design required a pedestrian design live load of 90 pounds per square foot.

PHASE 4: Recommendations for Rehabilitation

In order to meet design code requirements, the bridge will need to be rehabilitated. This work will include replacing members that are deficient in capacity with new or strengthened members.

- One of every three primary members (36.4%) do not have adequate capacity and need repaired or strengthened.
- Six of the 10 vertical columns in the south approach need to be strengthened.
- The stairs on both north and south approaches need to be replaced. Incorporate ADA accessibility.
- The paint system is failing in numerous locations. It is recommended that the existing paint be removed to bare metal and that a three-coat paint system be applied. This approach to the rehabilitation will aid in impeding the corrosion and deterioration of the structure, thereby lengthening the life of the bridge.

LIFE CYCLE COST ANALYSIS

As with most local governments, the City of Springfield deals with increasing infrastructure needs with limited funding opportunities. Many agencies are investigating economic tools such as bridge life cycle cost analysis (BLCCA) to help determine the most cost-effective alternatives and communicate the value of those choices to the public. By factoring in all costs over a project's total multiyear life cycle, BLCCA helps ensure that an agency can optimize its investment and avoid selecting an alternative based solely on the lowest initial cost.

REHABILITATION AND LIFE-CYCLE OPTIONS

(A comprehensive breakdown of the rehabilitation options, their associated life-cycle cost, and corresponding affect on the health of the footbridge can be found in the attached infographic.)

Option A: Do Nothing

Do not rehabilitate the bridge and schedule its demolition with no plans for a replacement bridge.

Option B: Minimal Rehabilitation with Future Replacement

Provide a minimal rehabilitation today with a replacement structure in 2029. The minimal rehabilitation would strengthen or replace the deficient members and provide an overcoat paint system. This alternative will provide for stabilizing the structure and allow it to be opened to pedestrians, but will not provide long-term stabilization of the bridge and therefore accounts for a replacement bridge to be built in 2029.

Option C: Preserve the Original Bridge

Provide a full rehabilitation today and rehabilitation every 24 years. The full rehabilitation will strengthen or replace the deficient members and remove the existing lead based paint to bare metal, apply a zinc primer and two finish coats of paint. This painting system will mitigate the continued deterioration of the bridge lengthening the time between rehabilitations. Future rehabilitations (every 24 years) will be addressing members which have experienced corrosion and applying a full overcoat.

Option D: Full Rehabilitation with Future Replacement

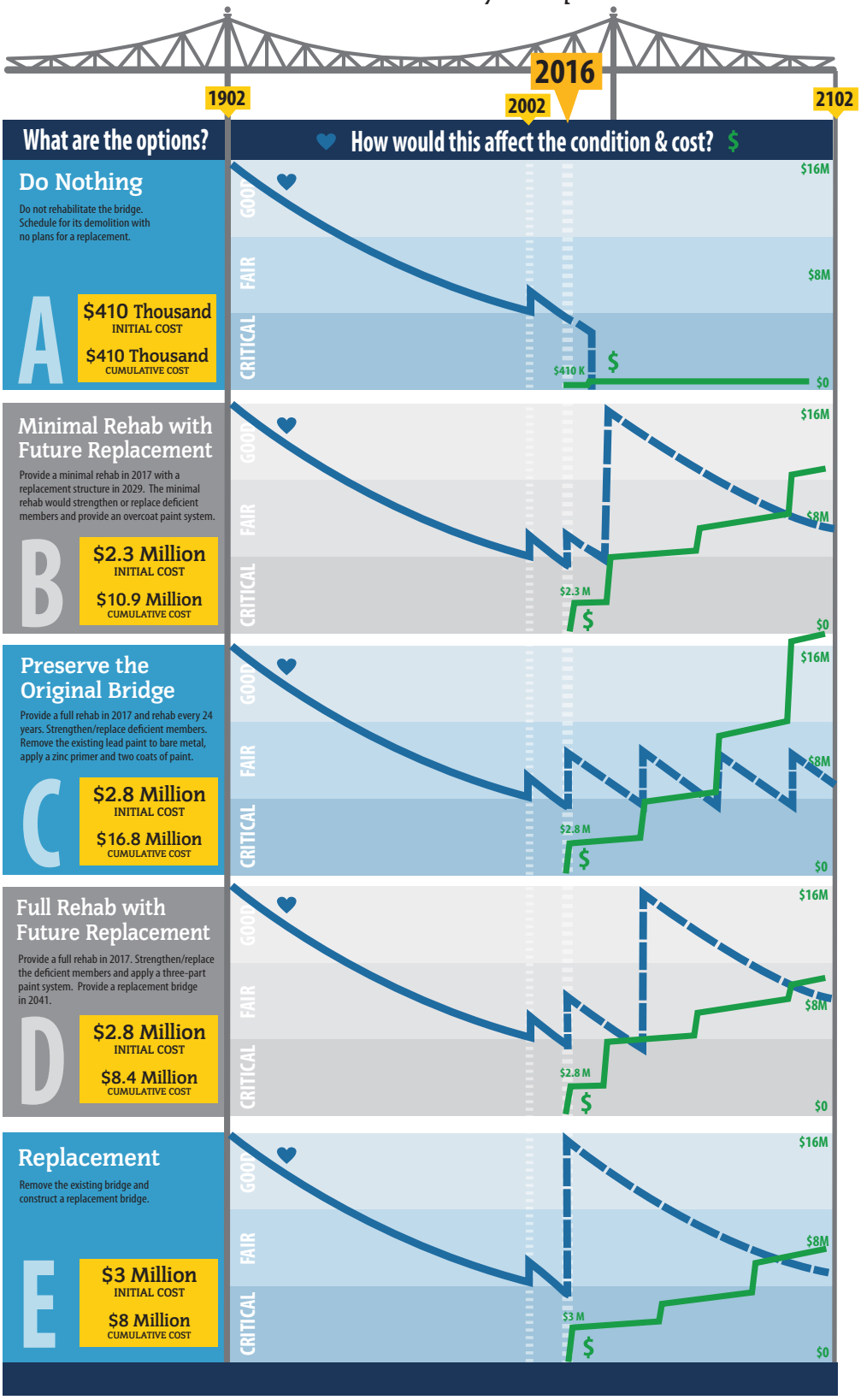
Provide a full rehabilitation. The full rehabilitation will strengthen or replace the deficient members and remove the existing lead based paint to bare metal, apply a zinc primer and two finish coats of paint. Provide a replacement bridge in 2041.

Option E: Replacement Bridge

Remove the existing bridge and construct a replacement bridge.

JEFFERSON AVENUE FOOTBRIDGE

Rehabilitation & Life-cycle Options



INTRODUCTION

The Jefferson Avenue Footbridge built in 1902, has been placed on the National Register of Historic Places. The 562 foot long bridge provides pedestrians access over 13 tracks of the Burlington Northern rail yard from Chase Steet to Commercial Street and has done so for 114 years (Figure 1). The bridge has been a very popular location for train watching and photographing for newlyweds, graduates, and families. The bridge was closed March 1, 2016 after an inspection revealed corrosion and steel loss in the north support column. Public Works hired Great River Engineering to conduct an initial evaluation of the column. While the bridge was not in imminent danger of collapse or catastrophic failure, the City deemed that in the best interest of the public to close the bridge and to conduct a full evaluation of deficiencies and required repairs to restore safe pedestrian use.

Great River Engineering began conducting an in-depth evaluation of the Jefferson Avenue Footbridge in June, 2016 to provide a full depiction of the structural integrity of the bridge.

FIGURE 1 - LOCATION MAP

Project Approach

The evaluation process for this project is a 4-phase process as described below:

- Phase 1 - Observation - Field inspection to collect information on the bridge and its individual members. This information includes measuring the dimensions, corrosion of the steel, alignment, and deformation of the bridge members.
- Phase 2 - Qualitative Evaluation - From the observations, identify the criticality of the conditions created by corrosion, misalignment, and deformation which will affect the performance of each member.
- Phase 3 - Quantitative Evaluation - Structural evaluation which includes computation of the loads which are applied to each member as well as the capacity of that member to carry the load.
- Phase 4 - Recommended rehabilitation of members whose capacities are below that required for the expected loads.

CHARACTER DEFINING FEATURES & HISTORIC INTEGRITY

Due to the Historic nature of the bridge, it is necessary to understand the characteristics that contribute to its uniqueness so that these features are preserved in any repair or rehabilitation considerations.

The original National Register nomination for the Jefferson Avenue Footbridge makes the case for the bridge's eligibility as a National Historic Place based upon its distinctive character's. These character-defining features include the design, function and the cantilever through-truss. Secondary features that contribute to the bridge's character include the railings.

In the National Register bulletin, "How to Apply the National Register Criteria or Evaluation," seven aspects of integrity are identified: location, design, setting, materials, workmanship, feeling, and association. The Jefferson Avenue Footbridge retains all of these aspects. The bridge is in its original location, and the three-span truss structure retains its original appearance from the time of its construction to include, maintaining integrity of design, materials, and workmanship. The setting of the bridge reinforces it's original construction in the early 1900's.

HISTORICAL BACKGROUND AND CONTEXT

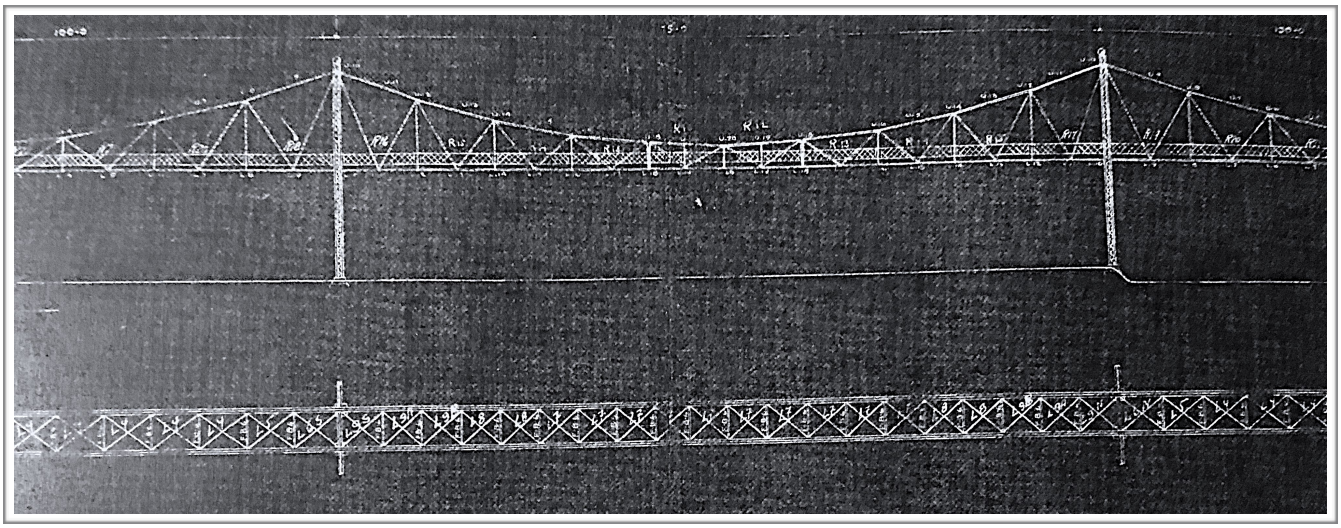
The following information is taken from the United States Department of Interior - National Register of Historic Places Registration Form prepared for the bridge in 2003.

"The Jefferson Street Footbridge exemplified both the tension and the cooperation that existed between Springfield City government and the St. Louis and San Francisco Railroad ("the Frisco Line").

"The Frisco was the City's largest and best-paying employer. The bridge was built in 1902 at public expense only after the Frisco threatening to pull its division headquarters out of Springfield. A pedestrian bridge was needed to solve a long-standing problem: residents from north of the yard walking across sixteen busy tracks to get to

Commercial Street, the principal business street of North Springfield. The consequent $40,000 bond issued was also to finance two vehicular underpasses beneath the tracks. The bridge itself cost only $8,500."

"Maintenance of all bridges is an ongoing project and expense. In the case of the Jefferson Street Footbridge, the maintenance problem was made more acute by its over-the-track location, its light construction, and the uncertainty about who was ultimately responsible for maintaining the bridge. The bridge was prone to corrosion due to the constant effusion of corrosive gases from coal-fired locomotives passing underneath and from its own light structure. The cooperative aspect of the relationship between city and railroad is illustrated finally by their joint efforts to maintain it. The Frisco was wary of workers other than their own coming on railroad property. So the Railroad seems ordinarily to have supplied the labor, with the City paying out-of-pocket costs."



"The Jefferson Street Foot Bridge, Springfield, Greene County, Missouri, is a three-span steel cantilever through truss footbridge, and the first of its kind known to be built in Missouri. The bridge, originally spanning sixteen railroad tracks of the St. Louis and San Francisco Railroad, is oriented in a north-south line, beginning north of the head of Jefferson Avenue (named Jefferson Street at the time of construction), where it intersects Commercial Street, and continues north over the railroad tracks to Chase Street and the adjacent residential area. The bridge is approximately 562 feet in length, including an 80 foot long south approach (but excluding entry stairs). The bridge's two towers rise about 50 ft. above grade. The steel substructure is 25 ft. above grade, is supported on concrete piers, and has a six-foot wide wooden walking deck. The footbridge is constructed with through truss with Warren webbing. The American Bridge Company of Pennsylvania constructed the bridge in 1902. The Construction Engineer was J.W. Hoover of Kansas City, Missouri. While the bridge has sustained some changes, such as the removal of the bicycle ramps restoration in recent years, it maintains it's integrity of material, association, setting, and function."

"The overall look and decorative features of the footbridge give it the appearance of a suspension bridge. There are two tall piers connected by trusses whose upper cords were built in catenary curves. However, the bridge is

made of rigid materials and is structurally a cantilever bridge. The principal bridge spans rests on four sets of railroad tracks. The piers are narrow, designed to fit between adjoining sets of railroad tracks in order to accommodate trains passing between them. The 80 foot-long approach ramp between the south entry stair and bridge rests on the first bridge pier and on a series of smaller footers along the approach's length. The north entry stair and the short north approach are supported on a series of verticals and diagonals also resting on square concrete footers. The stairs on either end of the bridge, which years ago replaced the bicycle ramps, are constructed of steel C-channels filled with concrete."

"The bridge was built using a through truss system with Warren webbing. The diagonals in Warren webbing act as both tension and compression. This web of diagonals allow for a very rigid and stable truss since Warren webbed trusses can be cantilevered into space with support only at one end."

"The bridge truss is built entirely of angle-irons. The angle-iron members were riveted together in pairs for stability along the member length. Gusset plates connect the structural members at each node. The two intermediate bent towers are made of steel S-members, angle irons, and steel straps. Standard railroad ties were used for the transverse deck beams and, together with the angle iron cross-bracing along the top and bottom of the truss, provide lateral stability to the truss. Four gold painted decorative balls cap the towers."

"The bridge has been altered over the years by essential maintenance and repairs. Corrosion has been a severe problem. Coal smoke and steam from thousands of locomotives passing just underneath caused dangerous deterioration of the bridge's lightweight structure. Some structural elements were consequently replaced over time. However, the character of the bridge remains unchanged. The most notable visual alteration is to the bridge by the stairs at either end. Intended originally for bicycle as well as foot traffic, stairs for pedestrians and ramps for bicycles were provided. In 1954 the ramps were removed, and the stair at the south end was reconfigured."

"In 1998 a major renovation was undertaken. Some angle irons were replaced. Steel angle irons were added to several members to increase the bridge's load capacity to modern code standards, while at the same time maintaining the aesthetics of the bridge. Several new gusset plates were installed. Some rivets were replaced with carriage bolts. Three of the four piers had their concrete footers replaced. The timber joists and deck were also replaced. The bridge was repainted with a white corrosion-resistant paint. The renovation also included new lighting. Lights are located both on the bridge itself and on the ground on either side of the bridge."

"The bridge is an impressive multiple-arched, cantilevered bridge built to span the St. Louis and San Francisco Railroad track and yard. At the time of construction in 1902, it was the first cantilevered bridge built in the state. In Missouri, the Jefferson Street Footbridge is the oldest cantilever bridge, the only known cantilever footbridge and is also most narrow bridge of its type in the state. Furthermore, it is the only known cantilevered bridge in Missouri that was not built at a major river crossing. The bridge is uniquely designed to span multiple, close setting railroad tracks and was built using only stock structural members."

TRUSS BRIDGE NOMENCLATURE

Throughout this report, elements of the structure are referred to using the technical definitions provided by Federal Highway Administration (FHWA) Bridge Inspector's Reference Manual. Figure 2 indicates the general nomenclature used for common truss elements. Figure 3 depicts the general nomenclature used for a typical gusset plate connection.

This bridge is considered a fracture critical bridge as defined by the National Bridge Inspection Standards (23 CFR 650 Subpart C). A fracture critical bridge is one that contains one or more fracture critical members. A fracture critical member is a steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse.

FIGURE 2 - TYPICAL TRUSS NOMENCLATURE

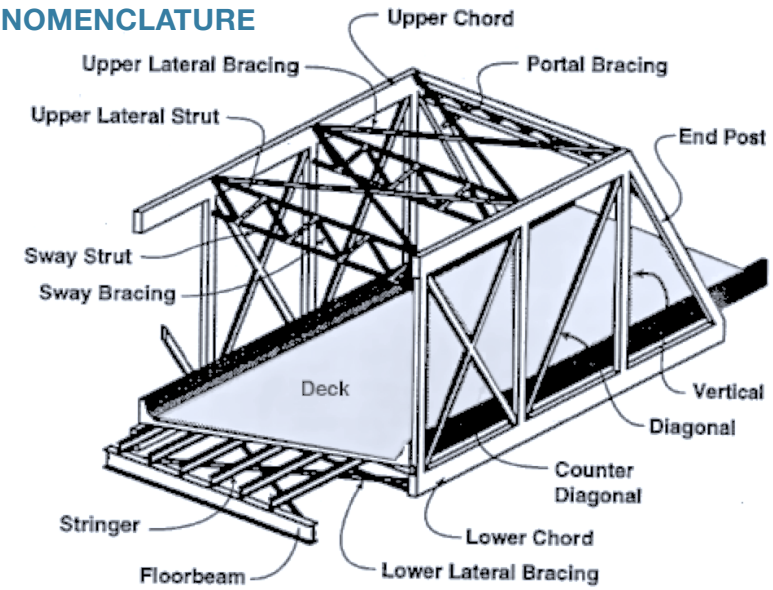
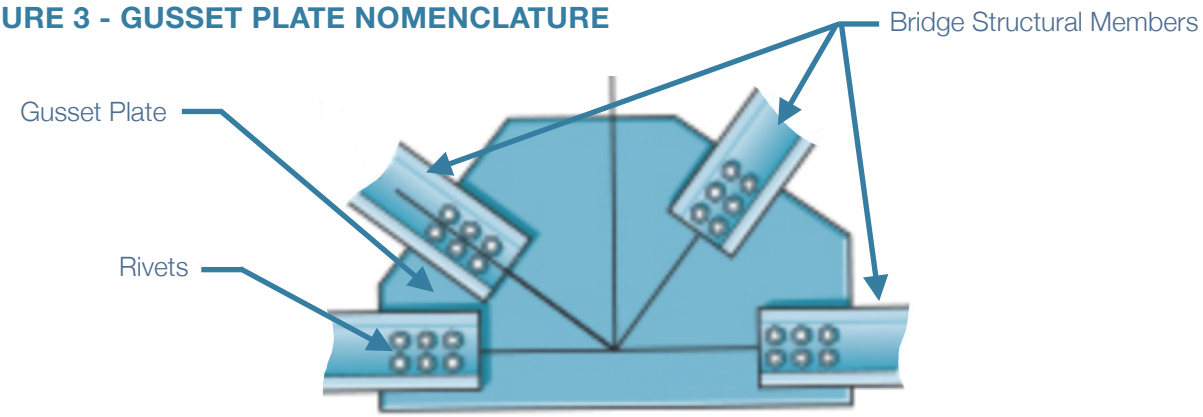
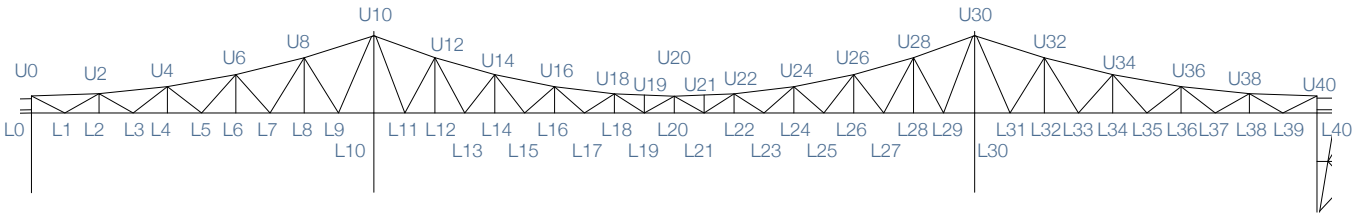


FIGURE 3 - GUSSET PLATE NOMENCLATURE



In addition to the standard truss nomenclature, specific element locations are referred to by truss panel points. Figure 4 indicates the panel point designations used throughout this report.

FIGURE 4 - TRUSS PANEL POINT DESIGNATION



FIELD INSPECTION

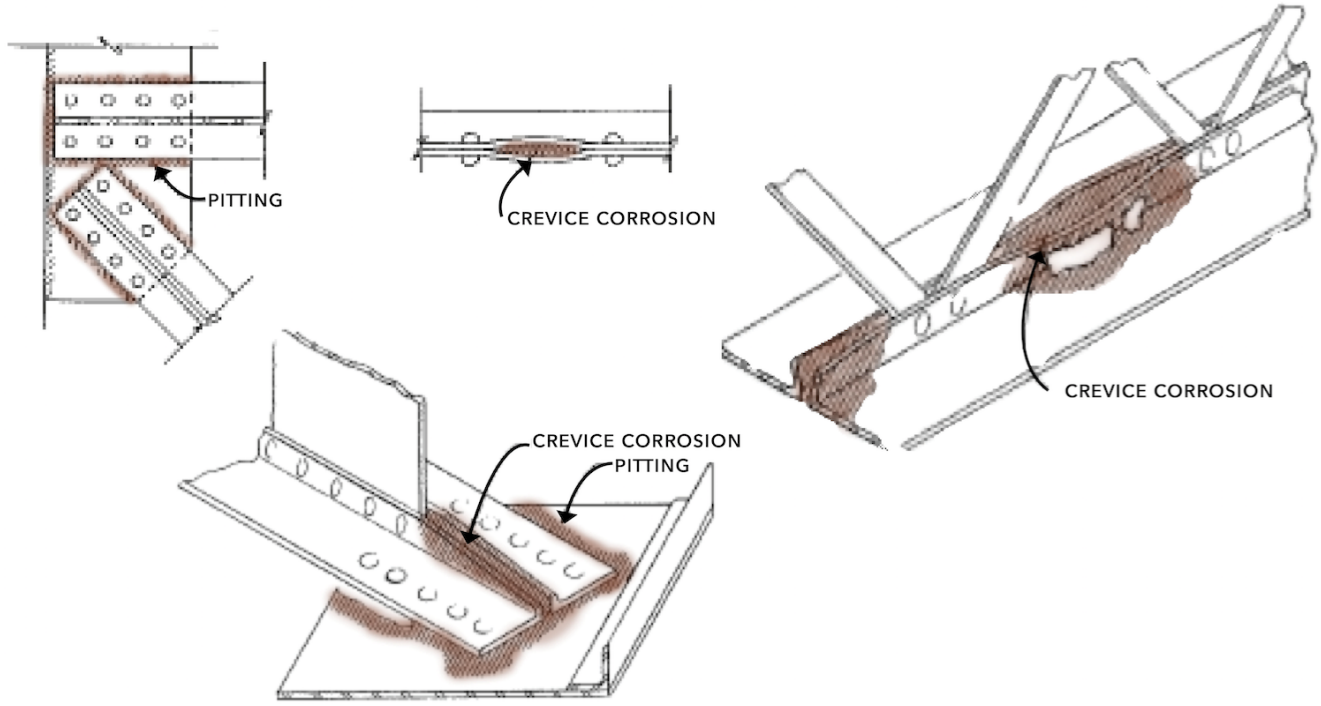
The purpose of the in-depth field inspection is to measure the dimensions, corrosion of the steel, alignment, and deformation of the bridge members. The critical issue is to determine how much deterioration of the steel has occurred in order to evaluate the load-carrying capacity of the bridge.

Corrosion of Steel

The type and grade of steel used has a major effect on the rate of corrosion. The grade of steel most common during the period the bridge was constructed was A7 steel. The corrosion resistance of A7 steel is most comparable to current A36 steel. Observing and collecting information on the condition of the steel is critical for the structural evaluation of the bridge. This information is key to computing the rate of deterioration, unintended restraint of parts, and remaining capacity of the members to carry loads.

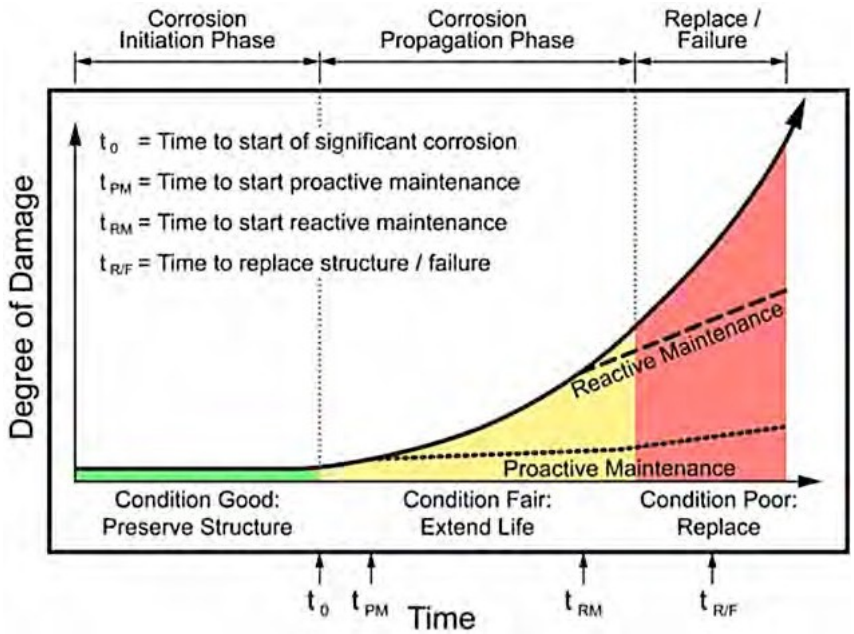
The most common effect of corrosion on steel bridges is the loss of steel (or reducing the the area of steel). This loss of steel can be uniform or localized on the steel member. With the loss of steel, the load carrying capacity of the member is reduced and the load distribution characteristics of the bridge may also be affected, resulting in increased loads to members adjacent to the deteriorated member.

The other important component regarding corrosion is understanding the type of bridge details used on a structure. These details serve an important role in the corrosion rate. Details that collect water or provide ideal nesting spots for birds are areas which are carefully checked for corrosion (Figure 5).



The extent of corrosion increases with time. Figure 6 shows the degradation of a typical bridge. This graphic demonstrates that not only does the degree of damage increase with time, but that the rate at which damage occurs also accelerates with time. For example, 2% damage occurring this year, may result in 3 or 4% more next year to bring the total to 5 or 6%.

FIGURE 6 - CORROSION IMPACTS OVER TIME



During the inspection, the primary forms of corrosion observed are as follows:

- Surface Rust (uniform corrosion) - Known as general corrosion, is a thinning of the steel in an overall general area.
- Pack Rust (crevice corrosion) - Occurs within gaps between mating surfaces such as along edge openings of built-up members, back-to-back angles, lacing bars, and adjoining components.
- Pitting - Localized corrosion attack which causes the formation of penetrations into the steel surface. It occurs where there are chemical or physical changes in the steel such as imperfections in the metallurgy of the steel.
- Section Loss - For the purposes of this report, Section Loss was identified in the field by visual and "hands-on" inspection of the members. Detailed measurements of the general condition and worst case conditions were collected. These measurements were taken by caliper readings and taped dimensions. This information was used to determine the effects of corrosion on the thickness of the steel for each member. AASHTO provisions provide some allowance for corrosion loss, but in no case should a thickness of 3/16 inch be allowed.

BRIDGE MEMBER STRUCTURAL PROPERTIES

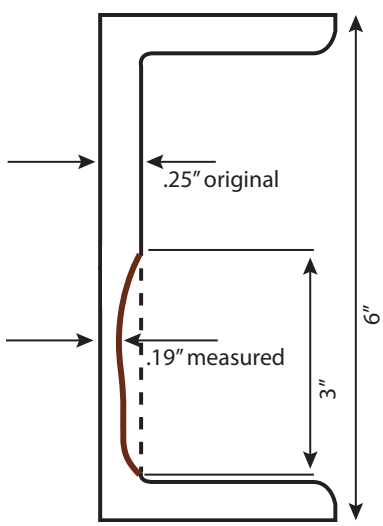
In order to perform the structural evaluation, it is important to understand the original section and the affects corrosion has on the section properties. One of the challenges is to interpret the existing available construction documents. Digital scans rendered from microfiche images of the original hand-drafted contract plans proved to be difficult to read in some instances, particularly with regard to reading fractional dimensions. These original plan dimensions were compared to the field measurements to verify the accuracy of information used for the structural evaluation.

The structural properties of the historic member section (i.e., strong and weak axis moments of inertia, section modulus, compressive areas, etc) was achieved by a combination of researching historical member property tables and analysis. This information was then combined with the results from the section loss computations from the field measurement to determine the current member properties.

For each member which exhibited measurable loss of steel, Figure 7 shows the methodology that was used to compute the section loss of a sample member. Due to the age of the bridge, it was assumed that all members had a minimum 10% section loss. When measurable loss was collected, that information was used as the section loss for that member. A summary of section losses by percent of all bridge members is at Table 1.

Examples of typical findings of various members are included in Appendix A.

FIGURE 7 - METHODOLOGY FOR SECTION LOSS COMPUTATION



% loss = 3/6 x .06/.25 x 100 = 12%

Enter 12% under depth. (Area loss)

TABLE 1 - CROSS SECTION LOSS OF TRUSS MEMBERS

Section Loss	Number of Members
50%	1
40-49%	6
30-39%	16
20-29%	44
10-19%	66
10%	117

EVALUATION OF LOAD CAPACITY

In an effort to determine the structural performance of the Jefferson Avenue Footbridge, the structure was analyzed in accordance with today's design standards (which is the industry standard approach). This approach takes advantage of the present methodology in bridge design and is the customary standard of practice to which new bridges are designed. The computational data presented in this report was prepared by analyzing the bridge in accordance with the American Association State Highway Transportation Officials (AASHTO) "Load Resistance Factor Design (LRFD) Guide Specifications for the Design of Pedestrian Bridges" 2009 and "Load Resistance Factor Design (LRFD) Bridge Design Specifications" 2014 as well as the American Institute of Steel Construction "Specification for Structural Steel Buildings" 2010 (ANSI/AISC 360-10). The bridge design required a pedestrian design live load of 90 pounds per square foot. To clarify what this load scenario looks like, Figure 8 is provided.

FIGURE 8 - LIVE LOAD OF 100 PSF

* Image from "NCHRP 20-07 TASK 244"

The LRFD approach uses loading in combination with other load effects, each of which are factored (either up or down) according to the likelihood of simultaneous occurrence and their relative variability. For the purpose of this evaluation, the analysis was conducted using the Strength 1 limit state (1.25 x Dead Load + 1.75 x Live Load).

Similarly, the theoretical ability of members to resist the design load effects is factored (always reduced) to account for unavoidable variations in materials, design equations, fabrication, and erection. The degree of the reduction factor is dependent upon statistical probability based upon data collected, related to these components.

METHODOLOGY

The following approach was used for both the truss member analysis and the north and south approach structures.

From the computations of the properties of each member, a three-dimensional model of the bridge spans and approaches was constructed utilizing the STAAD Pro V8i program. Within the STAAD Pro program, general members were defined by assigning their computed properties. The bridge elements were then assigned dead and live loading in accordance with the AASHTO Specifications. Factored load combinations were developed to determine the response of the bridge members to the various possible combinations of design pedestrian loads for the Strength 1 limit state.

Each member was then reviewed to identify the load case scenarios which provide the maximum load to each member. The maximum load effects were then compared to the computed member load carrying capacity.

Once the maximum load and factored capacity (resistance) for each member was determined, a comparison was made to assess if there is sufficient capacity in the member to resist the applied load. To assist in the evaluation, a Rating Factor against code minimums was calculated by applying the maximum load to the ratio of member capacity for each failure mode considered. A Rating Factor less than 1.0 would indicate the member capacity is less than the maximum load applied to the member.

In addition to the primary member analysis of the truss, the gusset plate connections were evaluated. To assist in the evaluation, a spreadsheet developed by the Michigan Department of Transportation "Gusset Plate LRFR Analysis V2.2" was used. This spreadsheet is based upon Federal Highway Administration Guidance Documents and AASHTO LRFD Bridge Design Specifications. The spreadsheet performs several checks including resistance of fasteners, gross section yielding, net section fracture, and block shear rupture. A Rating Factor based upon the AASHTO Strength 1 load combination is determined for each check. This Rating Factor compares the capacity of the connection to resist loads to the loads applied. Rating Factors of 1.0 or greater are considered satisfactory.

The geometry input for the spreadsheet is extensive. To achieve the best accuracy, the gusset plate connections were recreated in AutoCAD based upon field measurements and the original construction plans. From these recreated details, precise dimensions were determined directly. The gusset plates for the bridge consisted of two thicknesses: most were ½ inch while a few were ⅜ inch. For the evaluation, the measured section loss was reduced from the plate thickness and then used for the computations to verify the existing condition.

The spreadsheet factors loads internally, and the maximum member loads from the STAAD Pro model and also includes factored loads, therefore the dead load and live load factors within the spreadsheet were set to 1. With the governing load combinations and respective member forces determined, each connection was then evaluated in the spreadsheet. Effectively, this checked each connection for each maximum member load condition. The lowest reported Rating Factor reported governs for a given connection.

Connections with Rating Factors below 1.0 may be strengthened on an individual basis.

SUMMARY OF RESULTS

Analysis of Existing Condition

The results of the analysis performed indicate that 36.4% of the primary members would not have adequate capacity under pedestrian design loading for Strength 1 load combinations. Therefore, these members would require rehabilitation.

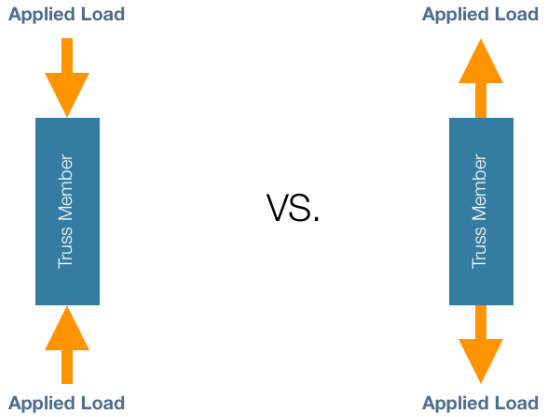
For the cantilever through-truss, based upon the loading scenario, members undergo both compression and tension. Therefore, all members were checked to for capacity to resist compression and tension based on the maximum compression and tension loads applied to that member. Rating Factors were then calculated for all members for the truss. Table 2 provides a breakdown of these Rating Factors. As shown, 91 truss members have an unsatisfactory capacity to resist applied loads.

TABLE 2 - RATING FACTOR OF TRUSS MEMBERS

Rating Factor	Number of Members
Greater than 1.0	159
0.90-0.99	35
0.76-0.89	36
0.41-0.74	20

Of the 250 primary truss members, 150 are controlled by the maximum load applied in compression while 100 are controlled by tension. Figure 9 shows the relationship of the truss members with applied loads in compression verses tension.

FIGURE 9 - COMPRESSION VERSES TENSION MEMBERS



MEMBER IN COMPRESSION MEMBER IN TENSION

As stated earlier in this report, the tension members for this type of bridge are considered fracture critical. Therefore, it is important to understand which members are controlled by the maximum tension load applied to them. Figure 10 shows which members are controlled in tension.

FIGURE 10 - FRACTURE CRITICAL MEMBERS

Results from Structural Evaluation of Existing Condition

Based upon the information derived from the Existing Condition Model, the truss in its current condition will not meet the code required pedestrian design loads.

Vertical Clearance over the Railroad

Another consideration for the bridge is the vertical clearance of the bottom of the truss to the top of the railroad track. The existing vertical clearance is 22 feet. It is important to verify that the deflection of the bridge under a live load scenario will not significantly reduce the vertical clearance to the railroad. For the maximum deflection to occur, the center span would be fully load with no live load on the approach spans. The maximum computed deflection would be 3¼ inches.

Current design standards for the Burlington Northern Railroad requires new overhead bridges to be designed to a vertical clearance of 23.5 feet.

PROPOSED REHABILITATION

TRUSS MEMBERS

The truss was evaluated on both the east and west sides. Each truss was modeled with 125 members. For the east truss, 51 members were identified as being structurally deficient. For the west truss, 40 members were identified as being structurally deficient. These members were analyzed to determine the proper replacement size necessary to carry the maximum load computed for each. The total weight of the members to be replaced is approximately 26,000 pounds of steel. With the replacement of these members, the trusses will be able to carry the required pedestrian loading.

GUSSET PLATES

As indicated in the inspection portion of this report, the primary gusset plate defects are section loss due to corrosion and pack rust that has built up between the plates and the main truss members. Addressing the reduced structural capacity, due to section loss of the gussets and addressing the pack rust at the gussets, is recommended.

While a number of the gusset plates currently have adequate structural capacity, further corrosion would reduce their strength. If the pack rust is allowed to continue, additional gussets and truss members would require replacement in the future. Additionally, the portions of gussets and truss members not visible could be suffering advanced corrosion and section loss in excess of what could be detected by the visual inspection. Therefore, an allowance has been made to include repairs and strengthening of the gusset plates.

UPPER LATERAL BRACING

A few upper lateral bracings are in need of repair. In most cases these are located at the connection with the top chord.

LOWER LATERAL BRACING

The lower lateral bracing is in good condition. Minimal spot repairs are required. The primary issue observed is at the connection of the plates to the lower chord.

BEARINGS

The end bearings of the truss should be reconditioned during the scope of work for the bridge. The anchor bolts fixing the bearing to the substructure are bearing on the back of the bearing plates. This restricts the necessary movement of the bridge to accommodate changes in geometry which results from live load and temperature variations.

RAILING

The material aspects of the railing appear to be functioning adequately. To ensure they maintain their integrity, it is recommended that they be included in the scope of work for painting the structure. Minor repairs will be necessary.

FLOOR BEAMS

The floor beams for the bridge were noted to be in good condition. The only floor beams noted with deficiencies were those located at the towers. These floor beams consist of C-channels.

TIMBER FLOOR STRINGERS

The Timber Floor Stringers are functioning properly. The inspection noted that a few of the stringers were cracked, split, and/or mildly bowed. No mold or decay was noted during the inspection.

TIMBER DECK

The timber deck is in reasonable condition based on its age. It is only necessary to replace a select few boards instead of the entire deck.

NORTH APPROACH

No significant deficiencies were noted for the North Approach. The primary issue with this portion of the bridge is the stairs and stair stringers which are discussed below.

SOUTH APPROACH

The South Approach consists of 4 spans and the stairway. The South Approach had several issues with the vertical support columns of the 10 primary vertical support columns on the South Approach, 6 did not have adequate capacity for the pedestrian load. The beams supporting the deck between the substructures did not have adequate capacity and are in need of being replaced.

STAIRS (NORTH & SOUTH)

Significant issues exist at both sets of stairs. The stairs need to be reconstructed and the details for this construction need to address the issues of accelerated deterioration of the connection of the stair treads to the stair stringers.

FOUNDATIONS

No notable deficiencies where noted in the inspection of the foundations. The repairs which were completed in 2003 appear to be functioning adequately.

SURFACE COATINGS AND TREATMENTS

In order to reduce future section loss and to provide an acceptable design life, it is recommended that a multiple coat, zinc-rich paint system be applied to all steel members of the rehabilitated bridge. Members to be painted include all truss members, gusset plates, floor beams, bearings, railing, approaches, and stairs. The timber stringers and timber deck are not recommended to be painted.

The color of the paint system should match the color of the original paint system.

During the inspection process it was determined that the bridge has three previous layers of paint. The top layer was applied in the 2002 rehabilitation of the bridge and does not contain any lead. The other 2 layers of paint tested positive for lead in the paint.

In order to provide a long term protection of the bridge, it is recommended to sandblast the existing steel to bare metal and apply a primer and two coats of paint. The primer coating will provide good adhesion to the steel, and is the foundation for the top coat. The use of an inorganic zinc-rich primer containing metallic zinc can provide galvanic protection to the underlying steel. Following the primer, intermediate and top coats are applied to complete the system. This approach can provide a 30-year service life.

Accomplishing this level of protective coating would require removal of all paint from the existing structure. Due to the presence of the lead based paint, the bridge must be covered to contain and collect the paint and sandblasting debris, containerized, labeled, and disposed of at an approved hazardous waste facility.

OPINION OF PROBABLE CONSTRUCTION COST

The cost for the Rehabilitation of the Bridge was computed by matching the existing configuration with the addition of adding ADA ramps to each approach. These ADA ramps were included with each option. As requested, also included is a cost for minimal repairs and providing an overcoat paint to the existing bridge. These Options are as noted in Table 3. Appendix B provides construction cost details.

TABLE 3 - OPINION OF PROBABLE CONSTRUCTION COST

Options	Project Cost
Do Nothing	$414,154.00
Minimal Rehabilitation	$2,299,544.32
Preserve Original Bridge	$2,784,312.10
Replacement Bridge	$2,997,297.61

*Cost for ADA Ramps is approximately $650,000

COMPLIANCE WITH SECTION 106

To avoid adverse effects under Section 106 of the National Historic Preservation Act of 1966, the project must meet the Secretary of the Interior's Standards for the Treatment of Historic Properties. In this case, application of the Standards for Rehabilitation and, for some components, preservation is the most appropriate. The design and implementation of the project will require collaboration with City engineers and State Historic Preservation Office in developing the rehabilitation plan of action. The proposed rehabilitation will require a balance of fiscal responsibility, and preserving the bridge's historic features and character while making it serviceable for many decades to come. The goal for the project should be to achieve a Section 106 finding of No Adverse Effect.

APPENDIX A

INSPECTION PHOTOS

U32L33 Eastside Diagonal

U38L39 Westside Diagonal

U32L33 Eastside Diagonal

U38L39 Westside Diagonal

North End Bent Column

U04L05 Westside Diagonal

APPENDIX B

OPINION OF PROBABLE CONSTRUCTION COST

City of Springfield
Jefferson Avenue Footbridge
Do Nothing

September 2016

OPINION OF PROBABLE CONSTRUCTION COSTS	UNITS	QUANTITY	UNIT PRICE	AMOUNT
Demolition of Existing Bridge	Sq. Feet	3,372	$ 35.00	$ 118,020.00
Sitework	Lump Sum	1	$ 70,000.00	$ 70,000.00
Railroad Cost for Flagger	Lump Sum	1	$ 100,000.00	$ 100,000.00
Mobilization (7%)	Lump Sum	1	$ 20,134.00	$ 20,134.00
Contingency (25%)	Lump Sum	1	$ 52,000.00	$ 52,000.00
Engineering Services (15%)	Lump Sum	1	$ 54,000.00	$ 54,000.00
			TOTAL	**$ 414,154.00**

City of Springfield
Jefferson Avenue Footbridge
Minimal Rehabilitation

September 2016

OPINION OF PROBABLE CONSTRUCTION COSTS	UNITS	QUANTITY	UNIT PRICE	AMOUNT
Deck Removal and Replacement	Sq. Feet	3,372	$ 15.00	$ 50,580.00
Truss Structural Steel Repairs/Replacement	Lbs.	18,000	$ 20.00	$ 360,000.00
Bearing Repairs	Each	4	$ 7,000.00	$ 28,000.00
Approach Repairs and Replacement	Lbs.	5,000	$ 14.00	$ 70,000.00
Stairs (North & South)	Lump Sum	1	$ 60,000.00	$ 60,000.00
ADA Approach Ramps	Sq. Feet	5,142	$ 92.00	$ 473,064.00
Repaint Bridge and Approach	Sq. Feet	14,750	$ 27.00	$ 398,250.00
Sitework	Lump Sum	1	$ 75,000.00	$ 75,000.00
Railroad Cost for Flagger	Lump Sum	1	$ 175,000.00	$ 175,000.00
Mobilization (7%)	Lump Sum	1	$ 118,292.58	$ 118,292.58
Contingency (15%)	Lump Sum	1	$ 244,977.99	$ 244,977.99
Engineering Services (12%)	Lump Sum	1	$ 246,379.75	$ 246,379.75
			TOTAL	**$ 2,299,544.32**

City of Springfield
Jefferson Avenue Footbridge
Preserve Original Bridge

September 2016

OPINION OF PROBABLE CONSTRUCTION COSTS	UNITS	QUANTITY	UNIT PRICE	AMOUNT
Deck Removal and Replacement	Sq. Feet	3,372	$ 15.00	$ 50,580.00
Truss Structural Steel Repairs/Replacement	Lbs.	26,000	$ 20.00	$ 520,000.00
Bearing Repairs	Each	4	$ 7,000.00	$ 28,000.00
Approach Repairs and Replacement	Lbs.	5,000	$ 14.00	$ 70,000.00
Stairs (North & South)	Lump Sum	1	$ 60,000.00	$ 60,000.00
ADA Approach Ramps	Sq. Feet	5,142	$ 92.00	$ 473,064.00
Repaint Bridge and Approach	Sq. Feet	14,750	$ 40.00	$ 590,000.00
Sitework	Lump Sum	1	$ 75,000.00	$ 75,000.00
Railroad Cost for Flagger	Lump Sum	1	$ 175,000.00	$ 175,000.00
Mobilization (7%)	Lump Sum	1	$ 142,915.08	$ 142,915.08
Contingency (15%)	Lump Sum	1	$ 301,433.86	$ 301,433.86
Engineering Services (12%)	Lump Sum	1	$ 298,319.15	$ 298,319.15
			TOTAL	**$ 2,784,312.10**

1

City of Springfield
Jefferson Avenue Footbridge
Replacement Bridge

September 2016

OPINION OF PROBABLE CONSTRUCTION COSTS	UNITS	QUANTITY	UNIT PRICE	AMOUNT
Demolition of Existing Bridge	Sq. Feet	3,372	$ 35.00	$ 118,020.00
New Bridge	Sq. Feet	3,000	$ 350.00	$ 1,050,000.00
Approachs	Sq. Feet	1,600	$ 80.00	$ 128,000.00
ADA Approach Ramps (North & South)	Sq. Feet	5,442	$ 80.00	$ 435,360.00
Sitework	Lump Sum	1	$ 75,000.00	$ 75,000.00
Railroad Cost for Flagger	Lump Sum	1	$ 175,000.00	$ 175,000.00
Mobilization (7%)	Lump Sum	1	$ 138,696.60	$ 138,696.60
Contingency (25%)	Lump Sum	1	$ 486,269.15	$ 486,269.15
Engineering Services (15%)	Lump Sum	1	$ 390,951.86	$ 390,951.86
			TOTAL	**$ 2,997,297.61**

SUPPLEMENTAL NO. 1

BRIDGE LIFE CYCLE COST ANALYSIS

BRIDGE LIFE CYCLE COST ANALYSIS

INTRODUCTION

The City of Springfield, as with most local governments, deals with increasing infrastructure needs with limited funding opportunities. Officials are under increasing obligation to demonstrate their stewardship of taxpayer investments in the construction and maintenance of public infrastructure, including bridges. Many agencies are investigating economic tools such as bridge life-cycle cost analysis (BLCCA) to help determine the most cost-effective options and communicate the value of those choices to the public.

The goal for the evaluation of this project is to use BLCCA to determine the design option that will accomplish the project's objectives at the lowest overall cost. By factoring in all costs over a project's total multiyear life cycle and not just the initial construction investment. BLCCA helps to ensure that an agency can optimize their investment and avoid selecting an option based solely on the lowest initial cost.

BLCCA METHODOLOGY

Life-cycle cost analysis can support bridge design and management decisions by evaluating the economic effectiveness of proposed construction or rehabilitation projects, while considering all costs incurred related to the bridge during its multiyear life cycle. All agency costs involved in each option over the planning period are factored into the analysis, potentially including costs for the following:

- Contingency and administration
- Inspection and routine maintenance
- Painting and repair
- Rehabilitation of Bridge
- New construction of Bridge

When evaluating the cost of a project, it is necessary to take into account the time value of money by converting the costs and benefits that take place in different years into an equivalent worth of a common year. Converting future costs that occur in different years into a value for a common year (Present Worth) is known as discounting. Another way to state this is that using the discounting approach represents the opportunity cost of money. This is a typical approach in analyzing most transportation projects.

This method to determine equivalent worth is useful in analyzing life-cycle cost options for the Jefferson Avenue Foot Bridge and has been applied to calculate such costs for each improvement option. In this economic analysis, all costs are discounted to the Present Worth of the year of analysis (current year, 2016).

Successfully applying life-cycle cost analysis to bridge management depends to a large extent on the availability and quality of relevant data such as types, costs, and frequencies of bridge maintenance and related activities. The lack of historical information requires several assumptions. These assumptions are clearly indicated and kept consistent between the Base Case and the options being considered. The objective in evaluating different scenarios (options) is to determine how different actions could impact the life of the structure and cost. Evaluating the timing of these actions and the timing of when these costs could occur help reveal the most advantageous scenario.

CASES CONSIDERED FOR EVALUATION

The following assumptions used for the evaluation are held constant and used in all cases for both a rehabilitated and new bridge:

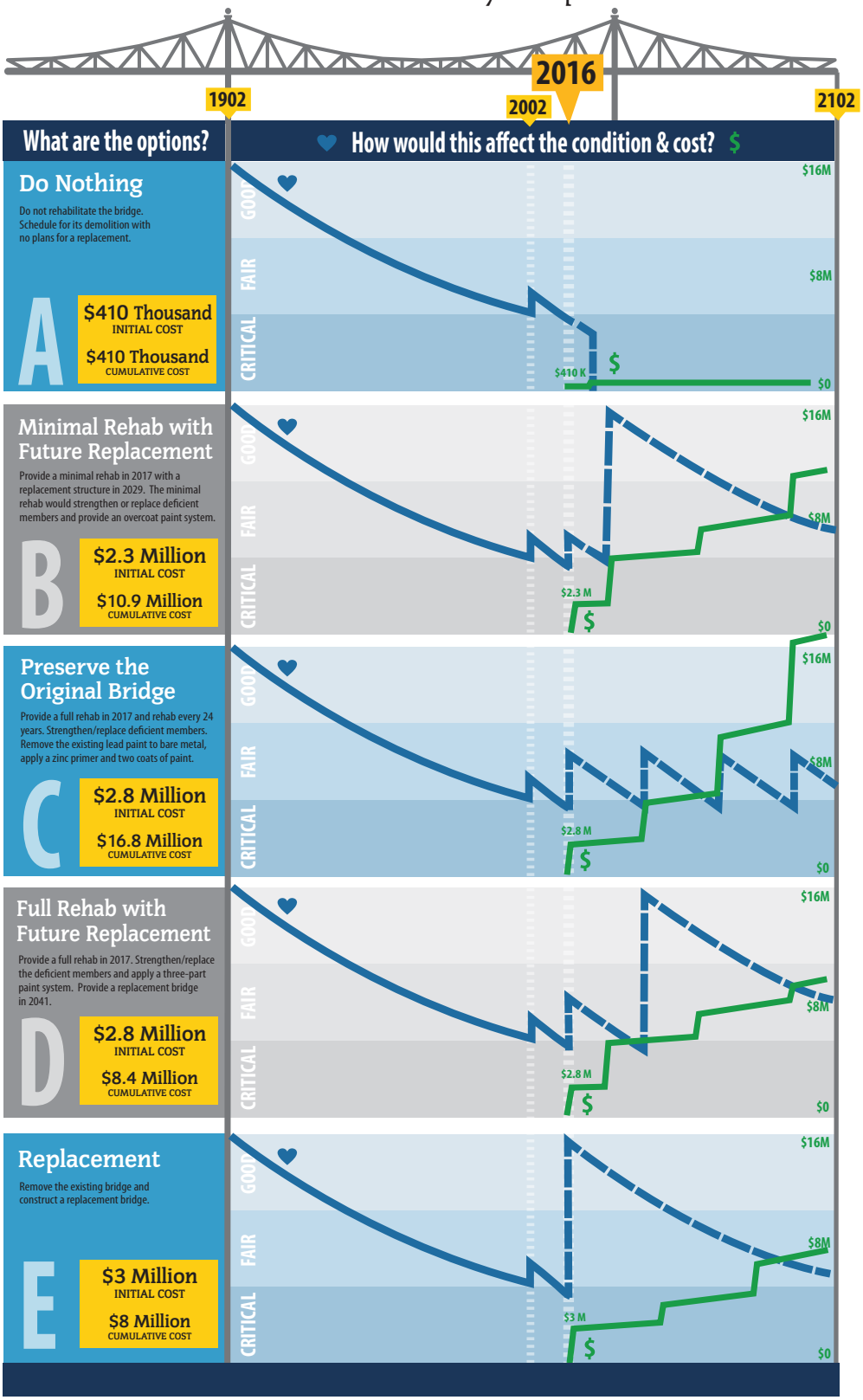
- The Analysis Time Frame - 85 Years
- The Base Year - 2016
- The Discount Rate - 4 %
- Maintenance cost of the Rehabilitated Bridge is twice that of a Replacement Bridge.
- Bridge Inspection will be conducted for all bridge options at an interval of every 5 years.
- A bridge constructed with steel has a service life of 30 years before needing some minor repairs and repainting.
- A Preservation of the Original Bridge requires repairs and/or rehabilitation every 24 years. The cost of this work is estimated to be 75% of the initial rehabilitation cost developed for this project due to the removal of the lead based paint and coating system applied to the bridge.
- A Replacement Bridge would be the equivalent length of the existing bridge but would be constructed with ADA compliant approaches.
- At the end of the Analysis Time Frame the bridge would not need a residual remaining value at the end of the analysis period, therefore a Residual Value for the bridge is given as a pro-rated portion of the cost of the bridge to its remaining service life

LIFE CYCLE COST ANALYSIS RESULTS

Options	2016 Construction Cost	Total Life Cycle Cost (Present Value)	Cumulative Cost
A - Do Nothing	**$414,154.00**	**$414,154**	**$414,154**
B - Minimal Rehab with Future Replacement	**$2,299,544.32**	**$4,566,483**	**$10,900,000**
C - Preserve Original Bridge	**$2,784,312.10**	**$4,260,430**	**$16,800,000**
D - Full Rehab with Future Replacement	**$2,784,312.10**	**$4,254,853**	**$8,400,000**
E - Replacement Bridge	**$2,997,297.61**	**$3,563,945**	**$8,000,000**

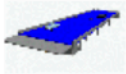
JEFFERSON AVENUE FOOTBRIDGE

Rehabilitation & Life-cycle Options



Analysis: Summary of Life-Cycle Costs

10/25/2016



	Name	Option B	Option E	Option C	Option D	Option A
	Total Life-Cycle Cost	**$ 4,566,483**	**$ 3,563,945**	**$ 4,260,430**	**$ 4,254,853**	**$ 354,021**
By Cost Bearer:	Agency Costs	$ 4,566,483	$ 3,563,945	$ 4,260,430	$ 4,254,853	$ 354,021
	User Costs	$ 0	$ 0	$ 0	$ 0	$ 0
	Third-Party Costs	$ 0	$ 0	$ 0	$ 0	$ 0
By Cost Timing:	Initial Construction Costs	$ 2,211,100	$ 2,882,017	$ 2,677,223	$ 2,677,223	$ 354,021
	OM&R Costs	$ 2,355,382	$ 681,929	$ 1,459,219	$ 1,577,629	$ 0
	Disposal Costs	$ 0	$ 0	$ 123,988	$ 0	$ 0
By Cost Component:	Elemental Costs	$ 0	$ 0	$ 0	$ 0	$ 354,021
	Non-elemental Costs	$ 4,566,483	$ 3,563,945	$ 4,260,430	$ 4,254,853	$ 0
	New-Technology Introduction	$ 0	$ 0	$ 0	$ 0	$ 0

Data: Individual Costs

10/25/2016

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Option B - Minimal Rehab with Future Replacement									
Agency									
Initial Construction									
Construction cost	<no event>	2	2	1.0000	1.000	LS	$ 2,299,544	$ 2,299,544	.
O, M, and R									
OM&R cost	<no event>	3	13	1.0000	1.000	LS	$ 5,000	$ 5,000	.
Disposal									
Residual Value	<no event>	85	85	1.0000	1.000	LS	$ 0	$ 0	
O, M, and R									
New Bridge	<no event>	14	14	1.0000	1.000	LS	$ 2,997,298	$ 2,997,298	
Bridge Inspection	<no event>	7	75	5.0000	1.000	LS	$ 60,000	$ 60,000	
OM&R New	<no event>	15	85	1.0000	1.000	LS	$ 3,000	$ 3,000	
Paint	<no event>	43	85	30.0000	1.000	LS	$ 880,000	$ 880,000	
Option E - Replacement									
Agency									
Initial Construction									
Construction cost	<no event>	2	2	1.0000	1.000	LS	$ 2,997,298	$ 2,997,298	.
O, M, and R									
OM&R cost	<no event>	2	85	1.0000	1.000	LS	$ 3,000	$ 3,000	.
Paint	<no event>	31	85	30.0000	1.000	LS	$ 880,000	$ 880,000	
Bridge Inspection	<no event>	7	85	5.0000	1.000	LS	$ 60,000	$ 60,000	
Disposal									
Residual Value	<no event>	85	85	1.0000	1.000	LS	$ 0	$ 0	
Option A- Do Nothing									
Agency									
Initial Construction									
Demolition	<no event>	5	5	1.0000	1.000	LS	$ 414,154	$ 414,154	

Data: Individual Costs

10/25/2016

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Alternative #3									
Agency									
Initial Construction									
Rehabilitation	<no event>	2	2	1.0000	1.000	LS	$ 2,784,312	$ 2,784,312	
Alternative #2									
Agency									
Initial Construction									
Initial Construction	<no event>	2	2	1.0000	1.000	LS	$ 2,784,312	$ 2,784,312	
Alternative #3									
Agency									
O, M, and R									
Bridge O&M	<no event>	3	25	1.0000	1.000	LS	$ 5,000	$ 5,000	
Bridge Inspection	<no event>	7	85	5.0000	1.000	LS	$ 60,000	$ 60,000	
New Bridge	<no event>	26	26	1.0000	1.000	LS	$ 2,997,298	$ 2,997,298	
New Bridge O&M	<no event>	27	85	1.0000	1.000	LS	$ 3,000	$ 3,000	
Paint	<no event>	56	85	30.0000	1.000	LS	$ 880,000	$ 880,000	
Alternative #2									
Agency									
O, M, and R									
Bridge O&M	<no event>	3	85	1.0000	1.000	LS	$ 5,000	$ 5,000	
Bridge Inspection	<no event>	7	85	5.0000	1.000	LS	$ 60,000	$ 60,000	
Future 1 Rehabilitation	<no event>	26	26	1.0000	1.000	LS	$ 2,088,234	$ 2,088,234	
Future 2 Rehabilitation	<no event>	50	50	1.0000	1.000	LS	$ 2,088,234	$ 2,088,234	
Alternative #3									
Agency									
Disposal									
Residual Value	<no event>	85	85	1.0000	1.000	LS	$ 0	$ 0	

Data: Individual Costs

10/25/2016

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Option C - Preserve the Original Bridge									
Agency									
Disposal									
Residual Value	<no event>	85	85	1.0000	1.000	LS	$ 0	$ 0	
Future 3 Rehabilitation	<no event>	73	73	1.0000	1.000	LS	$ 2,088,234	$ 2,088,234	