Route 66 Gasconade River Bridge | Structural Evaluation

Prepared for the Gasconade River Bridge Guardians

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Executive Summary

This report offers recommendations, a scope of work, and an associated opinion of cost for the structural rehabilitation of the Route 66 Gasconade River Bridge.

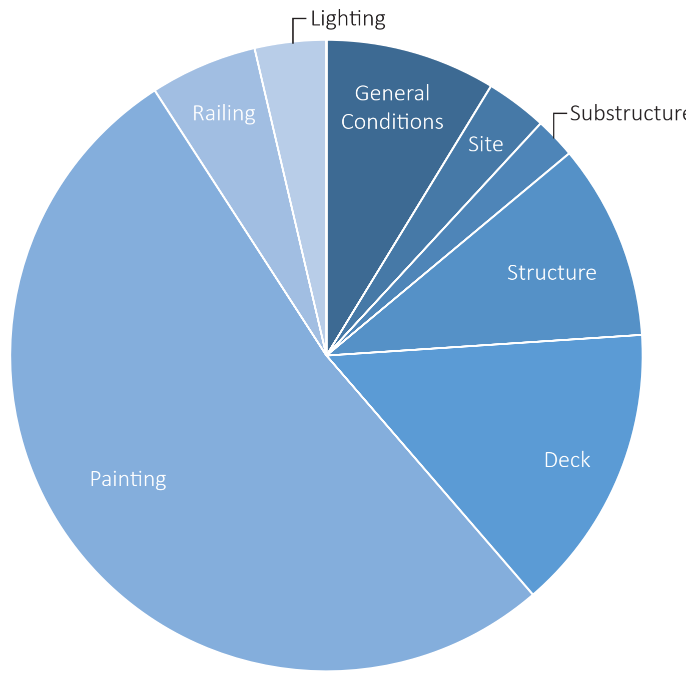
Our evaluation found that the primary deficiencies in the bridge are the deterioration of the concrete deck and the inadequate bridge railing. The steel superstructure and concrete substructures require some isolated repairs (e.g. horizontal bracing gusset plates) but otherwise are in good condition.

In general, our recommendations regarding the structural rehabilitation of the bridge are:

- Replace the concrete bridge deck.
- Repair/replace corroded steel components, primarily occurring below-deck.
- Clean and paint the bridge. As an alternative, paint only the bottom-chord and below-deck structure.
- Replace the bridge rail with one that meets current standards.
- Repair deteriorated concrete at the piers and abutments, primarily occurring on horizontal exposed surfaces of the pier caps.

Based on the scope of work identified in this study, we recommended the following probable rehabilitation costs and alternatives:

Construction Cost Budget Allocations



General Conditions	$	167,000
Site	$	60,000
Substructure	$	40,000
Structure	$	192,000
Deck	$	282,000
Painting	$	1,000,000
Railing	$	105,000
Lighting	$	70,000
Construction Cost	$	1,916,000
Fees & Contingency	$	640,000
Total Project Cost	$	2,556,000
Bid Alternate #1	$	(-300,000)

Scope and Limitations

Scope of the Structural Evaluation

This evaluation was focused on identifying structural repair needs and conceptual costs for rehabilitation of the Route 66 Gasconade River Bridge. We included review of available inspection reports[1], investigation and analysis of the structural condition, and limited testing.

Limitations

Conditions may exist or develop over time that were not identified during the evaluation. The recommendations and scope of rehabilitation outlined herein are necessarily general. They do not represent a final design or specification.

We visually inspected the truss bottom chord and riveted connections at selected locations.

1 *Missouri Department of Transportation State Bridge Inspection Report*, dated March 05, 2018.

Bridge Background

The Gasconade River Bridge is a circa 1922, four-span, riveted steel truss bridge with concrete piers and abutments and a concrete deck. The bridge is in Laclede County, Missouri, located along Route I-44 Outer Road (Old Route 66). The bridge is owned by the Missouri Department of Transportation (MoDOT).

The bridge was closed for traffic in 2014 and is being replaced functionally by a new bridge, currently under construction adjacent to the existing span. Our services were requested by the Gasconade River Bridge Guardians to advise on the structural condition of the existing bridge and the feasibility of its re-use as a pedestrian and bicycle bridge, and to provide opinions and recommendations for repairs and strengthening with an estimate of probable construction costs.

Condition Assessment

Our condition assessment included a visual survey of the bridge from the deck and accessible locations below, field measurements and field hardness testing of representative steel members, non-destructive concrete scanning for locating reinforcement in the bridge abutments and limited in-place testing for the depth of carbonation in the concrete abutments and bridge deck.

SEI principal Patrick Sparks, P.E. and senior engineer Zach Webb, P.E. visited the site on December 11, 2018 to perform the limited testing and condition survey of the bridge. The Gasconade Guardians provided an electric generator for our use in making probes in the concrete.

The following sections summarize our test results, observations and main condition findings.

Field hardness testing indicates the steel has an ultimate tensile strength of at least 55 ksi.

Steel Superstructure

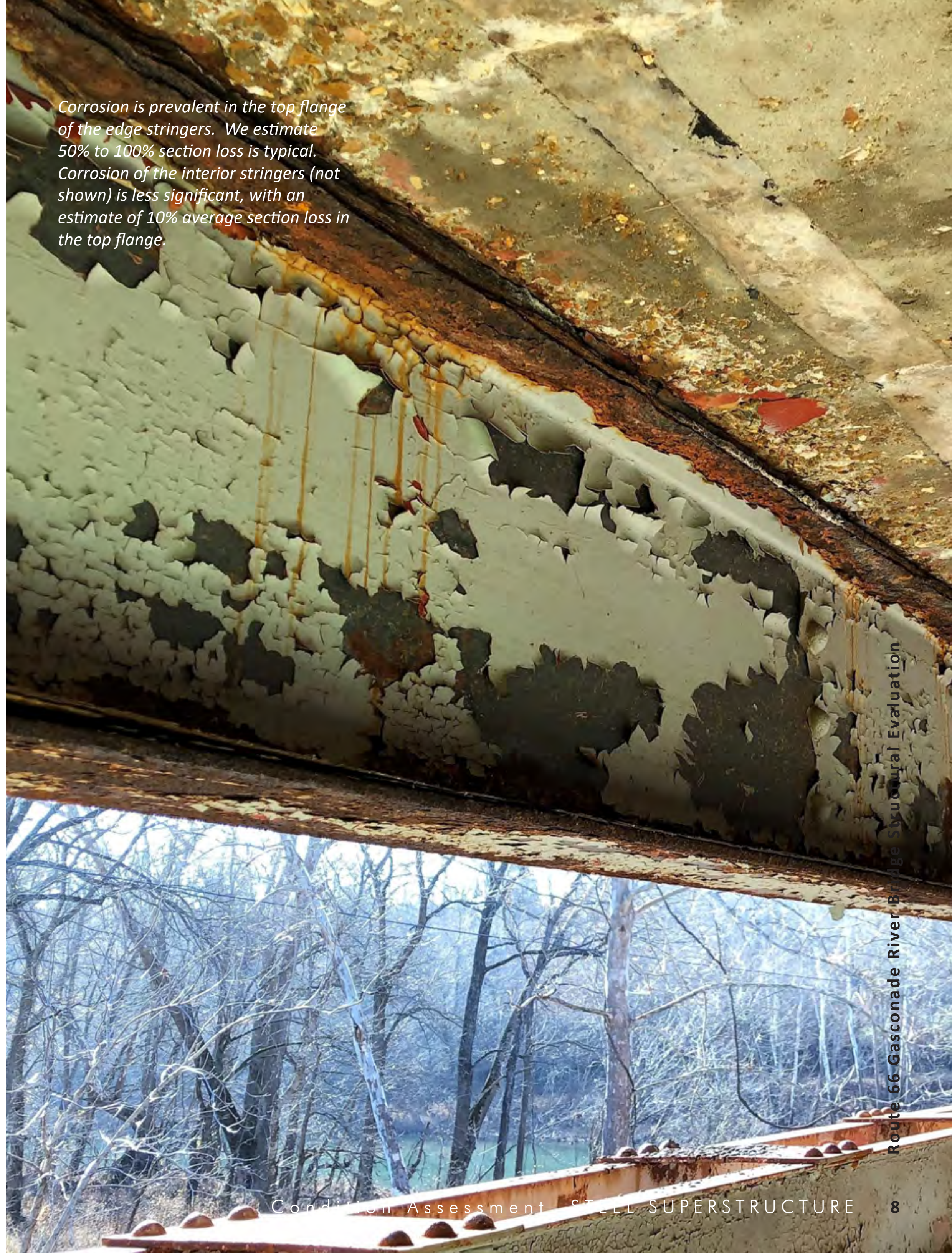
The superstructure has four spans composed of three-distinct steel trusses: an 80-foot Warren pony truss span, two identical 160-foot Parker through truss spans, and a 123-foot Pratt through truss span. The trusses are constructed of built-up, riveted steel sections and joined together with riveted gusset plates. Secondary components of the steel superstructure (e.g. below deck stringers, floor beams, lateral bracing, etc.) are typically rolled sections. We identified the following main deficiencies and condition findings:

- In-situ spark testing indicates that the steel is low carbon (ductile steel) and field hardness testing indicates that the tensile strength of the steel meets or exceeds the specified strength for material of that time period (55 ksi ultimate tensile).
- The paint is generally in poor condition, typically flaked or missing.
- Our observations suggest the rivets are sound and tight and in general the trusses appear to be in good condition, except for visible rusting in several of the top chord heel plates.
- Below deck, severe corrosion in the top flange of the edge stringers is prevalent. This condition appears to be mostly limited to the edge stringers, with less corrosion on interior stringers.
- The floor beams and other below-deck bracing appear to be typically in good condition, with some isolated locations with corrosion. Corrosion of the lateral bracing gusset plates is common, but generally appears to be isolated to the gussets only.
- There is visible distortion at the heel of one truss and in several of the portal struts, presumably from vehicle impact.

Localized pitting corrosion from chloride salts is common on the horizontal gusset plates directly below the edge of the concrete slab. However, the truss appears to be in good condition.

The corrosion is severe, but isolated, in several of the below-deck components such as this gusset plate which has significant section loss.

Close-up of severe corrosion.



Corrosion is prevalent in the top flange of the edge stringers. We estimate 50% to 100% section loss is typical. Corrosion of the interior stringers (not shown) is less significant, with an estimate of 10% average section loss in the top flange.

Deck and Railings

The bridge deck is nominally 6-inch thick reinforced concrete with an asphalt overlay. Deterioration of the concrete and corrosion of the concrete reinforcement is extensive. We performed several in-place qualitative tests for depth of carbonation[1] using a phenolphthalein reagent which changes color at pH 10.5, the carbonation boundary. We found that the concrete at the deck surface is carbonated to a depth of ½-inch, and uncarbonated below that. Therefore, the primary mechanism for the observed deterioration is salts contamination and freeze-thaw damage rather than carbonation. Regardless, deterioration of the reinforced concrete deck has progressed to the point where treatment and repairs are no longer feasible. Replacement is required.

The width of the deck is restrictive for combined vehicular traffic and pedestrian use. Rehabilitation planning can consider pedestrian/bicycle use with occasional vehicular traffic (e.g. emergency and maintenance vehicles) or vehicular re-use only, but not combined pedestrian and vehicular traffic.

A view from the underside of the bridge deck exemplifies the poor condition of the deck. Deterioration of the reinforced concrete has progressed to the point where repairs are no longer feasible. Replacement is required.

1 Carbonation is a natural process that causes a decrease in the alkalinity of the concrete over time, which increases the risk of corrosion.

Deck and Railings

The existing pipe railings are generally sound with some isolated damage; however, the railing does not meet current codes requirements. Replacement is required if the bridge is rehabilitated.

Piers and Abutments

The bridge substructure consists of concrete abutments and three mass concrete piers. We performed a visual survey of the piers and abutments for signs of distress (e.g. out-of-plumb, cracking, spalling) and tested the concrete at the east abutment for carbonation and reinforcement. Our assessment found the following main deficiencies and condition findings:

- The depth of carbonation in the abutment varied from ½ to 1-inch and the concrete was uncarbonated below that. Fortunately, we found the abutments are very lightly reinforced and the piers appear to be lightly reinforced or unreinforced as well.
- The top of the piers have a pattern of radial shrinkage cracking and deterioration at the ends where the top is exposed. Concrete surface repairs are recommended at the ends.
- Along the piers, the concrete exhibits some vertical shrinkage cracks, efflorescence, honeycombing, and horizontal cold joints; however, we found no structurally significant cracks or distress in the piers. Overall, the concrete substructure appears to be in good condition.
- A scour inspection was not included in our evaluation; however, we examined the base of the piers where they are readily accessible. Some minor erosion is apparent at the base of the piers; however, all piers appear to be plumb and level.
- The north wing of the east abutment has some concrete spalling which requires repair; otherwise the abutments are in excellent condition.

We found the mass concrete piers are generally in good condition, without structurally significant distress or deterioration.

The exposed concrete at the top of the piers exhibit some cracking and deterioration which require repair.

The concrete abutments are in good condition. Our concrete testing found the abutments are lightly reinforced and the depth of carbonation is ½ to 1-inch.

Structural Analysis

As part of our evaluation, we performed a structural analysis of representative bridge elements to estimate the load capacity and to identify the need for strengthening or repairs. Our analysis primarily considered two bridge components: the typical deck stringers and one of the two identical Parker through trusses (longest span trusses)[1].

Loads & Assumptions

We considered an accurate estimate of dead loads and applicable load cases of live loads for our structural analysis[2]. Live load cases consisted of a uniformly distributed pedestrian live load of 90-psf or a standard 15-ton truck (H15-44[3]) combined with a uniformly distributed lane load of 640-plf. This latter case was included in the event emergency or maintenance vehicles need to access the bridge.

1 The primary purpose of our analysis for this initial study was to evaluate the feasibility of pedestrian/bicycle reuse; therefore, our analysis was limited to 2-D modeling and applicable dead and live load cases. Refined analysis including additional load cases (e.g. snow, wind, seismic, flood, etc.) and consideration of fracture critical members is required for rehabilitation design. Based on our initial assessment of the bridge and our experience with similar structures we do not anticipate additional analysis will significantly alter the conclusions or recommendations contained in this report.

2 AASHTO 2006. Standard Specifications for Highway Bridges, 16th ed. Washington D.C.: American Association of State Highway and Transportation Officials.

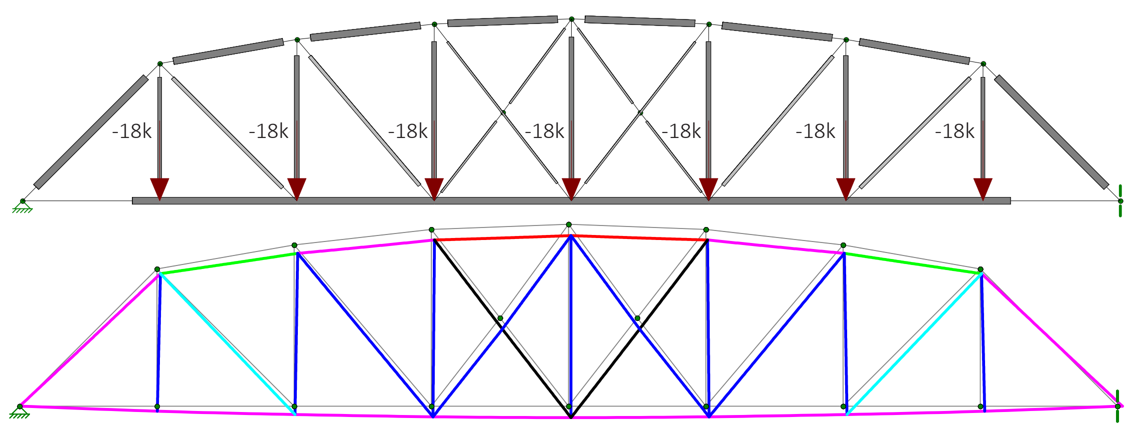
3 Axle load of a H15-44 is as follows: 6,000 lbs (front axle) and 24,000 lbs (rear axle) (AASHTO 1996).

We referred to our field measurements, in-situ testing, and available literature[4] to define the section and mechanical properties of the steel members. For our structural computer model of the truss, built-up members were approximated as solid sections with equivalent section properties and all members were considered as A7 steel with a yield stress of 30-ksi.

Structural Findings

In general, our analysis indicates that the bridge has sufficient capacity for pedestrian/bicycle reuse once the deck is replaced and repairs are made to the steel, without the need for additional strengthening or structural upgrades. Our analysis found that the truss top and bottom chords are at their maximum allowable design capacity with the dead load plus full pedestrian live load cases considered. Therefore, we recommend the rehabilitated bridge include deck replacement using a thinner concrete deck or an FRP deck for pedestrian reuse. We also found that the capacity of the stringers is typically adequate despite corrosion in the top flange and they can generally be reused with limited repairs.

4 *AISC Rehabilitation and Retrofit Guide. A Reference for Historic Shapes and Specifications.* Steel design guide series 15. Chicago: American Institute of Steel Construction



RISA 3D graphic representation of a Parker truss with pedestrian live load case. The deflection is amplified for clarity.

Opinions and Recommendations

In our opinion the Gasconade River Bridge can be successfully rehabilitated and have an extended service life as a pedestrian and bicycle bridge. Our condition assessment found the steel superstructure, piers, and abutments are overall in good condition, without significant structural deficiencies which would indicate a risk of imminent failure or collapse. To be sure, the steel and concrete substructure will require repairs before it can be placed back in service; however, these are generally well-defined and isolated. The primary deficiencies are the concrete deck which has reached the end of its useful life and requires replacement, and corrosion of the lower horizontal bracing gusset plates. In addition, the railing does not meet modern codes and requires replacement.

Our primary recommendations for repair of the existing structure are as follows:

Steel Superstructure

- Repair corroded steel members (stringers, gusset plates, and floor beams). Gusset plate repairs will likely consist of replacing the existing with a new bolted plate. Stringer repairs will consist of replacing the severely corroded top flanges (>50% section loss) with welded steel angles.
- Replace corroded top chord heel plates with bolted plates.
- Clean and paint the bridge. For economy, we suggest painting the bottom chord and below-deck supports only.

Deck & Railings

- Replace the concrete deck. The actual details of the deck will depend on further design; however, for planning purposes we suggest a cast-in-place, reinforced concrete deck placed over metal form decking (5-inch total deck thickness assumed). We have not included alternatives in our opinion of cost; however, precast concrete deck systems or a fiberglass reinforced polymer (FRP) bridge deck system could also be considered.
- Replace the existing pipe railing with new railing that integrates with the historic nature of the bridge and meets the code requirements.

Piers & Abutments

- Repair the concrete at the outer edges of the pier top (each) and the abutment wing (one location). Conceptually this will consist of removing deteriorated concrete and recasting with a cementitious concrete repair.

In addition, for planning purposes, our opinion of cost includes allowances for lighting, accessibility features, and improvement to the site for a complete bridge rehabilitation project.

Historic Rt 66 Bridge over the Gasconade River

Engineer's Opinion of Probable Cost

Category	Item	Quantity	Unit	Unit Price	Amount
General Conditions	Mobilization	1	LS	$ 150,000.00	$ 150,000.00
General Conditions	Project Signs	1	LS	$ 2,000.00	$ 2,000.00
General Conditions	Barriers and Warning and/or Detour Signs	1	LS	$ 10,000.00	$ 10,000.00
General Conditions	Tree Protection	1	LS	$ 5,000.00	$ 5,000.00
Site	Preparing Right-of-Way	1	LS	$ 15,000.00	$ 15,000.00
Deck	Remove & Dispose Bridge Deck	11,046	SF	$ 10.00	$ 110,000.00
Site	Remove East Approach Pavement	880	SF	$ 2.00	$ 2,000.00
Site	Remove Exisitng Railings	160	CY	$ 150.00	$ 24,000.00
Site	Storm Water Pollution Prevention	1	LS	$ 15,000.00	$ 15,000.00
Site	Approach Pavement	880	SF	$ 5.00	$ 4,000.00
Substructure	Concrete Structure Repair	100	SF	$ 400.00	$ 40,000.00
Deck	Bridge Joints	3	EA	$ 2,000.00	$ 6,000.00
Deck	Concrete Bridge Deck - 5"	11,046	SF	$ 15.00	$ 166,000.00
Railing	Pedestrian Railing	1,052	LF	$ 100.00	$ 105,000.00
Structure	Steel Structure Repair - Bracing Gussets	14	EA	$ 8,000.00	$ 112,000.00
Structure	Steel Structure Repair - Floor Beam Gussets	4	EA	$ 5,000.00	$ 20,000.00
Structure	Steel Structure Repair - Heel Cover Plates	5	EA	$ 2,000.00	$ 10,000.00
Structure	Steel Structure Repair - Top Flange Stringers	1,052	LF	$ 40.00	$ 42,000.00
Structure	Clean and Grease Bearings	16	EA	$ 500.00	$ 8,000.00
Painting	Cleaning and Painting Steel	50,000	SF	$ 20.00	$ 1,000,000.00
Lighting	Lighting Power, Controls, and Fixtures	1	LS	$ 70,000.00	$ 70,000.00
	Total Construction Cost				**$ 1,916,000.00**
	Design Fees	12%			$ 230,000.00
	Permitting (USACE)				$ 25,000.00
	Testing & Inspection	2%			$ 40,000.00
	Section 106 Compliance				$ 15,000.00
	Contingency	15%			$ 330,000.00
	Total Project Cost				**$ 2,556,000.00**
	Bid Alternates				
Alternate	Paint steel below deck only	-20,000	SF	$ 15.00	$ (300,000.00)

Excludes escalation, project management and administrative fees, land surveying, and public involvement.

This opinion of cost is for planning purposes and is intended only to provide information on the general magnitude of costs. Costs are based on our engineering judgment and experience with similar projects. The opinion of cost is not a quotation or guarantee of actual costs. We have no control over the actual cost or availability of labor, equipment or materials, market conditions or a contractor's method of pricing. Further, no detailed design documents have been developed on which to base the cost of a specific project. As with any preservation work, an appropriate contingency should be maintained in the project budget.

END OF REPORT