Restoration Study | 1887 West Sixth Street Bridge at Shoal Creek

West Sixth Street Bridge at Shoal Creek , laser scan image courtesy of the Center for Heritage Conservation - Texas A&M.

STATE OF TEXAS
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03-08-2016

SHOAL CREEK CONSERVANCY

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LIMBACHER & GODFREY ARCHITECTS

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Restoration Study funded by grants from the Burdine Johnson Foundation and the Texas Preservation Trust Fund.

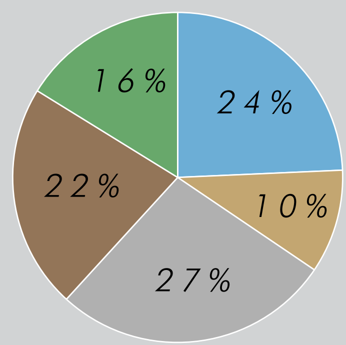
Executive Summary

The purpose of this study was to develop an appropriate restoration approach for the 1887 West Sixth Street Bridge at Shoal Creek, taking into account its actual structural condition as well as outlining a compatible holistic treatment of the streetscape and creekway. In addition, we are providing Shoal Creek Conservancy with prioritized conceptual costs for the restoration.

Our design team found that the bridge in its original condition would have had ample capacity for modern truck loading. However, as of December 2015 *the bridge had only about 20% of its original capacity remaining*. Of the several factors affecting the capacity, *mortar loss* was by far the most significant deficiency. We understand that a grouting effort is now underway (March 2016) by the City of Austin which will improve the load carrying capacity of the bridge. This is a first step in the restoration process outlined here to ensure that the robust masonry arch bridge will serve for many more generations.

Restoration work will include repointing and grouting of the limestone arches, reconstruction of the wing walls, strengthening of the existing south parapet and addition of a matching parapet on the north side, new concrete pavement, wider sidewalks, lighting, accessibility, wayfinding and interpretation.

Based on the scope of work identified in our study, we recommended the following prioritized budget[1] allocations:



Immediate Structural	$	414,300
Remaining Structural	$	173,300
Pavement	$	465,800
Creekway and Lighting	$	375,400
Interpretive Signs, Wayfinding, and Landscape	$	276,200
Construction Cost	$	1,705,000
Fees & Contingency	$	490,000
Total Project Cost	$	2,195,000

1 See page 22 for detailed Restoration Scope and Opinion of Cost.

**This report was revised on March 7, 2016 to reflect the grouting that was underway.*

Study Scope and Limitations

Scope of the Study

This study was focused on providing the Shoal Creek Conservancy with planning guidance for restoration of the bridge and improvements to the streetscape and creekway in the immediate vicinity of the bridge. We included review of available documents, limited historical research, investigation and analysis of the structural condition, an architectural assessment of accessibility, interpretation, landscaping, lighting and pedestrian enhancements.

Limitations

This study report is based on our review of available documents, assessment of the condition of the existing structure, limited testing and preliminary analysis. Conditions may exist or develop over time that were not identified in the study. The design elements, recommendations, and scope of construction outlined herein are necessarily general. They are not intended for construction.

Available Documents

Over the course of the restoration study, certain documents were provided to Sparks Engineering, Inc. to aid in the evaluation of the West Sixth Street Bridge at Shoal Creek. These documents include historical items as well as contemporary laser scans and field surveys procured and conducted by SEI. In addition to the available documents, SEI compiled reference material to aid in the structural analysis (see references section), as well as historical photographs and information (see appendix one).

Historic American Engineering Record (HAER) TX51 Notes prepared by Robert W. Jackson in August of 1996.

HAER TX51 Archival Drawings
- South Elevation
- Axonometric Section
- Plan

National Register of Historic Places Registration SBR Draft, February 2014, Submission by Jimena Cruz Pifano and Gregory Smith.

Texas Department of Transportation Bridge Inspection Summary Reports: *May 1984, May 1986, February 1988, December 1989, November 1991, August 1993, August 1995, August 1997, May 1998, July 2000, June 2002, April 2012.*

Texas Department of Transportation Channel Cross-Section Measurements Record: *March 2008, April 2010, April 2012.*

Various Historical Photographs from the HAER survey, NRHP SBR Draft, and Flood Events.

Lower Shoal Creek Bank Stabilization Design Standards, Prepared by Morgan Byars (Watershed Protection Department) 1/15/2011.

Site Plan - GSD&M Property

Shoal Creek Walk Site Plan - Schlosser Property

City of Austin Topography and Impervious Cover Shape Files, West Sixth Street.

Precinct Plan - 6th and Lamar Existing Conditions

Bridge History

The c. 1887 West Sixth Street Bridge is a three-span limestone arch bridge over Shoal Creek. Originally including ten foot sidewalks on either side of the roadway, the bridge served an important role in expanding Austin. The earliest bridge at this site was probably one of wood, replaced in 1869 by an iron bowstring. Although planned as a new iron bridge to replace the 1869 iron bowstring span, the design was redefined during procurement to be built of stone masonry. This divergent change is the main reason the bridge has continued to be in service today.

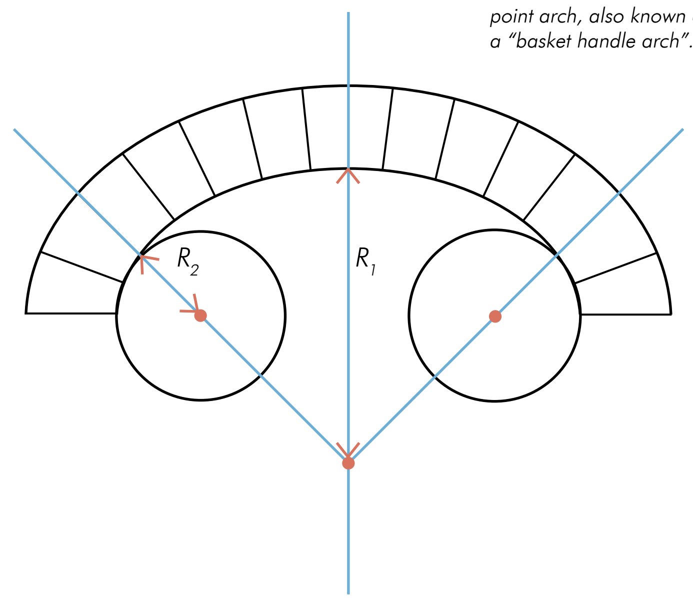
Of interest, our study found that:

- At least two building campaigns produced the bridge we see today: construction joints piecing the length of the arch vaults in thirds, as shown in the nearby image. The two end sections differ from the central section in stone selection, size, tooling, and coursing.
- The south parapet is likely original, and several of the original cap stones remain. Early aerial photography suggests there was originally a north parapet to match.
- The early concrete pavement and brick pavers from the trolley era remain beneath the asphalt.

Character Defining Features:

- Three-centered arches
- Native limestone construction
- Stone parapets

West Sixth Street Bridge, middle vault longitudinal section showing construction joints within the length.



Construction of a three-point arch, also known as a "basket handle arch".

"The first bridges men built were in wood, which were suited to their requirements at the time. But then they began to think about the immortality of their names. And because their richness gave them heart and made better things available to them, they began to build bridges in stone, which lasted longer, cost more, and brought glory to those that built them."

A. Palladio 1570

Study Philosophy and Methodology

Philosophical Approach

Because of the important historic significance of the bridge, we have based our approach to the restoration study on the following principles of structural conservation[1]:

- Keep intervention to the minimum.
- Use compatible materials.
- Preserve the distinguishing qualities of the structure.
- Imperfections can be maintained if they do not compromise the safety requirements.

Study Goals

As a vehicular bridge in a vibrant urban setting, the design must be inviting to all by providing not only a reliable and safe structure, but also creating a sense of place that anchors the historic West Sixth Street Bridge into its surrounding context.

To meet these goals, the constraints of the project must be addressed in a thoughtful and deliberate manner. The recommended restoration scope will also assure compatibility with the bridge's historic character, in accordance with The Secretary of the Interior's Standards for Rehabilitation (36 CFR §67.7).

Our design team identified the following key goals for the project:

- Safety — Improvements for safe access and use
- Utility — Continued multifunctional use
- Beauty — Simple enhancements that do not distract
- Permanence – Expected remaining life in excess of 100 years
- Economy — Efficient, constructible design

[1] *Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage*, ISCARSAH Scientific Committee, International Council on Monuments and Sites, 2003. www.iscarsah.icomos.org

Study Methodology

Our study methodology is based on the principal goal of retaining the historic arch bridge structure, keeping it in vehicular service, and enhancing awareness and enjoyment of the bridge and the creekway by the public. To these ends, we developed the study around the following components:

- Review of available documents, including current and planned site development plans adjacent to the bridge, creek and trail studies, and historical records and photographs. See the appendix for some of the historical information that was gathered.
- Laser Scanning of the bridge and surroundings to obtain highly accurate three-dimensional measurements of the arch structure for our structural analysis. The laser scan data constitutes an exact record of the bridge in time, and can also be used for developing construction drawings, interpretative rendering, stream modeling, etc.
- Condition assessment, including a detailed visual survey, selective probing and borescope inspection of the mortar joints, non-destructive testing for reinforcement in the concrete pier encasements, and test for carbonation of the encasement concrete.
- Structural analysis for understanding the current load capacity of the bridge, taking into account the observed conditions and actual geometry of the barrel vaults.
- Architectural assessment to identify enhancements for safety, accessibility, and public enjoyment.
- Opinion of probable cost based on our recommended scope of restoration.

Texas A&M Point Cloud Laser Scanning

Laser Scanning was provided by the Center for Heritage Conservation at Texas A&M University. The scans provided a detailed and highly accurate model of the existing bridge geometry for use in determining the original geometry and the amount of past distortion in the arch rings. The scans also extended to cover an area around the bridge for future use in site design.

Laser Scanner Point Cloud Composition with precise mapping of all elements for analysis and future maintenance.

Bat colonies at dark spots

Construction joint
- change in stone -

Broken stone / Missing mortar

Stone slippage at joint

Utilities cut into arch stones

Pinched arch stones

Root intrusion

Water infiltration

Tunnel collapse, vault A

Condition Assessment

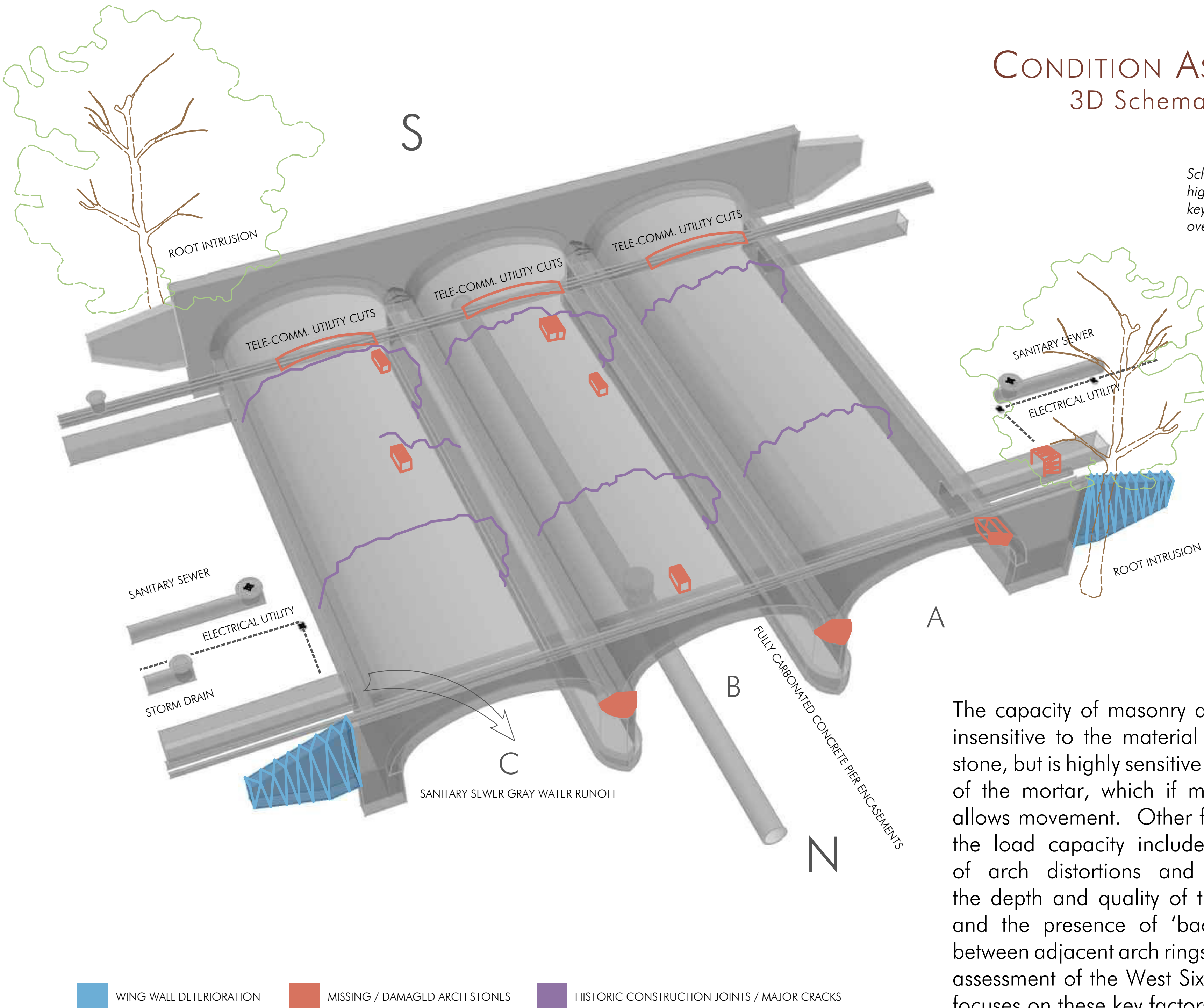
Our condition assessment included a detailed visual survey and selective use of non-destructive testing and probes. We identified the following main deficiencies and condition findings:

- Severe loss of mortar from the barrel vaults.
- Several crushed or cracked arch stones.
- Slippage of arch stones.
- One missing arch stone in vault C.
- Collapsed drainage tunnel, vault A.
- Telecom utility line cut into tops of vaults.
- Extensive root intrusion into the mortar joints of the bridge.
- Two historic construction joints in each vault.
- Instability of the north wing walls.
- Water infiltration.
- Concrete encasement around piers in good condition, although fully carbonated.
- Good condition of the spandrel walls.

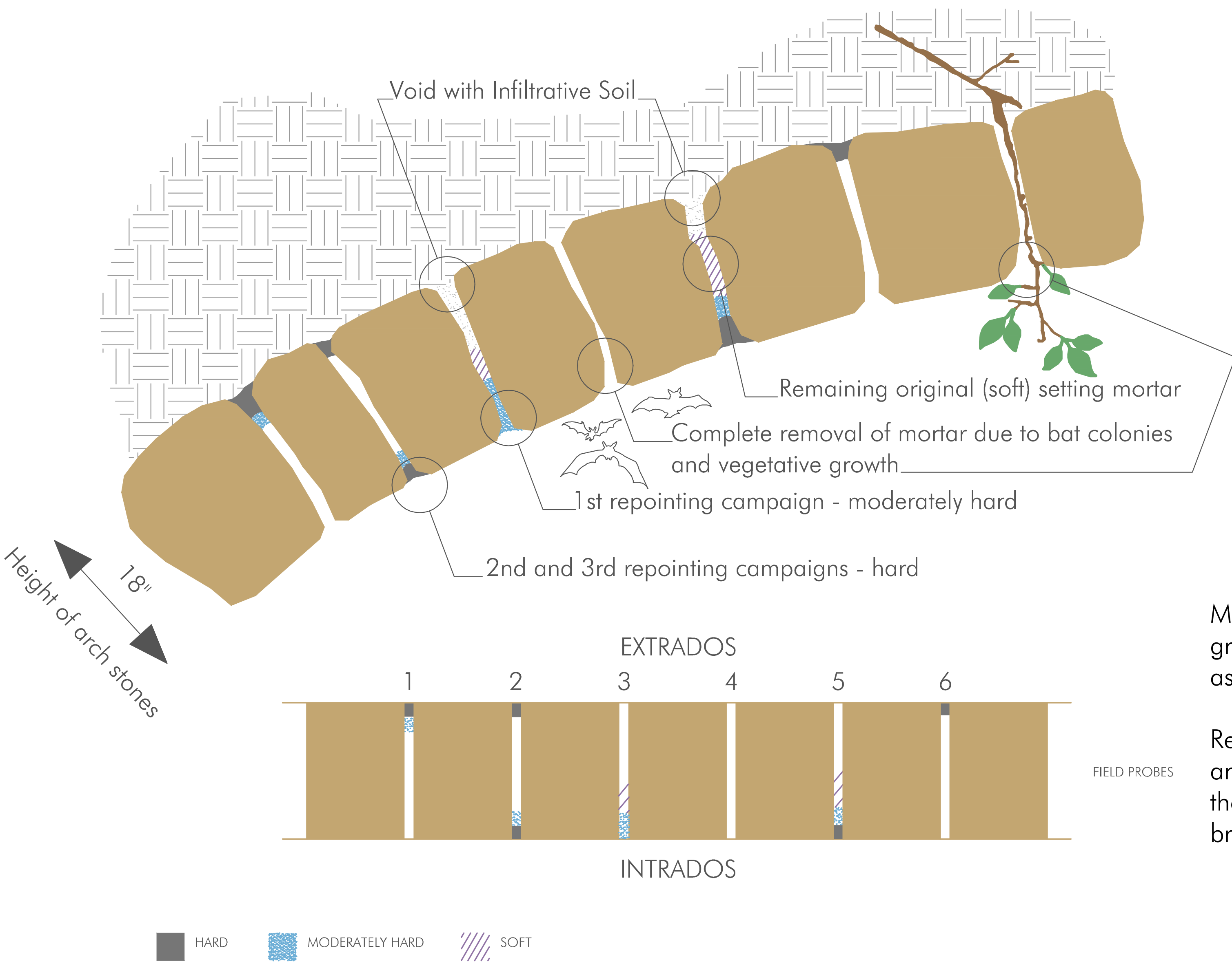
The photos at left illustrate the aforementioned findings. A 3d schematic diagram and detailed analysis of the deficiencies follow on the subsequent pages.

Condition Assessment
3D Schematic Diagram

Schematic Diagram highlighting some of the key factors of the bridges' overall condition.



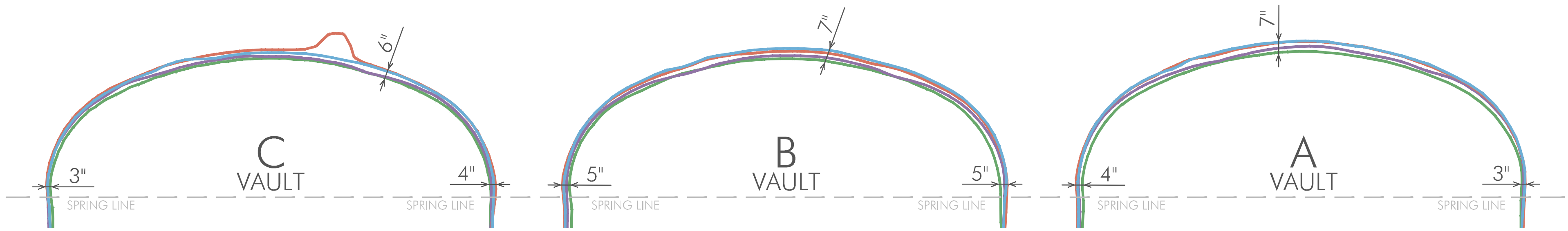
The capacity of masonry arches is largely insensitive to the material strength of the stone, but is highly sensitive to the condition of the mortar, which if missing or loose allows movement. Other factors affecting the load capacity include: the presence of arch distortions and discontinuities, the depth and quality of the fill material, and the presence of 'backing' masonry between adjacent arch rings. The condition assessment of the West Sixth Street Bridge focuses on these key factors.



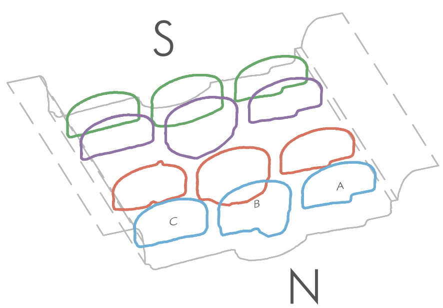
Mortar loss is significantly greater than previously assumed.

Repointing and grouting are required to recover the load capacity of the bridge.

Condition Assessment
Barrel Vault Ring Distortion



The shape of the barrel vaults varies as much as 7" in rise and 10" in span. The highest arch distortion occurs at the utility cuts in the top of the vaults to the south.

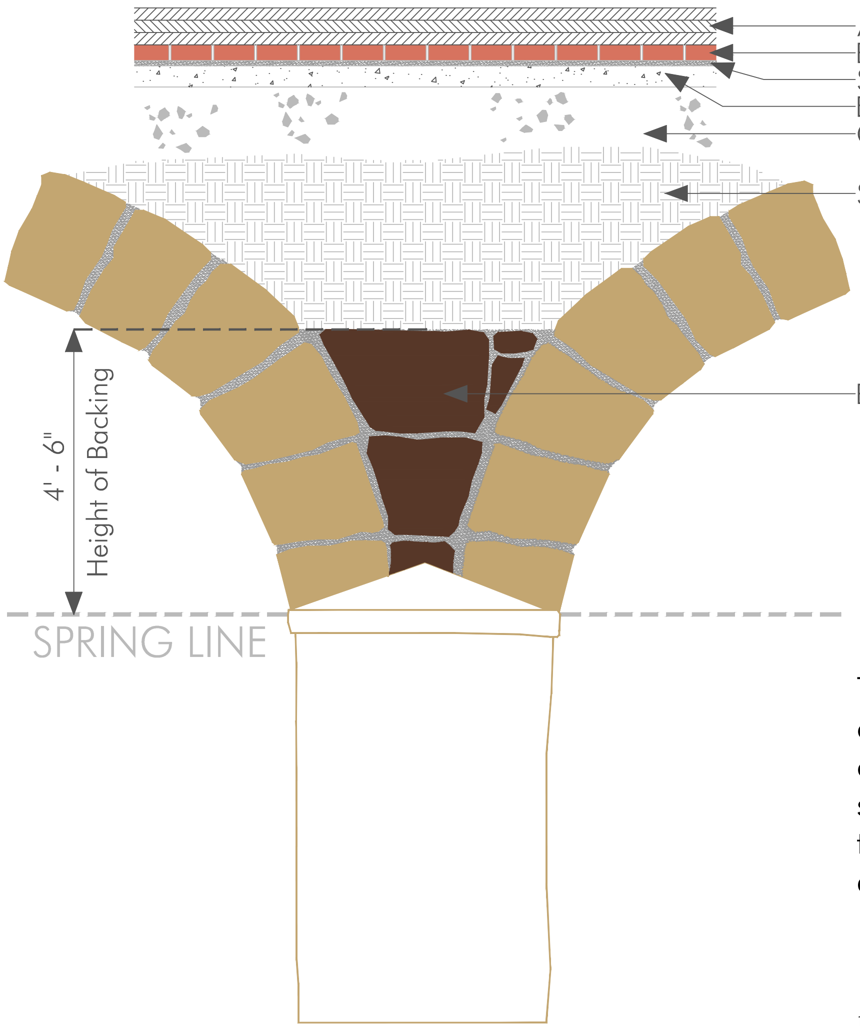


SECTION 4B - 14'-9" IN FROM NORTH

SECTION 10B - 34'-6" IN FROM NORTH

SECTION 19B - 64' IN FROM NORTH
**Location of Telecom Cuts*

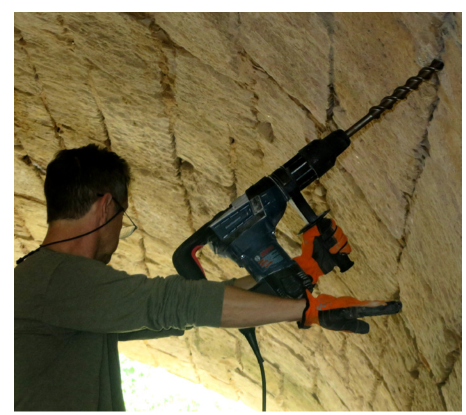
SECTION 23B - 77' IN FROM NORTH

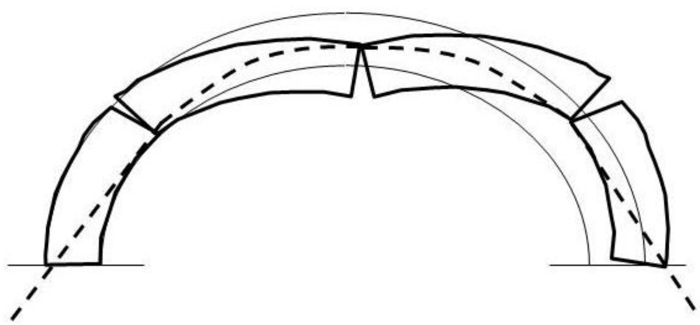


The backing[1] and fill[2] conditions (vital as a component to the structural system) discovered over the course of the study are depicted to the left.

[1] Direct probing was relied upon rather than ground penetrating radar.
[2] Fill section data from City of Austin street excavation.

SEI drilling through an arch stone mortar joint to determine the amount of backing present within the bridge.





Typical arch collapse mechanism - formation of hinges.

Structural Capacity Analysis

Masonry arches are intrinsically strong. The stresses are always low compared to the natural strength of the stone, and localized weaknesses in the material do not have a large effect on the structural capacity. It is the stability of the arch ring, either locally or globally, under concentrated load that determines capacity. The stability of a masonry arch bridge is governed entirely by its geometric proportions, principally the rise-to-span ratio, the depth of the arch ring, and the amount of overburden or fill (see backing and fill conditions diagram) above the arch crown.

As part of our study, we performed an initial structural analysis of the masonry arch bridge. Despite the apparent simplicity of arch structures, the direct calculation of exact load capacity is quite difficult and made ambiguous by the high level of indeterminacy within the arch. Moreover, U.S. bridge design standards do not address masonry arches. As such, we combined several methods to develop a rational understanding of the bridge's performance. We began with historical design methods to roughly define the allowable axle load to be supported by a single vault at mid-span, followed by other methods as described below.

Semi-Empirical Method – MEXE

The modified MEXE assessment of the arch barrel is an adaptation of the British method set out in "Military Load Classification (of Civil Bridges) by the Reconnaissance and Correlation Methods", Military Engineering Experiment Establishment, 1963[1]. This method is based on the results of past experience, and it has been found to give satisfactory results for a range of highway vehicles on spans less than 18m. It allows the application of empirical modifying factors. Taking their shortcomings into account[2], we implemented the Pippard's method and its derivative, the Military Engineering Experimental Establishment method (MEXE)[3]. Both methods primarily depend on the arch stone thickness, the vault span, and the total depth of material above the crown. Adjustment factors allow for the influence of defects such as vault discontinuities and mortar joint deterioration on the allowable axle load. We also varied the arch rise-to-span ratio to compare the idealized geometry with the as-measured shape of the barrel vaults.

Mechanism Analysis - RING 3.1

The RING software (LimitState Ltd.) relies on a rigid-plastic analysis that identifies the live load that transforms the structure into a mechanism. It also provides a visual representation of the failure mode. We used RING to explore the effect of mortar loss. From this analysis we determined that the loss of mortar was the dominant factor in loss of capacity.

Elastic Model – RISA

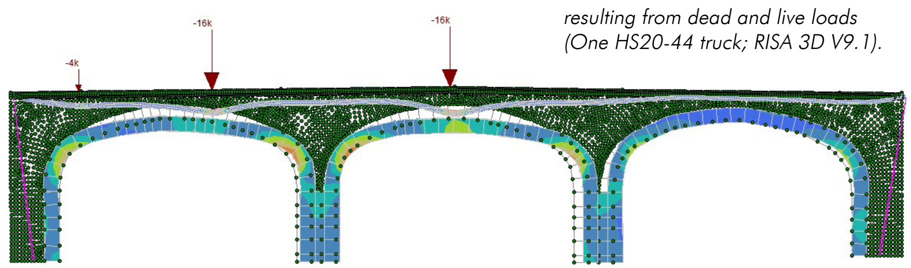
We prepared a 3D computer model using RISA-3D V9.1 software (RISA Technologies) which allowed us assess the stress state and deformation of the bridge, while performing a parametric study to identify the sensitivity to fill modulus, embankment pressure and pavement stiffness. This model produced an accurate simulation of wheel-load distribution not available in the other methods. As a result, we found that the bridge performance would be substantially enhanced by the addition of reinforced concrete pavement to distribute loads and to span defects in the arch ring.

Thrust-Line Method – Archie-M

We retained Bill Harvey Associates Limited, an expert masonry arch bridge consultancy in the UK, to review our findings and to provide a basic calculation using their proprietary software Archie-M (thrust-line model). The Archie-M results confirmed that the bridge, once rehabilitated, will meet the design loads for truck traffic, as shown in the MEXE analysis.

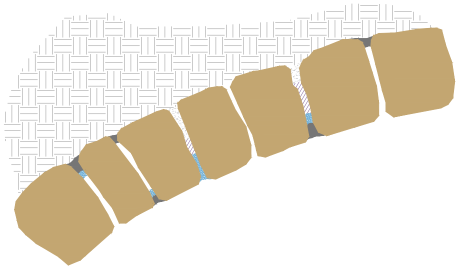
Assumptions

We referred to literature[4] to define the mechanical properties of the pier stones, arch stones, and backfill material[5]. One HS20-44 truck[6] was applied on the bridge at the location leading to the lowest ultimate load-carrying capacity. The following main modelling assumptions were used: effective bridge width of 10 feet (i.e., one lane), 27 arch stones per vault, arch stone thickness of 18 inches, 15 inches of backfill above key arch stone, neglected stiffening effect of spandrel walls.



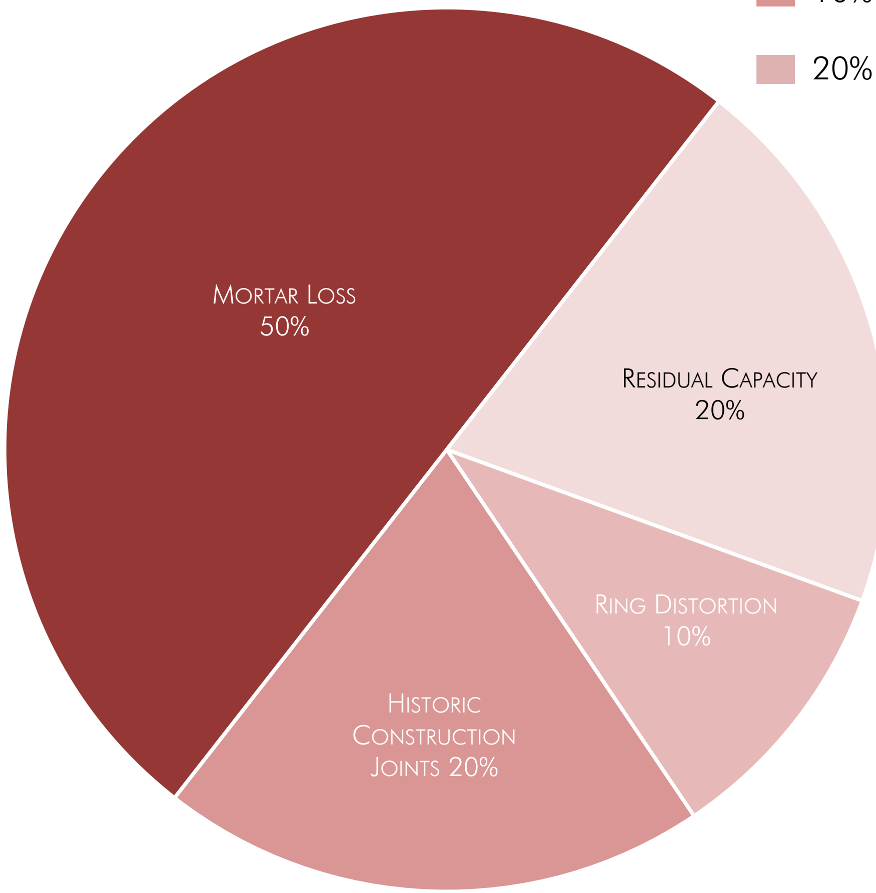
Deformation and Von Mises contour stresses of the barrel vault arches resulting from dead and live loads (One HS20-44 truck; RISA 3D V9.1).

[1]The MEXE method is related to that of Pippard, which is an analytical solution based on simplifying assumptions. In the case of the Shoal Creek bridge, the Pippard equation gave results compatible with the MEXE calculation.
[2]Wang J., Haynes J. & Melbourne C. (2013).
[3] Those simple methods are based on an elastic analysis of a two-hinged arch, and can be considered as (semi-)empirical.
[4]See for instance: Baker IO. (1892), Kessler DW. & Sligh WH. (1927), Youn H. (2008).
[5]We assumed the following material properties with RISA-3D: pier stones (Young's modulus 6,000 ksi, poisson's ratio 0.25, selfweight 165 pcf), arch stones (Young's modulus 4,000 ksi, poisson's ratio 0.25, selfweight 145 pcf), backfill (Young's modulus 15 ksi, poisson's ratio 0.25, selfweight 110 pcf). Identical materials' selfweights were used with RING.
[6] Axle load of a HS20-44 truck is as follows: 8,000 lbs (1st axle), 32,000 lbs (2nd axle) and 32,000 lbs (3rd axle). 14' is the fixed spacing between the first and second axles. 24' is the spacing between the second and third axles producing the lowest ultimate load-carrying capacity (AASHTO 1973).



Mortar Loss

Comparative Strength Loss Factors



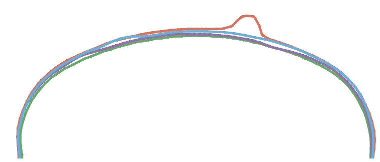
Initial Structural Findings:

- 50% Reduction due to loss of mortar.
- 10% Reduction due to distorted ring geometry.
- 20% Reduction due to point-loading over the historic construction joints.

Repointing and grouting all mortar joints is critical to recovering the structural integrity of the bridge.

Adding reinforced concrete pavement would greatly improve structural performance beyond the original capacity.

Historic Construction Joints



Barrel Vault Ring Distortion

The Reason to Include Architectural Enhancements

The primary purpose of this project is to restore the structural integrity of the bridge, and to replace lost or missing elements. But experience tells us that simply restoring structural integrity can easily go unnoticed and, therefore unappreciated by the public, leaving an untapped opportunity to bring positive attention to an important element of architectural history as well as to the work and the public stewardship involved in the restoration. For this reason, an architectural component was included in the scope. In particular, the idea is to surround the bridge's landscape context with architectural and interpretive elements to celebrate the history of the bridge and to make these restoration efforts visible and enjoyable for the public.

Conceptual Design Scope

The scope concentrates on a few key strategies to bring the bridge more fully into the public realm. It recognizes that architectural enhancements can have a meaningful, positive experience.

The Sixth Street Experience

Sadly, the experience of crossing at street level today is unremarkable to the extent that the bridge passage is barely noticeable. The sidewalks are cracked and narrow. Parallel parking runs across the bridge on both sides as if it were just more undifferentiated city street. Lighting is by standard utilitarian pole-mounted street lighting. With the exception of one stone parapet wall, nothing about the Sixth Street experience conveys the historical significance of the bridge. This design seeks to rectify that and to clearly differentiate the bridge experience from that of its more ordinary surroundings. In this way, it invites the public to better understand the importance of the bridge and its history. The design uses new lighting; new, distinctive and appropriate sidewalk paving, wood street furniture, plantings and new iconic totem elements that bring definition to the bridge location while providing a focus for interpretive storytelling.

To further enhance the Sixth Street experience, this design also eliminates parking on the bridge and gives that space over to more generous sidewalks. The idea stems from Austin's Great Streets initiative, and is appropriately adapted to fit this unique circumstance. Creating a more generous sidewalk sets the stage for installing sturdy, handsome wood benches and new iconic totems.

Because historical documentation did not suggest it, the discovery of covered-by-asphalt brick paving during the subsurface investigation was a surprise. To capitalize on that discovery, this design salvages and reuses them as sidewalk paving. In this way, this newly-discovered brick paving is not only given new life, but it is also given new purpose—to differentiate the bridge precinct from the rest of the city and its more-ordinary concrete sidewalks.

The Trail Experience

The trail experience in and around this important bridge is undifferentiated from the rest of the Shoal Creek trail, and offers little clue that the user has arrived at a uniquely important place. This design seeks to burnish a particular character through the use of lighting and new, simple but attractive walking surfaces. It also focuses on the northwest trail bank for special consideration including new, more naturalistic retaining walls and landscape attention to include ecological restoration. The new walking surfaces should be simple and durable and should contrast with the more-ordinary exposed-pebble walks that characterize much of the rest of the trail. The new paving may be as simple as tined-finished concrete, and should extend from the new accessible connection of this project south to the new accessible connection that is part of the in-progress Schlosser project along the southwest bank. As part of an effort to give the landscape a looser, more naturalistic appearance, new retaining walls should replace the existing vertical wall of cut stone. These new walls should be positioned to step back at the approach to the bridge to make that northern approach more spatially generous while also revealing more of the stone wall of the bridge itself. The stonework at the recently-completed Waller Creek outfall provides a useful model for this more naturalistic stonework idea.

New Accessible Connection

This idea is to transform an existing footpath on the northwest creek bank into an accessible route from Sixth Street down to the trail. From the sidewalk at Sixth Street, it should generally follow the track of the existing path, but proceeding at a steeper pace, seeking a slope that proceeds downward in a purposeful way. Along the way, an interpretive station should be included—an overlook with an intentional view back to the bridge to include an interpretive panel for telling the stories of the bridge.

This new connection will require adjustments to the existing topography. Recognizing the proximity of nearby trees and the hydrological challenge of altering the shape of the creek channel, retaining walls should be either rusty steel plate or steel sheet pilings, because either will be minimally intrusive by virtue of their very thin section.

Keeping the slopes at or below a 5% grade will bypass the architecturally-cumbersome requirements specific to a ramp (which is any path steeper than 5%) as defined by the Texas Accessibility Standards. Conceptually, this would seem to be possible from Sixth Street to the landing (depicted as a large oval). From the landing, a ramp will probably be required down to the trail.

Lighting

A thoughtful lighting design is crucial to both enhance a sense of safety and security around the bridge, and also to punctuate its presence on the urban scene. This concept includes a collection of complementary lighting strategies:

Lighting the facades. Using a shrouded linear fixture, light washes down the north and the south facades so that the bridge is clearly visible to approaching nighttime trail users.

Lighting the bridge vaults. Carefully locating shrouded fixtures at the apex of the arches, light washes the vaulted shapes so that the structural logic and arched geometry is expressed and highlighted.

Lighting the parapets. Using a shrouded linear fixture, light washes down the sidewalk side of the parapets to both call attention to the stonework and to provide lighting for pedestrian safety.

Uplighting in walking surfaces. Using low-wattage in-ground fixtures, the walking surfaces can be animated by points of light. These should be used in the sidewalk at street level as well on the trail as it passes through the bridge precinct.

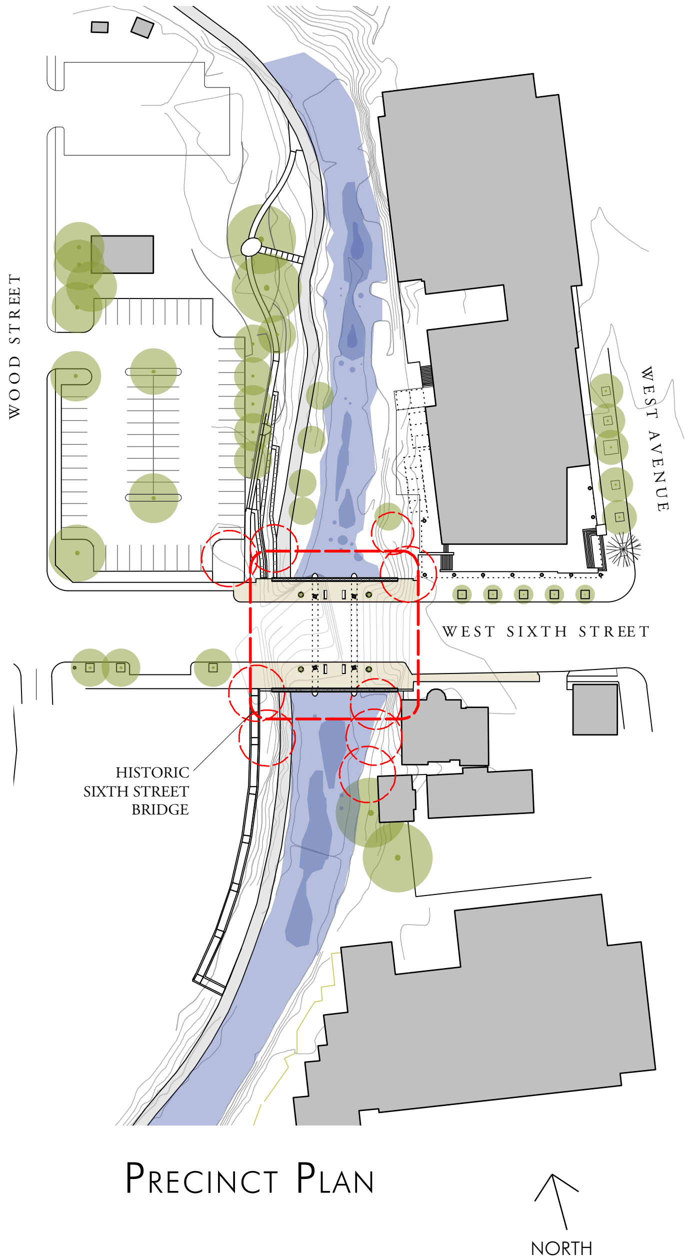
Totem lighting. Totems - vertical, celebratory elements - are included to intentionally mark the space and location of the bridge for users at street level. Their surfaces will carry interpretive graphics where the story of the bridge can be told. They will also be lit at night as a visible reminder of the bridge importance.

Front porch lighting. This design shines a welcoming pool of light onto the walking surface at the trail approach from both the north and the south. The discreet fixture is pole-mounted.

Landscape

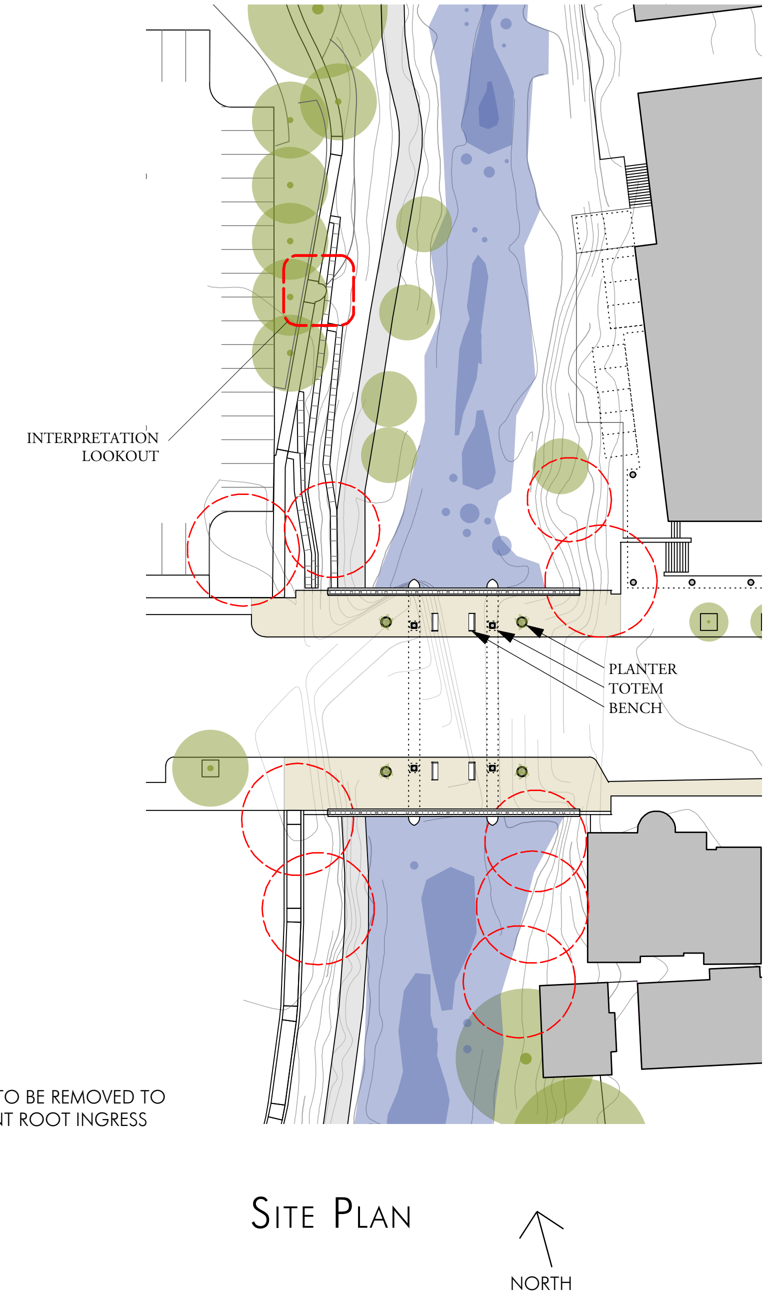
One of the chief causes of structural degradation of historic structures is root invasion from nearby trees and woody vegetation. So from a conservation standpoint alone, a no-tree zone in proximity to the bridge should be declared. Where that removal creates voids, new native plantings should be installed.

Taken together, these design interventions should create a palpable sense of urban importance at the bridge.



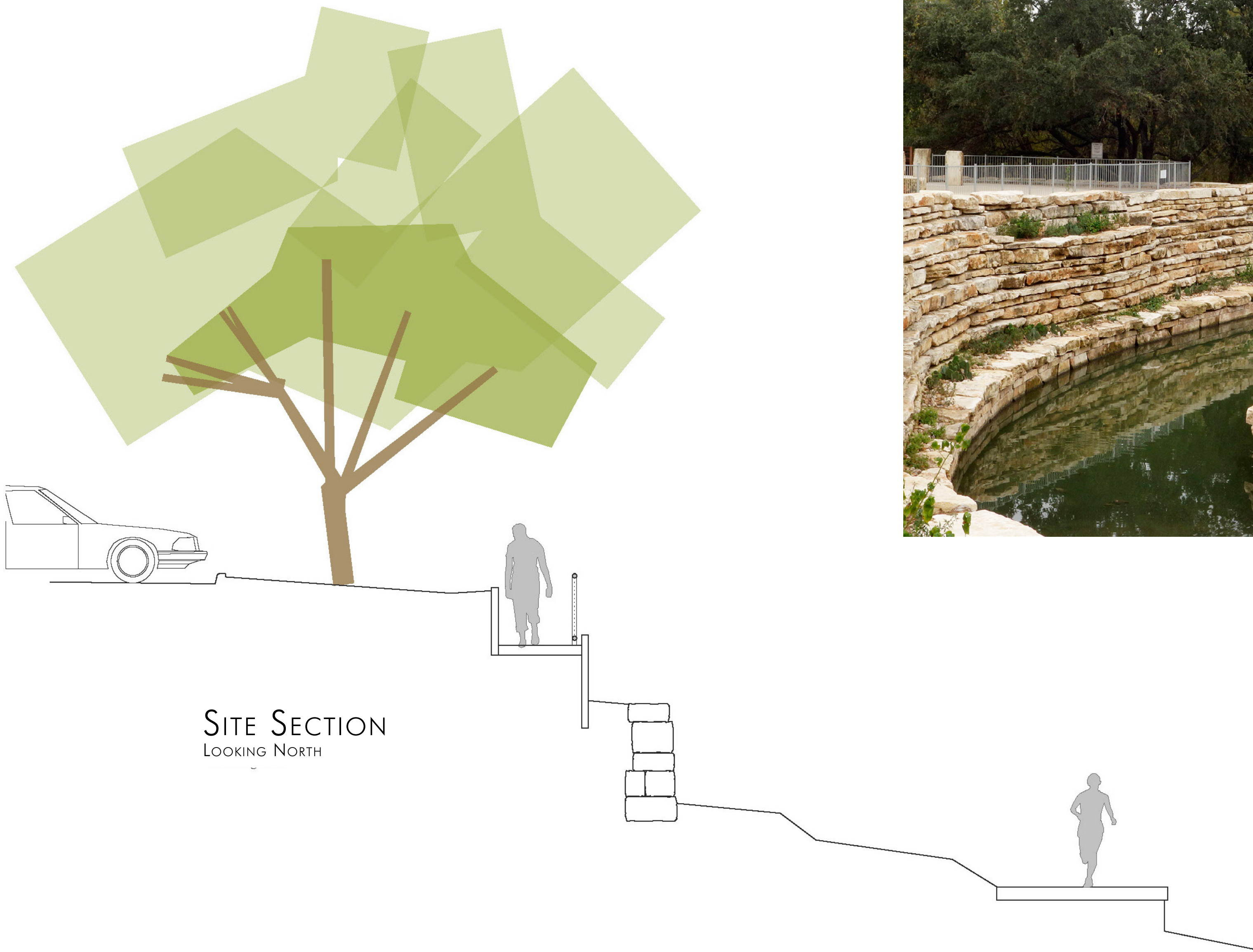
PRECINCT PLAN

TREES TO BE REMOVED TO PREVENT ROOT INGRESS



SITE PLAN

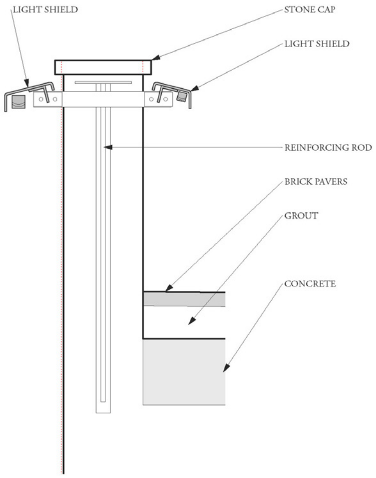
The Trail Experience



Stonework at Waller Creek intended to recall the layering found in local limestone bluffs. Note that the integration of native plants further reinforces the sense of naturalism.

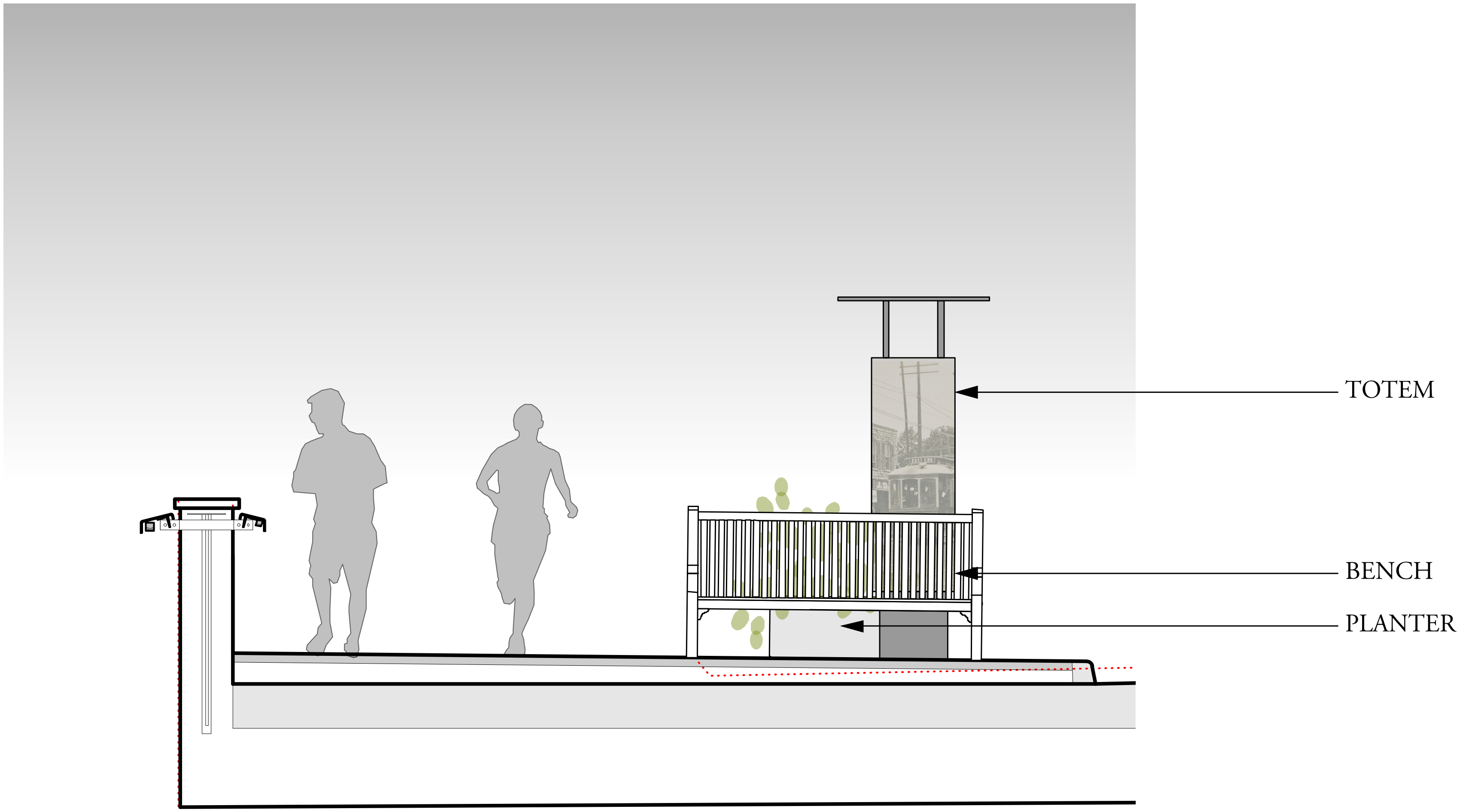

Coca-Co

Architectural Totem Marker



Parapet Section
Looking West

Interpretive Lookout Upstream of Bridge
Looking East



Longitudinal Section Through Sidewalk

Looking West

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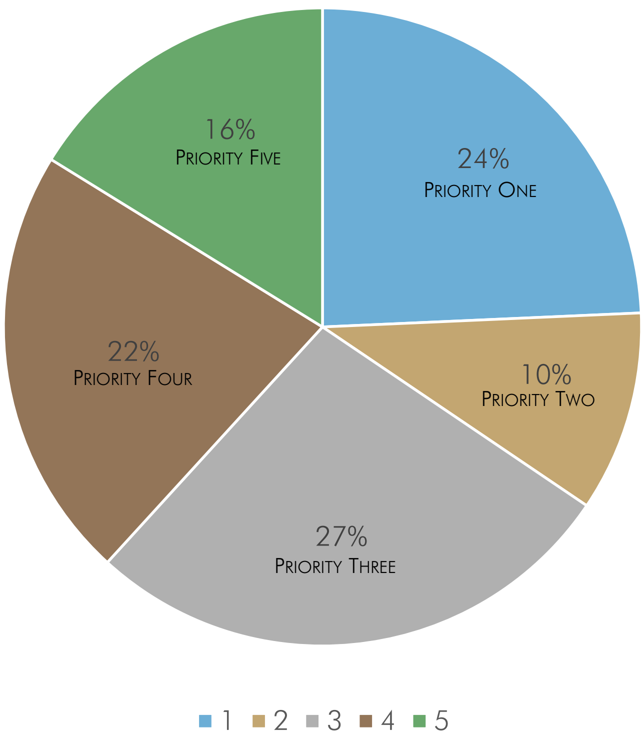
Construction Cost by Priority



Restoration Project Scope

The scope of the project encompasses structural conservation to keep the historic bridge in vehicular service for modern loads, along with safety and pedestrian enhancements. The envisioned work will involve stone repair, grouting and pointing of the mortar joints, rebuilding of the wing walls and north parapet, lighting on and under the bridge, landscaping, improved accessible route, roadway signage and interpretive wayfinding. We have prioritized the work based on safety of the bridge first, followed by arresting sources of damage, stabilizing and restoring the bridge, and finally bringing the beauty and permanence back to the bridge and creekway.

Priority One - Immediate Structural

- The joints of the arch rings are currently being grouted as recommended.
- Repair sanitary sewer leak.
- Remove trees within 50 ft. of the bridge to stop root growth inside the structure.
- Kill all vegetation growing on, or immediately adjacent to the bridge.

Priority Two - Remaining Structural

- Rebuild wing walls.
- Repoint remaining mortar joints.
- Rehabilitate south parapet and reconstruct north parapet.

Priority Three - Pavement

- Remove asphalt pavement, sidewalks, guard fence, and signs.
- New concrete pavement, sidewalks, curb and gutter, and street signs.

Priority Four - Creekway and Lighting

- Regrade creekway channel.
- New accessible trail and rebuild creekway trail.
- Bridge and creekway trail lighting.

Priority Five - Interpretive Signs, Landscape, Wayfinding, and Plantings

- Remove paint from stone.
- Street furniture and totems.
- Interpretive and wayfinding signs.
- Landscape stonework and plantings.

West 6th Street Bridge at Shoal Creek

Engineer's Opinion of Probable Cost

https://www.municode.com/library/tx/austin/codes/standard_specifications_manual

Priority	Category	Item	Quantity	Unit	Unit Price	Amount	Comments
Allocated		Prep ROW	1	AC	$ 10,000.00	$ 10,000.00	
		Mobilization & Contractor's General Requirements	1	LS	$ 335,000.00	$ 335,000.00	
		Project Signs	1	LS	$ 2,000.00	$ 2,000.00	
Priority One	Immediate Structural	Remove bats	1	Allowance	$ 10,000.00	$ 10,000.00	*Removal of Bats is underway (March 2016) by Bat Conservation International
		Grout & Repoint masonry joints barrel vaults	5,600	SF	$ 55.00	$ 308,000.00	*Grouting is underway (March 2016) by City of Austin Public Works
Priority Two	Remaining Structural	Remove trees & kill vegetation	1	LS	$ 12,000.00	$ 12,000.00	
		Apply root barrier at wing walls	700	SF	$ 10.00	$ 7,000.00	By City of Austin
		Stone - Repair stone-lined storm drainage tunnels	1	LS	$ 12,000.00	$ 12,000.00	NW tunnel has localized collapse ~20ft in. SW tunnel has 18-inch clay tile beginning at ~20ft in. NE tunnel conveying sewage. SE tunnel abandoned.
		Bridge parapet - new north railing	315	SF	$ 55.00	$ 17,000.00	Match stone work of south parapet
		Bridge parapet - restore south parapet	90	LF	$ 300.00	$ 27,000.00	Includes internal reinforcement
		Reconstruct two wing walls	300	SF	$ 100.00	$ 30,000.00	100% of joints
		Repoint spandrel walls & piers	3,000	SF	$ 12.00	$ 36,000.00	100% of joints
		Guardrails at parapet ends	60	LF	$ 150.00	$ 9,000.00	30% of joints, 5x90x2ea x30%
Priority Three	Pavement	Remove existing sidewalks	400	SY	$ 25.00	$ 10,000.00	
		Remove existing curb & gutter	400	LF	$ 10.00	$ 4,000.00	
		Temporary Traffic Control & Barricades	10	MOS	$ 5,000.00	$ 50,000.00	
		Vehicular signage, markings & controls	1	LS	$ 10,000.00	$ 10,000.00	
		Remove exisiting metal beam guard fence	90	LF	$ 20.00	$ 2,000.00	
		Remove signs, parking appurtenances	1	Allowance	$ 5,000.00	$ 5,000.00	
		Remove exisiting HMAC pavement	2,000	SY	$ 5.00	$ 10,000.00	300'x4'
		TY C HMAC Pavement	130	TON	$ 110.00	$ 14,000.00	300x60
		Concrete Pavement (Continuously Reinforced)	150	CY	$ 1,000.00	$ 150,000.00	210x44 - approaches
		Concrete Curb & Gutter	400	LF	$ 30.00	$ 12,000.00	90x60x6" plus 10x60x8"x2 EA Sleeper slab, full width
		Brick Paver Sidewalks	400	SY	$ 75.00	$ 30,000.00	
		Concrete Sidewalk - extension beyond bridge	200	SY	$ 75.00	$ 15,000.00	200'x9'x2EA at street level
		Colored Stamped Concrete	350	SY	$ 125.00	$ 44,000.00	Bridge deck proper
		Adjust existing telecom duct on bridge	1	LS	$ 15,000.00	$ 15,000.00	200x9x2EA
Priority Four	Creekway and Lighting	Lighting - bridge rail	1	LS	$ 20,000.00	$ 20,000.00	
		Lighting - arch spandrel	1	LS	$ 20,000.00	$ 20,000.00	300'x80' street level, 400'x30' creek level
		Lighting - vaults	1	LS	$ 20,000.00	$ 20,000.00	
		Lighting - pathway	1	LS	$ 10,000.00	$ 10,000.00	400'x5' beneath bridge, 200'x4'x2EA
		Landscape - Channel Grading	1,000	SY	$ 30.00	$ 30,000.00	200' x 2 EA
		Creekway Trail - concrete walkway	140	SY	$ 20.00	$ 3,000.00	
		Access Trail - concrete walkway	130	SY	$ 20.00	$ 3,000.00	
		Repair scoured pedestrian walkway	1	LS	$ 5,000.00	$ 5,000.00	
		ADA compliant grate (special fabrication)	2	EA	$ 1,000.00	$ 2,000.00	This appears to SW Bell lines. The arches were cut when it was installed originally.
		Trail Guardrail	440	LF	$ 150.00	$ 66,000.00	
		Metal light covers	600	LF	$ 200.00	$ 120,000.00	
		Landscape - Temporary Irrigation	1	LS	$ 10,000.00	$ 10,000.00	90 LF Rock Berm, 1,000 LF Silt Fence, 1,000 LF Mulch Sock, 10 EA Tree Protection, 1 EA Stab Const Entrances
Priority Five	Interpretive Signs, Ladscape, Wayfinding, and Plantings	Monument sign or totems	4	EA	$ 5,000.00	$ 20,000.00	3 rows at 300 LF
		Wayfinding signs	4	EA	$ 400.00	$ 2,000.00	20% of Direct Costs
		Interpretive signs or panels	1	LS	$ 1,000.00	$ 1,000.00	
		Paint removal from stone	300	SF	$ 40.00	$ 12,000.00	Special fabrications
		Landscape - Plants (5 gal)	100	EA	$ 100.00	$ 10,000.00	
		SWPPP, Erosion Controls, Tree Protection	1	LS	$ 45,000.00	$ 45,000.00	
		Landscape - Terraced Stonework	300	LF	$ 400.00	$ 120,000.00	
		Total Construction Cost				**$ 1,705,000.00**	
		Design Fees	14%			$ 240,000.00	
		Testing & Inspection	3%			$ 50,000.00	
		Contingency	10%			$ 200,000.00	
		Total Project Cost				**$ 2,195,000.00**	

** Excludes escalation, City of Austin project management and administrative fees, land surveying, and fees for hydraulics analysis*

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 restoration work, an appropriate contingency should be maintained in the project budget.

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Additional Historical Documents

The available documents did not illustrate or describe the original conditions of the bridge side rails, nor any subsequent modifications that have apparently been made to the rails, or the paving materials at the bridge. The study team conducted independent research at the Austin History Center and with the Texas Department of Transportation communications and photogrammetry divisions, to locate images or other information related to the original side rail conditions and paving materials, with limited success.

The bridge is depicted in fire insurance maps of Austin, prepared by the Sanborn Map Company in 1894, 1900, 1935 and 1961. The bridge is depicted without parapets in the earlier maps, and simply as "stone bridge" with parapets on each side, in the later maps. It is important to note that the purpose of the fire insurance maps was to document buildings and construction data and the maps were used to estimate the potential risk to urban structures in the event of fire. As such, the bridge construction may not have been recorded in great detail on the fire insurance maps.

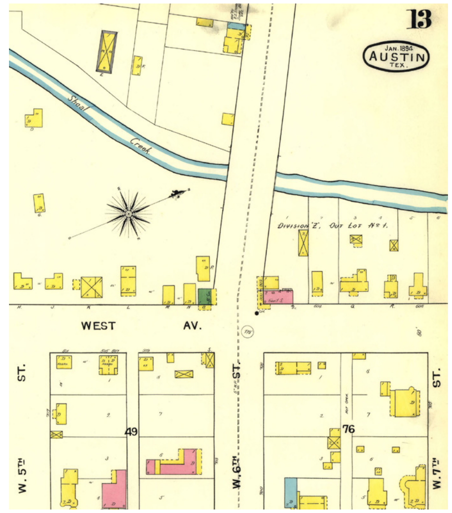
A series of photographs taken near the bridge, after a monumental flood on Shoal Creek on April 22, 1915, show conditions on West Sixth Street to the west of the bridge. The flood waters rose so high that the blocks on either side of the bridge were inundated, and the street cars couldn't cross the bridge. Witness accounts describe houses being washed down the creek and piling up around Sixth Street, so any existing bridge parapets may well have been damaged in the flood. However, none of the photographs of this event in the collection of the Austin History Center show the bridge itself; only views to the west of the bridge were found.

Regarding the original paving materials at the bridge, the documentation located to date is also limited. Street paving in Austin began in 1905, with the first increment of brick paving installed on Congress Avenue. The paving spread from there, and a reference in the February 28, 1911 City Council minutes approved paving a portion of West Sixth Street, from San Antonio Street to West Avenue, with bitulithic (asphalt) pavement. It is not clear when the bridge, itself, was paved, but Plate 2 of *A City Plan for Austin*, completed in 1928, shows Sixth Street paved out to West Lynn Street.

Later photographs show the installation of new street lighting along West Sixth Street near the bridge in 1939. In 1940, the street car tracks were removed from West Sixth Street, and the ruts infilled and paved over with new asphalt.

Two later photographs showing the bridge itself were located, but do not provide much useful detail about the parapets. An image taken at Sixth and Bowie around 1945, looking east towards the bridge, is obscured by vehicles where the parapets would show, but does offer information about sidewalk and street lighting at that time. An image taken from the east bank of Shoal Creek after the Memorial Day flood in 1981, looking north toward the bridge, shows the parapet on the south side of the bridge.

Finally, the Texas Department of Transportation had few images of the bridge in their collection, since it is not located on a state highway. The earliest aerial view of the bridge, taken in 1964, appears to show stone parapets on both the north and south sides of the bridge.



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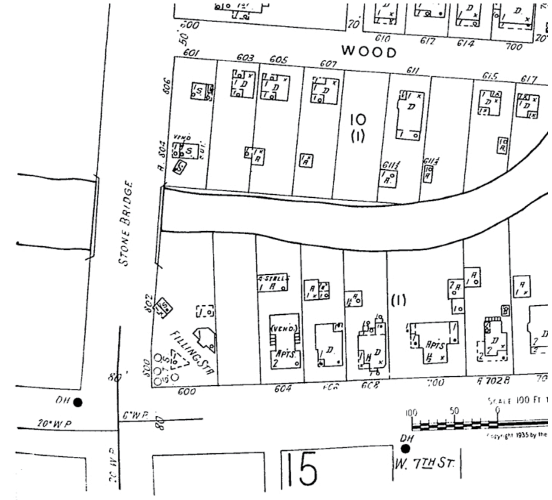

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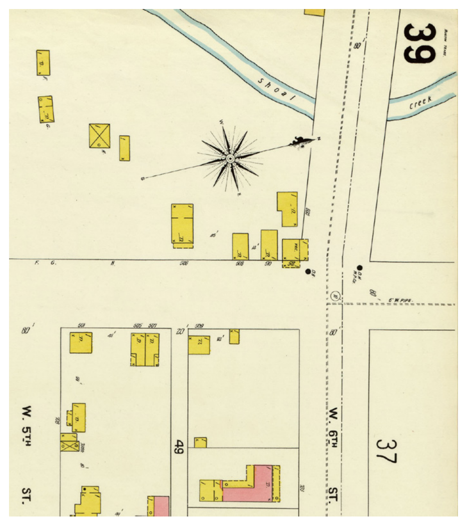

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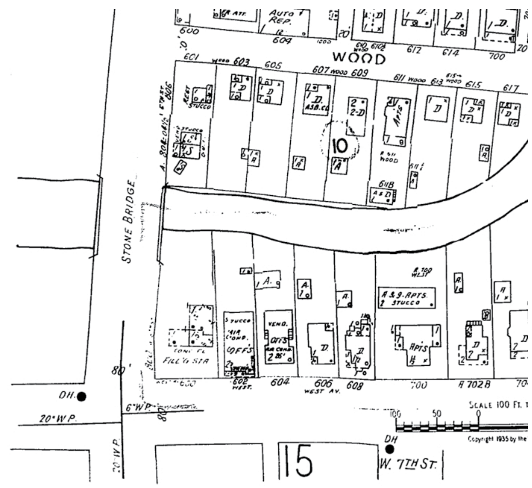

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Photo 1: West Sixth Street at Wood Street, looking west, 1915. CO 8563, Austin History Center, Austin Public Library.

Photo 2: West Sixth Street at Wood Street, looking west, 1915. CO 8527, Austin History Center, Austin Public Library.

Photo 3: West Sixth Street at Wood Street, looking west, 1915. CO 8529, Austin History Center, Austin Public Library.

Photo 4: West Sixth Street at Wood Street, looking west, 1915. CO 8541, Austin History Center, Austin Public Library.

Photo 5: West Sixth Street at Wood Street, looking west, 1915. CO 8535, Austin History Center, Austin Public Library.

Photo 7: West Sixth Street at Bowie Street, looking east, ca. 1945. PICA 26808, Austin History Center, Austin Public Library.

Photo 6: West Sixth Street, looking east, new street lighting, 1939. PICA 05082, Austin History Center, Austin Public Library.

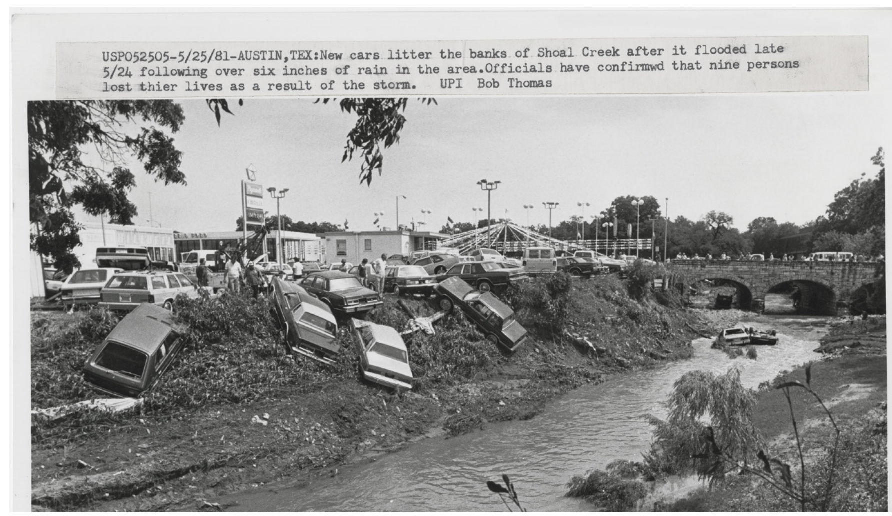

Photo 8: Shoal Creek, looking north, after Memorial Day flood, 1981. CO 8541, Austin History Center, Austin Public Library.

Aerial view, West Sixth Street bridge, 1964. North is at the bottom of the image. Texas Department of Transportation.

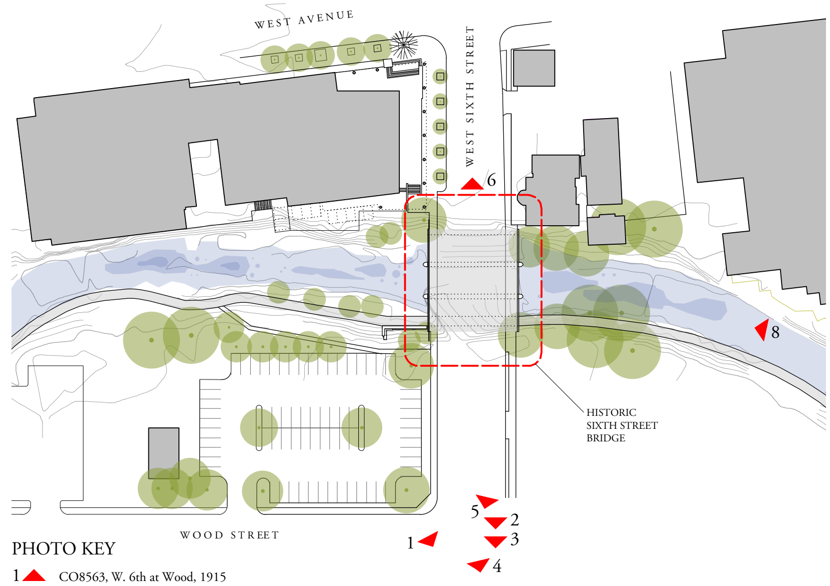

PHOTO KEY

1 ▲ CO8563, W. 6th at Wood, 1915

2 ▲ CO8527, W. 6th at Wood, 1915

3 ▲ CO8529, W. 6th at Wood, 1915

4 ▲ CO8541, W. 6th at Wood, 1915

5 ▲ CO8535, W. 6th at Wood, 1915

6 ▲ PICA 05082, New street lighting, W. 6th Street, 1939

7 ▲ PICA 26808, W. 6th Street at Bowie, ca. 1945

8 ▲ PICA 29471, Shoal Creek, Memorial Day Flood, 1981

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