# Appropriate Treatments and Techniques for the Maintenance and Rehabilitation of Historic Bridges

PennDOT District 6-0, April 24, 2018

Pennsylvania State Historic Preservation Office
PENNSYLVANIA HISTORICAL AND MUSEUM COMMISSION

pennsylvania
DEPARTMENT OF TRANSPORTATION

# Outline

Introduction to the Standards

Application by Type

- Covered Bridges
- Stone Arch Bridges
- Metal Truss Bridges
- Concrete Arch Bridges

# Standards: Section 106 and Section 4(f)

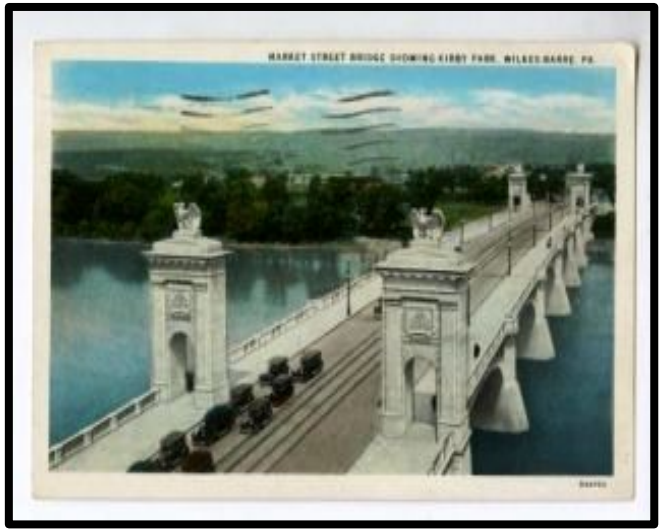
- Can a historic bridge can be rehabilitated in a manner that preserves historic character while meeting purpose and need?

- Avoid or minimize adverse effects under Section 106

- Avoid use under Section 4(f)

# Historic Bridge

- National Register eligible or listed
- Engineering or historic significance
- Contributing to historic district
- Statewide Historic Bridge Inventory



# Standards Goals

- Preserve historic materials and character
- Identify early
- Consider during maintenance and project planning

# Character Defining Features

- Visual (aesthetics) and physical features

- Allow bridge to convey significance

- Includes design features, materials, craftsmanship, connections, and decorative detailing

# Secretary of the Interior's Standards

- Administered by National Park Service
  www.nps.gov/tps

- Broad concepts

- Preservation, Rehabilitation, Restoration, and Reconstruction

# Maintenance

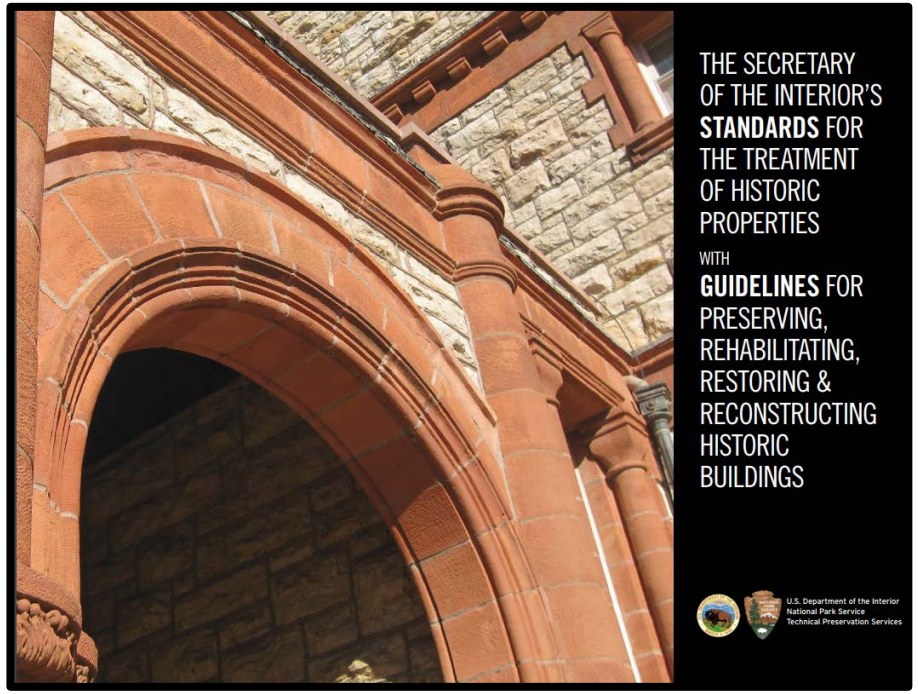
Emphasis is on retention and repair of historic materials, features, finishes, spaces, and spatial relationships with more latitude provided for replacement of deteriorated or missing features.

# Rehabilitation

Acknowledges the need to alter or add to a historic resource to meet continuing or new uses while retaining the property's historic character

# Guidelines

- Hierarchy for decision making from least to the greatest level of intervention
- Document existing conditions and justify proposed work



# 1) Identify, Protect and Maintain


- Identify Character Defining Features
  - Use National Register documentation
- Develop Measures for their Protection and Maintenance
  - ***Standard 2: The historic character of a property shall be retained and preserved.***
  - ***Standard 5: Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a historic property shall be preserved.***

# 2) Repair or Replacement In Kind

- Select the least degree of intervention
- Use recognized repair methods
- Limited in kind (same visual appearance) replacement

***Standard 6. Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials.***

# 3) Use of Substitute Materials

- Extensive deterioration of feature

- Feature needs to be stronger to accommodate new or continued use

- When there is no source for the original material

***Standard 6. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials.***

# 4) Design of Missing Features

- Replicate using documentation
- If no documentation of feature, replacement feature compatible with bridge is acceptable
- Differentiate new work from the old

***Standard 6. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.***

***Standard 9. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features.***

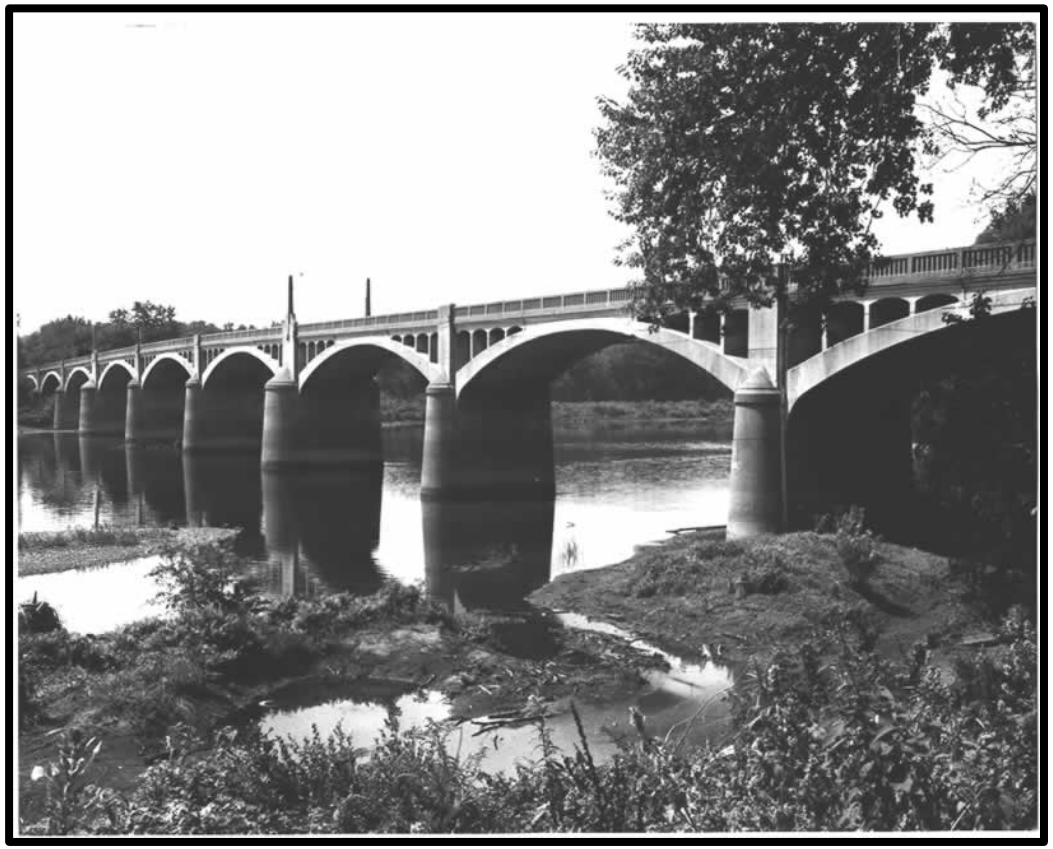
# Continued Use: Common Issues

Repair and/or Replacement In-Kind of bridge components

Load Issues – Increase carrying capacity

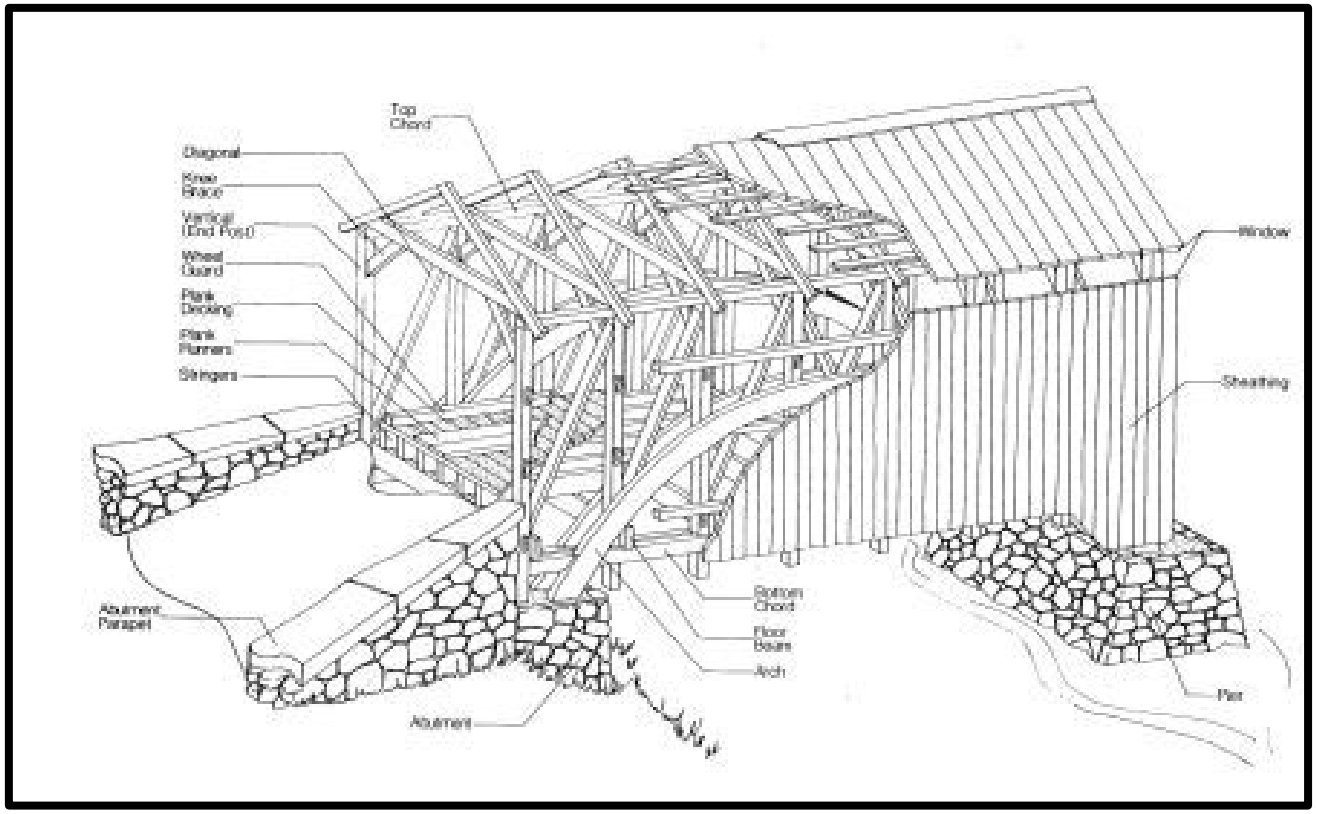
Vertical and/or Horizontal Clearance

Adaptive Re-use



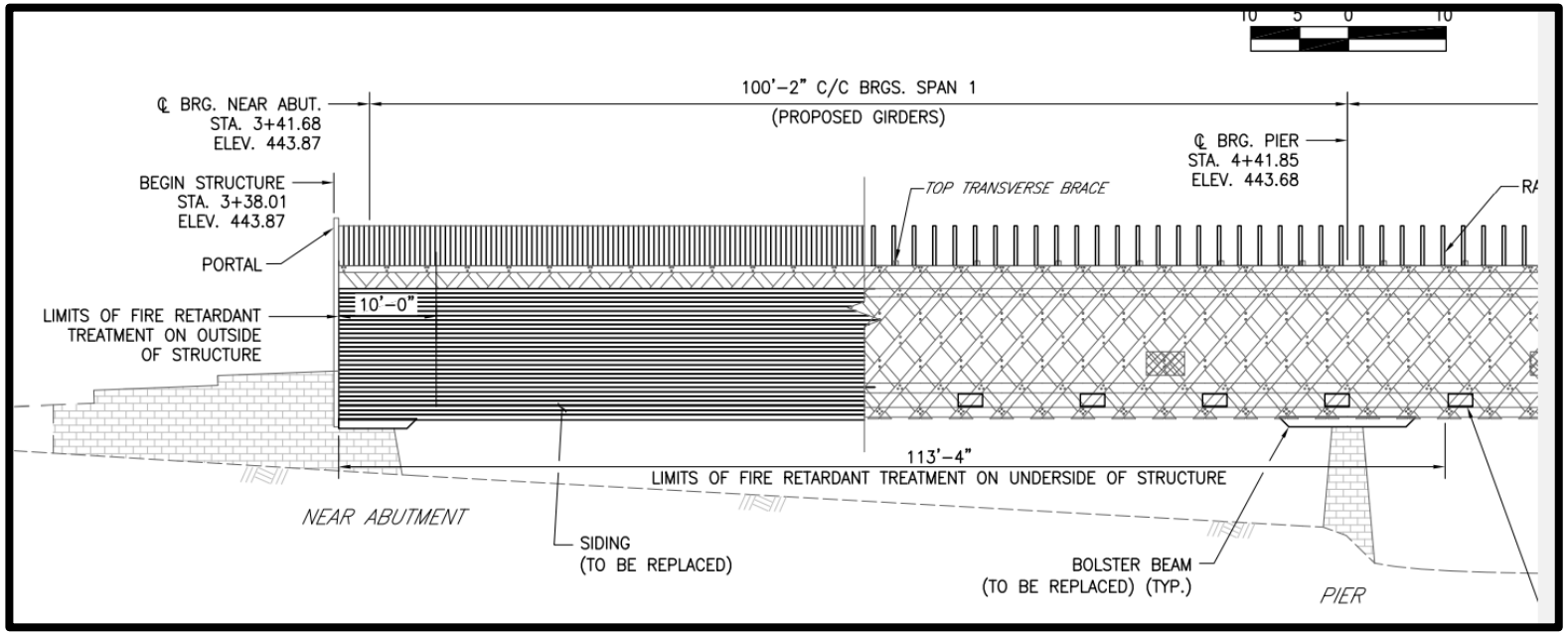
# Covered Bridges
# Character-Defining Features

- Heavy Timber Truss
- Floor system
- Overhead bracing
- Connections



# Covered Bridges Maintenance
# Preventative or Protective Measures: Fire

- Treatment of wood with fire retardant chemicals
- Installation of fire alarms or suppression (sprinkler) systems and video cameras



# Covered Bridges Maintenance
# Collision Damage

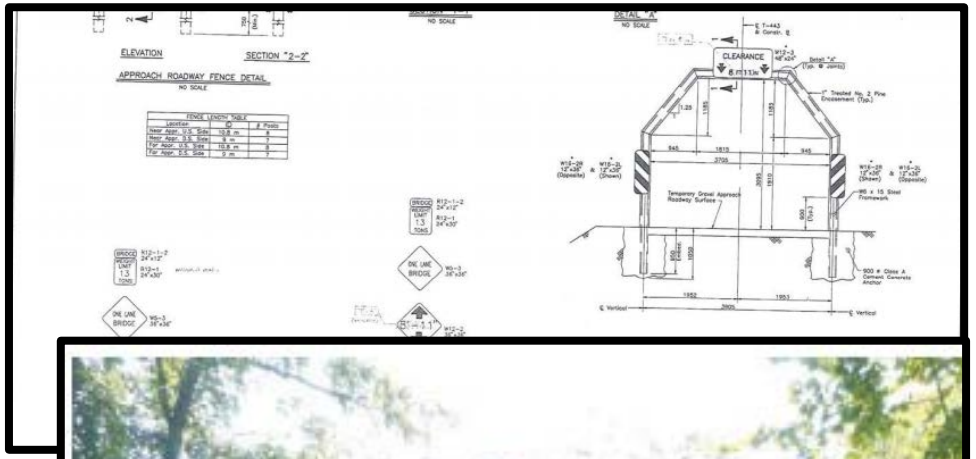
On 3/29/2018 Oversized vehicle hit Rapps Dam Road over French Creek in East Pikeland  Township.

Bridge on National Register of Historic Places.

# Covered Bridges Maintenance Preventive or Protective Measure:

## Oversized Vehicles

- Introduction of horizontal bars
  (headache bars)
- Speedbumps at or before the portals
- Warning signs
- Timber curbing

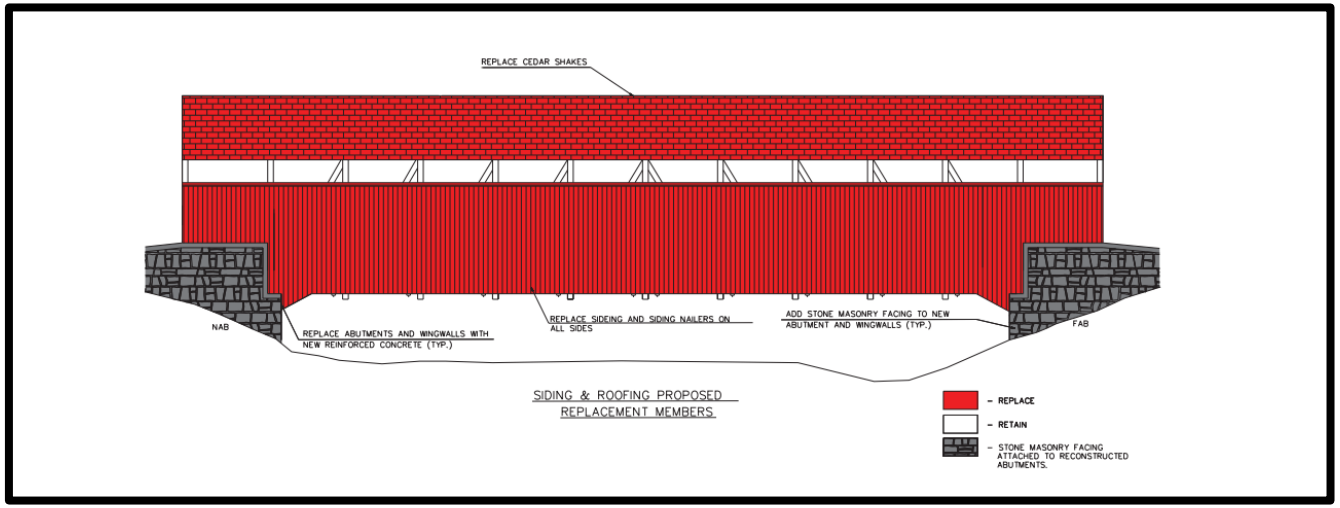



# Covered Bridges Maintenance
# Replacement In-Kind

**Potential Maintenance Activities**

PennDOT CRPs and PA SHPO Consultation Required

Replacement of the deck, siding, roof or flooring system

# Covered Bridges Rehabilitation

Speakman's Bridge Project

Built in 1881

Frog Hollow Road (SR 3047) over Buck Run

West Marlbourgh and East Fallowfield Townships, Chester County

Listed on National Register of Historic Places

Single span, Burr-Arch truss, timber covered bridge

# Covered Bridges Rehabilitation

Speakman's Bridge Project

## Pre Rehabilitation Conditions

Bridge sustained fire damage in 2004 and closed in 2011 when tractor trailer collided with it.


# Covered Bridges Rehabilitation

Speakman's Bridge Project

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Speakman's Bridge Project

# Covered Bridges Rehabilitation

Speakman's Bridge Project – No Adverse Effect

Speakman's Covered Bridge`...

*Purpose:* To provide a safe and reliable crossing of Buck Run for the public. Many timber members of the structure are deteriorated. The deterioration of the structure was accelerated when the bridge caught fire in 2004. The bridge was closed in 2011 when a tractor trailer collided with it.

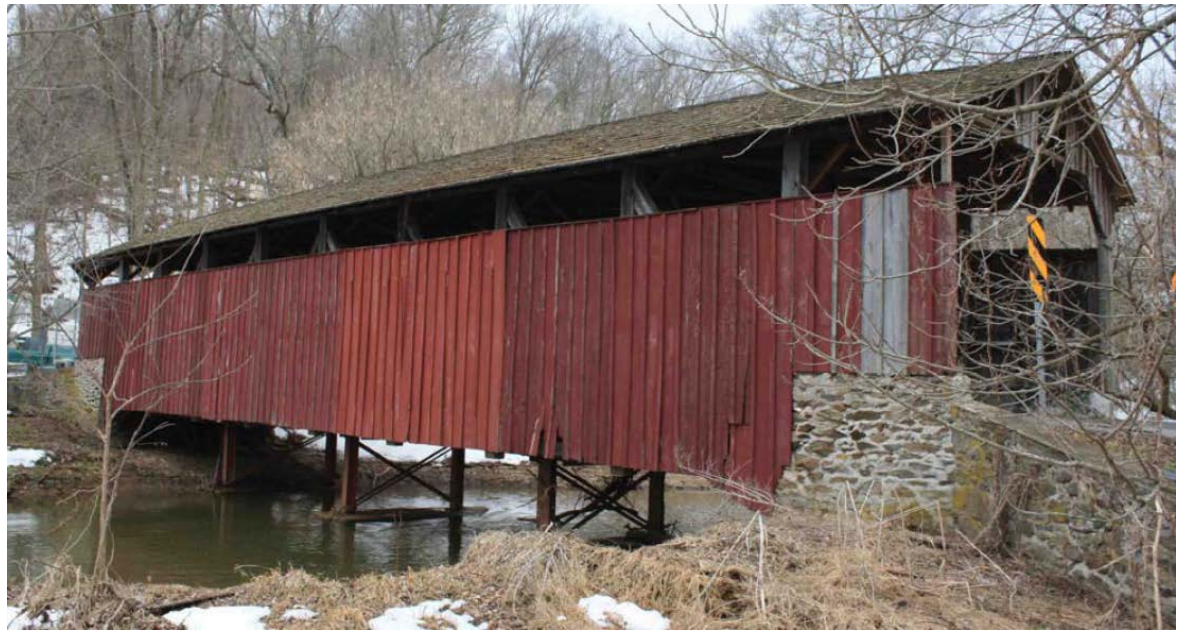
*Needs:*

- The bridge is structurally deficient and in need of repair.
- The bridge is unable to handle the modern transportation needs of the surrounding community.

# Covered Bridges Rehabilitation

Speakman's Bridge Project – No Adverse Effect

Character Defining Features:



Covered Bridge Housing

Burr Arches, Timber Trusses

# Covered Bridges Rehabilitation

Speakman's Bridge Project – No Adverse Effect

# Covered Bridges Rehabilitation

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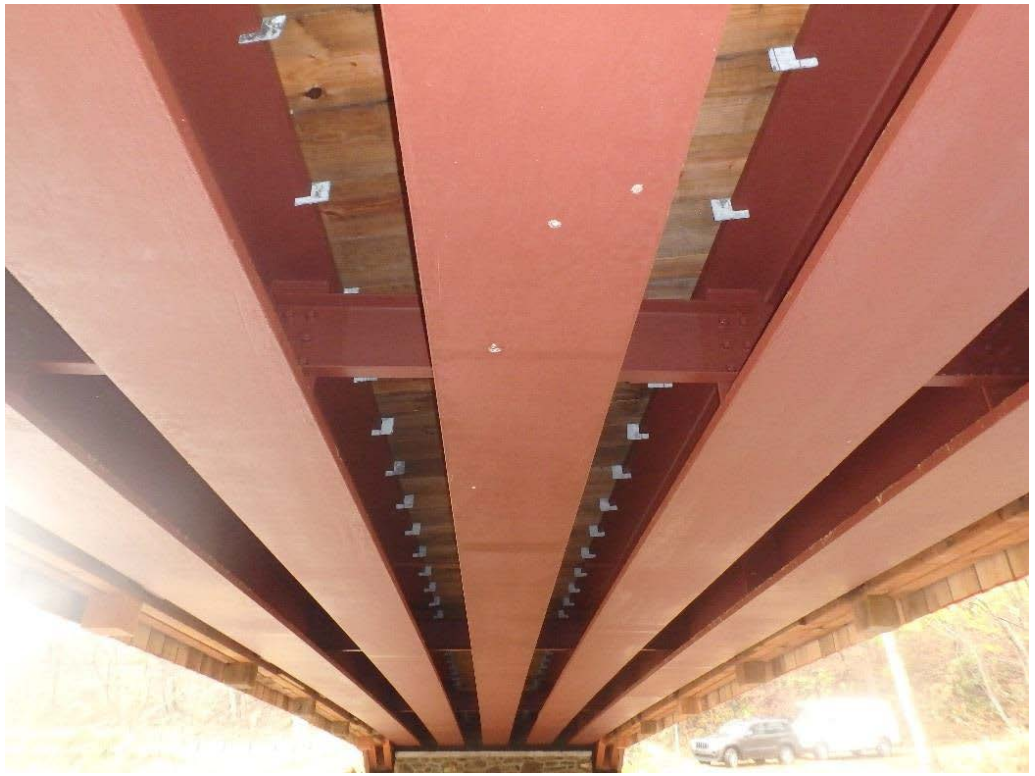
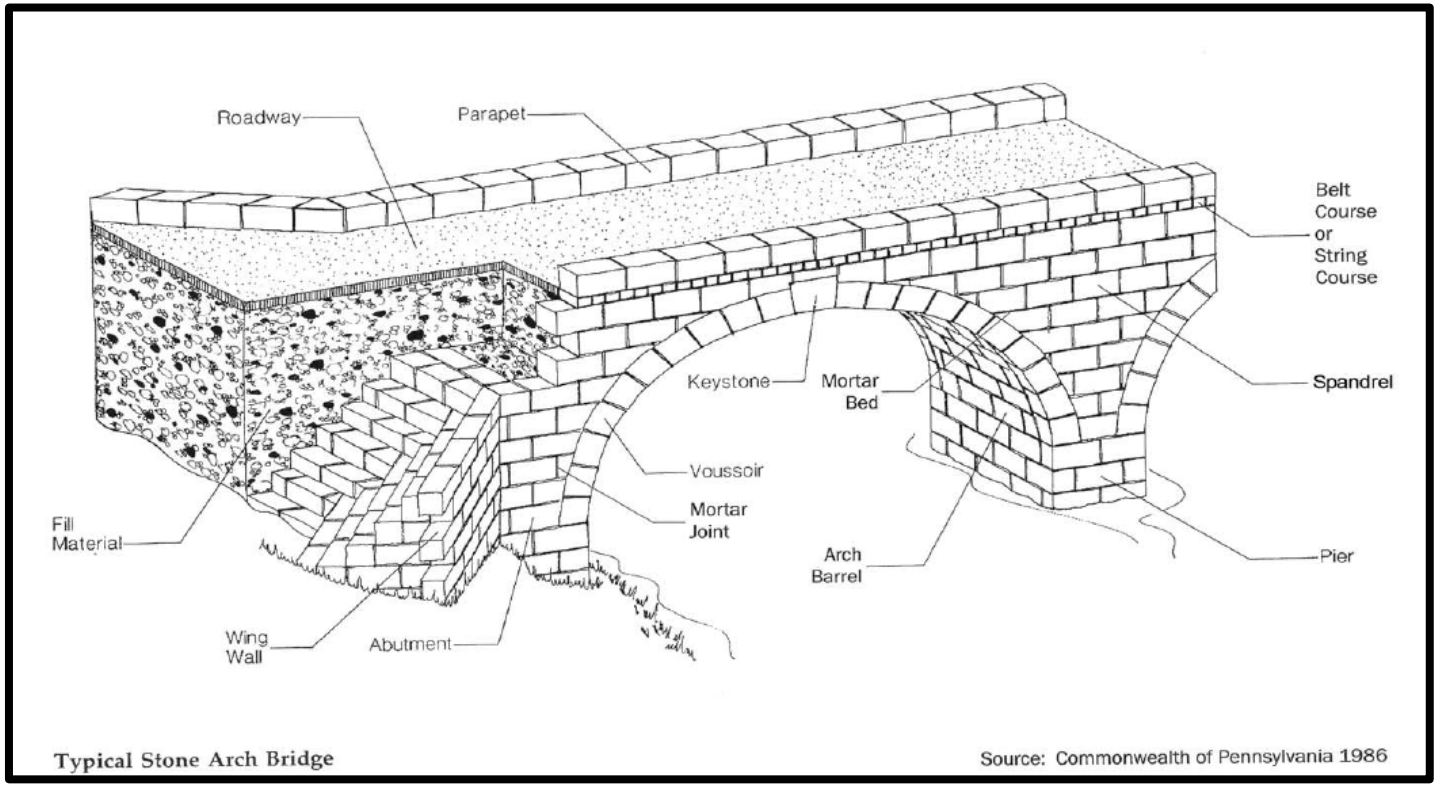
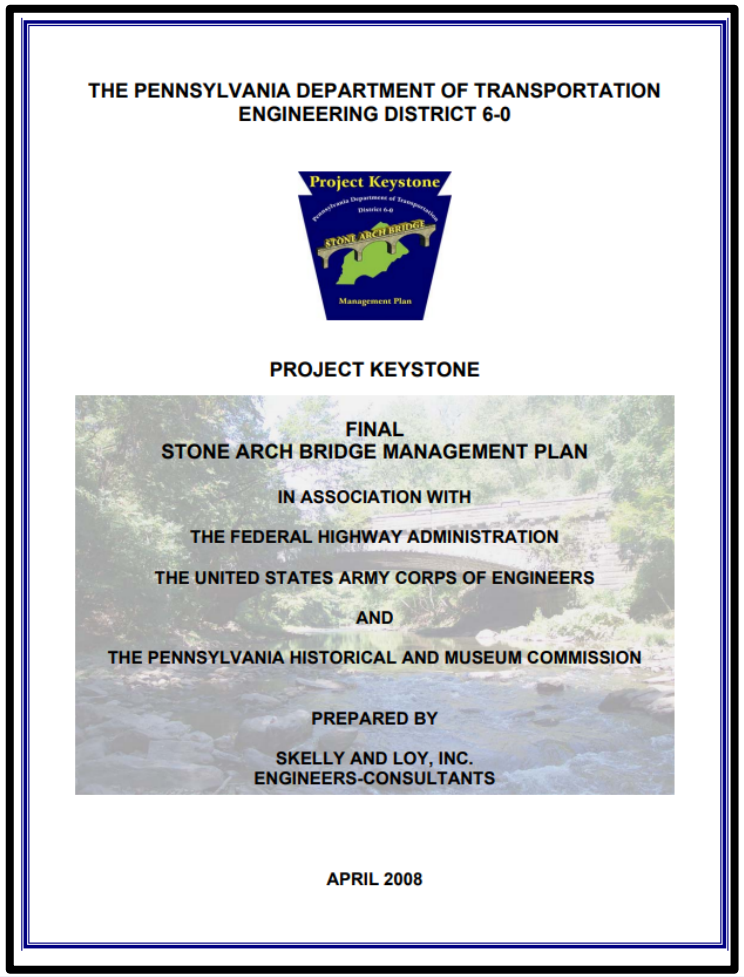


# Stone Arch Bridges
# Character-Defining Elements

- Voussoir Arch
- Stone material cut and coursing
- Stone abutments and wing walls
- Arch Barrel
- Parapet height and shape



# Stone Arch Bridges Maintenance Manual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# Stone Arch Bridges Maintenance
# Common Stone Deterioration Problems

## Water Infiltration

- Cracks
- Cyclic Freezing
- Movement
- Mortar Joint Failure
- Vegetation and accumulated debris

# Stone Arch Bridges Maintenance
# Preventive or Protective Measures

## Reducing Water Infiltration – Unacceptable Practices


**As a rule, waterproof and water-repellant coatings on historic masonry should be avoided**

# Stone Arch Bridges Maintenance
# Preventive or Protective Measures

## Reducing Water Infiltration – Unacceptable Practices

Repointed in part with Portland Cement

Poorly repointed

# Stone Arch Bridges Maintenance
# Preventive or Protective Measures

## Removing vegetation and accumulated debris


# Stone Arch Bridge Maintenance
# Unacceptable Maintenance Practice

Removing parapets and replacing with steel guide rails

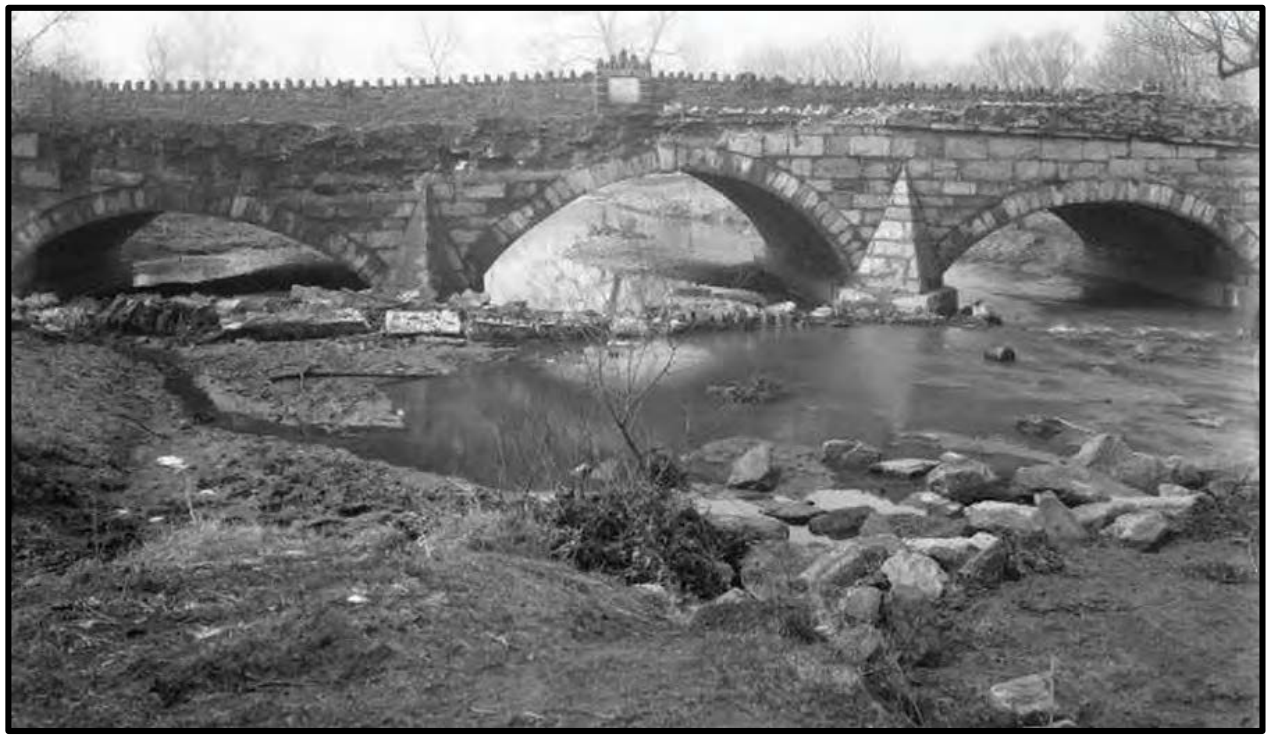
Removing parapets and replacing with metal railings, and capping the spandrels with concrete

# Stone Arch Bridges Rehabilitation

## Addressing Movement

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge



Closed-spandrel three-span masonry arch bridge

Constructed in 19th century; rebuilt 1941

Listed on the National Register of Historic Places

## Purpose and Need

**Adams Avenue (SR 1002) Bridge over Tacony Creek,**
**City of Philadelphia, Philadelphia County**

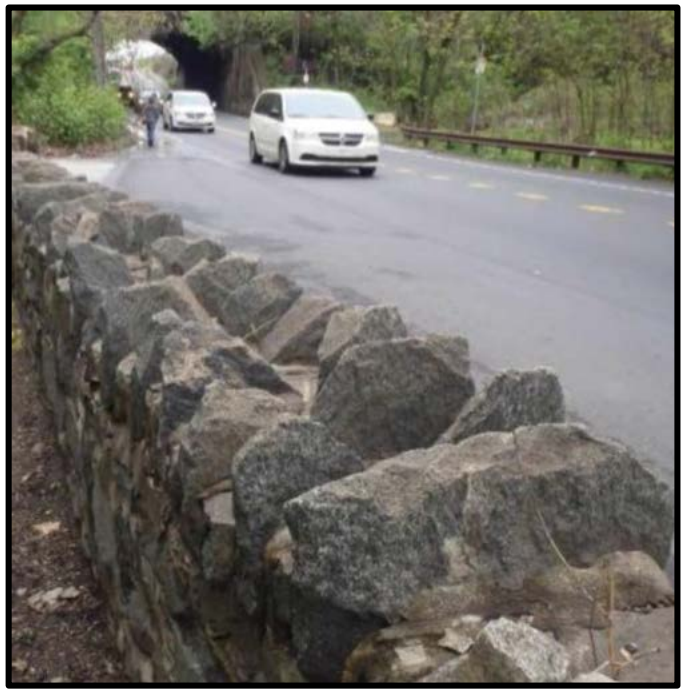
The bridge is structurally deficient due to severe deterioration of the stone masonry. The bridge is in overall "serious" condition due to the loss of mortar, stones, and flattening of the arch structure and has a sufficiency rating of 15.0. The bridge is listed on the National Register of Historic Places. The bridge has a current ADT (Average Daily Traffic) of 16,600 and is open to full legal loading. The purpose of the project is to address the structural deficiencies of the bridge and to provide a safe crossing over Tacony Creek.

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge

Character Defining Features:

Pylons



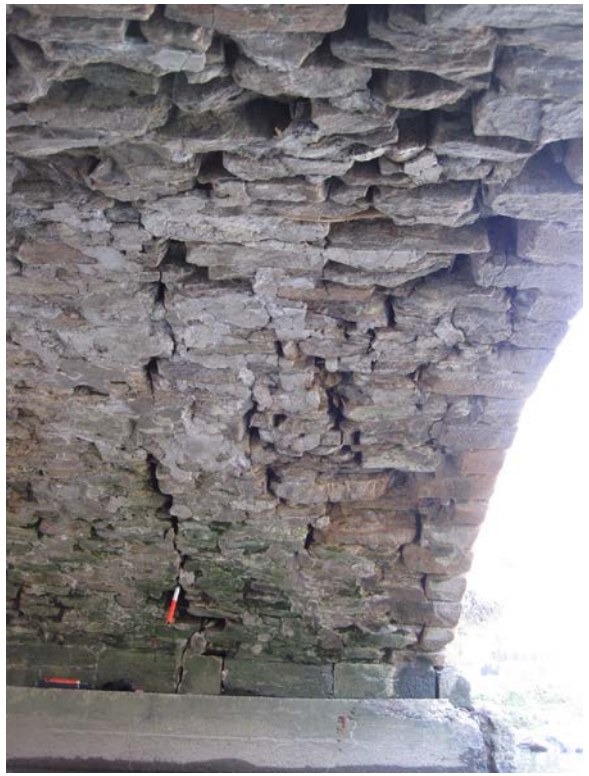
Crenelated Parapet Top

Pier Nose

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge

## Arch Intrados – Pre Rehabilitation



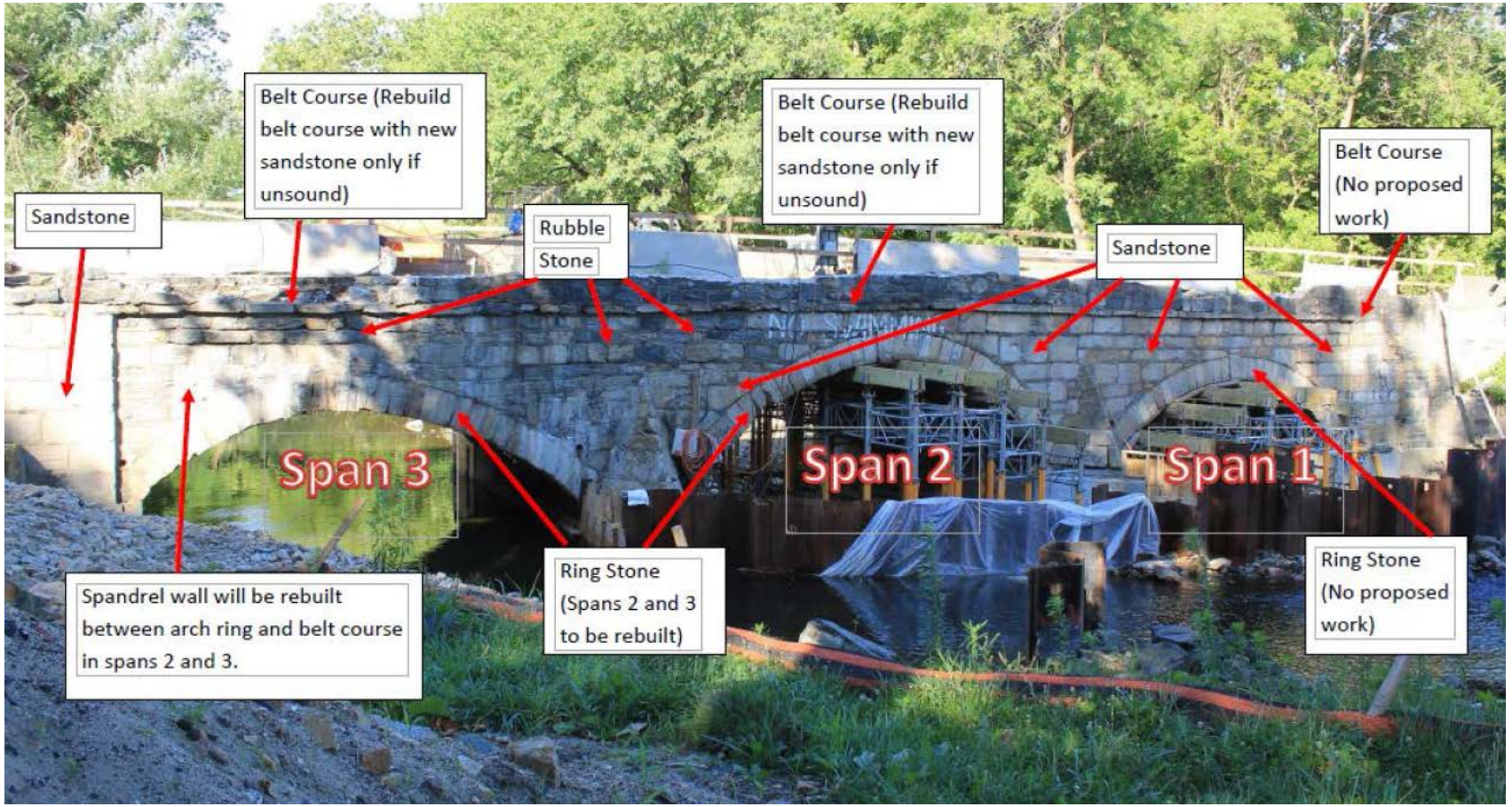
# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge

## Wing and Spandrel Wall Reconstruction

# Stone Arch Bridge Rehabilitation

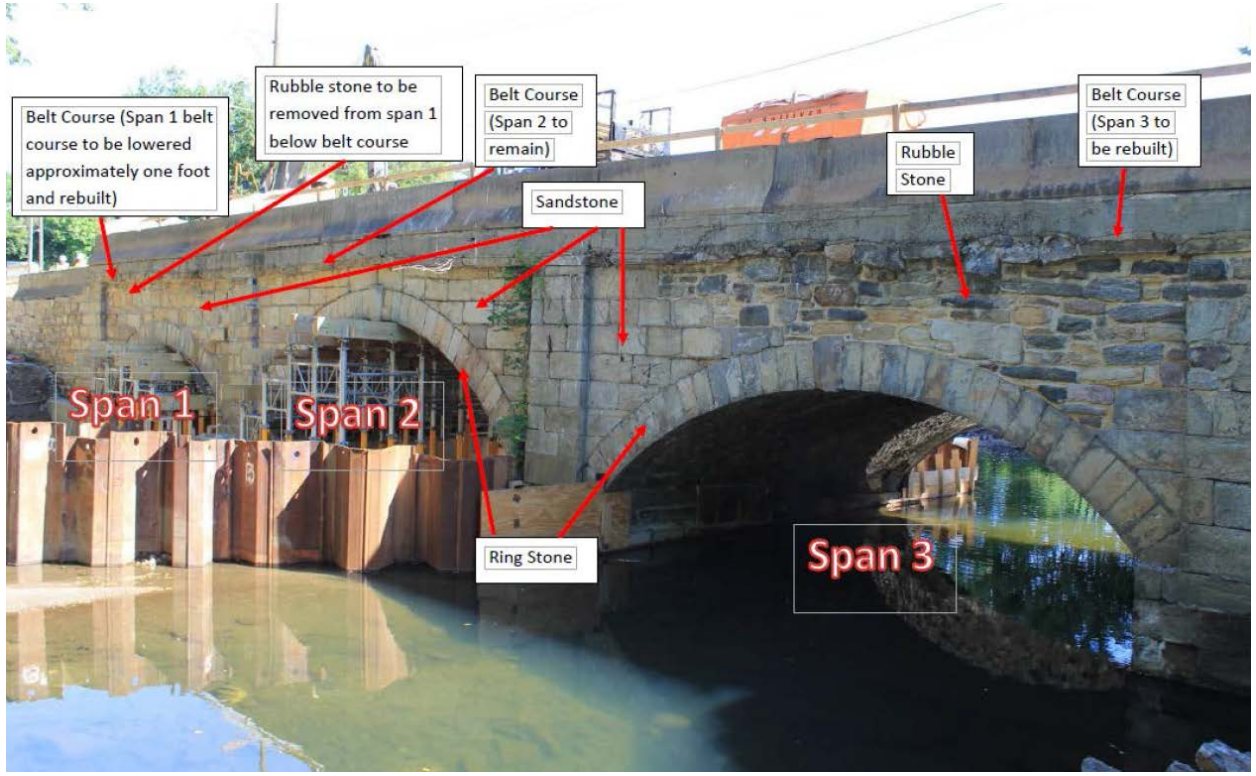
Adams Avenue Bridge – No Adverse Effect




Upstream (North) Elevation with proposed scope of work

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge – No Adverse Effect




Downstream (South) Elevation with proposed scope of work

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge – No Adverse Effect

Replication of crenelated top of parapet and pylons

Section 106 Consulting Parties – Sample Panels

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge – No Adverse Effect

Section 106 Consulting Parties – Crenelated Top

# Stone Arch Bridge Rehabilitation

Adjustments during construction

Pier 2 Left Portion of Far Face

FAB Left Corner – Large Voids

# Stone Arch Bridge Rehabilitation

Mud Slab Placement

Reinforced Concrete Apron

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge – No Adverse Effect

Arch Reconstruction

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge – No Adverse Effect

Spandrel Wall Reconstruction

# Stone Arch Bridge Rehabilitation

Adams Avenue Bridge – No Adverse Effect

Lightweight concrete fill Install

# Stone Arch Bridge Rehabilitation

Lightweight Concrete Fill, Belt Course and Spandrel Wall

# Stone Arch Bridge Rehabilitation

Salvaged Existing Stone for Facing

# Stone Arch Bridge Rehabilitation

Moment Slab and Concrete Core with Stone Facing during Construction

# Stone Arch Bridge Rehabilitation

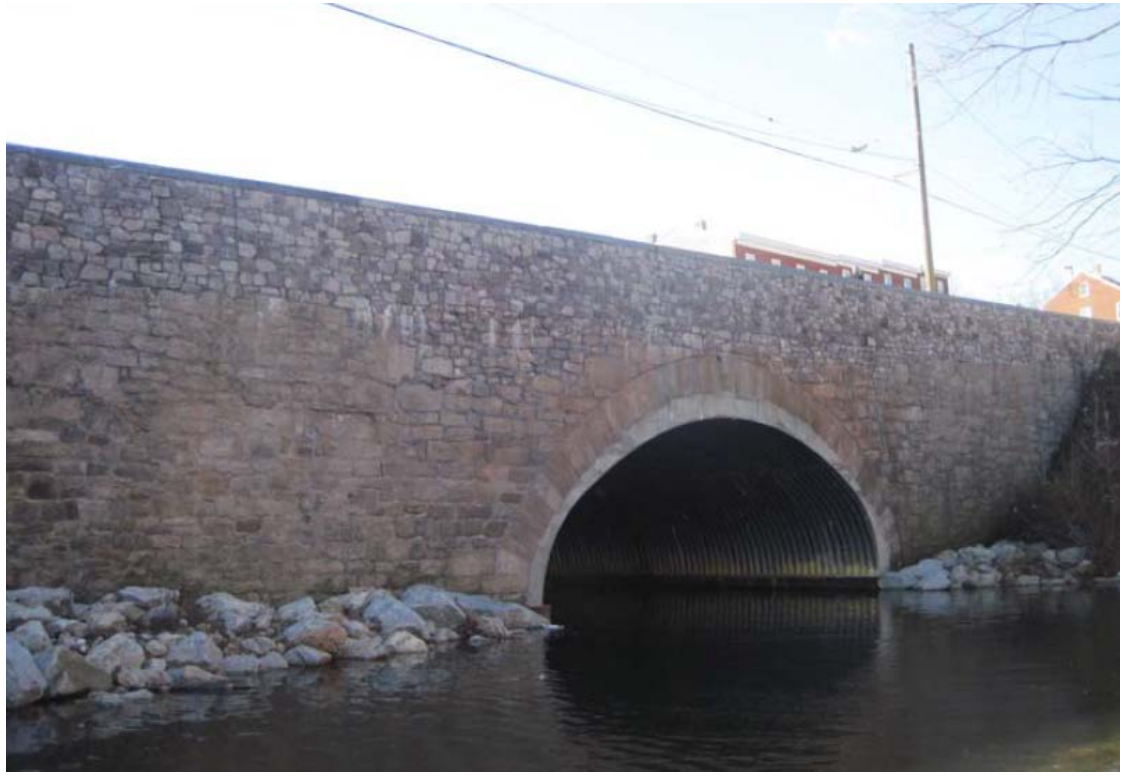
Before and After

# Stone Arch Bridge Rehabilitation

Before and After

# Stone Arch Bridge Rehabilitation

Main Street over Stony Creek – No Adverse Effect



Year Built: 1854

Single Span, 40’ long

Contributing to West Norristown Historic District

# Stone Arch Bridge Rehabilitation

Main Street over Stony Creek – No Adverse Effect

Another possible character defining feature of Stone Arch Bridge are capstones…

# Stone Arch Bridge Rehabilitation

Main Street over Stony Creek – No Adverse Effect

Approximately 80 LF of capstone was missing on north parapet due to partial collapse of the parapet into the creek.

# Stone Arch Bridge Rehabilitation

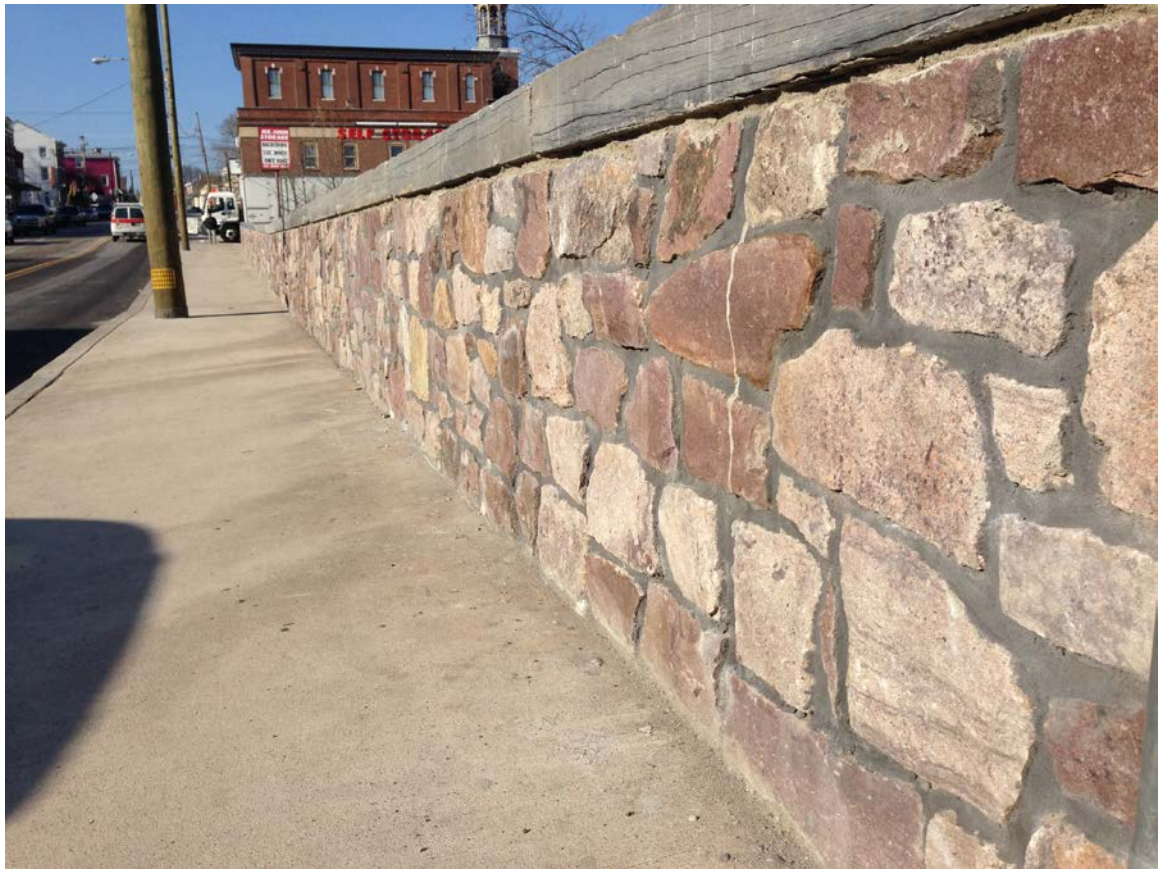
Main Street over Stony Creek – No Adverse Effect

# Stone Arch Bridge Rehabilitation

Main Street over Stony Creek – No Adverse Effect

# Stone Arch Bridge Rehabilitation

Main Street over Stony Creek – No Adverse Effect



# Stone Arch Bridge Rehabilitation

Sugan Road over Cuttalossa Creek – No Adverse Effect

Built in 1886

State Route 1002

Solebury Township, Bucks County

Contributes to a Historic District

# Stone Arch Bridge Rehabilitation

Sugan Road over Cuttalossa Creek – No Adverse Effect



Existing argillite capstones on left, proposed supplemental argillite capstones on right

# Stone Arch Bridge Rehabilitation

Mortonville Bridge – Adverse Effect

230’ four-span closed spandrel stone arch bridge

Carries Strasburg Road over the West Branch of the Brandywine Creek

Built in 1826 by Wilson Buffington

Listed on the National Register of Historic Places as a contributing element of the Strasburg Road Thematic Group

# Stone Arch Bridge Rehabilitation

Mortonville Bridge – Adverse Effect

To receive a “substantial rehabilitation” including a widening of up to four (4) feet on a cantilevered deck

# Stone Arch Bridge Rehabilitation

Mortonville Bridge – Adverse Effect

Project rebuilt and widened the bridge by six (6) feet in 2009

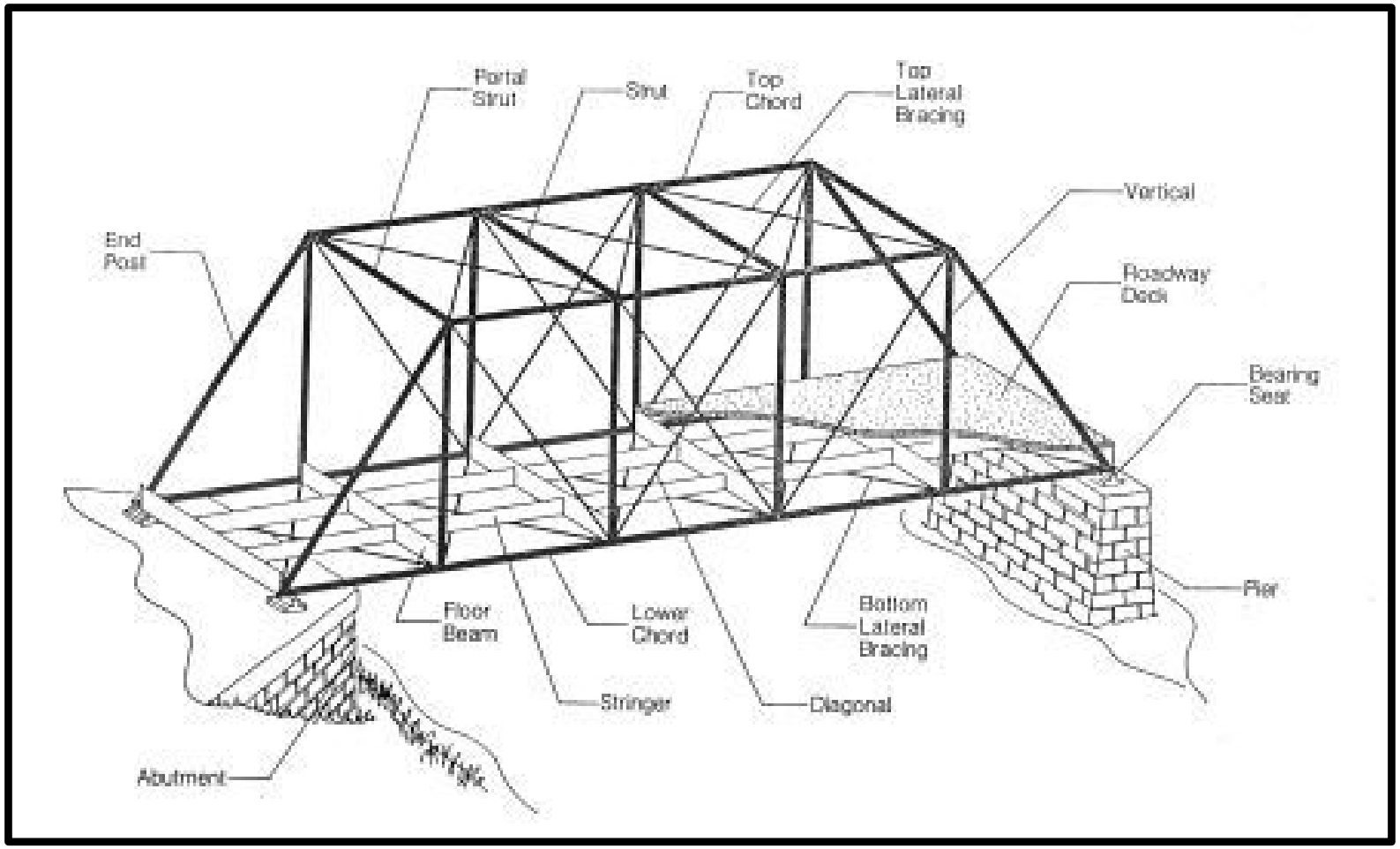
Removed from the National Register of Historic Places on July 16, 2010

# Stone Arch Bridge Rehabilitation

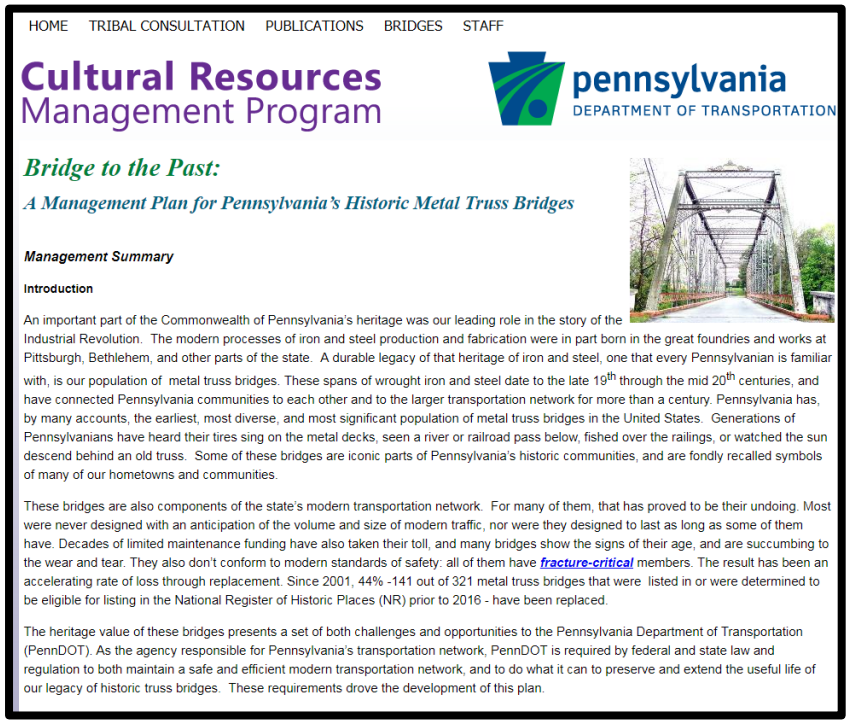
Mortonville Bridge – Adverse Effect

# Metal Truss Bridges
# Character-Defining Features

- Truss Form
- Structural Members
- Method of Connection



# Metal Truss Bridges Maintenance Manual

# Metal Truss Bridges Maintenance Preventive or Protective Measures

## Debris Removal and Rust Prevention

Truss Bearing Covered with Dirt and Debris

Flood Debris on Lower Chord and Floor System

Typical Debris Accumulation at Lower Chord Joints

# Metal Truss Bridges Maintenance
# Preventive or Protective Measures

## Maintain Decks, Joints and Drains

# Metal Truss Bridges Maintenace
# Preventive or Protective Measures

## Maintain Coating System


# Metal Truss Bridges Rehabilitation

To get to legal loads

**Low Cost Bridge Repair**

**Steel Stringer End Connection**

**Stringer Support Bracket**
PennDOT District 12-0
Westmoreland County
S.R. 993 over Brush Creek
Single span thru truss bridge, stringer ends repaired by installing steel support bracket. Rehabilitation performed to avoid a weight limit posting.

**Design:** In-House by District Personnel
**Construction:** Westmoreland County Maintenance Crew
**Duration of Construction:** 1 Week (3 man crew)
**Maintenance and Protection of Traffic:**
Lane closure over each stringer being repaired.
Cost: $4,000 Material Cost

**Stringer Support Bracket**

**Stringer Support Bracket**
**Lessons Learned:**

(1) Original design would repair deficient stringers at 5 locations and reduce the bridge's effective width. This design did not consider that this would prevent access to the bridge from a private business with a driveway adjacent to the bridge.

(2) Maintenance forces proposed 4 additional locations to avoid reducing the bridge width. Additional expense and time was minimal and provided a reasonable and cost effective solution.

# Metal Truss Bridges Maintenance
# Inappropriate Treatment Measures

Welding of pinned connections

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

Single span, pin connected steel Pratt Through Truss

Constructed in 1885

15/21 ton posted limit

Listed in the National Register of Historic Places

Rehabilitation included in ECMS 89340, Section HBS

Ross Fording Road Bridge SR 3052

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

Ross Fording Road Bridge SR 3052

Character Defining Features

Truss form

Pin Connections

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

Ross Fording Road Bridge SR 3052

Character Defining Features

Truss to Floorbeam connection

Upper chord Phoenix Column Section

# Metal Truss Bridges Rehabilitation

## Ross Fording Road Bridge SR 3052

Repair/Replacement of Components

Bridge closed on July 1, 2015, when the upstream truss of the bridge was struck by a truck. The impact resulted in complete fracture of the upstream truss upper chord east end post and partial failure of the bridge.

Bridge was rehabbed in 2013.

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

# Metal Truss Bridges Rehabilitation

## Purpose/Need – Ross Fording Road

**Project Purpose**:
The purpose of this project is to maintain the safe and effective movement of the public and emergency services.

**Project Needs:**

Due to a vehicular impact which occurred in July of 2015, the structure is currently closed to traffic. Therefore, the needs for the project are based off of the existing deficiencies present and minimizing future potential for vehicular damage and include the following:

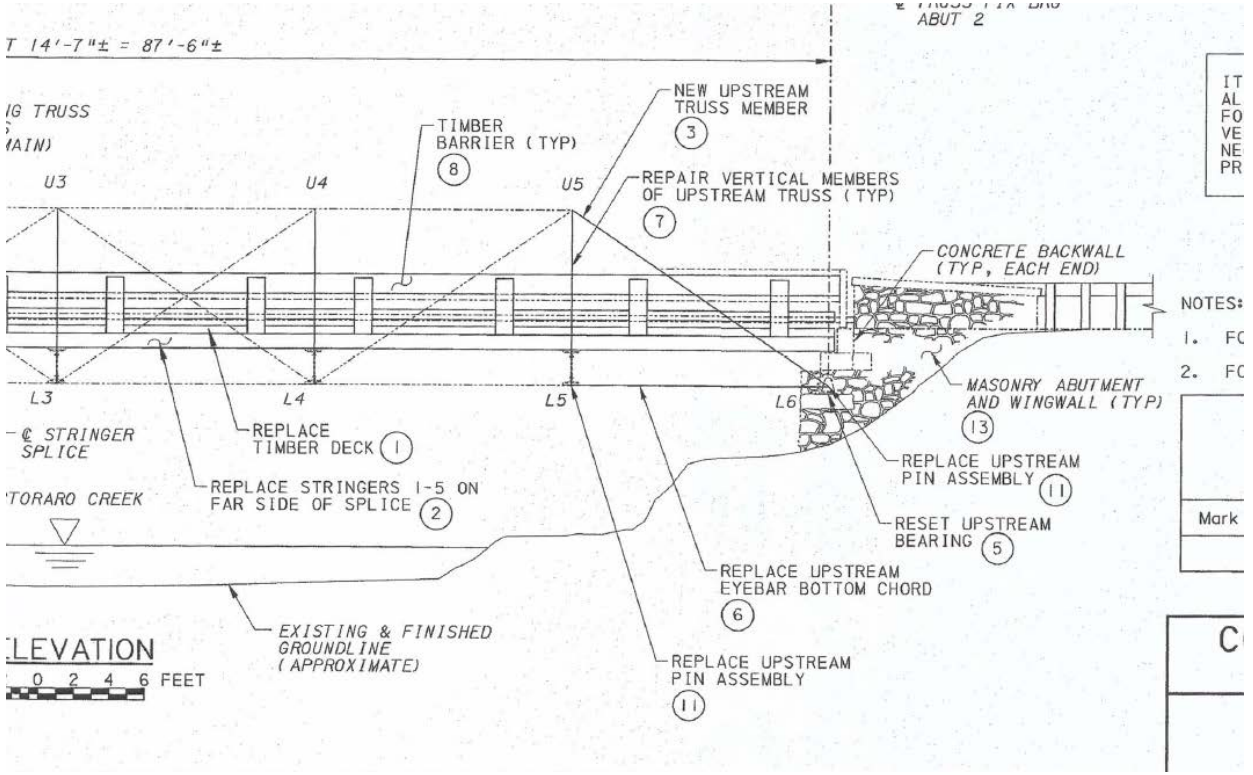
- The upstream truss upper chord is completely fractured
- The upstream truss vertical members are cracked and deformed
- The upstream truss lower chord is deformed
- The existing railing is prone to spread impact to multiple truss members
- Stringers 1 through 5 are deformed
- Based on the condition of the structure it was deemed unsafe for use and is closed

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Components

Structure to be rehabilitated in 2018
(ECMS 89340, Section HBS)

Replace timber deck.
Replace Stringers 1-5.
Replace top chord U5-L6 on upstream truss.
Replace bottom chord L5-L6 on upstream truss.
Reset bearing for upstream truss.
Replace existing timber curb w/timber barrier.



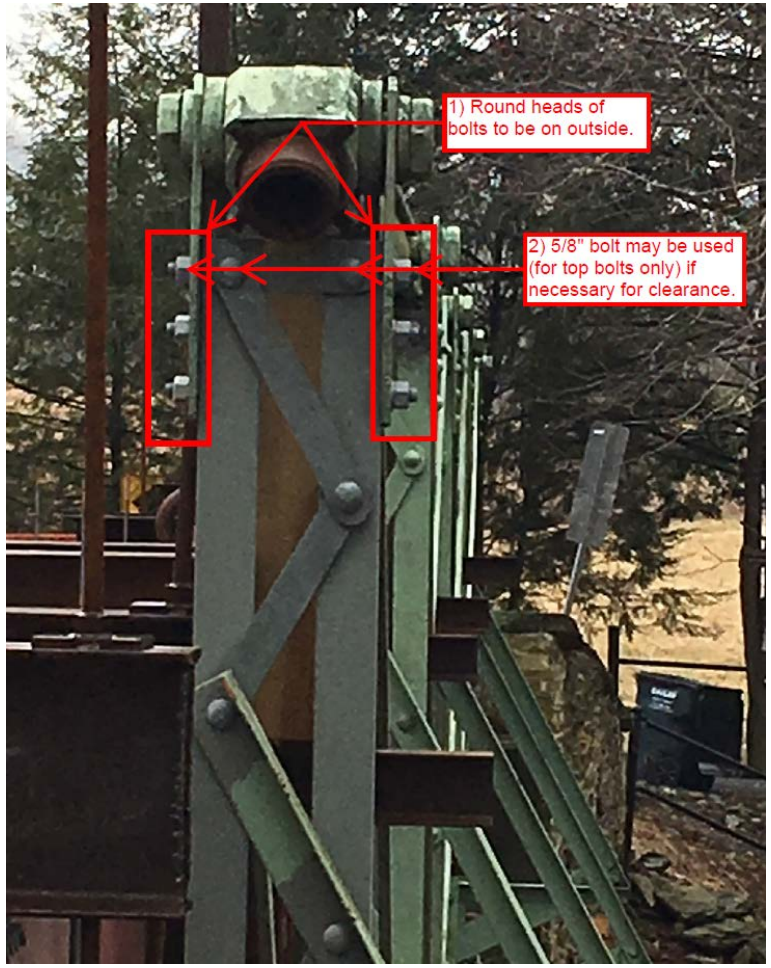
# Metal Truss Bridges Rehabilitation

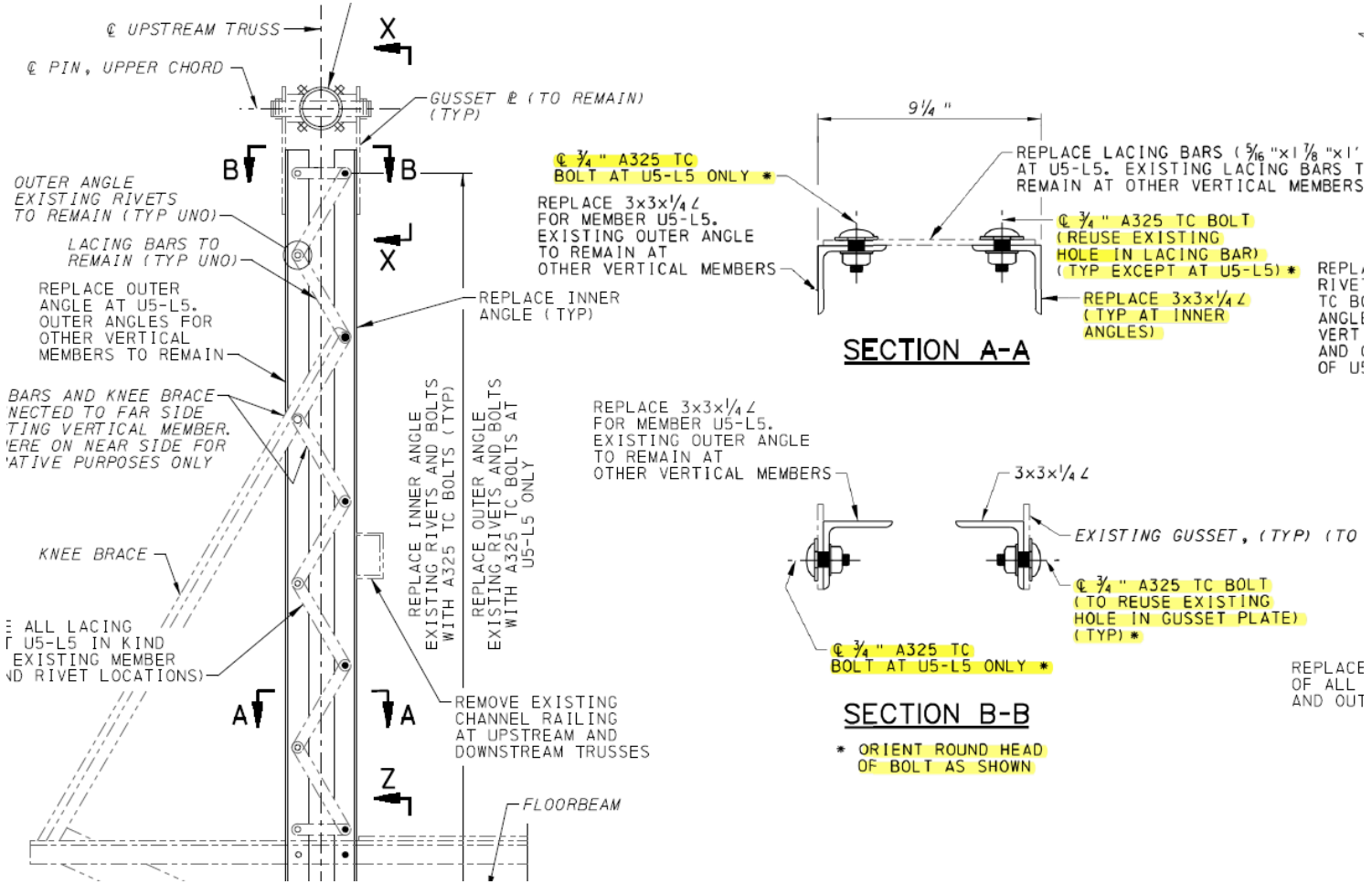
Replicating character defining features – Phoenix Column Section

Ross Fording Road Bridge SR 3052

# Metal Truss Bridges Rehabilitation

## Lessons Learned



# Metal Truss Bridges Rehabilitation

Lessons Learned

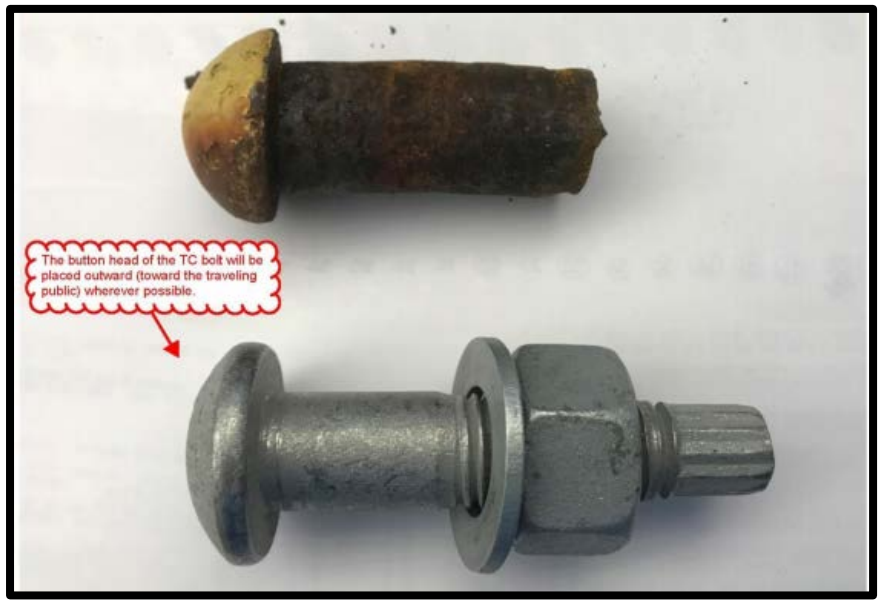
Phoenix Column storage – proper storage of significant character defining feature.

After vehicle impact Chester County Maintenance indicated they would save fractured truss section, however it was lost and scraped at the Chester County Maintenance yard.

# Metal Truss Bridges Rehabilitation

## Repair/Replacement of Connections

Ninth Street Bridge – Adverse Effect



# Metal Truss Bridges Rehabilitation

## Strengthening

Truss Member strengthening

# Metal Truss Bridges Rehabilitation

## Vertical Clearance


Substandard Vertical Clearance with Portals and Bracing Existing Collision Damage

# Metal Truss Bridges Rehabilitation

## Vertical Clearance

Modified Portal and Sway Bracing System Modified

# Metal Truss Bridges Rehabilitation

## Widening

Cambridge Springs Bridge – Adverse Effect

Single Span, 203 foot long pin-connected Pennsylvania Truss

Constructed in 1907

Uncommon surviving example of a Pennsylvania Truss Roadway bridge in the region

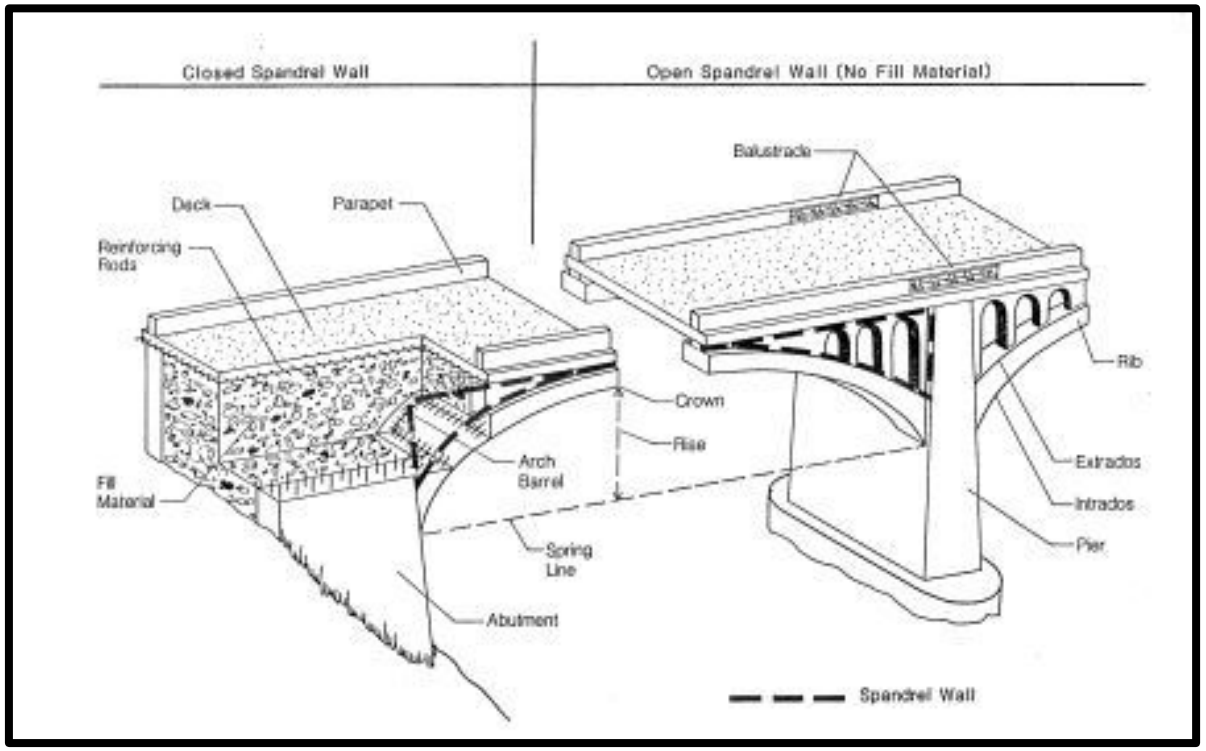
# Metal Truss Bridges Rehabilitation

## Widening

Cambridge Springs Bridge – Adverse Effect

# Concrete Arch Bridges
# Character-defining Features

- Structural system
- Decorative features
- Abutments, piers and wing walls



# Concrete Bridges Rehabilitation

Walnut Lane Bridge over Wissahickon Creek

Eligible for the National Register of Historic Places

Concrete open spandrel ribbed arch bridge, when it was constructed in 1908, it had the longest and tallest arch span in the world

The arch ribs are constructed of unreinforced concrete with embedded large flat stones

# Concrete Bridges Rehabilitation

Walnut Lane Bridge over Wissahickon Creek

# Concrete Bridges Rehabilitation

Walnut Lane Bridge over Wissahickon Creek

# Concrete Bridges Rehabilitation

Walnut Lane Bridge over Wissahickon Creek – No Adverse Effect

# Concrete Bridges Rehabilitation

Walnut Lane Bridge over Wissahickon Creek – No Adverse Effect

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Walnut Lane Bridge over Wissahickon Creek – No Adverse Effect

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Walnut Lane Bridge over Wissahickon Creek – No Adverse Effect

# Concrete Bridges Rehabilitation

Walnut Lane Bridge over Wissahickon Creek – No Adverse Effect

# Concrete Bridges Rehabilitation

Henry Avenue Bridge

# Concrete Bridges
# Rehabilitation

# Final Thoughts

- Purpose and Need
- Character Defining Features
- Analysis
- Early Coordination with CRP
- Collaboration throughout design and construction

# Coordination with CRP

# Recognition

2017 PA Historic Preservation Awards – Ralph Modjeski Award

# Sources for Additional Information

- FHWA Covered Bridge Manual available at: http://www.fhwa.dot.gov/publications/research/infrastructure/structures/04098/index.cfm
- *A Historic Context for Common Bridge Types* (NCHRP 25-25) available at: http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(15)_FR.pdf.
- PennDOT Historic Metal Truss Bridge Maintenance Manual, available at: https://www.paprojectpath.org/docs/default-source/penndot-crm---general-documents/truss-maintenance-manual-rev-2015-01-09-incorporated-epds-bomo-bqad-comments.pdf?sfvrsn=2
- Ohio Historic Bridge Preservation Manual, available at: http://www.dot.state.oh.us/Divisions/Planning/Environment/Cultural_Resources/HISTORIC_BRIDGES/Documents/OhioHistoricBridgePreservationManual910.pdf
- Guidance - PennDOT Stone Arch Bridge Maintenance Manual available at: https://www.paprojectpath.org/docs/penndot-crm---general-documents/stone-arch-bridge-maintenance-manual.pdf?sfvrsn=2
- Guidance - PennDOT Stone Arch Bridge District 6-0 Management Plan available at: https://www.paprojectpath.org/docs/penndot-crm---general-documents/stone-arch-bridge-management-plan.pdf?sfvrsn=2
- *Preservation Brief 2: Repointing Mortar Joint in Historic Masonry Buildings*, available at: http://www.nps.gov/tps/how-to-preserve/briefs/2-repoint-mortar-joints.htm
- *Preservation Briefs 15: Preservation of Historic Concrete: Problems and General Approaches* available at: http://www.nps.gov/tps/how-to-preserve/briefs/15-concrete.htmPreservation Brief 15:

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