



NCHRP

Web-Only Document 278:

Context-Sensitive Design Options for Workhorse Bridges in Rural Historic Districts Practitioner's Guide and Research Report

Steven Bedford
Camilla McDonald
Kate Umlauf
WSP USA
Kansas City, MO

Contractor's Final Report for NCHRP Project 25-25/Task 118
Submitted December 2019

The National Academies of
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SUMMARY

This study was conducted in response to the increasing number of rural bridge replacements within historic contexts encountered by state DOTs. The research objective of the project was to develop a practitioner-ready resource of context-sensitive design examples appropriate for workhorse bridges in rural historic districts. A synthesis of these examples provides practitioners with the tools to navigate the complex process of designing a context-sensitive bridge for the replacement of a workhorse bridges in rural historic districts. A secondary objective was to address design components common to successful context-sensitive designs as well as the costs associated with such designs.

The project team developed the following Practitioner's Guide and technical Research Report, and a supplemental Design Idea Book. The Practitioner's Guide (Part I) is organized to walk practitioners through the complex process of designing a context-sensitive bridge for the replacement of workhorse bridges in rural historic districts. The Research Report (Part II) presents a summary of the literature review and state of practice survey of the current context-sensitive design (CSD) process for replacement of workhorse bridges in rural historic districts.

The intent of the Design Idea Book, a separate illustrated document, is to present design features that have been used to achieve context-sensitive designs in or adjacent to rural historic districts. The highly illustrated Design Idea Book is laid out for use during the design and public involvement process to provide a range of possible bridge designs and approaches to the context-sensitive design/solutions (CSD/S) of workhorse bridge replacements.

CONTENTS

PART I. PRACTITIONER’S GUIDE

SUMMARY	1
SECTION 1.1: INTRODUCTION AND PURPOSE	4
SECTION 1.2: CONTEXT-SENSITIVE DESIGN/SOLUTIONS AND NATIONAL REGISTER OF HISTORIC PLACES	5
Context-Sensitive Design/Solutions	5
National Historic Preservation Act and the National Register of Historic Places.....	6
Relationship Between CSD/S and NRHP	7
Significance and Integrity	10
SECTION 1.3: UNDERSTANDING THE HISTORIC BRIDGE AND LOCAL HISTORIC CONTEXT	14
The Historic Bridge	14
Location.....	15
Setting.....	15
Materials and Design.....	16
SECTION 1.4: WHEN TO CONSIDER THE HISTORIC CONTEXT OF THE BRIDGE.....	18
SECTION 1.5: PUBLIC STAKEHOLDER INVOLVEMENT	20
SECTION 1.6: CASE STUDIES	24
Chenoweth Creek Bridge, Wasco County, Oregon (Regional Approach)	24
Project Description.....	24
Historic Context	24
Project Approach.....	26
Section 106/Consultation	26
Public Involvement	27
Design	27
Project Outcome/Evaluation of Success	29
Cook’s Chasm Bridge, Lincoln County, Oregon (Regional Approach).....	29
Project Description.....	30
Historic Context	30
Project Approach.....	30
Public Involvement	30
Design	30
Project Outcome/Evaluation of Success	32
Pennsylvania P3 Rapid Bridge Replacement Program/Project (Regional Approach)	32
Public Involvement	35
Project Outcome/Evaluation of Success	35
Gardners Bridge (Upper Bermudian Creek Road), Adams County, Pennsylvania.....	36
Project Description.....	36

Historic Context	37
Section 106/Consultation	37
Design	37
Project Outcome/Evaluation of Success	38
Kirks Mill Bridge, Lancaster County, Pennsylvania.....	38
Project Description.....	38
Historic Context	39
Public Involvement	39
Design	39
Project Outcome/Evaluation of Success	40
Carlisle Road Bridge, Cumberland County, Pennsylvania.....	41
Project Description.....	41
Historic Context	41
Design	41
Project Outcome/Evaluation of Success	43
Rosedale Road Bridge, Mercer County, New Jersey (Replication Approach).....	43
Historic Context	44
Design	44
Project Outcome/Evaluation of Success	45
Bridge 9 (Smith’s Bridge), Newcastle County, Delaware (Previous Bridge Approach)	46
Project Description.....	46
Historic Context	46
Project Approach.....	47
Section 106/Consultation	47
Public Involvement	48
Design	48
Project Outcome/Evaluation of Success	51
Stinesville Road Bridge, Monroe County, Indiana (Stakeholder-Driven Approach).....	51
Project Description.....	51
Historic Context	52
Section 106/Consultation	52
Public Involvement	53
Design	54
Project Outcome/Evaluation of Success	55
Defouri Street Bridge, Santa Fe County, New Mexico (Stakeholder-Driven Approach)	55
Project Description.....	55
Historic Context	56
Project Approach.....	56
Public Involvement	56
Design	57
Project Outcome/Evaluation of Success	59
Geigel Hill Road Bridge, Bucks County, Pennsylvania (Stakeholder-Driven Approach).....	59
Project Description.....	59
Historic Context	60
Design	60
Project Outcome/Evaluation of Success	60

Stoney Creek Mill Bridge, Oakland County, Michigan (Stakeholder-Driven Approach)	62
Project Description.....	62
Historic Context	62
Project Approach.....	63
Public Involvement	63
Section 106/Consultation	64
Design	64
Project Outcome/Evaluation of Success	66
Route 206 Flood Channel Bridge, Mercer County, New Jersey (Safety/Design-Driven Approach).....	67
Project Description.....	67
Historic Context	67
Public Involvement	68
Design	68
Project Outcome/Evaluation of Success	68
Falls County Road Bridge, Falls County, Texas (Safety/Design-Driven Approach).....	70
Project Description.....	71
Historic Context	71
Public Involvement	71
Section 106/Consultation	71
Design	72
Project Outcome/Evaluation of Success	72
Morgan’s Ford Bridge, Warren County, Virginia (Safety/Design-Driven Approach).....	74
Project Description.....	74
Historic Context	74
Project Approach.....	75
Public Involvement	75
Design	76
Project Outcome/Evaluation of Success	76
SECTION 1.7: EFFECTIVE STRATEGIES AND BEST PRACTICES	78
Best Practices	78
Design Elements.....	79
Bridge Type/Material	79
Bridge Rails.....	80
Texture	82
Scale.....	83
Abutments and Wing Walls	84
Color.....	85
Other Considerations	86
Embankments.....	86
Suggested Strategies.....	86
Regional Approach.....	87
Replication Approach.....	87
Previous Bridges Approach.....	88
Stakeholder-Driven Approach.....	88

Design/Safety-Driven Approach.....	88
Choosing a CSD approach.....	89
Guided Questions.....	89
Key Factors to Strategy Success.....	90
REFERENCES.....	91
ADDITIONAL RESOURCES.....	102

PART II. RESEARCH REPORT

SUMMARY.....	104
SECTION 2.1: INTRODUCTION AND RESEARCH OBJECTIVES.....	105
SECTION 2.2: LITERATURE REVIEW.....	105
Context-Sensitive Design/Solutions Guides and Manuals.....	105
National Sources.....	105
State Sources.....	106
Bridge Design and Aesthetics Guides and Manuals.....	109
National Sources.....	109
State Sources.....	109
Historic Preservation Sources.....	115
SECTION 2.3: STATE OF PRACTICE SURVEY.....	117
Screening Survey Results.....	117
CSD/S for Replacement Workhorse Bridges in Rural or Urban Historic District.....	118
Design Reference Materials.....	120
In-Depth Survey Results.....	120
Design Guidance.....	121
Understanding the Historic Context.....	122
Bridge Types and Standard Treatment Plans and Approaches.....	123
Cost Considerations.....	124
Common Obstacles/Concerns.....	124
Working with Stakeholders.....	125
CONCLUSION.....	127
REFERENCES.....	128

APPENDIX A: CSD/S PRINCIPLES AND OUTCOMES

APPENDIX B: SCREENING SURVEY

APPENDIX C: IN-DEPTH SURVEY QUESTIONS

APPENDIX D: SCREENING SURVEY RESULTS MATRIX

APPENDIX E: IN-DEPTH SURVEY RESULTS MATRIX

LIST OF FIGURES

Figure I-1: Gardners Bridge over Bermudian Creek before Replacement, 2015.....	8
Figure I-2: Bridge over Bermudian Creek after Replacement, June 2018.....	9
Figure I-3: Ross Mountain Park Bridge before Replacement.....	9
Figure I-4: Ross Mountain Park Bridge after Replacement.....	10
Figure I-5: Chenoweth Creek Bridge, May 2017.....	24
Figure I-6: Dry Canyon Bridge, May 2017.....	25
Figure I-7: During Construction of the Chenoweth Creek Bridge Stealth Railing, Summer 2018 ...	28
Figure I-8: Chenoweth Creek Bridge, August 2017	28
Figure I-9: Cooks Chasm Bridge, July 2011.....	32
Figure I-10: 1927 Concrete T-Beam Bridge, Montgomery County, Pennsylvania	33
Figure I-11: Pennsylvania Turnpike Bridge, Ca. 1968	33
Figure I-12: Base/Nominal Bridge Design Rendering from PennDOT Aesthetics Master Plan	34
Figure I-13: Gardners Bridge, 2015	37
Figure I-14: Gardners Bridge, June 2018.....	38
Figure I-15: Kirks Mill Bridge, 2015.....	39
Figure I-16: Kirks Mill Bridge, August 2018	40
Figure I-17: Carlisle Road Bridge, 2018.....	41
Figure I-18: Carlisle Road Bridge, January 2019	42
Figure I-19: Color Application Choices.....	42
Figure I-20: Rosedale Road Bridge, April 2005	44
Figure I-21: Rosedale Road Bridge, September 2010	45
Figure I-22: Smith's Bridge, Ca. 2000.....	46
Figure I-23: Smith's Bridge HABS Drawings, Ca.1936	49
Figure I-24: Smith's Bridge, June 2011	50
Figure I-25: Stinesville Road Bridge, Ca. 2010.....	51
Figure I-26: Western Bridge Approach with View of Town, Ca. 2010.....	52
Figure I-27: Aerial Photography of Project Area, 2014.....	53
Figure I-28: Stinesville Road Bridge, 2014	54
Figure I-29: Defouri Street Bridge, Ca. 2017	55
Figure I-30: Defouri Street Bridge, August 2017	58
Figure I-31: Geigel Hill Road Bridge, 2003	59
Figure I-32: Geigel Hill Road Bridge, 2011	61
Figure I-33: Stoney Creek Mill Bridge, 1978,	62
Figure I-34: Stoney Creek Mill Bridge with Concrete Barriers, Ca. 2008	62
Figure I-35: Stoney Creek Mill Bridge, 2019.....	65
Figure I-36: Flood Channel Bridge, 2017	67
Figure I-37: Flood Channel Bridge, 2018.....	69
Figure I-38: View of Abutment and Wing Wall Construction with Cut Ashlar Stone Facing, 2017	69
Figure I-39: Falls County Road Bridge, Ca. 2015	70
Figure I-40: T223 Railing	72
Figure I-41: Falls County Road Bridge, 2017.....	73
Figure I-42: Morgan's Ford Bridge, 2015	74

Figure I-43: Indian Hollow Road Low Water Bridge and New Adjacent Bridge	75
Figure I-44: Morgan's Ford Bridge, 2018	76
Figure I-45: Stoney Creek Mill Bridge Replacement, Rochester Hills, MI.....	80
Figure I-46: Chenoweth Creek Bridge Replacement, Wasco Co., OR.....	81
Figure I-47: Texas C411 Rail ("Texas Classic").....	81
Figure I-48: Stinesville Road Bridge, Monroe County	82
Figure I-49: Successful Application of Texture onto Bridge Face and Real Stone Masonry Abutments, River Road Bridge, PA.....	83
Figure I-50: The Historic Oyster River Bridge in Durham, NH.....	83
Figure I-51: Oyster River Bridge Replacement, in Durham, NH. Replacement Design Exhibits Retention of Scale	84
Figure I-52: Morgan's Ford Bridge Replacement Exhibits Compatible Abutment Design with the Natural Landscape	85
Figure II-1: Respondents with Workhorse Bridge Replacement Experience in Historic Districts....	118
Figure II-2: Respondents that have used a CSD/S Process for Bridge Design in a Historic District	118
Figure II-3: Design Reference Materials Utilized to Guide Historic Bridge Replacement Projects .	120
Figure II-4: Process(es) to Define or Understand the Historic Context of a Bridge	122
Figure II-5: Points of Consideration for the Historic Context during Design Development	123
Figure II-6: Number of Agencies that Employ a Standard Treatment Plan/Approach.....	123

LIST OF TABLES

Table I-1: CSD/S and Standard/Safety Design Elements of the New Chenoweth Creek Bridge	29
Table I-2: CSD/S and Standard/Safety Design Elements of the New Cooks Chasm Bridge	31
Table I-3: CSD/S Costs by Treatment Type	31
Table I-4: Aesthetics Criteria from Pennsylvania DOT P3 RBRP Aesthetics Master Plan	356
Table I-5: CSD/S Design Elements of the New Gardners Bridge	38
Table I-6: CSD/S Design Elements of the New Kirks Mill Bridge	40
Table I-7: CSD/S Design Elements of the New Carlisle Road Bridge	423
Table I-8: CSD/S and Standard/Safety Design Elements of the New Rosedale Road Bridge.....	45
Table I-9: CSD/S and Standard/Safety Design Elements of the New Smith's Bridge	50
Table I-10: CSD/S and Standard/Safety Design Elements of the New Stinesville Road Bridge	54
Table I-11: CSD/S and Standard/Safety Design Elements of the New Defouri Street Bridge.....	58
Table I-12: CSD/S Design Elements of the New Geigel Hill Road Bridge.....	61
Table I-13: CSD/S Design Elements of the New Stoney Creek Mill Bridge	66
Table I-14: CSD/S and Standard/Safety Design Elements of the New Flood Channel Bridge	70
Table I-15: CSD/S and Standard/Safety Design Elements of the New Falls County Road Bridge...	73
Table I-16: CSD/S and Standard/Safety Design Elements of the New Morgan's Ford Bridge	77
Table I-17. Key Factors to Strategy Success	90
Table II-1: Total Screening Survey Respondents by State and Agency	117
Table II-2. Bridge Replacement Projects Referred to in Screening Survey.....	119
Table II-3: In-Depth Survey Respondents by State and Agency	121
Table II-4: Commonly Used Bridge Enhancements or Design Guidelines for Replacement Designs	122

LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials	NPS	National Park Service
ADA	Americans with Disabilities Act	NRHP	National Register of Historic Places
Caltrans	California Department of Transportation	OTIA III	Oregon Transportation Investment Act III
CRH	Columbia River Highway	P3	public-private partnership
CS ³	Context-Sensitive Design/Solutions and Sustainability	P3 RBRP	Pennsylvania Rapid Bridge Replacement Program
CSD	Context-Sensitive Design	PHMC	Pennsylvania Historical and Museum Commission
CSD/S	Context-Sensitive Design/Solutions	Project PATH	Project for Pennsylvania Transportation and Heritage
DOT	Department of Transportation	PWKP	Plenary Walsh Keystone Partners
HABS/HAER	Historic American Buildings Survey/Historic American Engineering Record	SHPO	State Historic Preservation Office
HCRH AC	Historic Columbia River Highway Advisory Committee	SOI Standards	Secretary of the Interior's Standards for the Treatment of Historic Properties
HDRB	Historic Districts Review Board	Task Force	Contextual Bridge Preservation Task Force
NCHRP	National Cooperative Highway Research Program	TRB	Transportation Research Board
NEPA	National Environmental Policy Act	USACE	U.S. Army Corps of Engineers
NHL	National Historic Landmark	USFS	U.S. Forest Service
NHPA	National Historic Preservation Act		

PART I. PRACTITIONER'S GUIDE

SUMMARY

Thousands of workhorse bridges are located in historic districts or adjacent to historic structures. Workhorse bridges—i.e., spans of less than 300 feet, generally constant girder-type structures assembled from standard structural components and systems—are parts of the landscape that go unnoticed until it is time for their replacement. When these bridges are adjacent to or in rural historic districts, they may be considered character-defining features in the landscape, either as an important crossing or even as an unimportant feature that was designed to blend with the natural landscape. Therefore, whether considered contributing or not, and lacking any Section 106 delegation Programmatic Agreement, the design of a replacement bridge, even if a non-contributing element, would need to comply with Section 106 of the National Historic Preservation Act (NHPA) and Section 4(f) of the Department of Transportation Act.

The context-sensitive design (CSD) for bridges in rural historic districts presents a particular challenge because the built environment to supply design context is limited. Some publications on bridge aesthetics provide general guidance and examples of successful and unsuccessful designs for bridges in historic districts. However, the context and situation of each bridge replacement is unique, making it difficult to develop guidance that covers all possible scenarios.

This practitioner's guide seeks to provide both conceptual and practical guidance on the process of developing CSDs that are appropriate for workhorse bridges in rural historic districts. Conceptually, it can be difficult for historic preservation and transportation practitioners to understand the relationship between context-sensitive design/solutions (CSD/S) and character-defining elements of historic properties, specifically for bridges in rural historic districts. The CSD/S process is used to achieve design excellence by developing transportation solutions through continuous collaborative communication and consensus among transportation agencies, State Historic Preservation Offices (SHPOs), local governments, project consultants, the public, and all other stakeholders. The approach is meant to consider the total context of a transportation project with the goal of creating a project that is “harmonious with the community, and preserves aesthetics, history and the environmental resources, while integrating these innovative approaches with traditional transportation goals for safety and performance” (Georgia DOT 2016:1-2). The Secretary of the Interior's Standards for the Treatment of Historic Properties (SOI Standards) include guidelines for the treatment of various property types. These guidelines present a framework for assessing projects receiving federal money or tax benefits and for avoiding adverse effects to historic properties. The key elements of these standards that apply to bridges in rural historic districts are: “Changes that create a false sense of historical development . . . will not be undertaken” and “The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing. . . .”

The National Register of Historic Places (NRHP) plays a role in CSD/S and can influence the outcome of projects. CSD/S considers the character-defining features and seven aspects of NRHP integrity (location, design, setting, materials, workmanship, feeling, and association) when developing the design of a new bridge because these features often define the nature of an existing bridge as a historic property. The problem with workhorse bridges is that their straightforward construction may seem to result in few significant or character-defining features, leaving CSD/S practitioners to look elsewhere for historic context, overlooking the fact that the subtle structural nature of the bridge actually is a significant feature. In most cases, less is better than more in terms of design features on the replacement bridge.

The CSD/S consensus-building process may reveal that community design preferences do not align with a design that complies with the SOI Standards. Differing ideas on significance and integrity expressed by stakeholders versus the SOI Standards can be a main source of conflict in the CSD/S process. This conflict is inherent in the subjective, often difficult, nature of assigning value to historic resources, particularly in a rural historic district. The difficulty of gleaning the historical and cultural significance of a workhorse bridge in a rural historic district stems from the nature of historic bridges as a niche subject; knowledge about them is not commonly circulated across disciplines. Successful evaluation of a workhorse bridge's significance is grounded in an interdisciplinary approach that seeks a thorough understanding of both the physical features of the bridge and how these features relate to significance of a property.

One of the key considerations that can lead to a successful replacement of a workhorse bridge is when and how often the historic context of the bridge is considered throughout the design process. Current practices, based on survey responses, show consideration for the historic context of a bridge occurs first during preliminary design with continued consideration throughout the design process. According to McCahon et al. (2012, 1-6), integration of historic preservation throughout the planning and development of projects is considered to be "the single most effective way to achieve balanced solutions resulting in preservation of historic roads, or any historic property...."

Significant conflict can exist between public stakeholders and project engineers. Within the consensus-building process, community desires can conflict with the design of a safe and SOI-compliant bridge in favor of a design with the inappropriate application of seemingly "historic" materials. Careful consideration of the public involvement process is critical to the CSD/S process and to the successful melding of the wide range of stakeholder desires, SOI Standards, and engineering and safety standards in the design process. Among the many facets of the public involvement process, early and continuous outreach is most often cited as an important and effective strategy for successful stakeholder involvement. Additional components of the engagement process include visualization of a bridge in its settings, honest and clear communication regarding technical components of the design, and presentation of design options.

What remains undetermined is the most effective approach to solicitation of public input and to what extent decision-making power should be given to the stakeholders to achieve balanced solutions that conform to CSD/S principles, SOI Standards, and engineering standards. Two approaches to soliciting public input have been identified as (1) early open invitation and (2) delayed input on preferred design. The early open-invitation approach begins with a blank slate meeting with the public to allow the community to take ownership of the bridge design. The American Association of State Highway and Transportation Officials (AASHTO) also recommends involving the public as early as possible, before any design decisions are made, even at the risk of the community proposing "impractical" visions and ideas. Addressing those ideas early in the design process will limit challenges and setbacks down the road. The second approach, which to a certain extent limits public input, solicits feedback after the development of preferred designs. This approach seemingly has two objectives: to eliminate inappropriate design ideas expressed by the community and to reduce the timeline of a project. This approach is most often used when the project timeline is reduced because of potential safety issues or because it is part of a larger bridge replacement program. Public involvement can cause delays if public opinions differ from the design team, sometimes leading to legal action taken against bridge owners. Although those conflicts may be unavoidable at times, approaching the public with multiple preferred designs based on solid design and safety criteria and then allowing the community to choose aesthetic options, such as railing type, form liners, and colors, can function smoothly and effectively.

Overall, the consideration of character-defining features of a historic bridge, proper implementation of the principles of design aesthetics, and stakeholder engagement are key elements to a successful CSD/S process. Research and literature review also revealed a few key guiding principles in the process of designing replacements for either historic or non-historic bridges:

- Ensure that the seven aspects of integrity for historic properties mesh with the 13 controlling design criteria for roadway design (FHWA 2019);
- Address all current safety concerns while basing aesthetic design choices on features exhibited in the bridge to be replaced;
- Avoid creating new visual elements, such as retaining walls and expansive slopes;
- Understand that: “The source of historic significance defines the aspect that should be incorporated into the new design in order to retain historic character” (AASHTO 2010:51);
- Use the desirable features of a historic bridge as the basis for commonality between the old and the new (AASHTO 2010:51); and
- Incorporate proper aesthetic design principles to achieve reference to past features of historical significance.

Five general approaches to CSD/S for replacement bridges in or near rural historic districts have been identified as a result of the project:

- **Regional** – This approach draws influence from regional bridge styles as well as from a desire to create a modern, regional tradition.
- **Replication** – This approach is straightforward in its name; replacing a bridge with a replica design.
- **Previous Bridges** – This approach draws design influence from previous iterations of an existing bridge.
- **Stakeholder-Driven** – This approach is centered on the public involvement process and uses stakeholder input as a driving factor in proposed design elements.
- **Design/Safety Driven** – This approach stems from the necessity of a replacement design to address engineering design and safety issues of an existing bridge.

These approaches typically evolve naturally from the specific circumstances of the bridge, its context, the attitudes and interests of the public, and the design requirements of the new structure. Understanding these approaches may assist practitioners in guiding stakeholders and other interested parties through the CSD/S process to a successful outcome.

SECTION 1.1: INTRODUCTION AND PURPOSE

Workhorse bridges—i.e., spans of less than 300 feet, generally constant girder-type structures assembled from standard structural components and systems—are parts of the landscape that go unnoticed until it is time for their replacement. Nationwide, it is likely that thousands of such undistinguished bridges are located in historic districts or adjacent to historic structures; for instance, approximately 100 bridges are located in historic districts in Connecticut. The exact number nationwide is unknown. Many of these no doubt were built to standardized designs laid out in highway department bridge manuals that can date back to the 1920s or earlier. Particularly in rural areas, when these bridges are adjacent to or in rural historic districts, they may be considered character-defining features in the landscape, either as an important crossing or even as an unimportant feature that was designed to blend with the natural landscape. Therefore, whether considered contributing or not and lacking any Section 106 delegation Programmatic Agreement, the design of a replacement bridge, even if a non-contributing element, would require consultation with the SHPO on design. This is especially true if the span length, bridge width, centerline location, or approaches are changed. SHPO consultation and one-off design solutions are necessary to comply with Section 106 of the NHPA and Section 4(f) of the Department of Transportation Act, potentially greatly delaying the bridge construction process.

CSD for bridges in rural historic districts presents a particular challenge because the built environment to supply design context is limited. Many of the published examples of context-sensitive bridge designs are in urban settings or scenic areas. AASHTO's *Bridge Aesthetics Sourcebook* provides some guidance (AASHTO 2010, 46-48) and gives a few examples of successful and unsuccessful designs for bridges in historic districts. However, there is no repository of successful designs for new and/or replacement bridges in rural historic districts.

This guide is organized to walk practitioners through the complex process of designing a context-sensitive bridge for the replacement of workhorse bridges in rural historic districts.

Section 1.1 provides background information and summarizes the scope and organization of the report. Section 1.2, 1.3, and 1.4 help practitioners navigate through the abstract concepts of understanding the context of a bridge and glean the meaningful information to guide the design of a new bridge. The relationship and importance of public stakeholder involvement is discussed in Section 1.5. Section 1.6 provides specific examples of CSD/S for workhorse bridges through case studies. A summary of recommended strategies and best practices for practitioners is presented in Section 1.7. A Design Idea Book, with aids in navigating the CSD/S process and examples of successful design types, has been developed as a separate resource and is available to practitioners for use for stakeholder engagement during the design process. The Design Idea Book is available at <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4488>.

SECTION 1.2: CONTEXT-SENSITIVE DESIGN/SOLUTIONS AND NATIONAL REGISTER OF HISTORIC PLACES

This section describes the relationship between CSD/S and character-defining elements of historic properties, specifically focused on bridges in the setting of rural historic districts and those important aspects of integrity that relate to a property's context. It also seeks to place the NRHP guidance and the Secretary of the Interior's Standards for the Treatment of Historic Properties (SOI Standards) and guidelines within the CSD/S process (U.S. Department of the Interior 2019).

These two approaches address the issue of context and design from different perspectives. The intent of CSD/S is a process aimed to create a design that is in harmony with its surroundings and preserves the environmental, scenic, aesthetic, historic, and natural resource values of the area. The approach is very process driven. Guidance for the treatment of NRHP properties is published in the SOI Standards. Section 106 of the NHPA, a regulation codified at 36 CFR 800, is more prescriptive and direct, and although public participation is required, the level of participation is relatively limited in scope.

CONTEXT-SENSITIVE DESIGN/SOLUTIONS

The CSD/S process is used to achieve design excellence by developing transportation solutions through continuous collaborative communication and consensus among transportation agencies, SHPOs, local governments, project consultants, the public, and all other stakeholders. It begins during early transportation planning and project programming and continues through project development, preliminary engineering, final design, and construction and maintenance. The approach is meant to consider the total context of a transportation project with the goal of creating a project that is "harmonious with the community, and preserves aesthetics, history and the environmental resources, while integrating these innovative approaches with traditional transportation goals for safety and performance" (Georgia DOT 2016, 1-2). The process is used for many types of transportation projects, most of which do not deal with historic bridges.

The CSD/S process has been laid out in the CSD/S manuals of many states and through publications by the Federal Highway Administration (FHWA), AASHTO, Transportation Research Board (TRB), and the National Cooperative Highway Research Program (NCHRP). It is very participatory and interdisciplinary. The project teams can include community outreach professionals, design engineers, landscape architects, land use planners, city planners, environmental resource specialists, historic preservation and cultural resources staff, and public transportation professionals. It treats each project as unique.

CSD/S requires a very strong commitment to public involvement. Community residents and stakeholders play a key role in identifying local and regional issues and concerns. They are considered to have much to offer regarding strategies or solutions that will accommodate the needs of the community in the project.

It is important early in the engineering design process for the design team to understand the natural and built environment surrounding the projects. The roadway should be considered a part of the landscape and the project's impact on important resources in that landscape must be taken into account, including working with NRHP-listed bridges and cultural landscapes.

In addition, the CSD/S design approach is meant to avoid and/or minimize effects on important resources to the extent possible and create resource enhancement opportunities where impacts are unavoidable. The CSD/S process should not be completely bound to existing design solutions and should consider all possibilities to ensure flexibility in roadway design where feasible. Designers are encouraged to research new ways of solving transportation project needs and be willing to adapt solutions to the natural and

social contexts of their location. Engaging the public is important to the success of this process. The goals and tenets of CSD/S are most effectively met when project planners and designers engage with the public in public meetings, stakeholder groups, or focus groups.

Above all, CSD/S is a process that begins during early transportation planning and programming and continues through specific project development, preliminary engineering, final design, construction, and maintenance.

Key elements of the CSD/S process include managing diverse technical resources, incorporating meaningful public involvement, integrating collaborative solutions to develop multiple alternatives, and maintaining open and honest communications and decision-making processes that are well documented. CSD/S emphasizes careful listening to the community and stakeholders. Clarity in communication is a key element.

FHWA definitions, characteristics, and outcomes of CSD and context-sensitive solutions (CSS) are provided in Appendix A for reference.

NATIONAL HISTORIC PRESERVATION ACT AND THE NATIONAL REGISTER OF HISTORIC PLACES

Under the NHPA and the NRHP implementing regulations, the Secretary of the Interior is responsible for setting professional standards and advising on the proper preservation of heritage resources that are listed in or eligible for listing in the NRHP. In partial fulfillment of this mandate, the Secretary of the Interior's Standards for Historic Preservation Projects were first published in 1976. Since their publication, the SHPOs and National Park Service (NPS) have used the standards when assessing projects receiving federal money or tax benefits. These standards have also served as the basis for local design guidelines for preservation commissions.

In 1992, the standards were revamped so that they could be used on the broader range of heritage resource types found in the NRHP. The resource types are buildings, structures, sites, objects, districts, and landscapes. These new standards were renamed The Secretary of the Interior's Standards for the Treatment of Historic Properties (SOI Standards). This version considers four approaches: Preservation, Rehabilitation, Restoration, and Reconstruction. The SOI Standards include the guidelines for the treatment of various property types and how to apply the four approaches to create a project that meets the SOI Standards. As of 1995, the SOI Standards were codified as 36 CFR 68, replacing prior editions of versions of 1978 and 1983.

Two standards are directly applicable to bridge replacement and rehabilitation. Standard Three states:

each property will be recognized as a physical record of its time, place and use. Changes that create a false sense of historical development such as adding conjectural features or elements from other historic properties, will not be undertaken [U.S. Department of the Interior 2019].

Standard Nine states:

New additions, exterior alterations or related new construction will not destroy historic material features, and spatial relationships that characterize the property. The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and the environment [U.S. Department of the Interior 2019].

The key elements of these standards that apply to bridges in rural historic districts are: "Changes that

create a false sense of historical development . . . will not be undertaken” and “The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing. . . .”

In workhorse bridge replacements in rural historic districts, the issue is that the replacement occurs in a well-defined cultural landscape where the bridge, whether contributing or not, is a structure in the larger circulation network. A satisfactory outcome in terms of treatment would comply with not only the SOI Standards for treatment of both a structure and a cultural landscape but also with AASHTO and state Department of Transportation (DOT) design guidelines.

Many variables need to be considered in terms of the NRHP:

- What aspects of integrity of the bridge and its context are intact?
- What aspects of integrity have changed?
- What elements of the bridge’s context have changed over time?
- What are its character-defining features (the features that make the bridge a contributor or non-contributor to the historic district)?
- What is the age of the bridge relative to the period of significance of the historic district?
- What are general common bridge types for the period of significance in the region of the historic district?

The bridge would also be evaluated overall as part of the circulation network of the rural cultural landscape. Is it in an important part of the cultural landscape? Is it a contributing resource in the historic district or is it a non-contributing element? This type of information feeds into the CSD/S process, but the CSD/S process is more encompassing as it considers more environmental and social factors as well as roadway design and relies more on public involvement than the NRHP process does. The CSD/S process would focus on character-defining features of an existing bridge or new bridge as part of the aesthetics and context of the bridge, where the NRHP would view character-defining features as aspects of integrity that would need to be preserved in a bridge rehabilitation. Rehabilitation, as defined by NPS, U.S. Department of the Interior (2019), “acknowledges the need to alter or add to a historic property to meet continuing or changing uses while retaining the property’s historic character.”

Determining the NRHP eligibility of a bridge does not require consensus building. The NRHP nomination process is managed by professionals in the field who help determine the NRHP eligibility of a resource, and no public involvement is required. True, a property owner (or a group of owners in the case of a historic district) or a member of the public can object to listing, but this will not affect NRHP eligibility of the resource. In the case of CSD/S, the opinion of a majority of stakeholders can alter the nature of a transportation project.

RELATIONSHIP BETWEEN CSD/S AND NRHP

The NRHP plays a role in CSD/S and can influence the project outcomes. CSD/S considers the character-defining features and seven aspects of NRHP integrity when developing the design of the new bridge as these often define the nature of the existing bridge as a historic property. The NRHP recognizes a property’s integrity through location, design, setting, materials, workmanship, feeling, and association. The challenge is that the straightforward construction of workhorse bridges may seem to have few significant or character-defining features, leaving CSD/S practitioners to look elsewhere for historic context, overlooking the fact that the low-key structural nature of the bridge actually is a significant feature. In this case, CSD/S practitioners may turn to the historic district and surroundings for context,

which may or may not be relevant to the bridge's significance individually or as a contributing structure to the district. This can often lead to creating a historicized version of the new bridge, which is contrary to the SOI Standards; however, this does not mean that a bridge with historicized features or different construction will be rejected out of hand. Most SHPOs are going to be heavily influenced by credible solutions that are proposed during public information sessions. Compatibility in design can be a subjective decision, especially when trying to achieve consensus. Flexibility in decision-making resulting from gathering the views of the public in the Section 106 process can form a nexus with the flexibility in design from the CSD/S process. The collective context and comments influence the design.

The following two examples show two approaches to the CSD of simple workhorse bridges in a historic setting and examine their effectiveness in complying with the applicable SOI Standards as outlined above.

Gardners Bridge over Bermudian Creek



FIGURE I-1: Gardners Bridge over Bermudian Creek before Replacement, 2015 (Courtesy of Amisson 2016)

The historic bridge set for replacement in Adams County, Pennsylvania, was a simple two-span concrete T-beam bridge crossing Bermudian Creek, set amidst a small wooded area within a broader agricultural setting (Figure I-1). The Northern Adams County Fruitbelt Historic District is significant at the local level for its associations with fruit production from 1875 to 1960. Pennsylvania DOT determined that the bridge was a contributing feature in the historic district and thus its demolition was deemed an adverse effect. The small single-span bridge curved through the pocket of trees before exiting toward a large lumber yard on its west end. Views of the bridge from either side confirm a predominantly wooded landscape. The bridge, built in 1938, is of standard design for the era with a standard concrete highway balustrade supported by square balusters interspersed with pedestals.

This bridge was replaced as part of Pennsylvania’s P3 Rapid Bridge Replacement Program (P3 RBRP) (see case study on page 36). The bridge was replaced with a single-span spread box beam bridge with integral abutments, slightly widening the structure but overall allowing it to remain a minor feature in the landscape (Figure I-2). Pursuant with the Aesthetics Master Plan, the Context-Sensitive Base/Nominal Design was determined appropriate in the setting and implemented without the option of



FIGURE I-2: Bridge over Bermudian Creek after Replacement, June 2018 (Courtesy of PWKP 2018d)

additional enhancing treatments. The new bridge contains changes in length and width yet maintains the two-lane scale of the historic bridge. In addition, similar massing of the concrete bridge walls preserves the spatial relationship in the wooded setting. The resulting replacement bridge maintains harmony with its surrounding landscape, successfully complying with the SOI Standards.

Ross Mountain Park Road Bridge



FIGURE I-3: Ross Mountain Park Bridge before Replacement (Gargan 2010)

The historic bridge set for replacement in Ross Mountain Park, Pennsylvania, was a simple single-span steel I-beam structure, crossing a creek inlet to a small reservoir and set within a broader outdoor recreational setting dominated by dense forest (Figure I-3). Ross Mountain Park is set in a 65-acre historic district, which includes a private golf course (Ross Mountain Club) and 22 buildings associated with a historic private summer resort. The bridge featured six vertical steel I-beams bracing two horizontal steel rails, allowing for views of the landscape through its structural elements.

This bridge was replaced with a single-span concrete adjacent plank beam bridge with concrete form liners and tinted cast concrete that simulates a rustic stone guard wall (Figure I-4). The implemented CSD/S identified by the project engineers included a weathering steel guide rail approach, concrete stain,

and concrete form liner. Similar to the Bermudian Creek Bridge example above, the slight widening of the bridge and the retention of a two-lane road did not affect the overall circulation patterns in the district; however, changing the primary medium of the bridge from steel to concrete resulted in a dense design with massing that is out of scale in the historic context. The steel construction of the previous bridge was a character-defining feature in and of itself, but the smaller size of structural elements and the open,

transparent railing of the new bridge contributed to its subtle incorporation into the surrounding setting. Closing the railing eliminated the partial views of the lake beyond that had been made possible by the widely spaced steel railing.



FIGURE I-4: Ross Mountain Park Bridge after Replacement (Gargan 2010)

The new bridge makes a noticeable statement compared with its predecessor. From a distance it becomes a focal point in the landscape, rather than allowing the reservoir to effectively mask the natural-looking infrastructure. If the use of stone veneer form liners was to historicize the bridge, the result was a structurally confusing design because stone would never be used on a beam bridge. A reinforced concrete arch bridge with a stone veneer, including an arch ring and keystone, would be a more appropriate design. Lacking any obvious character-defining features in the existing steel I-beam bridge, project engineers and stakeholders looked for context in the stone materials of many of the houses located in the district, a common problem when dealing with the replacement of workhorse bridges. Although the local stakeholders may see the resulting bridge as complementary to the rural, rustic setting of the district, the replacement design does not meet the SOI Standards and serves as a cautionary tale for developing appropriate designs for workhorse bridges.

Significance and Integrity

CSD/S considers character-defining features and the seven aspects of integrity when developing the design of the new bridge, as these often define the nature of the existing bridge as a historic resource. The source of historical significance defines the aspect that should be incorporated into the new design in order to retain historic character (AASHTO 2010). The SOI Standards guide practitioners in the appropriate design considering its determined significance based on its character-defining features. Therefore it is necessary to understand how each aspect of integrity relates those applicable to the replacement of a workhorse bridge.

Compatibility plays a key role when relating significance and integrity to the SOI Standards. The CSD/S process and the Section 106 consultation process working together permit a broad interpretation of compatibility to both integrity and the contexts. Compatibility in this sense can be understood as two things existing together without conflict. The two subjects can be either the bridge and its surrounding environment, or the compatibility of the function of the old and new bridge. A bridge in its setting is both of and in its setting and its historic and surrounding environmental context, but when replaced it must still function on the landscape as it is designed: to serve as a conveyance to vehicular and pedestrian traffic.

The aspects of design, materials, and workmanship in a new bridge can risk creating a false sense of historical development if inaccurately understood from the historic example and context. They must be compatible with the historic property and environment to uphold its historic integrity, yet they must not

duplicate the exact form and detailing so that the new bridge appears historic. How do you make something new reflect its historical roots without misrepresenting its existing time, place, and use? This is where the interdisciplinary approach of CSD/S in an open dialogue comes into play.

Historic workhorse bridges are often representations of the technology of bridge design from a certain point in time. They reflect common forms, plans, and styles highly significant to historic character. They are not typically showpieces, or designed by notable designers, and they do not normally have overt aesthetic treatments. They are everyday working structures with no frills. The construction materials used identify the resources and technology available when a bridge was built and can provide clues into the character of the broader historic perspective. Applying stone decoration to a replacement bridge in an area where stone use is or was uncommon and rarely used on bridges would be incompatible with the historic context of the area and create a false sense of history through inappropriate use of materials. Use of stone veneer should also be compatible with the type of bridge being constructed (e.g., an arch bridge rather than a beam bridge). The CSD/S process, by involving both design and historic specialists, should steer project planners away from non-complimentary choices.

Workmanship can be evident through masonry techniques, concrete laying, or metal-working. Attempts to replicate workmanship in the creation of a replacement bridge would create a false sense of history. This does not mean that work should not be carried out in a workmanlike manner—it should, but a solution that emphasizes virtuoso masonry work would not be an appropriate replacement for a simple bridge with a steel railing.

The aspects of location and setting for a new bridge risk diminishing the spatial relationships that characterize the property or historic district. Relocating a bridge could impact its relationship with the surrounding landscape and potentially alter the circulation network of the district. The physical environment that a bridge occupies reflects the relationship of the bridge to other features, such as a body of water, the roadway, a building, and the landscape. Interruptions to the setting may result in a loss of historic character. All of this is vitally important to the context and integrity of a bridge; however, this does not mean that relocating a historic bridge—for example, for use on a multi-use trail—destroys its NRHP eligibility. Preservation of the structure and most of its aspects of integrity are often considered more important than loss of location and setting; many relocated historic bridges retain their NRHP eligibility. But once again, use of the CSD/S process, in balance with sound engineering principles, safety considerations, and preservation considerations, often allow participants in a project to achieve what's best for the traveling public and the historic bridge.

The aspects of feeling and association are expressed primarily through aesthetics, a sense of history, and a connection to history. A new design must fit harmoniously in size, scale, color, material, and character into its historic setting, and also fit harmoniously with its character, such as a rural, one-lane bridge that provided access to a small farming town. Replacing a one-lane bridge with a widened, two-lane bridge would be incompatible with its integrity as a very low-volume rural bridge that achieved a certain feeling and association with the history of the area. However, the widening of a bridge may be necessary as a safety requirement for the new bridge, and safety should always be the primary consideration. In another example, replacing a low metal railing with a high concrete railing could be considered a necessary requirement for bridge safety, even though it risks affecting the integrity of the bridge. Safety takes priority over historic preservation.

A conflict may arise when the interpretation of the source of significance and the meaning of the seven aspects of integrity by the general public and CSD/S practitioners differs, influencing the outcome of the project. How meaningful are the seven aspects of integrity to the general public involved in the CSD/S process? What aspects of integrity may be more relevant for workhorse bridges? Integrity of setting, location, materials, and design seem to be the most applicable to a workhorse bridge, especially in the mind of the layperson. The materials and design of the workhorse bridge are often immediately evident, although some standard concrete beam designs can look very similar to the layperson. The setting of the bridge is easily understood and translatable when discussing a new bridge. But what about the integrity of workmanship, feeling, and association? Workmanship can certainly be appreciated in decorative railings or arched spans of some workhorse bridges but can be hard to appreciate on other standard types, such as a steel beam bridge. Feeling is one of the more abstract aspects of integrity that can be challenging to define even for experienced historic preservation practitioners, and it is even more challenging to the public. This is probably the most difficult aspect to convey when defining the nature of what is a workhorse bridge.

In many situations, the bridge being replaced may not have been the original bridge. To the layperson, association may be more tied to an earlier bridge that may have more sentimental value (a covered bridge, a truss bridge). Value may be associated with particular bridges, for example, as a place of meeting, entrance to a neighborhood, or related to community tradition, potentially establishing associations or a sense of feeling not experienced by or accessible to CSD/S practitioners.

The consensus-building process may reveal that community design preferences do not align with a design that complies with the SOI Standards. Differing ideas on significance and integrity expressed by stakeholders versus the SOI Standards can be a main source of conflict in the CSD/S process. This conflict is inherent in the subjective, often difficult, nature of assigning value to historic resources, particularly in a rural historic district. The CSD/S process collects significance from a broad pool of stakeholders and must attempt to find a design that is compatible with the SOI Standards while also meeting engineering and safety requirements.

Significance is tied to a property's historical, cultural, architectural, or technological importance within a relevant historic context and the specific features that convey historic character. The character-defining features of workhorse bridges are related more to the structure type and standardized features that may be overlooked as significant in the CSD/S process. It is important to remember that a workhorse bridge was designed according to design standards and specifications that were in effect at the time of its construction. The form of the bridge may have been from a standard design that was used by the highway department at the time of its initial construction, reflecting the time and place of its inception. Replacement with a modern standard design would be in keeping with the intent of the original designers and in compliance with the SOI Standards. However, the use of a standard bridge as a replacement could seem to be unsympathetic, aesthetically, to stakeholders who may want to evoke more of the historic character of the built environment in the design of the new bridge. For example, if such a bridge was substandard and in poor condition on the edge of a small town/village, they may still want something eye catching as their entryway bridge, which may not be consistent with the existing bridge type.

Pennsylvania DOT addressed this problem through modernization of standard bridge designs. In 2008, the Contextual Bridge Preservation Task Force (Task Force), formed by Pennsylvania DOT, developed recommendations on decision-making regarding the preservation of existing bridges as well as the intersection of bridge replacement and the SOI Standards on Rehabilitation (Pennsylvania DOT 2009, 3). The Task Force presented a Principles of Bridge Aesthetics Statement that suggested the creation of standard bridge designs that consistently appeal to the public as well as bridge designers in early design

stages. Regarding single-span workhorse bridges, the stated goal was to develop a regional bridge style, based on historic bridge designs, by implementing updates to available material, using current technology, and highlighting simple motifs. Existing designs identified as potential candidates for modernization and standardization of a regional style included TL-2 open parapet and early turnpike bridges (Pennsylvania DOT 2009, 16).

This idea was integrated into the design process for the Pennsylvania DOT P3 RBRP, for which they developed an Aesthetics Master Plan that included a Context-Sensitive Base/Nominal Design for qualifying bridge replacements (PWKP 2015). Pennsylvania DOT's P3 RBRP program is discussed in detail in the Section 1.6 of this report. By adapting historic bridge designs relative to specific regions, the difficulty of balancing stakeholder input and the SOI Standards is reduced because the design is already compatible with its historic setting (based on an evaluation of significance) and will likely maintain a compatible size, scale, and massing that is visually and functionally valued by the general public.

The difficulty of gleaning the historical and cultural significance of a workhorse bridge in a rural historic district stems from the nature of historic bridges as a niche subject, knowledge not commonly circulated across disciplines. If historic preservation practitioners are not involved in the CSD/S process, how do CSD/S practitioners, namely engineers, but also city planners, project consultants, transportation professionals, environmental specialists, and landscape architects, accurately evaluate significance? Successful evaluation is grounded in an interdisciplinary approach that seeks a thorough understanding of both the physical features of the bridge and how they relate to significance of a property. For a historic preservation practitioner to accurately interpret the historic integrity of a workhorse bridge, it is imperative to understand bridge types, materials, and methods used in design and construction. Engineers and others more familiar with bridge structure can accurately provide that knowledge. For instance, concrete beam bridges for which design engineers used the Hardy Cross moment distribution method of analysis beginning in the early 1930s will have a characteristic appearance that is different from beams in bridges for which designers used traditional analysis. Engineers will recognize the differences in beam shape, but others might not. Hardy Cross's moment distribution method is a structural analysis method for statistically indeterminate beams and frames (Cross 1930). In addition, engineers chose the existing bridge type and materials for a reason, whether it was dictated by the conditions of the site, funding, or other factors. This aspect of a bridge's structure and engineering history can be just as important as any decorative features that may have more obvious historic significance to non-engineers. An interdisciplinary understanding of a historic bridge that blends the knowledge of both CSD/S practitioners and historic preservation practitioners is critical to the CSD of a replacement bridge.

SECTION 1.3: UNDERSTANDING THE HISTORIC BRIDGE AND LOCAL HISTORIC CONTEXT

The following discussion outlines considerations when evaluating the significance of a workhorse bridge in a local historic context. The bridge itself and its location, setting, and materials and design are common sources of significance that can lead to identifying character-defining features that could be reflected in a new design. The bridges discussed exist in historic districts and are not individually eligible for the NRHP; guidance on the evaluation of an individually eligible bridge is not within the scope of this study.

Useful tools when evaluating the significance of a bridge within a local historic context are state bridge survey reports and state historic bridge contexts or multiple property contexts listed in the NRHP. A compiled list of completed contexts (in 2004) is included as an appendix to *A Context for Common Historic Bridge Types* (PB and EIH 2005), which itself is a good resource for understanding the context of a bridge. State bridge survey reports and historic bridge contexts provide common bridge types and characteristics of crossings specific to the state that can be applied to the evaluation of the bridge at hand.

Other tools for evaluating local historic contexts include consultation with DOT and SHPO staff historians, collaboration with stakeholders, utilization of Geographic Information System (GIS) software to understand spatial relationships within the area, and visual observations and analysis to understand scale and aesthetic treatments.

THE HISTORIC BRIDGE

The character-defining features of workhorse bridges are related to the structure type and standardized features. It is important to remember that a workhorse bridge was designed according to the technology, design standards, and specifications that were in effect at the time of its construction. The form of the bridge may have been from a standard design that was used by the highway department at the time of its initial construction, reflecting the time and place of its inception.

Consider statewide bridge building trends during the period of significance of the historic district and how that may have contributed to the design choices of the existing bridge. What modern design trends are similar to those seen in the past?

Although most aesthetic treatments, especially applied ornamentation, should not be exactly replicated on a new bridge, any existing bridge elements that contribute to a distinct aesthetic appearance may be significant to the historic context. Is the railing of a particular ornate design? What colors, if any, contribute to the blending or prominence of the bridge in the setting? What materials and finishes were used on the existing bridge? When evaluating a historic context, consider the native materials available to the builders and why certain aesthetic choices were made. Workhorse bridges are most often simple working structures with no frills; any aspect that stands out as of particular aesthetic appearance may hold significance.

Consider the scale relationship between the existing bridge with other visible built structures as well as the surrounding natural landscape features. Does the scale of the bridge allow certain viewsheds of other significant features in the district? Does the scale of the bridge contribute to the visual harmony of the setting? The scale relationship between a bridge and its surroundings plays a large role in the visual characteristics of a district, contributing to integrity of setting, feeling, and association. Generally, bridges in rural areas are built modestly, deferring focus to the surrounding landscape rather than bringing attention to the structure itself. A similar sense of scale should be retained in a replacement bridge design in a historic district.

LOCATION

The location of a bridge may contribute to the overall circulation network and integrity of feeling of a historic district, characteristics that should be retained in a new design. Roads, bridges, pathways, and waterways facilitate movement within a landscape, and principal features of those routes can be contributing elements to a district. They must relate to the significant land use patterns presented within the historic period. Ira Beckerman, formerly of Pennsylvania DOT, suggests that the location of a bridge within a rural historic district significant for its landscape should not be altered more than 25 feet in a replacement design from that of the existing bridge (Beckerman 2019a). Significant changes to the location of a bridge could adversely impact a character-defining feature of the historic landscape. Sometimes, maintaining the centerline of an old bridge as the centerline of a new bridge is a commitment to help a project avoid an adverse effect on the historic district.

A gateway bridge marks a specific point of entry or departure from a historic district, which often carries a level of significance because it signals a transition in character. That function and feeling should be retained in the design of a gateway bridge replacement. Maintaining exact location, scale, and shape will aid in that retention.

A bridge located on a main thoroughfare within a historic setting may take on a more distinct visual image. Is it a landmark bridge within the town? To what is the bridge providing access? The location of a bridge may also signal use as a utility bridge, allowing transport of commercial goods or access to resource areas.

Another consideration on bridge location is how the design relates to the landscape it directly crosses or interacts with. Does the bridge take on a unique shape to accommodate a challenging landscape or crossing feature? This consideration is more immediate than the broader surrounding landscape, which may not have a direct impact on the design of the bridge.

SETTING

Historic districts are characterized by cohesiveness and continuity of related elements. They can be set in an urban, suburban, or rural context. Urban contexts are dominated by buildings near each other and a dense population. Rural contexts are dominated by the landscape that buildings and structures fit into. Suburban contexts are characterized by a blend of urban and rural patterns.

Because rural contexts are the focus of this study, they will serve as the basis of examples for this section. An evaluation of character-defining features of a landscape is just as critical to understanding the historic context of a bridge as an evaluation of the bridge itself and should aid in the design process. NPS describes the factors at play in the creation of a rural historic district in the following excerpt from *Cultural Landscapes: Rural Historic Districts in the National Park System*.

Rural historic districts, as a class, exhibit certain physical characteristics. They are extensive land areas where the composition of physical elements by a cultural group or groups was influenced by the natural characteristics of the location itself [e.g., a bridge was built to fit with its surroundings]. It was achieved, however, in a way which reflects the distinctiveness of the culture group(s) and their particular activities over the period of historical development...The rural historic district is more than just a set of landscape components. It is also the particular way in which the components relate to each other and are combined to form the distinct rural landscape which we see and experience [Melnick et al. 1984, 8].

Bridge design will therefore differ from state to state and district to district, based on the natural characteristics of the setting as well as the interests of the cultural group building them and the guiding modern design standards and technology.

With these concepts in mind, when approaching a bridge replacement project in a rural historic district, an evaluation of the natural landscape in relation to the existing bridge design may highlight areas of significance. Pennsylvania Wilds offers the perspective that “because their structural components can be seen from various angles, it is important, even more so with bridges, for bridge design to consider the surrounding context” (PA Wilds 2017, 265). Although natural features can change, that change occurs at a much slower rate compared to advances in bridge technology and can function as a constant in the continuing development of the area. Allowing the existing natural landscape to influence bridge design will result in a more compatible design because it will reflect the historical attitude present when the existing bridge was built. Rural landscapes are a canvas for a continuum of development, reflecting current and then-current technology, all influenced by the controlling criteria of the natural setting.

MATERIALS AND DESIGN

Existing local/regional architectural traditions can aid in understanding local historic context. A CSD/S approach encourages replacement designs that pay homage to a region’s significant architecture. Several transportation agencies express this sentiment in CSD/S manuals and policy statements. The California Department of Transportation (Caltrans) bridge team (BA&A) approaches CSD/S with inspiration from existing architectural traditions and aspirations. They focus on creating a continuity of existing designs throughout the state that impart a historical attitude without replicating historic designs (Caltrans 2015, 2-2). A similar statement comes from Colorado: CSD should acknowledge “a concern for local architectural identity and investment” (Colorado DOT 2019, 2-6). Maryland echoes that an appropriate design for the replacement of a “Preservation Priority Historic Bridge” would be a design that reflects “the state of twenty-first century bridge design and SHA’s engineering heritage (e.g., a concrete arch bridge)” (KCI and TranSystems 2012, 8). New Mexico DOT specifically recommends that existing local features, including railings, landscape design, and lighting fixtures, be used as patterns for any new project (Simon 2006, 87). Taking inspiration from regional traditions and similar structures nearby maintains a sense of place and can project a historical impression on a bridge or area without creating a false sense of history.

Consider the materials and design of nearby bridges. Are those materials native to the area? Do they contribute to a sense of architectural tradition in the area? Are the other nearby workhorse bridges similar in type and form to the existing bridge being replaced? Consider replacement with a similar bridge type if type continuity is seen across the district or area. Pennsylvania DOT’s work to modernize standard bridge designs provides a good example. In 2008, a task force convened by Pennsylvania DOT developed recommendations on decision-making regarding the preservation of existing bridges as well as the intersection of bridge replacement and the Secretary of the Interior’s Standards on Rehabilitation (Pennsylvania DOT 2009). The task force presented a Principles of Bridge Aesthetics Statement that suggested the creation of standard bridge designs that consistently appeal to the public as well as bridge designers in early design stages. Regarding single-span workhorse bridges, the stated goal was to develop a regional bridge style, based on historic bridge designs, by implementing updates to available material, using current technology, and highlighting simple motifs. Existing designs identified as potential candidates for modernization/adaptation and standardization to a regional style included TL-2 open parapet, examples of Pennsylvania concrete bridges from the 1920s, and early turnpike bridges (Pennsylvania DOT 2009).

Although workhorse bridges are not typically designed by notable designers, they are potentially part of larger engineering projects, including railroad extensions or improvements and corridor construction. Similarly, cultural happenings and transportation themes of the past may have had an influence on the type of bridge constructed at the time.

SECTION 1.4: WHEN TO CONSIDER THE HISTORIC CONTEXT OF THE BRIDGE

One of the key considerations that can lead to a successful replacement of a workhorse bridge is when and how often the historic context of the bridge is considered throughout the design process. Integration of historic preservation throughout the planning and development of projects is considered to be “the single most effective way to achieve balanced solutions resulting in preservation of historic roads, or any historic property...” (McCahon et al. 2012, 1-6). A purpose and needs statement with well-defined goals and objectives related to the historical significance of the property can serve as criteria in screening and evaluating alternatives for a project. Achieving a balanced solution is key.

This project collected information on current practices using both a screening and an in-depth survey. Survey respondents show consideration for the historic context of a bridge first during preliminary design with continued consideration throughout the design process (see Part II, Research Report). The preliminary design stage is cited by eight of 11 in-depth survey respondents as a common period for context evaluation, with four of those eight beginning the process during National Environmental Policy Act (NEPA) and inter-agency consultations (before preliminary design). Five of 11 survey respondents report consideration during three or more development stages, indicating that consideration throughout the development process may be helpful in making design choices at the later stages.

The Task Force suggests three occasions during project development when the historic context should be considered: a first analysis during planning that lays a base for the needs of the community; a second analysis during preliminary engineering that allows an extensive evaluation of the bridge, including environmental, cultural, and public considerations; and a third analysis during the final design stage that makes any changes to the design in light of any major concerns (Pennsylvania DOT 2009, 4-5). This is similar to the approach taken by P3 RBRP, in which bridges were initially vetted and the historic context evaluated for inclusion in the program and were again evaluated for historical significance during project scoping.

Arizona DOT considers the design of a historic bridge replacement before the concept studies are initiated in an Initial Bridge Study:

On projects involving rehabilitation or replacement of existing bridges, the project manager shall identify the historical significance of the bridge before concept studies are initiated. The historical significance is determined from the Arizona Structure Inventory and involves a variety of characteristics: the bridge may be a particularly unique example of the history of engineering; the crossing itself might be significant; the bridge might be associated with a historical property or area; or historical significance could be derived from the fact the bridge was associated with significant events or circumstances [Arizona DOT 2001, 1-6].

New Hampshire DOT considers historic issues and aesthetics, among others, in the type, size, and location phase used to determine the bridge structure type to be used (New Hampshire DOT 2015, 2.1-1). Although the argument set for this topic is to consider the historic context as early as possible and throughout the design process, one critical point of considerations should be during the design phase when bridge type is chosen.

The Stinesville Road and Defouri Street Bridge replacement projects, as described in the Case Studies section of this report, provide insight into the practice of historic context evaluation by the private sector. In the case of the Defouri Street Bridge, the consulting engineer considered the historic context of the bridge before contract award, during the proposal stage (Rotto 2019). Similarly, for the Stinesville Road

Bridge in Indiana, the consulting engineer expressed consideration for the historic context during project programming in the form of a Historic Properties Report.

A second critical point in the design process to consider the historic context is during all public engagement/involvement opportunities. Whether those opportunities occur once or multiple times, continued consultation with the public on the historic perspective helps to keep everyone on the same page through construction.

SECTION 1.5: PUBLIC STAKEHOLDER INVOLVEMENT

The engagement of all stakeholders is a key principle of CSD/S. Stakeholders are any individual or organization with direct interest, involvement, or investment in the project and can include area transportation commissions, planning organizations, historical commissions, neighborhood associations, government (federal, state, county, or city) agencies, and public stakeholders. Typically, the engagement of non-public stakeholders is carried out during the Section 106 process, and these stakeholders are identified as consulting parties. Public stakeholders, which can include professionals, contractors, media, and local property owners, are not included as consulting parties as part of Section 106, and their involvement and input must be sought through other means. Communication with public stakeholders is particularly important as their satisfaction with an outcome can partially dictate the success of the project.

Significant conflict can arise between public stakeholders and project engineers. Within the consensus-building process, it is possible that community desires could go against the design of a safe and SOI-compliant bridge in favor of a design with the inappropriate application of seemingly “historic” materials. Careful consideration of the public involvement process becomes critical to the CSD/S approach and the successful melding of the wide range of stakeholder desires, SOI Standards, and engineering and safety standards in the design process.

In the survey conducted for this project, respondents were asked to provide effective public outreach strategies for environmental, cultural, and design considerations. Similar strategies were suggested across all three areas. Public meetings and workshops ranked the most effective amongst respondents. Ideas to implement at these meetings and workshops included bringing samples of the proposed design to display and using exciting visual techniques, such as 3D printing, to do so. This approach is echoed in *NCHRP Web-Only Document 184: Going the Distance Together: A Citizen’s Guide to Context Sensitive Solutions for Better Transportation*, which recommends “establishing a common visual language (visual Simulation) to encourage community participation in the early stages of design” (D’Ignazio et al. 2010, II-15).

Among the many facets of the public involvement process, early and continuous outreach is cited most often as an important and effective strategy for successful stakeholder involvement. One survey respondent mentions at multiple locations in the survey that early outreach to the local community, even as early as directly after scoping, is helpful and effective. The majority of other sources also recommend early outreach and assemblage of stakeholder groups at the onset of project development (including Ohio DOT, Pennsylvania DOT, and Oregon DOT). Additional components of the engagement process include visualization of the bridge in its settings, honest and clear communication regarding technical components of the design, and presentation of design options.

What remains undetermined is the most effective approach to solicitation of public input and to what extent decision-making power should be given to the stakeholders to achieve balanced solutions that are in accordance with CSD/S principles, SOI Standards, and engineering standards.

Two approaches to the solicitation of public input have been identified as (1) early open-invitation and (2) delayed input on preferred design. A case study in Atlanta, Georgia, on the 17th Street Bridge replacement describes a public involvement process that began with an open-invitation community workshop run by the design team and focused on educating stakeholders on bridge layout, site constraints and safety, viewing sheds, initial concepts, and receiving stakeholder feedback on preferences. After a second open-invitation community workshop, it was clear to the design team that the community desired a shift in the design focus from a gateway, statement bridge for vehicles entering the city to a bridge that prioritized pedestrian use (Jeakle 2005, 48-52). The early input set the design team on a path with public

buy-in at the onset, preventing any later conflicts when design changes are more challenging to address. This approach begins with a blank slate meeting with the public to allow the community to take ownership of the bridge design.

AASHTO recommends a similar approach that uses mutual education as a key mindset during the public involvement process. Both the engineers and the stakeholders should take on each role as the educator and the learner and be willing to listen and learn from each perspective. AASHTO also recommends that participation of the public should occur as early as possible, before any design decisions are made, even at the risk of “impractical” visions and ideas expressed by the community. Addressing those ideas early in the design process will limit challenges and setbacks down the road (AASHTO 2010, 48).

The project referenced above also used multi-disciplinary focus groups and task groups composed of local professionals, including architects, landscape architects, and city business owners, to develop final enhancement options in small groups. Forming committees or working groups made up of local professionals, business owners, and local organizations appears to be a common tactic. *AASHTO Bridge Aesthetics Sourcebook* emphasizes early establishment of multi-disciplinary project teams specific to the project (AASHTO 2010, 47).

The following excerpt on early public involvement is taken from the Oregon DOT *Project Delivery Public Involvement Resource Guide*.

Early attention to stakeholder needs provides the information necessary to develop an appropriate and effective Public Involvement Plan and schedule. The earlier you start, the better. For example, involving key stakeholders during scope development helps the project leader or manager gather information that is critical to a project’s success. Certainly, there may be some guess work and lack of specifics in the beginning but understand that the plan can be refined as the project development process evolves. Early public involvement efforts during scoping may also help determine who will be most desirable to have supporting the project or help with criteria on consultant selection for public involvement services, for good timing with project start-up [ODOT 2010, 11].

Of the 12 case studies highlighted in Section 1.6, the following projects utilized an early open-invitation public involvement strategy.

- Indiana – Stinesville Road
- New Mexico – Defouri Street
- New Jersey – Route 206 Flood Channel Bridge
- Pennsylvania – Geigel Hill (non-P3 RBRP)
- Delaware – Smiths Bridge

The second approach, which to a certain extent limits public input, solicits feedback after the development of preferred designs. This approach seemingly has two objectives: to eliminate inappropriate design ideas expressed by the community, and to reduce the timeline of a project.

Ohio DOT presents a method of public involvement that involves categorizing design decisions at varying “levels” that places design elements on a scale of low to high flexibility. Those with high flexibility are proposed to the public for input (Ohio DOT 2019). Not every aspect of designing a bridge is up for public debate. Presenting the public with limited options, but options nonetheless, may reduce designs that are out of context and do not conform to the SOI Standards. Some state DOTs have solicited the input of local historical commissions on behalf of the public. In the case of a Michigan DOT project,

the public requested that the Historic District Commission make the decisions when asked for public input (Michigan DOT In-Depth Survey response).

This second approach to public involvement, as described above, is most often used when the project timeline is reduced because of potential safety issues and/or it is part of larger bridge replacement program. The public involvement process can cause delays if public opinions differ from the design team, sometimes leading to legal action taken against the bridge owners. Although those conflicts may be unavoidable at times, approaching the public with multiple preferred designs based on solid design and safety criteria and then allowing the community to choose aesthetic options, such as railing type, form liners, and colors, can function smoothly and effectively.

AASHTO comments on the subject of design options and suggests presenting “a minimum of four technically appropriate alternatives...[that have] already been through a conceptual engineering phase and be technically sound, economical, and efficient solutions...that can be further advanced at a minimum risk” (AASHTO 2010, 49).

A common concern from local communities, particularly in rural areas, is bridge width and changes from one-lane bridges to two-lane bridges. Many perceive the lane adjustment as likely to result in increased traffic disrupting the calmer rural setting. In such cases, AASHTO recommends four preferred designs that can be presented to the public with varying adjustments to bridge width and lane amounts as applicable (AASHTO 2010, 49). (Generally, if a bridge is already two lanes, it is less likely the community would desire a change.)

The following case studies, discussed in detail in the next section, used the delayed input on preferred designs strategy.

- Oregon – Chenoweth Creek
- Texas – Falls County Road
- Virginia – Morgan’s Ford
- Pennsylvania – P3 RBRP

The following sources provide in-depth guides to the CSD/S public involvement process applicable to bridge replacement projects. Additional perspectives on public involvement can be found in the numerous state DOT guides and manuals on CSD/S.

- AASHTO *Bridge Aesthetics Sourcebook: Practical Ideas for Short and Medium Span Bridges*
<https://store.transportation.org/Common/DownloadContentFiles?id=887>
- Georgia DOT, *Context-Sensitive Design Online Manual*
http://www.dot.ga.gov/PartnerSmart/DesignManuals/ContextSensitiveDesign/GDOT_CSD_Manual.pdf
- Michigan DOT, *Guidelines for Stakeholder Engagement*
https://www.michigan.gov/documents/mdot/MDOT_Guidelines_For_Stakeholder_Engagement_264850_7.pdf
- Minnesota DOT, *Hear Every Voice: A Guide to Public Involvement at Mn/DOT*
<https://www.dot.state.mn.us/publicinvolvement/pdf/hear-every-voice-1.pdf>

- Janet D'Ignazio, Matthew Day, Meg Maguire, Leigh Lane, Gary Toth, and Marie Venner, *NCHRP Web-Only Document 184: Going the Distance Together: A Citizen's Guide to Context Sensitive Solutions for Better Transportation*
<http://www.reconnectingamerica.org/assets/Uploads/201109nchrpW184.pdf>
- Ohio DOT, *ODOT's Public Involvement Process and CSD/CSS*
<https://slideplayer.com/slide/2484057/>
- *Design Aesthetics Public Involvement Update*
http://www.dot.state.oh.us/Divisions/Planning/Environment/manuals_guidance/Documents/Public%20Involvement/Design%20Aesthetics%20Public%20Involvement%20Update.pdf
- Oregon DOT, *Project Delivery Public Involvement Resource Guide*
<http://library.state.or.us/repository/2010/201007201523292/index.pdf>.

SECTION 1.6: CASE STUDIES

Four of the following case studies are set in rural historic districts. Five are set in rural villages/towns, two are located along historic/scenic highways, and one is in an urban environment. The projects not set in a rural location are useful to explore for potential relevance to CSD of workhorse bridges. Although certain design characteristics from an urban setting may not be translatable to a rural setting, project approaches and methods for evaluating contexts may be more universally applicable.

CHENOWETH CREEK BRIDGE, WASCO COUNTY, OREGON (REGIONAL APPROACH)

The Chenoweth Creek Bridge project is a great example of using a regional approach to a context-sensitive replacement along a linear historic resource; the Historic Columbia River Highway (CRH). The CRH served as the “region” and provided the design influence for the replacement bridge. The original Chenoweth Creek Bridge, completed in 1920, functioned as the eastern gateway to the CRH National Historic Landmark (NHL) District, which is characterized by plateau country and fruit orchards near The Dalles and transitions to basalt cliffs and alcoves along the river as it moves farther west (Figure I-5) (Hadlow 2000). This three-span reinforced concrete slab bridge was a product of the Oregon State Highway Department, under the direction of the state bridge engineer, Conde B. McCullough. Each span was 20 feet long. The bridge was topped with a segmental arch concrete railing, later replaced with metal guardrail (Oregon DOT 1986, 159).



FIGURE I-5: Chenoweth Creek Bridge, May 2017 (Courtesy of Oregon DOT 2018)

Project Description

Inspection of the bridge revealed significant cracking and scouring that could cause the bridge to become unstable. The replacement of the Chenoweth Creek Bridge was put out for bid in spring of 2017 as a package including the rehabilitation of two other historic bridges, Mosier Creek and Dry Canyon, also along the Columbia River Highway.

A project description located on the Oregon DOT website cited the replacement of the existing structure, installation of a “bridge railing fitting to the bridge’s original 1920s design,” and restoration of the stream below the bridge (Oregon DOT 2019a).

Historic Context

The Chenoweth Creek Bridge is located in the CRH NHL District, which is located along the south side of the Columbia River between the cities of Troutdale and The Dalles. The district encompasses three segments of the historic, rural highway, built in 1913–1922 as the first scenic highway in the United States. The highway was designed to access and highlight the beautiful views and natural features of the

Columbia River Gorge while also exhibiting outstanding engineering features along the way itself. The district was listed in the NRHP in 1983 and designated an NHL in 2000. The original Chenoweth Creek Bridge was a contributing structure to the eastern segment (No. 3) of the NHL district but was not individually eligible for inclusion in the NRHP.

As described in the NHL Nomination, each bridge was designed specifically to its location with aesthetics in mind. Arch bridges were often used along the CRH in areas with heavy cliffs and other similar rugged landscapes; however, the Chenoweth Creek Bridge was constructed in a location that was not suitable for an arch form and instead took on a simpler slab form. In addition, because there is no view of the Chenoweth Creek Bridge substructure for users, a more aesthetic arch substructure was not needed, which, on other bridges, is seen before crossing the bridge. What remained consistent across the collection of bridges in the eastern segment of the highway was a signature ornamental concrete railing, which would become the focus of the Chenoweth Creek Bridge replacement.

In the late 1990s, ODOT committed to recreate the concrete railings on the Chenoweth Creek Bridge. They would replace the metal railings that the agency had installed on the bridge in the 1980s as a quick fix in place of the original deteriorated concrete railings. However, the 1980s retrofit included cutting off the original concrete railings and the curbs, which made recreating the railings an onerous task. Despite its lack of integrity, the Chenoweth Creek Bridge was included as a contributing feature of the CRH NHL District, with the understanding that ODOT would recreate the original railing. That never happened.

The Mosier Creek Bridge and Dry Canyon Bridge (Figure I-6), which underwent rehabilitation as part of this project, are both individually eligible for inclusion in the NRHP. Their “significant historic values” warranted rehabilitation versus replacement (Hadlow 2017, 20). These two bridges represent a piece of the NHL district’s historic “style.” The unique reinforced concrete arch bridges of the CRH are impressive and integral to the historic integrity of the district, visually and intangibly.



FIGURE I-6: Dry Canyon Bridge, May 2017 (Courtesy of Oregon DOT 2019b)

With access to this wealth of information, the historic context of the bridge was easily evaluated and understood. Oregon DOT staff were already highly knowledgeable of the history of the CRH and the construction of its bridges and identified the original ornamental concrete railing as a main source of significance and compatibility for the replacement design. The chosen reference to these structures in the replacement design was the defining first step in the resulting context-sensitive bridge design. The design was successful in that there was no adverse effect to the NHL, and the appearance of the bridge is highly compatible with the surrounding landscape and regional bridge style.

Project Approach

Oregon DOT's context-sensitive design/solutions and sustainability (CS³) approach to design blends CSD/S concepts with sustainability. The CS³ approach "is designed to meet traditional DOT goals of maintaining safety and mobility while reflecting community values, supporting economic prosperity, achieving responsible stewardship of the natural environment and facilitating cost-effective solutions" (Oregon DOT 2005, 3). Three main areas of focus encourage (1) an all-encompassing view of design and construction functions for a project rather than individual components, (2) early consideration of design in project planning, and (3) openness to multiple solutions to achieve a successful outcome.

The project development process for the Chenoweth Creek Bridge replacement is exemplary of an approach to CSD/S using influence from regional bridge styles. The goal for the Chenoweth Creek Bridge replacement was to replace the original bridge while meeting modern safety and engineering standards and to create a design that complimented nearby bridges and was appropriate for the location.

Because the bridge was located in an NHL, a higher level of scrutiny was placed on the replacement design, which needed to be compatible with the nationally significant historic landmark. The CRH was the first scenic highway in the United States to be designated an NHL. It is significant under NHL Criterion 1 and NHL Criterion 4 for its pioneering advances in road design and its sensitivity to the natural landscape. In addition, the project was expedited as a rapid bridge replacement, scheduled for completion in only 21 days (Oregon DOT 2018, 4). Therefore the cooperation and collaboration of engineers, cultural resource professionals, and public stakeholders was key to the success of this project. Although a challenge, the design development process proceeded rather smoothly. DOT cultural staff and design engineers worked together to reach their common goal of creating a balanced solution, which is defined in the 2012 NCHRP report on the *Design and Management of Historic Roads* as "an outcome that respects and preserves historic significance without compromising safety and operations" (McCahon et al. 2012, i).

Section 106/Consultation

The SHPO concurred that removing the bridge would not have an adverse effect on the NHL, both the easternmost segment and the district as a whole. The bridge was listed as contributing to the historic district in 1983 and the NHL; however, the SHPO concurred that even though the bridge is a contributing feature of the NRHP and NHL historic districts, it lacks integrity because of the replacement of the original railing. Oregon DOT had intended to recreate the historic concrete railing on the bridge prior to this project, but it was not possible because of how the original railing was removed in the 1980s. Nevertheless, the SHPO's greater concern was the design of the replacement bridge, which had a higher risk of creating an adverse effect on the NHL district and therefore needed a context-sensitive design.

In consultation with the SHPO, Oregon DOT outlined the following design commitments in the Section 106 Finding of Effect to avoid an adverse effect on the NHL district.

- Maintain the existing bridge's centerline as the centerline of the highway.
- Construct the new bridge deck railings with structural steel encased in concrete to meet crash standards and to be a close reproduction of the "Standard Type A" arched railings that were originally on the bridge.
- Ensure the railing design complements the Mosier Creek Bridge and Dry Canyon Bridge, also in the eastern segment of the NHL, and features Standard Type A railing design.

Public Involvement

Because of the nature of a rapid bridge replacement, the public involvement process for the Chenoweth Creek Bridge was truncated compared to a typical CSD/S process. Oregon DOT completed the design development prior to any consultation with the public. At a public presentation, the uses of 3D modeling and 3D PDFs of the new railing offered a detailed visual of the proposed bridge. The models were presented at a public meeting, to the SHPO, and to additional stakeholder groups, including The Dalles Historic Landmarks Commission and the Historic Columbia River Highway Advisory Committee (HCRH AC). Oregon DOT staff created a presentation for each group and received overall positive responses to the design.

Consultation with the HCRH AC fulfilled the public involvement component of Section 106. The HCRH AC, established in 1987, consists of six private citizens and four agency representatives (Oregon DOT, SHPO, Oregon Parks and Recreation, and Travel Oregon™). This committee is prominent in the community and passionate about the highway. Although their involvement, and the engagement of other stakeholders, was on a small scale, it certainly influenced the bridge design. The AC Chairman was adamant that the bridge not become too wide, risking altering the historic feeling of the roadway. A compromise was made on width because safety standards had to be met to accommodate the heavy bike traffic on the route.

Design

Compatibility was achieved primarily through the railing design, which mimicked the original ornamental concrete railing using modern technology. Initially, project engineers indicated that a new railing would need to be solid, snag-free, and crash tested to accommodate a wider bridge design and higher design speed, very different in design from the original bridge railing, which featured open arches. There was a specific concern for snagging on the open arches if the curbs were too low. The desired historic style that would have normally been used on this bridge would therefore have to be modified to meet these requirements. Incorporating a taller curb section minimized the potential for vehicles snagging on the railing.

Prior to this replacement project, Oregon DOT had developed a “stealth rail” technology, which uses a structural steel skeleton encased in concrete that replicates historic or original decorative details. To meet current modern code requirements for this project, the stealth rails also included slight alterations to geometry, raising the rail to the required pedestrian height and blocking large openings. The goal of stealth rail is to produce a crashworthy replica bridge rail while maintaining visual accuracy with the original rail (Oregon DOT 2013, xxiii). Typically, the stealth rail technology is used for retrofitting new railings to historic bridges with lower design speeds. According to Robert Hadlow (Hadlow 2019), Oregon DOT has designed segmental arch openings, Gothic arch openings, Roman arch openings, and Union Jack (British flag) cutouts as stealth railings. The new Chenoweth Creek Bridge’s railings incorporated the segmental arch opening, which is reminiscent of the Standard Type A railing that McCullough had installed on the original Chenoweth Creek Bridge and on the Mosier Creek and Dry Canyon bridges. The railing was successfully modified to accommodate the higher design speed needed for the bridge (i.e., geometric alterations and railing height). The design team softened the visual impact of the tall, smooth curb section using a horizontal character line, or shadow line, to break it up and create some architectural interest. They added the line on both the deck side and on the elevation side of the railing (Figure I-7).

Oregon DOT designed the replacement rail according to its “Bridge Design/Drafting Manual for a TL-4 Loading.” (Hadlow 2017, 17). The state bridge engineer made possible the use of this non-crash-tested rail by approving a design exception.

The resulting replacement bridge consists of a clear-span precast concrete beam and deck system with a concrete encased steel railing with segmental arch openings (Figure I-8; Table I-1). The bridge is a majority precast structure including “five prestressed Deck BT 45 girders, two concrete end panels comprised of four sections each, two pile caps, four wing walls, and nearly 250 linear feet of ornamental bridge rail” (Oregon DOT 2018, 2).



FIGURE I-7: During Construction of the Chenoweth Creek Bridge Stealth Railing, Summer 2018 (Courtesy of Oregon DOT 2019b)



FIGURE I-8: Chenoweth Creek Bridge, August 2017 (Courtesy of Oregon DOT 2019b)

TABLE I-1: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW CHENOWETH CREEK BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Railing	Appearance very similar to the Standard Type A deck rails originally on the bridge.
Plaque	Plaque display with the name and year of construction, indicating it is a modern structure and not an old one.
Alignment	Centerline retained.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Girder Type	Girder type and closure allowed for the concealment of utilities. (Deck is part of the top flanges of the girder, use of high performance concrete to connect girders.)
Railing	Stealth railing designed with elevated curb, smooth lower surfaces that reduce vehicle snagging, appropriately sized openings with a wire along the back side to prevent children and small animals from falling through, and horizontal scoring with a small step back to mimic a curb line and break up the smooth lower surfaces.
Bridge Widened	Bridge was widened to meet current standards. Stakeholders wanted a narrower bridge; however, the amount of bicycle traffic on the road dictated a wider bridge for safety reasons.
Three Spans to One Span	Altering the bridge from three spans to one was not a concern for the SHPO or stakeholders. The landscape and influence from nearby bridges permitted a single-span bridge.

Project Outcome/Evaluation of Success

The replacement of Chenoweth Creek Bridge and rehabilitation of Mosier Creek Bridge and Dry Canyon Bridge were completed in August 2017 at an approximate cost of \$9.3 million (Oregon DOT 2019a).

Oregon DOT used CSD/S principles to improve the safety of the bridge and achieve a compatible design within the historic context, primarily accomplished by the railing design that complements the 1920s railings retained on the nearby Mosier Creek and Dry Canyon Bridges. The original Chenoweth Creek Bridge’s 1920s railing, before being retrofitted with a metal guardrail, was of the same style. The increased railing height and widened roadway meet current safety standard without an adverse effect to the NHL district. Although specifically designed for the Chenoweth Creek Bridge, the railing technology and design character of the bridge lend to a future standard design in Oregon. Oregon DOT would like to get the railing crash-tested at TL-4; however, the process is expensive and will take some time. Oregon DOT believes the railing is applicable throughout the state of Oregon as a signature state design and potentially applicable across the country in similar settings and historic contexts.

COOK’S CHASM BRIDGE, LINCOLN COUNTY, OREGON (REGIONAL APPROACH)

Cook’s Chasm Bridge (Oregon DOT Structure No. 1174), located on the Oregon Coast Highway (U.S. Route 101) near the town of Yachats, spans Cook’s Chasm in Lincoln County. The Oregon Coast Highway is a designated National Scenic Byway. Although not in a designated historic district, principles of CSD/S are well represented in this example.

The original bridge was built in 1931, a three-span slab beam and girder bridge, designed by state bridge engineer Conde D. McCullough (Oregon DOT 1986, 311; 2003, 1). It was considered “plain in contrast” to many of McCullough’s other 1930 designs (Hart-Chambers 2019).

Project Description

Because of the high salt content in the air from the “spouting horn” below, by 2001 the bridge was severely deteriorated, requiring full replacement. The replacement of the Cooks Chasm Bridge was put out for bid in fall 2001 and awarded to F.E. Ward. The replacement bridge was completed in May 2003 at a cost of \$3,436,000 (not including planning, design, and inspection) (McGowen and Johnson 2007, 22).

Historic Context

The Oregon Coast Highway No. 9 was designated as the Coast Highway No. 3 in 1917. In 1921 it was renamed the Roosevelt Coast Military Highway, and again renamed in 1932 (RWE 2017, 9-1) to its current title. The highway boasts the ornamental bridge designs of Conde McCullough from the 1920s and 1930s, distinct in their reinforced concrete construction and ornamental railings. This is the same McCullough whose team designed the Mosier Creek and Dry Canyon (arch) Bridges on the CRH and the original Chenoweth Creek Bridge that Oregon DOT replaced.

Project Approach

In approaching the Cook’s Chasm Bridge replacement, Oregon DOT’s goals were to design an aesthetically pleasing bridge that complemented the scenic highway and to “restore and maintain traffic” (McGowen and Johnson 2007, 2). Oregon DOT also wanted to eliminate the need for intermediate footings, and the location dictated the replication of typical features on McCullough coastal designs. Therefore, Oregon DOT chose a deck arch form. The agency also desired compatibility with walls built by the Civilian Conservation Corps along the highway (Oregon DOT 2003, 3). This replacement project is another example of using a regional style to guide the CSD process.

Public Involvement

As part of the CSD/S process, an Oregon DOT scenic byway specialist led a small working group consisting of the Executive Director of the county museum, a representative for the Yachats City Council, two community members previously active with Oregon DOT and U.S. Forest Service (USFS) projects, and a USFS landscape architect and Scenic Area Manager (Hart-Chambers 2019). At this early meeting, the group reviewed several replacement options and provided their recommendation of an arch bridge to Oregon DOT staff. Per the working group recommendation, Oregon DOT Bridge Section proceeded with design development and aesthetic decisions. Aesthetics were largely guided by an aesthetics team led by USFS.

Design

Because the bridge is located in a designated scenic area, the project team deemed USFS responsible for the final approval of aesthetic features. A landscape architect for USFS decided on the stain colors for the retaining walls and capstone; these colors were chosen to be compatible with the landscape and bridges along the scenic highway. The architect spent 66 days testing different colors before making final choices (Oregon DOT 2003, 3). The Oregon DOT railing design, however, is reported to have been primarily developed from community input on aesthetics (McGowen and Johnson 2007, 23). Contractors installed an ornamental handrail, made of black steel with a powder coating; however, rust quickly formed on the rail, so in a project report, Oregon DOT recommended use of galvanized steel or aluminum for future projects (Oregon DOT 2003, 3).

In addition, a form liner developed for a previous project was improved upon for Cooks Chasm Bridge. Americans with Disabilities Act (ADA) accessibility was needed because of the high number of elderly residents in the immediate area. Interpretive signage from previously standardized products for use along U.S. Route 101 was also integrated into the new design.

The preferred replacement design was then illustrated by an Oregon DOT graphic designer and presented to the community. Table I-2 describes the design elements incorporated into the final replacement design.

TABLE I-2: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW COOKS CHASM BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Bridge Form	Deck arch form influenced by historic bridge styles along U.S. Route 101.
Alignment	Maintained existing alignment.
ADA	Bridge was made ADA accessible in response to the local community desires.
Sidewalk	Sidewalk installed on one side of the bridge with ornamental rail to provide scenic viewing area.
Handrail	Ornamental steel handrail chosen for aesthetic reasons.
Interpretive Signage	Interpretive signage was installed to relate the history of the bridge and indicate the modern construction date of the replacement bridge.
Colors	The retaining walls and capstones were tinted to be compatible with the landscape and other bridges along the highway.
Abutments	Abutments treated with a form liner to mimic stone from the area.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Bridge Form	Deck arch form chosen to eliminate intermediate footings.
X-Beams	The beams were widened to a wedge shape at the ends because they were not wide enough to accommodate the Post tension Anchor Plates (Oregon DOT 2003, 4).

Table I-3 lists the CSD/S items and estimated costs from the project, as provided by McGowen and Johnson (2007, 22):

TABLE I-3: CSD/S COSTS BY TREATMENT TYPE

TREATMENT	COST
Bridge Architectural Treatment	\$16,200
Bridge Hand Rail	\$20,000
Wall Architectural Treatment	\$71,600
Wall Hand Rail	\$5,655
Ornamental Rail	\$92,760
Wall Architectural Treatment	\$31,000
Wall Hand Rail	\$8,905
Ornamental Rail	\$7,380
Credit for Form Liners	\$(10,500)
Rail Reinforcement Change	\$621
Planter Box & Soil	\$3,498
Design, Fabrication and Installation of Interpretive Signing	\$45,000

Project Outcome/Evaluation of Success

The resulting replacement bridge consists of a black steel reinforced concrete deck arch with precast arch and column pieces and cast-in-place footings and deck (Figure I-9). An ADA trail crossing the new sidewalk provides access to an interpretive scenic overlook. The new bridge retained its existing alignment. A detour bridge was constructed adjacent to the bridge, of which the approaches were left in place as parking and viewing areas for purposes of the scenic overlook and USFS site (Oregon DOT 2003, 2).



FIGURE I-9: Cooks Chasm Bridge, July 2011 (Photographer: Michael Goff, Courtesy of Bridgehunter.com)

PENNSYLVANIA P3 RAPID BRIDGE REPLACEMENT PROGRAM/PROJECT (REGIONAL APPROACH)

The P3 RBRP is a public-private partnership (P3) program implemented by Pennsylvania DOT to replace 558 structurally deficient state bridges. Pennsylvania DOT is partnered with a private consulting consortium that is tasked with funding, designing, constructing, and maintaining each bridge for a 28-year term. The bridges were to be constructed in the first 3 years of the term followed by 25 years of maintenance. The project was awarded in October 2014 (PWKP 2019a). On July 29, 2019, Plenary Walsh Keystone Partners (PWKP) reported that construction began on the final P3 RBRP bridge on July 8, 2019; all 558 program bridges were scheduled for completion by fall 2019 (PWKP 2019c).

P3 RBRP bridge designs were heavily influenced by Pennsylvania DOT's work to modernize standard bridge designs. In 2008, the Pennsylvania DOT Contextual Bridge Preservation Task Force (see the Significance and Integrity section of Section 1.2) developed recommendations on decision-making regarding the preservation of existing bridges as well as the intersection of bridge replacement and the Secretary of the Interior's Standards on Rehabilitation (Pennsylvania DOT 2009, 3). The Task Force presented a Principles of Bridge Aesthetics Statement that suggested the creation of standard bridge designs that consistently appeal to the public as well as bridge designers in early project stages. More specifically, regarding single-span workhorse bridges, the stated goal was to develop a regional bridge style, based on historic bridge designs, by implementing updates to available material, using current technology, and highlighting simple motifs. Existing designs identified as potential candidates for modernization/adaptation and standardization to a regional style included TL-2 open parapet, examples of Pennsylvania concrete bridges from the 1920s (Figure I-10), and early turnpike bridges (Figure I-11) (Pennsylvania DOT 2009, 16). This adaptation is evidenced in the resulting designs from the P3 RBRP.



FIGURE I-10: 1927 Concrete T-Beam Bridge, Montgomery County, Pennsylvania (Replaced In 2019) (Courtesy of PWKP 2018f)

Pennsylvania DOT’s approach to replacement design under the P3 RBRP allows for design flexibility while creating a cohesive bridge aesthetic that can be applied to both historic and non-historic bridges. Over 2,000 bridges were vetted and evaluated for inclusion in the project based on a variety of factors, including “age, length, number of lanes, average daily traffic, and a wide range of potential environmental impacts,” and 558 were included (PWKP 2019a). Bridges chosen for the program were generally single-span, two-lane

structures, located on smaller state highways and in rural areas, rather than on interstates or major waterway crossings. The 558 bridges share similar characteristics that allow replacements with a standard design, showing a clear regional approach to CSD based on a desire to create a compatible bridge aesthetic among all the program bridges. Historians will reflect on this project and recognize which bridges were part of the program based on the consistent design patterns used (Keim 2019).

The 558 bridges were also chosen based on achievability. Locations with complicated geometric and hydraulic needs were excluded from the final list of eligible bridges. Therefore structural design was not a major consideration for each replacement and more effort could be placed on aesthetics when necessary.

An extensive project development period produced an Aesthetics Master Plan for the project. Following this plan, each program bridge was

designated as one of five defined levels of aesthetic design: Base, Nominal 1 – Internal Context, Nominal 2 – External Context, Combined Nominal 1 and 2, and Enhanced. Internal Context is based on the experience moving across the bridge and External Context is based on the experience from below the



FIGURE I-11: Pennsylvania Turnpike Bridge, Ca. 1968 (Library of Congress 1968a)

bridge or from afar (PWKP 2015, 5). The levels of design were assigned corresponding to the level of aesthetic treatment warranted by the local context (e.g., historic, scenic, and environmental). Bridges vetted at the Base level did not require an aesthetics review unless requested by stakeholders or warranted after an additional assessment. Bridges vetted at any Nominal level were slated for an aesthetics review, no matter if requested by stakeholders, because the local context had already been determined to warrant potential enhancements. Bridges vetted at the Enhanced level were identified as requiring aesthetic enhancements and were designated as such prior to any construction.

Initial designation of aesthetic levels served as a guide to what was likely needed at each bridge site. Bridge vetting designated only one percent (7) of RBRP bridges as “Enhanced,” with 87 percent (493) of the bridges requiring only the “Base” level of aesthetics. The remaining bridges were divided among the Nominal levels (PWKP 2015, 5).

A program replacement design was developed by Pennsylvania DOT in consultation with FHWA and the Pennsylvania Historical and Museum Commission (PHMC) that met engineering standards and was context-sensitive to each program bridge location across the state. The design was titled the Base/Nominal design and provided a simple base design that allowed the option of aesthetic adjustments on a case-by-case basis. Because the 558 program bridges were chosen based on similar characteristics, the design would be appropriate as a replacement for each bridge whether vetted as Base or Nominal. Characteristics of the design include the program stamp, reminiscent of the Pennsylvania DOT logo, the historic Pennsylvania Turnpike Commission stamp, and the Pennsylvania Railroad stamp, and the patterned concrete barrier (Figure I-12).

Bridges in or adjacent to historic districts were chosen for the project if, based on the initial vetting, their removal would not have an adverse effect on the historic district and therefore the Base/Nominal level design would still be appropriate (Keim 2019). Pennsylvania DOT acknowledges that bridges in or adjacent to historic districts should be evaluated with the historic context in mind and aesthetic plans modified as needed.



FIGURE I-12: Base/Nominal Bridge Design Rendering from Penndot Aesthetics Master Plan (PWKP 2015:15)

According to Ira Beckerman (Beckerman 2019b), Pennsylvania DOT’s statewide Programmatic Agreement, negotiated among Pennsylvania DOT, FHWA, and PHMC (SHPO), “allows for a standard design to be acceptable for a replacement of a historic bridge that only contributes to a historic district, [as long as] SHPO agrees and no other consulting party is involved or objects.” This concept was incorporated into the P3 RBRP procedures when designing a replacement bridge with associations to a historic district. Under P3 RBRP, if the bridge contributes to the district, does not have an adverse effect on the district, and no stakeholders object to the Base/Nominal design, no enhancements are needed. If stakeholders do object to the base design and request enhancements, the Aesthetics Master Plan allows aesthetic treatments to bridges in historic districts, whether contributing or non-contributing, adverse or

not adverse. This policy is in accordance with Pennsylvania DOT's Cultural Resource Handbook (Pennsylvania DOT 2013). Eighteen of the 558 RBRP bridges were identified as either in or adjacent to a historic district or near a known historic property and warranted designation as a Nominal or Enhanced design (PWKP 2015, Appendix A). Some bridges, including Gardners Bridge and Kirks Mill Bridge, although in historic districts, did not warrant a Nominal or Enhanced design and were simply designated Base level and not explicitly identified as having associations with a historic resource in the *Technical Provisions* (Pennsylvania DOT 2014). It is likely that several other program bridges are located in or adjacent to historic districts but are not identified as such because they did not warrant a designation above the Base design.

Although the RBRP overall takes a regional approach to CSD when considering bridge replacements in a historic district, elements of a stakeholder-driven approach are evident, if not at the forefront of decision-making. Because program base designs were developed before any bridges were replaced, the emphasis on a regional style was already achieved when moving into the public involvement process. At this stage, stakeholders can drive the project without compromising the underlying cohesiveness of the replacements across the state.

Public Involvement

The public involvement process for the program was executed by the project partners' communications team that facilitated the flow of information to stakeholders. For any bridges involving Section 106 review, Pennsylvania DOT's Project for Pennsylvania Transportation and Heritage (Project PATH) online portal, which tracks project updates and the Section 106 process, was used to facilitate consulting party participation. In addition, for any P3 RBRP bridge involving Section 106 coordination, a cultural resource professional was assigned to the project to aid in the determination of effects assessment and coordination with stakeholders.

The amount of influence/input from stakeholders varied from project to project, typically with more influence on bridges in historic districts that were not contributing and did not constitute an adverse effect. Without an adverse effect, PHMC was generally accepting of stakeholder requests because there was no risk of creating an adverse effect and Section 106 calls for consideration of comments from consulting parties. Projects that did constitute an adverse effect were given more attention from PHMC regarding design; however, bridges were vetted and chosen because they likely would not have an adverse effect and the Base/Nominal design was developed to be context-sensitive and not to create an adverse effect, so there have been few occasions when an adverse effect occurred. Design and aesthetic criteria specified for use by the Aesthetics Master Plan are listed in Table I-4 (PWKP 2015, 8).

Project Outcome/Evaluation of Success

For each P3 RBRP project discussed below, the Base/Nominal design was used as a starting point. Gardners Bridge and Kirks Mill Bridge were vetted at the Base level and therefore any aesthetic treatments were only applied at the request of stakeholders or warranted by the context upon project assessment. Carlisle Road Bridge was vetted at the Combined Nominal level and was therefore planned for aesthetics review. The P3 RBRP was highly successful in implementing a "regional" bridge style throughout the state. Other states looking to systematically replace a large amount of bridges, including bridges in or adjacent to historic districts, should consider implementing a similar approach to the evaluation of those bridges and the design of replacement bridges.

TABLE I-4: AESTHETICS CRITERIA FROM PENNSYLVANIA DOT P3 RBRP AESTHETICS MASTER PLAN

DESIGN ELEMENT	DESCRIPTION
Color	<ul style="list-style-type: none"> • “Use color to create a cohesive identity among bridges from this project and ‘look’ that is distinctive for Pennsylvania.” • “Use color to add interest via contrasting colors to highlight some elements and/or to disguise/mask some elements.” • “There should be no more than two to three colors per bridge and no more than three to four color schemes applied across the Commonwealth.”
Stamp	<ul style="list-style-type: none"> • “A key component of the aesthetic master plan is the stamped emblem which identifies each replacement bridge as part of the PRBR Program.”
Abutments and Wing Walls	<ul style="list-style-type: none"> • “A simulated stone look should be reserved for and may be warranted in location where a historic district is present, and the intent is to complement existing stone and patterns used in neighboring abutments.” • “In Enhanced Contexts, an abutment/wingwall scheme may include tiles and/or reliefs on surfaces, and façade that show artistic and/or historical expressions.”
Barriers	<ul style="list-style-type: none"> • “A simulated stone look should be reserved for and may be warranted in locations where a historic district is present, and the intent is to complement existing stone and patterns used in neighboring abutments.”
Lighting	<ul style="list-style-type: none"> • “Existing standard and aesthetically enhanced lighting schemes will be documented during the survey and design phase to establish the basis for the replacement design.” • “Light design scheme should be limited to enhanced contexts, and where lighting is existing or recommended.”
Walls and Fencing	<ul style="list-style-type: none"> • “The aesthetics treatment of all walls and fencing will be consistent with other physical features such as structures, landscaping, and other highway components in the area adjacent to the Replacement Bridge.”

GARDNERS BRIDGE (UPPER BERMUDIAN CREEK ROAD), ADAMS COUNTY, PENNSYLVANIA

Project Description

This example covers the replacement of Gardners Bridge No. 230 (SR 1016) over Bermudian Creek. It is a waterway crossing located just east of the village of Gardners, a small rural community in northern Adams County, Pennsylvania. The area is characterized by large agricultural fields and farm complexes. The bridge is set in a small wooded pocket as it crosses the creek before exiting near a large lumber yard at its west end.

The original bridge was built in 1938: a two-span reinforced concrete T-beam bridge, 79 feet long and 25 feet wide, a standard design for the era with a standard concrete highway balustrade supported by square balusters interspersed with pedestals (Figure I-13). As reported in a Pennsylvania DOT scoping report, the bridge was determined structurally deficient and proposed the replacement project consisting of “replacing the deteriorating structure, updating guiderail, improving drainage, and milling and overlaying

the approaches” (Keim and Lenert 2015, 1). The replacement bridge was completed in June 2018 (PWKP 2018b).

Historic Context

Gardners Bridge is located in the NRHP-eligible Northern Adams County Fruitbelt Historic District, which encompasses a 4- to 6-mile wide section of land running north-south along the east slope of South Mountain, occupying the majority of the northern and western townships of Adams County



FIGURE I-13: Gardners Bridge, 2015 (Courtesy of PWKP 2018a)

(PHMC 2005, 8). The district was determined eligible for listing in the NRHP in April 2005, significant for its associations with fruit farming and production. The current landscape is dominated by twentieth-century orchards and ponds, sometimes covering the earlier fields and pastures.

In 2014, Gardners Bridge was determined a contributing structure to the Northern Adams County Fruitbelt Historic District, although not individually eligible for inclusion in the NRHP. Three other contributing features were identified in the area of potential effect and an assessment of effects was conducted. An adverse effect was determined because the contributing bridge was to be removed from the historic district. Minimization measures called for a CSD of the bridge replacement and limited land acquisition to minimize impacts to the adjacent contributing properties (Keim and Lenert 2016a).

Section 106/Consultation

This bridge was initially vetted as a Base level bridge (PWKP 2015, Appendix A-19). When it was determined that the bridge was a contributing resource and there would be an adverse effect to the historic district, consideration was given to mitigate that effect. Comment was solicited from consulting parties, of which there was only one other than the SHPO, and because no objections were raised, the Base/Nominal level design was implemented without additional enhancing treatments, such as color tinting of concrete form liners to simulate stone guard rails. The Pennsylvania DOT team determined the base design was appropriate because it was very similar to the existing bridge (Keim 2019). This bridge is located in an extremely rural setting and additional aesthetic treatments may have distracted views of the natural landscape.

Design

According to Ira Beckerman (Beckerman 2019b), early RBRP design aesthetic considerations did not allow for color treatments; it was not yet viewed as a necessary measure for compatibility when the treatment levels were being developed. Gardners Bridge may have received minimal color tinting had that practice been approved at the time. Color is now part of the Pennsylvania DOT aesthetics guidelines and is reflected in most P3 replacements. The resulting Gardners Bridge replacement exhibits the Base/Nominal design without additional aesthetic enhancements (Figure I-14; Table I-5).



FIGURE I-14: Gardners Bridge, June 2018 (Courtesy of PWKP 2018d)

TABLE I-5: CSD/S DESIGN ELEMENTS OF THE NEW GARDNERS BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Bridge Width	Widened the bridge the smallest amount possible.
No Lighting	No sidewalks or lighting, consistent with the rural agricultural character.

Project Outcome/Evaluation of Success

This case study demonstrates that aesthetic enhancements are not always warranted/necessary for workhorse bridges in or adjacent to a historic district. Compatible design depends on the context and the characteristics of the original bridge within that context. Gardners Bridge is located in a very rural setting, originally built to blend with the natural landscape, and by maintaining the two-lane scale of the historic bridge and eliminating aesthetics applications, it remains a minor feature within the landscape. In addition, massing that is similar to the previous bridge preserves the spatial relationship within the wooded setting. The bridge maintains harmony with its surrounding landscape, successfully complying with SOI Standards.

KIRKS MILL BRIDGE, LANCASTER COUNTY, PENNSYLVANIA

Project Description

This example covers the replacement of Kirks Mill Bridge (SR 2002) over Reynolds Run, a waterway crossing located in the historic village of Kirks Mill just east of Wrightsdale, a small settlement in the southern end of Lancaster County, Pennsylvania. The village of Kirks Mill was established around an early gristmill, which remains adjacent to the bridge crossing at its east end. The area is characterized by early Colonial to late Federal style buildings, mostly of brick construction, surrounded by green pastures and moderate tree coverage (Jackson 1978).



FIGURE I-15: Kirks Mill Bridge, 2015 (Courtesy of PWKP 2018c)

The existing bridge was built in 1948: a two-span concrete slab bridge (Figure I-15). As reported in the project early scoping results, the bridge was determined structurally deficient and its replacement was proposed with minor profile adjustments (Keim 2015, 1). Earlier bridges at this location potentially included a timber structure and ford. The replacement bridge was completed in August 2018 (PWKP 2018e).

Historic Context

Kirks Mill Bridge is located in the village of Kirks Mills Historic District, which encompasses a 210-acre plot of land containing late eighteenth- to late nineteenth-century village residences, school, farmstead, meeting house, tenant house, and ca. 1810 gristmill. The district was listed in the NRHP in 1978, significance for its associations with commerce and architecture of the late eighteenth to late nineteenth century (Jackson 1978).

The bridge was determined not eligible for the NRHP in 2007 and did not contribute to the historic district because it was constructed outside the period of significance. A determination of effects finding states that the removal of the non-contributing bridge did not have an adverse effect on the historic district (Keim 2016a,b). This bridge was vetted at the Base level; therefore the Base/Nominal design was determined appropriate and provided the option of additional enhancements at the request of stakeholders or if warranted by the setting.

Public Involvement

This project had a considerable amount of stakeholder involvement and consultation. Vocal property owners were most interested in a one-lane, possibly covered bridge. Stakeholders had a common concern that a new two-lane bridge would bring increased traffic and desired a design that would limit traffic and speed. It was not possible to reduce the bridge to one lane; trucks operated along the state route, which was not to be changed. Two lanes were needed for functionality and safety. In addition, the proximity of the mill building to the road, only about 3 feet away, dictated alignment design and did not allow much flexibility. Stakeholders seemed to have more comments on the structural design of the bridge than on aesthetics, yet the aesthetic decisions were what ultimately satisfied all parties (Keim 2019).

Design

After resolution on the structural design of the bridge (retention of two lanes rather than reducing to one lane), design measures turned to aesthetic applications. Consulting parties requested a design similar to Lees Bridge Road Bridge nearby. Lees Bridge Road was replaced in 2011, a single-span, box beam, concrete bridge with tinted stone form liners on both the exterior and interior parapet walls. The primary aesthetic design element was the use of form liners on the parapets, as done on Lees Bridge Road. In

initial design, the interior of the parapet was to remain smooth concrete and tinted to compliment the exterior; however, consultations requested use of the form liner on the interior as well incorporating a low reveal to avoid snagging.

The resulting replacement, using the Base/Nominal design, consists of a 44-foot-long single-span integral abutment bridge with a width increased from 27.3 feet to 31.5 feet and concrete form liner barriers tinted to a red stone color (Figure I-16; Table I-6).



FIGURE I-16: Kirks Mill Bridge, August 2018 (Courtesy of PWKP 2018e)

TABLE I-6: CSD/S DESIGN ELEMENTS OF THE NEW KIRKS MILL BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Parapets	Stone form liner was used on the exterior and interior of the bridge parapets to mimic the pattern, color, and shape of the foundation stone of the nearby Kirks Mill. No form liner used on the abutments or wing walls.
Color	The form liner was stained to match the color and mortar found on the mill building nearby.
Guiderail	The guiderail was painted brown to soften its appearance.
Alignment	Alignment kept as close to existing as possible because the mill building was close to the road.

Project Outcome/Evaluation of Success

Because this bridge was not designated at the Nominal aesthetic level, a review for aesthetic consideration was not initially intended. The Base/Nominal design without enhancements would have been considered appropriate if the public stakeholders had not objected. The SHPO concurred that the removal of the bridge would not have an adverse effect on the historic district and did not express any hesitation concerning the enhancement requests of the local community. If this bridge had been contributing to the historic district, more weight would have been given to meeting the SOI Standards, but because the bridge was not contributing and its removal did not constitute an adverse effect, public input was given priority to satisfy the desires of the local community. Following the SOI Standards, deferral to the smooth concrete finish of the previous bridge would be appropriate, rather than mimicking the stone finish of

nearby buildings. In this case, priority given to public input resulted in a different design than would have been used if the SOI Standards had been followed.

CARLISLE ROAD BRIDGE, CUMBERLAND COUNTY, PENNSYLVANIA

Project Description

The Carlisle Road Bridge (SR 0034) in Cumberland County, Pennsylvania, traverses Hunters Run and is located in Hunters Run, a small populated area along the edge of the Michaux State Forest. The Appalachian Trail crosses the Carlisle Road Bridge at Hunters Run.

The original bridge was built in 1926: a single-span concrete T-beam bridge with open metal railing (Figure I-17). In 1976 the bridge was extensively repaired and widened, including the removal of the original concrete balustrade and replacement steel guardrail. In 2015 the bridge was identified as structurally deficient and was replaced in January 2019 (PWKP 2019b).



FIGURE I-17: Carlisle Road Bridge, 2018 (Courtesy of PWKP 2018b)

Historic Context

The Carlisle Road Bridge is located in the Pennsylvania segment of the Appalachian Trail Historic District, determined NRHP-eligible in 2008. The Pennsylvania district encompasses segments of the 229 miles of trail constructed between 1926 and 1933. The district has a period of significance of 1922-1958 with associations in the area of Entertainment/Recreation. Because the bridge was significantly altered in 1976, it was determined not contributing to the district and therefore its removal did not have an adverse effect on the district (Keim and Lenert 2016b, 6). There was some concern from NPS about potential effects to the Appalachian Trail, which were addressed, stating that as long as the replacement bridge continued to carry the trail over the water, there would not be an adverse effect. The option for enhanced aesthetic treatments was left to participating stakeholders but was not a requirement for this bridge.

Design

This bridge was vetted at the Nominal level for having potential for additional aesthetic treatments; however, with a no adverse effect determination, those treatments were not necessary. Of three participating consulting parties—NPS, Appalachian Trail Conservancy, and the South Mountain Partnership—NPS was the primary consulting group and was interested in using a tinted form liner to achieve a compatible design. A second design option considered was the use of the Type 10M open metal railing option to retain views of the surrounding landscape, but it was ultimately rejected.

The resulting replacement design, using the Base/Nominal design, consists of a single-span integral abutment bridge with an out-to-out width increased from 28 feet to 42 feet, concrete form liner parapet and abutments, tinted to a burnt orange stone color (Figures I-18 and I-19; Table I-7).



FIGURE I-18: Carlisle Road Bridge, January 2019 (Courtesy of PWKP 2019b)



FIGURE I-19: Color Application Choices (A.D. Marble 2019)

TABLE I-7: CSD/S DESIGN ELEMENTS OF THE NEW CARLISLE ROAD BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Parapet and Abutments	A concrete form liner treatment was used only on the exterior of the parapets and the abutments (smooth, color tinted interior), colored to blend with natural rocks in the area. Abutments and wing walls were left gray to match the light gray limestones seen in the project area.
Form Liner Depth	The reveal depth of the form liner was reduced from 4 inches to 1.75 inches (Keim 2019).
Parapet Height	The parapet height was lowered to 32 inches for better views of the surrounding landscape from the bridge.
Riprap	Limestone was also used for the riprap, a material native to the area.
Color	Several color options for the form liner treatment were tested on the bridge. The final choice applied a burnt orange accent stone color and light application of dark gray with pale beige grout lines on parapet.

Project Outcome/Evaluation of Success

The historic context of the Carlisle Road Bridge is heavily characterized by the natural environment surrounding the bridge. The Appalachian Trail is designated as a historic district for its significance as an outdoor recreational feature; the feeling and experience of walking the trail is derived from the natural setting. Therefore, the focus of the bridge aesthetics on matching colors, rip rap, and form liner depth to the rocks and natural features in the vicinity make the replacement bridge design compatible with the historic context. Following the SOI Standards, the design maintains spatial relationships with the surrounding landscape and applies aesthetic finishes that are compatible with the natural features and convey the bridges source of historic significance. The use of form liners to “historicize” a bridge can result in a structurally confusing design; however, this bridge is a successful example of a bridge design that does not contradict its structural engineering. It is a concrete beam bridge with a masonry parapet wall, not a masonry bridge that would be structurally impossible.

ROSEDALE ROAD BRIDGE, MERCER COUNTY, NEW JERSEY (REPLICATION APPROACH)

The Rosedale Road (Route 604) Bridge (NJ No. 1100041) crosses Stony Brook in Princeton, Mercer County. Rosedale Road linked Princeton to the early Rosedale settlement. The bridge crosses Stony Brook and is set in a wooded residential area. Several open green spaces are scattered throughout the landscape, including golf courses and parks, one of which is the Princeton Battlefield State Park located just 2 miles south of the bridge.

The previous bridge was built in 1937: a single-span reinforced concrete rigid frame bridge, 70 feet long and 60 feet wide, with an arch-shaped superstructure, and stone facing on the wingwalls (Figure I-20). The stone parapet was capped with Bedford Indiana limestone the length of the bridge. This bridge type was common in the late 1930s and 1940s, designed to be aesthetically pleasing in the affluent residential areas in which they were built. The 1937 bridge replaced two steel truss bridges that collapsed in 1935.



FIGURE I-20: Rosedale Road Bridge, April 2005 (Courtesy of IHE 2019b)

Historic Context

The Rosedale Road Bridge lies just north of the Princeton Battlefield/Stony Brook Settlement Village Historic District, which encompasses 585 acres of historic village and farmlands. The existing district is the result of an enlargement in 1989 of the Princeton Battlefield Historic District, which was listed in the NRHP in 1972. Although the district does not extend to the Rosedale Road Bridge, it exhibits similar landscape characteristics and associations with Colonial architecture and military operations of the late eighteenth century as that surrounding the bridge. The bridge was not individually eligible for inclusion in the NRHP.

Design

In 2005, an inspection reported deterioration of the superstructure, requiring the full replacement. The replica replacement bridge was completed in 2009. The design development process for this project is exemplary of a replication approach to CSD/S. Decisions were guided by a desire for a resemblance to the original structure while meeting current safety and structural requirements (IHE 2009).

Consulting engineers expressed a goal to retain the architectural characteristics of the original bridge.

The resulting replacement bridge consists of a replica of the previous structure, with the incorporation of current structural requirements and safety standards (Figure I-21; Table I-8). As described by the contractor, IH Engineers, the “structural design included 13 precast, prestressed box beams, bearings, abutments, wingwalls and retaining walls on spread footings” (IHE 2009).

Prestressed precast box beams with the exact geometry of original arch bottom were designed. The new structure consists of thirteen (13) 4' wide x74'-6" long P/S beams for a total length of 968.5', and the two fascia beams have a 6" wide ledge for a nominal 4" thick stone facing. The P/S arch beam was modified from a standard box beam Type B-II, 48"(W)x33"(H). The thirteen adjacent P/S beams were transversely tied with post-tensioned strands at five diaphragm locations. A minimum of 5-inch thick slab of NJDOT High Performance Concrete (HPC) was placed on top of thirteen P/S beams to form a composite section which provides a stronger bridge section and protects the P/S beams below. The advantage of using HPC for deck slab and parapets is to extend service life for the structure by increasing durability & lowering permeability [IHE 2019a].



FIGURE I-21: Rosedale Road Bridge, September 2010 (Courtesy IHE 2019b)

TABLE I-8: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW ROSEDALE ROAD BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Cap Stones	Existing limestone coping retained for reuse on the replacement bridge parapets.
Parapets	Constructed of reinforced concrete with stone facing.
Superstructure Profile	Prestressed concrete beams with an arch shape were used to imitate the original superstructure profile.
Fascia Beams	The fascia beams have a 6” wide ledge for application of 4” thick stone facing.
Name Plate	New name plate with 2009 construction date.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Concrete	Concrete was used for the substructure, structural members, deck and parapets for its strength, durability, and reduced maintenance effort (IHE 2019a).
HPC Deck Slab and Parapet	High performance concrete used to extend service life by increasing durability and lowering permeability.

Project Outcome/Evaluation of Success

Design sensitivity was successfully achieved through the appropriate reuse of salvaged materials and replication of the historic design. Because this bridge was located adjacent to a historic district and not in a district, the design did not have to follow SOI Standards. Design considerations therefore fell to AASHTO recommendations, which suggest that a replication is appropriate when the bridge is integral to the character of the surrounding area and the replication is a faithful reproduction. The aesthetics of the original Rosedale Road Bridge, including the stone and limestone caps, were integral to the character of the surrounding area, and thus replication was appropriate to retain the character of the area. Modern technology is evident in the structural design, which differentiates the new bridge from the old, in accordance with the SOI Standards.

BRIDGE 9 (SMITH'S BRIDGE), NEWCASTLE COUNTY, DELAWARE (PREVIOUS BRIDGE APPROACH)

Smith's Bridge (No. 9) over Brandywine Creek in Newcastle County is a major waterway crossing, located in Granogue, a small rural area located west of Brandywine very near the Pennsylvania border.

The first bridge at this location, built in 1816, was destroyed only six years after its construction. The second structure built at this location is often referred to as the "original" bridge, to which the most recent replacement design decisions are traced. This bridge was built in 1839 and was a single-span Burr Truss timber-covered bridge with stone abutments. In the 1950s, the structure was reinforced with steel beams and two new concrete piers faced with stone were added to support the superstructure. The superstructure of the bridge was destroyed by arson in 1961. The existing three-span steel beam bridge with timber deck and railing was constructed on the previous substructure in 1962 (Figure I-22).

Project Description

The condition of the bridge slowly deteriorated after 1962 and became a significant maintenance problem for Delaware DOT. The wood deck boards often needed replacement and the railing was continually struck by vehicles, contributing to its deteriorated state and compromised safety at the time of replacement. The existing steel beam bridge carried local traffic through the rural area with a relatively high traffic volume of 2,492 vehicle crossings



FIGURE I-22: Smith's Bridge , Ca. 2000 (Courtesy of Delaware DOT 2000b)

per day as of the project start in 1997, a volume that was projected to increase to 2,978 by 2020 (Weber and Hastings 2019). Project development began in 1999, and the replacement bridge was completed in 2002 at an approximate cost of \$1.2 million (Weber and Hastings 2019).

Historic Context

Smith's Bridge is located in the NRHP-eligible Smith's Mill-Granogue Historic District, which encompasses a 614-acre area of rural residential properties. The district was determined eligible for listing in the NRHP in 1999 and is characterized by Colonial Revival and Federal style architecture, significant for its representation of a late eighteenth-century through twentieth-century rural, agricultural cultural landscape and later a "country house estate" and "chateau country" landscape of the 1920s. Among other features, the surviving roads, railroads, bridges, and farm fields, including Smith's Bridge, contribute significantly to the retention of the distinct cultural landscape.

The bridge is also located just north of the Beaver Valley Area of the First State National Historic Park, which includes several noncontiguous historic homesteads. The park encompasses a 1,105-acre area of land south of the Pennsylvania-Delaware border featuring agricultural fields, rolling hills, forested areas, streams, and winding roads.

A 1936 Historic American Buildings Survey (HABS) report on the bridge (Blake 1936) provides a written description of the original bridge as it stood at approximately 100 years old. Its condition in 1936 was reported as good, having not seen much heavy traffic in its life, being a minor rural route. “German Siding” is noted as likely not the original siding type used on the walls. The foundation and abutments were constructed of “stone, dashed, and whitewashed, except under the bridge at each end, at which places the stonework is pointed” and, at the time, new concrete footings (Blake 1936, 1). Foundation remnants of an early gristmill are noted at the east end of the bridge.

Throughout the 1800s, a variety of manufacturing operations, most prominently gristmills and sawmills, were located along the Brandywine. A mill property established by the Smith family at the east end of the Smith’s Bridge was said to be “well known” in the early 1800s, indicating a potentially distinct crossing point in the area (Pendleton 1999a, 6).

Set on the ca. 1839 substructure (with ca. 1960 concrete piers), only the substructure of the bridge is contributing to the historic district. The NRHP Registration Form states,

Although the present superstructure of Smiths Bridge dates to 1961, when the covered bridge built in 1839 burned, the abutments and wing walls of the 1839 structure survived in modified form (reduced somewhat in height to improve traffic visibility). These surviving elements of the historic bridge maintain the contour of that structure, thereby conveying a sense of its historic appearance (so that it demonstrates integrity of feeling), and thus constitute a contributing element in the historic district [Pendleton 1999b, 7-1].

The well-documented history of this bridge was a significant benefit to the 2002 replacement design process. Access to the HABS drawings was helpful in replicating the historic covered bridge type as closely as possible. Historical photographs and a tour of Pennsylvania covered bridges also aided in the understanding of the history of Smith’s Bridge and the feasibility of reverting to the covered bridge design.

Project Approach

The design development process for this project is exemplary of a previous bridge approach to CSD/S that draws design influence from previous bridges at the site. The original scope for this project was to replace the superstructure with a similar open bridge and rehabilitate the substructure of the 1962 bridge, which would retain elements of the 1839 bridge and subsequent reinforcements. Delaware DOT proposed a new two-lane bridge to safely accommodate the high traffic volume; however, after an early, open public workshop and continued stakeholder input, the decision was made to construct a new covered bridge, referring to the original 1839 Burr Truss.

Section 106/Consultation

The SHPO was content with the project development and had no objections to the covered bridge design. Other consulting parties involved included the New Castle County Historical Review Board, U.S. Army Corps of Engineers (USACE), and the Department of Natural Resources and Environmental Control.

Public Involvement

The first step in the public involvement process was to meet with each of the four adjacent property owners to ensure that the design would address the concerns of local residents. These interviews occurred prior to any preliminary plans, between December 1999 and January 2000, and simply gathered the opinions of the property owners and their desires for the new bridge. The consensus was to keep the speed limit low to prevent increased traffic; however, property owners had differing opinions about the covered-bridge option and the choice between a one-lane or two-lane road. Delaware DOT intended to build a two-lane structure with approach realignment, open concrete deck, and stone-faced parapets. This proposal, although well received by property owners, received significant pushback from the local group Preservation Delaware, which approached Delaware DOT with a stern appeal for a single-lane covered bridge (Delaware DOT 2000a).

At the request of local preservation groups, an open-ended public meeting was held in April 2000 to gauge community concerns and request their solutions for the replacement bridge design (Delaware DOT 2000b). Delaware DOT decided not to present a preferred design and was open to any and all suggestions from the public. This deviated slightly from their typical public involvement strategy and resulted in a successful period of public coordination. A questionnaire returned to Delaware DOT by 68 of 100 meeting attendees identified the top community concerns: (1) maintaining historic character (50 percent) and (2) traffic calming (34 percent). The local community saw value in the retention of a one-lane bridge to keep traffic volume at a minimum, preserving the feeling of the area, and saw the solution in the reconstruction of the historic covered bridge (Delaware DOT 2000d).

A second public meeting was held in June, at which Delaware DOT presented four design options to public and requested each person to rank the options one to four (Delaware DOT 2000c): one lane open, two lanes open, one lane covered, and one lane covered with bike/ped lane (Delaware DOT 2000d). Fifty-nine percent ranked a covered above an open bridge and a subsequent 15-member working group decided on a one-lane covered bridge with room for bicycles and pedestrians without creating a bike/ped lane (Delaware DOT 2000d). The working group comprised civic groups, organizations, property owners, and legislators.

Design

From an engineering perspective, the availability of historic as-built plans from the 1936 HABS documentation and 1956 rehabilitation was useful in developing a replacement design that was based on historic design qualities yet not an exact replica (Figure I-23). Modern technology was used to construct a bridge that met current safety and design standards while referring to the historic appearance. The 1956 steel beams were put back into the replacement design to maintain the carrying traffic load, although it likely would have been possible to achieve the required load amount with a true covered truss bridge.

The resulting replacement design consists of a one-lane timber covered bridge (Table I-9). The high-quality design was constructed by Eastern States Construction Services, Inc. (Figure I-24). An explanation of the design is provided in a Construction Excellence Award application submitted by ESCS in 2003 and outlined below (ESCS 2003).

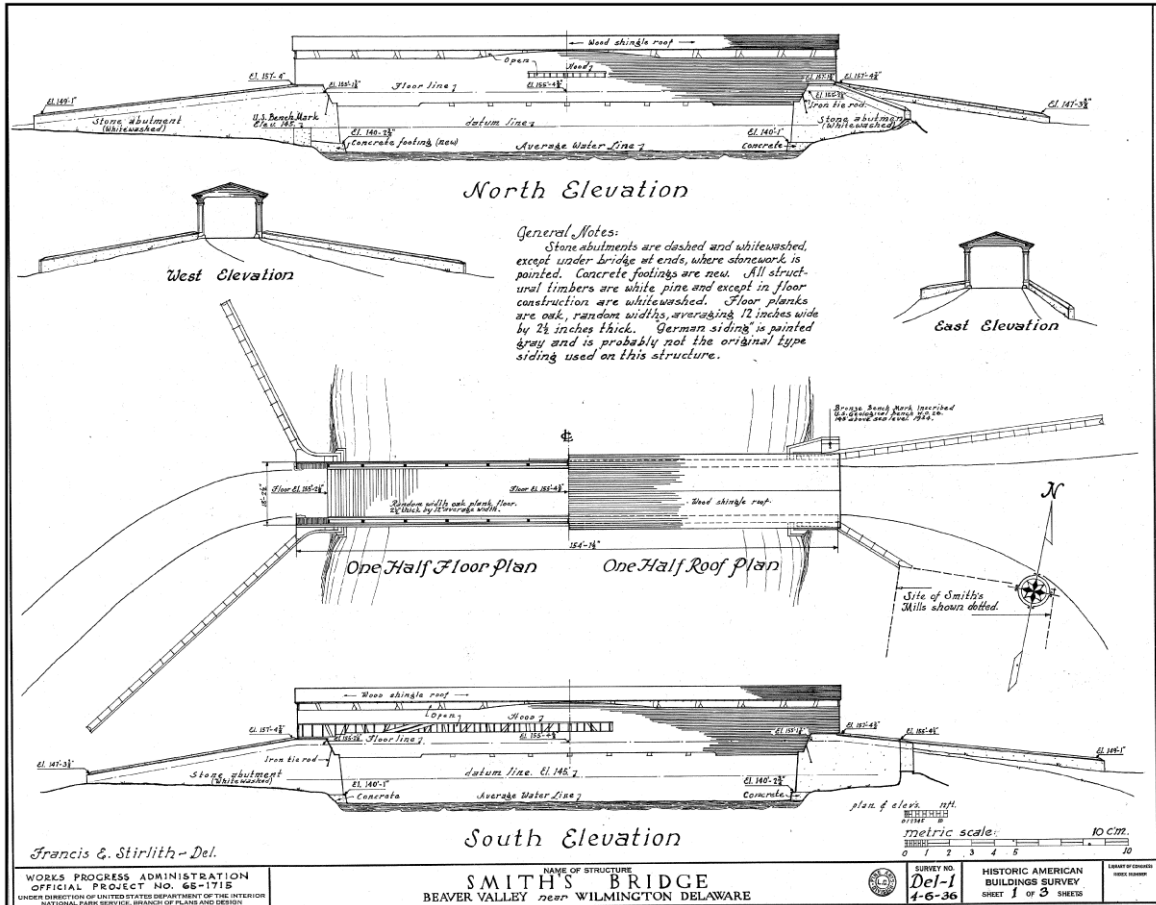


FIGURE I-23: Smith's Bridge HABS Drawings, Ca.1936 (Library of Congress 1933)

- Deck Structure
 - Can support modern highway loading
 - Five steel I-beams, which span the entire length of the bridge
 - Beams supported by two existing piers
 - Steel beams covered with wood decking for aesthetics
- Wood Truss Systems
 - Supports minor loads
 - Can match aesthetic desires more easily
 - Exotic wood chosen (Bongossi), not native to the area (fire resistant and very strong)



FIGURE I-24: Smith's Bridge, June 2011 (Photographer: Jodi Christman; Courtesy of Bridgehunter.com)

TABLE I-9: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW SMITH'S BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Piers and Abutments	The existing stone piers and abutments were retained in place, re-pointed and re-faced to match. The abutments were topped with a poured concrete footing.
Bridge Width	The bridge was built 15 feet wide to accommodate one lane of traffic as well as pedestrians and bikes. Retention of the existing bridge width was allowable by the unchanged abutments and piers.
Covered, Timber Burr Truss	The option to construct a one-lane covered timber truss bridge was a modern replication/interpretation of a previous bridge at the location. This design option required a design exception to AASHTO design guidelines.
Soffit Elevation Maintained	The existing soffit elevation was maintained despite the lowering of the bridge deck. This aids in matching the scale and profile of the new bridge to the existing, which creates a more compatible replacement design.
Rural Historic Landscape	Bridge an integral piece of the rural historic landscape, which was retained in the new bridge.
Wetland Protection	Concrete retaining wall was required to keep the reduction of wetlands to an acceptable level.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
North Side Alignment Adjusted	Slight realignment on the north side to improve sight distances on the approaches.
West End Approach	West end approach raised and realigned to improve sight line distances.
Deck Lowered	Section height of the superstructure was reduced by lowering the bridge deck by 1 foot to improve sightline distances.
Speed	Speed limit lowered to 20 mph, which was more appropriate for the one-lane covered bridge design.

Project Outcome/Evaluation of Success

Because public input was sought early in the project development, Delaware DOT avoided a potential conflict of designing a bridge the public did not like. If Delaware DOT had initially brought a preferred two-lane design to the community, there likely would have been significant pushback and resistance to the proposed design. Because the stakeholders were given a say in the type of bridge they wanted, there was early buy-in and support, which allowed the project to progress smoothly. According to Delaware DOT (Weber and Hastings 2019), the strategy of approaching the first public meeting with a “blank slate” was the most effective public involvement strategy it used during this project, and it has since employed that strategy for similar projects in Delaware. Improved safety was achieved through a slight realignment and raising of the approach and lowering of the deck by 1 foot, which improved sight distances and allowed a low speed limit of 20 mph, consistent with the interests of the local community.

STINESVILLE ROAD BRIDGE, MONROE COUNTY, INDIANA (STAKEHOLDER-DRIVEN APPROACH)

This case study covers the replacement of the N. Stinesville Road (Main Street) Bridge No. 12 over Jack’s Defeat Creek. The Stinesville Road Bridge is a gateway bridge located on the western edge of Stinesville, Indiana, a small town surrounded by a mix of agricultural fields and forested areas. Two large stone quarries are accessed along N. Stinesville Road, west of the bridge.



FIGURE I-25: Stinesville Road Bridge, Ca. 2010 (Courtesy of BLN 2019b)

The previous bridge was built in 1969: a prestressed concrete box-beam multiple with metal rail (Figure I-25). An inspection in 2010 determined the bridge to be deteriorated and of inadequate size (MCHD 2010, 10), requiring replacement of the functionally obsolete and structurally deficient bridge.

Project Description

The replacement was partially funded by a TIGER Grant as well as FHWA aid, and therefore the bridge was reviewed at the state level for compliance with federal design requirements. Section 106 and Section 4(f) documentation was completed for the project and mitigation efforts were executed to resolve an adverse effect to the Stinesville Historic District. Use of the TIGER Grant accelerated the project timeline and the bridge was successfully completed by the expiration of the grant funds. The new bridge was completed in 2014 at a cost of \$3,126,250. Of that, the design cost approximately \$260,250 (MCHD 2013).

Historic Context

The Stinesville Road Bridge is located on the border of the NRHP-eligible Stinesville Historic District as well as the NRHP-listed Stinesville Commercial Historic District. The Stinesville Historic District, encompassing the residential and commercial buildings of the town, was determined eligible for its association as a nineteenth- and twentieth-century quarry town. The district was determined eligible for inclusion in the NRHP in 2004. The Stinesville Commercial Historic District encompasses a small, five-



FIGURE I-26: Western Bridge Approach with View of Town, Ca. 2010
(Courtesy of BLN 2019b)

building section on Main Street, just east of the bridge (Figure I-26). The district was listed in the NRHP in 1995 and is characterized by Romanesque Revival and Renaissance Revival architecture of limestone construction and a landscape of gently rolling hills, significant for its architecture and associations with limestone quarrying and milling. Quarries were historically located along Jacks Defeat Creek, indicating that the Stinesville Road Bridge provided access to the quarries as well as the town (Walls et al. 1994).

The bridge was evaluated under Indiana’s historic bridge inventory and determined non-contributing to the Stinesville Historic District and recommended not individually eligible for NRHP as “no evidence was found...to indicate that this bridge is an important example of bridge design, engineering, or construction or that it possesses a significant association with important historical events or trends” (Indiana DOT 2010a, 766).

Section 106/Consultation

At the onset of the project, a Historic Properties Report was submitted to the SHPO and participating consulting parties for comment. Nine local organizations were invited to be consulting parties; Indiana Landmarks and Bloomington Restorations Inc. accepted the invitation. This Historic Properties Report provided basic project information, and SHPO concurred that the Stinesville Historic District was eligible for inclusion in the NRHP, that the Stinesville Commercial Historic District was listed in the NRHP in 1995, and that the Stinesville Road Bridge was not eligible for inclusion in the NRHP. An archaeological evaluation and report found no presence of archaeological resources in the project area, a finding with which SHPO concurred in July 2010.

Following an additional informational letter, describing in more detail the proposed project, SHPO recommended a finding of an adverse effect. The entirety of the bridge falls outside the historic district boundary; however, a proposed retaining wall on the east end extended into the historic district and therefore an adverse effect was found. No additional comments were received from participating consulting parties. The public was informed of the adverse effect in December 2010 and by January 2011,

SHPO concurred with the Adverse Effect Determination and agreed with the following mitigation stipulations (Indiana DOT 2011, 2).

- Application of Context-Sensitive solutions during design, in accordance with Indiana DOT policies
 - Use of a decorative concrete façade on the retaining wall that mimics the look of natural limestone.
- Prepare an NRHP nomination for the Stinesville Historic District

A Section 4(f) evaluation was triggered by the temporary right-of-way acquisition of property in the Stinesville Historic District. The only permanent right-of-way acquisition was located outside the Historic District boundaries.

The alternative to the utilization of a retaining wall would have largely increased the land acquisition necessary to construct the bridge, including the removal of the dwelling located at the southeast end of the bridge. Use of the retaining wall reduced the footprint of the project and therefore the impact on the surrounding historic district (Indiana DOT 2010b). Mitigation efforts would focus on the compatibility of the retaining wall with the surrounding district.

Public Involvement

The public involvement process for this project is exemplary for its stakeholder-driven approach to CSD: it is rare to garner the interest and support of an entire town, yet this project achieved just that. A ribbon-cutting ceremony seemingly attracted all 198 Stinesville residents to celebrate the collaborative efforts of the town, Monroe County, and the project designers.

Public input was first sought shortly after project designers decided on the replacement bridge size and alignment. The primary consideration delegated to the public was the choice of form liner to use on the retaining wall. Designers brought catalogues of potential designs into the public meetings, and the public was given the opportunity to indicate which design they liked best. The use of aerial photography was also well received as visual resource (Figure I-27). Project



FIGURE I-27: Aerial Photography of Project Area, 2014 (Courtesy of BLN 2019b)

designers stated that presenting the community members with visual examples of the potential designs, and multiple options, truly gave the public a voice and ultimately resulted in early buy-in from the local community. Town Hall meetings with town officials also alerted project designers of the desire for a signature gateway bridge and not a conventional, everyday design (Kennedy et al. 2019).

Design

The base-line design issues to address included limiting overtopping during flood events, accommodating the steep grade and curve of the bridge as it enters the town from the west, eliminating the substandard horizontal curve, and eliminating the need to cut into the steep hill at west end of the bridge. The resulting design solved these issues and produced a compatible design with the surrounding historic context.

The resulting replacement bridge consists of a two-span continuous composite prestressed concrete bulb-tee beam bridge with a concrete deck (Figure I-28; Table I-10). To accommodate the 13-foot rise, a 200-foot retaining wall was installed at the eastern end of the bridge along the south side of the road, incrementally decreasing in height from the west to the east and finished with a context-sensitive concrete form liner. An additional retaining wall was constructed along the north side of the road on the eastern approach, set just south of the Stinesville limestone monument in Victor Oolitic Park.



FIGURE I-28: Stinesville Road Bridge, 2014 (Courtesy of BLN 2019b)

TABLE I-10: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW STINESVILLE ROAD BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Retaining Wall	Large southeast retaining wall treated with a concrete form liner finish to mimic natural limestone material (mitigation measure)
Small Retaining Wall	Small northeast retaining wall constructed of native limestone blocks from nearby quarry
Retaining Wall Railing	Inconspicuous black metal railing along southeastern retaining wall, necessary for safety purposes
Bridge Rail	Concrete Texas Rail requested by the County as an aesthetic treatment. No design exception was needed. This rail is typical of an urban setting.
Lighting	Aesthetic lighting based on historic lighting researched by the Monroe County Historical Society
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Alignment Shift	Alignment shifted 12 feet south from existing centerline improve safety with a gentler slope and to reduce impacts of flooding.
Bridge Raised	Bridge raised 13 feet to improve safety with a gentler slope and to reduce impacts of flooding.

A mechanically stabilized earth wall was built around a precast concrete box culvert carrying Pogues Run (east of Jack’s Defeat Creek) through the project. The mechanically stabilized earth wall was also used at the west abutment, tied into the steep hill to reduce the bridge length and reduce project costs (BLN 2019a).

Project Outcome/Evaluation of Success

The project development process for replacing the Stinesville Road Bridge was effective and well executed. The early project scoping identified the critical structural issues to address in design and followed a highly stakeholder-driven approach to successfully achieve a CSD, as stipulated in the resolution of adverse effects on the historic district.

Because of early and ongoing stakeholder involvement and the design experience of the project engineers, the replacement bridge resulted in a compatible design to the surrounding historic context exhibiting appropriate materials, bridge type, aesthetic finishes, and retention as a gateway to the Stinesville Historic District. This design was extremely well received by the local community as well as the SHPO. The SHPO and FHWA inspected the bridge a couple of years after it was built and expressed their satisfaction with the architectural treatments and overall design to the project designers.

DEFOURI STREET BRIDGE, SANTA FE COUNTY, NEW MEXICO (STAKEHOLDER-DRIVEN APPROACH)

The Defouri Street Bridge over Footbridges Park is a waterway crossing located in downtown Santa Fe, set directly in an urban environment surrounded by residential and commercial buildings. The bridge crosses the Santa Fe River running through designated parkland.

The original bridge was built ca. 1935 and reconstructed in 1959; it is a two-span concrete channel beam bridge with unreinforced rock masonry abutments and central masonry pier (Figure I-29). Each span measured 26.5 feet long. The concrete deck replaced an original timber deck.



FIGURE I-29: Defouri Street Bridge, Ca. 2017 (Courtesy of WSP 2019)

Project Description

In 2011, New Mexico DOT determined that the bridge was structurally deficient with substandard railings and sidewalks, and replacement was proposed. The Defouri Street Bridge replacement project also included maintenance and repairs to the Guadalupe Street Bridge, which also needed replacement; however, because of limited funding, the Defouri Street Bridge was the primary focus. Construction was scheduled to begin in 2013, and the new bridge was completed in 2018.

This project was state funded with no federal funds allocated; however, because of a New Mexico state law that requires SHPO consultation for state projects, the project was reviewed under Section 106.

Historic Context

The Defouri Street Bridge is located on the western border of the locally designated Santa Fe Downtown and Eastside Historic District and the eastern border of the locally designated Westside Guadalupe Historic District. The Downtown district was designated in 1957, and the Westside district was established in 1983. The city of Santa Fe has three additional, contiguous local historic districts (City of Santa Fe 2010).

The bridge is potentially within the boundaries of the NRHP-listed Santa Fe Historic District, which encompasses an expansive section of Santa Fe consistent with the twisting street patterns of the 1600s. The boundary description is not precise and has been amended, but it does not clearly indicate the western border and whether the bridge is in the district. The district was listed in the NRHP in 1973, significant as the oldest capital city in the United States retaining a collective architectural character of Spanish-Pueblo, adobe, and flat-roof style buildings. The district is significant, among others, in the areas of Agriculture, Architecture, Art, Commerce, Education, Engineering, Politics, and Religion. The Defouri Street Bridge is not identified in the NRHP Nomination (Purdy 1972).

Footbridges Park is one of several contiguous parks along the Santa Fe River. The Santa Fe River Greenway, a paved trail, travels underneath the Defouri Street Bridge along the river and is characterized by native plants to restore and stabilize the channel. Although not explicitly stated in the NRHP nomination, the Santa Fe River likely contributes to the character of the district, and a context-sensitive bridge design would consider effects to the river and the natural landscape from perspectives both on and underneath the bridge.

Project Approach

Santa Fe has a robust history and dedication to historic preservation, and its residents greatly value the historic character the city retains. Consulting engineers approached the project aware of the potential for strong public opinion; therefore, CSD principles were followed even before project programming. The consulting engineer's proposal included recommended CSD elements. The Defouri Street Bridge replacement is another example of a stakeholder-driven approach to CSD.

The 2011 bridge inspection resulted in a determination by the city Historic Preservation Division that the bridge lacked significant architectural integrity, likely because of the bridge deck replacement in 1959, and therefore was not a contributing structure to the historic district. Design development proceeded under that determination.

Public Involvement

According to the project engineer (Rotto 2019), despite conflicting designs between the Public Works Department and the Historic Districts Review Board (HDRB), the public involvement process was rather typical. The following strategies for effective inter-agency coordination and stakeholder engagement were described as helpful during the Defouri Street project.

- Pick team members that are knowledgeable of the city and trends in transportation projects, licensed in the city (if applicable), and previously involved with projects that were well received by city review committees.
- As a consulting engineer, nurture good relationships with the Public Works Department.

- Make designs sensitive from the onset of the project in anticipation of public concerns for aesthetics.
- Consider each project individually for potential public reactions to the level of design initially presented. Some projects warrant a well-developed design at the first public meeting while others warrant an open-ended design, with few decisions already made.
- Keep the public involved for the entire project.
- Be open and honest when considering public comments.
- Be equipped with the reasons for how adverse impacts will be mitigated when presenting design options to the public.

Design

Santa Fe Public Works contracted the bridge design to a private consulting firm, which after initial project scoping, presented a design to the public with three options for bridge width. At this stage the design proposed to remove the central stone pier, retain the stone abutments, and retain the existing bridge profile as closely as possible. Upon public consultation, there was clear concern for changes to bridge width; many residents did not want to see the bridge widened at all for concern of increased speed and traffic as well as a concern for negative effects to the historic district. After two public meetings, taking into account public opinion, the city decided on the “middle” width proposed, which would increase the bridge from approximately 30 feet to 40 feet.

Additional structural and technical design elements were developed, accommodating difficult geometric and hydraulic issues and eventually a preferred design was approved by Public Works and presented to the local HDRB for review. The HDRB is the delegated decision-making power of the City Council on projects in the local historic districts. Their review and decisions are most often upheld by the City Council. In December 2013, contradicting the findings of the city Historic Preservation Division, the HDRB determined the bridge to be a contributing structure to the locally designated Downtown Historic District and ruled against the proposed design for concern of causing an adverse effect to the historic district. If considered a contributing structure, the new bridge design would need to comply with a city ordinance that would recommend retention of the existing bridge width as a character-defining feature.

The Review Board then proposed a design that widened the 30-foot bridge by only 3 feet and included one sidewalk instead of two. This design would not comply with the ADA, which requires 5-foot sidewalks on both sides, an expressed desire of the City Public Works Department.

Public Works appealed the decision of the HDRB to the City Council (the governing body), which overruled the decision of the HDRB and affirmed the design proposed by Public Works. The city was allowed to proceed with the widened design with a compromise that called for 4-foot sidewalks instead of 5-foot sidewalks.

The resulting replacement bridge takes on a similar look to the previous bridge, widened with an open metal railing of matching color to the previous bridge (Figure I-30; Table I-11). The substructure was altered from two spans to one span and retains the original stone abutments, although out of view. It is both safe and compatible with the surrounding setting.



FIGURE I-30: Defouri Street Bridge, August 2017 (Courtesy of WSP 2019)

TABLE I-11: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW DEFOURI STREET BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Sidewalks	Proposed 5-foot sidewalks reduced to 4-foot sidewalks as a compromise to the stakeholder desires. ADA compliance requires 5-foot sidewalks; therefore an exception was made to reduce the width.
Stone Abutments Retained	New concrete foundations were driven behind the existing abutments (not connected), effectively hiding the new foundations from view.
Railing	Type D state rail design (common type seen throughout the state on low speed roads) takes on a traditional style compatible with the setting.
Colored Concrete	Concrete tinted a neutral tan color (in compliance with local historic district ordinance), which blends well with the surroundings.
Bridge Profile	Existing bridge was flat with a low profile; the beam type chosen to match the low-profile shape.
Greenway Trail	The passage underneath the bridge was eliminated. There is no longer access underneath the bridge from the roadway. A bicycle trail travels along the “Greenway” at road level.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Bridge Widened	Lanes widened from 11 feet to 13 feet with the addition of shoulders for safety purposes. Nature of intersection warranted an improved turning radius and widths brought to current standards
Two Spans to One Span	The stone pier was removed. It was heavily deteriorated and obstructed the waterway. Bridge altered to one span as there was no need for a central pier. The waterway retained its existing width.
Slab Beam Bridge with Topping Slab	Standard adjacent slab beam design with topping slab, a Texas DOT design for solid slabs.

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Abutments Concrete Sill	A small amount of the top of the existing abutments was removed to make room for the new beams. A concrete sill, just a couple inches thick was applied to make the tops level.

Project Outcome/Evaluation of Success

Controversy surrounded the beginning stages of project development. Legal challenges to the proposed design and consistent input from residents in the immediate vicinity of the bridge had a large impact on the duration of the project and a slight impact on the resulting design, with the compromise to the width of the bridge.

Following the SOI Standards, the replacement design exhibits a bridge compatible in bridge and railing material, and scale, maintaining the source of significance of the existing bridge as an urban crossing.

GEIGEL HILL ROAD BRIDGE, BUCKS COUNTY, PENNSYLVANIA (STAKEHOLDER-DRIVEN APPROACH)

The Geigel Hill Road (SR 1014) Bridge (No. 47016) over Tincicum Creek is a waterway crossing located in Ottsville, a small rural community in Bucks County, approximately 15 miles west of the Delaware River. The area is characterized by steep slopes, exposed rock faces, winding roads, and creeks. The topography becomes less sharp, with rolling hills and flat land, approaching the river to the east. The bridge is set in a wooded area traversing the winding streams that drain into the Delaware amidst farmsteads and agricultural outbuildings. Bridges crossing the main streams in Tincicum Township are characteristic of the area, including many covered timber bridges, considered to have high integrity and historical significance.

The original bridge was built in 1887, a single-span timber decked steel pony truss, set on stone abutments (Figure I-31). It measures 53 feet, 10 inches long with one lane of traffic aligned on a tight S-curve.

Project Description

Initial scoping for this replacement began in 1987, when the bridge was still being used. In 2002, the bridge was struck by a truck and closed to traffic until the replacement (Pennsylvania



FIGURE I-31: Geigel Hill Road Bridge, 2003 (Courtesy of Benesch Engineering 2019)

DOT 2006a, 1). The replacement bridge was completed in 2011 at a cost of about \$1.4 million (Jordan 2011). The project was 100 percent state funded with federal accountability on USACE.

The project development process for this replacement is another example of a stakeholder-driven approach to CSD. Historian Robert W. Reynolds (2013, 4) reports that there were “many years of effort to achieve a replacement design [for Geigel Hill Road Bridge] that all parties could accept”. Stakeholders valued the single-lane construction as well as the stonework of the abutments. Every effort was made to reuse or replicate character-defining features of the bridge, including the steel trusses, stone abutments, curved wing walls, and bridge profile and alignment.

Historic Context

The Geigel Hill Road Bridge is located in the Ridge Valley Rural Historic District, which encompasses approximately 575 acres in Tincum Township (Reynolds 1992, 2). The district was listed in the NRHP in 1992, significant for its associations with farming in a small stream valley and its distinctive vernacular architecture. In 1992, the district contained six bridges, with two additional crossings still forded. Geigel Hill Road and nearby Headquarters Road functioned as the two primary roads running through the district, and therefore the Geigel Hill Road Bridge and Headquarters Road Bridge functioned as main crossing points.

All of the bridges in the Ridge Valley Historic District are listed as contributing structures, integral to the built character of the area. Prior to its replacement, the Geigel Hill Road Bridge “was the only bridge made by Nelson & Buchanan and/or the Pittsburgh Bridge Company that was located within a potential or listed historic district in Pennsylvania” (Reynolds 2015, 9). The bridge removal/replacement risked having a negative impact on the historic district, so CSD was of great importance to the local community. When approaching this replacement project, Pennsylvania DOT evaluated the historic context by way of the NRHP district nomination as well as the expressed feelings of the local community.

Design

A preliminary design for a replacement two-lane bridge was presented to the public with poor acceptance. Residents preferred a rehabilitation, hoping to retain the one-lane bridge and the character-defining stonework and trusses. A local property owner sued Pennsylvania DOT over the two-lane design, which eventually resulted in a compromise that shifted ownership of the bridge from Pennsylvania DOT to the Township and a single-lane design incorporating the rehabilitation and reuse of the original trusses.

The resulting replacement bridge is a single-span steel beam bridge with the original steel trusses applied to the side for aesthetics and stone-faced abutments and wingwalls (Figure I-32; Table I-12). The new structure is compatible because it maintains the original elevation of the previous bridge and defers to the historic character-defining features of the one-lane width, stone abutments, and through girder form; however, it loses its original function as a through truss.

Project Outcome/Evaluation of Success

Despite the lengthy project timeline and conflict between stakeholders and Pennsylvania DOT, the local community was satisfied with the resulting design, a key factor in determining success. Although decorative application of historic elements to a new design is generally discouraged from a SOI Standards viewpoint, in this case SHPO did not object to the stakeholders’ desire for such a design. SHPO was primarily concerned with the compatibility of the bridge in the historic district and did not express any hesitations to the application of the decorative trusses.



FIGURE I-32: Geigel Hill Road Bridge, 2011 (Courtesy of Benesch Engineering 2019)

TABLE I-12: CSD/S DESIGN ELEMENTS OF THE NEW GEIGEL HILL ROAD BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Pony Trusses	Original trusses were rehabbed and attached as a strictly decorative feature and painted green.
Roadway Profile	Thru-girders used to retain roadway profile.
Color	Bridge concrete deck and parapets tinted brown.
Bridge Width	One-lane width retained in replacement design (15 feet).
Alignment	Existing alignment and footprint retained as close as possible.
Red Shale Veneer	Red shale veneer applied to abutments and wing walls, in keeping with the local building materials.
Abutments and Wing Wall Placement	Constructed abutments and wing walls in the same locations to maintain existing stream banks.
Use of Existing Retaining Walls	New structure ties into existing retaining walls.
Riprap	Use of R-8 riprap along the opening of the bridge so as not to reduce the waterway opening.

In addition to the above mentioned design decisions, a Programmatic Agreement implemented the following stipulations (USACE, PHMC, ACHP, Pennsylvania DOT 2008, 4).

- Completion of a Pennsylvania Historic Resources Survey Form for permanent retention in the State Archives.
- Production of an archival copy of existing drawings of the bridge for permanent retention in the state archives.
- Archaeological monitoring during all excavation and earth moving activity.

STONEY CREEK MILL BRIDGE, OAKLAND COUNTY, MICHIGAN (STAKEHOLDER-DRIVEN APPROACH)

The Stoney Creek Mill Bridge (No. 8192) carries E. Tienken Road over Stoney Creek. The village of Stoney Creek is located in the city of Rochester Hills, north of Detroit. The bridge is a transportation link and gateway bridge providing west access to the small village located in the northeast corner of the city. Stoney Creek is a small town surrounded by large plots of infilled subdivisions. The original bridge was built in 1940 and consisted of a concrete deck supported by steel I-beams and concrete abutments (Figure I-33). An original ornamental metal railing with concrete railing posts was replaced with concrete barriers at an unknown date (Figure I-34). This area had been rapidly growing since as early as 1940; leading up to the bridge replacement, a new high school was built nearby and housing development continued, creating traffic increases and character changes to the historic area.

Project Description

A 2008 bridge inspection reported heavy cracking and spalling throughout the surface, joints, barriers, and deck of the bridge, with fair to poor condition ratings (Trahey 2008). The replacement was funded by the Local Bridge Program, a combination of state and federal funds. As reported by Rochester Media, the replacement was bid as a package with a second bridge replacement, Parkdale Road over Stoney Creek, combined at a cost of \$2.2 million. The Stoney Creek Mill replacement bridge was completed in 2010 (Rochester Media 2010).

Historic Context

The Stoney Creek Mill Bridge is located on the border of the Stoney Creek Village Historic District, which generally encompasses a large rectangular



FIGURE I-33: Stoney Creek Mill Bridge, 1978 (Courtesy of RHM 2019)



FIGURE I-34: Stoney Creek Mill Bridge with Concrete Barriers, Ca. 2008 (Courtesy of RCOC 2019)

block of dwellings set just east of the bridge. The district boundaries are bordered on the north by E. Tienken Road, on the east by Washington Road, on the south by Runyon Road, and on the west by Van Hoosen Road. The district was listed in the NRHP in 1972. At the time, it was predominantly rural in character, consisting of 17 dwellings and several agricultural outbuildings, holding significance in agriculture and architecture of the mid-nineteenth century. In 1972, the village of Stony Creek was surrounded by 350 acres of “rolling, open, pasture land” and described as having “...roads still graveled, overarched over by the thick branches of hardwood trees” (Lowery 1972, 2). The bridge was not individually eligible for inclusion in the NRHP; however, its proximity to the NRHP district did provide the project team with a historic context to consider. Today, the NRHP district retains the gravel roads, but a large infill of modern homes and subdivisions has completely surrounded the small historic village and significantly altered the broader rural character of the district. Despite these intrusions, the village center appears to retain its rural, agricultural community feel, maintaining the historical significance of the village.

Two locally designated historic districts, which overlap and extend far beyond the NRHP district boundary, known as the Stony Creek and Winkler Mill Pond Historic Districts, were listed in 1978 citing similar characteristics to those described in the NRHP nomination. There was significant concern from the local residents that the bridge replacement project would negatively impact the historic character of the area, and that concern is what initially prompted the context-sensitive approach to the bridge design.

Project Approach

The project development process for this replacement is exemplary of a stakeholder-driven approach to CSD/S. The Stony Creek Bridge replacement project was developed as part of a larger protection and improvement plan for the two locally designated historic districts. A mayor-appointed Advisory Committee for the entire improvement project, with input from the local community, focused on Tienken and Washington roads, two primary county roads that wind through residential areas.

Several goals were identified in the corridor improvement plan to protect the historic character of the village, including the context-sensitive replacement of the Stony Creek Bridge (OCPEDS et al. 2010). The pressure of development and increasing traffic in the area was threatening the historic districts, and the county was looking to preserve what was left. The bridge functions as a transportation link and gateway to and from the village. Although not within the historic district, the bridge contributed to the feeling of entering the historic village; its CSD aimed to retain those characteristics.

The Road Commission of Oakland County initially discussed a large expansion of the roadway from the existing two lanes to five lanes as the road moves west, narrowing to three lanes across the bridge. This proposal greatly concerned residents, and the commission reassessed the design options to keep the replacement bridge as narrow as possible.

Public Involvement

Public input was sought during project programming and continued through final design. Outreach began directly after the Advisory Committee was formed by way of flyers and web postings about upcoming public meetings and sessions. The environmental assessment triggered from the proposed widening of the bridge required the county to consult with the public and present design options for their consideration. Oakland County expressed their willingness to go with what the public desired (Road Commission of Oakland County [RCOC] 2019). In addition, sessions focused not only on the bridge but on the corridor improvement plan as a whole, which resulted in higher public buy-in of a larger concept instead of

needing to decide on only the bridge design. Approximately 100 public stakeholders were consistently engaged in the design process. The public involvement process utilized for this project is outlined below.

- Advisory Committee – Composed of two cities, the Road Commission of Oakland County, Oakland County, and Macomb County. Brought the decision-making agencies together to provide an effective forum for discussion for the project. The committee created an environment for effective interdisciplinary teamwork.
- Residents’ Forum – Was a highly facilitated, organized discussion with Rochester Hills residents. The county posted answers to questions brought forward in this forum on the county website.
- Awareness Walk and Review – Public workshop type session with a walk around the site, presentation of design sketches, and discussion on design options followed by breakouts into small teams to provide answers to questions, including what to preserve, what to add, what to remove, and what not to touch on the bridge. The small teams reported back the whole group.
- Written Survey – provided to receive feedback from public stakeholders who were not as comfortable voicing opinions and suggestions in a group.
- Public Meetings – two to three sessions were held at a neutral location in the village. County staff stated it is beneficial to hold public meetings at a neutral location rather than at city hall, which can often deter public participation.

The main concerns expressed by the public through meetings and the awareness walk included the amount of truck traffic and the overall compatibility of the bridge with the character of the village. An initial proposal to increase East Tienken Road to five lanes to better accommodate truck traffic caused concern over an increase in traffic and noise levels. Residents wanted the bridge to feel and look as it did in 2009 before replacement, having only two lanes of traffic.

Section 106/Consultation

The bridge was determined not eligible for the NRHP because of the removal of the original 1940s metal railing and the standard design of the bridge. SHPO concurred with a no adverse effect determination and therefore no mitigation specifications were needed. CSD decisions stemmed from the desire of the Road Commission, Oakland County, and the public to design a bridge as sensitive as possible to the surroundings.

Design

The stated goals for the new bridge replacement were (OCPEDS et al. 2010, 21-26):

- Slow traffic entering the village
- Improve pedestrian safety
- Incorporate new pedestrian component
- Keep the bridge as narrow as possible by use of design exceptions/exemptions
 - New elevation of bridge deck and approaches should maintain existing road topography and alignment
 - New elevation of bridge deck and approaches should maintain existing road topography and alignment
- New elevation of bridge deck and approaches should maintain existing road topography and alignment
- Utilize flexibility in design
- Railing design-consideration of materials and detailing

- Abutments design — consideration of materials and detailing
- Bridge lighting not recommended
- Approach walls design — consideration of materials and detailing
 - Retain existing vegetation during construction and replace with native vegetation when necessary
 - Retain existing vegetation during construction and replace with native vegetation when necessary
- Retain existing vegetation during construction and replace with native vegetation when necessary
- Stabilize stream bank during construction

The County obtained plans for the original metal railing and used them as a design influence for the replacement railing. The desired addition of a pedestrian walkway provided the framework for including a historic rail without needing a design exception. Because the historic rail was installed on the pedestrian side, it did not need to meet crash-testing as a vehicle barrier. Additional design concerns and obstacles included retention of the alignment, roadway width, and design speed.

The resulting replacement bridge consists of a precast concrete bridge with two lanes of traffic, each 12 feet wide with 2-foot shoulders, a pedestrian crossing integrated into the bridge deck, salvaged historic metal open railing paired with a low-profile concrete curb, and simple concrete finish on the abutments (Figure I-35; Table I-13).



FIGURE I-35: Stoney Creek Mill Bridge, 2019 (Paul Graham 2019)

TABLE I-13: CSD/S DESIGN ELEMENTS OF THE NEW STONEY CREEK MILL BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Pedestrian Crossing	A new pedestrian crossing, and walkway was integrated into the bridge deck. The walkway is separated from the roadway by a concrete barrier.
Bridge Width	Bridge width was kept as narrow as possible by use of design exemptions/exceptions. Widened only slightly to 24 feet with 2-foot shoulders and a 7.5-foot sidewalk.
Elevation/Alignment	The existing bridge elevation and alignment were retained in the replacement design; a challenge but successful in the design.
Pedestrian Railing	A historic metal railing with resemblance to the original 1940s railing was salvaged from a Michigan DOT bridge in Ingham County for use on the pedestrian side railing. No design exception was needed because it was not used as a barrier for vehicles.
Bridge Railing	The roadway railing consists of a concrete barrier topped with a two-tube metal railing, compatible with the historic style railing on the opposite side.
Curb	Low-profile concrete curb paired with metal railing for compatible mix of materials and level of detail.
Abutments	Standard concrete finish was used to not detract from the rest of the bridge. The Historic District Committee chose the colors and stamping used.
Approach Walls	Initially proposed fieldstone approach walls were forgone for simpler and cheaper, steel guardrail approaches. A wooden fence on the south side separates the pedestrian walkway from a nearby property.
Native Landscaping	Was reincorporated into the replacement design to allow the new bridge to blend in with its surroundings and the stream bank below. The result is a very natural feel to the crossing.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Design Speed	Two roundabouts previously constructed near the bridge were modified in their design to improve traffic calming as vehicles approach the bridge. Vegetation was brought closer to the road to slow traffic down as well.
Walkway	The pedestrian walkway was separated from the roadway to improve safety crossing the bridge.

Project Outcome/Evaluation of Success

The design is highly compatible with its natural surroundings and also with its unique historic context. Use of a similar railing to the historic rail sufficiently refers the modern design to its historic predecessor, and the simple concrete stamping and finishes of the abutments and superstructure allows the bridge to blend well with the mix of rural and newly developed portions of the village.

The Oakland County Road Commission implements a strategic planning process that allows individual communities to bring the commission any concerns regarding county roads. To date, no concerns have been expressed regarding the Stoney Creek Mill Bridge or the broader East Tienken Road improvements. If appropriate in another location, this bridge design would likely be used again (RCOC 2019).

ROUTE 206 FLOOD CHANNEL BRIDGE, MERCER COUNTY, NEW JERSEY (SAFETY/DESIGN-DRIVEN APPROACH)

The Route 206 Flood Channel Bridge crosses Stony Brook as part of the waterway crossing located in Princeton, linking Princeton to the early Stony Brook Village Settlement. The Flood Channel Bridge crosses the flood channel portion of the Stony Brook, set within a wooded residential area. Several open green spaces are scattered throughout the landscape, including golf courses and parks, one of which is the Princeton Battlefield State Park, located less than 1 mile south of the bridge.

The original Route 206 Flood Channel Bridge was constructed in ca. 1895 and rebuilt in 1924: a three-span encased steel stringer set on ashlar piers, with a modern concrete cap (Figure I-36). The bridge is 62 feet long with a 22-foot cartway. The existing reinforced concrete balustrade with rectangular openings was added in 1924, a standard type of the 1920 and 1930s, replacing an iron railing (Greiff 2000, 7-16, 34).



FIGURE I-36: Flood Channel Bridge, 2017 (Courtesy of UE 2019)

Project Description

The Route 206 Bridge serves as an approach to the historic Stony Brook Stone Arch Bridge. The replacement of the Flood Channel Bridge and reconstruction/rehabilitation of the adjacent Stone Arch Bridge was completed in 2018 at a cost of \$7.4 million, funded by the state. The project development process for this replacement is exemplary of a design/safety-driven approach to CSD/S. Because of a catastrophic storm event, the flood channel bridge and the adjacent stone arch bridge were in critical condition and had to be replaced as quickly as possible. A replacement project that typically would take two years took two months to complete. Somewhat challenged by the shortened timeline to build, designers rose above the difficulties and produced a compatible replacement design with interesting context-sensitive solutions.

Historic Context

The Route 206 Flood Channel Bridge is located in the Princeton Battlefield NHL, the Princeton Battlefield/Stony Brook Settlement Village (Princeton Battlefield Historic District), and the Kings Highway Historic Districts. The Battlefield was designated an NHL in 1961 and listed in the NRHP in 1977 (Greenwood 1975). The Princeton Battlefield Historic District, which includes the Battlefield NHL was listed in the NRHP in 1972, enlarged in 1989 (Craig 1987) and again in 2017 (Catts et al. 2017). It is characterized by many surviving buildings present during the Battle of Princeton, with few intrusions. It is also characterized by the relationship of the buildings to surrounding farmland, representing the organization of rural communities throughout the state in the eighteenth century. Although the Flood Channel Bridge is attached to the contributing Stone Arch Bridge, it is of a common type and does not contribute to the Princeton Battlefield Historic District.

The Kings Highway Historic District is a historic stretch of road that passes through the Princeton Battlefield Historic District by way of Route 206. Character-defining features of the road include its relatively unchanged alignment and width since the eighteenth century, vertical alignment, width and angle of intersections, bridges, retaining walls, bluestone sidewalks and curbing, markers, signs, walls, fences, vegetation, and lighting (Greiff 2000, 7-1). Both the Flood Channel Bridge and the Stone Arch Bridge are described in the Kings Highway Historic District nomination but are not explicitly identified as contributing structures.

Public Involvement

An emergency NEPA process was initiated at the start of the project. All environmental reviews went through the state DOT, and the consulting designers did internal evaluations of the historic context. There was a clear effort to complete the project quickly, but the highly sensitive historic context was not necessarily conducive to a rapid replacement. High stakeholder interest had to be managed and incorporated into the design process. Private consultants were hired to coordinate public involvement and another was hired to work on the design, all working together to achieve a successful compatible solution. The Department of Environmental Protection, SHPO, and New Jersey Historic Sites Council formed a working group to reach consensus as reviewers. Numerous public meetings were organized to conduct material testing and share information with the public. Public involvement was consistent from concept development through material selection (McAtee 2019).

An additional public involvement strategy, unique to this project, was a presentation from local police on the crash history at the bridge location, which educated the community on why certain safety measures had to be implemented. Lastly, an explanation of the AASHTO design guidelines for aesthetics on historic bridges was a convincing tactic when working with the public (McAtee 2019).

Design

The resulting replacement Flood Channel Bridge consists of "...a cut ashlar stone facing that was comprised of stones salvaged from the original bridge" (Figures I-37 and I-38; Table I-14) (UE 2018). The design also included a replacement railing and guiderail, slope stabilization, and a minor re-profiling of the roadway.

Project Outcome/Evaluation of Success

Sitting adjacent to the rehabilitated historic Stone Arch Bridge, the Flood Channel Bridge posed an interesting challenge to the design team. Creating a modern bridge compatible with one of the oldest bridges in New Jersey was not an easy task. The choice of stone and simple form references the old bridge in style but is clearly differentiated as a modern structure with the elimination of piers and modified Texas railing.



FIGURE I-37: Flood Channel Bridge, 2018 (Courtesy of UE 2019)



FIGURE I-38: View of Abutment and Wing Wall Construction with Cut Ashlar Stone Facing, 2017 (Courtesy of UE 2019)

TABLE I-14: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW FLOOD CHANNEL BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Triple-Span to One-Span	Two stone piers were removed.
Stone	Original stone was salvaged during construction for reuse on the replacement bridge. Original stone was mixed with cut ashlar to create a texture and pattern compatible with the adjacent stone arch material yet differentiated as modern construction.
Railing	Texas DOT Open Balustrade crashworthy rail is reminiscent of the historic concrete railing. Openings are true but not as long and concrete balustrades do not protrude above the rail cap as on the previous railing.
Bridge Type	Modern slab beam bridge replacing the encased steel stringers retains a similar profile while clearly proportioned as modern bridge technology with a less cumbersome beam.
Aesthetics	Scale, proportion, and color aesthetics are nicely exhibited on this bridge, providing a refreshing modern design while also referencing its historic appearance.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Parapet	The parapet height was raised to eliminate the safety hazard evident from the previous parapet height.

FALLS COUNTY ROAD BRIDGE, FALLS COUNTY, TEXAS (SAFETY/DESIGN-DRIVEN APPROACH)

The Falls County Road 386 Bridge No. 2038 over Branch of North Elm Creek is a waterway crossing located near Westphalia, a small rural community, approximately 35 miles south of Waco, Texas. The area is characterized by expansive meadows, pastures, and crop fields, with trees generally only occurring naturally along the winding creeks and scattered farmsteads surrounding the central village center. The bridge is set along a gravel rural road, southwest of Westphalia town center, surrounded by the lowland fields and pastures typical of the area.

The previous bridge was built in ca. 1940 and partially reconstructed in the 1980s, consisting of a timber stringer construction, with wood abutments, and a single span 27 feet long and 20 feet wide (Figure I-39). The bridge carries a two-lane rural gravel road over the creek (Texas DOT 2015).



FIGURE I-39: Falls County Road Bridge, Ca. 2015 (Courtesy of Texas DOT/Mead & Hunt 2019)

Project Description

Texas DOT completed an inspection in 2011, and by 2015 a public hearing was set to discuss the proposed replacement. The new bridge was completed in 2017, funded, in part, by the FHWA.

According to Texas DOT (Benn 2019), the CSD/S approach to this replacement occurred somewhat unconventionally. Although the project development process does not fall solidly into one of the proposed approaches to CSD, aspects of both a design/safety-driven approach and stakeholder-driven approach are evident.

Historic Context

The Falls County Road Bridge is located in the Westphalia Rural Historic District, which encompasses upwards of 5,500 acres of land in the western portion of Falls County. The district was listed in the NRHP in 1996, significant for its associations with late nineteenth- and early twentieth-century agriculture and settlement patterns in a rural setting (Myers 1996, 7-5).

The Falls County Road Bridge was not individually eligible for inclusion in the NRHP but was a contributing structure in the historic district, significant for its use within the rural, agricultural landscape as a means of transporting agricultural goods and linking farmsteads to the village center of Westphalia. The grid-like road pattern in the district is a character-defining feature of the landscape.

When the district was nominated for the NRHP, there were five wood bridges within the boundary. To date, only one remains; the others have all been replaced. Two were replaced with pipe culverts. It is not common for federal funds to be allocated to such a project, and in the past, as these bridges have come up for replacement, they have been designed economically and functionally with county funds, with a focus on reducing maintenance costs and lengthening lifespan rather than aesthetics within the historic district.

Because this bridge replacement was funded by the FHWA, compliance with Section 106 and Section 4(f) was required to consider the effects of undertakings on historic properties.

Public Involvement

Consultation between the Falls County and Texas DOT engineers began without Texas DOT knowledge of the historic district or the contributing status of the bridge. Design development was therefore initially influenced by community desires and engineering standards without direct consideration given to the historical significance of the bridge. At an early public hearing, local farmers expressed their desire for a wider structure that would better accommodate low-hanging and heavy agricultural equipment as well as their satisfaction with the early design ideas of the engineers. The county made clear a desire for use by school buses. As a result, the preferred design was load rated for heavy vehicles and a railing alteration was planned to lower the standard height from approximately 3 feet to 1 foot. No design exception was needed.

Section 106/Consultation

Upon realization of the historic status of the bridge, development was halted about four months prior to construction. As a FHWA-funded project, regulatory compliance was carried out, including Section 106, 4(f), and NEPA responsibilities. The Texas-based Historic Bridge Foundation served as the only consulting party during Section 106 compliance.

SHPO concurred with Texas DOT and the Historic Bridge Foundation that there was an adverse effect to the historic district because of the removal of a contributing resource. Texas DOT performed 4(f)

alternatives analysis, which determined that there was no prudent and feasible alternative to replacement. Rehabilitation of the existing bridge and construction of a parallel bridge or decommissioning of the existing bridge and construction of an adjacent bridge caused concern over changes to the circulation patterns and road/field relationships within the historic district. Rehabilitation and continued full use of the existing bridge did not improve the frequent overtopping that occurs during flood events. A timber bridge replacement option was determined not prudent because it would cost more than a concrete girder and require increased maintenance; notably, Falls County is designated as an Economically Disadvantaged County for highway projects (Texas DOT 2015).

The historic bridge was marketed to the public before removal. The option to remove the bridge was determined to have the least overall harm to the historic district. Mitigation of the adverse effect was disconnected from the bridge itself, focusing rather on the entire historic district, and presenting a history of the area and farming practices to the local community. Because the replacement bridge design was compatible with the setting and the majority of the bridges in the historic district were already replaced, there was less concern for the effect the bridge may have directly on the district. An effort to inform the community of the historic district was a more useful mitigation strategy for the preservation of the district rather than concentrating on just the bridge.

Design

The bridge design used a T223 railing type, a standard TL-3 design previously used in rural areas (Figure I-40). This railing had already been approved by SHPO and was known by engineers and Texas DOT cultural staff to maintain a low profile in the landscape; a character-defining feature of the bridge within its historic context.



FIGURE I-40: T223 Railing (Courtesy of Texas DOT 2019)

The resulting replacement bridge is a compatible concrete slab with low-profile railing to allow large overhanging agricultural equipment to pass over it (Figure I-41; Table I-15).

Cost considerations for CSD/S elements were not of concern because there was no difference in cost for the railing compared to a standard construction. Increased costs were related to staff time spent revisiting federal compliance after historic status was confirmed.

Project Outcome/Evaluation of Success

The design Texas DOT engineers developed prior to knowledge of the historic district and the bridge's contributing status was already sensitive to the historic context of the area. The significance of the region as a farming community with distinct road patterns was retained through the bridge type chosen and the railing style chosen. This meant that upon realization of the bridge's historic status, few changes to the proposed design were needed to follow the SOI Standards. Additions of the rail color and retention of the alignment were elements addressed under Sections 106 and 4(f).



FIGURE I-41: Falls County Road Bridge, 2017 (Courtesy of Texas DOT 2017)

TABLE I-15: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW FALLS COUNTY ROAD BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Rail	Texas DOT T223 Rail. Originally designed with a standard 3-foot tall concrete rail, the height was reduced to one foot to accommodate agricultural equipment and retain a low profile in the surrounding landscape.
Rail Color	A consideration to paint the rail brown was decided against in favor of allowing the concrete to weather and fade into the background.
Alignment	The characteristics of the road system were maintained. The narrow dirt roads following property boundaries is a character-defining feature of the district and care was taken not to disrupt those features.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Concrete Construction	Timber construction replaced with concrete construction for load bearing purposes.

Texas DOT believes the bridge design has strong potential to become a standard design in similar rural and historic settings. Mitigation for loss of bridge will be available online in the form of a story-map, documenting the history of area and how workhorse bridges built by counties helped farmers. This is to provide accessible information to interested stakeholders and potentially serve as a tool to aid similar projects in the future.

MORGAN'S FORD BRIDGE, WARREN COUNTY, VIRGINIA (SAFETY/DESIGN-DRIVEN APPROACH)

The Morgan's Ford (Route 624) Bridge (No. 6019) over the Shenandoah River is a major waterway crossing, located near Front Royal, a rural town set at the confluence of the North Fork and South Fork of the Shenandoah River, and a gateway to the Rockland Rural Historic District. The area is characterized by a mix of hills and open fields set amongst the Blue Ridge Mountains. The bridge is set northeast of the town, past the confluence of the North and South Forks, passing through a shady tree-lined state route.



FIGURE I-42: Morgan's Ford Bridge, 2015 (Photographer: Trevor Wrayton, Virginia DOT)

The original bridge was built in 1925; a 16-span single-lane low-water bridge, approximately 321 feet long (Figure I-42).

Project Description

The original bridge rail consisted of a curb only 4 to 6 inches high and was often overrun by floodwaters. The bridge was determined substandard, unsafe, and structurally deficient. In winter months, on occasions of heavy ice, the river displaced the concrete slabs, contributing to their deterioration. The replacement bridge was completed in 2018 (Virginia DOT 2018).

Historic Context

The Morgan's Ford Bridge is located in the Rockland Rural Historic District, which encompasses approximately 10,382 acres of land in northern Warren County. The district was listed in the NRHP in 2015, significant for its associations with rural farmstead and large estate development in the late eighteenth to mid-twentieth centuries as well as its association with transportation corridors of the late eighteenth and nineteenth centuries, linking northern and southern Warren County.

The Morgan's Ford Bridge is a contributing structure in the district, along with 39 other contributing structures, significant as a major crossing point of the Shenandoah River, the only access across the river in the district (Kalbian and Peters 2015).

The Morgan's Ford Bridge was built as part of a political drive in the state to improve the state's infrastructure (Miller and Thompson 2019). It was not an uncommon bridge type in the 1920s and 1930s. South along the river are two additional examples of low-water bridges crossing the river. These two low-water bridges have been abandoned and new bridges built adjacent: Indian Hollow Road (Figure I-43) and Bixlers Ferry Road. Most low-water bridges were built quickly, economically, and simply, and

were not meant to be all-season structures. Therefore, as the bridge became a rather high-volume road, it could not structurally accommodate year-round and heavy use. Virginia DOT reports that the Morgan's Ford Bridge was overtopped 60 days out of the year around the time of replacement (Miller and Thompson 2019).

The history of the bridge was interpreted differently by the design team and some stakeholders. There was a divide between those who viewed the bridge as a highly significant historic structure and those who viewed the bridge as a common iteration of an infrastructural necessity.



FIGURE I-43: Indian Hollow Road Low Water Bridge and New Adjacent Bridge (ACEC 2019)

Project Approach

The project development process for this replacement primarily took a design/safety-driven approach to CSD. Prior to replacement, there had been several drowning deaths during overtopping events, which remained the top concern when designing the replacement bridge.

Aspects of a regional approach to CSD is also evident. The replacement Morgan's Ford Bridge appears to take on a style similar to the earlier replaced Indian Hollow and Bixlers Ferry Road Bridges along the river, creating a modern regional tradition that reflects a similar historic architectural tradition in the area.

Public Involvement

According to Virginia DOT:

This bridge replacement involved considerable Stakeholder/CSD consultation and Section 106 review. Stakeholders were divided between local government and a number of residents who wanted a new bridge...and a regional preservation group and a few local landowners and preservationists who did not want a new bridge but wanted the badly deteriorated old bridge retained [Virginia DOT Survey Response].

Early public involvement consisted of a meeting prior to substantial design development. Improvements to safety were clear priorities to both stakeholders and Virginia DOT; however, stakeholders also presented several suggestions that were not feasible to implement, including the ability to fish from the bridge, which is not permitted in Virginia and posed a safety concern. Another challenge at the start of the project was working with a stakeholder-hired consultant who did not have the appropriate credentials to accurately assess and understand the bridge and the potential for rehabilitation or replacement. The consultant slowed SHPO and public consultation considerably.

Accounting for the primary safety concerns of the stakeholders, Virginia DOT designed a heightened superstructure composed of box beams side by side to create a smooth bottom to more effectively pass debris running under the bridge. A girder type was not desirable as it tends to catch debris more easily.

Aside from pushback from the stakeholders who wanted to preserve the bridge, neither the stakeholders nor the SHPO objected to raising the bridge to the new height.

Design

With safety as a number one priority, two design goals guided the design process. The first goal was to elevate the bridge so as to reduce overtopping events but avoid excessively lengthening the bridge, which would increase costs and complicate the design. Secondly, considerable time was spent on the railing design from a safety perspective as well as an aesthetics perspective. The railing had to be high enough to safely contain vehicles on the bridge and be visually compatible with the location.

Design of the railing system went through a few iterations. The Kansas Rail, which had been used by Virginia DOT in the past, was suggested but not well received by the Virginia DOT project team and discarded for a more attractive rail type. Decorative railings were also suggested but did not achieve the level of safety desired. Virginia DOT consultation with NPS directed the project team to use the Caltrans Concrete Barrier Type 80, which was considered sympathetic to the historic district, yet sturdy enough to withstand beatings from water.

The resulting replacement bridge consists of a 480-foot-long, two-lane, concrete box beam bridge with the Caltrans Concrete Barrier Type 80 rail. Most of the bridge is constructed of prestressed concrete (Figure I-44; Table I-16).

Project Outcome/ Evaluation of Success

Compatibility with the historic context was achieved primarily through the choice of rail system. The CSD/S process allowed Virginia DOT to coordinate with

Warren County and public stakeholders to achieve a design that effectively addressed safety concerns and function within the historic district. Virginia DOT is open to continued use of the Caltrans Type 80 rail on similar projects in the future and will consider getting the rail system approved by the Virginia DOT central office for streamlined use (Miller and Thompson 2019).

Unfortunately, the southern approach did not hold up well to water and has washed out as a result of overtopping. Redesign of this approach is currently planned. The bridge span and northern approach have held up to overtopping events as expected.

In direct response to the difficulties of consulting with the stakeholder-hired consultant on this project, Virginia DOT established a qualifications checklist for any consultant hired to represent stakeholders during a design project. Qualifications include being a licensed Professional Engineer in Virginia, having knowledge and experience with the bridge type at hand, and indicating a willingness to sign and stamp their reports. This checklist approach has significantly improved the public involvement process on



FIGURE I-44: Morgan's Ford Bridge, 2018 (Courtesy of Trevor Wrayton 2019)

Virginia DOT projects because it limits public input to feasible and practical suggestions informed by a qualified consultant.

TABLE I-16: CSD/S AND STANDARD/SAFETY DESIGN ELEMENTS OF THE NEW MORGAN'S FORD BRIDGE

CONTEXT-SENSITIVE DESIGN ELEMENTS	DESCRIPTION
Railing	Use of the Caltrans Type 80 rail; a 32" crash-tested railing chosen for safety and aesthetic appearance. This railing needed approval by the Virginia DOT central office because it was not listed as an approved Virginia DOT rail system. This design exception was possible because of the historic nature of the bridge.
Single-Lane to Two-Lane	Altered from single-lane to two-lane; an improvement on safety. Design standards called for a wider bridge than was ultimately built. Mitigation measures resulted in narrower bridge, made possible by a design exception.
Road Surface Treatment	Use of a high-friction surface treatment (epoxy system over asphalt), which provided a dark brown tint to the roadway approach to retain a gateway feel to the historic district; typically used for traction but used here for appearance.
Landscaping	Landscaping completed with native vegetation.
STANDARD/SAFETY DESIGN ELEMENTS	DESCRIPTION
Bridge Height	Bridge elevated 6 to 8 feet above the old bridge to reduce floodwaters overtopping.
Bridge Length	As a function of increased height, the bridge was lengthened from 321 feet to 480 feet.
Single-Lane to Double-Lane	Altered from a single-lane to a two-lane bridge; an improvement on safety. Design standards called for a wider bridge than was ultimately built. Mitigation measures resulted in narrower bridge, made possible by a design exception.
Speed	Speed limit reduced from 35 mph to 25 mph.
Alignment	Retention of the existing roadway alignment to create a bypass was not feasible because of safety concerns about the existing bridge.

SECTION 1.7: EFFECTIVE STRATEGIES AND BEST PRACTICES

BEST PRACTICES

A successful CSD/S of a workhorse bridge in a rural historic district should result in an appropriate design that “fits” the location, the reasons the setting is historic, and the underlying transportation issue needing a solution (McCahon et al. 2012, 5-6). To achieve these goals, the CSD/S process must be rooted in public involvement, flexibility in design, and aesthetic design principles (D’Ignazio et al. 2010, 26), keeping in mind that each transportation design project is unique and requires individual attention and solutions. Design appropriateness is based on qualitative opinions; there are not strictly quantitative results to assess the success of a design. Minnesota DOT affirms that “the success of a bridge design is often determined by the function of the structure and the level of acceptance by the public” (HNTB 1995, 1-2). Key questions to ask to achieve CSD/S goals are: Does the bridge achieve excellence in design and function? Does the bridge reflect the public values associated with the structure and its setting and are they satisfied? Does the bridge reflect the historic context appropriately?

The literature review conducted for the research project revealed key guiding principles that practitioners use to ensure the successful design of a bridge using the CSD process. Many of these principles were found in *NCHRP Web-Only Document 189: Design and Management of Historic Roads*, a 2012 NCHRP study, which can easily be applied to bridges in a historic district (McCahon et al. 2012, i). The study presents four strategies to be incorporated into the project delivery process:

- (1) Include historic preservation from the outset of project planning,
- (2) Understand and use inherent flexibility,
- (3) Use what makes a road historic a meaningful measure, and
- (4) Use what underlies the 13 controlling design criteria for roadways to develop balanced solutions.

FHWA (1997, 106) observes, “The solution for designing a visually attractive and context sensitive new bridge is to be flexible and to work with the community from the beginning to obtain public input. Professionals from other disciplines, such as architects, can also assist, especially if engaged early in the design of the structure.”

A common mistake on replacement bridges is the application of inappropriate notional features, such as historic light fixtures, imitation stone, and other decorative elements that attempt to create a historical appearance but instead create an inaccurate expression of significance and a false sense of history. Following the SOI Standards, a new bridge would be expected not to have decorative elements such as skirts and form liners to echo the former bridge unless those elements are differentiated enough to be clearly modern. Also, disguising the structural technology of the new bridge with features that represent a historical bridge type should be avoided. The source of historical significance should be used to influence the replacement design.

Stakeholders frequently influence the aesthetic design of a bridge. CSD/S calls for increased stakeholder involvement to reflect the values they place on a bridge in its design. However, not every design aspect of a bridge can be dictated by stakeholders because not every element is flexible in design. For a workhorse bridge there is little control over vertical and horizontal geometry (e.g., how high the bridge is) because geometry is usually dictated by the existing highway layout. Other design considerations with limited flexibility include superstructure type, pier placement, abutment placement, and superstructure shape. Maryland DOT suggests that pier shape, abutment shape, parapet and railing details, colors and textures,

and ornamentation are the more flexible considerations, potentially more compatible with stakeholder desires (Maryland DOT 1993, I-5).

Overall, the consideration of character-defining features of a historic bridge, proper implementation of the principles of design aesthetics, and stakeholder engagement are key elements to a successful CSD/S development process. A few guiding principles follow.

- Ensure the seven aspects of integrity for historic properties mesh with the 13 controlling design criteria for roadway design;
- Address all current safety concerns while deferring aesthetic design to the existing bridge to be replaced;
- Avoid creating new visual elements, such as retaining walls and expansive slopes;
- Understand that: “The source of historic significance defines the aspect that should be incorporated into the new design in order to retain historic character” (AASHTO 2010, 51);
- Use the desirable features of a historic bridge as the basis for commonality between the old and the new (AASHTO 2010, 51); and
- Incorporate proper aesthetic design principles to achieve reference to past features of historical significance.

DESIGN ELEMENTS

Bridge type and material, rails, texture, scale, and abutments and wing walls were identified as the most common design elements or features that contribute to successful workhorse bridge replacements in rural historic districts. These features were determined based on a majority consensus of survey respondents on design enhancements and elements typically used in replacement designs and on an evaluation of bridge replacement projects highlighted in relevant literature.

Each of the following sections will provide a description of the design feature under the purview of a workhorse bridge, followed by suggested strategies for achieving successful CSDs. Examples illustrating those design options and cost considerations are provided as available.

Bridge Type/Material

Bridge type principally refers to form. Other elements, such as material, span type, and connection method, also contribute to bridge type and can place a bridge into a more specific subtype. NCHRP 25-25/Task 115 identified seven common historic bridges types as: (1) Truss; (2) Arch; (3) Slab, Beam Girder, and Rigid Frame; (4) Moveable Span; (5) Suspension; (6) Trestles and Viaducts; and (7) Cantilevers (PB and EIH 2005, 3-1-3-2). Along with changes to connection method and span type, the introduction of different materials, including stone, concrete, reinforced concrete, prestressed concrete, steel, timber, rolled metal, and rigid metal to a common bridge type can significantly alter its function and appearance, and ultimately its significance. Careful attention to the type of the existing bridge to be replaced in relation to its historic context is crucial to the success of a context-sensitive replacement design. Bridge type, as well as other substantial design aspects such as form and shape, holds significantly more weight in design compatibility within a historic context than applied ornamentation or smaller-scale design elements (Simon 2006, 126).

Most often in a rural setting, substructures are composed of stone or concrete, or both (Beckerman 2019a). Does the type reflect local vernacular forms built with local materials, or does the type reflect a state standard design built with materials acquired or manufactured elsewhere? Does the superstructure type reflect the functionality of the bridge? The superstructure type may allow only passenger vehicle use

or it may lend to use by agricultural machinery or delivery of goods. A standard design superstructure may reflect a statewide or regional pattern of design and character in rural areas.

Suggested Strategies

- Bridge type should be decided as early as possible in the design process. An incompatible bridge type cannot be overcome by ornamentation during the final design stages.
- The existing bridge should be replaced with a structure of a similar type, or consideration should be given to drawing from the dominant structure types in the immediate area.
- Workhorse bridges were designed in line with design standards and specifications that were in effect at the time of its construction; a replacement bridge designed in line with modern design standards and specifications of the same or similar bridge type is often compatible.
- Workhorse bridges are characteristically subdued in their setting; a statement or signature bridge is likely not a compatible replacement.
- Structural design accuracy and suitability through appropriate choice of material and connection method (e.g., a concrete beam bridge is not suited for stone facing because a concrete beam bridge would never be constructed of stone) should be maintained.
- Choose materials appropriate to the context of surrounding area (e.g., proposing a red brick bridge where stone masonry structures are prominent would be incompatible with the context of the surrounding area) should be chosen (Maryland DOT 1993, II-7).
- Regionally available materials should be used when possible (see the Milwaukee Co. example on Honey Creek Parkway Stone Veneer Bridge, which used local stone on the old and new bridges).
- Simulation of historic materials with modern technology is a risk; instead, consideration should be given to reproducing elements of similar size, shape, and proportions to the existing bridge in the new design. For example, as the Maryland DOT has described, reproducing fieldstone with cast concrete could significantly detract from appearance (Maryland DOT 2008, II-9).

Bridge Rails

Bridge barriers, parapets, and railings carry significant weight in the compatibility of a replacement design. Although the bridge type chosen initially dictates compatibility of scale and function within a historic context, an incompatible rail design can be easily and overtly inconsistent with a historic context. It is difficult to exercise flexibility with a context-sensitive rail design while also adhering to current design standards and specifications. Historic features generally do not meet current safety standards and many times are one of the reasons a bridge is being replaced, yet few



FIGURE I-45: Stoney Creek Mill Bridge Replacement, Rochester Hills, MI (Paul Graham, WSP)

modern rail designs defer to a historic design. Some states have developed standard railings designs based on historic designs (e.g., Nevada, Oregon, and Michigan), offering quality examples and strategies to combat the challenge (Figures I-45 and I-46).

Although sometimes difficult to implement, railings can offer higher design flexibility compared to other design categories. Provided that the railing meets modern safety standards, it is a common tool for visually relating a new bridge to its historic context and setting. If a railing is not designed carefully, however, it can easily place the new bridge out of context or present a false sense of history. Also, railing design is often of high concern to public stakeholders. Engineers should approach railing design collaboratively with public stakeholders to achieve a CSD that is in character with its surroundings and satisfies the local community.

Suggested Strategies

- Railing types should match bridge type. It is “...not acceptable to specify metal lattice traffic railings on an all reinforced concrete unit T-beam bridge, which would have had open concrete railings or solid parapets” (KCI and TranSystems 2012, 24).
- Reinforced concrete railings made to look historic in design are often successful (see Oregon DOT Stealth Rail design in Chenoweth Creek Bridge Case Study, p. 24).
- Open railings are preferred in settings with scenic views. Metal railings generally maintain views better than solid concrete barriers.
- When possible (not required for safety), true openings, rather than indentations made to replicate the shape of historic true openings, are preferred.
- Points of rail type transitions, specifically the transition between different materials, should be compatible with each other and the surroundings (see Morgan’s Ford Bridge Case Study, p. 74).
- Community input and feedback on rail design should be included.
- Design innovations such as lower test level rails can be considered for aesthetic reasons (Ray and Carrigan 2014, 95).



FIGURE I-46: Chenoweth Creek Bridge Replacement, Wasco Co., OR (Courtesy of Oregon DOT 2019b)

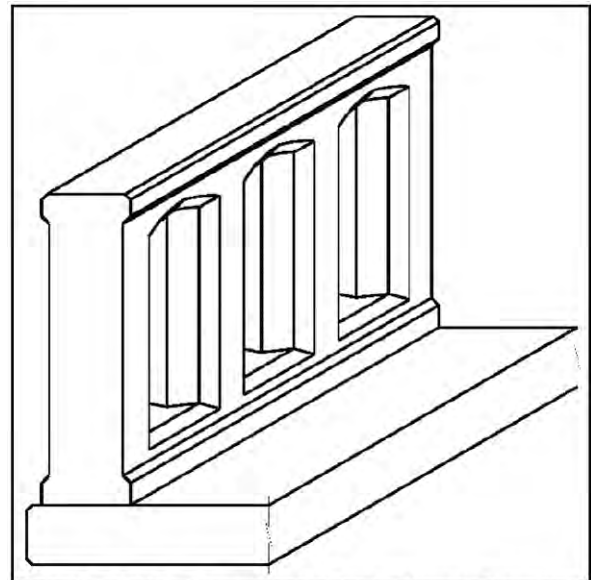


FIGURE I-47: Texas C411 Rail (“Texas Classic”) (Texas DOT 2018)

The Texas C411 rail, also known as the Texas Classic (Figure I-47), is a common railing style used in the replacement of historic bridges. Open or inset panels on solid barriers recall the pattern of the historic



FIGURE I-48: Stinesville Road Bridge, Monroe County, IN (Courtesy of BLN 2019b)

railing. This design is reminiscent of urban railing designs and is not typically suitable for strictly rural contexts. The Stinesville Road Bridge replacement provides an example when the railing was successfully used in a semi-rural historic context (Figure I-48)

Texture

Texture works to develop surface treatments on various bridge features. Abutments, wing walls, and retaining walls are often subjects of applied textures, including form liners,

stamping, veneers, panels, and acid treatments to achieve a desired visual effect or material representation. Texture applied as facing can be used to reflect structural capabilities and historic use (Maryland DOT 1993, V-12). However, similar to the consideration of bridge type and material of construction, textured applications must not logically contradict the structural framework of the new bridge.

Workhorse bridges in rural historic districts often defer to the textures that naturally surround them. In many cases, the bridge may be left without texture to allow the landscape to dominate the views, or on occasion the bridge exhibits textural elements using local materials, particularly the use of stone. One of the main sources of incompatibility in a replacement bridge design is the inappropriate type of stone, or the textural components are exhibited out of scale.

Six of 10 survey respondents reported the use of form liners as a common design element for replacement bridges in a historic context. Form liners are a convenient source of texture, useful for mimicking a specific material appearance, and often appealing to the budget as well as public stakeholders; however, there is an inherent risk in the easy application of texture/ornament, which may have nothing to do with the historic context or the previous bridge and can often result in an out of scale or out of context design.

Suggested Strategies

- Types of stone local to the area and historically use on similar types of bridges should be considered. Fieldstone, brick, and cut stone all can provide texture, as appropriate to the context (Figure I-49).
- Because substructure elements of workhorse bridges are often largest in scale relative to the surroundings, incorporating texture and repetitive features to these elements can help reduce their scale (Abraham and Showers 2007, 35).

Scale

Scale refers to “the size relationship among various features of the structure and between the total structure and its surroundings” (HNTB 1995, 2-4). A bridge should not appear out of human scale, which refers to the response a structure has with the human form. If it is too large, a bridge may appear monumental. A bridge should not have a heavy, bulky appearance that dominates a rural environment.

Scale is particularly important in the design of workhorse bridges in a rural historic district (Figures I-50 and I-51). Because these bridges are historic owing to their location within a district boundary and not as individually NRHP-eligible bridges, their relationship with the surrounding landscape, built and natural, can be a character-defining feature of the bridge within its historic context. Workhorse bridges were designed to complement their setting, and so should a replacement design. Scale becomes a significant aspect in achieving that harmony.



FIGURE I-49: Successful Application of Texture onto Bridge Face and Real Stone Masonry Abutments, River Road Bridge, PA (Photographer: Monica Harrower, Pennsylvania DOT; Courtesy of Harrower 2019)



FIGURE I-50: The Historic Oyster River Bridge In Durham, NH (Library of Congress 1968b)



FIGURE I-51: Oyster River Bridge Replacement, in Durham, NH. Replacement Design Exhibits Retention Of Scale (Courtesy of New Hampshire DOT 2019)

Suggested Strategies

- The scale of a replacement bridge should be similar to the existing bridge.
- The existing vertical profile should be maintained so as not to substantially alter the viewsheds to and from the bridge. Obscuring views of any structures or landscape features could change character-defining spatial relationships in the historic district.
- The number of columns used should be carefully considered (if applicable) because too many columns can have the appearance of a wall and on a shorter span can appear too bulky.
- Existing masonry characteristics, if applicable (e.g., size of stone, width of mortar), should be maintained.
- Adding driving lanes should be avoided because it will affect bridge scale.
- The bridge should be designed with the narrowest possible width under DOT guidance and transportation needs.

See also case studies for DeFouri Street Bridge (p. 55), Stoney Creek Mill Bridge (p. 62), and Falls County Road Bridge (p. 70).

Abutments and Wing Walls

Abutments are a major structural element as well as a major design element. Although a load-bearing member of the bridge, abutments are limited to the structural necessities that dictate their general size and placement. However, abutments and their extended wing walls still serve as an opportunity for design flexibility. On short-length workhorse bridges abutments often stand out because of their size in relation to the bridge span; they become a main aspect of the overall image of the bridge. In a rural setting, abutments are commonly constructed of local stone or integrated into the natural landscape (Figure I-52). When designing abutments, questions frequently arise concerning texture on wing walls and the height of the abutments.



FIGURE I-52: Morgan's Ford Bridge Replacement Exhibits Compatible Abutment Design with the Natural Landscape (Courtesy of Trevor Wrayton 2019)

Suggested Strategies

- Existing abutments should be replaced with those of similar material and form; for example, replace stone masonry abutments with stone veneer applied to cast-in-place concrete) (Texas DOT and Mead & Hunt 2018, 43).
- Abutment/wing wall exposure and finish should be carefully considered because shorter exposure may require paved embankments, which are not desirable in a rural setting. More exposure can allow the application of panels chosen for the specific context or increased surface area for color and texture options.
- Simulated stone (using form liners) on abutments and wing walls should be used only when in proximity to existing nearby bridges. Using form liners to reproduce a material appearance has a high risk of incompatibility.

Color

Color is a visual design element with the capability of changing perceptions and conveying visual ideas. Color can be achieved, among other methods, through material choice, paint, or stain. Color seen on workhorse bridges in rural historic districts commonly defers to colors in the surrounding landscape. Typically, workhorse bridges will not exhibit contrasting colors so that the bridge remains subdued.

Suggested Strategies

- Random and natural patterns should be used for bridges in a wooded area or other natural background (Stantec 2018, 4-8).
- No more than three colors should be used on one bridge (Pennsylvania DOT 2014, 14-4).
- Color can be used to highlight or disguise certain elements (Pennsylvania DOT 2014, 14-4).
- Natural colors of materials will blend better with a rural landscape; weathering steel or natural-tone concrete likely will have a more natural appearance than painted beams.
- If the bridge is meant to stand out, more contrast in colors should be used or colors should be selected to contrast with the surrounding landscape.

- If the bridge is a background structure, color schemes should be kept simple and subdued but should not match to the surroundings.

OTHER CONSIDERATIONS

Embankments

Shallower embankment slopes potentially provide a more balanced bridge composition. This also allows planted landscape features rather than paving the embankment, which can make the bridge appear out of scale. If in a rural historic district, the landscape is likely a significant feature and designing the embankments to reflect the natural landscape may be desired (CH2MH and Hoversten 2009, 15-16).

Alignment

Horizontal alignment accounts for horizontal curvature, sight distances, and superelevation. Vertical alignment characteristics fall more to aesthetics and the bridge safety as it relates to the grade of the roadway, vertical clearances, and vertical curvature. When significance is tied to the alignment of a historic bridge, it typically stems from the feeling of crossing the roadway and whether the alignment of the bridge allows for certain views or from the importance of the bridge within the circulation network of a historic district. Often maintaining the alignment of the bridge is critical to retaining a significant road pattern. This is reflected in several of the case study examples when mitigation required the retention of alignment (Chenoweth Creek Bridge (p. 24), Geigel Hill Road Bridge (p. 59), Stoney Creek Mill Bridge (p. 62), and Falls County Road Bridge (p. 70). The alignment of a bridge is not a flexible design feature and most adjustments to the alignment of a historic bridge are generally done to meet safety requirements.

On the occasion that an alignment adjustment is not critical to the retention of historic character or safety requirements, it can serve to better reveal a significant viewshed (D'Ignazio et al. 2010, 25).

Lighting

New lighting fixtures should only be considered when lighting existed on the old bridge or lighting is a character-defining feature of the historic district and can be utilized compatibly on the new bridge.

Date Stone and Markers

An original date stone should not be incorporated into the new bridge because it will create a false sense of history. Rather, consider creating a display, such as a small monument with the stone, near the new structure to provide for the interpretation of the historic bridge.

Informational signs may also include the date of original bridge construction, bridge designer, architectural style, and materials used.

SUGGESTED STRATEGIES

Review and analysis of the case studies revealed five general approaches to CSD/S for replacement bridges in or near rural historic districts. These approaches typically evolve naturally from the specific circumstances of the bridge, its context, the attitudes/interest of the public, and the design requirements of the new structure. Understanding these approaches may assist practitioners in guiding stakeholders and other interested parties through the CSD/S design process to a successful outcome. While each bridge replacement is unique, review of existing project examples indicates that most projects will follow one of the following approaches.

- **Regional** approach – draws influence from regional bridge styles as well as from a desire to create a modern, regional tradition. Examples include:
 - Chenoweth Creek Bridge, Wasco County, Oregon
 - Cook’s Chasm Bridge, Lincoln County, Oregon
 - Pennsylvania P3 Rapid Bridge Replacement Program
- **Replication** approach – is straightforward in its name, replacing a bridge with a replica design. Examples include:
 - Rosedale Road bridge, Mercer County, New Jersey
- **Previous Bridges** approach – draws design influence from previous iterations of an existing bridge. Examples include:
 - Bridge 9 (Smith’s Bridge), Newcastle County, Delaware
- **Stakeholder-Driven** approach is centered on the public involvement process and uses stakeholder input as a driving factor in proposed design elements. Examples include:
 - Stinesville Road Bridge, Monroe County, Indiana
 - Defouri Street Bridge, Santa Fe County, New Mexico
 - Geigel Hill Road Bridge, Bucks County, Pennsylvania
 - Stoney Creek Mill Bridge, Oakland County, Michigan
- **Design/Safety-Driven** approach stems from the necessity of a replacement design to address engineering design and safety issues of an existing bridge. Examples include:
 - Route 206 Flood Channel Bridge, Mercer County, New Jersey
 - Falls County Road Bridge, Falls County, Texas
 - Morgan’s Ford Bridge, Warren County, Virginia

Regional Approach

The regional approach to CSD/S draws design influence from existing regional bridge designs (often historic when near a historic district) and/or from a desire to create a modern, regional architectural tradition. The approach considers replicating common design trends seen amongst the area standards or regional architectural traditions to create continuity of design throughout a region.

A region could refer to a state, county or counties, a city, a town/village, a historic district—any area defined by its common characteristics. Historic roads and scenic byways would be a common area or region that would exhibit a collective style for replacement bridges. Identifying the most applicable “region” to the replacement project is important when considering this approach to CSD/S. The bridge to be replaced should relate its significance to whichever region type is chosen. For example, if a bridge is identified as built using a standard state design and is a common bridge type throughout the state, a statewide architectural tradition could be adhered to or created. The region can be as large or as small as can be accurately distinguished by architectural traditions or the potential for architectural tradition.

Taking inspiration from regional traditions and similar structures nearby maintains a sense of place and can project a historical impression on a bridge or area without creating a false sense of history.

Replication Approach

The replication approach to CSD/S is straightforward in its name. It aims to replace a bridge with a replica design using modern technology. The SOI Standards state that “new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and the environment.” AASHTO explores replication in

the *Bridge Aesthetics Sourcebook* and states that “unless the new design is going to be a faithful reproduction of what is being replaced, which is rarely the case, national preservation guidance...calls for using contemporary design that is compatible with the historic context” (AASHTO 2010, 51). AASHTO finds a reproduction of a bridge in a historic district acceptable when a certain “period character of a manipulated landscape” is desired to be preserved (AASHTO 2010, 53). Therefore this approach is most often, and most appropriately, taken when the surrounding landscape would be significantly adversely affected by the loss of the bridge; likely to happen when a bridge is identified as an integral/contributing feature of a historic landscape or district and often individually eligible for inclusion in the NRHP.

Because of the challenge of producing a faithful reproduction, practitioners must be critical in their use of this approach. Modern safety and engineering standards make retaining features such as width and railing design only achievable through design exceptions and buy-in from all stakeholders. It is important at the start of a project to determine the likelihood and achievability of acquiring multiple design exceptions.

Previous Bridges Approach

This approach to CSD/S draws design influence from previous iterations of the bridge. The existing bridge, at the time of replacement, is not always the original bridge. One or more bridges may have existed at the location and in this approach are a source of design inspiration.

This approach uses historical research to accurately determine which type or types of bridges were previously constructed at the location. Through evaluation of the historic context and public input, organizations may find value in referring to an older design. This approach does not, however, call for an exact replication of a historic design and is likely to require design exceptions.

Public input is a large part of this approach. It is often the values a local community associates with a past bridge that inspires returning to a specific tradition. Value may be associated with particular bridges, for example, as a place of meeting, entrance to a neighborhood, or related to community tradition, potentially establishing associations or a sense of feeling not experienced by or accessible to CSD/S practitioners.

Stakeholder-Driven Approach

The stakeholder-driven approach to CSD/S is centered on the public involvement process and uses stakeholder input as a driving factor in proposed design elements. This does not mean the public designs the entire bridge but rather that specific features, such as rail type, form liner finish, or factors of multi-modalism, are choices posed to stakeholders for a vote or opinion.

Design/Safety-Driven Approach

The design/safety-driven approach to CSD/S stems from the necessity of a replacement design to address design and safety issues of the existing bridge. Critical safety hazards and substandard features will spark that necessity, and solutions to those problems will be prioritized above public input and aesthetic treatments. Additionally, the replacement is often expedited to a rapid bridge replacement. The project team must still be able to accommodate CSD principles of public involvement and design compatibility within the expedited timeline.

Design decisions are based on how to eliminate safety issues, such as overtopping during flood events and substandard railing heights and road width causing increased traffic accidents, by use of creative hydraulic and geometric solutions. Aesthetic treatments are limited to only what is necessary to achieve compatibility with the surroundings, if used at all.

The public involvement process often takes the approach of a delayed presentation of a preferred design rather than an open-ended initial meeting seeking public input on design.

CHOOSING A CSD APPROACH

As noted above, a CSD approach typically evolves naturally from the specific circumstances of the bridge, its context, the attitudes/interest of the public, and the design requirements of the new structure. In order to lead practitioners and stakeholders through this selection process, a series of guided questions has been developed. Outlined below by general topic, these questions should be used to gain an understanding of the setting/context of the historic bridge, the important safety considerations of the project/site, and the desires of the stakeholder/community. These guided questions are also included in the Design Idea Book, which is a separate document available at <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4488>.

Guided Questions

Setting/Context

- Historically, how many bridges have been at the site?
 - Do previous bridges have more of a historical connection to the historic district than the current bridge?
- Why was the site historically chosen for a bridge?
 - Did the bridge serve as or create a natural/advantageous river crossing?
 - Was it built as a part of an engineered road network?
 - Was it part of a scenic route/parkway?
 - Did it function within an agricultural (farm to market) network?
- What was the historic function of the bridge within the historic district circulation network...Is it a gateway bridge, a transportation link, a utility bridge, a waterway or land feature crossing?
- Was the workhorse bridge designed to blend with the landscape or stand out?

Significance

- Is the bridge individually significant as well as contributing to a historic district?
- How is the bridge contributing to the historic district?
- Does the bridge share any aesthetic qualities (materials, form, etc.) with buildings or structures, particularly other bridges, within the historic district?

Design

- Is the bridge a standard state highway design?
- Are there other workhorse bridges within the historic district or nearby?
 - Are there common design features within the historic district or region?
- What are the design details/character-defining features of the workhorse bridge?
 - Railing?
 - Color?
 - Structure type?
 - Materials?

- Are there any other community/area-specific design parameters to consider?
 - Pedestrian crossing
 - Large machinery crossing in agricultural area
 - Designated truck route
 - Flood Resiliency

Safety

- What is the posted speed of the roadway that the bridge carries?
- Does the existing bridge to be replaced have any critical safety hazards?
- Does the existing bridge to be replaced have substandard design elements?

Public Involvement

- What is the attitude/interest of the public?
- Have any other nearby bridges been replaced prior to this project?
 - What were the lessons learned?

Key Factors to Strategy Success

The literature review and case studies revealed several key resources and agency programs are essential to the success of the each CSD/S strategy outlined in this section (Table I-17). While the success of each strategy does not solely depend on these factors, each strategy is more likely to have a successful outcome when these factors are present.

TABLE I-17. KEY FACTORS TO STRATEGY SUCCESS

APPROACH	TYPICAL ORGANIZATIONAL NEEDS
Regional	<ul style="list-style-type: none"> • Standard designs (historic and modern) • Region with similar or cohesive bridge designs • Effective interdisciplinary coordination • Developed bridge replacement program
Replication	<ul style="list-style-type: none"> • Well-developed historical narrative • Ability/resources to do a “faithful” replication (AASHTO Guidelines) • Available funding
Previous Bridge	<ul style="list-style-type: none"> • Well-developed historical narrative • Significant association between the previous bridge and historic district • Engaged community • Available funding
Stakeholder-Driven	<ul style="list-style-type: none"> • Flexible schedule • Ability to be flexible on design • Technological resources • Engaged community • Allowing community involvement in design early in the process • Effective interdisciplinary coordination
Design/Safety-Driven	<ul style="list-style-type: none"> • Used more for higher volume/speed crossings • Practitioners with CSD experience

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PART II. RESEARCH REPORT

SUMMARY

This research report presents a summary of the literature review and state of practice survey of the current CSD process for replacement of workhorse bridges in rural historic districts. The literature review was followed by both screening and intensive surveys of state Departments of Transportation (DOTs), State Historic Preservation Offices (SHPOs), and private sector consultants using both online surveys and telephone interviews.

The extensive literature review identified a number of national and state resources such as CSD/S guidebooks and manuals, bridge design and aesthetics manuals, and various historic preservation sources including historic bridge management plans, and historic district guidelines. Two important national sources that provide guidance on the replacement of workhorse bridges include AASHTO's *Bridge Aesthetics Sourcebook* and the *NCHRP Web-Only Document 189: Design and Management of Historic Roads*. State DOTs in Delaware, Georgia, Maryland, Massachusetts, Michigan, New Hampshire, New Mexico, Oregon, Pennsylvania, and Virginia have produced CSD/S-focused sources that offer strategies for a CSD/S approach specific to bridge design. State DOTs, particularly in New Jersey, Indiana, Minnesota, Maryland, Nevada, and Oregon, have developed their own bridge design and bridge aesthetics manuals and guides that referenced specific guidelines for historic bridge replacements.

Review of historic bridge replacement projects, the state of practice survey, and subsequent interviews with DOTs, agencies and practitioners revealed the following five general approaches to CSD/S.

- **Regional** approach – draws influence from regional bridge styles as well as from a desire to create a modern, regional tradition.
- **Replication** approach – is straightforward, replacing a bridge with a replica design.
- **Previous Bridges** approach – draws design influence from previous iterations of the existing bridge.
- **Stakeholder-Driven** approach – is centered on the public involvement process and uses stakeholder input as a driving factor in proposed design elements.
- **Design/Safety-Driven** approach – stems from the necessity of a replacement design to address engineering design and safety issues of the existing bridge.

SECTION 2.1: INTRODUCTION AND RESEARCH OBJECTIVES

The research objective for this project is to develop a practitioner-ready resource of CSD examples appropriate for workhorse bridges in rural historic districts. Along with design examples, the results of the research project would also address design components that are common to successful CSDs and the costs associated with such designs. Information provided in the research report was collected and evaluated to develop the practitioners' guide (Part 1).

This research report is organized into three sections (plus References Cited and Conclusion) and five appendices. A Design Idea Book is available as a separate resource at <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4488>.

- Introduction – The section provides background information and summarizes the scope and organization of the report.
- Literature Review – This section reviews the literature on CSD/S research, current practices in bridge design for common bridges, and potential effects of CSD/S on historic properties within the context of Section 106.
- State of Practice – This section summarizes and discusses the findings of the screening and in-depth surveys of state DOTs, SHPOs, and private sector consultants.

SECTION 2.2: LITERATURE REVIEW

An extensive literature review was conducted to identify and evaluate available information on CSD, current practices in bridge design for common bridges, and potential effects of CSD/S on historic properties within the context of Section 106.

The lifecycle of CSD/S can be traced back to early 1990s legislation, including the Intermodal Surface Transportation Efficiency Act, which emphasizes the preservation of historic, scenic, and cultural resources, and the National Highway System Designation Act, which prompted the development of the FHWA's approach in *Flexibility in Highway Design* (FHWA 1997). Over the next two decades, agencies including the TRB, AASHTO, and state DOTs contributed a myriad of research, literature, and examples toward the practice of CSD/S. On initial search, however, it was apparent that sources concerning rural historic districts were limited in number. The following sections synthesize the relevant literature and highlight the most useful resources to guide future CSD/S bridge replacement projects in rural historic districts. CSD/S guides/manuals, bridge design and aesthetic guides/manuals, and historic properties management plans and design guidelines are particularly appropriate.

CONTEXT-SENSITIVE DESIGN/SOLUTIONS GUIDES AND MANUALS

National Sources

In 2007, FHWA produced a report on the *Integration of Context Sensitive Solutions in the Transportation Planning Process*. This report commented on the state of practice of CSD/S, which by that time already had a wide-reaching influence in the transportation field, and provided an annotated bibliography of then current research projects and planning strategies. In 2018, FHWA published a state of the practice assessment on the use of context-sensitive solutions (CSS) to achieve CSD. The assessment provides general strategies for CSD, a record of each state DOT's current practices for implementation of CSD, and a summary of a handful of CSD case studies. These two reports aided in locating following existing literature on CSD produced and used by state DOTs and partnering transportation organizations.

- *Integration of Context Sensitive Solutions in the Transportation Planning Process*
(https://rosap.ntl.bts.gov/view/dot/1025/dot_1025_DS1.pdf)
- *Using Context Sensitive Solutions to Achieve Context Sensitive Design: State of the Practice Assessment*
- *Using Context Sensitive Solutions to Achieve Context Sensitive Design: State of the Practice Assessment*
(https://www.fhwa.dot.gov/planning/css/key_references/fhwahep18071.pdf)

At this stage in the evolution of CSD/S, although the majority of states have enacted policies and are guided by CSD/S principles, few sources have been developed that apply those principles directly to bridge design in a sensitive historic context. Such content is found in well-developed CSD/S manuals and most frequently in guidance for state byways because they offer specific settings, often historic, on which to base design decisions. It can be difficult to give CSD/S recommendations for bridge design in general terms; therefore limiting the scope of the setting can help produce more detailed strategies. CSD/S guides and manuals can offer the tools needed to successfully collaborate with public stakeholders and other disciplines, and to navigate the sensitive nature of historic places during the design process.

State Sources

The following is a compiled list of CSD/S-focused sources, produced by state DOTs, that offer strategies for a CSD/S approach specific to bridge design.

In 2011, **Delaware** DOT published *Context Sensitive Solutions for Delaware Byways*, prepared by Mahan Rykiel Associates Inc. and Whiteman, Requardt and Associates, LLP. This source comments on the bridge design components that are most important to any given context.

- *Context Sensitive Solutions for Delaware Byways*
(https://www.deldot.gov/Programs/byways/pdfs/Context_Sensitive_Solutions_for_Delaware_Byways.pdf)

Georgia DOT's *Context Sensitive Design Online Manual*, revised in 2016, provides CSD/S best practices illustrated through project examples throughout the state, highlighting communication strategies, design flexibility, environmental sensitivity, and stakeholder involvement. Of particular value is Chapter 3, "Leading with Best Practices," which summarizes several bridge replacement projects in both urban and rural settings that can give good insight and potential recommendations to similar projects in other states.

- *Context Sensitive Design Online Manual*
(http://www.dot.ga.gov/PartnerSmart/DesignManuals/ContextSensitiveDesign/GDOT_CSD_Manual.pdf)

In 2006, the **Maryland** State Highway Administration produced *Context Sensitive Solutions for the Maryland Historic National Road Scenic Byway*. This report gives detailed consideration for CSS as a means of meeting design goals. Regarding bridges, the report touches on railings, road widths, profiles, structural design, abutments, and detailing to achieve harmony with a historic setting.

- *Context Sensitive Solutions for the Maryland Historic National Road Scenic Byway*
(https://www.roads.maryland.gov/OED/mhnr-css_final061104.pdf)

In 2006, the **Massachusetts** Highway Department revised the *Project Development & Design Guide*. Chapter 10 is dedicated to bridges; section 10.3 highlights “Contextual Influences on Bridge Design.” That section discusses designing an appropriate bridge based on an understanding of the setting.

- *Project Development & Design Guidelines*
(<https://www.mass.gov/files/documents/2018/08/08/pddg.pdf>)

Michigan DOT has a wealth of experience implementing CSD/S principles and practices in its transportation projects. One of the most useful reports available through Michigan DOT is a document first produced by the Michigan Association of Planning, *Context Sensitive Solutions: Paving the way for better transportation*, which outlines the CSS approach as it specifically relates to transportation projects. Several project examples are highlighted in this document, including the River Bridge rehabilitation in Crystal Falls. The topic of defining context is also given consideration.

- *Context Sensitive Solutions: Paving the Way for Better Transportation*
(https://www.michigan.gov/documents/MDOT_CSS_article1_159512_7.pdf)

In 2004, Michigan DOT drafted a *CSS Draft Implementation Plan* toward the development of CSS procedures and guidelines for transportation projects in the state.

- *CSS Draft Implementation Plan*
(https://www.michigan.gov/documents/MDOT_Appx_D_Policies_Procedures_6-7_CSS_Draft_Implementati_160116_7.pdf)

In 2005, Michigan DOT defined its CSS Policy and developed the *Flexibility in Michigan DOT Design Standards*, which references the procedures necessary to achieve context-sensitive bridge designs. It followed up in 2006 with the *Fundamentals of Context Sensitive Solutions*.

- *Commission Policy on Context Sensitive Solutions*
(https://www.michigan.gov/documents/MDOT_CSS_Policy_159545_7.pdf)
- *Flexibility in Michigan DOT Design Standards*
(https://www.michigan.gov/documents/MDOT_Appx_D_Policies_Procedures_8-10_Flexibility_in_MDOT_D_160117_7.pdf)
- *Fundamentals of Context Sensitive Solutions*
(https://www.michigan.gov/documents/MDOT_CSSFundamentalsHandout_163739_7.pdf)

In 2009, Michigan DOT produced a detailed guide to stakeholder engagement as part of the CSS process. The resource provides the concepts and necessary steps to take when working with project stakeholders and how best to deliver a successful product. In 2010, Michigan enacted a Complete Streets Approach, requiring the State Transportation Commission to adopt the principles that consider the varying needs of local contexts, project costs, and mobility needs of users, which gives great insight into the CSS bridge designs exhibited throughout Michigan.

- *Guidelines for Stakeholder Engagement*
(https://www.michigan.gov/documents/mdot/MDOT_Guidelines_For_Stakeholder_Engagement_264850_7.pdf)
- “Complete Streets” presentation
(https://www.michigan.gov/documents/mdot/MDOTCompleteStreets_FAQ_Present-370903_7.pdf)

In 2008, **New Hampshire** DOT developed a context-sensitive solution “scaling matrix” that outlines the project attributes, public involvement strategies, context study/placemaking strategies, design suggestions, and project team make-up for a variety of settings, including rural and those with “place.”

- *Scaling CSS*
(<https://www.nh.gov/dot/org/projectdevelopment/highwaydesign/contextsensitivesolutions/documents/CSSScaling.pdf>)

In 2006, **New Mexico** DOT developed design guidelines for CSD/S that includes a section on bridges, addressing quality designs that avoid historicizing new structures and encourages using local traditions as a pattern book for contextual design. These guidelines introduce a method called the “Place Audit” to aid in establishing an understanding of local historic context. A more detailed example of the place audit is presented in *A Context Sensitive Design Approach for Scenic Byways in New Mexico*. This report provides some insight into design choices in a historic area.

- *Architectural and Visual Quality Design Guidelines for Context Sensitive Design and Context Sensitive Solutions*
(http://dot.state.nm.us/content/dam/nmdot/Infrastructure/EDS/NMDOT_Architectural_and_Visual_Quality_Design_Guidelines.pdf)
- *A Context-Sensitive Design Approach for Scenic Byways in New Mexico*
(http://dot.state.nm.us/content/dam/nmdot/Infrastructure/EDS/NMDOT_Best_Practices_A_Context-Sensitive_Design_Approach_for_Scenic_Byways.pdf)

Oregon DOT developed a unique approach to CSD/S to incorporate into the state Bridge Delivery Program (OTIA III) in the early 2000s. By integrating principles of sustainability with the principles of CSD/S, titled *CS³*, Oregon established an effective system for bridge design and development that results in compatible bridges that reflect community values while also being cost effective. The *CS³* process is described in the *CS³ Guidebook* developed by Oregon DOT.

- *Context Sensitive and Sustainable Solutions (CS³) Guidebook*
(<http://www.otiabridge.org/static/cs3-guidebook.pdf>)

In 2009, **Pennsylvania** DOT established a Contextual Bridge Preservation Task Force (Task Force). The Task Force was charged with establishing protocol for addressing contextual preservation of bridges. CSD was one topic of concern. The group developed principles of bridge aesthetics, as well as a project Development Process Form. A summary report on the findings of the Task Force proves a valuable resource regarding the evaluation of a bridge itself as well as various contexts in which a bridge can be located.

- *Contextual Bridge Preservation Task Force*
(<http://www.bucks.edu/media/bcccmialibrary/historicpreservation/documents/2009BridgeReport.pdf>)

In 2016, the **Virginia** DOT developed a memorandum about CSS. This Instructional and Information Memorandum guides Virginia DOT staff in the implementation of Common Sense Engineering and CSS to resolve transportation challenges. The memorandum provides policies and procedures that reflect on stakeholder involvement and preserving scenic, aesthetic, historic, and environmental resources associated with transportation projects without compromising safety. This source also provides links to related manuals and processes, including *Preliminary Engineering Project Development Process* and

Manual for Public Participation in Transportation Projects.

- *VDOT Location and Design Division Instructional and Informational Memorandum Number: IIM-LD-235.4* (http://www.extranet.vdot.state.va.us/locdes/electronic_pubs/iim/IIM235.pdf)

BRIDGE DESIGN AND AESTHETICS GUIDES AND MANUALS

National Sources

The *AASHTO LRFD (Load and Resistance Factor Design) Bridge Design Specifications* guides engineers in all new bridge designs. FHWA established that it should be the goal of all bridge engineers and transportation organizations to incorporate the AASHTO LRFD standards in all new bridges built after 2007 (AASHTO 2017, v). These specifications set the minimum requirements to provide for public safety and are not intended to replace any engineering training or design judgement. Flexibility is encouraged. The publication is often referenced by transportation organizations in CSD/S policies, bridge aesthetic policies, and overall design practices as base provisions. Bridge aesthetics are mentioned in Section 2.5 and relay that bridges “should complement their surroundings, be graceful in form, and present an appearance of adequate strength” (AASHTO 2017, 2-16). These specifications consider design in rural, rural town, suburban, and urban contexts but do not address historic contexts.

AASHTO’s *Bridge Aesthetics Sourcebook* provides the most detailed discussion on the design of bridges in a historic district. A warning is given to avoid creating modern bridges decorated to look old by focusing on developing a modern design, with modern bridge technology, that is also compatible with the historic context. The *Sourcebook* recommends that the scale, shape, and railing design of a bridge be significant contributors to the compatibility of a new bridge (AASHTO 2010, 51).

FHWA established 13 controlling design criteria for roadways: (1) design speed, (2) lane width, (3) shoulder width, (4) bridge width, (5) horizontal alignment, (6) superelevation, (7) vertical alignment, (8) grade, (9) stopping sight distance, (10) cross slope, (11) vertical clearance, (12) lateral offset to obstruction, (13) structural capacity. These criteria are considered the most important for the operational and safety performance of the highway and engineers give them special attention (National Academies 2014). Meshing these design criteria with the SOI Standards is critical to the CSD of workhorse bridges in or adjacent to rural historic districts.

The *NCHRP Web-Only Document 189: Design and Management of Historic Roads*, offers many parallels to the design and management of historic bridges. The document is cited by many CSD/S practitioners as a useful source for understanding critical steps in the design process for a historic resource.

State Sources

State DOT bridge design and bridge aesthetics manuals and guides are a heavily saturated source of information. Each state’s bridge design manual, and additional aesthetics guide, if available, was reviewed and evaluated for guidelines pertaining to bridge design in rural and historic settings, with attention paid to states referencing CSD/S principles in their design process.

Common themes regarding bridge replacement in a historic district synthesized from state bridge design manuals and aesthetic guides include the following.

- Use rating systems and levels of aesthetic treatments
 - States that use levels of aesthetic treatments to categorize the need for aesthetics and the cost allowances for the respective levels include, among others, California, Colorado, Florida, Iowa, Minnesota, Nevada, North Carolina, and Pennsylvania.
 - In each of these states, historic bridges and bridges in a historically significant setting are considered in need of higher aesthetic consideration and potentially eligible for increased funds to do so.
- Use careful application of flexibility in design and design exceptions to achieve designs sensitive to the historic context.
- Use the 13 controlling design criteria from the *AASHTO A Policy on Geometric Design of Highways and Streets (Green Book)* to develop balanced solutions (McCahon et al. 2012, i).
- Railing design will have a significant impact on the success of the design; careful consideration is given to type and aesthetics while adhering to current safety standards.
- Avoid applications to achieve a historic look; instead allow the bridge type and shape to dictate its underlying historic aesthetic.

Twenty state DOTs offer substantive consideration for replacement bridges in historic districts.

In 2001, the **Arizona** Bridge Group developed *Bridge Practice Guidelines* to document design criteria and provide general guidance on proper application of design aspects to the designer. Chapter 3 of Section 1 on Bridge Design Phases outlines three design phases: initial, preliminary, and final. It states that evaluation of the historical significance of a bridge to be replaced should occur during the initial design phase, before any C/DS are started. Arizona has also completed a Structure Inventory and Appraisal database that can guide the identification and evaluation of specific bridges in the state. That inventory is not available publicly.

- *Bridge Practice Guidelines*
(https://www.azdot.gov/docs/default-source/bridge-group/bridge-practice-guidelines_0305.pdf?sfvrsn=2)

In 2012, **New Jersey** DOT produced *Historic Roadway Design Guidelines*, with an objective of providing recommendations for designs to avoid or minimize adverse effects to significant historic roadways. The design recommendations blend CSD principles with the SOI Standards to best protect New Jersey's historic roadways. Chapter III, Design Strategies for Historic Roadways, provides two general principles for projects where no historic roadway features are present, but the historic setting remains as well as a section on structures/bridges and the suggested design strategies when approaching a design. Several project examples are pictured in the guidelines, showing successful design features on replacement historic bridges.

- *New Jersey Historic Roadway Design Guidelines*
(<https://www.state.nj.us/transportation/publicat/historicroadwaydesignguidelines.pdf>)

In 2015, the **North Carolina** DOT developed an *Aesthetics Guidance Manual* to aid North Carolina practitioners in the incorporation of aesthetics into North Carolina DOT transportation designs. Chapter 7 of the manual is dedicated to bridges, including a brief section defining "Historical Bridges," followed by a detailed outline of North Carolina DOT's approach to making aesthetics decisions for bridge designs. North Carolina DOT follows a tiered approach to designated bridges under recommended levels of aesthetics and provides visual and written examples of design elements at each level in this manual. A

Pattern Book was also developed as part of this effort to improve aesthetics in transportation facilities across the state. The *Pattern Book* is a curated collection of images that exhibit the desired approaches to aesthetics for the state. Chapter 3 is dedicated to bridges, with examples of the three levels of aesthetic treatments as designated in the Manual.

- *Aesthetics Guidance Manual*
(https://connect.ncdot.gov/resources/roadside/AestheticEngineeringDocuments/AGM_Manual.pdf)
- *Aesthetics Guidance Pattern Book*
(https://connect.ncdot.gov/resources/roadside/AestheticEngineeringDocuments/AGM_PatternBook.pdf)

In 2015, Caltrans completed updates to its *Bridge Design Practice* manual, which guides bridge designers on the application of standards in **California** bridge design. Chapter 2 outlines architecture and aesthetics practices, emphasizing the creation of continuity in regional design and using architectural traditions as inspiration for replacement designs. Caltrans also outlines their process of attributing levels of aesthetic treatments for every structure design project, including those in sensitive areas. A Caltrans report, *Bridge Rails and Barriers: A Reference Guide for Transportation Projects in the Coastal Zone*, discusses general guiding principles concerning the appearance of bridge rails and barriers, noting considerations for historic bridges.

- *Bridge Design Practice*, Chapter 2: “Bridge Architecture and Aesthetics”
(http://www.dot.ca.gov/des/techpubs/manuals/bridge-design-practice/page/BDP_Chapter_2.pdf)
- *Bridge Rails and Barriers: A Reference Guide for Transportation Projects in the Coastal Zone*
(http://www.dot.ca.gov/design/lap/livability/docs/Caltrans_Bridge_Rails_and_Barriers.pdf)

In 2016, **Indiana** DOT produced a report on replacement strategies for *Guardrails for Use on Historic Bridges*. The report does not directly address bridges in historic districts but rather provides a very useful discussion on railing modifications that are potentially highly applicable to workhorse bridge replacements in rural historic districts. As part of Indiana DOT’s Historic Bridge Survey and inventory efforts, each historic railing type across the state was identified. Research for this report then identified 42 historic railing types that could be “approximated” using a base modern railing modified to match its historic counterpart. Each approximated design utilizes a crash-tested base railing and meets the requirements of the Indiana Design Manual. The Texas DOT T221 and Oregon DOT Concrete Beam and post railings are the two base railings most commonly used by Indiana DOT. They offer simple geometric designs with workable areas to apply form liners or custom infills.

- *Guardrails for Use on Historic Bridges: Volume 1 – Replacement Strategies*
(<https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3154&context=jtrp>)

In 2019, **Colorado** DOT completed a *Bridge Design Manual* providing policies and procedures for design, rehabilitation, and repair of bridges and other structures. Chapter 2 on Aesthetics comments on the role of a landscape architect to recommend aesthetic treatments based on CSS that create “a sense of place, security, and context of scale” (Section 5.5). Historic value is considered for assumed levels of aesthetic treatment.

- *Bridge Design Manual*
(https://www.codot.gov/library/bridge/bridge-manuals/lrfd-bridge-design-manual/lrfd_bridgedesignmanual_june2017/at_download/file)

Connecticut DOT issues annual updates to its *Local Bridge Program Manual*, which guides local municipalities in bridge project development and funding opportunities. This source provides recommendations for timing of historic context evaluation and procedures for obtaining Section 106 approval. In addition, Connecticut DOT developed a *Bridge Design Manual* in 2003, updated through 2011. This manual provides guidelines for proper surface treatments and often highlights cases of design exceptions for historically significant structures.

- *Local Bridge Program Manual, Fiscal Year 2019*
(https://www.ct.gov/dot/lib/dot/documents/dbridgedesign/localbridgeprogram/local_bridge_program_manual_final_-_april_2019.pdf)
- *Bridge Design Manual*
(https://www.ct.gov/dot/lib/dot/documents/dpublications/bridge/ctdot_bridge_design_manual_04-19.pdf)

In 2018, **Florida** DOT updated *Structures Design Guidelines*, which provides detailed standards and criteria for engineers to follow when designing bridges and other highway structures. A designated historic bridges section outlines guidelines for historic railing improvement or replacement.

- *Structures Design Guidelines: Structures Manual Volume 1*
(https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/structures/structuresmanual/currentrelease/vol1sdge93d6390ed674b04817d8360c0372739.pdf?sfvrsn=875a28ad_2)

In 2018, **Iowa** DOT revised a *Bridge Design Manual* with detailed practices used by Iowa engineers. Chapter 9 outlines guidelines in bridge aesthetics, which includes sections on historic bridge considerations, levels of aesthetic treatment, and cost considerations for historic bridges, as well as a brief discussion of “placemaking” as it relates to designing a bridge to fit with its surroundings.

- *Bridge Design Manual*
(<https://iowadot.gov/bridge/policy/LRFDBridgeDesignManual.pdf>)

Maryland State Highway Administration’s 2005 *Aesthetic Bridges User Guide* provides an excellent analysis of aesthetics for workhorse bridges. Several sections are applicable to bridges in a historic context, including guidance on achieving harmony with surroundings, avoiding replication of the old bridge, and specific surface treatments (e.g., brick, form liners, stone, and color). Also, the *Management Plan for Historic Bridges* provides guidance on mitigation of adverse effects to historic bridges as well as specifics on compatible replacement railing design.

- *Aesthetic Bridges User Guide*
(<https://www.roads.maryland.gov/OBD/oos-aesthetics-guide.pdf>)
- Management Plan for Historic Bridges
(<https://www.roads.maryland.gov/OPPEN/Maryland%20SHA%20Management%20Plan%20for%20Historic%20Highway%20Bridges.pdf>)

In 2000, **Michigan** DOT enacted a policy on aesthetics that calls for protection of historic areas. This has guided Michigan DOT transportation projects down the CSD/S path successfully for many years. Michigan DOT's *Bridge Design Manual* guides present procedures and requirements for this policy with the subsequent CSS policies in mind. Chapter 12 on Rehabilitation Projects touches directly on historic bridges.

- *Commission Policy on Aesthetics*
(https://www.michigan.gov/documents/MDOT_Appx_D_Policies_Procedures_14_Commission_Policy_Aesth_160137_7.pdf)
- *Michigan Bridge Design Manual*
(<https://mdotcf.state.mi.us/public/design/englishbridgemanual/>)

In 1995, **Minnesota** DOT completed *Aesthetics Guidelines for Bridge Design*. The manual addresses characteristics of historic areas, levels of aesthetic treatment for historically sensitive locations, compatible railing design for historic districts, and basic aesthetic principles that should guide any bridge project.

- *Aesthetics Guidelines for Bridge Design*
(<https://www.dot.state.mn.us/bridge/pdf/aestheticguidelinesforbridgedesign.pdf>)

Nevada DOT began developing a standard treatment plan for “adversely affected historic bridges” in 2014. A draft plan provides guidelines and drawings for newly developed modern standard railing designs based on historic standardized designs. This treatment plan was developed as part of a programmatic agreement between Nevada DOT and Nevada SHPO. The designs offer options for specific railing architectural styles, such as Beaux Arts, Art Deco, Streamline Moderne, and Mid-Century Modern, to replace historic railings of the corresponding style. A second Nevada DOT publication of relevance to replacement bridge design in rural historic districts is the *Aesthetic Alternatives for NDOT Design Standards* from 2009. This report presents existing aesthetic design practices in Nevada and alternatives to those practices to improve aesthetic quality and continuity of Nevada highway bridges and corridors. Alternatives suggested for embankment and abutments design aesthetics are applicable to rural settings and considerations within historic contexts.

- *Standard Treatment Plan #1: Adversely Affected Historic Bridges*
(<https://www.nevadadot.com/home/showdocument?id=1785>)
- *Aesthetic Alternatives for NDOT Design Standards*
(<https://www.nevadadot.com/home/showdocument?id=1543>)

In 2015, **New Hampshire** DOT developed the *Bridge Design Manual* to guide engineering in continuity of design throughout New Hampshire. Chapter 2 outlines the bridge selection process that should be followed when determining the structure type for a replacement bridge. Relevant to bridges in a historic district, the chapter highlights bridge geometry in constrained areas, including historical sites, and aesthetic considerations, particularly when to address aesthetic concerns during a CSD/S process.

- *Bridge Design Manual, Chapter 2: “Bridge Selection”*
(<https://www.nh.gov/dot/org/projectdevelopment/bridgedesign/documents/CompleteChapter2Aug2018.pdf>)

New Jersey DOT's *Bridges and Structures Design Manual* provides state engineers with the procedures to implement during the bridge design and development process. Specific attention is given to the

analysis required for existing bridges found in planned projects, including consideration for their historical significance. The manual also establishes procedures for a vulnerability assessment, which includes historic bridges. Lastly, the manual establishes framework for bridge surveys that considers the historical significance of a bridge.

- *Bridges and Structures Design Manual*
(<https://www.state.nj.us/transportation/eng/documents/BSDM/>)

In 2017, the **New York** State DOT published a *Bridge Manual*, providing engineers with New York State policies and procedures on bridge project development. Sections on types of project enhancements (3.2.9.2) and Aesthetics (23) specifically address bridges in historically sensitive areas and give examples of what types of designs are appropriate in those settings.

- *Bridge Manual*
(https://www.dot.ny.gov/divisions/engineering/structures/repository/manuals/brman-usc/NYSDOT_bridge_manual_US_2017.pdf)

In 2010, the **Ohio** DOT produced *Ohio Historic Bridge Maintenance & Preservation Guidance* to encourage bridge stewards in the proper maintenance of the state's wide range of historic bridge types. Section 3.9.2 of this report discusses replacement options for deteriorated historic railings.

- *Ohio Historic Bridge Maintenance & Preservation Guidance*
(http://www.dot.state.oh.us/Divisions/Planning/Environment/Cultural_Resources/HISTORIC_BRIDGES/Documents/OhioHistoricBridgePreservationManual910.pdf)

In 2018, **Oregon** DOT revised its *Bridge Design Manual* to continue to guide state transportation engineers in the standards and practices applicable to bridge design. Chapter 2 outlines design guidance on accelerated bridge construction, appearance and aesthetics, type and selection, bridge layout, safety, security, and name plates and markers. Section 2.3 on "Structure Appearance and Aesthetics" touches on the inherent conflicts of aesthetic and environmental considerations, as well as specific recommendations for appropriate use of aesthetic elements, including type of stone and railings. In 2003, Oregon enacted the Oregon Transportation Investment Act III (OTIA III) State Bridge Delivery Program (<http://www.otiabridge.org/static/cs3-guidebook.pdf>). In conjunction with this program, Oregon DOT developed the *Visual Performance Standards*. The OTIA III Stage 2 through 5 Bridge Replacements and Repairs section of this report provides exceptional guidance on aesthetic choices in rural and historic contexts. Topics include level of aesthetic treatment, scale and proportion, structural systems, railings, and best practices for visually maintaining significant historic features.

- *Bridge Design Manual: Chapter 2*
(https://www.oregon.gov/ODOT/Bridge/Docs_BDDM/2018-05_BDM-02.pdf)
- *Visual Performance Standards: OTIA III Stage 2 through 5 Bridge Replacements and Repairs* (On file, Louis Berger, a WSP Company (WSP), Kansas City, Missouri. Available upon request, or available at Oregon DOT upon request.)

A technical proposal on *Preliminary Performance Plans and Design-Build Technical Solutions* for the *Pennsylvania Rapid Bridge Replacement Project* was prepared for **Pennsylvania** by PWKP, providing a preliminary management plan for the long-term bridge replacement and maintenance contract currently underway. This technical proposal identifies and briefly explains the development and use of an aesthetics master plan to provide five treatment levels/standard plans for bridge replacements. Bridges in historic

districts are mentioned as requiring specific treatment levels. In 2014, Pennsylvania DOT released the *Final Technical Provisions* for the Rapid Bridge Replacement Program. Section 4.4.5.9 of these provisions, entitled “Aesthetic Bridge Design in Historic Districts,” and Section 14 on CSD and aesthetics are of most relevance. A list of bridge replacements with their corresponding aesthetic treatment level is provided as an attachment (10-1) to the provisions. The table also specifies if the bridge is in a historic district.

- *Preliminary Performance Plans and Design-Build Technical Solutions, Pennsylvania Rapid Bridge Replacement Project*
(<https://www.penndot.gov/ProjectAndPrograms/p3forpa/Documents/Rapid%20Bridge%20Replacement%20Project/Preliminary%20Performance%20Plans.pdf>)
- *Rapid Bridge Replacement Program: Final Technical Provisions*
(<https://www.penndot.gov/ProjectAndPrograms/p3forpa/Documents/Rapid%20Bridge%20Replacement%20Project/Technical%20Provisions.pdf>)

In 1997, the **Vermont** DOT developed state design standards that direct designers to achieve designs that provide safe access and use and are also sensitive to the social and environmental context of Vermont. These standards are extremely useful when considering the design of a replacement bridge in a historic district. The standards describe varying transportation and community contexts in Vermont, including Large Towns and Cities, Small Towns and Villages, and Rural Corridors, commenting on the design considerations unique to each context. Special Design Guidelines (see Section 1.8) are listed for historic and archaeological resources, natural resources, and recreational resources and applied to the following transportation types: Freeways, Principal Arterial Roads and Streets, Minor Arterial Roads and Streets, Collector Roads and Streets, and Local Roads and Streets.

- *Vermont State Design Standards*
(<http://54.172.27.91/transportation/standards/VermontStateDesignStandards1997.pdf>)

HISTORIC PRESERVATION SOURCES

The SOI Standards provide practitioners with principles to ensure that replacement designs are compatible with the historic context and do not have an adverse effect on surrounding cultural resources.

- *The Secretary of the Interior’s Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitation, Restoring & Reconstructing Historic Buildings*
(<https://www.nps.gov/Tps/standards/treatment-guidelines-2017.pdf>)

Most historic bridge management plans and historic properties management plans focus on preservation and rehabilitation, without detailed attention given to complete replacement projects. However, a handful of plans were obtained that offer specific treatment recommendations for new bridge construction, most of which are found at the county or city levels.

Historic district design guidelines, also produced on a local level by certified local governments, historical commissions, and city and county DOTs, emerged as a useful source type contributing to the basic understanding of compatibility in specific settings, as well as occasionally presenting examples of successful designs for new structure construction or infill construction in the respective historic district.

The following historic properties management plans and district design guidelines contributed to the synthesis of design examples and strategies for the CSD of workhorse bridges in historic districts. On a project-by-project basis, it is recommended that transportation organizations carry out a search for local

historic properties management plans and district design guidelines that correspond to a similar historic context to their projects.

In 2007, the City of Minneapolis, Public Works Department produced the *Midtown Corridor Historic Bridge Study*, which provides a useful framework for evaluating bridge significance within a historic setting. The Chicago Milwaukee and St. Paul Railroad Grade Separation Historic District, although in an urban location, features 48 bridges crossing a railroad trench, creating a tunnel effect considered a character-defining feature of the district. The study further defines the historic district and identifies treatment options for each bridge in the district, some needing full replacement.

- *Midtown Corridor Historic Bridge Study*
(<http://midtowngreenway.org/files/mgc/ckfinder/files/MidtownCorridorHistoricBridgeStudy5-30-07.pdf>)

In 2013, the Milwaukee County and Wisconsin DOT developed a historic properties management plan for the Milwaukee County Parks and Parkways, which provides treatment recommendations for historic buildings, bridges, roads and trails, structures, and landscape features in the parkway system, including guidance for replacement of contributing and non-contributing bridges within the historic context.

- *Volume 2: Milwaukee County Parks and Parkways, Historic Properties Management Plan*
(<https://www.thc.texas.gov/public/upload/preserve/survey/highway/Milw%20Co%20Historic%20Properties%20Management%20Plan.pdf>)

In 2010, New Mexico DOT created design and maintenance guidelines for U.S. Roadway 380, an NHL in Lincoln. Specific guidelines are given regarding each aspect of the roadway, including buildings, structures, and objects. Two bridge examples are examined.

- *Design and Maintenance Guidelines: U.S. 380 Lincoln, New Mexico, National Historic Landmark*
(http://dot.state.nm.us/content/dam/nmdot/Infrastructure/EDS/US380_Design_Guide.pdf)

In 2015, the Town of Concord, Massachusetts, completed design guidelines for Concord's historic districts. The section on New Construction and Structures provides brief comments on making new designs compatible with the existing site and surroundings. Summaries of each historic district aid in the understanding of the district context prior to the list of design guidelines.

- *Historic District Design Guidelines*
(<https://concordma.gov/DocumentCenter/View/5806/Historic-Districts-Design-Guidelines---Amended-August-2015>)

In 2007 (updated in 2017), the Pennsylvania Wilds Center for Entrepreneurship developed the *PA Wilds Design Guide for Community Stewardship*, a complete guide to design concepts and principles to be followed for projects across the region. The Pennsylvania Wilds is a rural region of the state that covers 12.5 counties and 2.1 million acres of public land. Chapter 6 of the guide discusses context-sensitive transportation. A section dedicated to bridges offers some examples of design choices used. This source can serve as an example of a regional approach to CSD.

- *PA Wilds Design Guide*
(<http://www.pawildscenter.org/community-character-stewardship/>)

SECTION 2.3: STATE OF PRACTICE SURVEY

After completing the literature review, the project team sent out a screening survey to understand the current state of practice concerning replacement of workhorse bridges in rural historic districts and identify practitioners and case studies for further review. Using Google Forms, the screening survey questions were sent to each state DOT, as well as each SHPO and Deputy SHPO, and individual private consultants with potential experience with workhorse bridge replacement design (Appendix B).

To gather detailed information on the characterization of the CSD/S process for replacement bridge design in a rural historic district, an in-depth survey was sent to respondents of the screening survey whose answers confirmed experience with workhorse bridge replacement in a historic district. Some DOT and SHPO staff members, as well as some private consultants and individuals with previously documented experience, were sent the in-depth survey in lieu of the screening survey because their experience was already confirmed. See Appendix C for the list of in-depth survey questions.

SCREENING SURVEY RESULTS

Responses were received from 15 DOTs, one FHWA Division Office, and six SHPOs, a 29 percent response rate. In addition, four private sector contacts responded to the screening survey. One state had responses from both DOT and SHPO, and two states had responses from multiple staff within the agency (Table II-1). In total, 28 screening survey responses were received. The results of the screening survey were compiled into a matrix, provided in Appendix D.

TABLE II-1: TOTAL SCREENING SURVEY RESPONDENTS BY STATE AND AGENCY

STATE	SHPO RESPONSES	DOT RESPONSES	FHWA DIV. OFFICE RESPONSES	PRIVATE SECTOR
Alabama		1		
Arkansas		1		
California				1
Colorado		1		
Florida		1		1
Indiana		1		
Massachusetts		1		
Michigan		1		
Minnesota	1			1
Missouri		1		
Nevada			1	
Ohio		1		
Oregon		2		
Pennsylvania		2		1
Rhode Island	1			
South Carolina	1			
South Dakota	1	1		
Tennessee	1			
Texas		1		
Virginia		1		
West Virginia		1		
Wisconsin	1			
TOTAL	6	17	1	4

CSD/S for Replacement Workhorse Bridges in Rural or Urban Historic District

Screening survey contacts were asked if they have worked on a project involving the replacement of a workhorse bridge in a rural or urban historic district to identify which location (rural, urban, both, or none), and to provide any comments on the project referenced. Figure II-1 provides a demographic for the respondent pool. Seventy percent (19 out of 28 respondents) reported having experience in either rural historic districts or both rural and urban districts. Sixty percent of respondents reported use of some type of CSD/S process to reach a successful bridge design, either rural or urban (Figure II-2). In offering comments, nine respondents provided specific workhorse bridge replacement projects. Four states expressed not having examples of workhorse bridge replacements in historic districts or not having rural examples. The nine remaining respondents provided explanations regarding general experience and the use of CSD/S in typical replacement projects. The project examples provided were investigated for potential use as case studies (Table II-2).

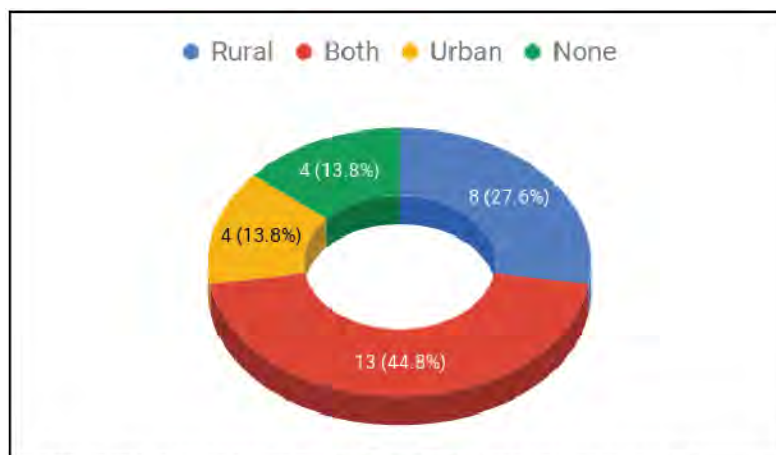


FIGURE II-1: Respondents with Workhorse Bridge Replacement Experience in Historic Districts

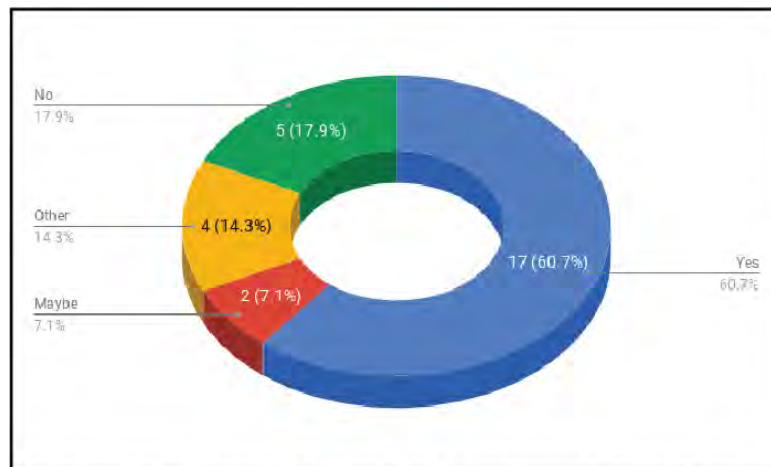


FIGURE II-2: Respondents that have used a CSD/S Process for Bridge Design in a Historic District

TABLE II-2. BRIDGE REPLACEMENT PROJECTS REFERRED TO IN SCREENING SURVEY

BRIDGE NAME	STATE (COUNTY)
Stinesville Road Bridge No. 12	Indiana (Monroe)
Lowell Canal Bridges (pending construction)	Massachusetts (Middlesex)
Bear Tavern Road and Jacobs Creek Road Bridges	New Jersey (Mercer)
Windham Street Bridge	Ohio (Portage)
Chenoweth Creek Bridge	Oregon (Wasco)
Geigel Hill Road Bridge	Pennsylvania (Bucks)
River Road Bridge	Pennsylvania (Bucks)
State Route 926 Bridge	Pennsylvania (Chester)
Willow Grove Avenue Bridge over SEPTA	Pennsylvania (Philadelphia)
York Street Bridges	South Carolina (Aiken)
Pine Street Bridge	South Dakota (Yankton)
Secretarys Sand Road Bridge No. 6092	Virginia (Albemarle)
Morgan’s Ford Bridge No. 6019	Virginia (Warren)
Scrabble Creek Bridge	West Virginia (Fayette)
Kinnickinnic River Parkway Bridge	Wisconsin (Milwaukee)
Saylesville Road Bridge	Wisconsin (Waukesha)

Specific explanations on the use of CSD/S were expressed through additional comments, quoted below.

- “We have used CSD and CSS. However, in every situation consultation pursuant to Section 106 of the National Historic Preservation Act or our State Historic Preservation Act has driven the decision-making process for aesthetic issues. In most situations, public input from stakeholders have been a primary consideration in these consultations.”
- “We obviously try to look to rehabilitation before replacement options, but when rehabilitation is not feasible we do work with the Department of Transportation and the Federal Highway Administration to try and ensure that any new bridge is visually in keeping with any historic district that it will be built in.”

Several respondents provided explanations for why a project was “successful.” One respondent stated a preference for rehabilitation before replacement, expressing that they do not have any completed examples of a replacement design. Some of the project examples are provided above in Table II-2. Additional project explanations are quoted below.

- “The successful project was a superstructure replacement in a downtown historic district. Several railing options for the replacement were produced by Michigan DOT landscape architects and engineers, vetted by the SHPO, and voted on by the local Historic District Commission (the public felt the Commission was the best choice to make the decision).”
- “The Rapid Bridge Replacement P3 project (558 bridges in 2014-2019) had an aesthetic design standard which was applied to all bridges. This standard is available from Pennsylvania DOT. Bridges in historic districts might have had other treatments depending on public involvement.”
- “Provide aesthetics that the local community has buy-in with and other features that provide connectivity for peds and bikes.”

- “Usually the CSD is limited to treatment on the parapets and is after the basic design is completed. Occasionally, where there is strong public involvement, we will do form liners on the abutments and piers. As to whether they are “successful” it depends upon who you ask. In general, the historic preservation “community”--which would include our SHPO and our Cultural Resource Professional staff--are not satisfied with the treatments, particularly the use of form liners as they rarely turn out well.”

Design Reference Materials

Lastly, screening survey respondents were asked to identify which design reference materials they have used as a guide or approach to historic bridge replacement projects. The SOI Standards, AASHTO (2017) Guidelines (i.e., *LRFD Bridge Design Specifications and Aesthetics Sourcebook*), and state DOT CSD/S guides and manuals are reported as the three design materials most commonly utilized (Figure II-3).

The following additional sources for guidance on design were recommended by respondents.

- Guidance/consultation with state historical personnel and SHPO staff
- Consultation with bridge design and landscape architect staff
- Community input via the Section 106 Process
- Historic bridge manuals and management plans
- Historic properties management plans

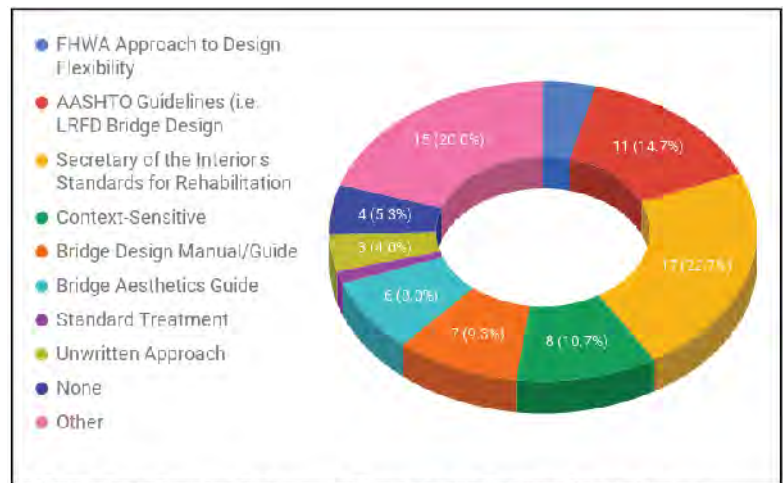


FIGURE II-3: Design Reference Materials Utilized to Guide Historic Bridge Replacement Projects

IN-DEPTH SURVEY RESULTS

Using Google Forms, the in-depth survey was sent to the 24 respondents of the screening survey whose answers confirmed experience with workhorse bridge replacement in a historic district. Some DOT and SHPO staff members, as well as some private consultants and individuals with previously documented experience, were sent the in-depth survey in lieu of the screening survey because their experience was already confirmed. A Microsoft Word version of the survey was made available upon request for those without access to Google Forms.

Nine responses were received from nine of 24 states (eight DOTs and one SHPO), a 37 percent response rate (Table II-3). In addition, two private sector contacts responded to the survey. Four of the 11 respondents had completed the screening survey beforehand, resulting in seven new screening survey responses gathered via the in-depth survey. The results of the in-depth survey were compiled into a matrix, provided in Appendix E.

TABLE II-3: IN-DEPTH SURVEY RESPONDENTS BY STATE AND AGENCY

STATE	SHPO RESPONSES	DOT RESPONSES	FHWA Div. Office RESPONSES	PRIVATE SECTOR
Colorado		1		
Florida		1		1
Indiana		1		
Massachusetts		1		
Michigan		1		
Ohio		1		
Oregon		1		
Pennsylvania				1
South Carolina	1			
Virginia		1		
TOTAL	1	8	0	2

The in-depth survey began with an option to complete the screening survey if not already completed, followed by three sections of questions regarding project approach, design, public outreach, bridge costs, and obstacles.

Design Guidance

None of the respondents reported having developed standard designs for replacement workhorse bridges in rural historic districts. Based on background research, however, it is known that Nevada, Michigan, and Oregon have developed standard railing designs for use in historic settings, and Pennsylvania’s RBRP has implemented standard, CSDs for workhorse bridges, applicable to historic settings. Despite the majority of respondents not having developed standard designs, most appear individually to consistently use identified enhancements to achieve successful designs in their respective states. Only one state reported that it had completed enough CSD/S replacement bridges to have commonly implemented enhancements.

Railings, form liners, scale, and abutments were reported as the most commonly used bridge enhancements or design elements for replacement bridges in historic districts (Table II-4).

Four respondents commented on specific design trends and aesthetic features they feel contributed to the success of a replacement project, quoted below.

- “Crash worthy railing on the deck with true openings and architectural ornamentation.”
- “Much depends upon the setting of the bridge; both its historic setting as well as the built nature of its surrounding environment. The most common features of importance are the scale (as appropriate to the historic district) and the rails.”
- “Community involvement on decisions and having realistic choices to present. Often design exceptions for width are the most desired.”

TABLE II-4: COMMONLY USED BRIDGE ENHANCEMENTS OR DESIGN GUIDELINES FOR REPLACEMENT DESIGNS

State	What bridge enhancements or design guidelines does your organization commonly use in replacement designs for workhorse bridges in historic districts?												
	Scale	Shape	Abutments	Piers	Railings	Columns	Form Liners	Color	Texture	Applied ornamentation	Arches	Lighting	Other
Colorado					X		X	X					
Florida (Private Sector)		X	X	X			X	X	X			X	
Florida (DOT)	X	X			X				X			X	X
Indiana			X	X	X	X	X					X	
Massachusetts	X		X	X	X					X			
Michigan					X		X	X	X				
Ohio			X	X									
Oregon	X	X			X		X				X		
Pennsylvania	X				X		X						X
South Carolina	X		X		X					X			

Understanding the Historic Context

To ensure that a bridge design is compatible with its historic setting, agencies must develop an understanding of the historic context of the existing bridge. Period of construction, bridge technology, bridge function, surrounding land use, and character-defining features of the bridge may contribute to the historic context and should be considered in the new design. Developing that understanding can be difficult and should be initiated early in the design process. Figure II-4 shows that respondents use both a process of evaluation of the context/environment as well as seek public input to define the historic context. Three respondents also reported using GIS to aid in their understanding.

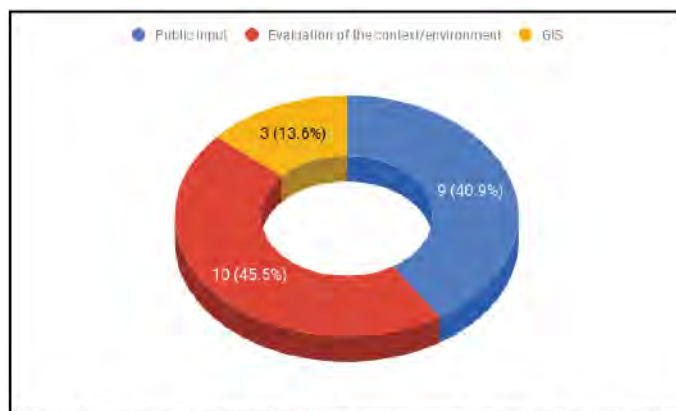


FIGURE II-4: Process(es) to Define or Understand the Historic Context of a Bridge

Other processes reported as aids to understanding the historic context of a bridge include:

- Consultation and coordination with DOT and SHPO staff historians
- A review of previous research pertaining to the project bridge
- A review of established historic bridge contexts, such as *A Context for Common Bridge Types* (PB and EIH 2005).

The timing of this research and evaluation of the historic context may influence the success of the design. Figure II-5 identifies the stages of design development during which responding agencies typically consider the historic context of the bridge.

Current practices appear first to consider the historic context of a bridge during preliminary design with continued consideration throughout the design process. The preliminary design stage was cited by eight of 11 respondents as a common period for evaluation, with four of those eight beginning the process during NEPA and inter-agency consultations. Only one respondent reported context evaluation earlier, during project programming. Other respondents noted that the period for context evaluation can depend on the specific bridge and the setting. Five of 11 respondents reported consideration during three or more development stages, indicating that consideration throughout the development process may be helpful in making design choices at the later stages.

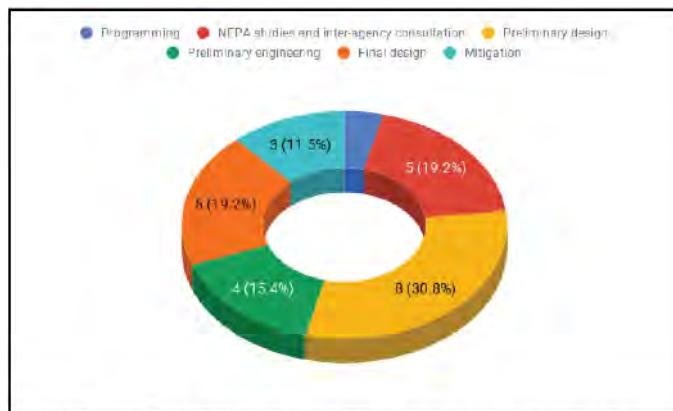


FIGURE II-5: Points of Consideration for the Historic Context During Design Development

Bridge Types and Standard Treatment Plans and Approaches

Most respondents reported not utilizing any standard treatment or approach when considering workhorse bridges in historic districts, indicating that there is little guidance available on the treatment of bridges to be replaced in historic settings. Three out of 11 respondents reported the use of standard treatment plans and approaches (Figure II-6), with the majority highlighting principles of CSD/S as the underlying control. One state commented that prior to removal, the bridge is marketed for reuse. The practice of marketing a historic bridge for reuse or relocation was solidified under the Surface Transportation and Uniform Relocation Assistance Act of 1987, which requires states to make a historic bridge available for donation to a state, locality, or private entity if its demolition is proposed by use of federal funds. Many states have adopted this practice in state historic bridge management plans. Two other states emphasized CSD/S policies established within the DOT, such as a Complete Streets Standard. One state reported a standard treatment plan implemented in a Programmatic Agreement between the DOT and SHPO.

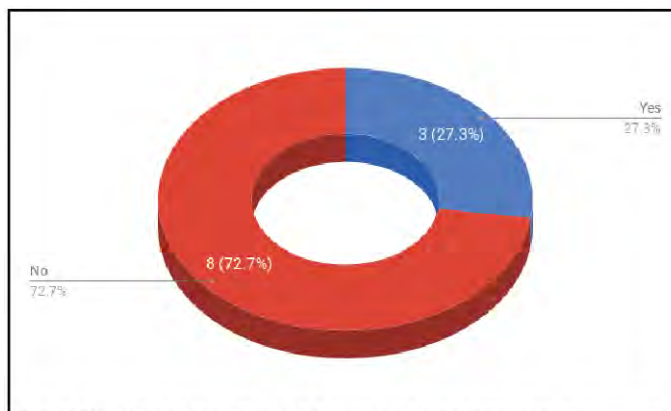


FIGURE II-6: Number of Agencies that Employ a Standard Treatment Plan/Approach

Respondents noted that on the occasion that the replacement resulted in a replica, the following factors played a role.

- Often the residents of the historic district are more supportive of mimicking. The most contentious issues are elevation of the new bridge and railings designs. Normally, it is easier to avoid mimicking the old bridge on larger structures than on the small structures that are immediate to the historic district.
- Replacement bridge was perceived by local stakeholders as very similar to the earlier truss that was replaced (although it was not an exact replica and would be recognized as a modern truss to those familiar with engineering designs).

In addition, one respondent clarified that a common practice of the state is to replicate only “key portions of the bridge, e.g. the bridge rail, etc.” rather than the entire bridge.

Cost Considerations

Only one respondent reported having cost comparison models for historic bridge replacements in relation to standard construction costs. One other respondent reported developing cost comparisons on a project-by-project basis.

Common Obstacles/Concerns

Designer/engineer perception of historic bridges and principles of CSD was the top concern of respondents, as quoted below:

- “Securing buy-in from engineers on outside-the-box CSD ideas”
- “Cost and designer perception, i.e., designer doesn’t think it’s that historical-what’s the big deal?”
- “Overly conservative bridge engineers for interior barrier treatment”

Design-focused obstacles and concerns were as follows:

- “Making sure that the railing passes the design exception process.”
- “The need for widening the bridges is frequently the most problematic issue.”
- “Over reliance on stone- or brick-look form liners to solve everything.”

Additional obstacles included the following.

- “The difficulty of satisfying the local property owners”
- “Understanding the history of the previous bridge”
- “Developing the design for an appropriate replacement crossing a historic canal”
- “[CSD/S] Requires ingenuity and design aptitude”
- “Inter-agency collaboration – Obstacles were overcome by working with City, Historic District Commission, engineering staff, and the SHPO”

The following solutions, steps, training, and processes were suggested as aids in overcoming the previously mentioned obstacles and concerns.

- DOT:
 - CSD/S training for engineers
 - Regular meetings
 - Online guides with successful examples
 - Bridge aesthetics classes for design engineers
 - Mining the Proposed AASHTO Guide Specifications for Historic Bridge Preservation for ideas for workhorse bridges in historic districts
 - Knowing AASHTO Guidelines for Historic Bridge Decision Making and Green Book for flexibility for low volume roads
 - Understanding the purpose and nature of consultation under Section 106
 - Crash data on recessed or holed interior bridge barriers
- SHPO:
 - On SHPO's part, the basic dynamics structures must meet in order to function for their intended purposes and the impacts of particular design options as related to bridge safety and function concerns
 - "Inter-agency collaboration – Obstacles were overcome by working with City, Historic District Commission, engineering staff, and the SHPO"
- Public:
 - Understanding the integration of design standards for safety and service purposes of the structure for their transportation purposes
 - Education

Working with Stakeholders

In-depth survey respondents were asked to comment on processes for stakeholder engagement as part of the CSD/S approach.

Effective Public Outreach Strategies

- For environmental considerations:
 - Host public meetings
 - Hold workshops
 - Reach out to the local community as early as possible after scoping
- For cultural resource considerations:
 - Use 3D PDF of Microstation drawings showing the proposed bridge
 - Use 3D printing of reduced size copies of proposed bridge railings to present to the public
 - Share NRHP significance of the bridge with stakeholders and the local historical society
 - Hold workshops
 - Form a Cultural Resources Coordinating Committee to steer the project through Section 106
 - Request public input for replacement options (or Historic District Commission)
 - Conduct early outreach for inter-agency coordination
- Bring samples of proposed bridge to public meetings
- Consider for design purposes
 - Host public meetings
 - Use 3D Microstation drawings showing the proposed bridge
 - Use 3D printing of reduced size copies of proposed bridge railings to present to the public
 - Hold workshops

- Identify the parties who would be most interested in the proposed action, including preservation community, officials, scientific community
- Involve the Historic District Commission and potentially allow it to vote on proposed design options

Effective Inter-agency/Interdisciplinary Strategies:

- Public Meetings
- Make sure the seven aspects of integrity mesh with the design engineers' 13 controlling design criteria for roadways
- DOT cultural resource staff and structural engineering staff together evaluate prudent and feasible alternatives to determine whether the historic bridge can remain in place while maintaining or enhancing safety and maintaining integrity
- When necessary, workshops
- When necessary, vetting railing options with SHPO before getting public comment
- Establish an "Advisory Team" to assist FHWA and DOT in developing project design details to implement the measures stipulated in a Memorandum of Agreement
- Maintain a good working relationship with SHPO

Working with Cultural Groups

Respondents were asked whether they have experience working with specific cultural groups and to explain their experience. Two respondents reported they worked with tribes in connection with workhorse bridge replacement projects. Two other respondents described their work with cultural groups:

- "Every town and city in Massachusetts has a Local Historical Commission, and many have Historic District Commissions tasked with project review within historic districts. MassDOT reaches out to both LHCs and HDCs for comments and input on project design."
- "The Historic Columbia River Highway (HCRH) Advisory Committee (AC) has advised the Oregon Department of Transportation (ODOT) and the Oregon Parks and Recreation Department (OPRD) since 1987 on all matters concerning the HCRH. The AC is made up of six private citizens, half appointed by the governor and half appointed by county commissions, and four agency representatives (ODOT, OPRD, the Oregon SHPO, and Travel Oregon). They consulted with the design team in developing the Chenoweth Creek Bridge replacement and for many years on other projects that involved historic bridges along the HCRH."

CONCLUSION

The conclusions outlined below are based on the information gathered from states through literature review, screening/in-depth surveys, and interviews with agencies and practitioners. Although based on a limited number of interviews and survey responses, the information below provides a wide range of scenarios and design options for workhorse bridges in rural historic districts.

CSD for bridges in rural historic districts is a particular challenge not only because of the limited built environment available to supply design context but also because of the complex and sometimes conflicting relationship between the CSD/S process and the NRHP Criteria and SOI Standards. The straightforward construction of workhorse bridges results in few obvious character-defining features to draw from for design inspiration. CSD/S practitioners may turn to the historic district and surroundings for context, which may or may not be relevant to the bridge's significance individually or as a contributing structure to the district. Stakeholders may also influence the bridge's design; community preferences may be based on ideas about aesthetics that do not accurately reflect the history of the bridge or reflect its workhorse heritage.

A review of CSD/S and bridge design sources revealed several CSD/S guides/manuals, bridge design and aesthetic guides/manuals, and historic properties management plans and design guidelines that provided some guidance on the subject. Guidance for bridge design in a sensitive historic context was found in well-developed CSD/S manuals and most frequently in guidance for state byways because they offer specific settings, often historic, on which to base design decisions. The *NCHRP Web-Only Document 189: Design and Management of Historic Roads* was cited in particular by practitioners as a useful source for the design of replacement bridges in rural historic districts. AASHTO's *Bridge Aesthetics Sourcebook* was cited as another source of detailed discussion on the design of bridges in a historic district. State DOTs, particularly in New Jersey, Indiana, Minnesota, Maryland, Nevada, and Oregon, have developed their own bridge design and bridge aesthetics manuals and guides that referenced specific guidelines for historic bridge replacements.

Review of historic bridge replacement projects, the state of practice survey, and subsequent interviews with DOTs, agencies, and practitioners revealed the following five general approaches to CSD/S.

- **Regional** approach – draws influence from regional bridge styles as well as from a desire to create a modern, regional tradition.
- **Replication** approach – is straightforward, replacing a bridge with a replica design.
- **Previous Bridges** approach – draws design influence from previous iterations of the existing bridge.
- **Stakeholder-Driven** approach – is centered on the public involvement process and uses stakeholder input as a driving factor in proposed design elements.
- **Design/Safety-Driven** approach – stems from the necessity of a replacement design to address engineering design and safety issues of the existing bridge.

These approaches evolved naturally from the specific circumstance of each bridge studied, its context, the attitudes/interest of the public, and the design requirements of the new structure. Although each bridge replacement is unique, review of existing project examples indicates that most projects will follow one of these five approaches. Understanding these approaches may assist practitioners in guiding stakeholders and other interested parties through the CSD/S design process to a successful outcome.

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APPENDIX A: CSD/S PRINCIPLES AND OUTCOMES

The most recent definition, characteristics, and outcomes of CSD/S, as published by FHWA, are provided below. Text is taken directly from the FHWA webpage “Context Sensitive Solutions and Design” (https://www.fhwa.dot.gov/planning/css/what_is_css/).

Definition of CSD

“Context Sensitive Design (CSD) is design process that not only considers physical aspects or standard specifications of a transportation facility, but also the economic, social, and environmental resources in the community being served by that facility.”

Definition of CSS

“Context Sensitive Solutions is a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions.”

Characteristics of CSS

- Communication with all stakeholders is open, respectful, honest, early, continuous, and is tailored to the context and phase.
- Establishes an interdisciplinary team early, including a full range of stakeholders, with skills based on the needs of the transportation activity.
- The landscape, community livability, valued resources, ecology, and construction issues are researched and understood before engineering design is started.
- There is a clearly defined decision-making process.
- Project teams track and honor commitments through lifecycle of the project.
- Full range of stakeholders and transportation officials are involved in identifying issues.
- Project purpose is clearly defined consensus is sought on the shared stakeholder vision and scope of projects and activities, while incorporating transportation, community, and environmental elements.
- There is commitment to the process from top agency officials and local leaders.
- Process involves multiple alternatives, resulting in a full examination of a range of possible solutions and agreement on the best path forward.
- Agency and stakeholder participants monitor how well the process is working and improve it as needed.
- Participants encourage mutually supportive transportation and land use decisions and consider the needs of a variety of transportation modes.
- Full range of communication and visualization tools are used to engage stakeholders.

Characteristics of the CSS Products or Design

- The project is in harmony with the community, and it preserves the environmental, scenic, aesthetic, historic, and natural resource values of the area.
- The project is a safe facility for all users and the community.
- The project solves problems, and satisfies the purpose and needs identified by a full range of stakeholders.

- The project exceeds the expectations of both designers and stakeholders, and is perceived as adding lasting value to the community as a whole.
- The project involves efficient and effective use of resources (time and budget) of all involved stakeholders.

APPENDIX B: SCREENING SURVEY

Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?

- Rural Both
 Urban None

Please provide any comments on the project referenced if applicable: _____

Has your organization used any type of CSD or CSS process to reach a successful bridge design solution in a historic district, either rural or urban?

- Yes Maybe
 No Other

Provide any examples of successful bridge replacements in a rural or urban historic district.

What design reference materials, if any, has your organization utilized as a guide or approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials, if applicable)

- FHWA Approach to Design Flexibility
 AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)
 Secretary of the Interior's Standards for Rehabilitation (SOI Standards)
 CSD/S Manual/Guide: _____
 Bridge Design Manual/Guide: _____
 Bridge Aesthetics Guide: _____
 Standard Treatment Plans/Approaches _____
 Unwritten Approach: _____
 Other: _____
 None

Would you be willing to provide a copy of reference materials to the research team?

- Yes
 No

If you are willing to share your materials, please contact Camilla McDonald at cmcdonald@louisberger.com.

Do you have any contacts for professionals and/or practitioners with experience in the CSD/S of workhorse bridges in rural or urban historic districts? (For example, district engineers, consultants, state DOT staff, FHWA staff, historic architects, SHPO staff, county engineers, city engineers, federal/state/local parks staff, city and county road commissions, historic bridge specialists)

If so, please provide name and contact information here: _____

APPENDIX C: IN-DEPTH SURVEY QUESTIONS

Project Approach (the following questions ask about your approach to a replacement bridge project):

What process(es) do you follow to define and/or understand the historic context of a bridge?

- Public input
- Evaluation of the context/environment
- GIS
- Other _____

At what point in the project development process do you consider the historic context of the existing bridge in design of the replacement bridge?

- Programming
- NEPA studies and inter-agency consultation
- Preliminary design
- Preliminary engineering
- Final design
- Mitigation
- Other _____

Besides safety and current design requirements, which of the following project areas is of most concern to you or your organization regarding the replacement of workhorse bridges?

- Environment
- Cultural resources
- Cost
- Design (e.g., enhancement opportunities)
- Other _____

What resources would be most helpful in making a CSD/CSS approach to workhorse bridge replacement in historic districts more practicable?

Design (the following questions center on the bridge design):

Does your organization employ any standard treatment plans/approaches when considering workhorse bridges in rural or urban historic districts?

- Yes
- No

(if yes, please describe, here: _____)

Has the replacement of a workhorse bridge in a historic district ever resulted in a replica of the existing or previous historic bridge?

- Yes
- No
- Maybe

(if yes, please describe, here: _____)

Is there a bridge type that is most often used as a replacement of a workhorse bridge?

- Yes
- No
- Other _____

(if yes, please describe, here: _____)

What bridge enhancements or design guidelines does your organization commonly use in replacement designs for workhorse bridges in historic districts?

- Scale
- Shape
- Abutments
- Piers
- Railings
- Columns
- Form Liners
- Color
- Texture
- Applied Ornamentation
- Arches
- Lighting
- Other _____

What specific design trends/aesthetics/other features do you believe made the project successful?

Has your organization developed any standard designs for replacement of workhorse bridges in rural historic districts?

- Yes
- No
- Maybe
- Other _____

Other Considerations (public outreach, bridge costs and obstacles):

Do you have guides/models on how much historic bridge replacements may cost over standard construction costs?

- Yes
- No
- Maybe
- Other _____

What are the two greatest obstacles that you had to overcome in developing plans for a replacement bridge?

What steps, training, and processes would help you in overcoming these obstacles?

What were the most effective public outreach strategies used for environmental considerations?

What were the most effective public outreach strategies used for cultural resource considerations?

What were the most effective public outreach strategies used for design considerations?

What type of inter-agency/interdisciplinary strategies were most effective for your project?

How did your agency ensure a shared stakeholder vision?

- Public Meetings
- Inter-agency Coordination
- Direct Mail
- Web Postings/Webinars
- Other _____

Do you have any CSD/S experience with specific cultural groups for bridge replacement designs in historic districts?

- Yes
- No
- Maybe

Please Explain: _____

APPENDIX D: SCREENING SURVEY RESULTS MATRIX

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)										
	Rural	Urban	Both	None	Comments	Yes	No	Maybe	Other		FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments
Private Sector	X				Bear Tavern Road Bridges Project	X				Relocation of historic 1880s iron truss for ped use, interpretive displays, stone façade on bridges and walls, stone façades, obelisks, historic plaques and interpretive displays, planned dismantling of historic truss, relocation of historic 1880s iron truss components as pedestrian bridge, coordination with local residents. Review of historical documents and facts about the area. Artifact search before construction. Project site very close to WSP Office.	X	X		X	X					
Massachusetts DOT			X			X				Lowell, MA TIGER Grant Bridges One bridge in Newberry, SC, over railroad line, that impacted a NRHP-listed residential historic district. I'm not sure if it has been constructed yet or not. Another bridge in Aiken, SC, also over a railroad cut (itself eligible for the NRHP) and in or adjacent to a listed historic district. Again, not certain if the bridge has been constructed. Aiken, SC York Street Bridge(s) Replacement, Broad River (Hwy 176) Bridge Replacement, Columbia, SC		X	X							Massachusetts Highway Department Project Development and Design Guide
South Carolina SHPO								X		The Chenoweth Creek Bridge replacement project in an NHL historic district			X							NCHRP 25-29A Web-Only 189: Design and Management of Historic Roads.
Oregon DOT	X				The Chenoweth Creek Bridge replacement project	X					X									

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)											
	Rural	Urban	Both	None	Comments	Yes	No	Maybe		Other	FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments	
Ohio DOT			X		Miami County Fairview Snodgrass Road Colorado doesn't have too many rural or urban historic districts and not many bridges in the ones we have. Generally, we are dealing with historical bridges rather than bridges within historical districts.	X														Ohio DOT Historic Bridge Maintenance and Preservation Guidelines	
Colorado DOT	X				We have replaced or rehabilitated small, common bridge types within and near historic districts which either contributed to or the replacement of could impact historic districts as well as individually eligible historic properties.								X							Generally, use guidance by state historical personnel & SHPO for individual projects	
Florida DOT			X																X		For design aesthetics the primary driver has been community input via the Section 106 process in order to avoid adverse effects on historic districts.

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)										
	Rural	Urban	Both	None	Comments	Yes	No	Maybe		Other	FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments
Michigan DOT	X				Michigan DOT has replaced bridges in historic districts, but most of them have not fallen into the "workhorse" category. The sole example that comes to mind was a simple concrete T-beam bridge in a downtown historic district.	X				The successful project was a superstructure replacement in a downtown historic district. Several railing options for the replacement were produced by Michigan DOT landscape architects and engineers, vetted by the SHPO, and voted on by the local Historic District Commission (the public felt the Commission was the best choice to make the decision). Monroe County Bridge #12 - adjacent the Stinesville Historic District, Stinesville, Monroe County, Indiana; US 27 Bridge over Spy Run Creek adjacent the Brookview-Irvington Park Historic District, Fort Wayne, Allen County, Indiana.		X				X				The standard plans are for various railing options that have been developed over the years. Meetings with SHPO, bridge design, and landscape architect staff. Came up with several appropriate replacement railing options for the community to consider.
Indiana DOT	X				No rural examples. One urban and one small town example.	X						X								

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)										
	Rural	Urban	Both	None	Comments	Yes	No	Maybe	Other		FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments
Private Sector		X			Working for Pennsylvania DOT, we replaced hundreds of workhorse bridges in a wide range of settings	X				The Rapid Bridge Replacement P3 project (558 bridges in 2014-2019) had an aesthetic design standard which was applied to all bridges. This standard is available from Pennsylvania DOT. Bridges in historic districts might have had other treatments depending on public involvement.				X						
Private Sector			X		Professionally I have worked on workhorse bridges in urban areas and the firm I work for has a large rail design section and certain others have worked on rural bridges based on the law of averages	X				All of my projects dating back 25 years have used CSD. Some of the most noteworthy are Hoover Dam, Lowry Avenue, and San Francisco Oakland Bay Bridge.	X	X	X	X	X					
FHWA, Nevada			X		Both projects went very well and had a lot of public involvement	X				Provide aesthetics that the local community has buy-in with and other features that provide connectivity for peds and bikes				X						
Minnesota SHPO	X					X						X								

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)																	
	Rural	Urban	Both	None	Comments	Yes	No	Maybe		Other	FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments							
Rhode Island SHPO	X				We have actually been able to rehabilitate a couple of our "workhorse" bridges in historic districts. The Albion and Albion Trench bridge (though not girder bridges) were truss bridges that had I-beams inserted to strengthen them and carry the load that needed to be carried, but the change was not visible to the NR Listed Albion Historic District.				We obviously try to look to rehabilitation before replacement options, but when rehabilitation is not feasible we do work with the Department of Transportation and the Federal Highway Administration to try and ensure that any new bridge is visually in keeping with any historic district that it will be built in.										X						I cannot speak to what sources the DOT or their consultants might try to use, only what I use on my end here are the SHPO		
South Dakota DOT				X			X																				
Tennessee SHPO			X				X																				Work with DOT

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)										
	Rural	Urban	Both	None	Comments	Yes	No	Maybe	Other		FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments
Private Sector			X			X				Talesin historic district bridge replacement, Saylesville WI rural historic district, Milwaukee County parkways historic district, various historic main streets in WI	X		X	X						https://www.dot.state.mn.us/historicbridges/bridge/greenway/midtown-corridor-mgmt-plan.pdf; https://www.thc.texas.gov/public/upload/preserve/survey/highway/Milw%20Co%20Historic%20Properties%20Management%20Plan.pdf
South Dakota SHPO					Although our state has many workhorse bridges, we do not have any that are in rural districts. Most were surveyed individually as part of a statewide bridge survey or during a project-specific 106 survey.			X		It is not an example of a workhorse bridge being replaced, but the Pine Street Bridge in Yankton, SD was replaced with a bridge that referenced the old concrete arch design.										
Alabama DOT				X			X											X		
West Virginia DOT	X				Small bridge replacement in historic district.	X				Scrabble Creek Bridge			X							

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?				Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?				Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)												
	Rural	Urban	Both	None	Comments	Yes	No	Maybe	Other		FHWA Approach to Design Flexibility	AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)	Secretary of the Interior's Standards for Rehabilitation	Context-Sensitive Design/Solutions (CSD/S) Manual/Guide	Bridge Design Manual/Guide	Bridge Aesthetics Guide	Standard Treatment Plans/Approaches	Unwritten Approach	None	Other/Comments		
Wisconsin SHPO				X	We (WI SHPO) couldn't find any "workhorse bridge" replacements that were specifically in historic districts. The project that comes to mind for a rural district was the Chenoweth Bridge replacement on the Historic Columbia River Highway. https://goo.gl/maps/6VEWwcRQL4A2 For urban, MLK viaduct. https://goo.gl/maps/v25efLBbM1K2 Over river, not viewable on top, but used masonry abutments and images on the edge of the slabs to reflect the history of the area and fit the canyon setting, bridge built in 1979. https://goo.gl/maps/CPfsnfcwf2P2				WI has been applying these same principles through the parts of Section 106 (PAs, MOAs, and consultation).				X									
Oregon DOT			X						Depend on the size of the project. For OBDP program, there is corridor guideline. See attached.	Chenoweth was definitely successful. The new bridge significantly improves safety, while also using a bridge rail design that resembles the historic rails elsewhere on the highway.	X	X	X	X	X						Oregon DOT BDM, AASHTO Publication	
Pennsylvania DOT			X			X				Philadelphia; Willow Grove Avenue over SEPTA; Bucks Co., River Road over Tohickon Creek; Chester Co., SR 926 over Brandywine Creek; Bucks Co., Geigel Hill Road over Tohickon Creek	X	X			X						Pennsylvania DOT Design Manual 4	

Agency	Have you or your organization worked on a project that involves the replacement of a workhorse bridge in either a rural or urban historic district?	Has your organization used any type of Context-Sensitive Design (CSD) or Context-Sensitive Solutions (CSS) process to reach a successful bridge design solution in a historic district, either rural or urban?	Provide any examples of successful bridge replacements in a rural or urban historic district.	What design reference materials, if any, has your organization utilized as a guide/approach to historic bridge replacement projects? (Select all that apply and please provide the title of materials in next question)
Missouri DOT	Rural	X	<p>Steel girder bridge replacements in a rural linear district eligible under criteria A for recreational significance (auto tourism), the replacement bridges were designed with railings that did not obstruct views from the bridge of the waterway and kept the driver experience similar to what it had been prior to the replacements.</p>	FHWA Approach to Design Flexibility
	Urban			AASHTO Guidelines (i.e., LRFD Bridge Design Specifications)
	Both			Secretary of the Interior's Standards for Rehabilitation
	None			Context-Sensitive Design/Solutions (CSD/S) Manual/Guide
				Bridge Design Manual/Guide
		Other	<p>The previous example was one; another example is bridge replacement in the Three Bridges Historic District--a concrete open-spandrel arch rail bridge was replaced (not a workhorse bridge) with a steel girder bridge, but the girders were haunched, the piers were given aesthetic treatments and the bridge railings were not the standard 16" concrete barrier rail to improve driver experience.</p>	Bridge Design Specifications
	Maybe			Secretary of the Interior's Standards for Rehabilitation
	No			Context-Sensitive Design/Solutions (CSD/S) Manual/Guide
	Yes			Bridge Design Manual/Guide
	Other			Bridge Aesthetics Guide
				Standard Treatment Plans/Approaches
				Unwritten Approach
				None
				Other/Comments

APPENDIX E: IN-DEPTH SURVEY RESULTS MATRIX

Project Approach

Agency	What process(es) do you follow to define and/or understand the historic context of a bridge?				At what point in the project development process do you consider the historic context of the existing bridge in design of the replacement bridge?							Besides safety and current design requirements, which of the following project areas is of the most concern to you or your organization regarding the replacement of historic workhorse bridges?					What resources would be most helpful to making a CSD/CSS approach to workhorse bridge replacement in historic district more practicable?	
	Public Input	Evaluation of the context/environment	GIS	Other	Programming	NEPA studies and inter-agency consultation	Preliminary design	Preliminary engineering	Final design	Mitigation	Other	Environment	Cultural Resources	Cost	Design (e.g. enhancement opportunities)	Other		
Private Sector	X					X	X	X	X			X	X	X			Unknown	
Massachusetts DOT		X				X												
South Carolina SHPO	X	X	X			X		X	X	X			X					
Oregon DOT		X				X	X	X	X				X				Guidance from NCHRP 25-25/Task 118	
Ohio DOT	X	X								X			X				4(f), design flexibility for low ADT, truck detour feasibility	management plans that outline options for site-specific needs and alternatives
Colorado DOT	X	X		DOT & SHPO historians research		X			X				X				case studies, examples of successful projects	

Agency	What process(es) do you follow to define and/or understand the historic context of a bridge?				At what point in the project development process do you consider the historic context of the existing bridge in design of the replacement bridge?							Besides safety and current design requirements, which of the following project areas is of the most concern to you or your organization regarding the replacement of historic workhorse bridges?					What resources would be most helpful to making a CSD/CSS approach to workhorse bridge replacement in historic district more practicable?
	Public Input	Evaluation of the context/environment	GIS	Other	Programming	NEPA studies and inter-agency consultation	Preliminary design	Preliminary engineering	Final design	Mitigation	Other	Environment	Cultural Resources	Cost	Design (e.g. enhancement opportunities)	Other	
Florida DOT	X	X		"A Context for Common Historic Bridge Types"		X	X	X	X	X	Normally, the primary decisions are laid out in our Section 106 Agreement Documents or they are contained as project commitments	X	X	X		Public input	Most of these bridges are important at the local level and in their particular contexts. Even when the bridge is located in an NHL district, the design aesthetics have to be sensitive to local sentiments. Structural requirements regarding bridge purpose and design standards have to be met regardless.
Michigan DOT	X	X	X	Consultation and Coordination with SHPO staff.	X		X					X	X	X		Public input and SHPO input are also important.	
Indiana DOT	X	X	X			X											
Virginia DOT	X	X		Previous research and current project research, as needed							It depends on the specific area and bridge, but generally pretty early in the project development process					Again, it depends on the specific area and bridge--all of these issues are given strong consideration	Stakeholders who have better educated themselves on bridge types/history, and who are less intent on "pretty" structures.
Private Sector	X	X		input from SHPO			X						X		Public involvement	Barrier testing data for various types of CSS barriers	

Agency	Does your organization employ any Standard Treatment Plans/Approaches when considering workhorse bridges in rural or urban historic districts?	Has the replacement of a workhorse bridge in a historic district ever resulted in a replica of the existing or previous historic bridge?	Is there a bridge type that is most often used as a replacement of a workhorse bridge?	What bridge enhancements or design guidelines does your organization commonly use in replacement designs for workhorse bridges in historic districts?	What specific design trends/aesthetics/other features do you believe made the project successful?	Has your organization developed any standard designs for replacement of workhorse bridges in rural historic districts?																																																				
Colorado DOT	<table border="1"> <tr> <td data-bbox="560 2660 903 2713">Yes</td> <td data-bbox="560 2365 903 2660">If "Yes" please describe here:</td> </tr> <tr> <td data-bbox="560 2604 903 2660">No</td> <td data-bbox="560 2604 903 2660"></td> </tr> <tr> <td data-bbox="560 2548 903 2604">Yes</td> <td data-bbox="560 2548 903 2604"></td> </tr> <tr> <td data-bbox="560 2461 903 2548">No</td> <td data-bbox="560 2461 903 2548"></td> </tr> <tr> <td data-bbox="560 2365 903 2461">Maybe</td> <td data-bbox="560 2365 903 2461">If "Yes" please describe here:</td> </tr> </table>	Yes	If "Yes" please describe here:	No		Yes		No		Maybe	If "Yes" please describe here:	<table border="1"> <tr> <td data-bbox="560 1951 903 2365">Yes</td> <td data-bbox="560 1951 903 2365">If "Yes" please describe here:</td> </tr> <tr> <td data-bbox="560 1833 903 1951">No</td> <td data-bbox="560 1833 903 1951"></td> </tr> <tr> <td data-bbox="560 1777 903 1833">Yes</td> <td data-bbox="560 1777 903 1833"></td> </tr> <tr> <td data-bbox="560 1690 903 1777">No</td> <td data-bbox="560 1690 903 1777"></td> </tr> <tr> <td data-bbox="560 1634 903 1690">Other</td> <td data-bbox="560 1634 903 1690"></td> </tr> </table>	Yes	If "Yes" please describe here:	No		Yes		No		Other		<table border="1"> <tr> <td data-bbox="560 1538 903 1951">Scale</td> <td data-bbox="560 1538 903 1951"></td> </tr> <tr> <td data-bbox="560 1482 903 1538">Shape</td> <td data-bbox="560 1482 903 1538"></td> </tr> <tr> <td data-bbox="560 1426 903 1482">Abutments</td> <td data-bbox="560 1426 903 1482"></td> </tr> <tr> <td data-bbox="560 1370 903 1426">Piers</td> <td data-bbox="560 1370 903 1426"></td> </tr> <tr> <td data-bbox="560 1314 903 1370">Railings</td> <td data-bbox="560 1314 903 1370">X</td> </tr> <tr> <td data-bbox="560 1258 903 1314">Columns</td> <td data-bbox="560 1258 903 1314"></td> </tr> <tr> <td data-bbox="560 1202 903 1258">Form Liners</td> <td data-bbox="560 1202 903 1258">X</td> </tr> <tr> <td data-bbox="560 1146 903 1202">Color</td> <td data-bbox="560 1146 903 1202">X</td> </tr> <tr> <td data-bbox="560 1090 903 1146">Texture</td> <td data-bbox="560 1090 903 1146"></td> </tr> <tr> <td data-bbox="560 1034 903 1090">Applied ornamentation</td> <td data-bbox="560 1034 903 1090"></td> </tr> <tr> <td data-bbox="560 979 903 1034">Arches</td> <td data-bbox="560 979 903 1034"></td> </tr> <tr> <td data-bbox="560 923 903 979">Lighting</td> <td data-bbox="560 923 903 979"></td> </tr> <tr> <td data-bbox="560 867 903 923">Other</td> <td data-bbox="560 867 903 923"></td> </tr> </table>	Scale		Shape		Abutments		Piers		Railings	X	Columns		Form Liners	X	Color	X	Texture		Applied ornamentation		Arches		Lighting		Other		<table border="1"> <tr> <td data-bbox="560 447 903 1538">Yes</td> <td data-bbox="560 447 903 1538"></td> </tr> <tr> <td data-bbox="560 391 903 447">No</td> <td data-bbox="560 391 903 447">X</td> </tr> <tr> <td data-bbox="560 335 903 391">Maybe</td> <td data-bbox="560 335 903 391"></td> </tr> <tr> <td data-bbox="560 279 903 335">Other</td> <td data-bbox="560 279 903 335"></td> </tr> </table>	Yes		No	X	Maybe		Other	
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Agency	Does your organization employ any Standard Treatment Plans/Approaches when considering workhorse bridges in rural or urban historic districts?	Yes	X
		No	
		If "Yes" please describe	From Indiana DOT's website: Indiana Context Sensitive Solutions : It is the policy of the Indiana DOT to incorporate context-sensitive solutions (CSS) into the planning, development, construction and maintenance process for improvement to the state jurisdictional system. The process for incorporating CSS is intended to establish a basis for the planning, development, construction, and maintenance process to incorporate a community's character and
	Has the replacement of a workhorse bridge in a historic district ever resulted in a replica of the existing or previous historic bridge?	Yes	
		No	X
		Maybe	
		If "Yes" please describe	
	Is there a bridge type that is most often used as a replacement of a workhorse bridge?	Yes	
		No	X
		Other	
		If "Yes" please describe	
	What bridge enhancements or design guidelines does your organization commonly use in replacement designs for workhorse bridges in historic districts?	Scale	
		Shape	
Abutments		X	
Piers		X	
Railings		X	
Columns		X	
Form Liners		X	
Color			
Texture			
Applied ornamentation			
Arches			
Lighting		X	
Other			
What specific design trends/aesthetics/other features do you believe made the project successful?	Yes		
	No	X	
	Maybe		
	Other		
Has your organization developed any standard designs for replacement of workhorse bridges in rural historic districts?	Yes		
	No	X	
	Maybe		
	Other		

Agency	Does your organization employ any Standard Treatment Plans/Approaches when considering workhorse bridges in rural or urban historic districts?	Yes	vision in transportation improvements, including pedestrians, cyclists, public transportation vehicles and passengers, trucks, and automobiles.
		No	
		If "Yes" please describe here:	
		Yes	
Agency	Has the replacement of a workhorse bridge in a historic district ever resulted in a replica of the existing or previous historic bridge?	Yes	If "Yes" please describe here:
		No	
		Maybe	
		Yes	
Agency	Is there a bridge type that is most often used as a replacement of a workhorse bridge?	Yes	If "Yes" please describe here:
		No	
		Other	
		Yes	
Agency	What bridge enhancements or design guidelines does your organization commonly use in replacement designs for workhorse bridges in historic districts?	Scale	
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		Abutments	
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		Applied ornamentation	
		Arches	
		Lighting	
Agency	What specific design trends/aesthetics/other features do you believe made the project successful?	Yes	
		No	
		Maybe	
		Other	
Agency	Has your organization developed any standard designs for replacement of workhorse bridges in rural historic districts?	Yes	
		No	
		Maybe	
		Other	

Agency	Does your organization employ any Standard Treatment Plans/Approaches when considering workhorse bridges in rural or urban historic districts?	Yes	agreement.
		No	
		If "Yes" please describe here:	
		Yes	
Agency	Has the replacement of a workhorse bridge in a historic district ever resulted in a replica of the existing or previous historic bridge?	Yes	If "Yes" please describe here:
		No	
		Maybe	
		Yes	
Agency	Is there a bridge type that is most often used as a replacement of a workhorse bridge?	Yes	If "Yes" please describe here:
		No	
		Other	
		Yes	
Agency	What bridge enhancements or design guidelines does your organization commonly use in replacement designs for workhorse bridges in historic districts?	Scale	If "Yes" please describe here:
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Agency	What specific design trends/aesthetics/other features do you believe made the project successful?	Yes	If "Yes" please describe here:
		No	
		Maybe	
		Other	
Agency	Has your organization developed any standard designs for replacement of workhorse bridges in rural historic districts?	Yes	If "Yes" please describe here:
		No	
		Maybe	
		Other	

Other Considerations

Agency	Do you have guides/models on how much historic bridge replacements may cost in relation to standard construction costs?				What are two of the greatest obstacles that you had to overcome in developing plans for a replacement for a historic bridge?	What steps, training, processes, would help you in overcoming these obstacles?	What were the most effective public outreach strategies used for Environmental considerations?	What were the most effective public outreach strategies used for Cultural Resource considerations?	What were the most effective public outreach strategies used for Design considerations?	What type of interdisciplinary strategies were most effective for your project?	How did you or your agency ensure a shared stakeholder vision?				Do you have any CSD/CSS experience with specific cultural groups for bridge replacement designs in historic districts?		
	Yes	No	Maybe	Other							Public Meetings	Inter-agency Coordination	Direct Mail	Web Postings/Webinars		Other	Yes
Private Sector	X				Satisfying the local property owners	Regular Meetings	Public Meetings	Unknown	Public Meetings	Public Meetings				X			
Massachusetts DOT			X		Securing buy-in from engineers on outside-the-box CSD ideas.	Training for engineers on CSD, why it's important.									X		Each town or city in MA has a Local Historical Commission, and many have Historic District Commissions tasked with project review within historic districts. Massachusetts DOT reaches out to both LHCs and HDCs for comments and input on project design.

Agency	Do you have guides/models on how much historic bridge replacements may cost in relation to standard construction costs?	Do you have any CSD/CSS experience with specific cultural groups for bridge replacement designs in historic districts?	How did you or your agency ensure a shared stakeholder vision?	What type of inter-agency/inter-disciplinary strategies were most effective for your project?	What were the most effective public outreach strategies used for Design considerations?	What were the most effective public outreach strategies used for Cultural Resource considerations?	What were the most effective public outreach strategies used for Environmental considerations?	What steps, training, processes, would help you in overcoming these obstacles?	What are two of the greatest obstacles that you had to overcome in developing plans for a replacement for a historic bridge?	What were the most effective public outreach strategies used for Environmental considerations?	What were the most effective public outreach strategies used for Cultural Resource considerations?	What were the most effective public outreach strategies used for Design considerations?			
	Yes No Maybe Other	Yes No Maybe Please explain:	Public Meetings Inter-agency Coordination Direct Mail Web Postings/Webinars Other												
Colorado DOT								flexibility.	cost and designer perception (e.g., designer does not think it's that historical - what's the big deal?)	workshops	workshops	workshops presenting options			

Agency	Do you have guides/models on how much historic bridge replacements may cost in relation to standard construction costs?				What are two of the greatest obstacles that you had to overcome in developing plans for a replacement for a historic bridge?	What steps, training, processes, would help you in overcoming these obstacles?	What were the most effective public outreach strategies used for Environmental considerations?	What were the most effective public outreach strategies used for Cultural Resource considerations?	What were the most effective public outreach strategies used for Design considerations?	What type of inter-agency/inter-disciplinary strategies were most effective for your project?	How did you or your agency ensure a shared stakeholder vision?					Do you have any CSD/CSS experience with specific cultural groups for bridge replacement designs in historic districts?							
	Yes	No	Maybe	Other							Public Meetings	Inter-agency Coordination	Direct Mail	Web Postings/Webinars	Other		Yes	No	Maybe	Please explain:			
																					Combination of the first two, when needed.	X	Excluding the SHPO none on a state-wide basis.
Florida DOT				Other	On our part, understanding the purpose and nature of consultation under Section 106. On the public's part, the same as previously, as well as the integration of design standards for safety and service purposes of the structure for their transportation purposes. On SHPO's part, the basic dynamics which structures must meet in order to function for their intended purposes and	We establish communities of interest opportunities where environmental issues are a driving impetus of the project. As noted previously, our context-sensitive design and our complete streets initiatives are very helpful for this.	For districts where there is a large community concern or local government interests, we have found forming a Cultural Resources Coordinating Committee to be of tremendous help in steering the project through the Section 106 process.	Usually working through the preservation community or officials to identify the parties that would be most interested in the proposed action as well as the general scientific community if there are natural resources of importance or requiring consideration.															

