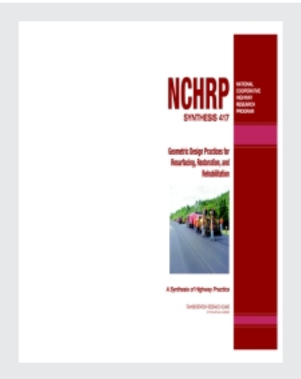

Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation

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Hugh W McGee; Transportation Research Board

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NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 417

Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation

A Synthesis of Highway Practice

CONSULTANT
HUGH W. McGEE, SR.
Vanasse Hangen Brustlin, Inc.
Vienna, Virginia

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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Cover figure: Paving operations in New York State (*courtesy*: New York State Department of Transportation).

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20–5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jon M. Williams
Program Director
Transportation Research Board

Each state transportation agency has its own design guidance and standards for nonfreeway resurfacing, restoration, and rehabilitation (3R) projects. These include enhancements to improve highway safety. The purpose of this study was to gather and synthesize current state practices related to 3R projects.

Information was acquired through a literature review and a survey of all state transportation agencies. Documents that provide state 3R policies were obtained either from state websites or directly from the states.

Hugh W. McGee, Sr., of Vanasse Hangen Brustlin, Inc., Vienna, Virginia, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

GEOMETRIC DESIGN PRACTICES FOR RESURFACING, RESTORATION, AND REHABILITATION

SUMMARY

The Resurfacing, Restoration, and Rehabilitation (3R) program began in 1976 when the U.S. Congress authorized funding for highway projects that were intended to extend the service life of an existing road. The program originally defined the 3Rs as follows:

1. Resurfacing—Work to place additional layers of surfacing on highway pavement, shoulders, and bridge decks, and necessary incidental work to extend the structural integrity of these features for a substantial time period.

2. Restoration—Work to return the pavement, shoulders, and bridges over a significant length of highway to an acceptable condition to ensure safety of operations for a substantial time period.

3. Rehabilitation—Work to remove and replace a major structural element of the highway to an acceptable condition to extend the service life of a significant segment for a substantial period of years commensurate with the cost to construct.

Over time, the desire and the requirement to make safety improvements to existing facilities in need of pavement repair changed the objective of 3R projects to include "enhance safety." Subsequently, the issue became one of how much an existing roadway should be improved to achieve the safety objective. Should roads requiring pavement repair or other maintenance activities to extend their service life be brought up to full standards for geometric design or other design features? Doing so would minimize the amount of mileage that could be improved under the limited funding of the 3R program.

In response to a provision in the Surface Transportation Assistance Act of 1982, TRB studied the safety and cost-effectiveness of highway geometric design standards and recommended minimum standards for 3R projects on two-lane rural highways. That study resulted in *TRB Special Report 214: Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation.* Pursuant to its adoption of *TRB SR 214*, on October 17, 1988, FHWA issued Technical Advisory T5040.28, *Developing Geometric Design Criteria and Processes for Non-Freeway RRR Projects.* The purpose of the advisory is to provide guidance on developing or modifying criteria for the design of federal-aid, nonfreeway 3R projects. The technical advisory provides procedures, a process for developing 3R programs and projects, and design criteria for individual geometric elements. Essentially, the advisory recognized that each state could adopt its own design policy for 3R projects, but that the FHWA needed to approve state policies.

Owing to the state-to-state variations in standards and guidelines for 3R projects, more information is needed on the current state of highway practice related to 3R design guidelines for all nonfreeway roadway types. Therefore, the main focus of this synthesis project was to gather and synthesize current practices related to 3R geometric design. The information presented in the synthesis is derived from the following sources:

1. A 15-question survey distributed to all state transportation agencies,

2. A compilation and review of the state design manuals that contained 3R policies, and

3. A focused literature review.

All but two states responded to the survey. According to the survey responses—

- All but eight states responding have an FHWA-approved 3R policy; the others have a program that has similar objectives.
- Most 3R projects are initiated because of the condition of the pavement, but then are reviewed to determine what safety enhancements are justified.
- The safety analyses typically include a review of crash history to see if a "crash problem" exists. However, some states are incorporating new safety tools and methods to include road safety audits/assessments and the application of safety models found in the new *Highway Safety Manual*.
- Design speed, lane width, and shoulder width are considered the most important design elements of the 13 controlling design criteria.
- The most frequent safety improvements are those related to the roadside, including increasing the clear zone and upgrading barriers and other roadside safety devices.
- Many states are including improvements for pedestrians and bicyclists within the constraints of 3R projects and are providing required Americans with Disabilities Act improvements such as accessible curb ramps and walkway slopes.
- There is wide state-by-state variation in the time it takes to have a 3R project implemented after the need has been identified and in the number of 3R projects completed each year.
- Many states expressed a need to improve 3R guidelines to include a process for determining how many safety upgrades should be made, given restricted budgets.

For nearly all states, the documents that provide their 3R policies were obtained from their website or directly provided by the state, and can be accessed at http://www.trb.org/SynthesisPrograms/Public/CompilationofStateDesignManuals.aspx.

A review of these documents confirmed the variation in the scope and content of the states' policies. They range from fairly concise documents of about 10 pages to much more comprehensive, lengthy documents, with the longest single document being 92 pages. Most states include the 13 controlling critical design elements determined by FWHA, for which design exceptions should be prepared if not within minimum values. However, many states go beyond these criteria and provide guidance on other features, including intersections, clear zone, roadside features, drainage, traffic control devices, driveways, lighting, and even landscaping. The report provides a discussion of how states treat these design elements for 3R projects.

The synthesis concludes with a summary of key findings and a recommendation for two general research efforts: to expand our knowledge of the relationship of design elements to safety and to continue to develop and improve upon crash modification factors for various safety improvements.

CHAPTER ONE

INTRODUCTION

BACKGROUND

The Resurfacing, Restoration, and Rehabilitation (3R) program began in 1976 when Congress authorized funding for highway projects that were intended to extend the service life of an existing road. Over time, the desire and the requirement to make safety improvements to an existing facility in need of pavement repair changed the objective of 3R projects to include "enhance safety." In response to a provision in the Surface Transportation Assistance Act of 1982, TRB studied the safety and cost-effectiveness of highway geometric design standards and recommended minimum standards for 3R projects on two-lane rural highways. That study resulted in *TRB Special Report (SR) 214: Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation (1)*. AASHTO subsequently amended the foreword of the *Policy on Geometric Design for Highways and Streets (2)* to include the following sentence: "This publication is not intended as a policy for Resurfacing, Restoration, or Rehabilitation (3R) projects and refers the reader to *TRB Special Report 214* for design guidance." In 2001, AASHTO published *Guidelines for Geometric Design for Very-Low Volume Local Roads (ADT ≤ 400) (3)*. This document does not specifically address 3R work, but it does provide some guidance related to improving the safety and cost-effectiveness of geometric design for existing, low-volume roads.

Although *TRB SR 214* specifically addresses 3R work on rural two-lane highways and AASHTO provides limited guidance on roads with an average daily traffic (ADT) of fewer than 400 vehicles per day, there is a lack of design guidance for 3R work on a wide range of roads, including urban nonfreeway facilities and rural multilane nonfreeway facilities. A need exists to document the state of highway practice related to 3R design guidelines for all nonfreeway roadway types. Most state transportation agencies have 3R design guidelines, but these differ greatly in scope and content, and as a result the range of current practice is considerable. Therefore, the main focus of this synthesis project was to gather and synthesize current practices related to 3R design. It is believed that such an effort will be of considerable value to transportation agencies preparing newly developed or revised guidelines for 3R projects. Although each state tailors design policies to its specific conditions, there are many commonalities with regard to geometric design and how these features affect safety.

OBJECTIVE OF SYNTHESIS

The synthesis project panel provided the following charge to the consultant preparing this report: Information was to be gathered for federal-aid and non-federal-aid design practices and for National Highway System (NHS) or non-NHS related to resurfacing, restoration, and rehabilitation for the following topics:

- Definitions of 1R, 2R, 3R, and maintenance;
- Controlling design criteria used in 3R guidelines;
- Basis for development of guidelines;
- To which facilities do the 3R and other standards apply (federal aid and non-federal aid);
- Safety and other risk analyses used, such as Road Safety Audits;
- Use of the *Highway Safety Manual* (HSM), Interactive Highway Safety Design Model (IHSDM), Roadside Safety Analysis Program (RSAP), or other predictive quantitative tools for 3R;
- How bicycle/pedestrian/Americans with Disabilities Act (ADA) considerations are addressed in 3R;
- Roadside safety design methods used in 3R;
- Scope limitations [e.g., right-of-way (ROW), edge of pavement, and pavement thickness] and what is or is not included; and
- Need for improved or updated guidance and future research.

As with most NCHRP synthesis projects, information to address these issues was gathered through a literature review, survey of transportation agencies, and selected interviews.

CONTENTS OF SYNTHESIS

Following this introduction, there are four chapters. Chapter two provides a chronology of the development of 3R design guidelines. Chapter three presents the results of a survey questionnaire sent to all states. Chapter four discusses how a sample of states deal with the various geometric design criteria as presented in their 3R policy documents. Chapter five provides a summary of major findings and recommendations for further research. Several appendixes provide supporting material.

CHAPTER TWO

HISTORY AND CURRENT STATUS OF DESIGN GUIDELINES FOR RESURFACING, RESTORATION, AND REHABILITATION PROJECTS

EVOLUTION OF THE RESURFACING, RESTORATION, AND REHABILITATION PROGRAM

The program of resurfacing, restoration, and rehabilitation, also known as 3R, emerged out of the 1976 Federal-Aid Highway Act (P.L. 94-280). Prior to that legislation, federal funding had been limited to constructing new roads or reconstructing existing roads to higher design standards. State and local agencies used their own transportation revenues to fund maintenance and preservation of roads that had approached the end of their design life. The Federal-Aid Highway Act amended the U.S. Code to include the 3Rs within the definition of construction. The legislation permitted the use of federal aid to rehabilitate highways to extend their useful life without necessarily improving existing geometrics. These projects were not required to comply with the then-current design standards, and typically would not change existing design dimensions. The 3Rs were defined as follows:

- **Resurfacing** – Work to place additional layers of surfacing on highway pavement, shoulders, and bridge decks, and necessary incidental work to extend the structural integrity of these features for a substantial time period.
- **Restoration** – Work to return the pavement, shoulders, and bridges over a significant length of highway to an acceptable condition to ensure safety of operations for a substantial time period. This work may include the following: grinding and repair of joints of portland cement concrete pavement, sealing of shoulders and pavement joints in conjunction with other work, placement of a skid resistant surface treatment, correction of minor drainage conditions, and work to prepare a bridge deck for an overlay.
- **Rehabilitation** – Work to remove and replace a major structural element of the highway to an acceptable condition to extend the service life of a significant segment for a substantial period of years commensurate with the cost to construct. This work may include the following: replacement of bridge deck, pavement, or shoulders without significant widening; recycling of pavement and shoulder materials: replacement of the individual bridge elements to correct a structural deficiency; and minor subgrade work incidental to other work.

In 1977, AASHTO published *Geometric Design Guide for Resurfacing, Restoration, and Rehabilitation (R-R-R) of Highways and Streets (4)* (also known as the *Purple Book*) to provide guidance to the states on the types of 3R projects, geometric guidelines, and design elements. The guide stated that the primary purpose of 3R projects was to "provide better riding surface, increase safety, and improve operating conditions, to the most feasible degree." It recognized that to stretch limited highway resources, flexibility in standards for improvements was essential. Design guidelines were provided for the following elements:

- Speed;
- Pavement (lane) and shoulder width;
- Superelevation;
- Grades, curvature, and stopping sight distance;
- Bridge structural capacity and width;
- Horizontal clearance to obstructions;
- Drainage;
- Curbing and channelization;
- Sidewalks;
- Bikeways;
- Utilities;
- Lighting;
- Aesthetics and landscaping; and
- Railroad crossings at grade.

FHWA did not accept the *Purple Book* for nationwide use, and it is no longer published by AASHTO. Instead, FHWA decided to develop its own geometric design criteria for federal-aid nonfreeway 3R projects. In 1978, an FHWA-developed guide was published as a notice of proposed rulemaking. The guide provided definitions and specific geometric criteria for various roadway design elements. The hallmark of the proposed guide was to provide minimums, but encouraged higher values where possible and practical. It provided flexibility in design that would allow for cost-effective improvements to safety without requiring total reconstruction. However, it was criticized by safety advocates who believed that safety would be compromised because only minimums would be followed. This criticism prompted more study by FHWA, which led to the technical report *RRR Alternative Evaluations for Non-Interstate Rural Arterial and Collector Highway Systems (5)*. The report concluded that greater overall system safety could be achieved by improving more miles with less costly improvements than fewer miles of full construction. This premise continues to be one of the key issues surrounding the 3R program—just how much should be invested for safety improvements for any given 3R project, which will then limit the amount available for other projects within a fiscal year.

On June 10, 1982, FHWA issued its final rule, entitled *Design Standards for Highways: Resurfacing, Restoration, and Rehabilitation of Streets and Highways Other Than Freeways (6)*. This final rule modified 23 CFR Part 625 to adopt a flexible approach to the geometric design of 3R projects. Part 625 was modified again on March 31, 1983, to explicitly state that one objective of 3R projects is to enhance highway safety. In the final rule, FHWA determined that it was not practical to adopt 3R design criteria for nationwide application; instead, each state can develop its own criteria and procedures for 3R projects, subject to FHWA approval. This allows each state to tailor its design criteria for the 3R program according to prevailing conditions. This approach is in contrast to the application of criteria for new construction and major reconstruction, for which AASHTO's *A Policy on Geometric Design of Highways and Streets (7)* provides nationwide criteria for application.

FHWA subsequently issued Technical Advisory T 5040.21, *Geometric Design Criteria for Nonfreeway RRR Projects*, in 1983 (*8*). It provided guidance relating to 11 factors to be addressed, as a minimum, in the geometric design criteria developed by a state for use on 3R projects.

In 1985, 23 CFR 625 was revised to adopt AASHTO's *A Policy on Geometric Design of Highway and Streets.* In the implementing memorandum of April 15, 1985, FHWA identified the following 13 controlling criteria:

1. Design speed
2. Lane width
3. Shoulder width
4. Bridge width
5. Structural capacity
6. Horizontal alignment
7. Vertical alignment
8. Stopping sight distance
9. Grades
10. Cross-slopes
11. Superelevation
12. Horizontal clearance
13. Vertical clearance.

Deviations from these criteria required a formal design exception. The 13 controlling criteria were relevant to new and reconstruction projects, but they were embraced later for 3R guidelines.

In response to a provision of the 1982 Surface Transportation Assistance Act, the National Academy of Sciences was requested to study the safety cost-effectiveness of geometric design standards and recommend minimum standards for 3R projects on existing nonfreeway federal-aid highways. This study led to *TRB SR 214: Designing Safer Roads, Practices for Resurfacing, Restoration, and Rehabilitation*, published in 1987 (*1*). Part 625 was again revised to add this report as a guide and reference to the list of publications for application on federal-aid projects. The report—

1. Reviewed the existing 3R design practices of 15 state departments of transportation (DOTs) and several local highway agencies.
2. Examined the relationship between highway accident potential and geometric design elements, based on existing research literature and on special research projects commissioned as part of the study.
3. Examined the relationship between the extent of geometric design improvements and the cost of 3R projects.
4. Discussed the issue of cost-effectiveness relative to geometric design improvements on 3R projects.
5. Reviewed the literature on tort liability and geometric design.
6. Presented a safety-conscious design process.
7. Presented specific numerical criteria for the geometric design of 3R projects for the following elements:
    - Lane and shoulder width
    - Horizontal curvature and superelevation
    - Vertical curvature
    - Bridge width
    - Side slopes
    - Pavement cross slope

Pursuant to its adoption of *TRB SR 214*, on October 17, 1988, FHWA issued Technical Advisory T5040.28, *Developing Geometric Design Criteria and Processes for Non-*

Freeway RRR Projects (9). The purpose of the advisory is to provide guidance on developing or modifying criteria for the design of federal-aid, nonfreeway 3R projects. The technical advisory—

1. Discusses the procedures for developing 3R criteria.

2. Discusses the factors that should be evaluated in a safety-conscious design process.

3. Discusses the application of design exceptions for the FHWA controlling design criteria on 3R projects.

4. Presents specific criteria for the design of 3R projects based on *TRB SR 214*.

The full document is provided as Appendix A; the highlights are discussed here.

The advisory provides procedures, a process for developing 3R programs and projects, and design criteria for individual geometric elements. Under Procedures, it states that "each State may choose one or a combination of the following options:

(1) develop and adopt geometric design criteria specifically for nonfreeway 3R projects,

(2) adopt and apply current geometric design criteria for new construction (referenced in 23 CFR 625.4(a)(1) to nonfreeway 3R projects , and/or

(3) continue to use previously approved geometric design criteria for nonfreeway 3R projects that have been in existing Certification Acceptance or Secondary Road Plan agreements, provided such criteria are consistent with 23 U.S.C. 109 (o)."

The advisory recognizes *TRB SR 214* as having "the most current source of data, procedures and recommendations regarding geometric design and its relationship to safety for 3R projects, and that it can be used to develop or modify criteria, processes and practices to achieve the twin objectives of 3R type projects—preservation and safety enhancement." It also states that the states' 3R design criteria should address all 13 controlling geometric elements mentioned previously and includes recommendations from *TRB SR 214* on lane and shoulder widths and bridge widths. In addition, guidance is provided on other design features, including pavement improvements, skid-resistant surfaces and pavement edge drop-off remediation; intersection improvements; and traffic controls and regulations.

CURRENT DESIGN POLICIES AND GUIDELINES APPLICABLE TO RESURFACING, RESTORATION, AND REHABILITATION PROJECTS

Currently, there are no national design guidelines for 3R projects. States can develop their own standards for these projects, and in doing so they have drawn from various design guideline documents, including the following documents from AASHTO, FHWA, and *TRB SR 214*.

AASHTO Design Guides

Most highway design guidelines followed by state DOTs are developed and published by AASHTO. The AASHTO Standing Committee on Highways is charged with developing these guides using subcommittees and assigned technical committees. The following AASHTO guides contain information on 3R design guidelines.

- *A Policy on Geometric Design of Highways and Streets* (7)—Known as the *Green Book*, this document provides guidelines for all road type designs, applicable to new and reconstructed roads. The foreword contains the following statement on 3R projects:

  > This publication is not intended as a policy for 3R projects. For projects of this type, where major revisions to horizontal or vertical curvature are not necessary or practical, existing design values may be retained. Specific site investigations and crash history analysis often indicate that the existing design features are performing in a satisfactory manner. The cost of full reconstruction for these facilities, particularly where major realignment is not needed, will often not be justified. 3R projects enable highway agencies to improve highway safety by selectively upgrading existing highway and roadside features without the cost of full reconstruction. When designing 3R projects, the designer should refer to *TRB Special Report 214, Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation* and related publications for guidance.

- *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400),* 2001 (*3*)—This design policy was prepared to address the needs of functionally classified local roads with average daily traffic volumes of up to 400 cars. Because these roads typically have low frequency of crashes and primarily serve drivers who are familiar with the roadway, it was believed that designers could apply less restrictive design criteria than those used for higher volume roads, and for which the *Green Book* would apply. This guide applies to both new construction and the improvement of existing roads, and its application to 3R projects is noted in the following statement:

> Projects on existing very low-volume local roads may involve reconstruction, resurfacing, rehabilitation, restoration and other improvements. Changes to roadway or roadside geometrics during such projects are generally recommended only where there is a documentable site-specific safety problem that can potentially be corrected by a roadway or road side improvement.

In general, the guidelines discourage widening of lanes and shoulders, changes in horizontal and vertical alignment, and roadside improvements, except in situations where such improvements are likely to provide substantial safety benefits.

- *Roadside Design Guide* (RDG) (10)—This document presents a synthesis of current information and operating practices related to roadside safety. The roadside is defined as that area beyond the traveled way (driving lanes) and the shoulder (if any) of the roadway. The focus of the guide is on safety treatments that minimize the likelihood of serious injuries when a driver runs off the road. Its guidelines are most applicable to new construction or major reconstruction projects. The RDG recognizes that the primary emphasis of 3R projects is generally placed on the roadway and that it is necessary to selectively incorporate roadside safety guidelines at locations where the greatest safety benefit can be realized. The RDG contains guidelines for one of the 13 controlling design elements—horizontal clearance (other than Clear Zone). However, the RDG discusses many roadside features that may be improved and upgraded during 3R projects, including the following:
  - Side slopes—foreslopes and backslopes;
  - Drainage features;
  - Curbs;
  - Sign, traffic signal, and luminare supports;
  - Roadside barriers;
  - Bridge railings; and
  - Barrier end treatments and crash cushions.

FHWA Guidance

Current FHWA guidance on geometric design criteria is found in aforementioned FHWA Technical Advisory T 5040.28, *Developing Geometric Design Criteria and Process for Nonfreeway RRR Projects* (*9*), which can be found in Appendix A.

Transportation Research Board Special Report 214

TRB SR 214, published in 1987, offered 23 recommendations for 3R projects with the objective of improving safety in a cost-effective manner. The following is a list of the recommendations, grouped into five major categories:

Safety-Conscious Design Process

1. Assessment of Site Conditions Affecting Safety
2. Determination of Project Scope
3. Documentation of the Design Process
4. Review by Traffic and Safety Engineers

Design Practices for Key Highway Features

5. Minimum Lane and Shoulder Widths

6, 7. Horizontal Curvature and Superelevation

8. Vertical Curvature and Stopping Sight Distance
9. Bridge Width
10. Sideslopes and Clear Zones
11. Pavement Edge Drop and Shoulder Type
12. Intersections
13. Normal Pavement Crown

Other Design Procedures and Assumptions

14. Traffic Volume Estimates for Evaluating Geometric Improvements
15. Speed Estimates for Evaluating Geometric Improvements
16. Design Values for Geometric Improvements
17. Design Exceptions

Planning and Programming RRR Projects

18. Screening of Highways Programmed for RRR projects
19. Assessment of the Systemwide Potential for Improving Safety

Safety Research and Training

20. Special Task Force to Assess Highway Safety Needs and Priorities
21. Compendium of Information on Safety Effects of Design Improvements

22. Increased Research on the Relationships Between Safety and Design

23. Safety Training Activities for Design Engineers

TRB SR 214 contains a complete discussion of these recommendations. It can be accessed at www.trb.org/publications/sr/sr214/sr214_001_fm.pdf. Appendix B contains a summary of the recommendations that pertain to the geometric design elements discussed in this synthesis.

The information presented in this chapter lays the foundation for the remainder of this synthesis. States were given the flexibility to develop their own design policies for 3R projects, and have used the aforementioned AASHTO policies, the FHWA technical advisory, *TRB SR 214*, and other documents in developing geometric design policy appropriate to their conditions and design procedures. The next chapter describes how states have developed their 3R policies and provides the responses to the questionnaire sent to the states.

CHAPTER THREE

RESULTS OF STATE SURVEY QUESTIONNAIRE

BACKGROUND

State practices for 3R standards and guidelines were identified in two ways. First, 3R policy documents were searched within the state DOT website. For many states, the documents were easily identified. Other states, however, did not have readily identifiable documents within the state DOT website, and some states did not have documents because the state does not have a specific 3R policy. Although many of the policies were obtained from this effort, a survey was utilized to (1) be certain that the documents obtained from the state DOT website were up-to-date, (2) obtain 3R policy documents from states that have not posted them on their state DOT's website, and (3) gather other information related to the objectives of the synthesis that was not available within the policy documents.

Appendix C contains the survey questionnaire. It was distributed to the mailing list of the AASHTO Subcommittee on Design. Forty-eight states and Puerto Rico responded to the survey. This chapter summarizes the key results from the survey. The complete responses are presented in a series of tables in Appendix D.

The state practices cited serve only as examples and are not necessarily the best or recommended practice. For any one item discussed, the practices and procedures followed by many states could have been mentioned. This chapter will discuss state practices with regard to specific geometric design criteria.

STATE PRACTICES AND PROCEDURES

How Many States Have a Formal 3R Policy?

Current federal regulations allow flexibility and local discretion in the geometric design of nonfreeway 3R projects. Each state may choose one or a combination of the following options:

1. Develop and adopt geometric design criteria specifically for nonfreeway 3R projects,
2. Adopt and apply current geometric design criteria for new construction [referenced in 23 CFR 625.4(a)(1)] to nonfreeway 3R projects , and/or
3. Continue to use previously approved geometric design criteria for nonfreeway 3R projects that are in existing Certification Acceptance or Secondary Road Plan agreements, provided such criteria are consistent with 23 U.S.C. 109 (o).

According to the survey responses (see Appendix D, Table D1) and information obtained from the states' websites, 42 states have a formal 3R policy document, and nearly all of these have been approved by FHWA. A state's 3R policy documentation can be a separate document, such as a design information bulletin, a chapter of its *Roadway Design Manual* or other similar document, or policy elements contained in several different chapters or sections of the *Roadway Design Manual*. The self-contained documents or chapters of a design manual range from fewer than 10 pages (several states) to 92 pages (Indiana). The longer documents are more comprehensive in their coverage, and they tend to be more recently prepared. Two states responded that they are in the process of revising their 3R policies and updating their documents. The policy documents for each of the states that provided them can be seen at http://www.trb.org/Synthesis-Programs/Public/CompilationofStateDesignManuals.aspx.

Most states use the term 3R collectively and make no distinction among resurfacing, restoration, or rehabilitation. Some exceptions include California, Colorado, Idaho, Louisiana, New York, Vermont, and Wyoming.

The California DOT (Caltrans) has a *Highway Design Manual* (HDM) that prescribes design guidance and standards for the design of highways within the California state highway system. Caltrans also issues Design Information Bulletins (DIBs) that provide additional guidance and standards to supplement the HDM. Caltrans issued DIB 79-03, "Design Guidance and Standards for Roadway Rehabilitation Project [Pavement Focused (2R) and Resurfacing, Restoration, and Rehabilitation (3R) Projects] and Certain Other Projects [Storm Drainage, Protective Betterment, Operational Improvement and Safety-funded Projects]," which includes the following key elements:

> Generally speaking, the purpose and need for 2R and 3R projects is to restore the facility to a state of good repair so that the roadway will be in a condition that only requires minimal maintenance expenditures by the Department. 2R (resurfacing and restoration) projects are programmed as "pavement-focused" projects with

> their primary goal being to extend the service life of the pavement structure. 3R (2R plus rehabilitation) projects are additionally programmed to replace and upgrade other highway appurtenances and facilities within the project limits that are failing, worn out or functionally obsolete. The determination of whether a segment of highway is to proceed as either a 2R or 3R project is to be made after Safety Screening has occurred and during the Project Initiation Document (PID) phase. The project development process for roadway rehabilitation projects is described in the Project Development Procedures Manual. The PID typically used for roadway rehabilitation projects is the "Project Scope Summary Report (PSSR) for 3R Projects."
>
> The scope of any project is driven by the purpose and need for the project. The need for pavement improvements comes from the condition data in the Pavement Management System. The need for safety improvements, which will move the project into a 3R, is determined by the Safety Screening. The Safety Screening is undertaken by the District Safety Unit. If the Safety Screening determines that targeted and cost-effective traffic operations strategies are the only needed safety enhancements within the project limits, the project becomes a 2R project. Targeted improvements include the addition of protective devices, such as metal beam guard *rail*, and cost-effective safety improvements include relatively low cost devices such as signing and striping.
>
> If the Safety Screening results in the determination that more extensive safety work is required, then the project will be identified as a 3R project. The safety 'work' is usually countermeasures that would not require reconstruction.

In Colorado, a 3R project is any project that consists of resurfacing, restoration, and/or rehabilitation, according to the following definitions:

- Resurfacing: Placement of additional surfacing material (1.5 to 6 in. thick) over the existing roadway to improve serviceability and/or provide additional strength.
- Restoration and Rehabilitation:
  - Work required to restore the existing pavement (including shoulders) to a condition of adequate structural support or to a condition adequate for placement of an additional stage of construction.
  - Work required to widen the lanes and/or shoulders of an existing facility.
  - Adding acceleration/deceleration, turn, short climbing lanes, etc., but not through lanes.
  - Work required to correct minor structure safety defects or deficiencies.

Colorado states that maintenance projects with resurfacing depth greater than or equal to 1.5 in. will follow 3R procedures. Also, it states that safety projects do not fall under 3R procedures.

New York defines the following for each of the R types:

- **1R project**—single-course freeway or nonfreeway resurfacing projects; overlays limited to single course with maximum thickness of 2 in. with additional thickness for superelevation improvement.
- **2R project**—multicourse resurfacing that may include milling, superelevation, traffic signals, turn lanes, driveway modifications, roadside work, minor safety work, lane and shoulder widening, drainage work, sidewalk curb ramps, etc. The primary advantage of a 2R project compared with a 3R project is the simplified design approval document.
- **3R project**—nonfreeway projects designed to preserve and extend the service life of an existing highway, including any cost-effective safety improvements and other safety improvements. 3R projects are "required" to enhance safety.

Chapter 7 of the New York State DOT *Highway Design Manual* provides further information and guidance to determine which type of project is appropriate. In summary, it states—

- Projects that include single-course resurfacing with no pavement widening or other work beyond the scope of 1R project can be progressed as a 1R project.
- Projects that include multicourse resurfacing or do not meet the 1R requirements should be progressed as 2R if they meet the 2R Screening/Scoping Checklist (see Appendix E) and do not include—
  - Substantial amounts of reconstruction.
  - Additional through travel lanes.
  - New two-way left-turn lanes, additional through lanes, or medians.
  - Bridge work (other than element-specific eligible bridge work).
  - Substantial environmental impacts.
  - Anticipated controversy.
  - Formal public hearings.
  - Extensive ROW.

- Projects that do not meet all of the screening requirements of 2R projects should be progressed as a 3R project unless they require—
  - Substantial amounts of reconstruction.
  - Additional through travel lanes, except short auxiliary through lanes to help intersection capacity.

This chapter and the next will provide more information on how the states' 3R policy documents deal with issues related to this synthesis.

If a State Does Not Have a Formal 3R Policy, Does It Have Standards or Procedures Similar to 3R?

The eight states listed in Table 1 responded that they do not have a formal 3R policy. Their comments as to why they do not have a formal policy have been included where available.

TABLE 1
STATES THAT DO NOT HAVE FORMAL 3R POLICY

State	Reasons Provided
Alabama	None provided
Delaware	Have pavement resurfacing projects only milling and filling and patchwork. Are required to improve curb ramps to meet ADA; otherwise, make no safety improvements
Maryland	3R type projects are dealt with by 4 offices—(1) Highway Development; (2) the 7 District Offices—responsible for incorporating 3R principles into their projects; (3) Office of Structures—rehab and resurfacing of structures; (4) Office of Materials and Technology—deals with pavement condition and makes recommendations to design offices
Minnesota	Have preservation projects
New Hampshire	None provided
New Jersey	Prior to 1996 had 3R standards, but are no longer followed; projects are differentiated as one of the Rs
Rhode Island	Have constructability reviews at every stage of design
Washington	Has separate programs and design guidelines for improvement and preservation projects

Minnesota has "Preservation" projects for roads, but not bridges. Preservation projects are those that (1) do not meet the definition for New Construction/Reconstruction, (2) do not fit in the Exempt category, and (3) are not on freeways. Examples of Preservation projects would include the following:

- Non-NHS bituminous overlays with increased pavement thickness greater than 2 in.
- NHS bituminous overlays greater than 2 in.
- Channelization for turn lanes.
- Shoulder replacement.
- Shoulder widening.

The Preservation standard is the existing condition or the New Construction/Reconstruction standard, whichever is less, for each of the 13 controlling design elements. Exempt projects include Pavement Preventive Maintenance projects, which apply where the pavement is in good condition with significant remaining service life. Preventive Maintenance projects do not significantly increase structural capacity, but use surface or near-surface treatments to structurally sound pavements to prevent deterioration of the pavement.

As listed in Table 1, Washington State does not have a formal 3R policy but does have "Modified Design Level," which "preserves and improves existing roadway geometrics, safety and operational elements." Chapter 1130 of the Washington State design manual provides the design criteria for this type of improvement.

Are 3R Standards/Guidelines the Same for National Highway Systems Projects and for Non-NHS Projects?

Appendix D, Table D2 provides the responses from all of the states. Of the 48 states that responded to this question, 27 (56%) answered yes, and 21 (44%) answered no. Some of the explanations for not having the same standards were as follows:

- Our state guidelines do not refer to speed where the 3R guidelines do refer to posted speed based on the requirements of FHWA. (Louisiana)
- We have adopted a Programmatic Exception to Standards process that allows substandard geometric features to stay in place based on the results of a safety screening analysis. This cannot be applied to certain features on NHS routes. (Wisconsin)
- We are not requiring design exceptions for non-NHS 3R (pavement preservation) projects. (Arizona)
- For non-NHS highways, preservation standards apply if the overlay increases the road profile by more than 2 in.; for NHS highways, preservation standards apply if the thickness of the new pavement is greater than 2 in., regardless of the final pavement elevation. (Note: Minnesota uses the term "preservation" for 3R projects.) (Minnesota)

One example of how 3R standards and guidelines differ between NHS and non-NHS routes is that of West Virginia. The West Virginia DOT (WVDOT) has two separate "Design Directives" for Non-NHS (DD-606) and Non-Freeway NHS (DD-604) RRR policy. Table 2 shows how the guidelines differ for these two road types for several of the geometric design criteria.

The WVDOT guidelines also discuss "Safety Enhancements" with the guidance for NHS routes to refer to the *NCHRP 500* series (11) and the application of the Interactive Highway Safety Design Model (IHSDM). IHSDM is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways (for more information, see http://www.tfhrc.gov/safety/ihsdm/ihsdm.htm). IHSDM can be used to predict the net safety performance of a proposed improvement to the project. Road Safety Audits (RSAs) (see http://safety.fhwa.dot.gov/rsa/) can also be used on multilane 3R projects. For non-NHS routes, the designer is also referred to the *NCHRP 500* series, but there is no reference to IHSDM or RSA.

TABLE 2
3R GUIDELINES FOR NHS AND NON-NHS IN WEST VIRGINIA

Design Element	Nonfreeway NHS	Non-NHS
Design Speed	Use existing speed limit	Speed study to determine
Horizontal Curvature/Superelevation	Consider variety of nongeometric changes; refer to Vol. 7 of *NCHRP 500*	Same
Vertical Alignment	Review for possible reconstruction if safety deficiencies and if cost-effective	Same but also adds condition that ADT > 2,000
Lane and Shoulder Width	Specific values for divided and undivided arterials	Refers to *NCHRP Report 362;* widen only if accident rate can be reduced; minimum values are less than NHS
Cross Slope and Superelevation	Cross slope minimum of 1.6%; meet AASHTO standards if crash history	Same as NHS
Vertical Clearance	14 ft	13 ft 6 in.
Clear Zone	Multilane highways refer to RDG; specific values for 2-lane based on ADT and speed	Only general guidance
Bridge Structural Capacity	HS-20 threshold	HS-15 threshold
Bridge Width	Specific values for divided and undivided arterials	Specific values based on ADT and Speed; lower than NHS

Are 3R Standards/Guidelines for Non-NHS Projects the Same for Both Federal-Aid and State-Aid Projects?

The complete responses to this question are found in Appendix D, Table D2. Only 7 of the 48 states indicated that their standards are different for non-NHS projects, depending on the funding source. However, reviewing the reasons and comments provided by these states reveals only minor variations. For example, one state responded that a new section on railroad crossing upgrades in or near a 3R project applies to federal-aid but not state-aid projects. Another state responded "no," but commented that its 3R policy applies to all roads in the state highway system.

How Many 3R Projects Are Implemented Each Year and How Many Lane-miles Are Treated by 3R Projects?

These two questions asked for information on the number of 3R projects implemented annually: one asked how many projects are implemented and the other asked how many lane-miles are treated. Only 31 states provided data on these related questions. Presumably, states that did not answer these questions did not have this information in a database for easy retrieval, or if it was available in a database, the responder was not aware of its existence. Ideally, it would be useful for a state to have this information as an integral component of a management information system.

Table 3 shows the results of these two questions. The information provided includes the number of 3R projects and the number of lane-miles treated by a 3R project, as well as the miles treated per project, which is calculated from the two responses. Only the states that answered at least the first question are included, and they are listed in order of the highest to lowest for the number of 3R projects. If a state responded with a range, such as "20 to 30," then the mid-value was used for this table.

Responding states had a wide range in the values for number of projects and miles treated. Many states indicated that 10 or fewer 3R projects were implemented each year. At the high end of the range were Michigan, Georgia, Alabama, and Wisconsin, which responded that they implemented about 600, 550, 500, and 400 projects annually, respectively. Similar results were observed for lane-mileage. On the low side, mileages of 30 or fewer miles were reported; on the high side, Michigan reported 7,000 miles (12 miles per project), Missouri reported 6,000 miles (24 miles per project), and Texas reported 5,000 miles (25 miles per project). An analysis was performed to determine if this variation reflected the number of miles under the respective state control; that is, would a state whose jurisdiction includes most of the highway mileage within its borders tend to have more miles of 3R projects? Although the data are not shown, there did not appear to be any correlation.

Since there was such a wide variation in the number of projects, a few of the states were contacted to better understand these statistics. Several indicated that the values provided were estimates or even guesses. Only one of the five persons interviewed was able to identify the number of projects from a database that identified projects by type, including 3R.

TABLE 3
NUMBER OF 3R PROJECTS AND LANE MILEAGE PER YEAR

State	Average Number 3R Projects Each Year	Average Lane-Miles Treated Each Year	Average Lane-Miles per Project
Michigan	600	7,000	12
Georgia	550	1,300	2
Alabama	500	4,800	10
Wisconsin	400	1,500	4
Missouri	250	6,000	24
Maryland	200	1,000	5
Texas	200	5,000	25
Louisiana	165	1,450	9
Florida	150	2,000	13
South Dakota	130	no response	N/A
Minnesota	88	521	6
Idaho	80	160	2
Indiana	75	200	3
Nebraska	70	1,240	18
Utah	48	no response	N/A
Iowa	35	400	11
Pennsylvania	35	150	4
New York	12	210	18
Oregon	12	400	33
New Mexico	10	100	10
Wyoming	10	40	4
Illinois	9	25	3
Arkansas	7	7	1
Kentucky	5	100	20
North Dakota	5	50	10
New Hampshire	4	75	19
Ohio	3	30	10
Puerto Rico	3	40	13
Rhode Island	3	5	2
Kansas	2	8	4
Vermont	2	5	3

N/A = not available.

What Is the Average Duration to Progress a 3R Project from Conception to Start of Construction?

The purpose of this question was to establish how much time it typically takes to implement a 3R project once it is planned. Many states did not provide an answer, presumably because they did not have that information readily available.

It may not be realistic to expect states to keep a database that would record when a project was first considered and when construction actually was started and then completed. Table 4 shows the answers from the 34 states that did respond to this question. The answers that were provided are likely approximations based on the experiences of the responder, which was confirmed by follow-up calls to several states.

TABLE 4
AVERAGE TIME (MONTHS) TO IMPLEMENT A 3R PROJECT

State	Time to Progress 3R Projects (months)
Alabama	9
Arkansas	12 to 15
California	48
Florida	36
Idaho	24
Illinois	24
Indiana	12 to 24
Iowa	24
Kansas	36
Kentucky	About 12
Louisiana	12
Maine	9
Maryland	12
Michigan	12
Minnesota	22
Missouri	20
Nebraska	30
Nevada	12
New Hampshire	16 to 24
New Mexico	18
New York	30
North Dakota	24
Ohio	12
Oklahoma	9
Oregon	30
Pennsylvania	8
Rhode Island	12
South Dakota	12 to 24
Texas	14
Utah	2
Vermont	24 to 60
Virginia	8 to 30
Wisconsin	24 to 48
Wyoming	36

Given that a typical 3R project is usually limited in scope, it could be expected that the time to initiation of construction would be relatively short. However, the results do not bear out this hypothesis. Table 4 shows that answers varied widely, from as short as 2 months (Utah) to as long as 60 months (Vermont); the more typical range was 12 to 24 months. This wide variation is likely the result of the scope of the 3R project (e.g., simple resurfacing versus a more complex project involving several upgrades to geometric and roadside features). It also could reflect the need for environmental reviews or public vetting. This was confirmed by at least one state, Nebraska. A follow-up call revealed that National Environmental Policy Act (NEPA) documentation, which can be required even for resurfacing projects, can extend the time by as much as 12 months. One responder stated that there is a need to streamline the implementation of 3R projects.

New York State DOT (NYSDOT) provided an explanation of its timeframe, which may be similar to those of other states. The NYSDOT resurfacing program involves different categories designated as 1R, 2R, and 3R, based on the pavement and nonpavement scope. Development periods vary. The 1R projects involve routine maintenance activities and can be delivered in as little as 4 months. The 2R projects, which involve more extensive pavement work (e.g., multiple layer overlay) and other potential improvements (e.g., cross-section improvements), can often be delivered in 12 months. The 3R projects often entail substantial pavement improvements, including sections of reconstruction, and geometric improvements. The development process may be complicated (e.g., substantial ROW, public involvement) and generally requires 2 to 3 years to complete. For several other agencies, the resurfacing program is developed from project identification through construction in 12 months or less.

How Are Resurfacing, Restoration, and Rehabilitation Projects Initially Determined?

The states were asked to indicate how a 3R project is initially determined and were given three options: (1) condition of the pavement, (2) safety problem, (3) other and to explain. The results are shown in Table 5 (see Appendix D, Table D3 for the responses by state).

TABLE 5
HOW 3R PROJECTS ARE DETERMINED

How Determined	No. of Responses
Pavement Condition	28
Safety Analysis	3
Other	15

As shown by the table, a majority of the states responded that a 3R project is initially determined by the condition of the pavement. For example, Mississippi's design manual states that "3R projects are often programmed because of a significant deterioration of the pavement structure. The extent of the deterioration will influence the decision on whether a project should be designed using the 3R design criteria or whether it should be designed using reconstruction criteria." Illinois has a nearly identical statement, but goes on to state,

> Whenever the proposed pavement improvement is major, it may be practical to include significant geometric improvements (e.g., lane and shoulder widening) in the project design. However, the proper level of geometric improvements is often determined by many additional factors other than the extent of pavement improvement. These include available right of way, environmental studies, traffic volumes, crash experience, and available funds for the project. Therefore it may be appropriate for the 3R project to include, for example, full-depth pavement reconstruction and minimal geometric improvement if supported by safety studies and the operational objectives of the 3R program.

Only three states responded that safety issues initially determine the need for a 3R project. Of the 15 that said "other," 7 states responded that the need for a 3R project was based on both the condition of the pavement and safety needs. Some "other" factors included small bridge or culvert condition, political pressure, and community requests.

Some states provide guidelines to determine if a project is to be a 3R project. Ohio provides a flow chart (see Figure 1) to determine if a project is to qualify as 3R.

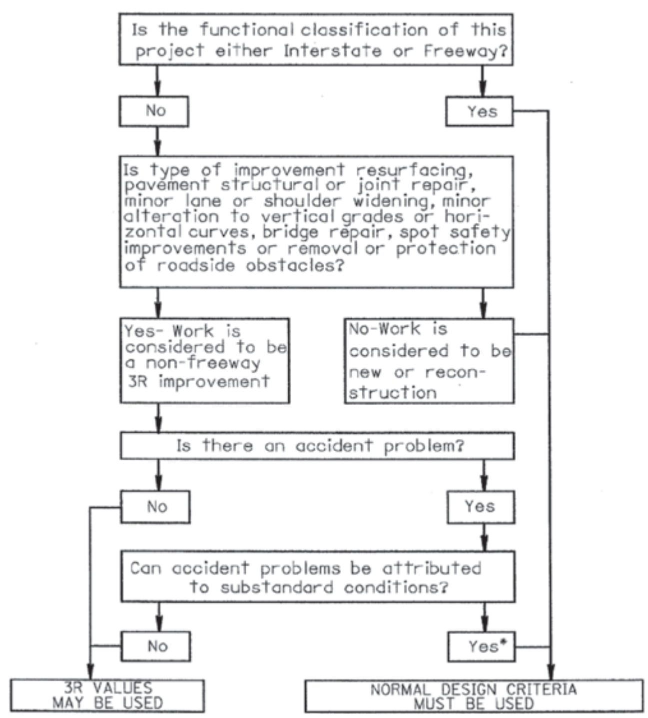


FIGURE 1 Flow chart to determine use of 3R values (Ohio).

Does the State Perform Safety Analysis or Risk Assessment to Develop Project Scope for 3R Projects?

The purpose of this question was to ascertain to what extent states conduct a safety analysis in developing a 3R project. Thirty-five states replied "yes" and 11 replied "no" (see Table D4 in Appendix D). Those who responded "yes" were asked to explain the type of analyses performed. The following are some of the common responses:

- Review of crash data,
- Benefit/cost analysis,
- Road safety audits,
- Roadside safety review, and
- Safety screening.

New York is one state that routinely conducts a safety analysis as part of determining the scope of a 3R project. NYSDOT's Safety Appurtenance Program (SAFETAP) ensures that safety considerations are incorporated into the department's maintenance paving projects. SAFETAP requires a project review of paving sites by a team of qualified department staff for the purpose of deciding the low-cost safety work to be implemented before, at the time of, or soon after, construction. During project scoping, one or more licensed professional experts from Traffic, Design, and Maintenance, and any other experts as deemed appropriate, form a safety assessment team. This team is required to—

- Perform a simple analysis of site-related computerized accident data.
- Examine the sites selected.
- Make recommendations for low-cost safety work based on the safety assessment and the selected pavement treatment.
- Complete the Resurfacing Safety Assessment Form (shown in Appendix D) that summarizes the safety related items that need to be documented. This encourages the consideration of low-cost safety and other operational improvements.

Colorado's policy is that the Headquarters Safety and Traffic Engineering Branch must perform a safety evaluation for all 3R projects. The safety evaluation is to consider all 13 geometric design criteria for the entire project and complete design exception variance requests as needed. Figure 2 shows Colorado's process for addressing safety requirements on 3R projects.

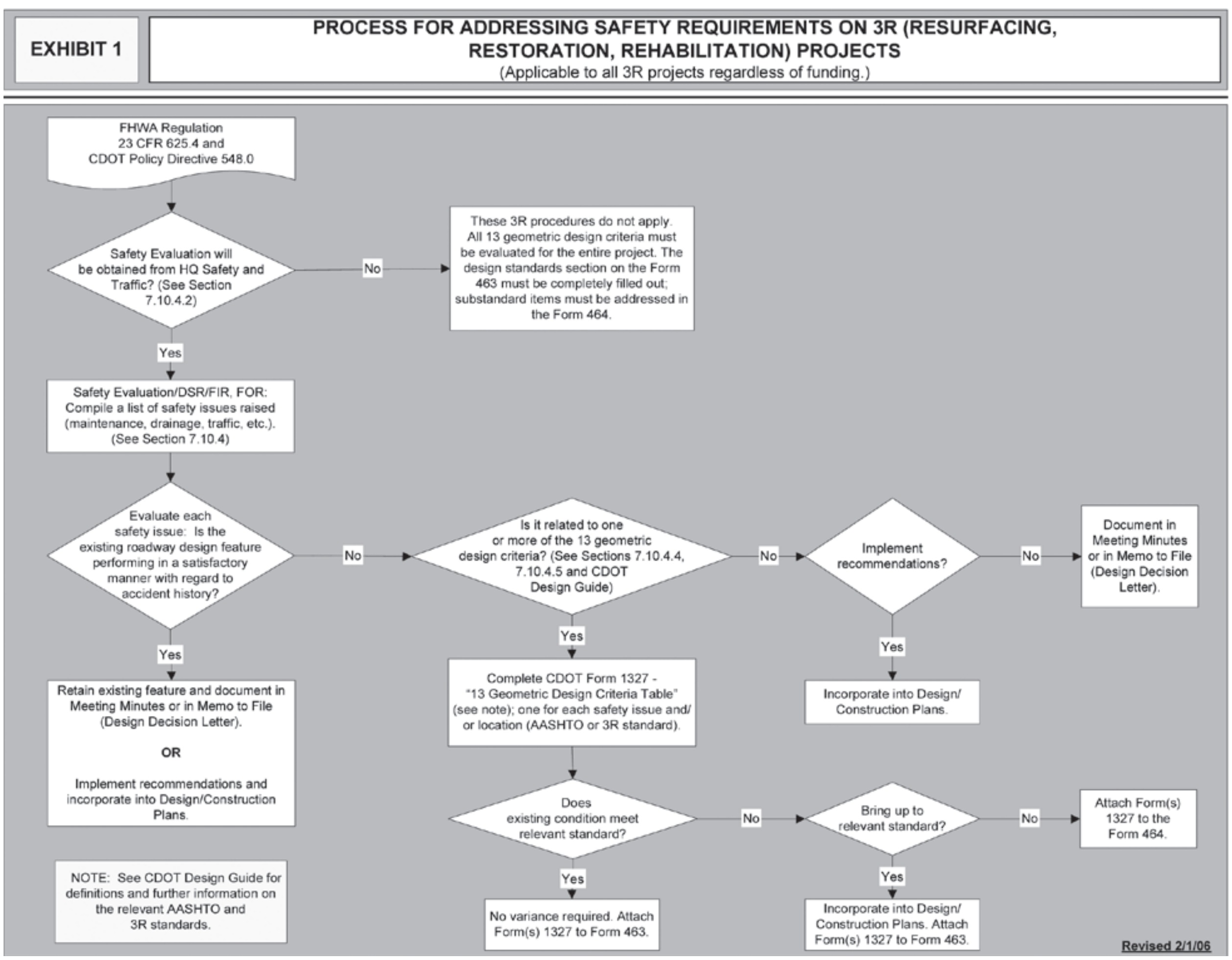


FIGURE 2 Process for addressing safety requirements on 3R projects in Colorado.

In West Virginia's non-freeway NHS 3R policy, safety enhancement is considered essential. Several years of accident data must be analyzed for each selected 3R project route segment. The designer is to coordinate with the district traffic engineer to determine if the project includes locations with known safety issues, based on the Division of Highway's tracking system prioritized safety improvements list. The 3R policy directs the designer to the *NHCRP Report 500* series and the AASHTO Strategic Highway Safety Plan (as of the preparation of its 3R policy, West Virginia had not yet prepared its own Strategic Highway Safety Plan). West Virginia makes the connection of the 3R projects with safety improvements. The policy also recommends the use of IHSDM and Road Safety Audits in determining safety improvements.

South Dakota was the only state that acknowledged the recently released *Highway Safety Manual* (*12*) by responding "*Highway Safety Manual* analysis on section for crash prediction." Appendix F provides more information on the use of *Highway Safety Manual* in determining safety improvements. No states indicated using the SafetyAnalyst software package, which is designed to help guide the decision-making process to identify safety improvement needs and develop a systemwide program of site-specific improvement projects. (More information is available at www.safetyanalyst.org/.)

Safety Improvements Included in 3R Projects

The states were asked to list the five most frequent safety improvements included in a 3R project. Table 6 shows the results of this question (see Appendix D, Table D5 for all responses). The table lists from highest to lowest the number of times an improvement was listed. Only those with at least two responses are included. Improvements made to barriers or guardrails were the most frequently listed, more than double that of the next highest improvement. Adding or improving bridge barriers and rails was listed five times, and this number could be added to the overall number for barriers. Barriers are cost-effective safety devices that do not require working beyond the ROW, and therefore are often included in a 3R project.

The second most frequently mentioned improvement was shoulder improvement, with 15 responses. This improvement includes adding, widening, and/or paving the shoulder. Although not confirmed with the responding states, it is likely that these improvements were made within the ROW. Improving the shoulder was more frequently mentioned than widening the lane width.

TABLE 6
LIST OF SAFETY IMPROVEMENTS FOR 3R PROJECTS BY NUMBER OF RESPONSES

Safety Improvement	No. of Responses
Barrier/Guardrail	30
Shoulder Addition/Widening	15
Clear Zone Obstacle Removal/Shielding	12
Intersection Improvements	12
Signs	11
Superelevation Correction	11
Rumble Strips	10
Pavement Rehabilitation	10
Pavement Markings and Delineation	9
Lane Width Widening	9
Horizontal Alignment	8
Slope Flattening	7
Cross Slope Corrections	7
Sight Distance	6
Drainage	6
Pavement Edge Drop Off	5
Bridge Barriers	5
Culvert Extensions	2
ADA Curb Ramps	2
Structures	2
Pedestrian and Bike Accommodations	2

Improvements to the clear zone and intersections were tied as the third-most-listed improvements. The types of clear zone improvements mentioned were removing or shielding roadside obstacles and removing trees. Intersection improvements mentioned included signal upgrades, curb radius increase, and additional turn lanes. Other safety improvements mentioned by 10 or more states include the following:

- Signs, which could be due to loss of retroreflectivity, damage to the sign or post, or not being needed or in compliance with the *Manual on Uniform Traffic Control Devices* (*MUTCD*).
- Superelevation correction, which would apply to curved sections and is sometimes needed with resurfacing.
- Rumble strips, a treatment for centerlines (on two-lane roads) and/or shoulders that is now being used by more states owing to its effectiveness in reducing crashes.
- Pavement rehabilitation. Because most 3R projects include pavement resurfacing, this designation may indicate a pavement improvement project more substantial than just resurfacing.

TABLE 7
RANKING OF CONTROLLING DESIGN ELEMENTS

Design Criteria	Number of Times Ranked From 1 to 13													Average Ranking
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Lane Width	9	11	4	9	6	1	1	4	2	0	0	1	0	3.8
Shoulder Width	3	8	8	7	8	5	3	0	2	3	0	0	1	4.6
Design Speed	19	5	0	4	2	5	3	1	1	1	1	2	4	4.6
Stopping Sight Distance	4	4	9	1	4	5	7	5	4	1	2	0	2	5.8
Horizontal Alignment	2	4	7	2	4	3	6	7	4	3	5	0	1	6.4
Structural Capacity	7	5	2	1	3	6	3	2	3	1	3	7	5	7.0
Superelevation	1	1	3	7	3	6	4	6	5	2	3	3	2	7.1
Bridge Width	0	1	3	4	8	4	4	4	6	5	6	3	0	7.4
Vertical Alignment	0	1	4	5	0	6	4	8	6	5	4	4	1	7.7
Cross Slopes	1	3	3	2	3	4	4	4	2	8	7	2	5	8.1
Horizontal Clearance	1	0	3	2	5	1	2	2	4	4	5	13	6	9.3
Vertical Clearance	1	3	2	3	2	1	3	1	2	4	7	4	15	9.3
Grades	0	2	0	1	0	1	2	4	7	11	5	9	6	9.9

The FHWA report *Good Practices: Incorporating Safety into Resurfacing and Restoration Projects* (*13*) is a good resource for how states can include low-cost safety improvements in their 3R projects. The types of improvements were identified through a scan tour conducted in Colorado, Iowa, New York, Pennsylvania, Utah, and Washington. During the scan, numerous good practices were observed; they are classified as either institutional or technical good practices. Appendix G provides some key excerpts from that report, which can be accessed at http://safety.fhwa.dot.gov/roadway_dept/strat_approach/fhwasa07001/.

Ranking the Importance of Design Criteria for 3R Projects

The states were asked to rank the 13 controlling design criteria from 1 (most) to 13 (least) important for a 3R project. Appendix D, Table D6 provides the responses from each state. The summary results are presented in Table 7, which shows how many times each design criterion was ranked from 1 to 13 and then the average ranking. Design criteria are listed from most important to least important. Based on the average ranking, the three most important were lane width, shoulder width, and design speed, in that order. The three least important were horizontal clearance, vertical clearance, and grades. The three design criteria that were most frequently ranked as the most important were design speed, lane width, and structural capacity.

The states were asked to explain why they considered the three highest ranking design criteria more important than the other ten criteria. The state responses are provided in Appendix D, Table D7, but some are highlighted here.

- Nineteen states listed design speed as the most important, or at least within the top three criteria. They noted that an accurate selection of design speed is essential to determining the best values for the other design elements.
- Some states replied that the highest ranking criteria are most directly related to the safety of the roadway. Some feel that the greatest safety improvements are achieved by providing adequate lane and shoulder widths. Whether the lane or shoulder width is more critical depends on the existing widths, traffic volumes, and congestion issues, as well as an assessment of accident characteristics.
- Some states mentioned that they based their ranking on what changes were more common to 3R projects, not necessarily the most important ones. For example, to be considered a 3R project, the work typically remains within the existing crown and cannot require additional ROW. The top four selected criteria can typically be adjusted within the existing crown and may improve safety by making small adjustments. If alignments, grades, and bridges are to be modified, the project typically requires ROW and utility adjustments, and therefore would fall under the reconstruction category and would not be eligible for the 3R program.

We consider the main purpose of the 3R program to be pavement maintenance. The existing structural capacity of the pavement affects the repair strategies, including the type of repair done and the thickness of the overlay. These elements are not considered more important than the others, but they are elements that typically can be addressed as part of a 3R project. Other items further down the list are important but are less likely to be brought to standard through a maintenance-type project.

A few states did not rank the criteria, and a few commented why they did not:

- A ranking of the items above was not performed. The engineer needs to weigh these items on a project specific basis.
- I do not necessarily consider them more important. Importance of design criteria should be project specific.
- This ranking is difficult, because all criteria need to be taken into consideration.
- It should be noted that the most important design feature should be assessed on a project-by-project basis, based on the unique problems that have been experienced at specific locations.

Other Design Elements That Should Be Considered for 3R Projects

States were asked if additional design elements should be considered for 3R projects beyond the 13 controlling design criteria. The full list of suggested elements from the states that responded to this question is found in Appendix D, Table D7.

Collectively, 27 design elements and other features were suggested. Table 8 shows elements or features that were mentioned by at least two states. The design element that was mentioned the most (nine responses) was clear zones. Adding the responses involving roadside safety features that relate to clear zones—guardrail upgrades (seven responses), side slopes (four responses), and crashworthy roadside features (three responses)—would increase that number to 26. The second highest design element was intersection sight distance, mentioned by six states. Given that stopping sight distance is one of the 13 design criteria, presumably the respondents were referring to the corner sight triangle distances need for turning left or right or crossing the intersection. Adding the five states that mentioned other intersection design elements (five responses) would increase intersections design criteria to 11 responses.

TABLE 8
OTHER DESIGN ELEMENTS FOR 3R PROJECTS

Other Design Elements	No. of Responses
Clear Zone	9
Intersection Sight Distance	6
Intersection Elements	5
Pavement Condition	5
ADA	4
Guardrail/Barrier Upgrades	4
Traffic Volume	4
Pedestrian Access	4
Drainage	4
Side Slopes	4
Crashworthy Roadside Features	3
Environmental Impacts	2
Bicycle Access	2
Pavement Edge Drop-Off	2

State 3R Policies for Pedestrians, Bicyclists, and ADA Requirements

One of the specific objectives of this synthesis was to ascertain how states are considering pedestrians, bicyclists, and the needs of the disabled users in their 3R policies. Three separate questions were asked for this purpose. The complete responses to these questions are in Appendix D, Table D8, for pedestrians and bicyclists and Table D9 for ADA requirements.

Of the 37 states that provided answers to the three questions,

- Thirty-four responded that consideration is given to pedestrians,
- Thirty-three responded that consideration is given to bicyclists, and
- All 37 consider ADA requirements as part of their 3R projects.

For pedestrians, the frequent descriptions were providing sidewalks, crosswalks, and pedestrian signals. For bicycle accommodations, several states mentioned widening lanes or more often widening shoulders to accommodate a bike lane or path. However, this type of improvement is dependent upon a designated bike route and/or significant bike demand, and at least two states noted that 3R projects rarely warrant significant upgrades for bicyclists. For ADA requirements, nearly all states mentioned the need to install curb ramps and other design changes to accommodate pedestrians with disabilities at intersection crossings.

Most Unanswered Issue Regarding 3R Projects

The last question on the survey solicited information on potentially unanswered issues for 3R projects. The intent was to have the states identify gaps in the guidance for effectively implementing their 3R programs. The complete responses are found in Appendix D, Table D10. Listed here are comments condensed into phrases and grouped into several themes that reflect the range of responses received.

General 3R Policy Issues

- The appropriate degree of improvement and the pitfalls of inaction.
- The constraints of accomplishing as much as possible within the ROW footprint.
- Level of safety required in system (pavement) preservation projects.
- Prioritizing upgrades to address geometric deficiencies when all cannot be met.
- The extent to which 3R projects, developed to enhance safety, have actually done so and the level of cost-effectiveness reached in that effort in these projects.
- The design criteria are very complicated. Is there a simpler list of criteria that will maximize safety and minimize cost?
- Lack of a national standard to determine the minimum design criteria that can be applied to a 3R project. Many times, engineers are reluctant to go below the minimum standards without definitive guidance to support the deviation. Development of national 3R design standards would provide a baseline from which an engineer could make a judgment call.
- Better examples of what types of projects do not qualify for 3R standards based on the language in *TRB SR 214*.
- Where is the line between new construction and 3R? Should a PCC (portland cement concrete) overlay of 8 in. get different criteria than a new pavement that is not much thicker? Many of our roadways will never be reconstructed because they are low volume and overlays are sufficient. Do we ever need to consider major upgrades on the geometrics and cross section? Currently we focus on safety upgrades that don't require substantial ROW.
- At what level does a restoration become an improvement/betterment and someone has to answer why the roadway was not reconstructed to full standards. At what point is the only reason a project was not brought to full standards because simply not enough money was budgeted for the project?
- Too much time is spent on NEPA for 3R projects. Can it be streamlined?

Specific Design Issues

- What do states do when resurfacing a roadway that was originally built with recoverable slopes in which the resurfacing results in a significant grade rise: narrow the shoulders, regrade the foreslopes, tie in steeper slopes as quickly as possible?
- A 3R project should not degrade the existing road design. However, resurfacing will sometimes raise the road profile. This can result in negative effects on the cross section design: narrowing the shoulder, steepening the shoulder cross-slope, steepening the sideslope, degrading the clear zone. How much degradation is acceptable; how should the trade-offs be determined; when should it not be allowed?
- At what values are the lack of design superelevation most critical and when is it really cost-effective to reconstruct to correct superelevation?

Pedestrian, Bicycle, and ADA Requirements

- When are projects exempt from improving bicycle and pedestrian accommodations?
- To what extent beyond signalized pedestrian crossings should such facilities be upgraded for ADA compliance?
- Accommodations for pedestrians, ADA, and bicyclists are encouraged; however, funding is never adequate. Funding is a huge issue for the three elements that if not incorporated into a project, the project's 3R aspect is dead.

Funding

- Projects are becoming more expensive because of federal and state requirements.
- It would be nice to have greater flexibility with using the federal funding that we get. We struggle with getting the most bang for our buck in regard to the pavement condition while balancing the other needs of the system, such as safety, ADA, other improvements.

CHAPTER FOUR

GEOMETRIC DESIGN CRITERIA FOLLOWED BY STATES

As stipulated in FHWA Technical Advisory T 5040.28, 13 geometric elements were established as the controlling criteria for geometric design. The survey did not ask what each state used for these design elements for 3R projects; this information was gleaned from the 3R policy documents. Design guidelines for 32 states were reviewed.

It would be difficult and impractical to describe what each state follows for the geometric elements because the standards vary widely. Many states have different standards for their class of roads, volume levels, rural vs. urban, and other categories. The design standards for each state can be seen from viewing their documents, which can be accessed at http://www.trb.org/SynthesisPrograms/Public/CompilationofStateDesignManuals.aspx.

Some state practices will be summarized in this chapter. Throughout the discussion, examples from various states will be provided; they are not necessarily meant to be examples of best practice, but an indication of the variation in how the states treat the various design elements.

Several states discuss their geometric design approach; that of Mississippi is highlighted here (from Chapter 11 of the Mississippi design manual):

> 11-2.01.03 Approach
>
> The Department's approach to the geometric design of 3R projects is to adopt, where justifiable, a revised set of numerical criteria. The design criteria throughout the other Manual chapters proved the frame of reference for the 3R criteria. The following summarizes the approach which has been adopted:
>
> 1. **Design Speed.** The tables in Section 11-2.09 present the 3R design speeds for rural arterials and rural collectors on the State highway system. Note that these speeds are lower than those for new construction/reconstruction projects, subject to the posted/regulatory speed limit.
>
> 2. **Speed-Related Criteria.** Many geometric design values are calculated directly from the design speed (e.g., vertical curves, horizontal degree of curvature). The 3R design speed is used to determine these speed-related criteria. For many speed-related elements, Chapter 11 presents an acceptable threshold value for the element which is considerably below the 3R design speed. For example, if the calculated design speed of an existing crest vertical curve is within 15 mph of the 3R project design speed and there is not an adverse accident history, the existing crest vertical curve may be retained in the project design without a design exception.
>
> 3. **Cross-Section Widths.** The criteria in Chapter 2 have been evaluated relative to the typical constraints of the 3R projects. Where justifiable, the values of the cross section width criteria have been reduced.
>
> 4. **Other Design Criteria.** The Department's Design Manual contains many other details on proper geometric design techniques. These criteria are obviously applicable to new construction and reconstruction. For 3R projects, these criteria have been evaluated and a judgment has been made on their proper application to 3R projects. Unless, stated otherwise in this Chapter, the criteria in other chapters apply to 3R projects and should be incorporated if practical.
>
> 5. **NHS Projects.** For 3R projects on NHS facilities, it is not acceptable to propose a design value which is less than the value for the existing facility. For example, the proposed roadway width must equal or exceed the existing roadway width.

This is just one state's approach to geometric design of 3R projects, although in many respects it is similar to those used by other states.

THIRTEEN CONTROLLING DESIGN CRITERIA

FHWA has identified 13 controlling criteria as having such substantial importance to the operational and safety performance of any highway that special attention should be paid to them in design decisions. FHWA requires a formal written design exception if design criteria on the NHS are not met for any of the following 13 criteria:

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. Horizontal clearance (also known as lateral offset to obstruction)

13. Structural capacity.

Table 9 shows the number of states that had design values or at least mentioned each of the 13 design elements in their 3R guidance. As shown, 31 of the 32 states have design values for lane width and shoulder width. At the other end of the distribution, only 20 of the 32 states had values for, or at least discussed, vertical clearance and grade within their 3R design policy.

TABLE 9
NUMBER OF STATES WITH DESIGN ELEMENT INCLUDED IN 3R POLICY

Design Element	No. of States
Lane Width	31
Shoulder Width	31
Bridge Width	28
Horizontal Alignment	28
Vertical Alignment	28
Design Speed	28
Cross Slope	26
Superelevation	24
Structural Capacity	24
Stopping Sight Distance	23
Horizontal Clearance	23
Vertical Clearance	20
Grade	20

Although most states discuss each of these design elements to varying degrees, a few simply present the guidelines in a table without further explanation. For example, Table 10, extracted from Michigan's road design manual, shows 3R minimum guidelines for the 13 controlling criteria applicable to non-NHS roads. A similar table is provided for NHS roads.

The following sections present examples of how the states discuss the 13 controlling criteria.

Design Speed

This criterion is typically the first mentioned, understandably so as several other design criteria are based on it. According to AASHTO (7), design speed is "a selected speed used to determine the various geometric design features of the roadway.… Once … selected, all of the pertinent highway features should be related to it to obtain a balanced design." The current edition of the *Green Book* devotes four and a half pages of discussion to design speed. In discussing design speed, references are often made to operating speed, posted speed limit, and 85th percentile speed. See Donnell (*14*) for a good discussion of alternative speed concepts and the explanation of a new speed concept.

As presented in chapter three, respondents ranked design speed as the most critical of the 13 controlling design elements, more often than any of the other elements. In the state design documents, most states mention design speed, but they differ as to which speed should be referenced, including speed limit, 85th percentile speed, and average running speed. Texas is one of a few states that have design speeds that vary by road type.

Florida DOT has the most extensive discussion of design speed in its 3R guidelines. Chapter 25 of Florida's *Plans Preparation Manual* provides Florida's design criteria for 3R projects. In general, Florida's design speed criterion is that the design speed used in the original design of the highway should be used in 3R projects and that it should not be less than the legal posted speed. (It is recognized that many 3R projects are for roads that did not have an original design speed and that the speed limit is all that is available.) Florida provides the guidance found in Table 11 for determining the appropriate design speed for three different cases.

CASE 1: The existing posted speed falls within an acceptable range of the original design speed [i.e., $PS \le DS_o \le (PS + 10$ mph). Example $DS_o = 65$ mph and $PS = 55$ mph].

CASE 2: The existing posted speed falls below an acceptable range of the original design speed. In a case like this, the posted speed was reduced, and the operational conditions have changed [i.e., $DS_o > (PS + 10$ mph). Example $DS_o = 65$ mph and $PS = 35$ mph].

CASE 3: The existing posted speed falls above an acceptable range of the original design speed. In a case like this, the posted speed was increased, and the operational conditions have changed [i.e., $PS > DS_o$). Example $DS_o = 50$ mph and $PS = 60$ mph].

Legend:

DS_o = Design speed used in the original project,

DS_p = Proposed design speed for project, and

PS = Existing (or proposed if different) posted speed.

TABLE 10
MINIMUM GUIDELINES FOR 13 CONTROLLING CRITERIA FOR NON-NHS 3R PROJECTS (Michigan)

B. Non-Freeway, Non-NHS

Geometric Elements	Non-Freeway, Non-NHS 3R Minimum Guidelines		
Design Speed	Posted Speed Minimum		
Shoulder Width	Current ADT Two-Way	Inside and Outside Shoulder Width	
NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.	≤750	2'-0" (Gravel)	
	750 - 2000	3'-0" (Paved)	
	> 2000	6'-0" (3'-0" Paved)	
	Multi-Lane (Divided & Undivided)	Inside (Divided)	Outside (Both sides for un-divided)
		3'-0" Paved	6'-0" (3'-0" Paved)
Lane Width	ADT	Lane Width	
	≤750	10'-0"	
	>750	11'-0"	
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000).	
		12'-0" lanes are desirable on the Priority Commercial Network (PCN) and the National Network (also known as the National Truck Network). Existing narrower lanes may be retained without design exceptions. Reduction of existing lane widths on the National Network to less than 12-0" require a design exception request having a high burden of justification.	
Bridge Width, Structural Capacity & Horizontal Clearances (Existing Bridges to remain in place)	ADT (Design Year)	Minimum Design Loading	Usable Width
	0 - 750	H15	Width of traveled way.
	751 - 1500	HS15	Width of traveled way.
	1501 - 2000	HS15	Width of traveled way plus 1' each side.
	2001 - 4000	HS15	Width of traveled way plus 2' each side.
	> 4000	HS15	Width of traveled way plus 3' each side.
Horizontal / Vertical Alignment and Stopping Sight Distance	Existing alignment and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph (horizontal alignment) or 20 mph (vertical alignment) below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. . See current AASHTO Green Book or MDOT Sight Distance Guidelines.		
Grade	Review crash data. Existing grade may be retained without crash concentration.		
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05		
Superelevation	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.		
Vertical Clearance	See Section 3.12.		

Lane and Shoulder Width

Wider travel lanes and wider shoulders are associated with higher capacity, higher operating speeds, and increased safety. For 3R projects, these two cross-section elements are discussed together, especially for two-lane facilities. They were also highly rated by the survey responders as critical criteria for 3R projects. In many cases, the 3R projects involve roads with lane (pavement) and shoulder widths that are less than desirable. However, widening either or both for a 3R project can be problematic, especially if additional ROW is needed. Aside from the costs for the improvement to the road, obtaining ROW can be costly and requires additional studies and approvals. Hence, it is critical for 3R projects to set design criteria for these two elements.

Table 12 shows the minimum lane and shoulder widths for two-lane rural highways recommended in *TRB SR 214*. The table in that report has been revised to show shoulder width. In *TRB SR 214*, there are two columns labeled "Combined Lane and Shoulder Width." In preparing Table 12, it is assumed that the shoulder width is the combined lane and shoulder width minus the lane width.

TABLE 11
3R DESIGN SPEED VERSUS POSTED SPEED (Florida DOT)

Condition	Establishing Proposed Project Design Speed (DS_p)
Case 1	Use the design speed used in original design of highway. $DS_P = DS_o$
Case 2	Use the design speed used in original design of highway unless a reduced design speed (not less than posted speed) is approved by the District Design Engineer and District Traffic Operations Engineer. $DS_p = DS_o$
Case 3	Use the design speed used in original design of highway unless there is a significant crash history associated with a specific highway feature. If so, then the design speed used in correcting the feature shall be equal to or greater than the posted speed. The posted speed shall also be used as the design speed for any other new highway features (not replacements). $DS_p = DS_o$ and $DS_p = PS$ (for design of features that are new or have a significant crash history)

The review of the states' design manuals on 3R revealed considerable variation for these two cross-section elements, not so much in the actual widths but in the conditions. Some states have one value for all road types and conditions, whereas several others have values that vary by ADT, speed, urban vs. rural, and road type. Vermont is an example of a state that has minimum values for lane and shoulder width that vary by ADT, rural vs. urban location, and NHS vs. non-NHS facility. Table 13 shows their values. In addition, Vermont's guidelines state that all shoulder widths should be reviewed for accommodation of bicycle and pedestrian traffic according to its *Pedestrian and Bicycle Facility Planning and Design Manual*.

TABLE 13
MINIMUM LANE/SHOULDER WIDTHS FOR VERMONT 3R PROJECTS

Design ADT	NHS		Non-NHS	
	Rural	Urban	Rural	Urban
<10,000	11/3	12/2	9/1	12/2
≥10,000	11/4	12/2	11/3	12/2

A relevant question for 3R projects is, "Given a fixed roadway width for two-lane, undivided, rural roads, which is safer—wider shoulders or wider lanes?" This question is particularly relevant to 3R projects because these projects are typically constrained to be within the existing ROW. If any geometric improvements are to be made for a specific project, one question to consider is whether it is more cost-effective to widen the lanes, with a corresponding reduction in shoulder width, or widen the shoulder, with a corresponding reduction in lane width. This question was the subject of a study by Gross et al. (*15*), who used geometric, traffic, and crash data for more than 44,500 miles of roadway segments in Pennsylvania and 8,300 miles in Washington State to evaluate the safety effectiveness of lane-shoulder configurations for fixed total paved widths. The results from these two states were combined with two other relevant information sources on this topic: (1) the chapter on two-lane rural roads from the *Highway Safety Manual* (*12*), and (2) a report by Texas DOT (*16*). From these three sources, Gross et al. developed the Crash Modification Factors (CMF), which are graphically presented in Figure 3 in relation to a 36-ft baseline with 12-ft lanes and 6-ft shoulders. The general finding is that, given a fixed paved width, configurations with wide lanes and narrow shoulders are associated with a reduction in crashes. This finding supports the notion that, all things being equal, it is more important to keep the motorist on the travel lane than to provide more space for recovery at the expense of travel lane width. It also demonstrates that wider pavement widths (32 ft to 36 ft) are associated with fewer crashes than narrow pavement widths (26 ft to 30 ft).

TABLE 12
MINIMUM LANE AND SHOULDER WIDTHS RECOMMENDED IN *TRB SR 214*

Volume/Speed		10 Percent or More Trucks[a]		Less Than 10 Percent Trucks	
Design Year Volume (ADT)	Running Speed (mph)	Lane Width (ft)	Shoulder Width (ft)	Lane Width (ft)	Shoulder Width[b] (ft)
1–750	Under 50	10	2	9	2
	50 and over	10	2	10	2
751–2,000	Under 50	11	2	10	2
	50 and over	12	3	10	3
More than 2,000	All	12	6	11	6

a Trucks are defined as heavy vehicles with six or more tires.
b One ft less for highways on mountainous terrain.

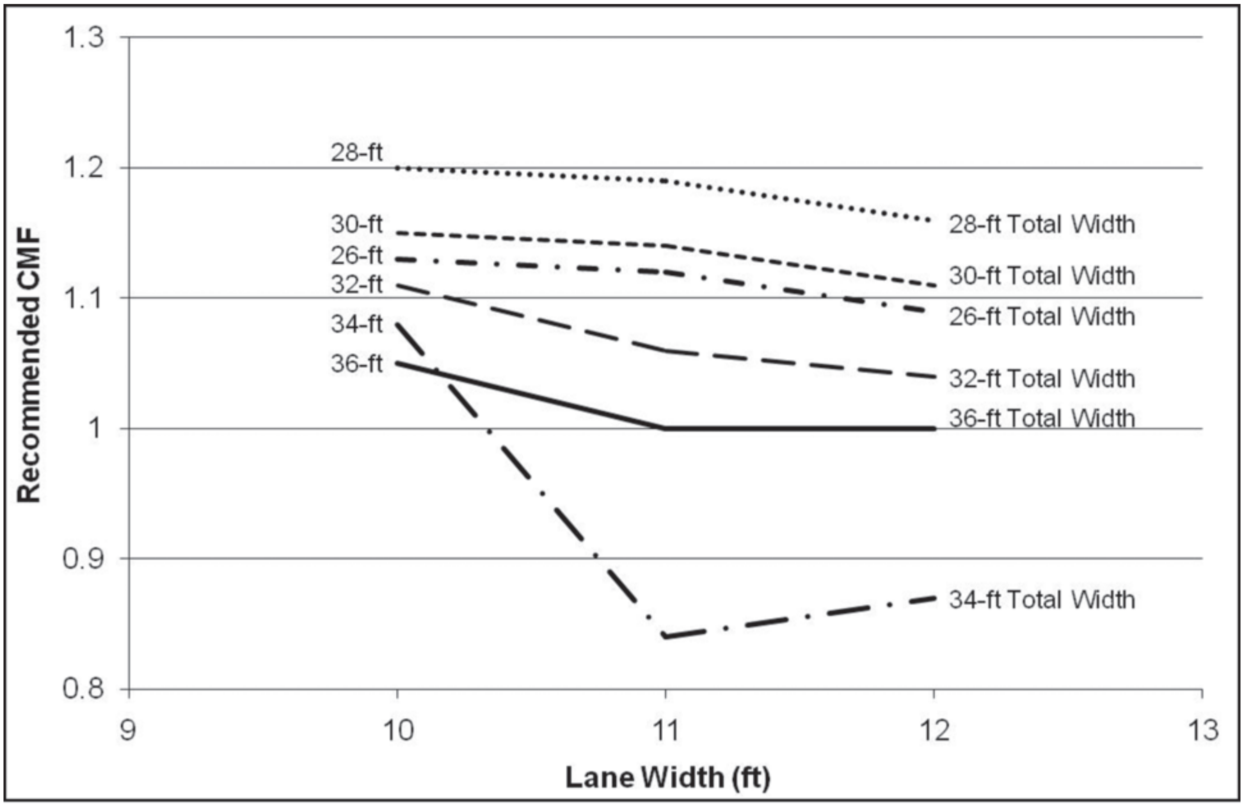


FIGURE 3 Selected CMFs from research and literature in relation to 36-ft baseline with 12-ft lanes and 6-ft shoulders [*Source:* Mahoney et al. 2006 (*13*)].

Bridge Width

Quite often, especially for rural roads, the width of the bridge is less than the width of the approach roadway. The shoulders are often eliminated and the total travel lane width may be less than that of the approach roadway. This can be a safety hazard even if the bridge has adequate bridge rails and barriers. *TRB SR 214* recommended that highway agencies evaluate bridge replacement or widening if the bridge is less than 100 ft long and the clear width of the bridge is less than the following values:

Design Year Volume (ADT)	Clear Bridge Width (ft)
0–750	Width of approach lanes
751–2,000	Width of approach lanes plus 2 ft
2,001–4,000	Width of approach lanes plus 4 ft
More than 4,000	Width of approach lanes plus 6 ft

The recommendation also stated that if lane widening is planned as part of the 3R project, the clear (the term used in *TRB SR 214* is "usable," which is the same as "clear," the term used by AASHTO) bridge width should be compared with the planned width of the approaches after they are widened. This recommendation is included in FHWA Technical Advisory T 5040.28.

Florida is one state that has a slightly higher guideline. Table 14 shows the clear width criteria for bridges to remain in place.

TABLE 14
CLEAR WIDTH CRITERIA FOR BRIDGES (Florida)

Design Year (ADT)		Minimum Usable Bridge Width (ft)
Undivided	0–750	Total width of approach lanes + 4
	750+	Total width of approach lanes + 8
Divided	ALL	Total width of approach lanes + 5.5 (median separator)*
		Total width of approach lanes + 6.5 (median barrier wall)**
One-Way Bridges	ALL	Total width of approach lanes + 6.5 (2.5 Lt. and 4.0 Rt.)

*1.5 ft median and 4 ft outside shoulder.
**2.5 ft median and 4 ft outside shoulder.

Structural Capacity

This design element refers to bridge structural capacity. Bridges are usually designed to accommodate either an H-15 or HS-20 loading. An H-15 loading is represented by a two-axle single-unit truck weighing 15 tons with 2 tons on its steering axle and 12 tons on its drive axle. An HS-20 loading is represented by a three-axle semitrailer combination weighing 36 tons with 4 tons on its steering axle, 16 tons on its drive axle, and 16 tons on the semitrailer axle. The "20" is 20 tons for the 4 tons on steering axle and 16 tons on the drive axle. The "S" stands for semitrailer combination, which adds in the additional 16 tons for the third axle to give a total of 36 tons.

Many states do not mention structural capacity in their 3R guidelines. Examples of states that do have a structural capacity requirement include the following:

- Alaska—If structural capacity is less than HS-15, replace member.
- Georgia—Retained bridges must have HS-15 capacity.
- Florida—Bridges on collector facilities are to have an HS-15 capacity and HS-20 on arterial facilities.
- Ohio—Bridges on expressways and arterials are to have minimum design capacity of HS-20; all other roads are to be HS-15, except that local roads with ADTs of 50 or less can have an HS-10 capacity.

Horizontal Alignment and Superelevation

In terms of the 13 controlling criteria, horizontal alignment refers only to the horizontal curvature of the roadway. The adopted design criteria specify a minimum radius for the selected design speed, which is calculated from the maximum rate of superelevation (set by policy from a range of options) and the side friction factor (established by policy through research). Although superelevation is considered a separate criterion, it is often discussed in relation to horizontal curvature. Horizontal alignment influences stopping sight distance, another primary controlling criterion.

TRB SR 214 has two recommendations regarding horizontal curvature (and superelevation):

- Recommendation No. 6. Highway agencies should increase the superelevation of horizontal curves when the design speed of an existing curve is below the running speeds (85th percentile speed is to be used for this comparison) of approaching vehicles and the existing superelevation is below the allowable maximum specified by AASHTO new construction policies. Highway agencies should evaluate reconstruction of horizontal curves when the design speed of the existing curve is more than 15 mph below the running speeds of approaching vehicles (assuming improved superelevation cannot reduce this difference below 15 mph) and the average daily traffic volume is greater than 750 vehicles per day.

- Recommendation No. 7. At horizontal curves where reconstruction is unwarranted, highway agencies should evaluate less costly safety measures such as widening lanes, widening and paving shoulders, flattening steep sideslopes, removing or relocating roadside obstacles, and installing traffic control devices.

Nearly every state's design guidelines discuss their policy with regard to horizontal alignment, or specifically, horizontal curves. Some refer to the FHWA Technical Advisory and/or *TRB SR 214*, or have essentially the same information as contained in Recommendation No. 6. Georgia's policy, shown in Table 15, is tied to the accident history of the existing curve and the speed (presumably running speed, because not mentioned).

TABLE 15
POLICY FOR HORIZONTAL ALIGNMENT FOR EXISTING FEATURES (Georgia)

Condition	Accident History	Policy
≤10 mph below AASHTO guidelines	Low, compared with statewide average	Retain. The designer shall address and justify existing features to be retained which do not meet 3R guidelines
≤10 mph below AASHTO guidelines	Directly related accident history compared with statewide average	Correct to AASHTO guidelines or to the highest design speed practical
>10 mph below AASHTO guidelines	Not applicable	Correct to AASHTO guideline if practicable. If not, correct to highest design practicable and request a design exception.

Wisconsin's *Facility Development Manual* provides the following for horizontal curves and superelevation:

> 1.5.3 Horizontal Curves and Superelevation
>
> Identify potentially hazardous curves through crash analysis and safety reviews. (See Attachment 1.7 [Figure 4] for a decision tree flow chart on the treatment of existing horizontal curves.) Evaluate these for reconstruction or application of other safety measures. Even if a location doesn't have a high crash rate, improvements may still be desirable. Superelevation rates in excess of 8% shall be reduced to 8%, or less (see FDM 11-10-5).
>
> High hazard locations, regardless of AADT, need to be identified and corrected, as noted above. In addition, deficient horizontal curves or superelevation shall be upgraded on highways where the design traffic volume exceeds 750 AADT and where any of the following conditions exist:
>
> 1. If the existing curve radius equals or exceeds that required for the project design speed, but the superelevation is less than required, then increase the superelevation to the required rate.
>
> 2. If the existing curve radius is less than, but within 15 mph of, that required for the project design speed, but the superelevation is less than e max, then increase the superelevation to the e max rate (see FDM 11-10-5).

3. If the existing curve radius is less than, and not within 15 mph of that required for the project design speed, then realign the curve. Curve realignment, when warranted, is desirably to new construction standards, but as a minimum shall provide a design speed through the curve that is within 10 mph of the overall project design speed.

Proposed curve or superelevation modifications that aren't warranted, as described above, will desirably be consistent with adjacent sections of road, and will minimally not reduce the existing curve speed rating. If a deficient curve is either not reconstructed or is reconstructed to less than new construction standards, then apply appropriate safety mitigation measures.

Vertical Alignment

In terms of the 13 controlling criteria, vertical alignment includes only vertical curvature (both crest and sag). Grade is considered separately and discussed below. As horizontal curves are to horizontal alignment, vertical curves are to vertical alignment. Vertical curvature influences stopping sight distance, another primary controlling criterion. The geometric design basis for minimum length of crest vertical curvature is to provide the minimum stopping sight distance for the combination of grades and design speed. Sag vertical curves are normally designed so that the curve does not restrict the distance of roadway illuminated by vehicle headlights, which would reduce stopping sight distance at night.

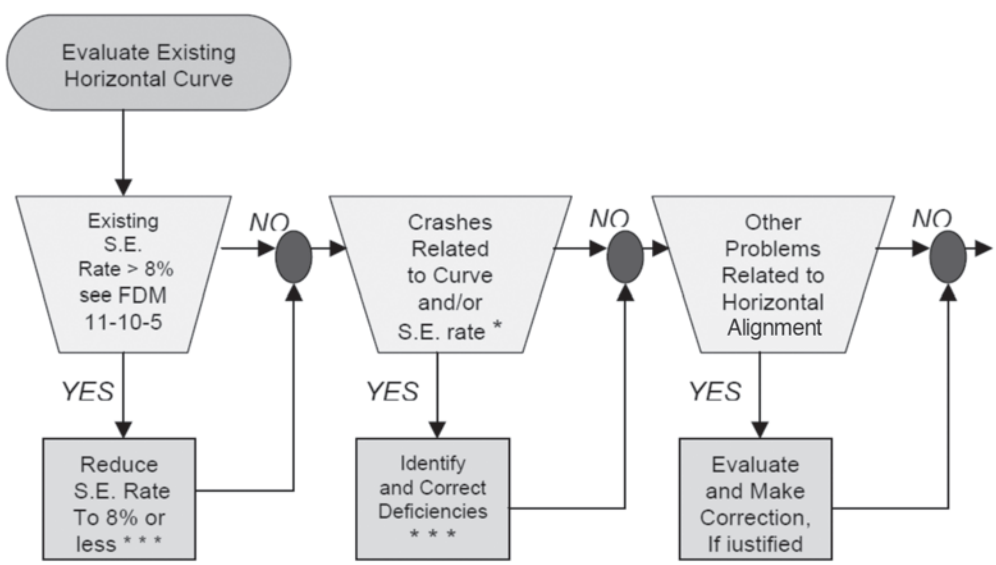
TRB SR 214 makes the following recommendation with regard to vertical curvature and stopping sight distance:

> Recommendation No. 8: Highway agencies should evaluate the reconstruction of hill crests when (a) the hill crest hides from view major hazards such as intersections, sharp horizontal curves, or narrow bridges; (b) the average daily traffic is greater than 1,500 vehicles per day; and (c) the design speed of the hill crest (based on minimum stopping sight distance) is more than 20 mph below the running speeds (85th percentile) of vehicles on the crest.

The review of the states' design policies for this feature shows that most states have stated guidelines, with several following *TRB SR 214*. Several states note that improvement to a vertical curve is determined by its safety record. Utah includes the *TRB SR 214* recommendation, and summarizes its policy as shown Table 16. Georgia DOT uses the same guideline used for horizontal alignment, which was shown in Table 15.

Stopping Sight Distance

Stopping sight distance is an important design criterion for safety. The longitudinal sight distance provided along the road will determine a driver's ability to stop to avoid an object in the road given the vehicle speed. AASHTO's *Green Book* provides minimum stopping sight distance based on design speed and grade.



*Accelerated Design Process Can Be Used for

**e.g., -Curve Hidden From View by Crest of Hill
- Sharp Curve in a Series of Gentle Curves
- Compound Curve
- Sight Distance Deficiency Due to Horizontal.

***This Needs to Be Done Unless There Is an Approved Exception to Standards or a Programmatic Exception to Standards (PESR) (see Accelerated Design Process).

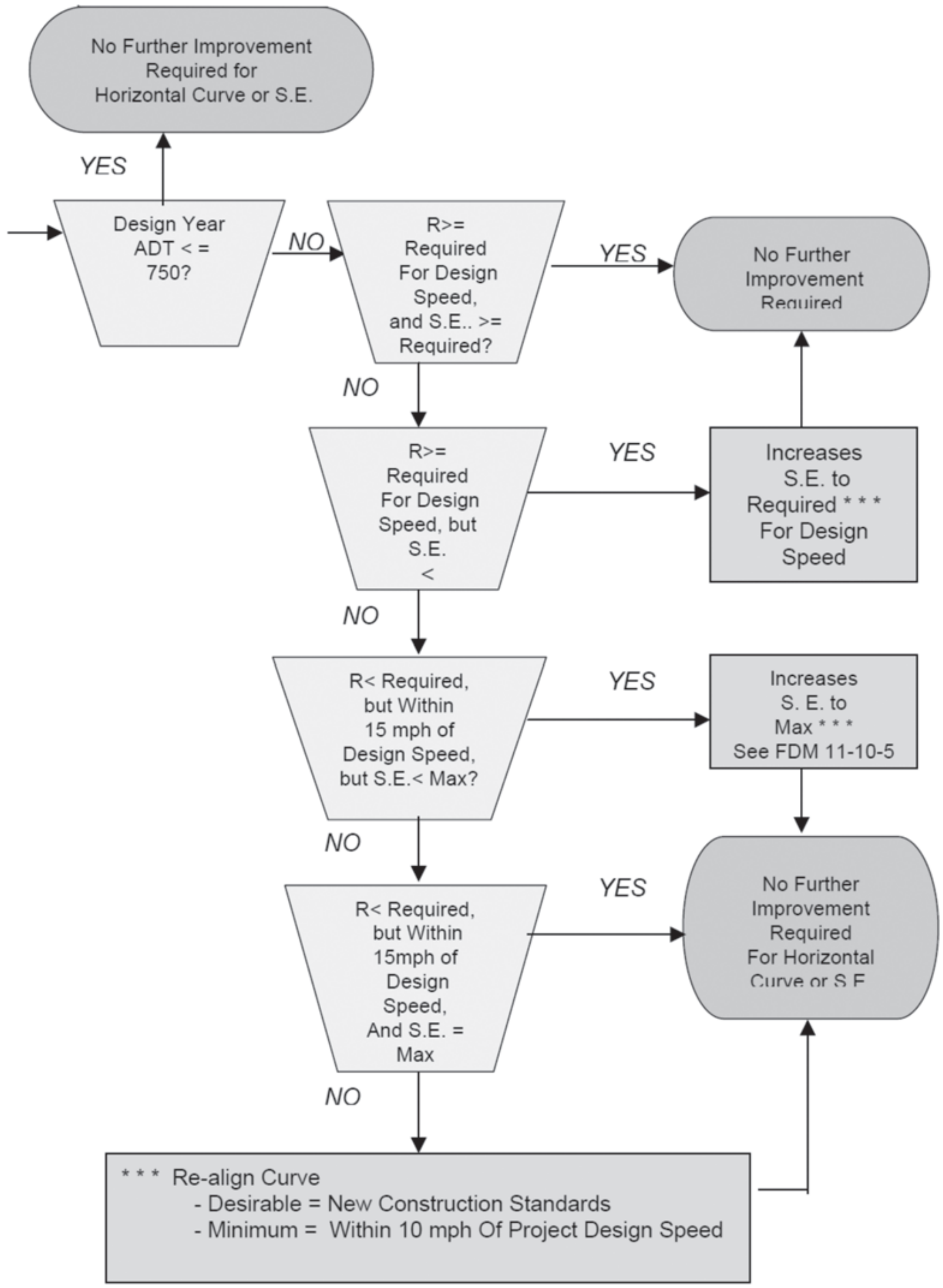


FIGURE 4 Decision tree for treatment of existing horizontal curves.

Because stopping sight distance is integral to horizontal and vertical alignment, many states discuss it within these two alignment features. For example, Wisconsin has the following guideline for crest vertical curves that is based on stopping sight distance:

> All crest vertical curves with an existing design speed based on stopping sight distance provided, not within 15 mph of the overall project design speed shall be upgraded on highways with a design traffic volume over 1,500 AADT.

Alabama has a similar guideline:

> Crest vertical curves should be evaluated for reconstruction when:
>
> - The design speed of the curve (based on stopping sight distance) is more than 20 mph below the project design speed, and
> - The design year ADT is greater than 1,500 vehicles per day.

Florida simply provides a table showing its requirements for stopping sight distance (see Table 17).

TABLE 16
VERTICAL CURVE IMPROVEMENT GUIDELINE (Utah DOT)

Design Speed (D.S.) > AADT >	Lower than Project D.S. <1,500 VPD	Lower than Project D.S. >1,500 VPD	Within 20 mph of Project D.S. < 1,500 VPD	Within 20 mph of Project D.S. >1,500 VPD
Alignment *	MI/R	R	M	MI/R

M = Mitigate for existing substandard design elements.
MI = Minor design improvements other than reconstruction.
R = Reconstruct vertical curve to current UDOT standards based on cost/benefit analysis.
* High-accident locations must be analyzed for reconstruction to current UDOT standards.

TABLE 17
STOPPING SIGHT DISTANCE REQUIRED FOR 3R PROJECTS IN FLORIDA

Design Speed (mph)	Stopping Sight Distance (ft)
15	80
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645

Cross Slope

Typically, the pavement surface is sloped slightly to facilitate water drainage. For undivided road on tangents or flat curves, there is a crown or high point at the middle and a cross slope downward toward both edges. On divided multilane roads, the cross slope can be sloped either one way across the travel lanes or two ways. Normal travel way cross slopes range from 1.5% to 2% for paved surfaces (any asphalt or concrete type surface) and 2% to 6.5% for unpaved surfaces (earth, gravel, or crushed stone). If the slope is too small water will stand on the pavement, but if the slope is too large it can affect vehicle tracking. On curved sections, the cross slope essentially becomes the superelevation and the speed-curvature relationships determine the required slope. For 3R projects, there are two concerns—the existing pavement may have inappropriate cross slopes (or superelevation), and the resurfacing could change the cross slope (superelevation) from adequate to inadequate if not done properly.

The review of many state design manuals showed that several did not discuss cross slope. For those that did, several simply stated that the minimum should be 1.5%, with the maximum being 2.5% (e.g., Alabama and Georgia) or 3.0% (e.g., Utah and New York). Wisconsin specifies that when 3R projects include new pavement or pavement resurfacing, a 2% pavement cross slope should be provided. However, a 1.5% cross slope may be provided when resurfacing portland cement concrete pavements that have a cross slope of 1% or flatter.

Some states provide cross slope values for shoulders. For example, New York specifies a minimum of 2% to 8% maximum and even specifies values for parking lanes on urban facilities—1.5% minimum to 5% maximum.

Grades

The grade of the road can affect operating speed, especially for trucks and other large vehicles. Steep grades can have deleterious effects on safety, especially on downgrades. According to the *Green Book*, maximum grades of about 5% are considered appropriate for a design speed of 70 mph and 7% to 12% for a design speed of 30 mph. The terrain plays a major factor in the grade provided.

Most of the states do not mention grade requirements for 3R projects. It was ranked as the least important design criterion. Some states that do mention grades in their 3R policy state that the existing grade should remain unless there is an identified safety problem associated with the section and the improvement can be made cost-effectively. When the grade has to be reduced for safety or operational reasons, it usually requires significant reconstruction, which moves the project out of the 3R program.

Horizontal Clearance (Other Than Clear Zone)

The requirement for horizontal clearance is sometimes confused with clear zone. Horizontal clearance is defined as the lateral distance (offset) from the edge of the travel lane to a roadside feature or object, such as curbs, walls, barriers, bridge piers, sign and signal supports, trees, and utility poles. This is not the same as clear zone. Clear zone is a clear recovery area, free of rigid obstacles and steep slopes, that allows vehicles that have run off the road to safely recover or come to a stop. While horizontal clearance can be thought of as an operational offset, the clear zone primarily serves a substantive safety function.

Few states provide guidance on this design feature for 3R projects. An exception is Florida, which provides guidance for horizontal clearances for traffic control signs, light poles, utility installations, signal poles and trees (see Chapter 25 of the Florida DOT's *Plans Preparation Manual*).

Vertical Clearance

Vertical clearance is the distance from the top of the pavement (at the highest elevation) to the bottom of the overhead structure, usually a bridge overpass for another road or railroad, or possibly a sign truss or pedestrian bridge. If a new layer of pavement surfacing is placed over the existing surface, the clearance will decrease by the depth of the resurfacing, which could be an inch or more. This will decrease the vertical clearance accordingly, so it should be taken into consideration for 3R projects. Also, the existing road may already have an overpass structure that does not meet minimum vertical clearance standards.

Only a few states discuss vertical clearance in their 3R policy. Those that do cite 14 ft as a minimum for keeping a structure as is, and as low as 13.5 ft for non-NHS routes. Oklahoma requires 14 ft 6 in. for existing bridges on state highways and 14 ft for nonstate highways for 3R projects. Indiana requires 17 ft minimum for existing sign trusses or pedestrian bridges.

OTHER DESIGN CRITERIA

One of the survey questions asked whether the states felt that other design features beyond the 13 controlling criteria should be considered. The responses to that question are presented in Table 8. Many design elements were suggested, with the highest responses related to roadside elements including clear zone, guardrail upgrades, and crashworthy roadside features.

Clear Zone and Side Slope

The review of the states' design documents showed that several states have guidelines for roadside elements, with at least 18 states providing clear zone guidance. The guidelines for clear zone vary from specific values to general statements of the desirability of adequate clear zone. For example, Mississippi's design manual for 3R projects notes that providing full clear zone for 3R projects can be difficult to achieve, and therefore the designer must exercise considerable judgment when determining the appropriate clear zone. Factors to be considered in that judgment include the following:

- Accident data – specifically, clusters of run-off-the-road accidents.
- Utilities – relocation is mandatory when the poles physically interfere with construction, but relocations for safety benefits must be evaluated on a project-by-project basis.
- Application – selective application of the roadside clear zone criteria may be appropriate, depending upon the nature of the hazards.
- Public – the community impact should be considered, especially when it involves tree removal.
- Safety appurtenances – installing barriers or impact attenuators is an alternative to providing a clear zone.

In addition to this general guidance, Mississippi provides a table for recommended clear zone distances that are based on design speed, design ADT groups, and side slope for both fill and back slopes.

Ohio's guideline states that "on 3R improvements, unless accident history, public complaint or site inspections indicate a problem, it may not be cost effective to fully comply with the clear zone requirements for new construction [reference is made to a figure that is in compliance with the guidance provided in the Roadside Design Guide]. Therefore, the clear zone criteria shown [in the referenced figure] may be reduced by 50% on 3R improvements."

West Virginia has different design guidance for clear zone for NHS and non-NHS routes. For NHS multilane highways, the minimum clear zone is to be that stipulated in the RDG. Separate values are provided for two-lane rural and urban highways. For non-NHS highways, there are no set clear zone width values. The mountainous terrain of West Virginia makes it difficult to provide a clear zone. It is acknowledged that a policy that requires a statewide uniform clear zone distance would be neither practical nor effective.

Side slopes are relevant to the provision of clear zone; hence, several states refer to the need for flattening steep side slopes. Florida's guidance on side slopes is listed below:

Front slopes:

1. 1:6 are desirable.
2. 1:4 may be constructed within the clear zone.
3. 1:3 may be constructed outside the clear zone.
4. Existing front slopes 1:3 or flatter may remain within the clear zone. Shielding may be required.
5. Steeper than 1:3 shall be shielded.
6. Consideration should be given to flattening slopes of 1:3 or steeper at locations where run-off-the-road type crashes are likely to occur (e.g. on the outsides of horizontal curves).
7. The proposed construction should not result in slopes steeper than the existing slopes in violation of the above values.

Back Slopes:

1. 1:4 are desirable.
2. 1:3 may be constructed in the clear zone.
3. 1:2 may be constructed outside the clear zone without shielding.
4. Existing back slopes 1:2 and flatter may remain.
5. Existing back slopes steeper than 1:3 within the clear zone may require shielding.

Pedestrian and Bicycle Accommodations

Most states have guidelines for making improvements to accommodate pedestrians and bicycles as part of 3R projects. Florida noted that according to its state statute, it must fully consider pedestrian and bicycle ways in every transportation project, especially those in or within 1 mile of an urban area. Within its *Plans Preparation Manual*, Florida provides a considerable discussion of providing for pedestrian, bicyclist, and transit needs. As with most states, Florida's guidelines call for meeting ADA requirements on detectable warnings and curb ramps. For bicyclist needs, Florida has guidance for providing space within the travel way for bicycles; bicycle lanes at right-turn lanes; and proper treatment of drainage inlets, grates, and utility covers. Under transit needs, it states that a 5-ft-wide sidewalk that connects a transit stop or facility with an existing sidewalk or shared use path shall be included to comply with ADA accessibility standards.

Other Considerations

Many states include guidance for other design features for 3R projects. A partial list of those features includes intersections, drainage, railroad grade crossings, highway lighting, signing and markings, and utilities.

CHAPTER FIVE

SUMMARY OF FINDINGS AND RECOMMENDATIONS FOR FURTHER RESEARCH

Under the current federal law, states may set their own design criteria and standards for resurfacing, restoration, and rehabilitation (3R) projects, with FHWA approval. Given that allowance, wide variations are to be expected in the states' 3R policy and geometric design guidelines. According to the state survey responses, their practices can be summarized as follows:

1. All but eight states have an FHWA-approved 3R policy. The remaining eight states have similar programs and design policies that have been developed to achieve the same purpose—extend the service life and enhance the safety of the selected road.

2. The number of 3R projects implemented annually varies widely among the states, from as few as 2 to 3 to as many as 500 to 600 projects. This variation is not directly related to the size of the state or the mileage under its control, but rather depends on the types of improvements made under 3R. The large numbers of 3R projects reflect projects that involve only pavement improvements, whereas those with only a few projects involve more improvements.

3. The time necessary for implementing 3R projects also vary widely among the states, ranging from a few months to 2 or more years. This variation also relates to the type of 3R project and the need for special studies, including environmental reviews and citizen vetting.

4. Nearly all states routinely consider safety improvements in developing 3R projects. The three safety improvements most frequently implemented as part of a 3R project are (1) barrier upgrades, (2) shoulder addition or widening, and (3) clear zone obstacle removal or shielding.

5. Although many states include safety improvements, there appears to be limited use of analytical assessments of safety beyond "looking at crash data." The use of new safety analysis tools and methods, such as road safety audits/assessments, the application of the information in the new *Highway Safety Manual*, the Interactive Highway Safety Design Model, and SafetyAnalyst, is only just emerging.

6. Although there are wide variations in the scope of the 3R guidelines, nearly all states include design levels or at least discussions for the 13 controlling design elements. Design speed, lane width, and shoulder width are the geometric design criteria that are viewed as the most critical for 3R projects.

7. Several states indicated that other design criteria should be included. The most cited features were clear zone; intersection sight distance; and accommodations for pedestrians, bicyclists, and Americans with Disabilities Act requirements.

8. Nearly all states responded that there are unanswered issues regarding the 3R program. The key issues appear to be the following:

- What is the appropriate degree of improvement to enhance safety?
- Prioritizing upgrades to address geometric deficiencies when all cannot be met.
- Lack of a national standard to determine the minimum design criteria that can be applied to a 3R project.
- Better guidance on what type of improvements should be made for pedestrians and bicyclists and when are projects exempt from improving bicycle and pedestrian accommodations.

Some key questions still remain. Is it better to improve more projects to less stringent but adequate standards than to build fewer projects to currently accepted standards for new highway construction? Is it better to construct only those safety features that are cost-effective rather than bringing every feature of every project up to the latest standards? The conundrum facing highway officials is how to decide which well-serving objectives can be met most cost-effectively.

The recommended research stemming from this synthesis can be summarized as two major needs:

1. A general research need is to continually advance the state of the art of the relationship of the various design elements, individually or in combination, to safety. States need to know what safety benefit will be derived from an improvement in any geometric

element alone and in combination with others. With "perfect" information on these relationships, states will be able to select safety improvements that will yield the largest safety return for the available funds for any specific 3R project or for their entire annual 3R program. This effort would include developing crash prediction models for various design elements under different conditions of road types, volume levels, and other influencing variables, and expanding the database on crash reduction/modification factors for individual safety improvements.

2. States need a proven optimization model or program that would allow them to decide how best to allocate their limited funds for 3R improvements. Within a given budget cycle, there will be competing projects, each of which is likely have a net benefit. Selecting projects from a simple ranking of highest to lowest benefit or benefit to cost will not always yield the most effective allocation of funds. Several factors affect project selection, and to the extent possible these factors should be captured within an optimization program for rational selection of projects.

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APPENDIX A

FHWA Technical Advisory T 5040.28
Developing Geometric Design Criteria and Processes for Nonfreeway 3R Projects

U.S. Department of Transportation
Federal Highway Administration

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Technical Advisory

Developing Geometric Design Criteria and Processes for Nonfreeway RRR Projects

T 5040. 28

October 17, 1988

1. **PURPOSE** . To provide guidance on developing or modifying criteria for the design of Federal-aid, nonfreeway resurfacing, restoration, or rehabilitation (RRR) projects.
2. **CANCELLATION** . FHWA Technical Advisory T 5040. 21, Geometric Design Criteria for Nonfreeway RRR Projects, dated April 4, 1983, is canceled.
3. **BACKGROUND**
   a. Part 625 of Title 23, Code of Federal Regulations (CFR) , "Highways" (23 CFR 625) , was revised on June 4, 1982 (47 FR 25263, June 10, 1982) , to allow greater flexibility and local discretion in the geometric design of nonfreeway RRR projects. Effective July 12, 1982, minimum geometric design criteria for new construction and reconstruction no longer applied to Federal-aid nonfreeway projects unless a State specifically proposed adoption of those criteria for nonfreeway RRR projects. Separate geometric design criteria could be developed and adopted for nonfreeway RRR projects.
   b. Part 625 was further revised on March 24, 1983 (48 FR 13410, March 31, 1983) to comply with subsection 109(o) , Title 23, United States Code (U. S. C.) , "Highways" (23 U. S. C. 109(o)) added by Section 110(a) of the Surface Transportation Assistance Act of 1982.

      This subsection clarifies that federally funded nonfreeway RRR projects shall be constructed to preserve and extend the service life of existing highways and enhance highway safety.

   c. Technical Advisory T 5040. 21, Geometric Design Criteria for Nonfreeway RRR Projects, dated April 4, 1983, was issued to provide guidance relating to 11 factors to be addressed, as a minimum, in the geometric design criteria developed by a State for use on RRR projects.
   d. Part 625 was again revised on April 9, 1985 (50 FR 14914, April 15, 1985) , to adopt as policy for geometric design a new publication by The American Association of State Highway and Transportation Officials titled "A Policy on Geometric Design of Highways and Streets." In the implementing memorandum dated April 15, 1985, subject "Implementation of New Design Criteria for Federal-Aid Projects," 13 controlling criteria were identified. Deviation from these criteria required a formal design exception.
   e. "Special Report 214, Designing Safer Roads, Practices for Resurfacing, Restoration, and Rehabilitation," Transportation Research Board (TRB) , 1987, was the result of a study on safety cost-effectiveness of highway geometric design standards for RRR projects onexisting Federal-aid highways mandated by the Surface Transportation Assistance Act of 1982. Part 625 was amended on April 25, 1988 (53 FR 15669, May 3, 1988) , to add this report, as a guide and reference, to the list of publications for application on Federal-aid projects. The recommendations on design criteria and procedures in Special Report 214 have been incorporated into this Technical Advisory.
4. **PROCEDURES**
   a. As used in this Technical Advisory, the term "criteria" as it relates to RRR means either specific design criteria or procedures or a process which establishes geometric design values for individual projects or groups of projects.
   b. Each State may choose one or a combination of the following options:

      (1) develop and adopt geometric design criteria specifically for nonfreeway RRR projects,

      (2) adopt and apply current geometric design criteria for new construction (referenced in 23 CFR 625. 4(a) (1)) to nonfreeway RRR projects, and/or

      (3) continue to use previously approved geometric design criteria for nonfreeway RRR projects which have been in existing Certification Acceptance or Secondary Road Plan agreements, provided such criteria are consistent with 23 U. S. C. 109(o).

   c. The RRR criteria developed by a State should indicate the types of projects covered. Criteria may be adopted to cover all RRR projects, or RRR projects grouped by geographic region, type of work involved, functional classification, special purpose, or other appropriate manner.

d. The recommendations and other information contained in TRB Special Report 214 relating to geometric design may be used as the basis for modifying or developing RRR criteria. This document does not contain standards and should not be interpreted as such.

e. The geometric design criteria developed by each State pursuant to 23 CFR 625 and this Technical Advisory, and approved by the FHWA constitute the standards required by 23 U. S. C. 109(a) . If a State elects to apply current criteria for new construction to nonfreeway RRR projects, a letter stating this intention will be sufficient for FHWA approval.

5. **DISCUSSION** . The following paragraphs present information on a process for developing RRR programs and individual RRR projects as well as design criteria for individual geometric elements.

a. Special design criteria adopted for RRR projects should consider overall highway geometry, design of adjacent segments, and expected trends in traffic growth and truck use, such as on the National Network.

(1) The criteria adopted by a highway agency, and approved by the FHWA, become the benchmark for evaluation of the design of a RRR project.

(2) The RRR design criteria should address, by modification or incorporation, all controlling elements, and may address additional items selected by a highway agency.

(a) As indicated in paragraph 3d, 13 geometric elements were established as the controlling criteria for geometric design. The controlling criteria are design speed, lane and shoulder widths, bridge widths, structural capacity, horizontal and vertical alignment, stopping sight distance, grades, cross-slopes, superelevation, and horizontal and vertical clearances.

(b) New construction standards apply for those controlling elements not addressed by special RRR criteria.

(3) Adoption of RRR criteria for the geometric elements for nonfreeways does not relieve agencies from meeting new construction policies, standards or standard specifications for all nongeometric elements. Deviations substandard to these policies and standards require approval on a project-by-project basis as discussed in paragraph 5a(4) .

(4) Deviations substandard to the adopted RRR criteria require justification on a project-by-project basis. The documentation justifying the lesser criterion might include, as appropriate and depending on the scope of the project, a discussion of the proposal including alternatives to the proposed action, compatibility of the exception with adjacent sections of roadway and future improvements on the route; a complete description or a sketch showing the design feature and its relation to other roadway elements; a cost analysis; an accident analysis; proposed mitigation measures, if any; the expected safety consequences; and other considerations to support the recommendation to use a design exception.

b. Paragraph 6, "Safety Conscious Design Process," gives guidance on a systematic approach to developing a program of projects and on a consistent application of key activities for design of individual projects.

(1) The purpose of RRR is to preserve and extend the service life of existing highways and enhance highway safety (23 U. S. C. 109(o)) .

(a) The most current source of data, procedures and recommendations regarding geometric design and its relationship to safety for RRR projects is contained in TRB Special Report 214.

(b) The information in Report 214, together with current program guidance and other technical material can be used to develop or modify criteria, processes and practices to achieve the twin objectives of RRR type projects -preservation and safety enhancement.

(2) By their purpose and definition, RRR projects reflect and emphasize the management of the highway system by extending the service life and deriving the maximum benefit from existing highways. Economic considerations are a major factor in determining the priority and scope of RRR work.

(a) Special geometric design criteria developed for RRR projects should acknowledge this factor and emphasize implementation of cost-effective improvements where practical.

(b) Special Report 214 contains economic evaluation procedures for several of the elements included in its recommendations. These evaluation procedures may be used to consider the economic consequences of a proposed improvement.

(3) The topics addressed in paragraph 7, "Design Practices for Key Highway Features," include 10 of the 13 controlling criteria as they relate to RRR.

(a) The 10 controlling criteria discussed under appropriate headings are design speed, horizontal and vertical alignment, lane and shoulder widths, bridge widths, cross-slope, superelevation, stopping sight distance, and horizontal clearance.

(b) The three not addressed here or in the TRB Special Report 214 are vertical clearance, structural capacity, and grades. No new data was available or developed on which to base specific recommendations. However, if these elements are modified by special RRR criteria, special consideration should be given to the size and weight of trucks legally allowed to operate on the affected route.

6. **SAFETY CONSCIOUS DESIGN PROCESS** . The RRR program should reflect the needs and objectives of the highway agency in its management of the highway system. Sound pavement management practices, and the need to improve and extend the useful life of the pavement is often the reason for initiating a RRR project. While it may not be the primary reason for initiating a RRR project, highway safety is an essential element of all projects. Federal-aid RRR projects are to be developed in a manner which identifies and incorporates appropriate safety enhancements.

a. Effective pavement and safety management programs which systematically identify and incorporate needed safety and geometric corrections and enhancements into the project development procedure should be developed and applied.

(1) Correction of safety deficiencies and inclusion of appropriate enhancements must be integrated into the design process in the early stages of project identification as well as during each phase of project development.

(2) The RRR work often provides an opportunity to incorporate safety improvements into a project in conjunction with the pavement and geometric work. Consideration of the roadway, the roadside andoperational features is required to integrate the safety improvements.

(a) Safety improvements can include intersection and access point adjustments that increase sight distance and reduce vehicle conflicts, replacement or rehabilitation of obsolete bridge rails and guardrails, removal of roadside obstacles and unnecessary guardrails, slope flattening, ditch relocation and/or regrading, upgrading roadside appurtenances, new or improved signing, pavement markings and other traffic control devices.

(b) Special Report 214 provides information to develop programs and procedures that insure the consideration for safety is included in the initial scope and estimate for a project.

b. A process that insures that safety is an integral part of project development consists of several critical elements which include:

(1) the determination of existing geometric, safety and operational features throughout the project. The designers of RRR projects can draw on a substantial amount of information in the preparation of a design.

(a) The information available includes lane and shoulder widths; degree, length and superelevation of horizontal curves; length of vertical curves; stopping sight distances; grades; sideslopes; clear recovery areas; available right-of-way; potentially hazardous obstacles; location and design of intersections; type and location of highway signs; pavement markings; delineation and traffic signals.

(b) Line diagrams, strip maps, as-built plans, photologs, etc. are useful sources of information.

(2) A procedure to gather and analyze accident, speed and volume data. The analysis of this information can be used to identify specific safety or operational problems and develop appropriate countermeasures.

(3) A method to obtain speed data, using generally accepted study procedures, at various locations where they are to be used for design within the project limits for speed dependent design elements. The use of various speed measures is discussed in paragraphs 7a, 7c(1) , 7c(2) , and 7d(1) .

(4) A thorough field review by personnel knowledgeable about and trained in design, safety, traffic operations and maintenance to identify potentially hazardous locations and features, and recommend appropriate safety enhancements. Field reviews are also beneficial to verify existing conditions and identify recent changes.

(5) Consideration and incorporation, as appropriate, of high hazard locations, intersection, roadside and traffic control improvements that may result in enhanced safety. There are many relatively low-cost improvements that can be highly cost effective when incorporated into certain RRR projects. Paragraph 7h discusses alternate safety improvements.

(6) A procedure for routine review of projects during development by traffic and safety specialists. This should include periodic consultation with these specialists before final approval of the project plans.

c. A systematic process to accomplish the above data and information collection and analysis involves a series ofactivities which can culminate in a design and safety report.

(1) This report can serve as documentation of the design process undertaken to develop the RRR project, assist in design decisions and provide the background information needed to obtain any necessary design approvals.

(a) The components which should be incorporated in the report include the existing and proposed geometric and roadside features, current and estimated future traffic volumes, speeds accident history, applicable design standards and design options.

(b) Specific safety problems or concerns should be identified and addressed along with options, costs and recommendations to alleviate the problem.

(c) Any identified design exceptions (geometric and nongeometric) and appropriate mitigations should also be included in this report.

(2) While neither a format nor a length for this report is specified, it should be as detailed as the size, scope, and complexity of the project requires. A simple form summarizing the information may be sufficient for many projects, while a detailed report may be necessary for more complex projects or in situations where accident and traffic histories warrant consideration.

d. Desirable geometric and safety improvements are frequently dependent upon acquisition of right-of-way. Although right-of-way acquisition problems are a concern, adverse social, environmental, or economic impacts on the surrounding land and development also often limit the scope of improvements.

(1) These problems are evident in those locales with significant adjacent development or where existing right-of-way for the highway is narrow. These factors are frequently the cause for delay in advancing the project to construction.

(2) These potential conflicts should be taken into account early in the RRR process. A process to screen candidate projects to identify locationswhere improvements are desirable and require right-of-way should be instituted.

(a) With these locations identified, the design at these sites can be expedited to determine the actual right-of-way requirements. Using timesaving techniques, the acquisition of the necessary real estate for the project can be expedited to insure its availability in time for construction.

(b) A process can be instituted to work in advance with affected parties to identify environmental and community impacts in order to develop an acceptable balance between community concerns and project needs.

e. Whenever possible, RRR projects should include other anticipated work in or adjacent to the project area. While the need for RRR and other type improvements may originate from separate and distinct processes for identifying deficiencies, they should be coordinated, as the implementation of projects in one area of concern may influence priorities in another. Experience indicates that cost savings may be achieved and needless duplication of construction and traffic disruption can be avoided when separate projects in the same area are combined into a single contract.

f. Consistency of roadway, roadside, and operational design is an essential element for assuring safe an appropriate driver responses. Drivers associate andexpect certain features and conditions for each category of highway. Improving the consistency of design within each category helps to satisfy driver expectations and reduce the possibilities of driver confusion.

(1) Highway agencies are encouraged to perform a periodic assessment of the potential for systemwide, route, or route section safety upgrading design in connection with or in addition to programs to identify and correct specific hazardous locations.

(2) These periodic assessments of improvements on the basis of one of the preceding classifications can increase the positive impact of RRR projects on safety in several ways.

(a) The results could be used to help tailor design practices and standards to the circumstances of a particular highway agency.

(b) The results could detect opportunities for effective safety improvements that warrant project programming earlier than previously anticipated.

(c) The assessment could be linked to other safety programs to gauge overall progress toward improving highway safety.

(d) Along with the results of other analyses, the assessments could serve as input for establishing future highway programs and funding requirements.

7. DESIGN PRACTICES FOR KEY HIGHWAY FEATURES

a. **Design Speed** . Vehicle speed is an essential parameter for a number of geometric criteria. A design speed is selected to correlate the various design elements. The definition of design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features govern. It is important that any speed selected as the design speed for a project realistically reflect the speeds at which vehicles can be expected to operate or are actually operated on the highway.

(1) There are two methods that can be used to select the design speed for a RRR project. These procedures may be used alone or in combination. In either case, the objective is to coordinate the various geometric elements to produce a safe highway.

(a) One method is to select an overall project design speed. This is defined as the speed that equals or exceeds the posted or regulatory speed on the section of highway being improved. All the various geometric elements on the project are correlated by this one design speed.

(b) A second method involves a series of design speeds. This method requires the determination of the speeds that affect four of the individual elements.

1 The average running speed throughout the project length may be used as the design speed in determining lane and shoulder widths. The average running speed is the average speed of a vehicle over a specified section of highway.

2 The 85th percentile speed may be used for horizontal and vertical curves. The 85th percentile speed is the speed below which 85 percent of the vehicles are operating.

(c) The specific applications of these speeds are discussed in paragraphs 7c(1) , 7c(2) , and 7d (1) .

(2) When a speed less than the posted or regulatory speed is used, speed studies using generally accepted study procedures are required to establish the speed at each location where the average running or 85th percentile speed is to be applied. The results of these studies are to be used as the basis for determining the design speed for the element whether the posted or regulatory speed is exceeded or not.

b. **Traffic Volumes** . Traffic data is needed in the design of all highway improvements, including RRR. It is an important consideration both in the determination of the appropriate level of improvement (i. e. , reconstruction vs. RRR) and in the selection of actual values for the various geometric features.

(1) Design decisions for particular highway features should be based on conditions that reflect the anticipated service life of the feature even though the expected performance period of the pavement rehabilitation work may be much less than the performance period for geometric improvements.

(a) For RRR, the need for a formal forecast of future traffic is the greatest when the current traffic is approaching the capacity of the highway, and decisions must be made regarding the timing of major improvements such as additional lanes.

(b) Studies to determine future traffic are not normally necessary on very low-volume roads where even high-percentage increases in traffic do not significantly impact design decisions.

(2) Preferably, the design traffic volume for a given feature should match the average traffic anticipated over the service life of the affected feature such as alignment and widths.

c. **Alignment**

(1) **Horizontal Curves**

(a) An existing horizontal curve may be retained as is without further evaluation if:

1 the existing curve design, assuming correct superelevation is provided, corresponds to a speed that is within 15miles per hour (mph) of the 85th percentile speed of the approaching vehicles; or within 15 mph of the overall project design speed, and

2 the design volume is less than 750 vehicles per day.

(b) Reconstruction to either new construction standards or to approved RRR standards is to be considered and evaluated when the above speed and/or volume criteria are exceeded.

(c) If the curve reconstruction is not justified, or if it is reconstructed to less than new construction standards, appropriate safety and other mitigation measures should be applied. Safety measures that are less costly than reconstruction include, but are not limited to, those enumerated in paragraph 7h(2) . These measures may be applied either separately or in combination.

(d) The 85th percentile speed, defined in paragraph 7a(1) (b) **2** , is to be measured at a point ahead of each end of the curve where vehicle operators have not begun adjusting their speed. Project design speed is as defined in paragraph 7a(1) (a) .

(2) **Vertical Curves**

(a) An existing vertical curve may be retained as is, without further evaluation if:

E

1 the existing curve design speed, based on the stopping sight distance provided, corresponds to a speed that is within 20 mph of the 85th percentile speed of vehicles on the crest, or within 20 mph of the overall project design speed; and

2 the design volume is less than 1,500 vehicles per day.

(b) Reconstruction of crest vertical curves to either new construction standards or to approved RRR standards is to be evaluated when the above speed and/or volume criteria are exceeded, and the vertical curve hides major hazards from view.

(c) Whether or not an evaluation is required, designers should routinely examine the nature of potential hazards such as intersections, sharp horizontal curves, or narrow bridges hidden by a vertical curve, their location in relation to the portion of the highway where sight distance falls below new construction standards, and other options to reconstruction such as relocating or correcting the hazard or providing warning signs.

(d) If curve reconstruction is not justified, or the curve is reconstructed to less than new construction standards, appropriate safety and other mitigation measures should be applied. Safety measures that are less costly than reconstruction include, but are not limited to, those identified in paragraph 7h(2) . These measures may be applied separately or in combination.

(e) The 85th percentile speed, defined in paragraph 7a(1) (b) **2** , is to be measured on the crest of individual vertical curves for vehicles traveling in both directions. Project design speed is as defined in paragraph 7a(1) (a) .

(f) While the preceding discussion focused on crest vertical curves, sag verticals should not be ignored. Substandard sag vertical curvesshould be investigated to insure that potential hazards do not exist, especially ones that become apparent when weather conditions or nighttime reduces visibility.

(3) **Curves in Series** . Frequently the alignment of a segment of a roadway consists of a series of reverse curves or curves connected by short tangents. A succession of curves may be analyzed as a unit rather than as individual curves, applying the criteria in paragraphs 7c(1) and 7c(2) as appropriate.

(a) The first substandard curve in a series should receive special attention because this change in alignment prepares the driver for the remaining curves in the series.

(b) Any intermediate curve in a series of substandard curves that is significantly worse than the others in the series should also be analyzed individually.

(c) These controlling curves can be used to determine the safety and/or other mitigation measures to apply throughout the series.

(d) When improvements are considered to any curve in a series, the effect on the series of curves as a whole should be evaluated.

d. **Cross-Section**

(1) **Lane and Shoulder Widths** . Wide lanes and shoulders provide motorists increased lateral separation between overtaking and meeting vehicles and an opportunity for safe recovery when their vehicles run off the road. Additional safety benefits include reduced interruption of the traffic flow as the result of emergency stopping and road maintenance activities, less pavement and shoulder damage at the lane edge, improved sight distance at critical horizontal curves, and improved roadway surface drainage.

(a) Suggested minimum lane widths and combined lane and shoulder widths are provided in Table 1 of Attachment 1. The suggested minimums explicitly consider vehicle speed and the amount of truck traffic, which influence the safety benefits derived from wider lanes and shoulders.

(b) Either of the two methods may be used as the speed parameter for determination of appropriate lane and shoulder widths.

1 Average running speed throughout the project length is one method. This speed is defined in paragraph 7a(1) (b) **1**.

2 The overall project design speed is the second method that may be used. Design speed is defined in paragraph 7a(1) (a).

(2) **Bridge Widths** . Hazards associated with bridge widths can be significant. Roadway constriction at narrow bridges reduces the opportunity for safe recovery of out-of-control vehicles and can result in end-of-bridge collisions. Furthermore, bridge approaches are often on a downgrade, a factor responsible for increases in speed, and particularly in the case of older spans, are often sharply curved. When coupled with other factors such as premature icing in winter and substandard bridge

rail, the special hazards associated with bridges are readily understood.

(a) An existing bridge may be retained when the suggested bridge widths in Table 2 of Attachment 1 exist.

(b) A bridge should be evaluated for replacement or widening on a case-by-case basis when the criteria suggested in Table 2 are not met.

(c) Safety at narrow bridges can also be improved by transition guardrails at bridge approaches, new or rehabilitated bridge rails and warning devices.

1 If an existing bridge is to be retained, substandard bridge rail should be upgraded to current standards and "safety" curbs which can cause vehicles to vault the rail should be eliminated. Exceptions may be considered on a case-by-case basis where safety can be adequately enhanced but cost effective considerations prevent full widening or full upgrading of the bridge rail.

2 On all projects involving bridges, the approach guardrail should be evaluated and upgraded to current standards. Approach guardrail must be properly anchored to the bridge.

3 The transition between the approach guardrail and the bridge rail should be smooth and of sufficient strength (i. e. , reduced post spacing) to prevent snags and vehicle pocketing.

4 Only approved crash-tested bridge rails, guardrail, and transitions should be used.

5 A partial list of alternate safety measures is identified in paragraph 7h(2) .

(3) **Cross-Slope and Superelevation**

(a) On RRR projects that include resurfacing, pavement cross-slopes should be restored to new construction standards.

(b) Superelevation rates on horizontal curves should be increased, if necessary, to the appropriate rate for new construction for the design speed being used at the location.

(4) **Roadside Features** . Accident data firmly establish that roadside characteristics are important in determining the overall level of safety provided by a highway. Accident rates are lower and accidents are less severe on highways with few obstacles near the travelway.

(a) Consistent procedures should be developed for evaluating and improving roadside features with the following objectives:

1 Remove, relocate, shield, or reconstruct to a breakaway design isolated roadside obstacles.

2 Flatten sideslopes that are 3:1 or steeper at locations where run-off-road accidents are likely to occur (e. g. , on the outside of sharp horizontal curves) .

3 Retain current slope ratios (i. e. , do not steepen sideslopes) when widening lanes and shoulders unless warranted by special circumstances.

(b) Clear zone policies can be tailored to particular types of obstacles commonly encountered by a highway agency to reflect differences in the cost of removal, relocation, or shielding.

e. **Pavement**

(1) The existing pavement condition and the scope of needed pavement improvements dictate to a large extent those improvements which are feasible, prudent, or practical. More significant geometric upgrading might be appropriate if the pavement improvements are substantial, but may not be appropriate or economical if needed pavement work is relatively minor. Conversely, the geometric deficiencies may be so severe that the overall highway improvements must be more substantial than those which may be appropriate with only minor pavement improvements.

(a) Geometric design criteria should indicate how existing pavement condition and the scope of pavement improvements will interrelate with the scope of geometric improvements and the values used for design.

(b) Pavement rehabilitation is to be developed in accordance with current FHWA pavement policy.

(2) A skid resistant surface is an essential part of any pavement surface improvement, regardless of the scope of geometric problems or upgrading. Current policy requires that each Federal-aid project, including RRR projects, involving pavement construction shall provide a skid resistant surface.

(3) Pavement edge drops are undesirable, no matter how they develop, because of the safety implicationsassociated with the vehicle recovery maneuver. Pavement edge drops, defined as vertical discontinuities at the edge of the paved surface, often develop between the pavement surface and the adjacent unpaved shoulder or roadside. They can result from adding a layer of

surfacing without regrading the existing shoulder; wear or erosion of gravel, turf, or earth shoulder materials.

(a) Properly designed and constructed RRR projects can reduce edge drop related accidents. Existing policy requires that edge drops be eliminated on Federal-aid projects. Any RRR criteria developed should include procedures and practices to eliminate designs and construction operations which lead to creation of edge drops, and that reduce their occurrence along existing highways.

(b) There are several practices which can reduce the occurrence or mitigate the impact of edge drops. These practices include:

1 paving the full top width between shoulder breaks;

2 selectively paving shoulders at points where vehicle encroachments are likely to create pavement edge drops, such as on the inside of horizontal curves; or

3 constructing a beveled or tapered pavement edge so that any edge drop that develops has a reduced impact on the recovery maneuver.

(c) Any paving of the shoulder area should incorporate a pavement structure capable of supporting anticipated loadings.

f. **Intersections** . Intersections deserve special attention, since accidents tend to concentrate at these locations.

(1) Although specific guidelines for intersection improvements are not appropriate because of the wide variety of physical and operational features affecting safety, it is recommended that consistent procedures and checklists be developed for evaluating intersection improvements on RRR projects.

(2) Intersection improvements should be tailored to each individual situation with due recognition being given to traffic volumes on each of the intersecting roadways, prior accident pattern and physical characteristics of the site.

(a) The improvements at intersections generally focus on reducing conflicts and improving driver guidance. Reducing approach speed and improving skid resistance can be important also.

(b) There are several useful analysis procedures available to assist in selecting safety improvements, including collision diagrams, condition diagrams, and a field review of the intersection.

g. **Traffic Controls and Regulations**

(1) Signs and markings in conformance with the Manual on Uniform Traffic Control Devices (MUTCD) are required on all federally funded highway projects, including RRR.

(2) While traffic control devices cannot fully mitigate all problems associated with substandard geometric features, they are a relatively low-cost measure that can compensate for certain operational deficiencies.

(a) Where roadway geometry or other roadway or roadside features are less than standard, do not meet the driver's expectancy, and reconstruction is not appropriate, additional signs, markings, delineation, and other devices beyond normal requirements of the MUTCD should be considered.

(b) Judicious use of special traffic regulations, positive guidance techniques and traffic operational improvements can often forestall expensive reconstruction by minimizing or eliminating adverse safety and operational features on or along existing highways.

h. **Alternate Safety Measures**

(1) Highway design practice provides a broad range of alternative measures that can be used alone or in combination with others to mitigate the effects of geometric deficiencies and provide for safer operations on existing highways.

(2) A partial list of alternatives to reconstruction for several geometric deficiencies is provided in the following table.

GEOMETRIC DEFICIENCY	ALTERNATE SAFETY MEASURE
Narrow lanes and shoulders	Pavement edge lines Raised pavement markers Post delineators
Steep sideslopes;	Roadside hazard markings

roadside obstacles	Slope flattening Round ditches Obstacle removal Breakaway safety hardware Guardrail
Narrow bridge	Traffic control devices Approach guardrail Hazard markers Pavement markings
Poor sight distance at hill crest	Traffic control devices Fixed-hazard removal Shoulder widening Driveway relocation
Sharp horizontal curve	Traffic control devices Shoulder widening Appropriate superelevation Slope flattening Pavement antiskid treatment Obstacle removal Obstacle shielding
Hazardous intersections	Traffic control devices Traffic signalization Fixed lighting Pavement antiskid treatment Speed controls

8. **ATTACHMENT** . Attachment 2 to this Technical Advisory is a list of program guidance memoranda, Technical Material, and Training Courses that have been identified as being related to activities concerning RRR type projects.

Thomas O. Willett, Director
Office of Engineering

Table 1[1] Land And Shoulder Widths

Design Year Volume (ADT)	Running Speed[a] (mph)	10 Percent or More Trucks[b]		Less Than 10 Percent Trucks[b]	
		Lane Width[c] (ft)	Combined Lane and Shoulder Width[d] (ft)	Lane Width[c] (ft)	Combined Lane and Shoulder Width[d] (ft)
1-750	Under 50	10	12	9	11
	50 and over	10	12	10	12
751-2000	Under 50	11	13	10	12
	50 and over	12	15	11	14
Over 2000	All	12	18	11	17

[a] Highway segments should be classified as "under 50" only if most vehicles have an average speed of less than 50 mph over the length of the segment.

[b] For this comparison, trucks are defined as heavy vehicles with six or more tires.

[c] If the highway is included on the National Network or is an access road for the network, a 12-foot lane width should be used.

[d] One foot less for highways on mountainous terrain.

Table 2[1] Bridge Widths

Design Year Volume (ADT)	Usable Bridge Width(ft)
0 - 750	Width of approach lanes
751 - 2000	Width of approach lanes plus 2 ft.
2001 - 4000	Width of approach lanes plus 4 ft.
Over 4000	Width of approach lanes plus 6 ft.

If lane widening is planned as part of the RRR project, the usable bridge width should be compared with the planned width of the approaches after they are widened.

[1] From Special Report 214, "Designing Safer Roads, Practices for Resurfacing, Restoration, and Rehabilitation," TRB 1987.

APPENDIX B
Summary of *TRB Special Report 214*

Transportation Research Board Special Report 214, published in 1987, offered 23 recommendations for 3R projects with the objective of improving safety in a cost-effective manner. Table B1 provides a listing of the recommendations that were grouped into five major categories.

Table B1
Listing of Recommendations in *SR 214*

- Safety-Conscious Design Process
  1. Assessment of Site Conditions Affecting Safety
  2. Determination of Project Scope
  3. Documentation of the Design Process
  4. Review by Traffic and Safety Engineers
- Design Practices for Key Highway Features
  - 5. Minimum Lane and Shoulder Widths
  - 6,7. Horizontal Curvature and Superelevation
  - 8. Vertical Curvature and Stopping Sight Distance
  - 9. Bridge Width
  - 10. Sideslopes and Clear Zones
  - 11. Pavement Edge Drop and Shoulder Type
  - 12. Intersections
  - 13. Normal Pavement Crown
- Other Design Procedures and Assumptions
  - 14. Traffic Volume Estimates for Evaluating Geometric Improvements
  - 15. Speed Estimates for Evaluating Geometric Improvements
  - 16. Design Values for Geometric Improvements
  - 17. Design Exceptions
- Planning and Programming RRR Projects
  - 18. Screening of Highways Programmed for RRR Projects
  - 19. Assessment of the Systemwide Potential for Improving Safety
- Safety Research and Training
  - 20. Special Task Force to Assess Highway Safety Needs and Priorities
  - 21. Compendium of Information on Safety Effects of Design Improvements
  - 22. Increased Research on the Relationships Between Safety and Design
  - 23. Safety Training Activities for Design Engineers

The reader is referred to that document for a complete discussion of these recommendations. Summarized here are the recommendations that pertain to geometric design elements discussed in this synthesis.

Minimum Lane and Shoulder Widths

Recommendation 5: The following minimum lane and shoulder width values are recommended for two-lane rural highways (Table B2):

TABLE B2
MINIMUM LANE AND SHOULDER WIDTHS RECOMMENDED IN
TRB SR 214

		10 Percent or More Trucks[a]		Less Than 10 Percent Trucks	
Design Year Volume (ADT)	Running Speed (mph)	Lane Width (ft)	Shoulder Width[b] (ft)	Lane Width (ft)	Shoulder Width (ft)
1–750	Under 50	10	2	9	2
	50 & over	10	2	10	2
751–2,000	Under 50	11	2	10	2
	50 & over	12	3	10	3
More than 2,000	All	12	6	11	6

[a] Trucks are defined as heavy vehicles with six or more tires.
[b] One ft less for highways on mountainous terrain.

(The table in that report has been revised to show shoulder width.) In *SR 214*, there are two columns labeled "Combined Lane and Shoulder Width." In preparing Table B2, it is assumed that the shoulder width is the combined lane and shoulder width minus the lane width. No recommendation was made for multi-lane roads.

Horizontal Curvature and Superelevation

Recommendation 6: Highway agencies should increase the superelevation of horizontal curves when the design speed of an existing curve is below the running speeds (85th percentile) of approaching vehicles and the existing superelevation is below the allowable maximum specified by AASHTO new construction polices. Highway agencies should evaluate reconstruction of horizontal curves when the design speed of the existing curve is more than 15 mph below the running speeds of approaching vehicles (assuming improved superelevation cannot reduce the difference below the 15 mph) and the average daily traffic volume is greater than 750 vehicles per day.

Recommendation 7: At horizontal curves where reconstruction is unwarranted, highway agencies should evaluate less costly safety measures.

Vertical Curvature and Stopping Sight Distance

Recommendation 8: Highway agencies should evaluate the reconstruction of hill crests when (a) the hill crest hides from view major hazards such as intersections, sharp horizontal curves, or narrow bridges; (b) the average daily traffic is greater than 1,500 vehicles per day; and (c) the design speed of the hill crest (based on the minimum stopping sight distance provided) is more than 20 mph below the running speeds (85th percentile) of the vehicles on the crest.

Bridge Width

Recommendation 9: Highway agencies should evaluate bridge replacement or widening if the bridge is less than 100 ft long and the usable width of the bridge is less than the following values:

Design Year Volume (ADT)	Usable Bridge Width (ft)
0–750	Width of approach lanes
751–2,000	Width of approach lanes plus 2 ft
2,001–4,000	Width of approach lanes plus 4 ft
More than 4,000	Width of approach lanes plus 6 ft

Sideslopes and Clear Zones

Recommendation 10: State highway agencies should develop consistent procedures for evaluating and improving roadside features with the following objectives:

- Flatten side slopes of 3:1 or steeper at locations where run-off-road accidents are likely to occur (e.g., on the outside of sharp horizontal curves);
- Retain current slope widths (without steepening side slopes) when widening lanes and shoulders unless warranted by special circumstances; and
- Remove, relocate, or shield isolated roadside obstacles.

Pavement Edge Drop and Shoulder Type

Recommendation 11: To reduce pavement edge-drop hazards on highways with narrow paved shoulders, highway agencies should either:

- Selectively pave shoulders at points where out-of-lane vehicle encroachments and pavement edge-drop problems are likely to develop (e.g., at horizontal curves); or
- Construct a beveled or tapered pavement edge shape at these points.

Intersections

Recommendation 12: State highway agencies should develop consistent procedures and checklists for evaluating intersection improvements on RRR projects.

Normal Pavement Crown

Recommendation 13: On resurfacing projects, highway agencies should construct pavement overlays with normal pavement crowns that match new construction standards.

APPENDIX C
Survey Questionnaire

STATE PRACTICES SURVEY QUESTIONNAIRE - Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation

Page One

Dear State Design Engineer:

The Transportation Research Board is preparing a synthesis on Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation (3R). This is being done for the National Cooperative Highway Research Program (NCHRP), under the sponsorship of the American Association of State Highway and Transportation Officials in cooperation with the Federal Highway Administration.

There is currently a lack of national design guidance for 3R work on a wide range of roads, including urban non-freeway facilities and rural multi-lane non-freeway facilities. Recognizing this need, NCHRP has developed this Synthesis project to document the state of highway practice related to 3R design guidelines for all non-freeway roadway types. The product of this study will be of considerable value to transportation agencies in need of a document that highlights current practices of 3R design used in the U.S.

This survey is being sent to all State Departments of Transportation. Your cooperation in completing the questionnaire will ensure the success of this effort. We estimate that it should take no more than 30 minutes to complete. We request that this survey be completed and submitted by February 22, 2010.

QUESTIONNAIRE INSTRUCTIONS

We have formulated the questions to be answered as easily as possible, however several require text responses. If you prefer you may respond to these or any other questions by phone. To do so, please contact our consultant Hugh McGee by email at hmcgee@vhb.com or by phone at 703-847-3071 to arrange a date and time.

To view and print the entire questionnaire, Click on this link, and print using "control p".
To view and print your answers before submitting the survey including any answers filled in, click forward to the page following question18. Print using "control p".
To quit the questionnaire and save your partial answers, or to forward a partially completed questionnaire to another party, click on "save and continue survey later" in the upper right hand corner of your screen. This will email a link to the partial survey.

In the questionnaire we refer to standards/guidelines to mean any policy statements, design standards, design guidelines, or procedures to be followed from planning to implementation. Our consultant has already obtained documents for most States either through the web sites or from direct request. Before completing this questionnaire we suggest you view what has been obtained

for your State at the following link:
State Documents Link

From this link you can select your state and view what documents have already been obtained.

Please enter the date (MM/DD/YYYY).

Please enter your contact information.

First Name

Last Name

Title

Company Name

Street Address

Apt/Suite/Office

City

State

Postal Code

Email Address

Phone Number

STATE PRACTICES SURVEY QUESTIONNAIRE - Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation

Mobile Phone

[ ]

1. Do you have published design standards/guidelines for 3R projects?
   - ◯ Yes - Please proceed to Question 1.a.
   - ◯ No - Please proceed to Question 1.b.

1.a. If you answered yes, and if the material on the TRB site is not correct or complete please contact us:

Post: Hugh W. McGee, 8330 Boone Boulevard, Suite 700, Vienna, VA 22182,

Phone: (703) 847-3071,

Email: HMcGee@VHB.com, or

Please provide a link.

[ ]

1.b. If you answered no, do you have standards or procedures for projects similar to 3R? If so, please explain.

[ ]

Untitled Page

2. What year was your 3R policy reviewed and approved by FHWA?
   - ◯ Year [ ]
   - ◯ Not Approved by FHWA

3. Are your 3R standards/guidelines the same for National Highway Systems (NHS) projects and for non-NHS projects?
   - ◯ No
   - ◯ Yes

If "Yes," Please explain if not discussed in the policy documentation provided in Question #1.

[ ]

4. Are your 3R standards/ guidelines for non-NHS projects the same for both Federal-aid and State-aid projects?
   - ◯ No
   - ◯ Yes

If "Yes," please explain if not discussed in the policy documentation provided in Question #1

[ ]

5. How many 3R projects does your agency progress each year?

[ ]

6. How many lane miles are treated by 3R projects each year?

[ ]

7. What is the average duration (in months) to progress a 3R project from conception to start of construction?

[ ]

8. How are 3R projects initially determined (please check one)?
   - ○ Condition of pavement
   - ○ Safety analysis identifying as a problem location
   - ○ Other

If "Other," please, explain if not documented in your policy

Untitled Page

9. The following are the 13 designated controlling design elements. Please rank these from 1 (most) to 13 (least) as to how important each is for 3R projects. With the up or down arrows you can resort the list in order of importance.

(Please mark each option in the desired order: 1 to 13)

- [ ] Design Speed
- [ ] Lane Width
- [ ] Shoulder Width
- [ ] Bridge Width
- [ ] Structural Capacity
- [ ] Horizontal Alignment
- [ ] Vertical Alignment
- [ ] Grades
- [ ] Stopping Sight Distance
- [ ] Cross Slopes
- [ ] Superelevation
- [ ] Horizontal Clearance
- [ ] Vertical Clearance

10. Considering the three design criteria that you ranked highest, why do you consider them more important than the others?

11. List other design elements that should be considered for 3R projects.

12. Do you perform safety analyses/risk assessment, e.g. road safety audits, benefit/cost analysis, in preparation of developing project scope and design for 3R projects?

- ○ Yes
- ○ No

If "Yes," please explain type of analyses.

13. How often are safety improvements considered in a 3R project (please check one)?
- ◯ Not normally considered
- ◯ Not considered unless safety problem identified
- ◯ Routinely considered

14. Please list the five most frequent safety improvements included in a 3R project.
1)
2)
3)
4)
5)

15. Is consideration given to pedestrians?
- ◯ Yes
- ◯ No

If "Yes," please describe.

16. Are considerations given to bicyclists?
- ◯ Yes
- ◯ No

If "Yes," please describe.

STATE PRACTICES SURVEY QUESTIONNAIRE - Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation

17. Are considerations given to ADA requirements, such as accessible curb ramps and walkway slopes?

- ◯ Yes
- ◯ No

If "Yes," please describe.

18. What do you believe is the most unanswered issue regarding 3R project design?

APPENDIX D
Survey Responses by State Transportation Agencies

TABLE D1
STATUS OF STATES' 3R POLICIES (QUESTIONS 1, 1a, 1b, and 2)

State	Do you have published design standards/guidelines for 3R projects?	What year was your 3R policy reviewed and approved by FHWA?	If you answered no, do you have standards or procedures for projects similar to 3R? If so, please explain.
AK	Yes	2004	
AL	No	Not approved by FHWA	We do have a design guide for preventive maintenance and 3R of streets and highways. Our definition of 3R is the work undertaken to extend the service life of an existing highway. This will mainly involve the placement of additional surface materials and other work necessary to return an existing roadway to a condition of structural and functional adequacy. In addition to resurfacing, 3R projects may include pavement structure repair, minor lane and shoulder widening, adding turn lanes, shoulder pavement, upgrading horizontal and vertical alignment, intersection improvements, removing or shielding roadside obstacles, modification of side slopes/ditches, drainage improvements, and signals.
AR	Yes	1989	
AZ	Yes	Not approved by FHWA	
CA	Yes	2007	
CO	Yes	2006	
CT	Yes	1984	
DE	No	Not approved by FHWA	
FL	Yes	1977	
GA	Yes	2005	
HI	Yes	1984	
IA	Yes	1994	
ID	Yes	2010	
IL	Yes	1986	
IN	Yes	1994	
KS	Yes	1990	
KY	Yes	1993	
LA	Yes	2009	
MA	Yes	2010	We have our Project Development and Design Guide that addresses context sensitivity/complete streets and more flexible design standards. We also have an Engineering Directive E-09-005 that addresses Design Exceptions on 3R NHS projects.

Table D1 continued on p. 56

Table D1 continued from p. 55

State	Do you have published design standards/guidelines for 3R projects?	What year was your 3R policy reviewed and approved by FHWA?	If you answered no, do you have standards or procedures for projects similar to 3R? If so, please explain.
MD	No	Not approved by FHWA	There are 4 offices that primarily deal with 3R projects. The Office of Highway Development, The Office of Structures, The Office of Materials and Technology, and the 7 District Offices throughout the State of MD. Each office works on projects related to 3R, but none of them have the specific responsibility for all 3R projects. The Office of Materials and Technology deals with the pavement conditions of the highways in the state. They will perform pavement analysis of existing conditions and make recommendations to various design offices responsible to complete the rehabilitation or resurfacing work. The Office of Structures deals with the rehabilitation and resurfacing of existing structures. The Office of Highway Development and the District Offices are responsible to incorporate 3R principals into the projects that are designed or managed in their offices. Each office has guidelines and or procedures for their projects as it relates to design standards and practices, and project management processes. The SHA uses the 2001 AASHTO Green Book as its primary geometric design guideline.
ME	Yes	1991	
MI	Yes	1998	
MN	Yes	2007	
MO	Yes	2006	
MS	Yes	2001	
MT	Yes	2000	
NC	Yes	1983	
ND	Yes	2010	
NE	Yes	Not approved by FHWA	
NH	No	Not approved by FHWA	We use our *Highway Design Manual*, AASHTO *Greenbook and Roadside Design Guide*
NJ	No	Not approved by FHWA	Prior to 1996, the NJDOT did have 3R standards. At this time, we have do not. Projects are differentiated as Resurfacing, Rehabilitation, Reconstruction, etc.
NM	No		NMDOT does not have a stand-alone manual or standard. We have implemented some design directives that offer guidance and direction on certain design policy issues.
NV	Yes	2003	
NY	Yes	2009	
OH	Yes	1992	
OK	Yes	1992	
OR	Yes	1988	
PA	Yes	2009	
PR	No	Not approved by FHWA	We do have specifications to perform several pavements rehabilitation and reconstruction, but we do not have Design Standard or Guidelines for 3R projects.

Table D1 continued on p. 57

Table D1 continued from p.56

State	Do you have published design standards/guidelines for 3R projects?	What year was your 3R policy reviewed and approved by FHWA?	If you answered no, do you have standards or procedures for projects similar to 3R? If so, please explain.
RI	No	Not approved by FHWA	We have constructability reviews at every stage of design to go over problems and materials.
SC	Yes	2003	
SD	Yes	1998	
TX	Yes	2009 during last update	
UT	Yes	2008	
VA	Yes	1989	
VT	Yes	2006	
WA	No		WSDOT has separate programs and design guidelines for Improvement and Preservation projects. Within our preservation projects, we do have guidance that allows for spot safety improvements.
WI	Yes	1989	
WY	Yes	2008	

TABLE D2
HOW 3R POLICIES DIFFER FOR NHS VS. NON-NHS AND FEDERAL VS NON-FEDERAL AID (RESPONSES TO QUESTIONS 3 AND 4)

State	3R policies same for National Highway Systems (NHS) projects and for non-NHS projects?	If "No," Please explain	3R policies non-NHS projects the same for both federal-aid and state-aid projects?	If "No," please explain
AK	No		Yes	
AL	Yes		Yes	
AR	Yes		Yes	
AZ	No	We are not doing design exceptions for non-NHS 3R (pavement preservation) projects.	Yes	
CA	Yes	Applies to all roads on the State Highway System.	Yes	Applies to all roads on the State Highway System.
CO	Yes		Yes	
CT	Yes		Yes	
DE	No	Delaware does not have a formal 3R program.	No	Delaware does not have a formal 3R program.
FL	No		No	New section on railroad crossings upgrades in or near the project apply to federal-aid but not state-funded.
GA	No	Table 1 in GDOT's 3R guidelines defines the different design standards.	Yes	
HI	Yes		Yes	
IA	No	Our 3R agreement is very old and there is quite a bit of confusion over how it is applied. We have been working on a new one for several years, but it is difficult to agree on criteria.	Yes	
ID	No	See *Design Manual* sections A.10—3R IMPROVEMENT—NATIONAL HIGHWAY SYSTEM, section A.15—STATE DESIGN STANDARDS FOR NON-NHS, and A.20—REHABILITATION (1R) STANDARDS	Yes	
IL	Yes		Yes	
IN	Yes		Yes	
KS	Yes		Yes	
KY	No	We sometime do things differently on non-NHS routes.	No	

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State	3R policies same for National Highway Systems (NHS) projects and for non-NHS projects?	If "No," Please explain	3R policies non-NHS projects the same for both federal-aid and state-aid projects?	If "No," please explain
LA	No	Our 3R only apply to non-Interstate NHS. Our state guidelines apply to all but Interstate. Our state guidelines do not refer to speed where the 3R guidelines do refer to posted speed based on requirements of FHWA.	No	3R in our state only applies to NHS routes. But our state guidelines are the same for federal vs. state projects and also apply to NHS routes. (A state-funded NHS route would follow both the state guidelines and 3R guidelines.)
MA	No	MassDOT Engineering Directive E-09-005 discusses this.	Yes	
MD	Yes		Yes	
ME	No	Maine DOT has a set of "State Standards" for non-NHS highways	Yes	
MI	No		Yes	
MN	No	For Mn/DOT, 3R or preservation standards are the same BUT the criteria is different for NHS and non-NHS highways. For non-NHS highways, preservation standards apply if the overlay increases the road profile by more than 2 in. For NHS highways, preservation standards apply when the thickness of new pavement is more.	Yes	
MO	Yes		Yes	
MS	No		No	
MT	No	Explained in guidelines.	No	Explained in guidelines.
NC	Yes		Yes	
ND	Yes		Yes	
NE	No		Yes	We use the same 3R guidelines for non-NHS projects regardless of funding source.
NH	Yes		Yes	
NJ				
NM	Yes		Yes	
NV	No		Yes	
NY	Yes		Yes	

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State	3R policies same for National Highway Systems (NHS) projects and for non-NHS projects?	If "No," Please explain	3R policies non-NHS projects the same for both federal-aid and state-aid projects?	If "No," please explain
OH	Yes	ODOT also uses a Resurfacing Accident Analysis for non-NHS, non-freeway facilities. See Section 106 here: http://www.dot.state.oh.us/Divisions/ProdMgt/Roadway/roadwaystandards/Location%20and%20Design%20Manual/100-oct09.pdf	Yes	
OK	Yes		Yes	
OR	Yes		Yes	
PA	Yes		Yes	
PR	Yes	We design pavement rehabilitation projects "independently" if it is on an NHS or non-NHS.	No	
RI	Yes	We adhere to the *Green Book*, experience, technical experience.	Yes	
SC	Yes		Yes	
SD	No	See follow-up e-mail.	Yes	
TX	Yes		Yes	
UT	Yes		Yes	
VA	Yes		Yes	
VT	No	Examples included in the document are separate categories for vertical curves/lane widths.	Yes	
WA	No	We do not use the 3R approach. WSDOT has separate design levels for NHS and non-NHS routes.	Yes	
WI	No	WisDOT has adopted Programmatic Exception to Standards process, which allows substandard geometric features to stay in place based on the results of a safety screening analysis. This can't be applied to certain features on NHS routes.	Yes	
WY	Yes		Yes	

TABLE D3
HOW 3R PROJECTS ARE INITIALLY DETERMINED (RESPONSES TO QUESTION 8)

State	How are 3R projects initially determined?	If "Other," please explain
AK	Other	Generally, it is a combination of pavement condition and safety analysis.
AL	Condition of pavement	
AR	Safety analysis identifying as a problem location	We also use 3R Guidelines as the design criteria for our Passing Lane projects.
AZ	Condition of pavement	
CA	Condition of pavement	
CO	Safety analysis identifying as a problem location	
CT	Other	We don't have a formal 3R program. Projects are initiated to address a specific need. Once the scope of the project is established, it is determined whether the 3R guidelines would be applicable.
FL	Condition of pavement	
HI	Condition of pavement	
IA	Condition of pavement	
ID	Condition of pavement	
IL	Condition of pavement	
IN	Other	See *Indiana Design Manual*, Sections 55-1.0 and 55-2.0
KS	Other	Other includes pavement condition as well as structure (usually small bridge or culvert) condition.
KY	Condition of pavement	
LA	Other	Pavement conditions, PMS recommendations, public input, funding, and maintenance costs all play an important part in the districts' selection of projects.
MA	Condition of pavement	
MD	Other	The initial determination can be made by safety analysis or condition of pavement. It depends on the type of project that you are considering.
ME	Condition of pavement	
MI	Condition of pavement	
MN	Condition of pavement	
MO	Condition of pavement	
MS	Other	Both safety and condition of pavement are considered when identifying 3R projects.
MT	Condition of pavement	
NC	Condition of pavement	
ND	Other	Condition of pavement, need for widening.
NE	Condition of pavement	
NH	Condition of pavement	
NJ		
NM	Condition of pavement	

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State	How are 3R projects initially determined?	If "Other," please explain
NV	Other	Our 3R program is based on a pavement life cycle: Interstate and Freeways—8-year cycle, NHS or ADT > 10,000—10-year cycle, 1,600 < ADT < 10,000—12 years, 500 < ADT < 1600—15 years. Additional roadway segments are added to the initial list using data provided by the Pavement Management System (PMS). The PMS data allow us to capture roads not living up to the expected life cycle for the type of roadway. The initial list of roadway segments is then field reviewed to determine the need and type of strategy. The projects are then prioritized by type, volume, and condition.
NY	Condition of pavement	
OH	Condition of pavement	
OK	Condition of pavement	
OR	Condition of pavement	
PA	Condition of pavement	
PR	Other	Condition of pavement and political pressure (majors, public).
RI	Other	Communities request highways to be placed on the transportation improvement program for selection.
SC	Safety analysis identifying as a problem location	
SD	Condition of pavement	
TX	Other	Both pavement and safety.
UT	Condition of pavement	

TABLE D4
SAFETY ANALYSIS IN PREPARATION OF DEVELOPING PROJECT SCOPE FOR 3R PROJECTS (RESPONSE TO QUESTION 12)

State	Do you perform safety analyses/risk assessment (e.g., road safety audits, benefit/cost analysis) in preparation of developing project scope and design for 3R projects?	If "Yes," please explain type of analyses.
AK	Yes	1. Actual vs. predicted accident rates using *TRB 214* formulas and methods; 2. B/C analysis to see if an improvement is cost-effective; 3. Accident analysis to identify accident clusters and then see if clusters are related to a specific geometry or intersection issue. 4. Speed studies to determine the 85th percentile driver speeds.
AL	Yes	Reviews and analyses of the existing geometric and physical conditions, crash history, and field survey are performed. For 2- to 4-lane conversions, an evaluation of existing and new lane alignment or any other improvements that will affect rights-of-way are accounted for.
AR	No	
AZ	No	
CA	Yes	A "Safety Screening" as defined in policy document DIB 79-03
CO	Yes	Please refer to sections 7.10, 7.10.2, and 7.10.4.3 of CDot's 3R guidelines.
CT	No	
FL	Yes	Roadside safety audits and often B/C analysis.
GA	Yes	
HI	Yes	A traffic accident analysis is prepared to determine if the project limits contain an area of concern.
IA	Yes	A certain amount of our 3R budget is devoted to safety projects that get a full safety analysis. All other projects get some analysis depending on the project.
ID	Yes	Accident history is looked at to see if clusters can be associated with roadway features.
IL	Yes	A safety analysis is performed on each 3R project.
IN	Yes	Analysis process may include any of the above. See IDM Section 55-2.0 for additional considerations.
KS	No	
KY	No	
LA	Yes	Just beginning to perform Road Safety Audits if crash history exists.
MA	Yes	RSAs.
MD	No	Roadside Safety Audits, Safety Analysis and Cost/Benefit Analysis are performed to help develop scope of a project. However, traditional system preservation projects (areawide resurfacing projects) do not go through such analysis.
ME	Yes	We systematically look at out network and do risk assessment on these projects to review whether or not our scope is correct. This has gotten more difficult in recent years due to less funding, more needs, and our falling behind in capital improvement projects.
MI	Yes	Safety analysis of crash types as related to geometric element in question and operational analysis. Risk assessments are not undertaken.

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State	Do you perform safety analyses/risk assessment (e.g., road safety audits, benefit/cost analysis) in preparation of developing project scope and design for 3R projects?	If "Yes," please explain type of analyses.
MN	No	Project development goes through Project Safety Review. It is a process used to determine potential safety improvements for a given section of roadway. It is usually done during scoping phase and it strives to come up with a list of safety improvements and their relative safety effectiveness.
MO	Yes	Missouri has a fledgling RSA process and not all 3R projects are analyzed today. A great deal of analysis goes into the design of roadside safety because of the severity of roadway departure crashes and because upgrades are cost-effective within the 3R environment.
MS	Yes	
MT	Yes	Accident analysis includes a reporting of the number, rate, and severity of crashes in the project corridor, along with an analysis of the trends and crash clusters. Recommendations are given in the analysis as well. We also look at guardrails and discuss other safety issues with Maintenance representatives (snow drifting areas, roadkill/animal–vehicle collisions, etc.).
NC	No	
ND	Yes	Use RSAP for cost-benefit analysis.
NE	Yes	We review the crash history for possible corrective measures to mitigate crashes during the scope phase. We use RSAP as a benefit/cost analysis at spot locations during the design phase.
NH	No	
NM	Yes	Evaluation of crash data and prioritizing facilities based on highest usage and need.
NV	Yes	Department conducts road safety audits on all 3R projects on the Interstate. If time and resources permit, other 3R projects also have road safety audits. In addition to the road safety audits, the Department does a roadside safety review focusing on clear zone issues and standards compliance.
NY	Yes	Road Safety Assessments (i.e., audits) are performed. B/C analyses are performed for proposed safety enhancements/counter measures.
OH	Yes	Safety analysis to determine crash hot spots.
OK	Yes	An accident analysis by type and location is correlated with existing geometric features and physical constraints. This is used to determine where specific safety improvements are needed.
OR	Yes	Usually do a b/c analysis to justify not meeting a design standard on a 3R project.
PA	Yes	All projects are reviewed by our District (Regional) Office Safety Review Committees.
PR	Yes	We evaluate accident reports and perform construction cost analysis for several rehabilitation alternatives. In addition, we consider traffic impact.
RI	Yes	We look at guardrails, mail boxes, sight distances, sidewalk conditions, accidents reports, and encroachments.
SC	No	
SD	Yes	*Highway Safety Manual* analysis on section for crash prediction. Benefit/cost analysis conducted as needed to help determine what work types should be done with current 3R project, deferred to later date, or not done at all.
TX	Yes	Benefit/cost, safety indices.

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State	Do you perform safety analyses/risk assessment (e.g., road safety audits, benefit/cost analysis) in preparation of developing project scope and design for 3R projects?	If "Yes," please explain type of analyses.
UT	Yes	One purpose of a 3R improvement is to correct an existing or potential safety problem. Weigh the cost of any improvements against potential accident reduction. In a number of circumstances it is necessary to provide a safety benefit-cost analysis of the potential improvements including but not be limited to the following: 1. Skid resistance, 2. Pavement edge drop-off, 3. Drainage, 4. Bicycle access, 5. Rumble strips, 6. Delineation, 7.Channelization, 8. Approach grade, 9. Alignment, 10. Bridge rail improvements (new bridge rail or bridge retrofit).
VA	Yes	All projects utilizing 3R standards are reviewed to validate that the impacts of areas with high accidents, traffic speed is compatible with design speed, and the geometrics of the proposed design will help to increase safety.
VT	Yes	Not a formal RSA or cost analysis, rather cost estimation, review of crash data and, when necessary, more in-depth review of alternative and/or safety issues.
WA	No	WSDOT is currently piloting the use of RSAs on developing the scope of safety improvement projects.
WI	Yes	Safety Screening Analysis [described in WisDOT's Facilities Development Manual (FDM) Procedure 11-1-4].
WY	No	

TABLE D5
FIVE MOST FREQUENT SAFETY IMPROVEMENTS INCLUDED IN 3R PROJECTS (RESPONSES TO QUESTION 14)

State	The Five Most Frequent Safety Improvements Included in a 3R Project				
	#1	**#2**	**#3**	**#4**	**#5**
AK	Upgrade of guardrail end treatments	Lane edge and centerline rumble strips	Obstacle/hazard shielding or removal	Horizontal curve flattening	Roadway edge delineation
AL	Roadway widening	Cross slope	Superelevation	Scoring paved shoulders	Guardrail
AR	Lane widths	Shoulder widths	Superelevation	Clear zones	Horizontal and vertical geometry
AZ	Guardrail upgrades	Culvert extensions	Striping and delineation	Slope flattening	Bridge rail upgrades
CA	Shoulder widening	Superelevation correction	Curve radius improvement	Sight distance improvement	Clear recovery zone improvement
CO	ADA curb ramps and sidewalks	Pedestrian crossing	Climbing lanes	Pavement resurfacing	Signalized intersection
CT	Guiderail upgrades	Alignment modifications	Drainage improvements	Intersection design	Pedestrian accessibility
FL	Adding 5 ft-wide paved shoulders	Removing objects from the clear zone	Re-establishing design superelevation	Re-establishing design cross slope	Upgrading barriers and rails
GA	Superelevation	Cross slope	Guardrail upgrades	Improved signage	Barrier walls
HI	New signs	Rumble strips	Culvert extensions	Guardrail end treatments	Bridge railings
IA	Paving of some width of the shoulder	Milled rumble strips	Guardrail updates, replacing installations with new materials, adding guardrail as needed	Turn lanes	Flattening entrance slopes and foreslopes
ID	Rumble strips	Safety edge/slope shoe/sloped pavement edge	Addressing substandard guardrail issues	Addressing roadside signing	Surface restoration
IL	Delineation, such as striping, signing, and guardrail	Traffic control improvements	Intersection radius improvements	Auxiliary lane additions	Side road and entrance improvements
IN	Lane widths—Widen if needed and possible	Shoulder widths—Increase width and improve surface	Superelevation—Improve rates (higher or lower)	Pavement surface—Improve or repair	Intersection Improvements—Add auxiliary lanes, etc.
KS	Edge drop-off	Shoulder width	Foreslopes	Design speed	Guardrail
KY	Upgrade guardrail end Treatments	Upgrade guardrail	Add guardrail to bridges if possible	Safety headwalls/flatten slopes	Bridge barriers
LA	Striping, replacing deficient signs, adding shoulder material	Lane widening	Cross slope corrections	Shoulder wedge	Rumble strips
MA	Improve pavement condition	Improve intersection geometry	Guardrail upgrades	Shoulder widening	Wheelchair ramps

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State	The Five Most Frequent Safety Improvements Included in a 3R Project				
	#1	#2	#3	#4	#5
MD	Pavement/skid analysis	Drainage	Sight distance	Guardrail/rumble strips	Pedestrian/bike accommodations
ME	Design speed	Geometrics	Sight distance	Restoring cross slope	Proper superelevation
MI	Intersection improvements	Lane width with crush and shape work	Superelevation/cross slope	Paved shoulder width	Roadside safety
MN	Shoulder rumble strips	Roadside hardware update (e.g., updating twisted-end guardrails)	Signing and delineation (e.g., chevrons)	Pavement edge drop-off correction (e.g., aggregate shouldering)	Shoulder paving
MO	Upgrades of end terminals	Clear zone maintenance	Pavement edge drop-off correction	Pavement surface correction	Pavement marking upgrades
MS	Shoulder widening	Side slopes	Guardrail	Clearing trees	Resurfacing
MT	Guardrail upgrades	Side slope flattening	Rumble strips	Fencing	Signing upgrades
NC	Pavement edges	Paved shoulders	Shoulder reconstruction		
ND	Guardrail	Pipe extensions	Steep slopes	Signs	Breakaway hardware
NE	Upgrading guardrail	Providing the proper superelevation	New pavement marking/delineators/chevrons	Milled rumble strips	Surfaced turnouts for mailboxes
NH	Sight distance	Clear zone	Signing	Guardrail improvement	Pavement condition
NM	Guardrail	Shoulders	Drainage	Lane width	Alignment (horizontal and vertical)
NV	Slope flattening	Guardrail and end treatment upgrades to bring up to current standards including length of need	Replace signs to ensure reflectivity	Median barrier rail	Pipe extensions and safety end section installation
NY	Clear zone	Guide rail (i.e., guardrail)	Superelevation	Turn lanes	Widen shoulder
OH	Signing	Superelevation correction	Shoulder width	Lane width	Bridge width
OK	Lane and/or shoulder widening.	Correction of minor vertical alignment problems	Correction of superelevation	Extension of drainage structures to clear zone	Upgrade safety appurtenances
OR	Left-turn lane added	Barrier system added	Intersection improvement	Striping	Rumble strips
PA	Guide rail and end treatments	Pavement markings and delineations	Lane widths	Shoulder widths	Obstruction removal
PR	Guardrail-upgrade/installation	Pavement markings and markers	End treatments	Lighting	Signing
RI	Sidewalk improvement	Traffic signal improvement	Striping	Signage	Pavement rehabilitation
SC	Improve roadside safety by adding guardrail	Improving clear zone	Improving horizontal alignment	Improving sight distances	Improving operations (adding turn lanes)

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State	The Five Most Frequent Safety Improvements Included in a 3R Project				
	#1	**#2**	**#3**	**#4**	**#5**
SD	Shoulder width	Rumble strips or stripes	Signing	Guardrail	Pipe/box culvert extension. 6) Inslope or approach slope flattening
TX	Improved pavement condition	Structural components	Roadway width if deficient		
UT	Skid resistance	Pavement edge drop-off	Drainage	Rumble strips	Approach grade
VA	Improving shoulders	Removal or protection of roadside obstacles	Repairs to restore bridge structural integrity, installation of deck protective systems, and upgrading substandard bridge rail	Resurfacing (nonmaintenance activities)	Roadside hazard removal and guardrail installation
VT	Sight distance	Pavement markings	Signage	Lane/shoulder width	Roadside hazards
WA	Barrier terminals	Sight distance improvement	Rumble strips	Signing updating	Delineation
WI	Add or widen paved shoulders	Upgrade beam-guard terminals	Signing and pavement marking	Re-align horizontal curves	Intersection improvements
WY	Superelevation correction	Side slope correction	Guardrail upgrade	Signing upgrade	Bridge rail upgrade

TABLE D6
RANKING OF 13 CONTROLLING CRITERIA (RESPONSE TO QUESTION 9)

State	Ranking of 13 controlling criteria from 1 (most) to 13 (least) as to how important each is for 3R projects												
	1	2	3	4	5	6	7	8	9	10	11	12	13
AK	LW	SW	HA	DS	SSD	BW	SC	VA	HC	GR	CS	SUP	VC
AL	SC	CS	SUP	LW	SW	DS	VC	BW	HC	SSD	HA	VA	GR
AR	DS	HA	VA	GR	LW	SW	HC	SUP	CS	VC	BW	SC	SSD
AZ	DS	SSD	HA	VA	LW	SW	SUP	BW	GR	CS	VC	SC	HC
CA	DS	HA	SSD	LW	SW	BW	SUP	VC	VA	HC	GR	SC	CS
CO	HA	DS	HC	LW	SSD	SW	CS	VA	SUP	GR	BW	SC	VC
FL	SSD	SC	SW	SUP	VC	HC	BW	LW	CS	HA	VA	DS	GR
GA	SUP	CS	SC	VC	HC	DS	HA	VA	SSD	GR	BW	LW	SW
HI	DS	LW	SSD	SW	HA	VA	BW	SC	SUP	VC	HC	GR	CS
IA	DS	LW	SW	HA	SUP	CS	VC	SC	VA	BW	GR	HC	SSS
ID	DS	SSD	SW	LW	BW	VA	SC	HA	SUP	GR	CS	HC	VC
IL	DS	HA	VA	SSD	SUP	LW	SW	BW	GR	CS	HC	VC	SC
IN	DS	LW	SSD	SUP	BW	SC	SW	HA	VA	CS	GR	VC	HC
KS	DS	LW	SC	SW	BW	HA	SUP	SSD	VA	GR	CS	HC	VC
KY	SC	VC	SW	BW	HC	CS	SUP	SSD	LW	GR	DS	VA	HA
LA	LS	SW	CS	SUP	HC	VC	DS	SSD	HA	VA	BW	GR	SC
MA	SW	LW	BW	VC	SC	DS	SSD	HA	VA	GR	CS	SUP	HC
MD	SC	SSD	CS	SUP	DS	BW	HC	HA	LW	SW	VA	VC	GR
ME	DS	GR	VA	HA	CS	SUP	LS	SSD	SW	BW	SC	HC	VC
MI	VC	SC	BW	DS	LW	SUP	SSD	CS	SW	HC	HA	GR	VA
MN	SW	CS	VC	LW	SSD	VA	GR	SUP	DS	HC	HA	BW	SC
MO	HC	SC	CS	SUP	VC	DS	SSD	LW	BW	SW	HA	VA	GR
MS	LW	SW	SSD	DS	BW	SC	HA	VA	GR	CS	SUP	HC	VC
MT	DS	LW	SW	BW	SC	HA	SSD	VA	GR	CS	SUP	HC	VC
NC	DS	VC	HC	LW	BW	SC	SW	HA	VA	GR	SSD	CS	SUP
ND	SSD	DS	LW	SW	BW	SC	SUP	CS	HA	VA	GR	HC	VC
NE	LW	SW	SSD	BW	SC	DS	CS	SUP	HA	VA	VC	GR	HC
NH	DS	SSD	HC	LW	SW	SC	CS	SUP	BW	HA	VA	GR	VC
NJ	DS	LW	SW	CS	HA	VA	SSD	HC	VC	SUP	BW	GR	SC
NM	DS	SC	HA	LW	SW	BW	VA	GR	SSD	SUP	VC	HC	CS
NV	SC	SW	VC	HC	DS	SSD	BW	LW	HA	VA	CS	SUP	GR
NY	DS	LW	SW	SUP	HC	SSD	CS	HA	BW	VA	GR	SC	VC
OH	SSD	HA	SUP	SW	LW	VA	BW	CS	HC	GR	VC	SC	DS
OK	SC	DS	LW	SW	HA	SUP	VA	SSD	GR	BW	VC	HC	CS
OR	DS	SUP	LW	BW	CS	VA	SSD	HA	VC	SW	SC	GR	HC
PA	LW	BW	SUP	CS	SW	SSD	HA	VA	GR	HC	VC	SC	DS
PR	SC	VC	VA	HC	LW	SW	HA	SUP	GR	CS	SSD	BW	DS
RI	LW	SC	BW	DS	SW	GR	HA	VA	SSD	VC	HC	CS	SUP
SC	HA	VA	SSD	LW	SW	SU	GR	DS	SC	BW	CS	HC	VC

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State	Ranking of 13 controlling criteria from 1 (most) to 13 (least) as to how important each is for 3R projects												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
SD	LW	SW	SSD	SC	SUP	CS	VC	HC	BW	GR	HA	VA	DS
TX	SC	DS	LW	SW	BW	HA	VA	GR	SSD	CS	SUP	HC	VC
UT	CS	GR	SSD	SW	HA	SUP	VA	LW	HC	DS	SC	BW	VC
VA	SSD	DS	HA	VA	LW	SW	SC	BW	SUP	CS	HC	VC	GR
VT	DS	LW	SW	SUP	CS	SSD	HA	VA	SC	GR	BW	HC	VC
WA	LW	SW	SSD	VC	HC	CS	DS	SUP	BW	HA	VA	GR	SC
WY	DS	LW	HA	VA	SW	SSD	SUP	CS	SC	BW	VC	GR	HC

Key:

DS	design speed	VA	vertical alignment
LW	lane width	SUP	superelevation
SW	shoulder width	CS	cross slope
BW	bridge width	GR	grades
SC	structural capacity	HC	horizontal clearance
SSD	stopping sight distance	VC	vertical clearance
HA	horizontal alignment		

TABLE D7
REASONS FOR THREE HIGHEST RANKED CRITERIA (RESPONSES TO QUESTIONS 10 AND 11)

State	Considering the three design criteria that you ranked highest, why do you consider them more important than the others?	List other design elements that should be considered for 3R projects.
AK	Highest correlation with safety and accidents.	Traffic volume. Skid resistance. Signage. Driveways. Economics.
AL	The roadway needs to be able to handle the current traffic and % trucks throughout pavement life. The cross slope and superelevation mitigates run-off-the-road accidents and helps with drainage	
AR	If you do not have the 3R criteria met for horizontal and vertical alignment and grades, the 3R criteria cannot be used and AASHTO Guidelines override the 3R criteria for design speed of the facility.	I believe the design elements we currently use are sufficient.
AZ	The most impact on safety.	Intersection sight distance
CA	Directly related to safety of the roadway.	Pavement design life, safety improvements
CO	3R projects address safety and other issues on existing facilities. It is generally typical for the safety deficiencies to be related to horizontal alignment, design speed, and horizontal clearances.	
CT	A ranking of the items above was not performed. The engineer needs to weigh these items on a project-specific basis.	ISD, clear zone, pedestrian access, ADA and to a lesser extent bicycle access
FL	Florida is a “flat” state with many bodies of water adjacent to our roads. Thus, we want to first be sure we provide immediate safety to motorists on the road (stopping sight distance) as well those who stray off it (shoulder width). Finally, deficiencies in structural capacity could be catastrophic with higher rates of serious injuries and fatalities.	Crashworthy roadside features.
GA	1 and 2 are more generally easily corrected with this type of project. 3 is an absolute value the bridge either can or can’t handle the required loading.	Guardrail and side barrier upgrade.
HI	Design speed is important as it determines the recommended design figures for various other roadway elements. Lane width should be considered as it contributes to driver perception of roadway conditions (“implied” safe speed, proximity to adjacent cars, etc.) and affects behavior. Stopping sight distance is critical because it is the allowance incorporated into the roadway design to allow drivers to react to hazards or uncertainties.	

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State	Considering the three design criteria that you ranked highest, why do you consider them more important than the others?	List other design elements that should be considered for 3R projects.
IA	The design speed is in this list because it controls so many of the others; changing it can hide other problems. Lane width is important because it is the main area the cars use. We try to maintain full lane widths. Safety is impacted with edge rut problems, run-off-road crashes, cross centerline crashes, etc. Shoulder width is related to lane width and can influence crashes similar to narrow lane width.	Clear zone and guardrail updates, ADA requirements, safety enhancements (milled rumble strips, paved shoulders, improved signing) operational and capacity aspects of intersections (turn and auxiliary lanes).
ID	Design speed because it dictates rest of standards associated with roadway. Sight distance because of its effect on drivers' perception of the roadway. Shoulder/lane widths for consistency of section.	Pavement edge—should be sloped to avoid edge drop offs.
IL	1. Design speed governs all other criteria. 2. Horizontal alignment is often related to safety issues. 3. Vertical alignment affects stopping and passing sight distances.	Traffic volumes, combinations of curves, roadside features, pavement conditions, intersection conditions, and traffic control conditions
IN	Design Speed—Many design elements are speed-sensitive. Lane Width—Adequate lane width is essential to provide maneuvering space for the predominate type of user vehicle. Stopping Sight Distance—Important consideration in preventing rear-end crashes that occur frequently and also involves vertical and horizontal alignment.	See *Indiana Design Manual* (IDM) Section 55-2.01
KS	They relate to traffic operations, safety, and preservation of the roadway function.	Drainage and overtopping frequency
KY	Generally, our trigger for doing 3R type projects on Interstates and parkways are driven by ride, pavement conditions, and safety features.	None
LA	To be considered a "3R"-type project, the work typically remains within the existing crown and cannot require additional right-of-way. The top four selected criteria can typically be adjusted within the existing crown and may improve safety by making small adjustments. If alignments, grades, and bridges are to be modified, the project typically requires right-of-way and utility adjustments and would then fall under the reconstruction category and not eligible for this program.	ADT, percentage of trucks
MA	Safe accommodation of all users; pedestrians, bicyclists, motorists.	
MD	The top three are safety driven measures.	Pedestrian safety, bicycle compatibility, ADA compliance
ME	Typically on 3R we try to establish the best possible highway standards practical while realizing we cannot fix everything.	Design year traffic volumes, level of service, traffic data, capacity analysis
MI	Bridges are fixed, more costly, longer service life, and less flexible in alternative repairs than road facilities.	Roadside safety

Table D7 continued on p. 73

Table D7 continued from p. 72

State	Considering the three design criteria that you ranked highest, why do you consider them more important than the others?	List other design elements that should be considered for 3R projects.
MN	They are the most commonly degraded or improved elements by 3R projects.	Roadside hardware (e.g., guardrails, signing, lighting); pavement markings; and general sight distance (e.g., trimming overgrown vegetation to improve sight distance).
MO	Horizontal clearance is critical given the severity of roadway departure crashes. Structural capacity is closely monitored, although it's generally analyzed outside of the 3R process. Structures are rarely resurfaced during 3R. Cross slopes and superelevations aren't nearly as critical as the previous two factors, but can be readily corrected within the 3R environment.	Given the rehabilitative nature of 3R work, the scope doesn't usually include a great deal of work requiring design.
MT	Design Speed. An accurate selection of the design speed is essential to determining the best values for the other design elements. Lane and Shoulder Widths. The greatest safety improvements are achieved by providing adequate lane and shoulder widths. Whether the lane or shoulder width is more critical is dependent on the existing widths, traffic volumes, congestion issues, and an assessment of accident characteristics.	Clear zones, intersection sight distance
NC	Design speed.	Guardrail, pavement edge drop-offs.
ND	Adequate sight distance appears to be factor when developing safety projects. On a 3R project, normally we will be moving dirt. It is an opportune time to address stopping sight distance. Design speed is the main control for calculating many of the design elements. Appropriate roadway width is usually obtained by widening the roadway for a 3R project.	Traffic operations—such as turn lanes; typical section—foreslope, ditch bottom, and backslope; pavement slough treatment; environmental impacts, cultural impacts; right-of-way impacts; safety review; corridor consistency; pedestrian impacts
NE	Criteria 1–5 are listed in the Nebraska Board of Public Roads Classifications & Standards Minimum Design Standards and must be met or a design exception is required.	Clear zones. Surfaced shoulder widths.
NH	Safety	Drainage condition, guardrail condition and length of need, pavement condition, and slopes along the corridor
NJ	Design speed affects many of the other criteria. Lane and shoulder widths play a major role in driver comfort and safety.	Curb face height, guide rail
NM	I do not necessarily consider them more important. Importance of design criteria should be project-specific.	

Table D7 continued on p. 74

Table D7 continued from p. 73

State	Considering the three design criteria that you ranked highest, why do you consider them more important than the others?	List other design elements that should be considered for 3R projects.
NV	We consider the main purpose of the 3R program to be pavement maintenance. Our repair strategies are impacted by the existing structural capacity of the pavement. The type of repair done and the thickness of the overlay are impacted by it. Safety is also a priority of the Department. We have portions of the NHS in the rural sections of the state that have substandard shoulder width. We are taking the opportunity when funding allows to bring the shoulder widths up to standards. The vertical clearance is considered to ensure that our repair strategies do not reduce the existing clearances. In some cases, the strategy is modified to get additional clearance under existing structures.	Clear zone—achieving or maintaining recoverable slopes, meeting length of the need on guardrail, etc. ADA compliance in urban areas, sidewalk ramps, pedestrian signal buttons, etc.
NY	Design speed sets the criteria for most of the other elements. Lane and shoulder width can have the greatest impact the operation, safety, and ability to accommodate other users (bicyclists and pedestrians).	Pedestrian accessibility.
OH	More common, not necessarily more important.	
OK	Structural Capacity—the state of Oklahoma has made replacement of load posted bridges a priority. Design Speed—This is a core design element; most design criteria are determined based on the design speed. Lane Width/Shoulder Width—this is usually one of the easiest elements to improve that yields substantial safety benefits.	Flattening of side slopes, clear zone adjustments, drainage improvements, adjustment of driveway locations and spacing, intersection improvements, upgrading safety appurtenances, etc.
OR	Design speed defines a significant number of other design criteria. Superelevation and lane width affect the overall safety of the project for the users.	Intersection sight distance, left-turn lanes, right-turn lanes
PA	It should be noted that the most important design feature should be assessed on a project-by-project basis, based on the unique problems that have been experienced at specific locations. These elements, as well as others, on safety and operations of the roadway.	Pedestrian accommodations.
PR	The structural capacity of the existing pavement is the start point to evaluate what type of rehabilitation the pavement needs. Vertical clearance and vertical alignment control pavement rehabilitation options.	Budget, MOT (traffic), safety, drainage.
RI	RI has very old roadways with limited ROW. Bridges are ranked 49 out of 50 states and need replacing.	Pavement make-up, soils, historical issues, environmental issues. RI has coastal and many wetlands.
SC	These three are directly related to the safety and operations of the facility.	Roadside safety and clear zone, available right-of-way, environmental impacts, intersection sight distance, pedestrians, ADA accessibility, bicyclists
SD	Safety and LOS impacts	N/A
TX	Their impacts to safety	Pavement condition and crash history

Table D7 continued on p. 75

Table D7 continued from p. 74

State	Considering the three design criteria that you ranked highest, why do you consider them more important than the others?	List other design elements that should be considered for 3R projects.
UT	These elements are not considered more important than the others, but they are elements that can typically be addressed as part of a 3R project. Other items farther down the list are important but are less likely to be brought to standard through a maintenance type project.	Clear zone, intersection sight distance, ramp terminal sight distance, shoulder/travelway (gutter pan), curb configuration, rumble strips
VA	The three highest ranked items have a higher level of safety risk associated with them.	Accident rates, pavement deterioration, ADT
VT	This ranking is difficult, because all criteria need to be taken into consideration. However, of our top three, our projects follow our State Design standards. These criteria are used to set the footprint of the project and accommodate to the best our ability all users of the highway while always considering safety.	
WA	WSDOT does not use the 3R approach to projects. WSDOT separates out Preservation and Improvement projects. WSDOT places these criteria higher because they are safety related and there is a potential of correcting these criteria on preservation type projects.	Barrier and intersection related criteria.
WI	WisDOT has never explicitly ranked the design criteria. It is somewhat of a subjective question and could be answered differently depending on how “importance” is defined.	Intersection sight distance, bridge rails, roadside safety and design (e.g., clear zone, side slopes, barriers), curb ramps, intersection geometry, pavement marking and signing
WY	Believe they significantly impact safety.	

TABLE D8
RESPONSES TO QUESTION 13

State	How often are safety improvements considered in a 3R project (please check one)?
AK	Routinely considered
AL	Routinely considered
AR	Routinely considered
AZ	Routinely considered
CA	Routinely considered
CO	Routinely considered
CT	Routinely considered
FL	Routinely considered
GA	Routinely considered
HI	Routinely considered
IA	Routinely considered
ID	Routinely considered
IL	Routinely considered
IN	Routinely considered
KS	Routinely considered
KY	Not normally considered
LA	Routinely considered
MA	Routinely considered
MD	Routinely considered
ME	Routinely considered
MI	Routinely considered
MN	Not considered unless safety problem identified
MO	Routinely considered
MS	Routinely considered
MT	Routinely considered
NC	Not considered unless safety problem identified
ND	Routinely considered
NE	Routinely considered
NH	Routinely considered
NM	Routinely considered
NV	Routinely considered
NY	Routinely considered
OH	Routinely considered
OK	Routinely considered
OR	Not considered unless safety problem identified
PA	Not considered unless safety problem identified
PR	Routinely considered
SC	Routinely considered
SD	Routinely considered

Table D8 continued on p. 77

Table D8 continued from p. 76

State	How often are safety improvements considered in a 3R project (please check one)?
TX	Routinely considered
UT	Routinely considered
VA	Routinely considered
VT	Routinely considered
WA	Routinely considered
WI	Routinely considered
WY	Routinely considered

TABLE D9
IS CONSIDERATION GIVEN TO PEDESTRIANS AND BICYCLIST IN 3R PROJECTS?
(RESPONSES TO QUESTIONS 15 AND 16)

State	Consideration given to pedestrians?	If "Yes," please describe	Consideration given to bicyclists?	If "Yes," please describe
AK	No		No	
AL	Yes	For existing pedestrian facilities we look for compliance to ADA	Yes	For existing bicyclist facilities we look for compliance to ADA
AR	Yes	Only in urban areas	No	
AZ	Yes	Sidewalk ramps are reviewed for ADA compliance.	Yes	Pavement treatments accommodate bicycle travel. Local requests for additional width for bicycle travel are considered.
CA	Yes	Sidewalks are considered. ADA is addressed.	Yes	If part of a designated bike route, shoulders are designed accordingly. If bikes are allowed but not part of a designated bike route, shoulders are provided when practical.
CO	Yes	Considerations are given for pedestrian crossings at intersections or mid-bock on a given facility and sidewalks.	Yes	Wherever applicable considerations are given for bicycle lanes adjacent to edge of travel or shoulder
CT	Yes		Yes	
FL	Yes	By Florida Statute 335.065 we must fully consider bicycle and pedestrian ways into every transportation project, especially those in or within one mile of an urban area. http://www.dot.state.fl.us/rddesign/PPMManual/2010/Volume1/Chap08.pdf	Yes	See #15 above.
GA	Yes	Consideration is given to appropriateness of crosswalks. All ramps are upgraded or installed to comply with the ADA.	Yes	
HI	Yes	Pedestrians are considered in 3R projects as ADA improvements and guardrail placement is designed to accommodate a useable path.	No	

Table D9 continued on p. 79

Table D9 continued from p. 78

State	Consideration given to pedestrians?	If "Yes," please describe	Consideration given to bicyclists?	If "Yes," please describe
IA	Yes	ADA upgrades are made.	Yes	Milled shoulder rumble strip policy was developed with bicyclists to allow them to ride on paved shoulders when possible.
ID	Yes	ADA issues are looked at and addressed in urban situations. Particularly related to curb cuts and ramps.	Yes	Shoulders are commonly looked at for bicycle accommodations. Some minor widening is performed where appropriate that will enhance bicycle accommodations.
IL	Yes	Each 3R project considers pedestrians. See http://www.dot.il.gov/desenv/BDE%20Manual/BDE/pdf/chap17.pdf.	Yes	Each 3R project considers bicyclists. See http://www.dot.il.gov/desenv/BDE%20Manual/BDE/pdf/chap17.pdf.
IN	Yes	See Question No. 17 response.	Yes	Where bicycle traffic is high, lane or shoulder widening or separate bicycle lanes or facilities may be provided if space or funds are available and there is public interest in such facilities.
KS	Yes	Pedestrian activity is reviewed and accommodated to the extent practicable.	Yes	Check if there is bicycle demand and accommodate to the extent practicable.
KY	No		No	
LA	Yes	If curb ramps, crosswalks, and signals exist, they are updated as applicable.	Yes	If bicycle lanes and striping exist, they will be updated if applicable.
MA	Yes	Accommodation for pedestrians with ADA sidewalks, wheelchair ramps, crosswalks, pedestrian signals, etc.	Yes	Accommodation for bicyclists with adequate shoulder width, signing, pavement markings, signals, etc.
MD	Yes	Continuity of pedestrian movements (filling in the gaps of sidewalks), ADA compliance—ramps, sidewalk width, accessible pedestrian signals, bus stop relocations	Yes	On road bicycle compatible lanes/shoulders, signage, drainage improvements
ME	No		No	
MI	Yes	ADA upgrades and incorporation of sidewalks	Yes	Shared usage of paved shoulder width with nonmotorized, earth buffer width to sidewalks
MN	Yes	Shoulder and crosswalk improvements are considered on 3R projects.	Yes	In rural areas, paving shoulders are considered for 3R projects. In urban areas, providing bike lanes is considered.

Table D9 continued on p. 80

Table D9 continued from p. 79

State	Consideration given to pedestrians?	If "Yes," please describe	Consideration given to bicyclists?	If "Yes," please describe
MO	Yes	MoDOT considers the needs of its pedestrians (particularly those with disabilities) on all projects. Remedial ADA action is taken in keeping with the published transition plan.	Yes	MoDOT considers the needs of its bicyclists on all projects. However, 3R work rarely warrants significant upgrades.
MS	Yes	In urban areas, sidewalks will be added where needed.	Yes	Shoulders may be paved where needed
MT	Yes	ADA upgrades are included in urban projects. Pedestrian crossings are considered with striping upgrades.	Yes	Accommodations are included if practicable depending on the scope of work. Resurfacing projects may include delineating bike lanes. Major rehabilitations may provide additional shoulder width to enhance bicycle usage.
NC	No		No	
ND	Yes	Try to bring existing facilities up to current ADA and *MUTCD* standards. If there is a pedestrian plan, this is considered. Look at crosswalks.	Yes	Update existing bicycle facilities. Consider installation of new facilities where an overall plan exists.
NE	Yes	By Nebraska Statues, municipalities are responsible for everything outside of the driving lanes. See 17 below.	Yes	We do not place milled rumble strips on surfaced shoulders less than 6 ft wide.
NH	Yes	If involved in sidewalks we replace sidewalk corners with tip-downs and truncated domes.	Yes	Investigate if segment is on a bike route and try to accommodate an acceptable shoulder width with the scope of the project.
NM	Yes	Only when deemed necessary (urban and semi-urban). NM is mostly rural.	Yes	With 6 ft shoulders or "Share the Road" 14 ft outside lanes.

Table D9 continued on p.81

Table D9 continued from p. 80

State	Consideration given to pedestrians?	If "Yes," please describe	Consideration given to bicyclists?	If "Yes," please describe
NV	Yes	Existing sidewalk is evaluated and improved to ensure it meets current ADA standards, when feasible. Improvements may include replacing substandard sidewalk ramps and installing or updating pedestrian buttons on traffic signals. In some cases, where short sections of sidewalk are missing, new sidewalks may be added to close the gap. Pedestrian movements during construction are considered during the development of the traffic control.	Yes	Projects in the urban Clark County area are stripped to provide a wider outside lane to better allow a shared use of that lane with bicyclists. In addition, the established bicycle plan covering the project is referenced to determine the type of facility planned for the road. Striping and signing is adjusted where appropriate to accommodate the plan. We generally do no widening on a 3R project to provide for bike lanes or routes.
NY	Yes	New sidewalks are considered where there are pedestrian generators. On arterials and collectors, a minimum 4 ft shoulder is used in rural areas to provide for the occasional pedestrian.	Yes	On arterials and collectors, a minimum 4 ft shoulder is used in rural areas to provide for the bicyclists. On arterials and collectors, a minimum 5 ft shoulder is used in urban areas adjacent to curb to provide for the bicyclists.
OH	Yes	Pedestrians are considered by ODOT policy 20-004(P).	Yes	Bicycles are considered by ODOT policy 20-004(P).
OK	Yes	If a 3R project disturbs a sidewalk, the sidewalk is replaced. Existing sidewalks may be resurfaced if necessary. Where sidewalk does not currently exist, the need for a sidewalk is evaluated.	Yes	This would be very unusual, but if a bicycle route has been identified it would be included in the project.
OR	Yes	Address pedestrian access routes. Evaluate current ADA accommodations.	Yes	Bike lanes or paved shoulders are provided in 3R projects. All projects accommodate bicyclists.
PA	Yes	PennDOT utilizes a Bike/Ped checklist for all projects to ensure needs are considered in project development.	Yes	PennDOT utilizes a Bike/Ped checklist for all projects to ensure needs are considered in project development.
PR	Yes	When applicable	Yes	When the need is "obvious."
RI	Yes	Most 3Rs are in urban areas of the state where sidewalks are in poor condition, intersections are obsolete.	Yes	In RI bikes are considered a vehicle. We have an extensive bike network and we try to connect bike routes to bike routes.

Table D9 continued on p. 82

Table D9 continued from p. 81

State	Consideration given to pedestrians?	If "Yes," please describe	Consideration given to bicyclists?	If "Yes," please describe
SC	Yes	Sidewalk may be reconstructed or added as part of the scope of the project.	Yes	Additional paved shoulder width is a betterment to bicyclists. We attempt to add a minimum of 4 ft of paved shoulder on roadways identified as part of a state bicycle route.
SD	Yes	Providing ADA-accessible curb ramps as per ADA guidelines	Yes	Review shoulder width and rumble strip/stripe installation.
TX	Yes	Improvements are made for pedestrian traffic including signals, crosswalks, and signing.	Yes	Additional pavement width and signing at appropriate locations
UT	Yes	Consideration given to accessible curb ramps and walkway slopes and drainage.	Yes	Consideration given to bike accessibility.
VA	Yes	All projects are reviewed for the purposes of including new facilities for pedestrians or upgrading current facilities.	Yes	All projects are reviewed for the purposes of including new facilities for bicyclists or upgrading current facilities.
VT	Yes	All aspects associated with pedestrian safety and mobility are considered, whether it be ADA accessibility, crosswalks, delineation, signal timing, etc.	Yes	All aspects associated with bicycle safety and mobility are considered, whether it be shoulder width, pavement markings, signage, etc.
WA	Yes	ADA curb ramps and crosswalks are reviewed and updated if needed to bring them into compliance. Also, pedestrian detours are provided during construction.	Yes	Consideration is given to bicyclists regarding how the incorporation of any safety item may affect them. For example if considering the installation of rumble strips, bike use is considered.
WI	Yes	Curb ramp policy in FDM Procedure 11-25-30	Yes	Traversable drainage grates and wider paved shoulders
WY	No		No	

TABLE D11
IS CONSIDERATION GIVEN TO ADA REQUIREMENTS FOR 3R PROJECTS?
(RESPONSES TO QUESTION 17)

State	**Consideration given to ADA requirements, such as accessible curb ramps and walkway slopes?**	**If “Yes,” please describe.**
AK	Yes	Upgrades of curb ramps and walkways are required to meet ADA requirements.
AL	Yes	We adhere to the ADA standards for accessible design.
AR	Yes	Only in urban areas.
AZ	Yes	Sidewalk ramps are reviewed for ADA compliance.
CA	Yes	ADA improvements are within the scope of a 3R project.
CO	Yes	Curb ramps and curb cuts at pedestrian crossings are constructed/retrofitted to be ADA accessible and in compliance with federal and FHWA guidance and requirements.
CT	Yes	ADA-compliant sidewalks and curb ramps are provided, except where it is technically not feasible.
FL	Yes	See *Plans Preparation Manual* Chapter 8, Section 8.3.2.
GA	Yes	Curb ramps are always considered. Walkway cross slopes may be included.
HI	Yes	If within the projects limits, ADA improvements are typically absorbed into a 3R project, as a policy.
IA	Yes	We make all required ADA upgrades with our projects.
ID	Yes	See pedestrian considerations.
IL	Yes	Current ADA requirements are considered on each 3R project. See http://www.dot.il.gov/desenv/BDE%20Manual/BDE/pdf/chap58.pdf.
IN	Yes	All ADA requirements are addressed.
KS	Yes	If the surfacing is modified, curb ramps and sidewalks should be updated as well.
KY	No	
LA	Yes	All projects, with exception of preventive maintenance, must meet ADA requirements for curb ramps.
MA	Yes	All wheelchair ramps must be in brought into compliance.
MD	Yes	If ramps or sidewalk are present, we will ensure that they meet the latest SHA guidelines for ADA. If not, they will be reconstructed. If sidewalk is present, but there is a need, we will include it in the project and ensure that all logical connections are being made to complete the pedestrian network. SHA has guidelines that can be forwarded to you for additional information pertaining to this subject.
ME	Yes	If we make any adjustments to a sidewalk we are required by policy to make it ADA compliant.
MI	Yes	With surfacing > ¾ in. (two-course overlay).
MN	Yes	Installing truncated domes and curb ramp retrofits are considered on 3R projects.
MO	Yes	Remedial ADA action is taken in keeping with the published transition plan. Moreover, regardless of any published requirement, MoDOT takes a “do the right thing” approach to ADA.
MS	Yes	All sidewalks are brought up to ADA compliance.
MT	Yes	Resurfacing projects include ADA upgrades to ensure that existing curb ramps are accessible. Some sidewalk repair may be included if practicable. New curb ramps may be included if a need is identified.
NC	Yes	ADA upgrades are required for all resurfacing projects.
ND	Yes	We update curb ramps and review other ADA requirements.

Table D11 continued on p. 84

Table D11 continued from p. 83

State	Consideration given to ADA requirements, such as accessible curb ramps and walkway slopes?	If "Yes," please describe.
NE	Yes	If a 3R project includes any work in a marked or unmarked crosswalk having curb or other barrier to entry from a walkway, and where accessible on-street parking is provided, we construct ADA-compliant curb ramps, building new sidewalks only as required to match into the existing sidewalk.
NH	Yes	If involved with sidewalks we include work to incorporate curb ramps with tip-downs and truncated domes.
NM	Yes	Always considered using AASHTO guidelines.
NV	Yes	All ramps are brought up to current standards. Sidewalks are reviewed to ensure the widths meet standards. Usually, any improvements that can be completed within the right-of-way are incorporated into the project. Those outside of the right-of-way are further evaluated to determine the feasibility of making the improvements.
NY	Yes	All curb ramps and existing sidewalks are brought into conformance with ADA.
OH	Yes	Curb ramps are required to be built to standard either before project start or done concurrently with a resurfacing project. http://www.dot.state.oh.us/policy/PoliciesandSOPs/Policies/519-002(P).pdf.
OK	Yes	Accessible ramps and walkway slopes are included when relevant.
OR	Yes	Accessible route check on projects along with all of the ADA features that are installed or required.
PA	Yes	All projects are reviewed for ADA compliance.
PR	Yes	Our design standards provide ADA requirements and we include it where it is needed.
RI	Yes	Always. If we touch a roadway, we improve the sidewalk.
SC	Yes	We routinely replace curb ramps and correct improper driveway designs when the cross slopes do not adhere to our current guidelines.
SD	Yes	Curb ramps are upgraded so they are ADA accessible.
TX	Yes	Curb ramps are added and slopes evaluated.
UT	Yes	ADA requirements must be met on 3R projects.
VA	Yes	All projects must meet the applicable ADA requirements.
VT	Yes	Always.
WA	Yes	Curb ramps and crosswalks are brought into compliance with current requirements. Also, traffic control plans are developed to accommodate pedestrians during construction.
WI	Yes	FDM 11-25-30: "Curb ramps with detectable warnings shall be installed on all state or federally funded projects with sidewalks (including resurfacing, SHRM, and Preventative Maintenance projects) where curb ramps do not exist."
WY	Yes	Upgrade ADA curb ramps.

TABLE D12
MOST UNANSWERED ISSUE REGARDING 3R PROJECT DESIGN (RESPONSE TO QUESTION 18)

State	What do you believe is the most unanswered issue regarding 3R project design?
AK	For Alaska, it is that we have not split out Preventative Maintenance (1R) projects from 3R projects yet. PM (1R) projects are burdened with our full 3R procedures at this time.
AR	No response thought of.
AZ	At what values are the lack of design superelevations most critical and when is it really cost-effective to reconstruct to correct.
CO	ADA requirements for existing sidewalks, pedestrian crossings along existing facilities. To what extent beyond signalized pedestrian crossings should such facilities be upgraded for ADA compliance?
CT	What is the appropriate degree of improvement (what are the pitfalls of inaction)?
FL	Balancing the level of surveying necessary during design and included in the plans (especially to accurately portray cross-slope and supereleveation corrections) with ever-increasing need to reduce project costs.
GA	The need to process Design Exceptions for the work being performed.
IA	Where is the line between new construction and 3R? Should a PCC overlay of 8 in. get different criteria than a new pavement that is not much thicker? Many of our roadways will never be reconstructed because they are low volume and overlays are sufficient. Do we ever need to consider major upgrades on the geometrics and cross section? Currently, we focus on safety upgrades that don't require substantial ROW.
ID	Tort liability. At what level does a restoration become an improvement/betterment and someone has to answer why the roadway was not reconstructed to full standards? At what point is the only reason a project was not brought to full standards because simply not enough money was budgeted for the project?
IL	3R projects are intended to extend the service life of the existing facility and to return its features to a condition of structural or functional adequacy; to incorporate cost-effective, practical improvements to the geometric design of the existing facility, and to enhance highway safety. It is unclear to many the extent to which the 3R concept has succeeded in the last objective, and the level of cost-effectiveness reached in that effort in these projects.
IN	How to achieve wider shoulders or flatter side slopes within the existing ROW since ROW acquisition is typically minimal on a 3R project.
KS	Long-term benefit/cost. This could include such things as design life, safety performance, and legal liability.
MA	When are projects exempt from improving bicycle and pedestrian accommodation.
MD	Level of safety required in system (pavement) preservation projects.
ME	Consistency of application.
MI	Prioritizing upgrades to address geometric deficiencies when all cannot be met.
MN	When to make location-specific geometric improvements that are proactive in addressing safety. In other words, when and whether to apply the recommendations in the *TRB SR 214*.
MO	N/A
MT	None I can think of. The federal guidance for improving accessibility is somewhat confusing in that it notes that alterations that require improvements to accessibility are "projects that could affect the structure." The same guidance indicates that thin overlays are considered maintenance even though they do increase the structure of the road surface. What constitutes a maintenance thin-lift overlay? LOS?
NC	Superelevation.
NE	What do states do when resurfacing a roadway that was originally built with recoverable slopes in which the resurfacing results in a significant grade raise? Narrow the shoulders? Regrade the foreslopes? Tie in steeper slopes as quickly as possible?
NH	Need to be flexible with design standards when you can't meet the minimums due to type of work. Scope of work does not permit addressing all controlling design elements, and requires solid engineering judgment to develop cost-effective solutions to maximize highway and roadside safety.
NM	Accommodations for pedestrians, ADA, and bicyclists are encouraged; however, funding is never adequate. Funding is a huge issue for the three elements that if not incorporated into a project, the project's 3R aspect is dead.
NV	Funding. We struggle with getting the most bang for our buck in regard to the pavement condition while balancing the other needs of the system, such as safety, ADA, other improvements. It would be nice to have greater flexibility with using the federal funding that we get, safety and bridge funds.
NY	The design criteria are very complicated. Is there a simpler list of criteria that will maximize safety and minimize cost? Too much time is spent on NEPA for 3R projects. Can it be streamlined?

Table D12 continued on p. 86

Table D11 continued from p. 85

State	What do you believe is the most unanswered issue regarding 3R project design?
OH	Our 3R is based off of the old guidelines and it needs to be updated, and it needs to include other facility types.
OK	Are 3R projects more susceptible to tort claims?
OR	Lack of funding for upgrades to the system. Surface treatment takes most of the dollars and all other features are generally ignored. This is the same issue identified in *TRB Special Report 214* in 1987. (See 4th paragraph of Executive Summary on page 1.)
PA	Clear zone obstructions.
PR	Since the Agency does not have a policy established for 3R projects, the most unanswered issue in PR is the need of a published Design Process or Guidelines for 3R projects instead of performing cold milling and overlays without analysis and design.
RI	Money; projects are becoming more expensive because of federal and state requirements.
SC	Specifying a project as 3R occurs on a case-by-case basis and I am not aware of any national standards that determine the minimum design criteria that can be applied to a 3R project. Many times, engineers are reluctant to go below the minimum standards without definitive guidance to support the deviation. Development of national 3R design standards would provide a baseline from which an engineer could make a judgment call.
TX	None.
VA	Better examples of what types of projects do not qualify for 3R standards based upon the language in *Special Report 214*.
VT	In Vermont the link between “maintaining and/or rehabilitation” on existing alignment and the significant impact of project timeline/delivery based on environmental permitting considerations.
WI	A 3R project should not degrade the existing road design. However, resurfacing will sometimes raise the road profile. This can result in negative effects on the cross-section design: narrowing the shoulder, steepening the shoulder cross-slope, steepening the sideslope, degrading the clear zone. How much degradation is acceptable; how should the tradeoffs be determined; when should it not be allowed? Another issue is the lack of guidance on WZTC provisions for pedestrians on urban 3R projects.
WY	What maximum design life is appropriate for a 3R project?

APPENDIX E
New York State Resurfacing Safety Assessment Form and Checklists

Resurfacing Safety Assessment Form (Page 1 of 2)

PIN =		Date =	
Safety Assessment Team Design = Traffic = Maintenance =			

Y	Element	Guidance	Comments
The Following Elements Apply to Single and Multicourse Resurfacing Projects (1R, 2R, and 3R):			
☐	Signing	• Signs should be installed as needed in accordance with the *MUTCD*. Review for condition (retroreflectivity), location, post type (breakaway or rigid), and appropriateness (need). • Immediately notify the Resident Engineer of any missing regulatory or warning signs.	
☐	Pavement Markings	Pavement markings should be installed in accordance with the *MUTCD*. The adequacy of existing passing zones should be evaluated. Current EI's and specifications must be followed.	
☐	Delineation	Delineation should be installed per the *MUTCD*.	
☐	Sight Distance	Trim, remove, or replace vegetation to improve substandard intersection sight distance, and horizontal and vertical stopping sight distance. Guidance: • Intersection Sight Distance - HDM §5.9.5.1 • Passing Sight Distance - HDM §5.7.2.2 • Horizontal & Sag Vertical SSD - HDM Chapter 2 and HDM §5.7.2.1 and HDM §5.7.2.4	
☐	Fixed Objects	For 1R projects: Address obvious objects that are within the prevailing clear area and within the ROW based on engineering judgment from a field visit (e.g., tree removal on the outside of a curve or installation of traversable driveway culvert end sections). For 2R/3R projects: Reestablish the clear zone and remove, relocate, modify to make crash worthy, shield by guide rail/crash cushion, or delineate any fixed objects. For guidance on identifying fixed objects, refer to HDM §10.3.1.2 B.	
☐	Guide Rail	The following should be used to evaluate the need for guide rail and other roadside work. • HDM §10.2.2.1 - point of need • HDM Table 10-7 - acceptable guide rail height • HDM §10.3.1.2 B - guidance on determining severely deteriorated guide rail and non-functional guide rail • HDM §10.2.2.3 and Table 10-3 - barrier deflection distance • HDM §10.2.2 - design of new guide rail • Current EIs and EBs.	
☐	Bridge Rail Transitions	The Regional Structures Group, Regional Design Group, Main Office Structures, and Design Quality Assurance Bureau should be contacted, as needed, to help identify substandard connections to bridge rail and for the recommended treatment.	
☐	Rail Road Crossing	Contact Regional Rail Coordinator. Contact Office of Design if replacing crossing surface as required per HDM Ch 23.	
☐	Rumble Strips	On rural, high speed facilities (80 km/h or greater) consider shoulder rumble strips in accordance with HDM §3.2.5.4. Centerline rumble strips should be considered for similar facilities and where head-on and sideswipe rates are above average.	

Resurfacing Safety Assessment Form (Page 2 of 2)

Y	Element	Guidance	Comments
☐	Shoulder Resurfacing	Unpaved, stabilized shoulders should be paved in order to reinforce the edge of the traveled way, accommodate bicyclists, and increase safety. A 1:10 pavement wedge maybe used to transition between the travel way paving and a paved shoulder that will not be resurfaced on nonfreeways.	
☐	Edge Drop-Offs	Edge drop-offs are not permitted between the traveled way and shoulder. Where edge drop-offs will remain at the outside edge of fully paved shoulders and vehicles could have a wheel leave and return to the roadway, the edge is to be sloped at 1:1 or flatter and have a maximum height of ≤ 50 mm to help accommodate motorcycles and trucks.	
☐	Superelevation	Consult HDM §5.7.3. Identify where the recommended speed is less than design speed (use Section 2.6.1.1 of this manual). Improve superelevation (up to the maximum rate as necessary using AASHTO Superelevation Distribution Method 2) to have the recommended speed equal to the design speed. Where the maximum rate is insufficient, install advisory speed signs and consider additional treatments (e.g., chevrons, roadside clearing), as needed.	
The Following Are Additional Elements Where Multicourse Resurfacing (2R and 3R) is Recommended:			
☐	Superelevation	For Freeway projects, the superelevation is to be improved to meet the values in HDM Ch 2, Tables 2-13 or 2-14 (which utilizes AASHTO Superelevation Distribution Method 5).	
☐	Speed Change Lanes	Speed change lanes should meet AASHTO “Green Book” Chapter 10 standards.	
☐	Clear Zone(s)	Establish based on HDM §10.3.2.2 A for non-freeway and HDM §10.2.1 for freeways.	
☐	Traffic Signals	Signal heads should be upgraded to meet current requirements. Detection systems should be evaluated for actuated signals and considered for fixed-time signals. New traffic signals that meet the signal warrants may be included.	
☐	Shoulder Widening	Shoulders should be widened to 0.6 m on local rural roads and 1.2 m on other nonfreeway rural facilities for motor vehicle recovery, bicyclists, and pedestrians.	
☐	Lane Widening	Non-freeway lanes may be widened per HDM §7.5.3. New through travel lanes are not permitted.	
☐	Design Vehicle	Intersections should accommodate the design vehicle without encroachment into other travel lanes or turning lanes.	
☐	Driveways	Driveways shall meet the spirit and intent of the most recent “Policy and Standards for the Design of Entrances to State Highways” in Chapter 5, Appendix 5A of this manual.	
☐	Turn Lanes	Turn lanes should meet the requirements of HDM §5.9.8.2	
☐	Curbing	Curbing must meet the requirements of HDM §10.2.2.4. For freeways, curbing that cannot be eliminated should be replaced with the 1:3 slope, 100 mm high traversable curb.	
☐	Drainage	Closed drainage work may include new closed drainage structures, culverts, and the cleaning and repair of existing systems. Subsurface utility exploration should be considered for closed drainage system modifications.	
☐	Pedestrian & Bicycle	Sidewalk curb ramps and existing sidewalks must meet HDM Chapter 18 requirements. Consider cross walks and pedestrian push buttons at signals. Minimum shoulder width of 1.2 m if no curbing.	
☐	Other		

2R Screening/Scoping Checklist (Page 1 of 2)

PIN:	U
1. PAVEMENT TREATMENT SCREENING • No full-depth replacement of pavement except in localized areas (i.e., must be 1 km or less of continuous reconstruction and less that 25% of the project length). • At a minimum, shoulders, if any, must be restored to a satisfactory condition and be flush with the edge of traveled way.	☐
2. CAPACITY SCREENING Through Capacity—A Level of Service (LOS) analysis is performed in accordance with HDM §5.2. Note: secondary data may be used if approved by the RPPM or Regional Traffic Engineer. • For Interstates, the ETC+10 LOS must meet the criteria in HDM Chapter 2. Justify any non-standard LOS. • For non-Interstates, the ETC+10 LOS is at least "D" or, the design approval documents that "The RPPM does not anticipate capacity improvements within ten years." Non-Freeway Intersection Capacity—Intersections with observed operational or safety problems due to lack of turn lane or insufficient length of turn lane are analyzed in accordance with HDM §5.2. Note: secondary data may be used if approved by the RPPM or Regional Traffic Engineer. • New turn lanes needed at intersections (signalized and unsignalized) are to: • Meet the length required by HDM §5.9.8.2 or include an explanation for non-conforming lengths in the design approval document. • Meet the width requirement in M7.5.3.1 B for rural highways or M7.5.3.2 B for urban highways. • Meet the air quality requirements of Environmental Procedure Manual (EPM) §1.1.	☐
3. GEOMETRIC DESIGN CRITERIA SCREENING • Non-freeway routes: 3R standards referenced in HDM §M7.5. • Interstate System or other freeways: HDM §2.7.1.1 as modified by §M7.6.3. • All non-standard geometric features are justified in accordance with HDM §2.8. • Non-conforming features (HDM §5.1) are listed in the design approval document with an explanation, as necessary.	☐
4. GENERAL DESIGN SCREENING • Interstate System or other freeway routes meet the requirements of HDM §M7.6. • Roadside design meets the requirements for 3R projects in HDM §10.3. • Bridge work is eligible for the element-specific process. (Refer to PDM Appendix 7.)	☐

2R Screening/Scoping Checklist (Page 2 of 2)

5. SAFETY SCREENING - A 3-year accident history review indicates the following: (This can be quickly accomplished using readily available products from the Department's Safety Information Management System (SIMS) and the computerized TE-164 methodology). • The overall 3-year accident rate is less than the average rate for a comparable type of facility, as shown in SIMS. • The occurrence of Fatal, Injury, and combined Fatal+Injury accidents is not above average for similar type highways. • Locations listed on the regular Priority Investigation Location (PIL) list within the project limits are addressed. A PIL is considered addressed if it has been investigated in the last 5 years and the recommendations implemented or are incorporated into the proposed project. • Locations listed on the "Fixed Object & Run-Off Road" PIL list within the project limits are addressed. • Locations listed on the Wet-Road PIL list within the project limits are addressed. Note: Segments that do not meet all of the above shall undergo an accident analysis using the methodology in HDM §5.3. The accident analysis and recommendations should be attached to the design approval document as an appendix. If, based on the accident analysis, it is decided to undertake a safety improvement that cannot be implemented in a 2R project, a 3R or other type of project should be progressed.	☐
6. SAFETY ASSESSMENT - Perform a road safety assessment (Exhibit M7-1) as discussed in Section M7.2 of this chapter. Safety work that meets either of the following criteria is to be implemented under the multi-course requirements: • The safety treatments are necessary to avoid degrading safety, or • The safety treatments are practical and necessary to address existing or potential safety problems.	☐
7. PUBLIC OUTREACH SCREENING • Appropriate public involvement is done (see PDM Appendix 2) and community concerns are satisfactorily addressed. • No formal public hearings are required or held.	☐
8. ENVIRONMENTAL SCREENING • SEQR (All projects): The project is determined to be a SEQR Type II [i.e., complies with 17 NYCRR 15.14(d) and 17 NYCRR 15.14(e)(37)]. • NEPA (Federal-Aid projects): NEPA Assessment Checklist is completed and the project is determined to be either a NEPA Class II Programmatic Categorical Exclusion or a Categorical Exclusion with documentation and FHWA approval concurrence must be obtained.	☐
NOTE: Only segments that meet all of the requirements above can be progressed as 2R.	

Non Freeway 3R Screening/Scoping Checklist (Page 1 of 2)

PIN:	U
1. FUNCTIONAL CLASSIFICATION ▪ Highway is not classified as an Interstate or other freeway as defined by Chapter 2, Section 2.4.	☐
2. PAVEMENT TREATMENT SCREENING • No full-depth replacement of pavement except in localized areas (i.e., must be 1 km or less of continuous reconstruction and less that 25% of the project length). • At a minimum, shoulders, if any, must be restored to a satisfactory condition and be flush with the edge of traveled way. • Pavement treatments are to be designed to a minimum expected service life (ESL) of 10 years and desirably 15 to 20 years. ESL's of 5 to 9 years are non-conforming features that require an explanation.	☐
3. CAPACITY SCREENING Through Capacity - A Level of Service (LOS) analysis is performed in accordance with HDM §5.2 Note: secondary data may be used if approved by the RPPM. The ETC+10 LOS will be at least "D" or the design approval documents that the RPPM or Regional Traffic Engineer does not anticipate capacity improvements within ten years. • Additional through travel lanes cannot be created/constructed. This includes restriping an existing 4-lane highway to 6 lanes, with or without widening the existing pavement. • Intermittent climbing and passing lanes are allowed. • New or existing Continuous Left Turn Median Lanes are to be a minimum of 3.3 m wide with minimal reconstruction work (e.g., through restriping, minor widening, changing a 4 lane road to a 3 lane road). NOTE: Additional through travel lanes substantially change the operating characteristics of the highway and violate the basic premise of the non-freeway 3R standards. Additionally, added travel lanes may create safety and operational problems, not only for the project segment, but at other locations within the highway system. Significant social, economic, and environmental concerns may also result from increasing the number of travel lanes. Intersection Capacity - Intersections with observed operational or safety problems due to lack of turn lane or insufficient length of turn lane are analyzed in accordance with HDM §5.2. Note: secondary data may be used if approved by the RPPM or Regional Traffic Engineer. • New turn lanes needed at intersections (signalized and unsignalized) are to: • Meet the length required by HDM §5.9.8.2 or include an explanation for non-conforming lengths in the design approval document per HDM §5.1. • Meet the width requirement in M7.5.3.1 B for rural highways or M7.5.3.2 B for urban highways. • Meet the air quality requirements of Environmental Procedure Manual (EPM) §1.1. • New, longer, and/or wider auxiliary lanes through an intersection with minimal reconstruction work.	☐
4. GEOMETRIC DESIGN CRITERIA SCREENING • Non-freeway 3R standards in HDM §M7.5.3 • All non-standard geometric features are justified in accordance with HDM §2.8. • Non-conforming features (HDM §5.1) are listed in the design approval document with an explanation, as necessary.	☐

Non Freeway 3R Screening/Scoping Checklist (Page 2 of 2)

5. GENERAL DESIGN SCREENING • Roadside design meets the requirements for 3R projects in HDM §10.3. • Bridge work is eligible for the element-specific process. (Refer to PDM Appendix 7.) • Medians may be widened or created with minimal reconstruction work.	☐
6. SAFETY SCREENING - A 3-year accident history review indicates the following: (This can be quickly accomplished using readily available products from the Department's Safety Information Management System (SIMS) and the computerized TE-164 methodology.) • The overall 3-year accident rate is less than the average rate for a comparable type of facility, as shown in SIMS. • The occurrence of Fatal, Injury, and combined Fatal+Injury accidents is not above average for similar type highways. • Locations listed on the regular Priority Investigation Location (PIL) list within the project limits are addressed. A PIL is considered addressed if it has been investigated in the last 5 years and the recommendations implemented or are incorporated into the proposed project. • Locations listed on the 'Fixed Object & Run-Off Road' PIL list within the project limits are addressed. • Locations listed on the Wet-Road PIL list within the project limits are addressed. Note: Segments that do not meet all of the above shall undergo an accident analysis using the methodology in HDM §5.3. The accident analysis and recommendations should be attached to the design approval document as an appendix. If, based on the accident analysis, it is decided to undertake a safety improvement that cannot be implemented in a 3R project (e.g., a new grade separation), a reconstruction or other type of project should be progressed.	☐
7. SAFETY ASSESSMENT - Perform a road safety Assessment as discussed in Section M7.2 of this chapter. Safety work that meet either of the following criteria are to be implemented under the multi-course requirements: • The safety treatments are necessary to avoid degrading safety, or • The safety treatments are practical and necessary to address existing or likely safety problems.	☐
8. PUBLIC OUTREACH SCREENING - Appropriate public involvement is done (see PDM Appendix 2) and community concerns are satisfactorily addressed.	☐
9. ENVIRONMENTAL SCREENING - A SEQR type and NEPA classification are required. There are no restrictions on the environmental processing for 3R projects.	☐
NOTE: Only segments that meet all of the requirements above can be progressed as 3R.	

APPENDIX F
Highway Safety Manual and Crash Reduction Factors

Many of the criteria used for design of new roads and roads being rehabilitated or reconstructed, including the 13 critical design elements discussed in this report, have been developed, in part, based on safety relationships. With an understanding of how crashes change with changes in lane width, for example, under varying conditions of speed, alignment, traffic volume, etc., design standards and guidelines can be developed.

TRB Special Report 214 devoted a full chapter discussing the relationships of safety and geometric design. This was also the subject of an NCHRP study that was reported as *NCHRP Report 374: Effects of Highway Design Standards on Highway Safety*.

In recent years, research on safety relationships have focused not just on developing prediction models; that is, equation relationships, but also on developing crash reduction factors (CRFs) and crash modification factors (CMFs). For example, *NCHRP Report 633: Impact of Shoulder Width and Median Width on Safety* yielded CMFs for shoulder width and median width for four-lane roads with 12-ft lanes. The results of safety relationship research such as this has been included in the newly published *Highway Safety Manual* and the Crash Modification Clearinghouse provides an on-line database of all current crash reduction factors. These two sources are summarized in this appendix as they apply to 3R projects.

HIGHWAY SAFETY MANUAL

The *Highway Safety Manual* has been recently completed and is published by AASHTO. The purpose of the *HSM* is to provide analytical tools and techniques for quantifying the potential effects on crashes as a result of decisions made in planning, design, operations, and maintenance. As stated in the *HSM*, it can be used to:

- Identify sites with the most potential for crash frequency or severity reduction;
- Identify factors contributing to crashes and associated potential countermeasures to address these issues;
- Conduct economic appraisals of improvements and prioritize projects;
- Evaluate the crash reduction benefits of implemented treatments;
- Calculate the effect of various design alternatives on crash frequency and severity;
- Estimate potential crash frequency and severity on highway networks; and

- Estimate potential effects on crash frequency and severity of planning, design, operations, and policy decisions.

These applications would be applicable to the 3R process in determining the scope of a 3R project given that safety improvements are to be considered in a 3R project.

One of the key tools that can be used to determine what types of safety improvements could be included within any 3R project is the CMF or AMF. A full explanation of CMF is provided in Chapter 3 of the *HSM*; a brief one follows.

CMFs represent the relative change in crash frequency due to a change in one specific condition. CMFs are the ratio of the crash frequency of a site under two different conditions and can be expressed by the following general equation:

$$\text{CMF} = \frac{\textbf{Expected average crash frequency with condition}('\mathbf{b}')}{\textbf{Expected average crash frequency with conditin } '\mathbf{a}'}$$

CMFs defined in this way can be used to determine the expected change in crashes if a certain countermeasure is included within a 3R project; for example, widening or paving a shoulder. The relationship between the CMF and the expected percent change in crash frequency is shown here:

Percent Reduction in Crashes = 100 x (1.00 – AMF)

Therefore, if a CMF = 0.90, then the expected change in accidents would be a 10% reduction; if the CMF = 1.20, then the expected change would be a 20% increase.

With information on CMFs for various possible safety improvements, an agency can predict the change in crashes with any one or combination of improvements (the *HSM* explains how to determine the crash change with multiple improvements) and use that value in a benefit/cost analysis for selection and prioritization of 3R project safety improvements.

The *HSM* provides the best research-based CMFs available at the time of its preparation. CMFs can be developed by an agency for its road system and procedures for doing so are provided in the *HSM*. New

CMFs being developed through research by states or other agencies are being amassed in a national database that can be accessed from a web-based clearinghouse.

CRASH MODIFICATION CLEARINGHOUSE

Crash Modification Factors can also be found at the CMF clearinghouse, which is a web-based database of CMFs along with supporting information. It is sponsored by the FHWA and maintained by the Highway Safety Research Center at the University of North Carolina. It can be accessed at http://www.cmfclearinghouse.org/. It contains all the CMFs in the *HSM* and continually updates that list as new CMFs are developed. CMFs are provided for the following categories:

- Access Management
- Advanced Technology and ITS
- Alignment
- Highway Lighting
- Interchange Design
- Interchange Geometry
- Intersection Traffic Control
- On-street Parking
- Pedestrians and Bicyclists
- Railroad Grade Crossings
- Roadside
- Roadway
- Roadway Delineation
- Roadway Signs and Traffic Control
- Shoulder Treatments
- Speed Management
- Work Zones

Upon entering the clearinghouse, the user has the ability to search for specific countermeasures within the above groupings. The information that is provided includes—

- The CMF expressed as a decimal.
- The CRF expressed as a percentage.
- A star quality rating—The star quality rating indicates the quality or confidence in the results of the study producing the CMF. It is based on a scale (1 to 5), where 5 indicates the highest or most reliable rating.

- The crash type to which the factors apply.
- The crash severity to which the factors apply.
- The roadway type to which the factors apply.
- The area type to which the factors apply.
- The reference from which the factor was obtained. The reference can be viewed as well.

An example of one listing from "Shoulder Treatment" is shown here.

Countermeasure: Continuous milled-in shoulder rumble strips

CMF	CRF (%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type	Reference
0.21 [B]	79	★★★★☆	Run off road	All	Principal Arterial Other Freeways and Expressways	Not specified	Perrillo, K., 1998
0.9	10	★★★☆☆	Run off road	All	Principal Arterial Other	Rural	Carrasco et al., 2004
0.78	22	★★★☆☆	Run off road	Serious injury, Minor injury	Principal Arterial Other	Rural	Carrasco et al., 2004
0.84 [B]	16	★★★☆☆	All	All	Principal Arterial Other	Rural	Carrasco et al., 2004
0.83 [I]	17	★★★☆☆	All	Serious injury, Minor injury	Principal Arterial Other	Rural	Carrasco et al., 2004

APPENDIX G

Summary of *Good Practices: Incorporating Safety into Resurfacing and Restoration Projects*

The FWHA report *Good Practices: Incorporating Safety into Resurfacing and Restoration Projects* has been singled out as a good resource for how states can include low-cost safety improvements in their 3R projects. The full report can be accessed through FHWA's Office of Safety website at http://safety.fhwa.dot.gov/roadway_dept/strat_approach/fhwasa07001/. This appendix provides a summary of that document. The material provided is excerpts from the report.

Good practices were identified through a scan tour conducted in Colorado, Iowa, New York, Pennsylvania, Utah, and Washington. During the scan, numerous good practices were observed, some used by one agency and some used by several or all agencies visited. They are classified as either institutional or technical good practices and are discussed below.

INSTITUTIONAL PRACTICES

Institutional Practice 1—Integrate Safety into Preservation Projects

The scan confirmed the premise that integrating safety improvements into resurfacing and restoration projects is generally an effective and efficient method of simultaneously pursuing two transportation goals. In many cases, resurfacing projects are the only regular (or quasi-regular) road improvement activity. A number of "base" actions are needed to develop and implement a resurfacing project. Base actions include an inventory of existing conditions and features, development of specifications, contract bidding and award, contractor mobilization, and construction administration. The cost of these items is substantial and does not change significantly with modest scope expansion. However, there are situations where separate projects for pavement and safety improvement are advantageous, such as area- or corridor-level focused safety projects (e.g., rumble strip, barrier placement). When safety improvements are the sole or primary scope of the project, unit costs are often lower than where the same treatment is included in a resurfacing project.

Institutional Practice 2—Establish Multifund Project Tracking

Transportation funds are suballocated into numerous categories corresponding to a primary purpose, system, or mode. Flexibility varies. In some cases, categorical allocations are legislatively prescribed and explicitly define eligible expenditures and amounts. In others cases, agency leaders and managers have substantial discretion on proportional allocation and eligibility. The addition of safety improvements to resurfacing projects may be viewed by some as misappropriation. All operational units of transportation agencies have target expenditure levels for major program areas. When a single activity is intended to accomplish multiple purposes (e.g., pavement preservation and improved safety), the cost associated with each improvement should be attributed to the appropriate program. The absence of this capability will inhibit cost-effective multipurpose projects and encourage delivery of only single-purpose projects. The ability to distribute the cost of a single project to multiple cost centers is an important asset.

Institutional Practice 3—Allow for Flexible Project Development Cycles

Resurfacing projects are awarded each and every year. Ideally, the need to meet targeted awards should not result in projects that exclude cost-effective improvements. However, if the time allowed for project development is very short (e.g., 4 to 8 months) and all projects in the development phase are needed to attain contract award goals, then safety improvements may be omitted when they require longer preconstruction phases. Some resurfacing projects can be properly developed in a short period of time; however, additional time may be needed to include cost-effective safety improvements. During the scan, several techniques were observed that provide for additional development time when needed and still allow the agency to attain its resurfacing and contract award goals.

The New York State DOT resurfacing program involves different categories designated as 1R, 2R, and 3R, based on the pavement and nonpavement scope. Development periods vary. The 1R projects involve routine maintenance activities and can be delivered in as little as 4 months. The 2R projects, which involve more extensive pavement work (i.e., multiple layer overlay) and other potential improvements (i.e., cross-section improvements), can often be delivered in 12 months. The 3R projects often entail substantial pavement improvements, including sections of reconstruction and geometric improvements. The development process may be complicated (e.g., substantial right-of-way, public involvement) and generally requires 2 to 3 years for completion. For several other agencies, the resurfacing program is developed from project identification through construction in 12 months or less. For the Iowa DOT, the typical time frame from identification to construction of 3R projects is 3 years.

Institutional Practice 4—Strengthen State–Local Relationships

Local government units have jurisdiction over approximately 75 percent of the public highway mileage in the United States. Ownership of two-lane rural roads is even more highly concentrated with local governments. State DOTs have *direct* responsibility and control over only a fraction of the facilities with the highest crash rates. Yet states can substantially influence local transportation efforts.

State DOTs can support local efforts in many ways, including funding, technical assistance, and identification of high-crash locations on locally owned highways and streets. [A recent (2010) scan tour in seven states was documented in *Good Practices: Addressing Safety on Local Roads, A Domestic Scan*.] Model practices in data collection and analysis; local project identification; local project administration; funding; training and technical assistance; outreach and partnerships between state DOTs and local agencies are discussed in the report. The report was in final draft as of the preparation of this report and should be available from the FHWA Office of Safety website: http://safety.fhwa.dot.gov.

Institutional Practice 5—Develop a Procedure for Expedient Acquisition of Minor Rights-of-Way

Right-of-way acquisition is often time-consuming. When an otherwise desirable safety improvement is found to require additional right-of-way, the agency must decide between delaying project delivery or omitting the improvement. Some agencies have a categorical policy: no right-of-way is to be acquired for resurfacing projects. Therefore, the combination of limited rights-of-way and a time-consuming acquisition process is a major impediment to improving safety through resurfacing projects. A streamlined process for acquiring small areas and slivers is very useful and increases the range of improvements that can practically be considered in resurfacing projects. The New York State DOT has this authority (known as “de minimis”), and routinely employs it as part of resurfacing, especially 2R projects.

Institutional Practice 6—Engage Safety Experts in Project Development

Safety analysis is a complex and evolving discipline. Specialized knowledge is required to identify cost-effective safety improvements. During the scan, a spectrum of arrangements was observed for engaging safety expertise in project development. In some state DOTs (e.g., Colorado and Utah), the central office bureaus are responsible for conducting the analyses and formulating recommendations. In other state

DOTs, the central office safety office serves in an advisory and instructional role. For example, the Iowa DOT has decentralized 3R project delivery. The Office of Traffic and Safety, which previously had direct involvement in project development, was recast into an educational and resource role. In recent years, this office has worked diligently and successfully to instill a safety ethic and skill set within the district office design groups. Periodically, safety audits are conducted of completed resurfacing projects by teams of personnel from several organizations. In other states, safety analysis responsibilities are distributed between central and district/region offices. Both the New York State DOT and PennDOT perform certain crash analysis functions and screening centrally and provided to the district/region offices. Each PennDOT district office has a safety review committee.

TECHNICAL PRACTICES

Technical Practice 1—Identify Targeted Safety Improvements

Selective safety upgrades can be integrated into resurfacing projects. Identifying specific and cost-effective safety improvements requires consideration of infrastructure and crash data. Comprehensive and accurate crash data are a valuable asset to safety analysts. Several states visited are systematically improving crash data through multiple location coding options (e.g., GPS, route and mile marker, street address), additional descriptive data fields, and electronic reporting and retrieval. During the scan, several promising crash record and statistical analysis techniques were observed, namely:

- The Colorado DOT designs resurfacing projects through a unique approach. Safety improvements are identified largely on the basis of crash data analysis, rather than dimensional criteria. The Empirical Bayes statistical method is used to combine safety performance functions for categories of roadways and observed accident frequencies into a single estimate of the expected accident frequency. This analysis leads to a LOSS determination, which reflects the likelihood of improving safety through intervention.
- In Iowa, crash data and analysis are developed and distributed to state and local agencies. Some reports on trends, year-to-year comparisons, and specific categories (e.g., motorcycle, fatal) are developed on a biweekly basis. The Iowa DOT has a close and productive relationship with the Iowa State University, Governor's Traffic Safety Bureau, and enforcement community. The Iowa Traffic Safety Data Service is a product of that partnership and provides users with readily available crash data analysis resources and uses geographic information systems technology. Iowa DOT central and district offices, counties, and the enforcement community are principal users of these data and analyses.
- Pennsylvania has an ambitious Low Cost Safety Improvement program. The implementation guidance developed by PennDOT's Bureau of Highway Safety and Traffic Engineering (BHSTE) identifies 12 crash categories and 13 suggested countermeasures, with each crash category having from one to five countermeasures. These safety improvements can be self-standing (i.e., safety-only projects) or integrated into other projects, such as resurfacing. The BHSTE is developing additional analytic capabilities based on historical safety performance that assist in the selection of appropriate safety countermeasures.
- The Utah DOT Traffic and Safety unit prepares Operational Safety Reports for certain resurfacing projects. These safety reports recommend safety improvements and provide the benefit/cost ratio associated with implementation.

Technical Practice 2—Make Selective Geometric Improvements

Agencies visited during the scan were observed to invest in a range of geometric improvements as part of resurfacing projects. Common improvements include—

- Auxiliary lanes (turn lanes and climbing lanes).
- Cross-slope improvement.
- Drainage (additional inlets, improve cross drain capacity).
- Segment roadway cross section improvements:
  - Traveled way widening.
  - Shoulder addition and widening.
  - Paving aggregate shoulders, full or part width.
- Sight distance improvements by vegetation clearing and slope work.
- Sight distance improvements by lengthening vertical curves.
- Superelevation improvement.

The report provides illustrative examples of these types of improvements.

Technical Practice 3—Install Traffic Control Devices and Guidance

All agencies visited routinely install and/or upgrade selected traffic control devices in conjunction with resurfacing projects, including the following specific measures:

- Edge rumble strips.
- Centerline rumble strips.
- Curve delineation/warning (pavement markings and chevrons).
- Pavement markings.
- Reflective pavement markers.
- Sheet delineation (on median barrier).
- Signs.
- Signal upgrades.

The report also provides illustrative examples of these treatments.

Technical Practice 4—Improve Roadsides

All states visited on the scan are aware of how important the roadside is for rural highway safety. The roadside safety principles outlined in the AASHTO *Roadside Design Guide* are considered in developing resurfacing projects. Specific conditions (e.g., slopes, drainage structures, mailboxes, existing barrier systems) are addressed through a combination of policy, analysis, and judgment.

PennDOT District 3 employs two strategies worthy of note—selective clearing and “Ground to Sky.” Trees are part of the natural environment but pose a threat to errant vehicles when located close to a roadway. PennDOT has an initiative of selectively removing trees within the right-of-way. Locations and corridors are identified using GIS data. A dense forest canopy prevents sunlight from reaching the road surface and contributes to slick driving conditions, including black ice. The “Ground to Sky” treatment removes trees and branches, thereby allowing sunlight to reach the roadway surface. Public opposition to tree removal (for both strategies) is sometimes strong. PennDOT has instituted procedures to reduce negative reactions. Adjacent landowners are provided with advance notice of removal and may be allowed to retrieve the harvested wood. PennDOT tracks the safety records of roadways where tree countermeasures are used and reports positive results.

All agencies evaluate and selectively include countermeasures in resurfacing projects to reduce the frequency and severity of run-off-road crashes, which are overrepresented on two-lane rural roads. The following strategies were observed during the scan:

- Bridge rail, connection, and transition improvements.
- Culvert end treatments (traversable).
- Culvert extensions.
- Installation of side drains (in swales) and slope flattening.
- Edge drop-off mitigation (shoulder backup, safety edge).
- Flattening transverse (driveway, median turnaround) slopes.
- Guardrail installation.
- Guardrail replacement.
- Guardrail adjustments.
- Guardrail terminal upgrades.
- Headwall replacement (with inlets).
- Mailbox (control or replacement).
- Obstacle removal.
- Obstacle delineation.
- Removal of unwarranted barriers.
- Rigid barrier installation and adjustment.
- Selective clearing.
- Slope stabilization.
- Utility pole relocation.

Technical Practice 5—Improve Private and Public Access Points

Access points are locations of inherent conflict. At grade intersections and property access, design techniques can be employed to eliminate or manage conflicts. The following types of access improvements are included in resurfacing projects by agencies visited during the scan:

- Safety dikes.[1]
- Intersection reconfiguration (horizontal and vertical realignment).
- Commercial entrance consolidation.
- Commercial entrance reconfiguration.
- Farm drive consolidation.
- Farm drive reconfiguration.
- Lighting.

[1]A "safety dike" is a clear zone created on the far side of a T-intersection by relocating utility poles, making the ditch slope traversable, and removing other fixed objects to lessen the severity of a crash if a motorist fails to stop at the intersecting side road.

Abbreviations used without definition in TRB Publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETY-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

TRANSPORTATION RESEARCH BOARD
500 Fifth Street, N.W.
Washington, D.C. 20001

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