



Incorporating On-Road Bicycle Networks into Resurfacing Projects



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Introduction

Installing bicycle facilities during roadway resurfacing projects is an efficient and cost-effective way for communities to create connected networks of bicycle facilities. This workbook provides recommendations for how roadway agencies can integrate bicycle facilities into their resurfacing program. The workbook also provides methods for fitting bicycle facilities onto existing roadways, cost considerations, and case studies. The workbook does not present detailed design guidance, but highlights existing guidance, justifications, and best practices for providing bikeways during resurfacing projects.

1.1 | Why Include Bicycle Facilities When Resurfacing a Roadway?

There are a variety of reasons for including bicycle facilities when resurfacing a roadway.

Create Connected Networks

Well designed interconnected bicycle transportation facilities allow bicyclists to safely and conveniently get where they want to go. They enhance access to jobs, schools, and essential services and make bicycling for transportation a viable choice for a broad range of people. Including bicycle facilities during roadway resurfacing is one method communities can use to expand their bicycle system and create connected bicycle networks.

Federal Support for Bicycling

United States Department of Transportation (U.S. DOT) policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. This policy makes clear that it is the responsibility of every transportation agency in the United States to improve conditions for bicycling and to integrate bicycling into their transportation systems.

Additionally, transportation agencies are encouraged not just to meet the minimum requirements of providing bicycle facilities, but to go beyond minimum standards to provide the safest and most convenient bicycle facilities practicable. More information about this policy is available from U.S. DOT: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/policy_accom.cfm.

Cost Efficiencies

All levels of government, from the local level to the State level, operate with constrained budgets for building and maintaining roadways. Constructing a bicycle facility during a resurfacing project is more cost effective than providing the same facility as a standalone project. A Performance-Based Practical Design (PBPD) process modifies a traditional transportation project design approach to a “design up” approach where transportation decisionmakers exercise engineering judgment to build up the improvements from existing conditions to meet both project and system objectives. PBPD uses appropriate performance-analysis tools and considers both short- and long-term project and system goals while addressing project purpose and need. Including bicycle facilities during resurfacing projects can help meet the objectives of PBPD by working toward system network goals in a cost efficient manner.



John Keating, City of Overland Park, KS

Bike lanes were added to 133rd Street in Overland Park, KS, by narrowing excessively wide lanes. Bike lane markings and signs had not yet been installed when the photo was taken.

Chapter 4 provides more information about the cost efficiencies that are realized by including bicycle facilities during routine resurfacing projects.

More information about PBPD is available from the Federal Highway Administration (FHWA): <https://www.fhwa.dot.gov/design/pbpd>.

Create Safer and More Comfortable Roadways

Providing bicycle facilities on existing roadways often requires narrowing travel lanes or roadway reconfiguration to provide space for the bicycle facility. Both narrowing and reconfiguration can increase the overall safety and comfort of a roadway for bicyclists and pedestrians without negatively impacting vehicular operation. Reducing lane widths can result in lower traffic speeds that better align with posted speed limits and lower traffic speeds typically result in less severe injuries in the event of a crash. A Road Diet or Roadway Reconfiguration can also lower speeds and reduce pedestrian crossing distances, which can result in fewer pedestrian crashes. Adding bicycle facilities significantly improves the safety and comfort of bicycling on a roadway. These factors combine to create a safer and more comfortable roadway for all users.

High Quality Markings

Installing bicycle facilities during a resurfacing project allows for the use of high quality and long lasting pavement marking materials. Bicycle facilities that are installed on existing pavements often use less durable materials and because the markings are installed on older pavement, the materials often do not adhere as well. A resurfacing project provides new pavement that provides a better surface for applying markings than older pavements. Chapter 4 provides information based on current practice and available research about different marking materials and the advantages of installing markings on new pavement versus older pavement.

Interest from Communities

Many communities across the United States are interested in improving bicycling conditions and expanding their bicycle networks. More than 230 cities joined the U.S. DOT *Mayors' Challenge for Safer*

What is a Bikeway?

A bikeway is any facility that is open for the use of bicyclists. Bikeways include on-street facilities such as bike lanes and separated bike lanes, as well as off-street facilities such as shared use paths. For the purposes of this workbook, “bikeway” is used interchangeably with “bicycle facility,” and primarily refers to bicycle lanes—standard bicycle lanes, buffered bicycle lanes, or separated bike lanes. Including these facilities on a roadway requires adequate pavement width, as opposed to shared lane markings which can be installed without changing the street cross section.



Randy Dittberner, Virginia DOT



Randy Dittberner, Virginia DOT

Bike lanes were added to Soapstone Drive in Reston, VA, through a four- to three-lane Road Diet.

People and Safer Streets in 2014. The Challenge builds on the 2010 U.S. DOT Policy Statement on Bicycle and Pedestrian Accommodation to incorporate safe and convenient walking and bicycling facilities into transportation projects. A key component of the Challenge is to take advantage of opportunities to create and complete bicycle networks through maintenance and resurfacing projects. A number of Challenge Cities contributed to the creation of this workbook by sharing information on how they are using resurfacing projects to provide connected bicycle networks.

U.S. DOT Mayors' Challenge Participation

The following U.S. DOT *Mayors' Challenge for Safer People and Safer Streets* communities and agencies were involved in the development of this workbook by participating in focus groups, interviews, and peer exchanges.

- Ann Arbor, MI
- Austin, TX
- Baltimore, MD
- Bellevue, WA
- Boston, MA
- Broward MPO, FL
- Carrboro, NC
- Casselberry, FL
- Chapel Hill, NC
- Chicago, IL
- Dayton, OH
- Erie County, PA
- Flint, MI
- Glendale, CA
- Kansas City, MO
- Kauai County, HI
- Lexington, KY
- Longwood, FL
- Madison, WI
- Milwaukie, OR
- Myrtle Beach, FL
- Nashville, TN
- Newport, RI
- Norwalk, CT
- Oakland, CA
- Orange County, FL
- Oro Valley, AZ
- Peoria, IL
- Portsmouth, NH
- Revere, MA
- Ridgeland, MS
- Seattle, WA
- St. Louis, MO
- St. Petersburg, FL
- Temple Terrace, FL
- Tigard, OR
- Travis County, TX
- Tucson, AZ
- Washington, DC
- Winston-Salem, NC

Significant Amounts of Money are Invested in Resurfacing

Billions of dollars are spent annually in the United States to resurface roadways—it is important to ensure that these investments are providing complete transportation networks. While national or even State-level figures about resurfacing costs are difficult to attain, it is clear that large amounts of money are used for resurfacing roadways. For example, the 2015 budget for roadway resurfacing in New York City was \$226 million, while Cleveland, OH, budgeted \$26 million for resurfacing in 2014.¹ The Wisconsin Department of Transportation has budgeted over \$120 million per year for resurfacing and reconditioning on the State highway network in 2016, 2017, and 2018.² Including bicycle facilities in resurfacing projects can improve roadway conditions and safety at very low cost relative to the funds already being spent on resurfacing projects.

1.2 | Workbook Application

This workbook focuses on providing bicycle facilities as a part of resurfacing projects. However, the methods and practices described here may also be applicable to restoration, rehabilitation, and reconstruction projects. Users of the workbook should not be overly concerned with a strict definition of what constitutes a resurfacing project; the intent is to be inclusive and demonstrate how communities can create and expand bikeway networks by including bikeways as a part of other projects. The workbook highlights best practices from different communities. Some of these practices may seem outside the scope of resurfacing, however, readers can benefit from a demonstration of what is possible for expanding bikeway networks during roadway projects that include a new surface layer.

1.3 | Design Resources

This document is not intended to be a design guide, but rather to highlight the reasons for providing bicycle facilities when resurfacing roadways and to provide methods and techniques for doing so. Detailed roadway design information is available from a variety of sources including the American Association of State Highway and Transportation Officials (AASHTO), the

FHWA, the Institute of Traffic Engineers (ITE), the National Association of City Transportation Officials (NACTO), and other resources. Traffic control devices that are used must comply with the Manual on Uniform Traffic Control Devices (MUTCD). FHWA maintains a web page regarding the MUTCD approval status of various bicycle-related treatments: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/mutcd.

1.4 | Workbook Development

The information and recommendations in the workbook were derived from a variety of resources. A traditional literature review of design guidance was conducted, along with research into resurfacing practices and policies of various local, county, and State agencies. Focus groups were conducted that targeted planners, engineers, bicycle planning and design staff, and public works managers at all levels of government. Follow-up interviews were conducted with many of the focus group participants. The time and contributions of the focus group and interview participants were invaluable to the development of the workbook.



Randy Dittberner, Virginia DOT

Bike lanes were added Sherwood Hill Lane in Alexandria, VA, by narrowing unnecessarily wide parking lanes.

Resurfacing and the Americans with Disabilities Act (ADA)

Resurfacing roadways often triggers requirements for providing accessible curb ramps within the project extents. Although not directly relevant to providing bikeways, this must be considered whenever roadways are resurfaced. More information is available from a joint technical assistance memorandum issued by the United States Department of Justice and Department of Transportation. This memorandum and additional supplemental material are highlighted below:

- Department of Justice/Department of Transportation Joint Technical Assistance on the Title II of the Americans with Disabilities Act Requirements to Provide Curb Ramps when Streets, Roads, or Highways are Altered through Resurfacing
http://www.fhwa.dot.gov/civilrights/programs/doj_fhwa_ta.cfm
- Glossary of Terms for DOJ/FHWA Joint Technical Assistance on the ADA Title II Requirements to Provide Curb Ramps When Streets Roads or Highways are Altered through Resurfacing
http://www.fhwa.dot.gov/civilrights/programs/doj_fhwa_ta_glossary.cfm
- Q and A Supplement to the 2013 DOJ/ DOT Joint Technical Assistance on the Title II of the Americans with Disabilities Act Requirements To Provide Curb Ramps when Streets, Roads, or Highways are Altered through Resurfacing
http://www.fhwa.dot.gov/civilrights/programs/ada_resurfacing_qa.cfm

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Resurfacing Process and Timelines

Including bicycle facilities as part of resurfacing projects takes planning—a clear process is needed to determine if a roadway should include bicycle facilities when it is resurfaced and the project timeline must allow for design work and public outreach that may be required to include a bicycle facility. This chapter provides a recommended process for a resurfacing program that formally incorporates the consideration of bikeways into resurfacing projects. It analyzes the major components of the process and makes suggestions on how to incorporate bicycle facilities. Finally, the chapter recommends that the process provide adequate time, engage the appropriate staff and the public throughout, and make use of established roadway design flexibility.

2.1 | The Resurfacing Process

Nearly every agency that maintains roadways has a resurfacing process or schedule. The process is typically built around the consideration of pavement conditions as a key determining factor in scheduling resurfacing projects—that is, the worse the pavement, the higher a roadway will rank on the resurfacing list. The resurfacing process is often incorporated within a broader asset management approach that utilizes numerous rating systems to assess the condition of roadways to identify which can be preserved through resurfacing. Many agencies also consider a variety of other factors in addition to pavement condition when considering roadways for resurfacing; these are explained in more detail in this chapter.

Understanding how the resurfacing process works and the steps involved is critical to determining when to consider the addition of bikeways as a regular part of that process.

Major Components of the Resurfacing Process

Figure 1 diagrams a common, generalized approach to identify and prepare projects for resurfacing. The resurfacing process, from project selection through actual resurfacing work, takes anywhere from six months to several years to complete. In some cases, especially with State Departments of Transportation, the resurfacing program is integrated with a comprehensive five- or six-year street or highway improvement program. In general, city agencies have shorter project development timeframes, often in the range of six to eighteen months. It is not uncommon for cities to develop their resurfacing list for a given year during the prior fall. This short timeframe—often less than nine months from the resurfacing list being developed to bids being requested—can make it difficult to incorporate bikeways into resurfacing projects, if the consideration of bicycle facilities is not well-integrated as part of the process. Some cities and most States are working with longer timeframes for their resurfacing programs, with streets being identified for resurfacing two to five years before the project actually occurs.



Bicycle lanes were installed on Lynn Fells Parkway in Saugus, MA, by narrowing the travel lanes.

Resurfacing Project Selection Considerations

Resurfacing processes are all driven to some extent by roadway conditions. For many municipalities and counties, and most State agencies, pavement condition has become the only factor considered when selecting resurfacing projects, and sophisticated rating tools are used to quantify the conditions of pavements. A widely practiced approach to resurfacing involves intervening early to preserve pavement condition and to extend the life of the pavement. A range of conditions exist where preventative measures are viable. If pavement conditions are good for a roadway, resurfacing dollars may be spent unnecessarily when other simple and more cost-effective maintenance measures may

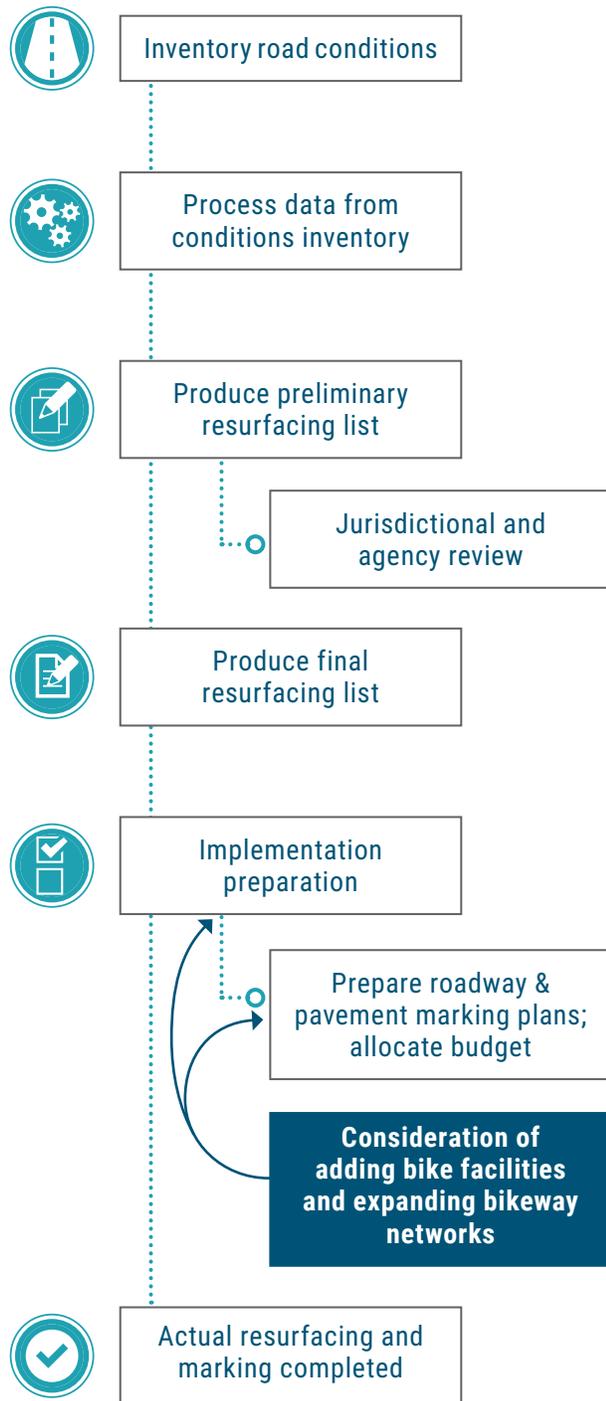


FIGURE 1: Typical approach to identifying and preparing projects for resurfacing



Ponce de Leon Avenue NE/U.S. Highway 29 in Atlanta, GA, as it existed in 1953 and in 2015 following a resurfacing project that added buffered bicycle lanes

Bottom: Katelyn Digoia, Georgia DOT; Top: Special Collections Department, Pullen Library, Georgia State University

have sufficed. If pavements have deteriorated too far, replacing the entire pavement or undertaking a complete street reconstruction may be necessary.

In addition to pavement condition, other factors are sometimes considered when evaluating streets for resurfacing, such as improving safety or the opportunity to provide bicycle facilities. These factors are often considered only tangentially to pavement condition as selection criteria. There is a limit to the types of safety improvements that can be incorporated into a resurfacing project, so for many jurisdictions it does not make sense to consider safety improvements when rating roadways for resurfacing. Some Federal Aid resurfacing projects are constrained in the scoping process to fit a streamlined environmental review process. However, as the type of project becomes more involved, more safety improvements may be incorporated. Several State DOTs contacted for this project cited safety as a consideration for project selection, although it is always second to pavement condition.

It is not unusual for communities and States to consider how bikeways can be incorporated into resurfacing projects, but bikeway consideration is only rarely used as a selection criterion for which roads will be resurfaced. Typically a project is placed on the resurfacing list before it is examined for bikeway opportunities. The resurfacing program in Oakland, CA, is one exception. Oakland has many potential resurfacing projects that are nearly equally ranked for pavement condition; projects that add new bikeways are considered priorities and that factor is used as a “tie-breaker” among projects with similar pavement ratings.

Political considerations can also influence project selection. Chicago, IL, distributes some resurfacing funds by aldermanic districts and council members or alders select or help select projects (along with the consideration of pavement ratings). In some other cities, a set-aside of funds is established for council members to determine projects.

➤ CASE STUDY

Standard Provision of Bicycle Accommodations

Madison, WI

The City of Madison, Wisconsin, has had a policy of providing bicycle accommodations on arterial and collector streets since their first bicycle plan rolled out in 1972. The policy has been updated several times to reflect changes in bicycle facilities and standards. Currently whenever arterial and collector streets are resurfaced, reconstructed, or built new, bike lanes are added whenever feasible. The City’s bicycle plan identifies streets that lack bicycle facilities and calls for these streets to receive them in the future. The City’s policy ensures that each project is examined for the possibility of providing bicycle facilities and expanding the City’s bicycle network.

Other aspects of the resurfacing program include:

- All streets and paths are rated for pavement condition every two years.
- The City maintains a five-year street improvement program and the inclusion of bicycle facilities begins when a street project is placed in the program.

- Coordination between the Traffic Engineering and City Engineering Divisions has resulted in improved progress of identifying and implementing bikeways on resurfacing projects.



Bluff Street in Madison, WI, had a bicycle lane installed in the uphill direction and shared lane markings in the downhill direction during a resurfacing project. This configuration allowed parking to be preserved on one side of the street.

Resurfacing Process Major Steps

The major steps in the generalized resurfacing process are highlighted below.



1 | Inventory Road Conditions

The resurfacing process begins when agencies examine and rate the conditions of their streets. This step involves conducting field work, reviewing video logs, and assessing other asset management resources to examine the condition of the pavement. Some jurisdictions conduct this process annually while other communities and States conduct this process on a two- or three-year cycle.



2 | Process Street or Road Conditions Data

Roadways are rated using a graduated grading system once pavement condition data are collected. The most commonly used rating scheme is the Pavement Condition Index (PCI). A key to successful resurfacing program implementation is the ability to repair roadways rated within a specific range according to the rating scheme. If streets deteriorate to below a moderately-low rating, often the pavement cannot be preserved and expensive pavement replacement or reconstruction are the only remaining solutions.



3 | Produce Preliminary Resurfacing List

A preliminary list of candidate projects is assembled following the roadway condition rating. The list is reviewed and often a preliminary decision is made on whether it is feasible to include bikeways during the resurfacing project. Communities that are effective at incorporating bikeways compare the preliminary resurfacing list to bicycle master plans, small area plans, and city and State policies. State DOTs and county agencies will often seek input from local jurisdictions. Bicycle coordinators and staff who oversee bikeway projects, are often brought into discussions at this point and asked about ways to include bicycle facilities in potential projects.



4 | Produce Final List

Adjustments are made to the preliminary list based on input from stakeholders and a final resurfacing project list is produced. If the community or State has a multiyear process, this list will be updated to reflect changing pavement conditions.



5 | Project Development and Implementation

Projects are developed and prepared for bid solicitation after the final resurfacing list is produced. Several key sub-steps occur at this time including public involvement and plan preparation. When bikeways are being added into a project, a new pavement marking (or striping) plan is needed. In many communities, additional public involvement is necessary when adding bikeways, depending on the method used to reallocate space for the bikeway. Agencies that wait until this point to consider integrating bikeways have to operate within a condensed timeframe for the public involvement and roadway/bikeway design process.



6 | Resurfacing Occurs

For most resurfacing projects, especially mill overlays and simple overlaying of existing pavements, the paving aspects of projects are completed in one to two days.



7 | Marking Occurs

Pavement markings may be installed by a different contractor than the contractor that completed the pavement work, or may be installed by municipal staff. Marking a resurfaced roadway typically takes one day. Depending on the marking material that will be used, a gap of several days may be left between resurfacing and marking. Other aspects of the project, such as new signage, signal adjustments, and pedestrian accessibility improvements that may be required, may take several additional weeks to complete.

2.2 | Improvements to the Typical Resurfacing Process

The generalized resurfacing process described in section 2.1 works well for resurfacing roadways and marking them identically to how they were marked prior to resurfacing. However, due to the need for additional time for plan development, public outreach, and the design of new marking plans, this process is often not conducive to adding bicycle facilities during a resurfacing project. Several factors that will enhance the feasibility of including bikeways through the resurfacing process are identified below.

Provide Adequate Time

Providing sufficient time to consider bikeways in projects is a major factor in enabling the inclusion of bikeways. A longer timeframe provides a greater opportunity for bikeways to be incorporated into resurfacing projects as staff have more time to:

- Consider methods for finding space for bikeways;
- Develop or update marking plans to include bikeways;
- Perform public outreach; and
- Overcome unanticipated obstacles.

Longer timeframes also allow simple projects to move up the resurfacing project queue, while more challenging projects may be delayed to allow for detailed planning or public outreach. However, having a multiyear process does not automatically lead to more bikeways. State departments of transportation have multiyear lists up to six years in the making, but do not always use that time to include bikeways in resurfacing projects.

Multimodal Approach and Including Key Staff

Including the right people in the resurfacing process at the right time can be the key to capturing opportunities to include bikeways with resurfacing projects. These key people include bicycle staff who understand how bikeways can be accommodated within limited space, ask detailed questions about specific projects, and offer suggestions on how bikeways can be included with projects. The emphasis

of this workbook is on bikeways, but including key pedestrian and transit staff in the resurfacing process is vital to improving walking and transit access conditions with resurfacing projects; staff from transit agencies and the jurisdiction's pedestrian coordinator should also provide input on resurfacing projects.

Review the Bike Plan

Local, regional, and State bicycle plans should be consulted when developing resurfacing lists. Roadways that are included in relevant bicycle plans should be closely examined for the feasibility of including bicycle facilities during resurfacing. However, if a roadway does not appear as a bikeway in the bicycle plan it does not mean that it should automatically not be considered for bicycle facilities during resurfacing; an examination of the opportunities provided by the resurfacing, connections that the roadway makes, and other factors should be undertaken to determine if bicycle facilities should be included. While many municipalities and States have specific bicycle staff who can help determine overlap between resurfacing lists and bicycle plans, resurfacing staff should be familiar with all relevant bicycle plans, and should look for opportunities to coordinate and make linkages between the bicycle plan and relevant asset management databases

Flexibility in Design

Including bicycle facilities on roadways that did not previously have them often requires a flexible design approach, specifically on how the roadway is designed and marked. There are few opportunities where there is enough space between curb lines to restripe a project with bikeways without changes to lane widths or configurations. Designers need to be willing to work with the flexibility already provided in national design guidance to “create” the space to add bikeways within existing roadway width. FHWA supports flexibility in the design of pedestrian and bicycle facilities, as noted in the memorandum at:

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_flexibility.cfm.

Chapter 3 provides more information on design flexibility, particularly regarding the use of narrower motor vehicle travel lanes.

2.3 | Recommended Resurfacing Process

Figure 2 revises the typical resurfacing process illustrated in figure 1 to include the consideration of bikeways earlier in the resurfacing process. Ideally, decisions about the inclusion of bikeways should be made at the time that the preliminary resurfacing list is created. Considering bikeways early in the resurfacing process provides a significant advantage in how agencies can take advantage of the timing for bikeway consideration and will provide a longer timeframe for design work and public involvement.

Development of the resurfacing project list and who is involved in the process, are of equal importance to the amount of time that is built into the project development process. Figure 2 highlights two boxes in blue that illustrate opportune times in the process to include bikeway discussions and what should occur at those junctures.

The first blue box occurs immediately after the preliminary resurfacing list is established. At this point, an initial scope of the project is established. The scope could be as simple as a minor overlay, or more involved such as the pavement being replaced.

Key bikeway considerations occur at this point and multiple questions should be asked:

- Is this route in the bike plan?
- Is the project covered by the agency’s bicycle policy (e.g. “All arterial and major collector streets should include a bikeway”)?
- Can this project enhance the connectivity of the existing bike network?
- If this is a neighborhood street, is a bike lane needed?
- Will this be a bicycle boulevard or neighborhood greenway?
- What are the potential methods (e.g. Road Diet, Lane Diet, parking removal, etc.) that could be used to include bikeways? Are certain methods more suitable than others based on the context?



FIGURE 2: The recommended resurfacing process identifies opportunities to add bicycle facilities early in the process.

- What questions need to be resolved to reach a final recommendation for a bikeway? For instance, will a traffic study need to be conducted to ensure that a four- to three-lane conversion will work or will a 10-foot wide outside travel lane be adequate for the amount of truck traffic and transit vehicles?
- Does the narrowness of the street eliminate all of the potential methods of finding space for bikeways?
- Is there a history of speeding or speed-related complaints about the street that a roadway reconfiguration could help address?
- If this is rural cross-section roadway, will the scope of the project allow paved shoulders? How wide can the shoulders be? Will they be marked as bike lanes or simply left as paved shoulders with an edge line?

Engineers and planners who have experience scoping project descriptions and working with resurfacing programs can be trained to ask these questions and address these considerations. However, if agencies have a bicycle program (and/or pedestrian program), staff from that program, section, or unit should be brought into the discussion at this point. Given that resurfacing

programs are a continuous process with new projects added every year, the bicycle staff should be involved throughout. Bicycle and resurfacing program staff should have regular recurring meetings to discuss the resurfacing program.

As a final resurfacing list is created, it may be possible to delay some resurfacing projects for a year or two if the consideration of bikeways is not complete but solutions appear workable or likely. When considering delaying a project, it is important to ensure that the delay will not lead to significantly worse pavement conditions that may not be able to be resurfaced. The second blue box in figure 2 reflects when this occurs. This is also the appropriate time to return to earlier questions that arose as the preliminary resurfacing list was established. A key question is whether a method to include the bikeway has been determined. Changes to the bike plan or nearby existing bikeways that impact the project or connections to the project should also be considered at this time.

Nearly every resurfacing project that includes new bikeways will require a marking plan; this is noted as a box to the right of project implementation and is critical to the successful completion of the project.



Simon Blenski, City of Minneapolis, MN

5th Street SE in Minneapolis, MN, includes clearly marked bike and parking lanes following a resurfacing project.

2.4 | Recommended Resurfacing Timeline

A minimum two-year timeframe is recommended for resurfacing projects to successfully integrate bicycle facilities. Figure 3 illustrates the timeline for key components of a resurfacing program beginning in the summer of the first year and ending with project start and completion in the spring and summer of the second year. The resurfacing process constantly cycles—as Year 2 projects move on to construction, Year 1 projects move to Year 2, and new list of candidate projects appear as Year 1 projects.

A key link between Year 1 and Year 2 involves the reshuffling of projects. If it is clear that a project may be able to include bicycle facilities, but additional time is needed for public outreach, design, or other considerations, it may be possible to defer the project rather than advancing the project to the Year 2 process.

If an agency has a process that includes a significant number of more involved projects such as restoration and pavement replacement projects, a timeframe of three years or longer is desirable.

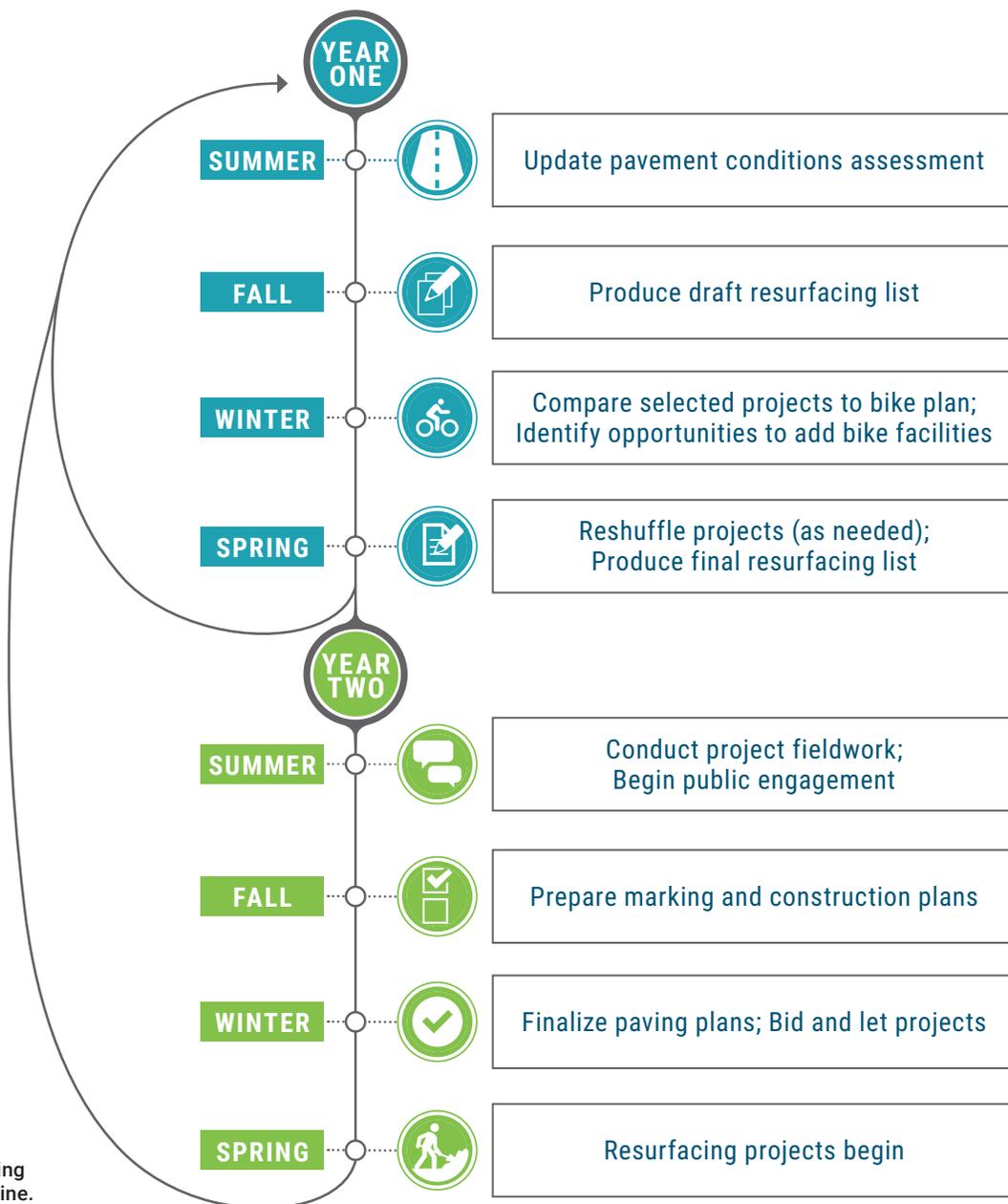


FIGURE 3:
Example two
year resurfacing
process timeline.

2.5 | Common Pitfalls

There are a number of common pitfalls or hurdles that agencies face once they decide to proactively integrate bikeways into resurfacing projects. Many of the challenges are associated with having an abbreviated timeframe in which to consider bikeway options or to prepare pavement marking plans. This is particularly true for projects that need expanded public outreach because of proposed changes to a roadway. Projects may also have design constraints that will need to be considered. Another pitfall is when resurfacing projects are not thoroughly considered for bicycle facilities at the onset of the project scoping, are not included in the project needs statement, and are dismissed when they may have been possible.

Too Short of a Timeframe

The timeframe needed to successfully include bicycle facilities varies based on the type and complexity of the project. Some projects—such as pavement replacement projects—are inherently more complex, but they usually have more lead time for design, project development, and delivery than simple mill and overlay projects. Simple resurfacing projects where just overlays of asphalt are applied to streets have some of the tightest timetables and present significant challenges for bikeway installation because of the tight timeline. Additionally, the use of Federal-aid Highway Funds may require programming and environmental documentation (see 23 CFR 450.220 and 23 CFR 771.117). While resurfacing projects generally qualify as categorical exclusions (CE), time still must be allotted for analysis and documentation of a CE. Programmatic categorical exclusions (PCE) are also a tool for accelerating project delivery.

Resolution

The discussion of options for bicycle facilities should be initiated in the planning process and should occur immediately during project scoping if the timeframe for project development is less than two years. Short timeframes are not uncommon for cities where budgets are established in the fall and resurfacing projects are included in the capital budget for the next calendar year. Resurfacing projects should be determined several years in advance of the anticipated project, similar

to most capital improvement programs. The general feasibility of installing bikeways with each project should be determined when the project is added to the resurfacing list. When a project is placed in the final project list, bikeway design and a pavement marking plan can be completed.

Inadequate Time for Public Participation

In accordance with their state public involvement plan, transportation agencies have become more attentive to the role of the public in asking questions and sharing opinions and concerns about projects. In the past, agencies might not have conducted public outreach for resurfacing projects, but this has changed in many communities and States. Adding new bicycle facilities during resurfacing projects can contribute to the complexity of a project's design or require reconfiguration of travel or parking lanes; this can trigger more questions and concerns than usual from the public.

Resolution

Resurfacing projects that propose to reallocate travel lanes or parking to incorporate bicycle facilities should include expanded public outreach timeframes from the outset, or agencies should be in a position to elongate the public involvement, if necessary. The addition of bicycle facilities to projects through treatments such as lane narrowing are typically not controversial and may not require extended public involvement timeframes. Residents and businesses should always be informed about how the new bicycle facilities function and what the implications are for their street and neighborhood. Providing brochures and handouts that explain these impacts and show how different bicycle facilities work is recommended.

Design Constraints

Changing or repurposing streets to include bicycle facilities can present design challenges. Wider streets with generous parking and travel lane widths are the easiest to redesign to incorporate bicycle facilities, but when travel or parking lanes have to be removed, analysis may have to be performed, and designs and decisionmaking may be more difficult.

Resolution

Design flexibility should be an ever present part of the design process for resurfacing projects. For most bicycle facilities to be included in resurfacing projects, travel and/or parking lanes will need to be narrowed or reallocated. This may require design flexibility on the part of roadway designers. Additionally, a range of methods to incorporate bicycle facilities should be explored for each project—if Road Diets worked for the last two projects, it does not necessarily mean that the best option for the next project is also a Road Diet.

Project Scoping Challenges

Resurfacing projects present challenges to staff from a time-management standpoint. It is easier for staff with time constraints to return a street to the same cross-section as currently exists than to make changes to incorporate bicycle facilities.

Resolution

Agency staff should approach each project from a multimodal perspective. Inviting staff from different sections of the agency and creating a team approach to scoping projects is valuable. The goal is to move the project beyond the early dismissal of bicycle facilities to a true assessment of bicycle facility options and to balance the focus on quality and quantity of projects while also addressing the multi-modal transportation needs of the community.

Loss of Bicycle Facilities

Resurfacing projects occasionally result in the loss of an existing bicycle facility if care is not taken to ensure that the resurfaced roadway is marked the same as it was previous to the resurfacing. This can occur if the marking crew has been provided with an older marking plan that did not show the existing bikeway, or if no marking plan exists and the marking crew was not aware that the street had a bikeway.

Resolution

Agency staff should ensure that marking plans provided to marking crews, contractors, or agency staff properly reflect existing bikeways. Whenever possible, agency staff should field check preliminary markings on the roadway prior to final markings being installed.

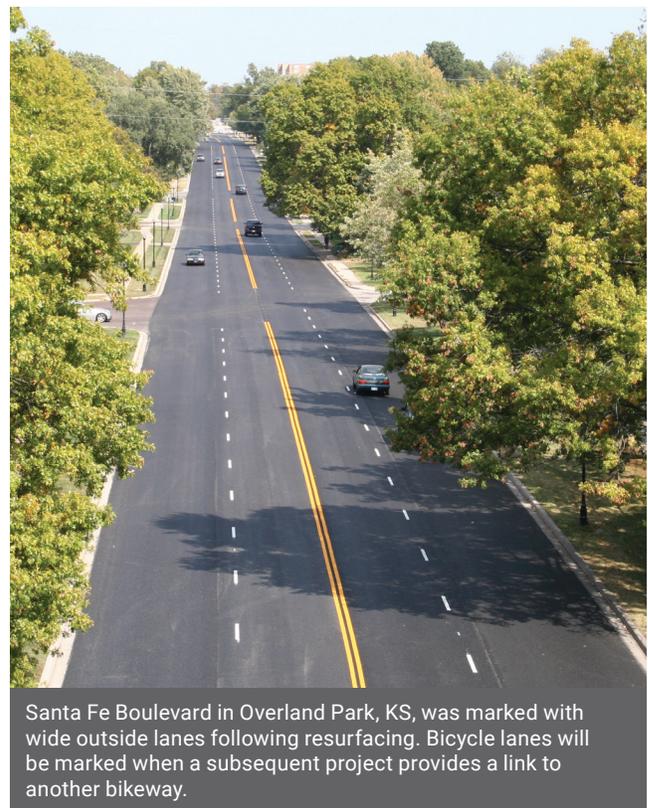
Agencies should also consider how georeferenced bike marking plans are or could be tracked in the asset management plan and process so existing facilities are reflected in internal management databases and remain in future contract documents.

Lack of Logical Project Extents

Resurfacing projects often provide opportunities to incorporate bicycle facilities, but are nearly always driven by existing pavement quality, and not the opportunity to install bicycle facilities. Ideally resurfacing projects would enable long, high-priority segments of bikeways to be built, but when the project development cycle becomes too rushed there is a risk of missing potential connections to nearby bikeways.

Resolution

Agency staff should identify and incorporate connections when planning the project. For example, it may be possible to provide a connection to a nearby bikeway by extending the resurfacing project a short distance. It may also be possible to extend new pavement markings beyond the limits of the resurfacing project to connect to nearby bikeways.



Santa Fe Boulevard in Overland Park, KS, was marked with wide outside lanes following resurfacing. Bicycle lanes will be marked when a subsequent project provides a link to another bikeway.

John Keating, City of Overland Park, KS



CASE STUDY

Best Practice: Integrating Bikeway and Resurfacing Planning

Oakland, CA

The City of Oakland, CA, has coordinated its paving program with bikeway installations since 2007. This coordination has improved in the past several years and has resulted in approximately 75 percent of all new on-street bikeways being implemented as part of a resurfacing project. A number of factors have been successful in helping city staff implement bikeways with resurfacing projects:

- The City has a five-year resurfacing outlook. Having an idea of the streets that will be resurfaced in the next five years provides time to move projects up or back in the queue as needed to allow for additional planning, engineering, or public outreach that may need to occur with a given project.
- Staff responsible for the paving program and the bicycle program meet monthly to discuss ongoing and upcoming projects as well as the longer term program outlook.

- Bikeways are used as a criterion for selection of resurfacing projects. Like many cities, Oakland has more candidate resurfacing projects than can be addressed in a year, and many are equally ranked for pavement condition. Projects that incorporate bikeways are considered priorities using that factor as a “tie-breaker.”
- The City has a working draft Checklist for Complete Streets / Paving Project Coordination (provided on next page) that must be completed for all resurfacing projects. The Checklist specifically asks if a Road Diet has been considered for multilane streets, and if deemed infeasible, what the rationale is. The Checklist also details Complete Streets design elements that should be considered as a part of every project, including the addition or upgrading of bikeways.
- The City regularly exercises design flexibility on resurfacing projects. The City will use a combination of 10-foot travel lanes, 11-foot travel lanes, and 7-foot parking lanes to create bike lanes, even on streets with buses and trucks. The City will also extend new pavement markings beyond the limits of a resurfacing project to connect to nearby bikeways.
- The City bicycle coordinator field checks all preliminary markings for bike lanes before they are permanently installed.



Buffered bike lanes were added to Broadway in Oakland, CA, during a resurfacing project by removing one travel lane in each direction.

Jason Patton, City of Oakland, CA

Jason Patton, Oakland’s Bicycle & Pedestrian Program Manager, explains, “This coordination has allowed us to implement more projects more quickly and at lower cost. Paving projects provide a clean slate for redesigning roadway striping. And new bike lanes are brilliant on new asphalt.”

This coordinated process to considering bicycle facilities with resurfacing projects has led to a connected network of bicycle facilities throughout Oakland that continues to expand each year.

City of Oakland Checklist for Complete Streets / Paving Project Coordination

This checklist is completed for each roadway segment proposed for paving. The section headers specify which groups contribute information. The final checklist documents the scope for integrating design improvements with the paving project.

1. Project Description (Pavement Management Program)

Roadway: _____ From: _____ To: _____

Length (feet): _____ Paving Treatment: _____

Does the project include concrete work (curb ramps, sidewalk repair)? Yes No

2. Coordination with Overlapping Projects (All Divisions in Engineering & Construction)

ITS Project: _____

Other City Project: _____

Other Agency Project: _____

3. Safety (Transportation Services): Is the street in the top 50 for crashes (weighted by severity) in the most recent citywide crash analysis? If yes, consider an additional scope of work with funding from other sources, including the Pedestrian Master Plan CIP project (pedestrian countdown signal heads, rapid flash beacons, refuge islands, bulbouts).

No Yes. If yes, describe the additional scope of work: _____

4. Road Diets (Transportation Services, Transportation Planning): All multi-lane streets will be considered for Road Diets. Candidate streets will be determined based on the Bicycle Master Plan, pedestrian safety issues, speeding issues, and available data on traffic volumes.

A Road Diet will be considered for inclusion. Status (feasibility, outreach, approval): _____

A Road Diet was considered but will not be included. Rationale: _____

Not applicable (the existing condition is one travel lane per direction).

5. Complete Streets Design Elements (Transportation Services): The project design will include the following elements based on an evaluation of field conditions and available data (e.g., traffic counts, speed surveys, crash data).

▪ Motorist Safety (review crash history)

Evaluate and upgrade markings and signs; identify removal of unneeded signs.

Evaluate channelization at irregular intersections (stop/yield control, islands).

Evaluate Hills streets for low-visibility driving (edge markings, curve warnings).

▪ Pedestrian Safety (applicable throughout the Flatlands, some Hills locations)

Evaluate crosswalk locations per TSD's crosswalk policy.

Identify opportunities for pedestrian refuge islands.

Update crosswalk markings and signs to best practices.

▪ Bikeways (per Bicycle Master Plan and other roadways with available space)

Implement proposed bikeway: _____

Upgrade existing bikeway to best practices: _____

No existing/proposed bikeway

▪ Parking Management (applicable to bus routes, commercial districts)

Bus stops: Evaluate bus stop lengths and locations.

ADA parking: Evaluate quantity, placement, and condition.

On-street parking: Evaluate feasibility of new parking stalls and/or meters.

Loading zones: Evaluate the location and length of loading zones.

6. Notes on Scope & Schedule: _____

7. Project Management: This scope of work will be managed by: _____

8. Approval of Complete Streets Scope

Supervising Engineer

Date

Transportation Services Division Manager

Date

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3

Methods for Including Bikeways

Adding a bikeway during a resurfacing project requires reconfiguration of the existing roadway design to “create” the space for the new bicycle facilities. This chapter provides an overview of the flexibility in roadway design that is often necessary to add bicycle facilities to existing roadways.

3.1 | Including Bikeways in Resurfacing Projects

To include a bikeway during a resurfacing project on a street that did not have a bikeway prior to the project, it is necessary to reallocate space on the roadway. This can be accomplished through three primary means: Lane Narrowing / Lane Diet, Roadway Reconfiguration / Road Diet, and Parking Removal.

In addition to evaluating options to reallocate space, it may be possible in rural areas to pave existing gravel shoulders as part of a roadway project. Shoulder paving is discussed as part of this chapter.

3.2 | Flexibility in Design

Significant flexibility may be necessary to provide bicycle facilities during a resurfacing project on a roadway that did not previously have facilities. Flexibility is needed in two areas: process and design. This section briefly highlights the different ways in which planners and engineers may need to use available flexibility when adding bicycle facilities during a resurfacing project.

Process Flexibility

Including new bicycle facilities during a resurfacing project requires flexibility in the planning process for the project.

Scope Consideration

It is relatively simple to resurface a roadway and provide the same lane configuration following the project as existed prior to the project. However, it is important to consider each resurfacing project independently, and not assume that bicycle facilities will be excluded. This may require flexibility within the standard project development process to ensure that all options for providing bikeways are considered.

Timeline

Providing bikeways as part of a resurfacing project can impact the standard resurfacing timeline. It is important for staff involved in the project to recognize that the timeline for the project may need to be extended to account for expanded public outreach,

additional analysis, the development of new marking plans, and other factors. Ideally the flexibility exists to delay a resurfacing project by one or two years to account for these factors if there is the opportunity to include bicycle facilities.

Public Outreach

The amount of public outreach that is conducted for a resurfacing project varies significantly from community to community. At minimum, all communities provide notice that resurfacing will be occurring. Depending on how the space will be created, including bikeways in a resurfacing project may require more public outreach than for a standard project. In particular, if parking or travel lanes are being removed, staff should plan for a robust public outreach process that may extend the project timeline.



Providing flexibility for increased public outreach can increase the likelihood of successful project implementation.

Design Flexibility

Including new bicycle facilities as part of a roadway resurfacing project may require design flexibility. The primary area in which design flexibility is necessary during resurfacing projects is determining lane widths.

Lane Widths

Of the options to reallocate space, narrowing a travel or parking lane does not impact traffic capacity and is likely the least controversial option. There is often a misconception that travel lanes narrower than 12 feet negatively impact safety or traffic capacity. In general, this is not the case and national guidance provides support for the use of narrower travel lanes when used in appropriate contexts.

Lane width impacts motor vehicle speed, pedestrian crossing distances, and pedestrian traffic exposure. In locations where pedestrian and bicycle use are desired or expected, the context and desired safety and usage outcomes should influence the roadway design.

FHWA recognizes that lane widths affect rural, urban, and suburban environments differently. While wider lanes may prevent the occurrence of head-on crashes in higher-speed rural areas, the risk of these crashes is lower in reduced-speed urban environments. Reduced lane widths have benefits in urban or suburban corridors: “Narrower lanes may be chosen to manage or reduce speed and shorten crossing distances for pedestrians” (FHWA Mitigation Strategies for Design Exceptions, p. 28). During resurfacing, this space could be reallocated for bicycle facilities.

AASHTO’s *A Policy on Geometric Design of Highways and Streets, 6th Edition* (The Green Book, p. 4-7) offers substantial flexibility on lane widths, providing a range of between 9 and 12 feet, depending on desired speed, capacity, and context of a roadway. Additionally, according to the FHWA memo *Bicycle and Pedestrian Funding, Design and Environmental Review: Addressing Common Misconceptions*, dated August 20, 2015, “there is no minimum lane width requirement to be eligible for Federal funding.” Furthermore, “there is no outright prohibition against using lane widths less than those stated in the Green Book, if a design exception is justified and approved in accordance with FHWA regulations and policy.”

FHWA Support for Design Flexibility

FHWA supports taking a flexible approach to accommodate bicyclists and pedestrians in transportation design. The 2013 *Bicycle and Pedestrian Design Flexibility* memo recognizes the AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* and the *Guide for the Development of Bicycle Facilities* as the primary national resources for pedestrian and bicycle facility design. The memo also supports the use of additional resources that build off the flexibilities provided in the AASHTO *Pedestrian and Bicycle Guides*, as well as the Green Book. These resources include the National Association of City Transportation Officials’ *Urban Bikeway Design Guide* and the Institute of Transportation Engineers’ *Designing Walkable Urban Thoroughfares*.

Lane Width Safety

A study by the Midwest Research Institute entitled *Relationship of Lane Width to Safety for Urban and Suburban Arterials* concluded that “there is no indication that crash frequencies increase as lane width decreases for arterial roadway segments or arterial intersection approaches.” The study compared 408 miles of urban and suburban arterials under State and local jurisdictions in two States with lane widths ranging from 9 to over 13 feet.

According to the study, “A safety evaluation of lane widths for arterial roadway segments found no indication, except in limited cases, that the use of narrower lanes increases crash frequencies.” Further, the study found that “the lane width effects in the analyses conducted were generally either not statistically significant or indicated that narrower lanes were associated with lower rather than higher crash frequencies.” Similarly, the study found no indication, except in limited cases, that the use of narrower lanes for arterial intersection approaches increases crash frequencies. The study notes that “lane widths of 10 feet or less on four lane undivided arterials and lane widths of 9 feet or less on four-lane divided arterials should be used cautiously unless local experience indicates otherwise.”

Use of Narrow Travel Lanes

The focus groups and interviews conducted for this workbook highlighted the widespread use of travel lanes that are less than 12 feet wide in conjunction with bicycle facilities. Such lanes are in use on urban and suburban arterials with two to seven lanes, and posted speeds of 35 miles per hour and above. Many of these facilities have existed for decades, and subsequently, preconversion data and current data are very limited for most locations due to lack of study or publicly available data. Based on correspondence with various agency staff, roadways that had lanes narrowed to accommodate bicycle facilities did not have increases in injury collisions or a notable increase in congestion.

Observations on the use of 10-foot travel lanes drawn from focus groups and interviews include:

- Cities across the country are using 10-foot travel lanes, with and without bike lanes, on collectors, arterials, and thoroughfare-type streets.
- 10-foot lanes are rapidly becoming more common in many urban and suburban settings and are included in current city-level design guidance.
- Cities are using 10-foot lanes on roads with as many as seven travel lanes (including a center turn lane).
- 10-foot lanes are used on streets with traffic volumes exceeding 50,000 vehicles per day.
- 10-foot lanes carry heavy truck volumes at least as high as 13 percent.
- Some cities have been using 10-foot lanes with bike lanes for more than 10 years.
- Speed limits vary from 25 miles per hour to 45 miles per hour on streets with 10-foot lanes and bike lanes.
- Careful consideration should be given to the use of narrow lanes on routes carrying high volumes of truck or transit traffic.

The safety study described previously included roads with buses and heavy vehicles. These vehicles are wider than single-occupancy vehicles (10.5 feet inclusive of mirrors on buses and trucks compared to 8 feet for smaller motor vehicles). Providing a bike lane or paved shoulder adjacent to a lane that carries higher heavy vehicles volumes can increase the total effective width of the roadway by providing dedicated space for bicyclists and heavy vehicles. The study notes that “lane widths less than 12 feet should be used cautiously where substantial volumes of bicyclists share the road with motor vehicles, unless an alternative facility for bicycles such as a wider curb lane or paved shoulder is provided.”

A report of the National Cooperative Highway Research Program report titled *Effective Utilization of Street Width on Urban Arterials* reached a similar conclusion. This report considered the effectiveness of various strategies to reallocate widths on urban arterials. The report surveyed a wide range of crash data and found no consistent relationship between 10-foot lanes and increased crash rates. The report recommends that narrower lanes be considered as a strategy to implement other geometric improvements.

In appropriate contexts, narrower lanes, combined with other features associated with them, can be marginally safer than wider lanes. The FHWA supports the use of



This two-way separated bike lane was added during a resurfacing project on NE 40th Street in Seattle, WA.



A Road Diet in Seattle, WA, allowed the installation of buffered bike lanes.

sound engineering judgment in design.

Lane Width Capacity

Research has also been done to determine the effect of reducing lane widths on motor vehicle capacity. NCHRP Project 3-72 entitled *Lane Widths, Channelized Right Turns, and Right-turn Deceleration Lanes in Urban and Suburban Areas* studied saturation flow rates for various lane widths, and found only a negligible difference (less than 5 percent) between the saturation flow rate of a 12-foot travel lane versus a 9.5-foot travel lane. Reducing a travel lane width from 12 feet to 10 feet has been found to have little adverse effects on motor vehicle capacity in urban and suburban locations. The *Highway Capacity Manual* (HCM) is the standard reference document for determining the capacity of roadways and intersections; the 2010 edition reflects these lane width findings.

Comfort and Preference for Bicyclist Separation

Bicyclists generally prefer using a bicycle lane next to a narrow travel lane rather than sharing a wide lane with motor vehicles. The Florida Department of Transportation sponsored research to develop a “Bicycle Level of Service” model to measure the comfort of various bicycle facilities for bicyclists. The research concluded bicyclist comfort increased with additional lateral separation from motorized traffic on roadways and decreased with increasing speed and/or volume of traffic (i.e. LOS A = very comfortable, LOS F = very uncomfortable). Generally speaking, the provision of bike lanes provides bicyclists a substantially higher degree of comfort than a shared wide travel lane. This research has been thoroughly evaluated and calibrated through its application in bicycle master plans throughout the United States. The procedure is included in the 2010 Highway Capacity Manual. Table 1 illustrates an application of the model to compare a wide outside lane to a bike lane.

A 2013 Transportation Research Record paper documents findings that motorists prefer the presence of bike lanes when interacting with bicyclists.³ Evidence of this is also found in a recent survey of drivers in the San Francisco Bay Area, who overwhelmingly agreed that bike lanes “make bicyclists more predictable” and “give bicyclists their own space.”⁴ Finally, bike lanes have been shown to encourage more bicyclists to ride on the roadway instead of the sidewalk, improving safety for pedestrians using the sidewalk.

Narrowing travel lanes to provide a bike lane generally results in increased bicyclist comfort.

TABLE 1: Changes in Bicycle Level of Service when remarking a wide outside lane to a narrower travel land and bike lane

	Lane Width Combination	Bicycle Level of Service Score	Bicycle Level of Service Grade
1	15-Foot Wide Outside Lane	3.86	D
2	10-Foot Travel Lane, 5-Foot Bike lane	2.99	C

Note: Example roadway characteristics: 4 undivided travel lanes, 16,000 ADT, 6% heavy vehicles, 35 mph speed limit, good pavement condition, no parking, 15-foot outside lane.



CASE STUDY

Implementing a Bike Plan Through Resurfacing

Overland Park, KS

The City of Overland Park, KS, adopted its first bicycle plan in April 2015. Overland Park is the second most populous city in Kansas, and is the largest suburb in the Kansas City Metro Area. Prior to the adoption of the plan, the City had no on-street bicycle facilities, although it has an extensive network of shared use paths. While these paths are heavily used, they form a discontinuous bikeway network, and do not reach many areas of the city or specific destinations. In recognition of this, the City of Overland Park Safe Bicycle Use Outreach Project called for the implementation of approximately 215 miles of bicycle lanes and buffered bicycle lanes in the coming decades to provide a connected bicycle network throughout the city.

Overland Park is a relatively new city—the city incorporated in 1960—and its streets are in a generally good state of repair. Because most streets in the city will not be reconstructed for many years, the City will use Lane Diets and the occasional Road Diet to implement the bicycle lanes recommended for existing streets (including two-lane neighborhood streets and more heavily traveled four- and six-lane thoroughfares). In order to implement these facilities in the most cost-efficient manner, the City will primarily install bicycle lanes when streets are being resurfaced, which happens

on average every seven to ten years. By installing bicycle lanes during resurfacing projects the City avoids costs associated with eradicating existing markings during the installation, traffic control is already provided for the resurfacing, and the City shows progress in putting the bike plan into action. Brian Shields, City Traffic Engineer, said “Our Governing Body was concerned about the cost of the proposed bike plan with so many other competing needs throughout the city. The incremental implementation through resurfacing projects gave them the comfort level they needed to allow us to move forward.”

In 2015, Overland Park implemented approximately 20 centerline miles of bicycle lanes, largely through resurfacing projects. The primary issue the City faces is that pavement conditions—not the need for bicycle facilities—drives resurfacing projects. While some resurfacing projects are contiguous or cover large parts of neighborhoods, installing bicycle facilities with resurfacing projects can result in a discontinuous bikeway network, particularly early in the implementation cycle. To overcome this, the City is installing bicycle lanes on some street sections not being resurfaced in order to provide connections between bikeways.



John Keating, City of Overland Park, KS

Bicycle lanes were added to Switzer Road in Overland Park, KS, during a resurfacing project by narrowing the travel lanes.

3.3 | Methods for Providing Bicycle Facilities

Bike lanes, including buffered and separated bike lanes, can often be added to a roadway during a resurfacing project. Adding these bicycle facilities to a roadway typically means finding space within the existing pavement width. This section highlights common methods for providing this space during routine resurfacing projects including:

- Lane Narrowing / Lane Diet
- Roadway Reconfiguration / Road Diet
- Parking Removal

The following pages describe benefits and challenges associated with each method as well as brief design considerations, additional considerations, select locations where each method has been applied, and success stories from communities. Each method also provides generalized diagrams of a roadway before and after the method was applied. The applicability of each method will vary widely from location to location.

In addition to evaluating options to reallocate space, it may be possible in rural areas to pave existing gravel shoulders as part of a roadway project. However, paving shoulders during a resurfacing project is not as simple as extending the new layer of pavement over an existing gravel shoulder. Additional shoulder preparation work should be completed, and a thicker layer of pavement should be laid on the gravel shoulder than on the existing roadway surface. A better opportunity to pave gravel shoulders occurs when the existing pavement is removed and new pavement for the travel lanes and a full depth paved shoulder is installed. These methods are larger in scope than a typical resurfacing project for many agencies; however, because paved shoulders can be installed with less than a full roadway reconstruction, such projects present an opportunity to expand bicycle networks.

Bicycle facilities in the diagrams on the following pages show the use of green-colored pavement. Green-colored pavement has received interim approval from FHWA. Agencies wishing to use green-colored pavement need to request and receive the FHWA's approval to use this interim approved device. Requests for jurisdiction-wide approval are encouraged.

The Role of a Pavement Marking Plan

The difference between a standard resurfacing project and a resurfacing project that adds a new bikeway is a pavement marking plan. Remarketing a street in the same manner as existed before a resurfacing project is challenging enough for agencies and is often done without a marking plan. Moving beyond that to incorporate bicycle facilities requires a pavement marking or striping plan.

Pavement marking plans indicate exactly where travel and bike lane lines and symbols should be placed (often down to the inch). They are one of the last elements completed in the design process and are often done when the agency is pressed for time. It is recommended that agencies complete marking plans earlier in the process. Further, except in the simplest cases, agencies should do the work in-house, rather than rely on a maintenance crew or pavement marking vendor to design the markings on-site. A quality marking plan can be reused when the street gets resurfaced.



A marking plan is essential to ensure bikeways are marked as intended following a resurfacing. Green pavement markings have received interim approval from FHWA, but agencies must seek approval from FHWA prior to using green markings.



METHOD FOR INCLUDING BIKEWAYS: Lane Narrowing / Lane Diet

The width needed for bike lanes or paved shoulders can sometimes be obtained by narrowing travel lanes, commonly known as a “Lane Diet.” Lane widths on many roads are greater than the minimum values recommended in the AASHTO Green Book. Research has shown that narrower lane widths slow vehicle speeds without decreasing safety or adversely impacting capacity under most urban and suburban conditions.

Wide outside lanes or parking lanes can result in higher traffic speeds or two motor vehicles operating side by side in what is technically a single lane. Reallocating a portion of wide parking or travel lanes as a bike lane can mitigate these issues while providing dedicated space for bicyclists.

Benefits

- Narrower lanes generally result in lowered vehicle speeds, reducing crash severity.
- Narrower lanes provide additional roadway space for bicycle facilities.
- While outside the scope of resurfacing projects, narrower lanes can make it easier to install curb extensions or median crossing islands, providing pedestrian safety benefits.
- There are no significant safety or capacity differences between 10-foot and 12-foot wide travel lanes under most urban and suburban conditions.

Challenges

- City and State policies regarding minimum lane widths can be a barrier to Lane Diets.
- Many U.S. cities already have 10-foot lanes in the downtown core and cannot narrow them further.
- The public may oppose lane narrowing if citizens or elected officials believe it will slow traffic or increase congestion on streets that are already congested. There may also be opposition to allocating more roadway space for cyclists. However, providing space for bicyclists removes them from the general purpose travel lane and may improve flow for motor vehicles.

Example Locations Where Applied

Chicago, IL; Philadelphia, PA; Oakland, CA; Austin, TX; Madison, WI; Fort Collins, CO; Colorado Springs, CO; Kirkland, WA; Minnesota; Charlottesville, VA; Boston, MA

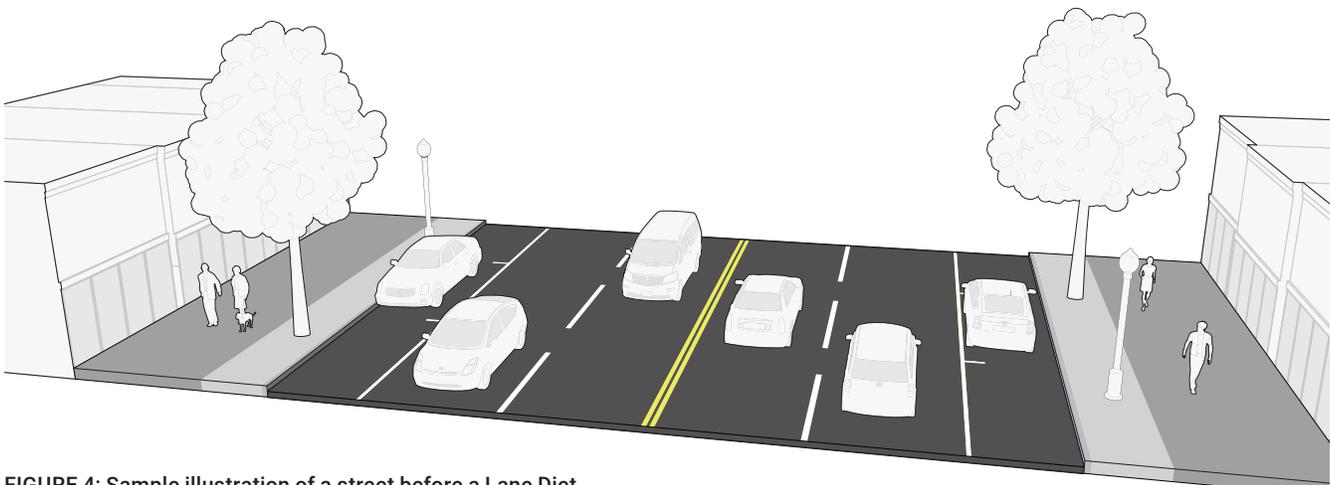


FIGURE 4: Sample illustration of a street before a Lane Diet.

Design Considerations

The AASHTO Green Book recommends the following *minimum* travel lane widths:

- 10-foot lanes for vehicular travel lanes in constrained areas where heavy vehicle traffic is low;
- 10-foot lanes for turn lanes; and
- 11-foot lanes to accommodate large volumes of trucks, buses, or larger vehicles (typically where volumes of large vehicles are greater than eight percent).

See the NACTO Urban Street Design Guide for information about parking lane widths of 7 to 9 feet.

Additional Considerations

- For multilane roadways where transit or freight vehicles are present, the wider lane should be the outside lane (curbside or next to parking). Inside lanes may be designed at a minimum width.
- On roadways with excess vehicle capacity, it may be preferable to reduce the number of travel lanes to provide more benefits for all road users (see Roadway Reconfiguration / Road Diet).
- If more than sufficient space is available, extra width should not be given to travel lanes. Adding striped buffers can be a way of taking up space, providing additional comfort for bikes, and keeping travel lanes the desired width.

Specific Successes

- Lane Diets are the most common method of adding bicycle facilities for the City of Chicago. The City was able to implement 25 miles of basic bike lanes (10-foot travel lanes with 5-foot bike lanes) and 67 miles of buffered bike lanes (10-foot lanes and 2-foot buffers) through Lane Diets.
- The City of Austin has narrowed 12-foot travel lanes to 10-foot lanes, while adding two 5-foot bike lanes on many of their five lane 60-foot wide streets. The transit system has benefited from the conversion: buses have had fewer sign strikes and other damage from curb-related incidents because of the additional distance from the curb.
- Forest Home Avenue (Wisconsin State Highway 24) forms a major connection between the City of Milwaukee and the southwest suburbs of Milwaukee County. Constructed as a four-lane boulevard with parking in the late 1960's, traffic volumes are moderately-low for an urban State highway—between 15,000 and 20,000 vehicles per day. The street was recently resurfaced and since it had generous travel lane and parking lane widths was remarked with bike lanes by narrowing all lanes. The bike lanes also provide better delineation between the parking lanes and travel lanes to discourage drivers from using the parking lane as a third lane for inappropriate passing maneuvers.

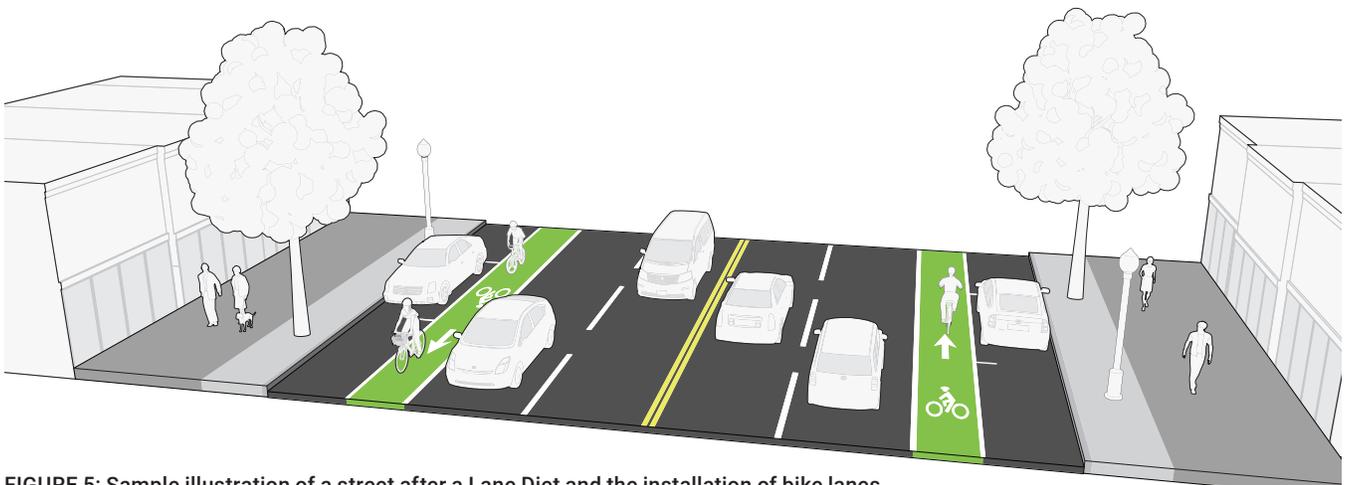


FIGURE 5: Sample illustration of a street after a Lane Diet and the installation of bike lanes.



METHOD FOR INCLUDING BIKEWAYS: Roadway Reconfiguration / Road Diet

A roadway reconfiguration, commonly referred to as a “Road Diet,” involves the reconfiguration of the roadway and the removal of one or more motor vehicle lanes. According to the FHWA, a classic Road Diet converts an existing four-lane undivided roadway segment to a three-lane segment consisting of two through lanes and a center two-way left turn lane (TWLTL).

A Road Diet provides an opportunity to allocate excess roadway width to other purposes, including bike lanes. This use of space reduces potential crash conflicts and allows for the addition of bike lanes. The FHWA Road Diet Informational Guide provides detailed information about the use of Road Diets.

Benefits

- Space gained by removing one lane can be used to provide bike lanes or shoulders on both sides of the road.
- Bike lanes increase separation from traffic for pedestrians and improves the comfort of walking on sidewalks.
- Center turn lanes reduce crashes and improve roadway operation by reducing conflicts with turning vehicles. Left-turning vehicles can wait in a center turn lane instead of the travel lane. Center turn lanes have been shown to reduce crash rates between 19 to 47 percent.⁵
- One travel lane in each direction allows prudent drivers who follow posted speed limits to set the prevailing speed.
- A center turn lane can be converted to a raised median and provide pedestrian refuge islands at crossing locations, making it easier for pedestrians to cross the street and adding traffic calming measures.
- For streets that are converted from four to three lanes, the reduction from two lanes to one lane in each direction reduces the likelihood of “multiple threat” crashes where a driver in one lane yields to a pedestrian in a crosswalk, but the driver in the next lane continues at speed. This benefit applies to both pedestrians and left-turning drivers.
- Road Diets that provide a center turn lane typically do not reduce throughput on a roadway.

Challenges

- Resurfacing projects that include Road Diets can be more challenging than Lane Diets or space reallocation projects.
- The public involvement requirements of Road Diets may delay a resurfacing project.
- Local businesses may object to a Road Diet if they believe that it will result in less traffic along the street, however, many Road Diets have been shown to have no impact or a positive economic impact along the corridor.⁶
- For streets that are converted from four to three lanes, the reduction from two lanes to one lane in each direction can result in transit or delivery vehicles occupying travel lanes or bike lanes during stops.
- A traffic study may be needed to determine the feasibility of a Road Diet.
- Changes may be needed to signs and signals on the roadway.

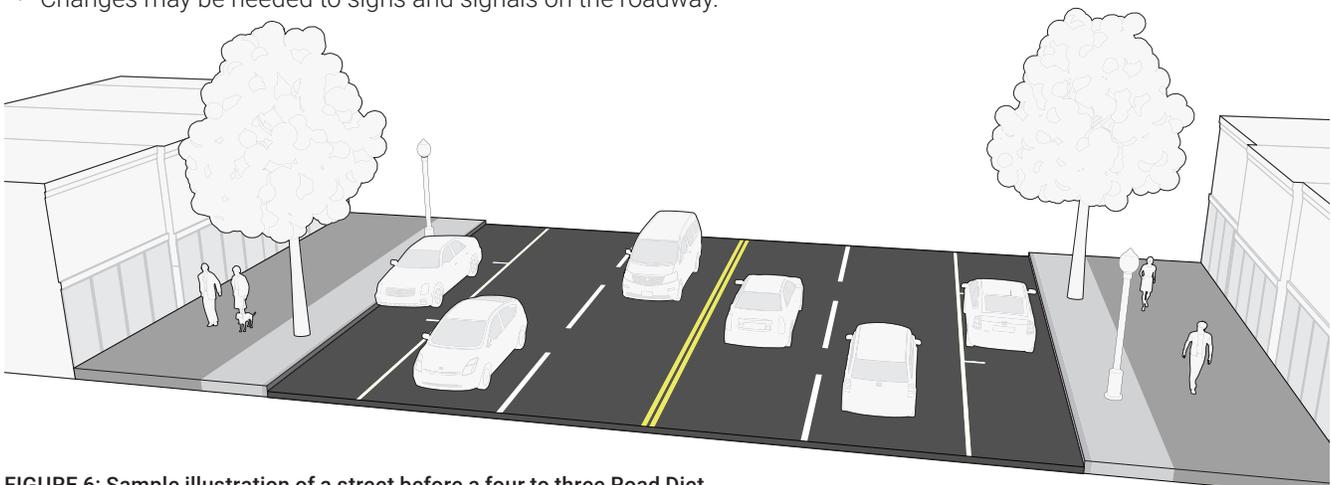


FIGURE 6: Sample illustration of a street before a four to three Road Diet.

Example Locations Where Applied

Billings, MT; Fort Collins, CO; Austin, TX; Urbana, IL; Minneapolis, MN; Alexandria, VA; Durham, NC; Seattle, WA; Washington, DC; San Francisco, CA

Design Considerations

- Four-to-three-lane conversions of two-way streets should be considered for roadways with moderate volumes (FHWA recommends less than 20,000 Average Daily Traffic, but agencies have seen success with up to 25,000 ADT in some cases).
- Travel lane widths can be 10 to 12 feet, depending on the types of vehicles likely to use the road.
- The width of the center turn lane provided as part of a Road Diet typically ranges from 10 to 16 feet, depending on the vehicles typically using the street.
- Intermittent raised medians and left-turn bays help eliminate the use of the center turn lane as a passing lane.

Additional Considerations

- Lane reductions on higher volume roadways (more than 20,000 ADT) should be studied carefully to ensure that traffic signals and driveway access are appropriate for larger volumes of traffic.
- Before implementing a Road Diet, determine if alternative parallel routes will be impacted.
- Treatments such as medians and plantings may be added after the installation of the striping for the Road Diet.
- A four-to-three-lane Road Diet is compatible with single-lane roundabouts.

Specific Successes

- The City of Urbana, Illinois, transformed Philo Road from four lanes to three, with a continuous two-way-left turn lane in the center. The City also constructed a raised landscaped median for a mid-block pedestrian crossing to accommodate bus passengers. The new design has helped rejuvenate commercial activity along the street.
- Valencia Street in San Francisco is an important north-south corridor carrying about 22,000 vehicles per day. The City converted a section of the street from four-to-three travel lanes on a one-year trial basis. The Road Diet led to approximately ten percent of motor vehicles shifting to parallel routes, but also led to a 140 percent increase in bicycle usage along the street.

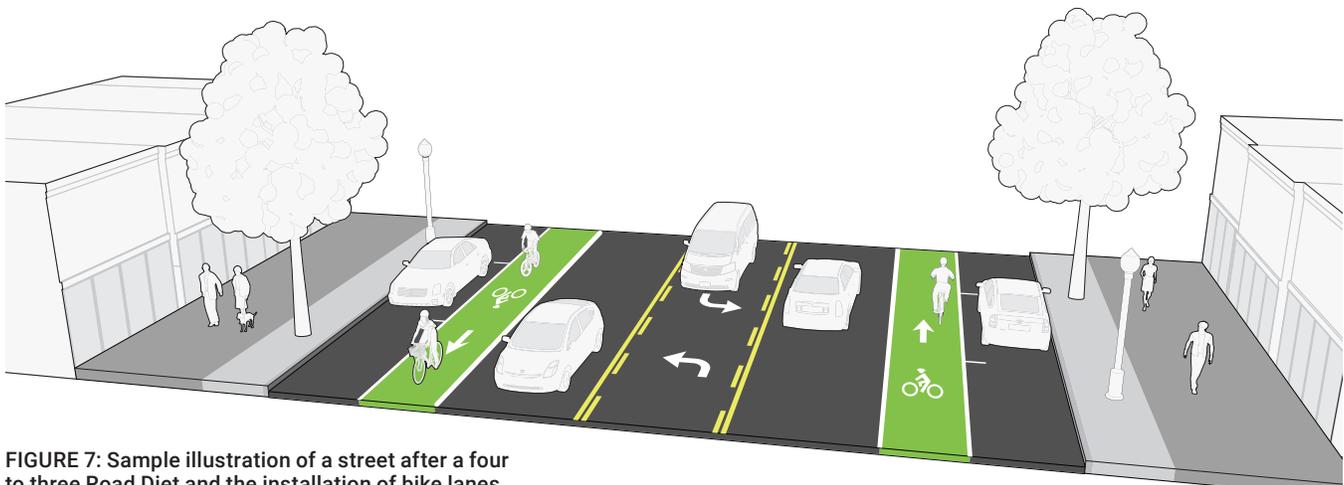


FIGURE 7: Sample illustration of a street after a four to three Road Diet and the installation of bike lanes.

➤ **METHOD FOR INCLUDING BIKEWAYS: Roadway Reconfiguration / Road Diet**

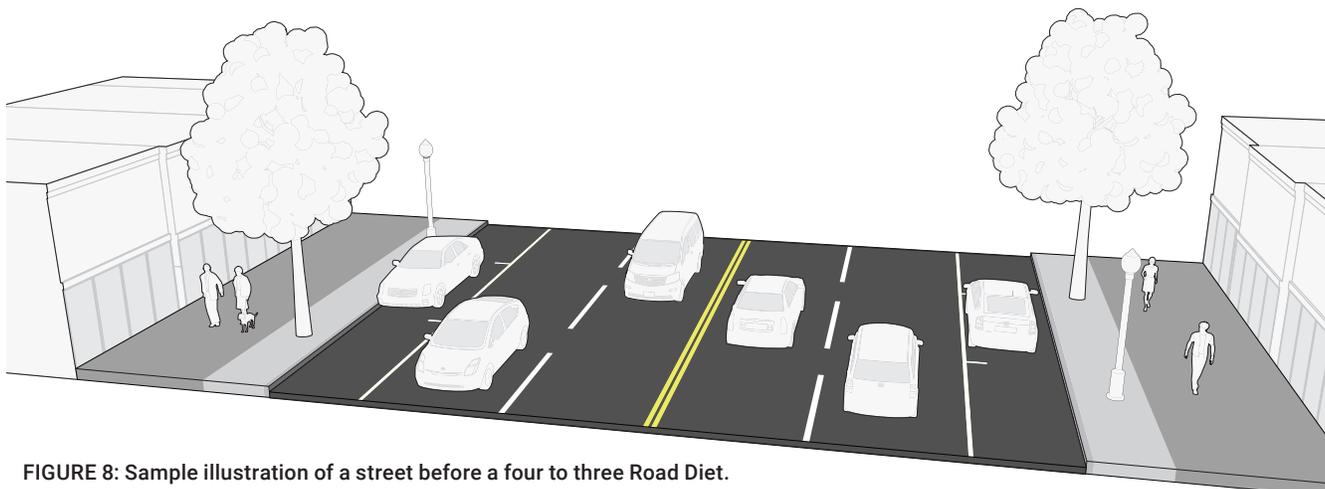


FIGURE 8: Sample illustration of a street before a four to three Road Diet.

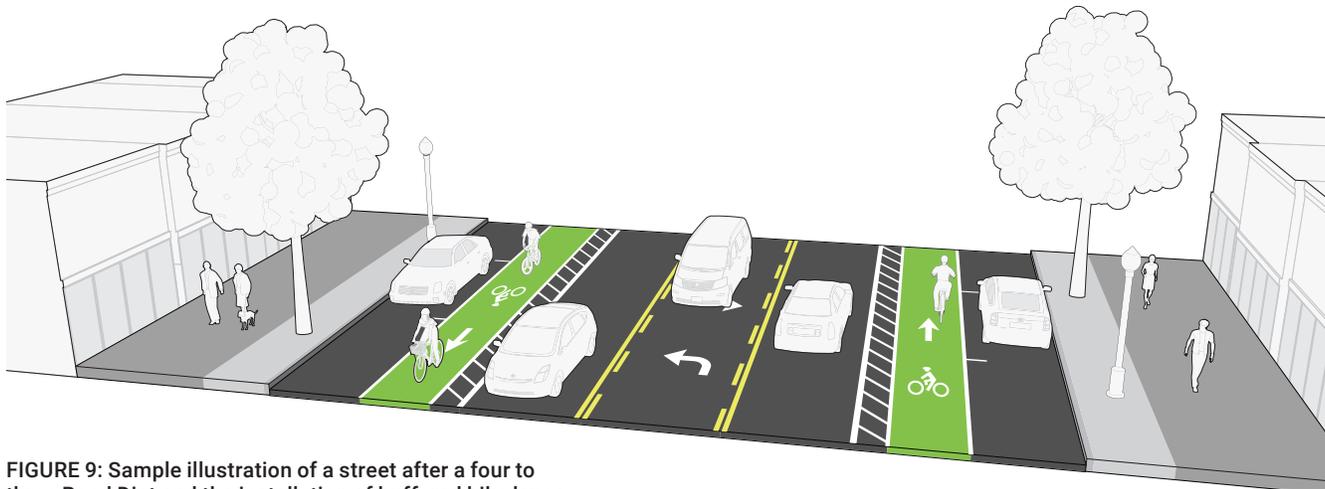


FIGURE 9: Sample illustration of a street after a four to three Road Diet and the installation of buffered bike lanes.

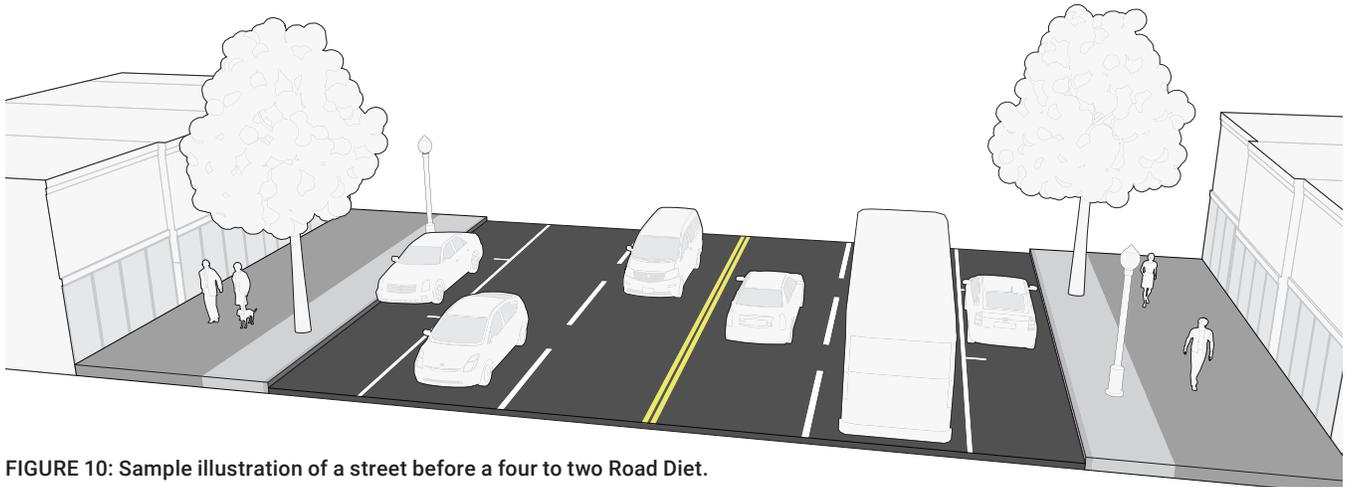


FIGURE 10: Sample illustration of a street before a four to two Road Diet.

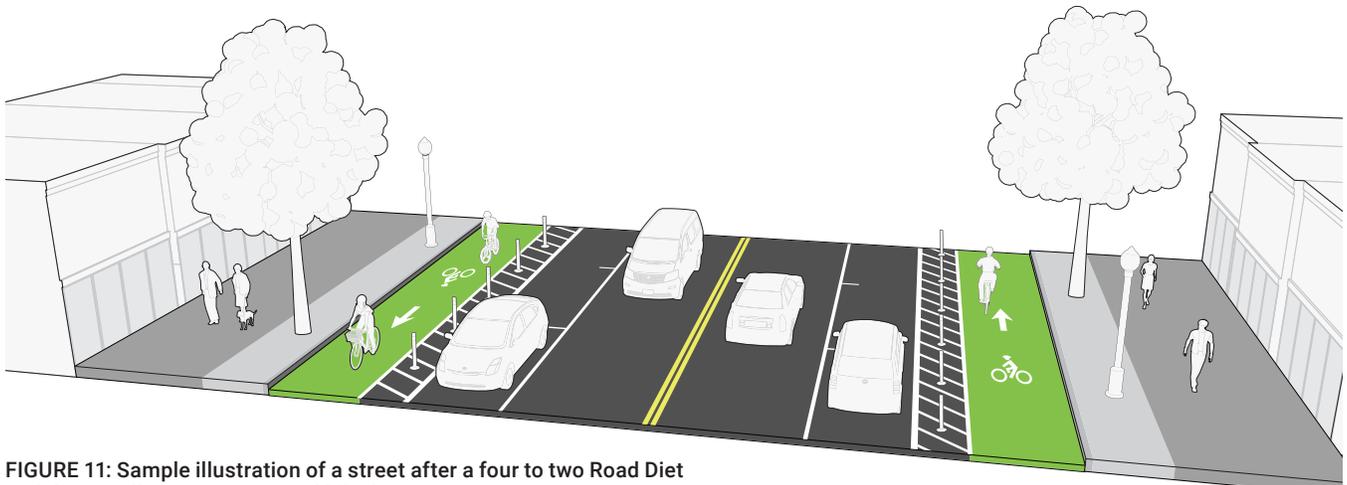


FIGURE 11: Sample illustration of a street after a four to two Road Diet and the installation of separated bike lanes.



METHOD FOR INCLUDING BIKEWAYS: Parking Removal

The removal of on-street parking provides space for bicyclists can reduce conflicts between bicyclists and motorists. Policies that may help reduce parking demand, provide more parking on side streets, or provide more shared off-street parking areas should be considered when parking is removed.

Benefits

- Reduces conflicts with bicyclists as drivers pull into and out of parking spaces and drivers and passengers open doors of parked vehicles.
- Provides additional roadway space for bicycle facilities.
- Improves sight distance for all roadway users.

Challenges

- Resurfacing projects that include parking removal are usually more challenging than Lane Diets due to resident or business community resistance to losing parking and potential impacts on loading and freight delivery.

Example Locations Where Applied

- Fort Collins, CO; Austin, TX; Eugene, OR

Design Considerations

- On most streets with parking on both sides, removal of all on-street parking is not necessary to add bike lanes. If the street includes businesses, it is preferential to remove parking on the side of the street with fewer or no businesses.
- Parking may be alternated from one side of the street to the other with proper transitioning. This pattern may cause motorists to reduce their speed.
- For a roadway with two 10-foot parking lanes, the removal of one parking lane can provide space for a 4-foot bike lane next to a 2-foot gutter on one side of the street, and a 6-foot bike lane next to an 8-foot parking lane on the other side of the street.

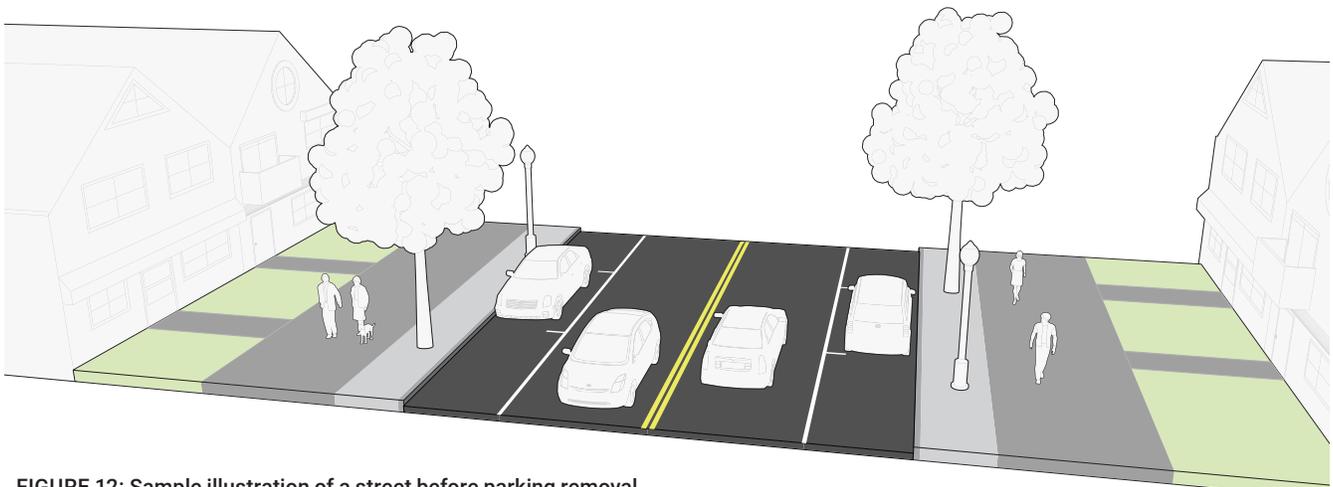


FIGURE 12: Sample illustration of a street before parking removal.

Additional Considerations

- When parking lanes are converted to bike lanes, ensure that drainage grates are compatible with bicycle use, that manhole or utility covers are flush with the pavement, and that gutter joints are smooth and not a hazard to bicyclists.
- Overall parking demand and space should be evaluated from the standpoint of the community's needs and values, including the value of using the street for mobility of all users, the desire to reduce single-occupancy vehicles, and the need to promote bicycling or transit.

Specific Successes

- The City of Austin removed on-street parking to add a two-way separated bike lane along Bluebonnet Lane.

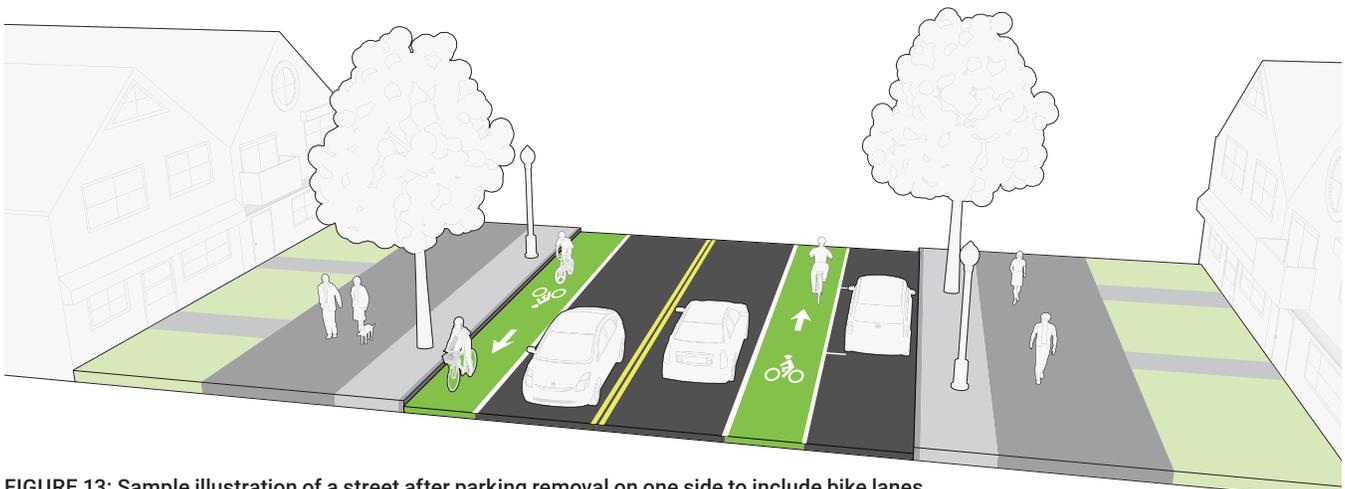


FIGURE 13: Sample illustration of a street after parking removal on one side to include bike lanes.

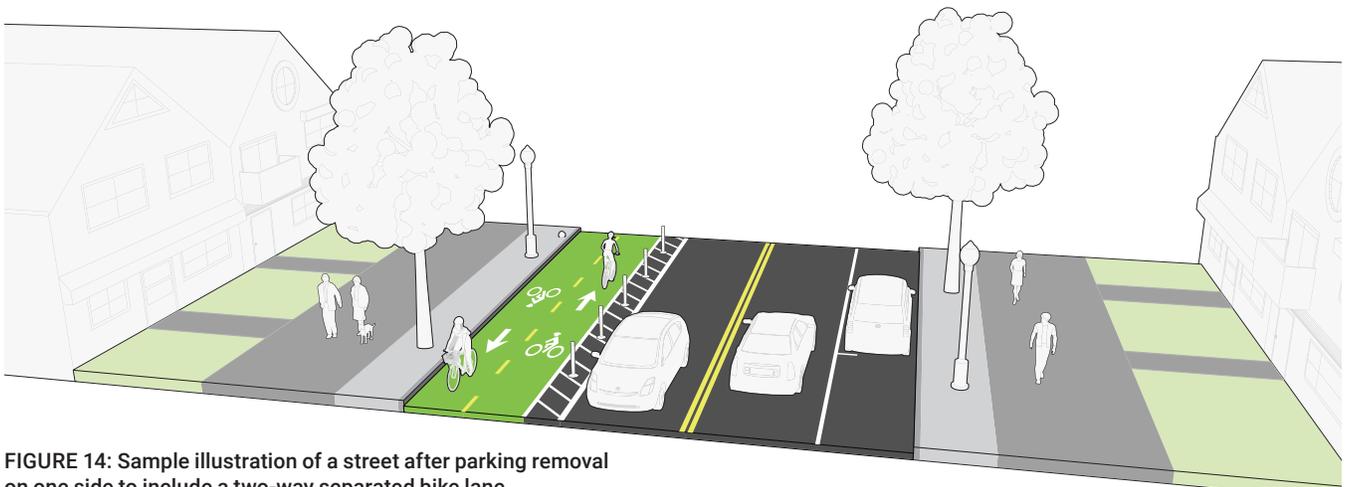


FIGURE 14: Sample illustration of a street after parking removal on one side to include a two-way separated bike lane.



METHOD FOR INCLUDING BIKEWAYS: Shoulder Paving

Paving existing gravel shoulders can greatly improve bicycling conditions on rural roadways with higher speeds or traffic volumes, as well as benefit motorists. Paved shoulders also extend the service life of the road and can ease maintenance operations.

Benefits

- Provides a stable surface for bicyclists when shared use paths near or within the road right-of-way cannot be provided.
- Improves comfort for bicyclists by providing space outside of the motor vehicle travel lanes.
- Improves roadway drainage.
- Extends the service life of the road by reducing edge deterioration.
- Reduces shoulder maintenance requirements.
- Provides additional operating space for agricultural equipment and maintenance vehicles.

Challenges

- Roadways in constrained locations may not have shoulders wide enough to pave.
- Bridges along the roadway may be narrow and it may be impractical to widen an existing bridge when shoulders are paved, creating a situation in which bicyclists may need to transition into the motor vehicle lanes to cross the bridge.
- Some States have policies that prohibit bicycling on roadway shoulders.
- Some jurisdictions will add rumble strips on paved shoulders to reduce run-off-road crashes for motorists. Rumble strips on narrow shoulders may force bicyclists to ride in the travel lane rather than on the shoulder.
- This method is difficult to use as part of simple resurfacing projects and typically can only be done effectively with pavement rehabilitation (i.e. pavement replacement) projects.
- Increased impervious area may require changes to drainage and stormwater management.
- Subgrade deficiencies.

Example Locations Where Applied

Wilmington, NC; Springfield, OH; Florence, OR; Wisconsin Great River Road

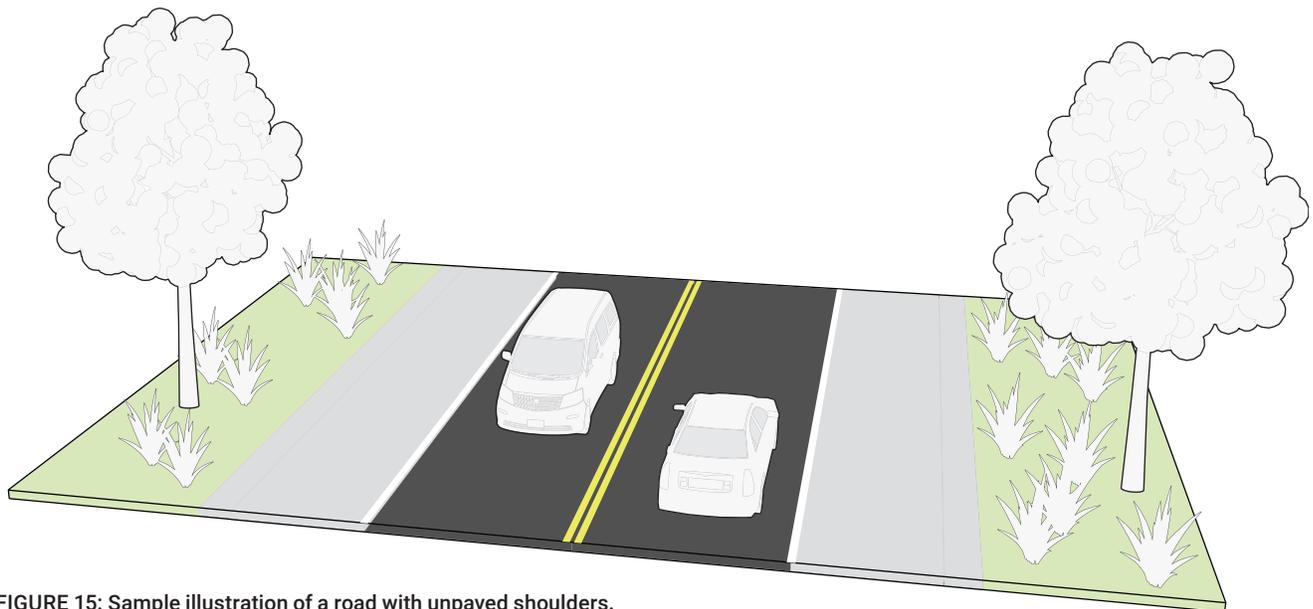


FIGURE 15: Sample illustration of a road with unpaved shoulders.

Design Considerations

- The AASHTO Bike Guide recommends that on uncurbed cross sections, paved shoulders should be at least four-feet wide, and at least five feet of width should be provided if there are signs, guardrails, curbs, or other vertical barriers. Six- to eight-foot wide shoulders are recommended if motor vehicle speeds exceed 50 miles per hour or if the road is commonly used by heavy trucks, buses, or recreational vehicles.
- Where pavement is being widened to provide paved shoulders or bike lanes, ensure that the joint between the old and new asphalt does not extend across the area traveled by bicyclists.
- Ensure sufficient subgrade is available or can be provided.
- Ensure compliance with pedestrian accessibility requirements if the shoulder is intended for pedestrian use.

Additional Considerations

- The best time to add paved shoulders is during a roadway reconstruction or pavement replacement, so that the gravel shoulder can be excavated and graded with an appropriate subbase to allow a sufficient layer of asphalt.
- Where paved shoulders are present, accommodations should be made for bicyclists through intersections when shoulders are dropped to provide for right turn lanes. Such accommodation could be a bike lane only at intersections to provide for through bicycle travel; or signage that directs bicyclists and motorists to share the road.
- Flexibility in the design of rumble strips may be needed on shoulders used by bicyclists unless there is a minimum clear path of four feet from the rumble strip to the outside edge of a paved shoulder, or five feet if there are guardrails or curbs present. Periodic gaps should be provided in rumble strips to allow bicyclists to move across them to avoid debris, make left turns, or pass.

Specific Successes

“The Great River Road” is a national scenic byway that travels along the Mississippi River through ten States. The designated Great River Road Route in Wisconsin is along State Highway 35. Despite significant space constraints, over 90 percent of the paved shoulders on State Highway 35 have been expanded to at least five feet since 1995.

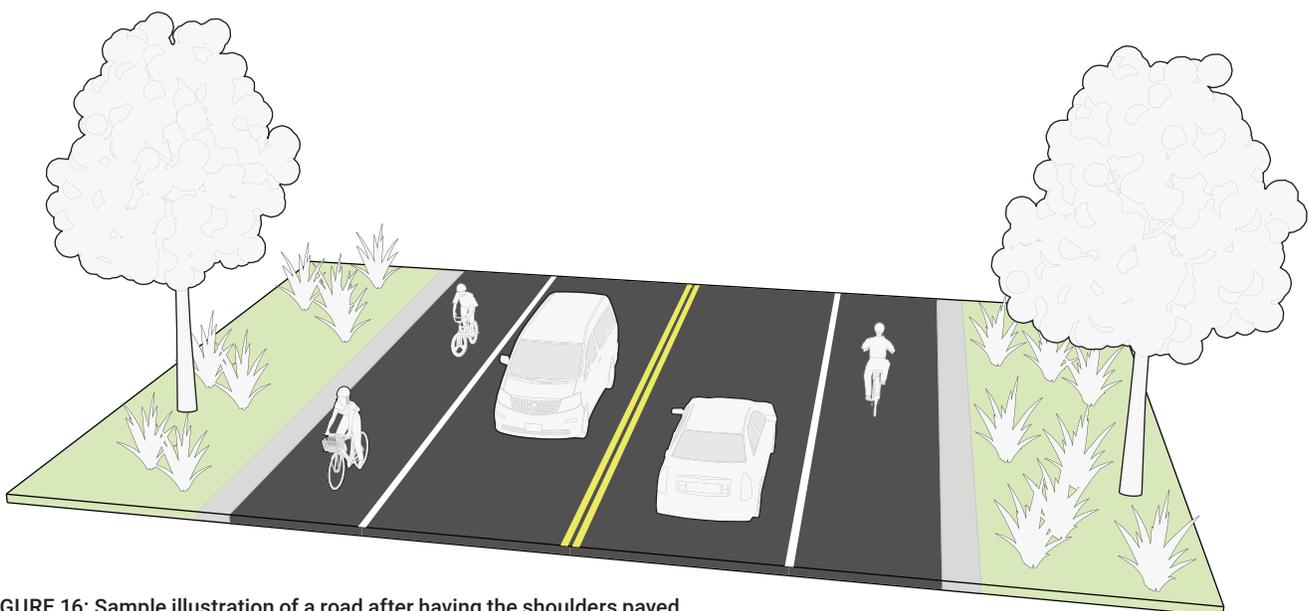


FIGURE 16: Sample illustration of a road after having the shoulders paved.



METHOD FOR INCLUDING BIKEWAYS: References and Resources

Lane Narrowing/Lane Diet

- NACTO Urban Street Design Guide (2013)
- Pedestrian & Bicycle Information Center, Bicycle Safety Guide and Countermeasure Selection System (pedbikeinfo.org)
- Potts, Harwood, and Richard. "Relationship of Lane Width to Safety for Urban and Suburban Arterials." TRB Annual Meeting, Washington DC. (2007)

Roadway Reconfiguration/Road Diet

- FHWA Road Diet Informational Guide (2014)
- NACTO Urban Street Design Guide (2013)
- AASHTO Guide for the Development of Bicycle Facilities (2012)

Parking Removal

- AASHTO A Policy on Geometric Design of Highways and Streets, Sixth Edition (Green Book) (2012)
- FHWA Pedestrian and Bicycle Information Center, Bicycle Safety Guide and Countermeasure Selection System, pedbikesafe.org
- Jaffe, Eric. "The Complete Business Case for Converting Street Parking into Bike Lanes," Citylab.com. (2015)

Shoulder Paving

- AASHTO, Guide for the Development of Bicycle Facilities, Fourth Edition
- FHWA Safety Benefits of Walkways, Sidewalks, and Paved Shoulders
- FHWA Technical Advisory on Shoulder and Edge Line Rumble Strips
- Maryland SHA Bicycle and Pedestrian Design Guidelines
- Wisconsin Bicycle Facility Design Handbook

3.4 | Practices to Avoid

There are several practices that should be avoided when resurfacing streets and roads. Some of these can actually make conditions worse for bicycling than simply returning the roadway to the same lane configuration as before resurfacing. In many cases, minor modifications to project plans can mitigate problems for bicyclists.

Overuse of Design Minimums

Methods discussed in this workbook call for flexibility in the use of design criteria, particularly travel lane widths. Without reducing travel lanes to a minimum width, it will be difficult to use that particular method effectively. It is not necessary to use minimum widths for an entire street cross-section. If a travel lane is proposed with a minimum width, the adjacent bike lane should be standard width.

If minimum widths are used in combination (i.e. minimum width travel lanes and bike lanes), consider the following:

- First, take into account the volume and speed of motor vehicle traffic. A lightly traveled three-lane street with a 30 miles per hour speed is considerably different than a high volume and high speed four-lane or six-lane highway.
- Second, lane configuration matters. For instance, a 3-lane street (with the middle lane being a continuous left turn lane) with minimum lane widths in all lanes allows motorists to edge over to the center turn lane when overtaking bicyclists.
- Third, evaluate the type of traffic on a roadway. The use of a minimum outside lane width with a high amount of truck and bus traffic may be problematic next to a minimum width bike lane. On the other hand, a street that has few heavy vehicles may be a good candidate for bike lanes even with minimum travel and bike lane widths.



Kenneth Tippet, City of Charlotte, NC

A Road Diet on East Boulevard in Charlotte, NC, allowed the installation of bike lanes as well as pedestrian improvements.

Rumble Strip Placement

The practice of paving shoulders has grown in popularity among transportation agencies over the past three decades after it became clear that paved shoulders provide significant safety benefits and roadway maintenance savings. An additional benefit of paving shoulders is that roadways with paved shoulders better serve bicyclists. The innovation of rumble strips has proven to be an effective safety measure for motorists on many roadway types. However, where and how rumble strips are installed can dramatically impact bicycling conditions. A poorly placed rumble strip can render a paved shoulder useless for bicyclists or even present a safety hazard.

There is latitude for the placement of rumble strips. For some time it was thought that shoulder rumble placement had an effect on the crash rate. Recent studies conclude that this is true for rural multi-lane freeways, but there is no relationship between longitudinal placement and crash reductions for rural two-lane roadways, which are often popular bicycling routes. According to National Cooperative Highway Research Program Report 641, Guidance for the Design and Application of Shoulder and Centerline Rumble Strips:

... for rural two-lane roads, the estimates of the safety effects of edgeline and non-edgeline rumble strips are so close (i.e., 39.2 percent reduction compared to a 41.9 percent reduction) that, for all practical purposes, the placement of shoulder rumble strips on rural two-lane roads has no impact on their safety effectiveness.

Rumble strips that are placed according to AASHTO guidance, providing at least four feet of usable paved shoulder between the rumble and edge of the paved shoulder, have the least negative impact on bicyclists while still providing the full benefit of rumble strips to motorists. If at least four feet of pavement cannot be provided to the right of the rumble strip, a rumble strip placed at the edge of the paved shoulder, narrowed if necessary, will allow most of the paved shoulder to be usable by bicyclists immediately adjacent to the travel lane.

The adjacent photograph shows a narrow paved shoulder recently added to a two-lane highway; although the rumble strip itself is narrow, its placement leaves less than two feet of paved shoulder for bicyclists

to use. In this case, placing the rumble strip as close to the edge of the pavement as feasible would allow the bicyclist to travel in the shoulder immediately adjacent to the travel lane.

In order to reduce severe motor vehicle crashes while accommodating bicyclists, many States have developed standards with narrower and shallower rumble strips. Rumble strips 0.375 inches deep and as narrow as six to eight inches may provide adequate sound to alert inattentive, distracted, drowsy, or fatigued drivers. These narrower and shallower rumble strips leave more shoulder space for bicyclists to operate, especially if they are placed under the edge line pavement marking; this placement also provides the benefit of improved wet nighttime visibility and a longer-lasting pavement marking. The narrower strips are also easier for a bicyclist to ride over if necessary. Providing periodic gaps in rumble strips allows bicyclists to cross the rumble strip without riding over the grooved pavement.

Rumble stripes can also be considered as an alternative to rumble strips as they typically provide more operating space for bicyclists. More information on rumble stripes is available at http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips.





CASE STUDY

Best Practice: Paved Shoulders and Bicycle-Tolerable Rumble Strips

Wisconsin DOT

Paved shoulders provide a variety of benefits on rural roads:

- Additional width for oversize vehicles to operate;
- Usable area for vehicles to pull onto during emergencies;
- Lateral support for the roadway;
- Reduced maintenance costs;
- Space for recovery and avoidance maneuvers; and
- On-road bicycle accommodation.

Adding rumble strips to paved shoulder provides a safety benefit by reducing run-off-road crashes. However, rumble strips can have a negative impact on bicyclists using a roadway if they are poorly placed. Wisconsin DOT recently established a number of policies that ensure that paved shoulders on rural roadways adequately serve bicyclists while also accommodating rumble strips.

Beginning in 2014, all reconstruction, new construction and pavement replacement rural asphalt roadway projects having a total shoulder width of 6 feet or more require a 5-foot paved shoulder. As noted above, this paved shoulder provides a wide variety of benefits including reduced roadway maintenance and increased longevity, in addition to serving as a bicycle

accommodation. With the requirement of 5-foot paved shoulders on State roads, Wisconsin DOT issued new guidance on the installation of rumble strips that limit the negative impact on bicyclists:

- The minimum paved shoulder width for a rural road with rumble strips is 5 feet, regardless of traffic volume.
- Rumble strips are placed 6 inches from the edge line, and are 8 inches wide, leaving approximately four feet or more of clear space to the right of the rumble strip that can be used by bicyclists.
- A minimum 12-foot long gap is placed in the rumble strip every 48 feet, which allows bicyclists to cross the rumble strip should they need to.
- Rumble strips grooves are $\frac{3}{8}$ to $\frac{1}{2}$ inch deep, which is less likely to cause control issues for bicyclists riding over the grooves than deeper rumble strips.
- Rumble strips are discontinued across all intersections, driveways, and path crossings.

These features result in paved shoulders that accommodate bicyclists while also offering safety features for motorists.



Highway 26 near Rosendale, WI, was recently resurfaced with 5-foot wide shoulders and narrow rumble strips that leave four feet of clear pavement to the right of the rumble strip.

Rough Aggregate

Roadway resurfacing treatments use aggregate to form the new surface. Most resurfacing treatments compact the aggregate with heavy rollers. However, some minor resurfacing techniques mix crushed aggregate with an asphalt emulsifier and apply it cold without a roller. When the aggregate is angular and not fine enough, there is potential for the bicycle facilities to be very rough riding. This problem was identified mostly in western States when existing paved shoulders were resurfaced. It is especially problematic for narrower bicycle tires, but can cause discomfort and even safety concerns for any bicyclist. Overly rough aggregate can cause paved shoulders to be unusable or very undesirable to ride on. The easiest solution is to use a fine enough aggregate and to make sure that the aggregate is screened before it is delivered to the on-site equipment.

Dead Ending Bikeway Markings

Ideally resurfacing projects would enable long, high-priority segments of bikeways to be built. In practice, resurfacing projects come in many different lengths, and project scheduling is determined by the condition of the pavement, not bikeway priority. Incorporating bikeways to take advantage of these projects has long-lasting advantages, but it may result in short-term connectivity challenges for the bikeway network.

Over time, the bikeway network can be completed as the principle streets in a community are resurfaced or reconstructed—but this may take a long time and leave a bicycle network disconnected in the interim. There are a number of steps that can be taken to close gaps in the network in the near term. For example, adding a short street section to a resurfacing project can sometimes make a connection to a nearby bikeway or shared use path. Similarly, the limits of marking can be extended without extending the entire resurfacing project, by grinding off old markings and applying ones to match the resurfacing project. Finally, interim markings can connect nearby bikeways using shared lane markings or wide outside lanes.



Nathan Wilkes, City of Austin, TX

4

Cost and Material Considerations

This chapter provides information about cost and material considerations for including bikeways in resurfacing projects. The chapter highlights the cost efficiencies of including bikeways as part of a resurfacing project versus installing a bikeway as a standalone project. The chapter also provides information about material selection for marking bikeways.

4.1 | Connected Bicycle Network Cost Savings

Using resurfacing opportunities to develop a connected bicycle network has a broad appeal for two main reasons: costs savings and a shortened timeframe for bikeway implementation as compared to installing bikeways as standalone projects. Resurfacing a roadway occurs several times over the life of a pavement and represents the most common project type that can be used to include bikeways. Installing bikeways as standalone projects can be more expensive and does not take advantage of the economies of scale present when a resurfacing project is already occurring. Utilizing resurfacing projects to install bikeways will help communities develop an interconnected network of bikeways sooner and at lower cost than if they attempt to install all bikeways in their network as standalone projects or expand the footprint of the street when complete reconstruction occurs.

4.2 | Cost Considerations

It is generally significantly less expensive to install a bikeway as part of a resurfacing project than to build it as a standalone project. These cost savings accrue for a variety of reasons:

Marking Eradication: Installing a bikeway on an existing street typically requires shifting existing lane markings to create space for the bikeway. Eradication of existing roadway markings is a process that significantly increases the overall cost of remarking a roadway. Additionally, marking eradication leaves visible grooves on the pavement that can be confused for roadway markings under wet or low-light conditions. Marking eradication can also damage the pavement as material is removed from the roadway. Following resurfacing, new pavement presents a blank slate for placing markings where they need to be placed without performing any eradication.



Eradicated lane lines remain visible next to new lane lines on this Road Diet project in Seattle, WA.

Traffic Control: Retrofitting a bikeway requires setting up traffic control to divert traffic around the project area while work is performed. This can be a significant expense as an overall portion of a standalone bikeway project. When a street is resurfaced, traffic control is already accounted for in the resurfacing project and no additional traffic control is needed for adding the bikeway.

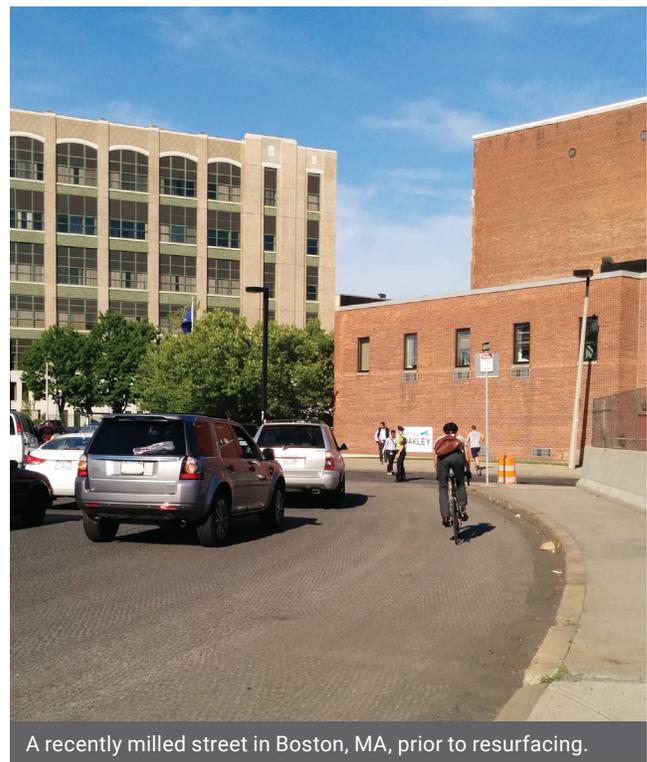
Marking Costs: The cost for pavement marking is typically folded into the overall cost of a street resurfacing and is included in the project budget. On the other hand, marking retrofit bikeways often requires paying for marking materials out of an agency's operating budget. By including a bikeway as part of a resurfacing project, bikeway marking costs can be wrapped into the overall project budget and can make use of State or Federal funds that are being used for the project. Additionally, the types of marking materials available for use is broader when a new surface is being marked than when remarking an existing surface. This can allow agencies to select more durable marking types and elongate the life of the initial bikeway markings before maintenance and remarking is necessary.

Paving Shoulders: Paving shoulders during a resurfacing project is not as simple as extending the new layer of pavement over an existing gravel shoulder. To pave shoulders on mill and overlay projects, additional shoulder preparation work should be completed, and a thicker layer of pavement should be laid on the gravel shoulder than on the existing roadway surface. A better opportunity to pave gravel shoulders occurs when the existing pavement is removed and new pavement for the travel lanes and a full depth paved shoulder is installed.

Typical Costs for Bikeway Development

Implementing bikeways through resurfacing projects is economical and accelerates the development of an interconnected system of bikeways. Another way to express the cost savings is by comparing these costs with the costs of incorporating bikeways by widening roadways. Expanding a street with curb and gutters to include a bikeways is often so expensive that it is rarely considered until a street is reconstructed, if then. Often these streets exist in constrained settings which increases the costs and complexity of expansion. Additionally, storm sewers may need to be moved or modified for new curb and gutter locations and additional costs would be encountered over and above the pavement costs.

As an example, the cost of widening a roadway to add bike lanes can range from \$225,000 to more than \$450,000 (2015 dollars) per mile for both sides of the road, just for grading and pavement. This does not include any real estate purchases or storm sewer relocation costs, and in many cases the full cost for widening a roadway to add bike lanes would be significantly higher than these amounts.



A recently milled street in Boston, MA, prior to resurfacing.



COST EXAMPLE

Four-Lane to Three-Lane Road Diet with Bike Lanes

Table 2 displays construction costs for an example project to add bike lanes through a one mile four-lane to three-lane Road Diet, as a standalone project. Table 3 displays the marginal construction cost to include bike lanes as part of a resurfacing project. These tables include many assumptions, and are only intended to indicate the relative cost savings possible by providing bike lanes during a resurfacing project versus as a standalone project.

Tables 2 and 3 show that the cost for adding bike lanes during a resurfacing project is approximately 40 percent of the cost of adding the lanes as a standalone project. Many communities contacted during the production of the Workbook indicated that their average cost to add bike lanes during a resurfacing project is approximately \$20,000 (2015 dollars) per mile—substantially less than the sample cost figures included in Table 3.

TABLE 2: Estimated cost to add bike lanes to a roadway by reducing four travel lanes to three travel lanes as a standalone project

Add Bike Lanes (4-3 Road Diet, No Resurfacing)					
Item	Unit	Quant.	2015 Est. Unit Cost	Total Cost per Mile	Comment
Eradication	LF	15,000	\$1.50	\$22,500	Assume 3 lines entire length
Bike Lane Lines: Thermoplastic (6")	LF	10,000	\$1.50	\$15,000	Assume 2 solid lines entire length
Travel Lane Lines: Thermoplastic (4")	LF	15,000	\$1.00	\$15,000	Assume two solid lines entire length and two striped lines at 50% coverage entire length
Bike Lane Thermoplastic Pavement Marking Symbol	EA	40	\$300.00	\$12,000	Assume 1 Symbol every 250' each side of road (bike lane)
Bike Lane Sign	EA	20	\$250.00	\$5,000	Assume 1 Sign every 500'
Left-Turn Thermoplastic Pavement Marking Symbol	EA	20	\$300.00	\$6,000	Assume 1 symbol every 250' (Left-Turn arrows)
Lump Sum Items					
Maintenance of Traffic (10%)	LS	1.00	\$7,500	\$7,500	
Subtotal				\$83,000	
20% Contingency				\$17,000	
Total Estimated Cost				\$100,000	

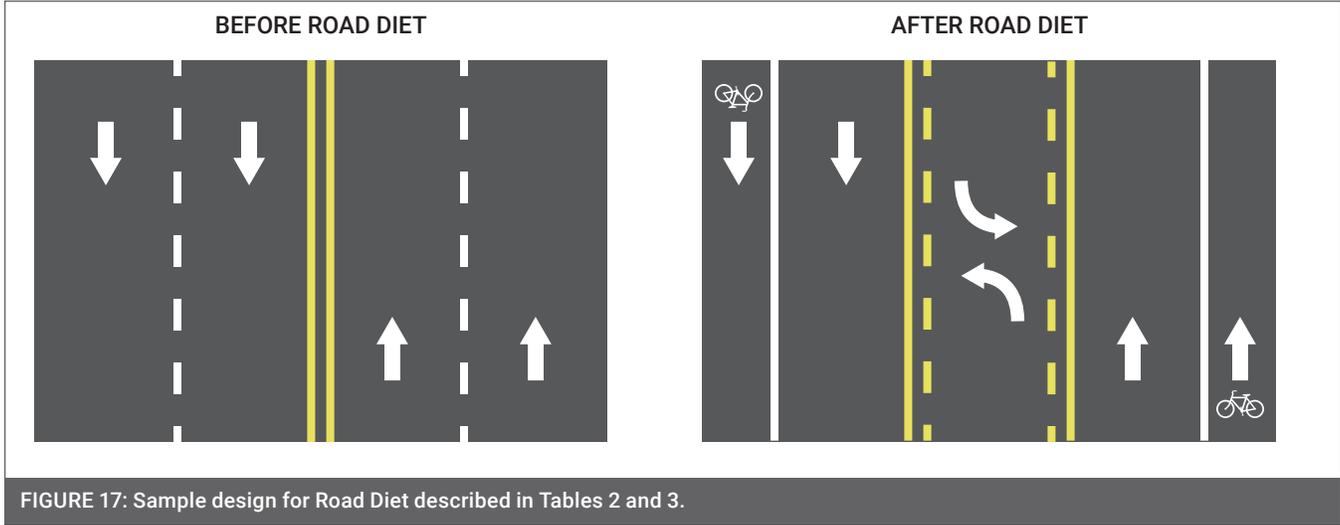


TABLE 3: Estimated cost to add bike lanes to a roadway by reducing four travel lanes to three travel lanes during a resurfacing project

Add Bike Lanes (4-3 Road Diet, Full Resurfacing)					
Item	Unit	Quant.	2015 Est. Unit Cost	Total Cost per Mile	Comment
Eradication	LF	15,000	\$1.50	\$0	Not necessary with resurfacing
Bike Lane Lines: Thermoplastic (6")	LF	10,000	\$1.50	\$15,000	Assume 2 solid lines entire length
Travel Lane Lines: Thermoplastic (4")	LF	15,000	\$1.00	\$0	Included with resurfacing project
Bike Lane Thermoplastic Pavement Marking Symbol	EA	40	\$300.00	\$12,000	Assume 1 Symbol every 250' each side of road (bike lane)
Bike Lane Sign	EA	20	\$250.00	\$5,000	Assume 1 Sign every 500'
Left-Turn Thermoplastic Pavement Marking Symbol	EA	20	\$300.00	\$0	Included with resurfacing project
Lump Sum Items					
Maintenance of Traffic (10%)	LS	1.00	\$3,922	\$0	Included with resurfacing project
Subtotal				\$32,000	
20% Contingency				\$6,400	
Total Estimated Cost				\$38,400	

4.3 | Accommodating Bicycles by Adding Paved Shoulders on Rural Highways

In rural and some suburban areas, paved shoulders serve as excellent bikeways, even if they are not specifically marked for bicycle use. Under most conditions, it is not practical to add paved shoulders as part of resurfacing or restoration projects. In a resurfacing project, only one to three inches of new surface asphalt is laid over an existing pavement or a milled pavement base. This is not thick enough for a new or expanded paved shoulder. Figure 4 displays a typical two-lane roadway with unpaved shoulders. As shown in figure 5, to accommodate a layer of asphalt thick enough to be durable, the unpaved shoulder should be partially excavated and a layer of base asphalt is applied before the final surface is installed on the entire roadway; this requires additional equipment and is relatively labor-intensive. In some scenarios, a jurisdiction with its own road crew and equipment could do this economically as part of a resurfacing or restoration project, particularly for short stretches of roadway.

The best opportunity to add paved shoulders comes during a pavement replacement project where all of the pavement on a roadway is replaced, but the underlying base is not reconstructed. In this case, a full-depth shoulder can be added with the rest of the roadway pavement as shown in figure 6.

There are several advantages to adding paved shoulders during pavement replacement:

Cost/Efficiencies of Scale. During a pavement replacement project, the equipment necessary to excavate the shoulder subbase to the proper depth would already be in use on the project. Additionally, more asphalt or concrete is needed to replace the entire pavement rather than just provide an overlay. This may

result in lower material unit costs due to efficiencies of scale. In a pavement replacement project, the cost for provision of shoulders is a relatively small portion of the cost of the entire project. Table 4 displays the estimated additional cost of paving wide shoulders on one mile of highway.

Longevity. When shoulders are paved as part of pavement replacement project, the underlying base material can be uniform, and the asphalt on the shoulders can be thicker. This will lead to longer-lasting shoulders and smooth shoulders that will not develop reflection cracks due to inconsistencies in the underlying base.



A paved shoulder has been added to Whalen Road in Fitchburg, WI, in uphill directions as part of a resurfacing project; markings have not yet been added.

TABLE 4: Estimated cost per mile of adding paved shoulders as part of a pavement replacement project

Item	Low Cost 4-foot paved shoulders, 4" depth	High Cost 6-foot paved shoulders, 6" to 7.5" depth
Estimated cost of asphalt needed	\$80,000 to \$120,000	\$200,000 to \$300,000

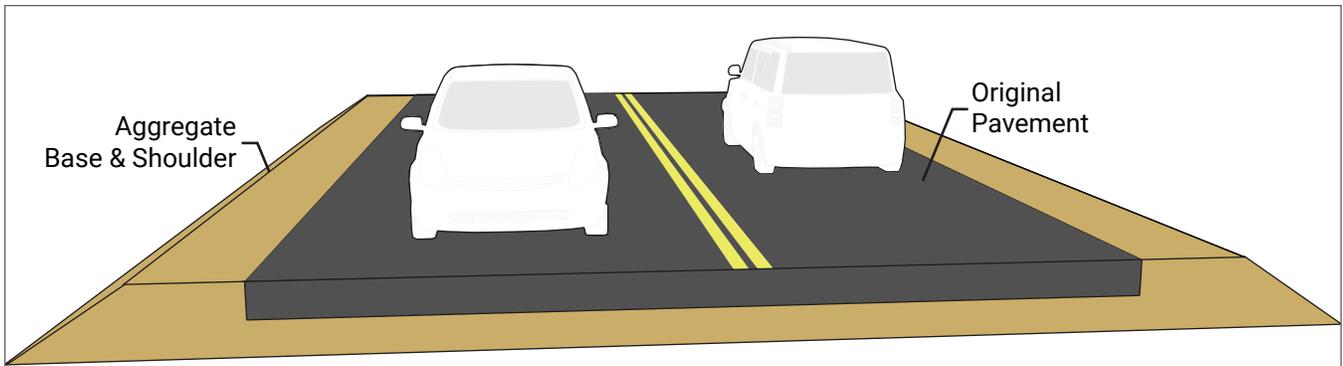


FIGURE 18: Diagram of a two-lane roadway with unpaved shoulders.

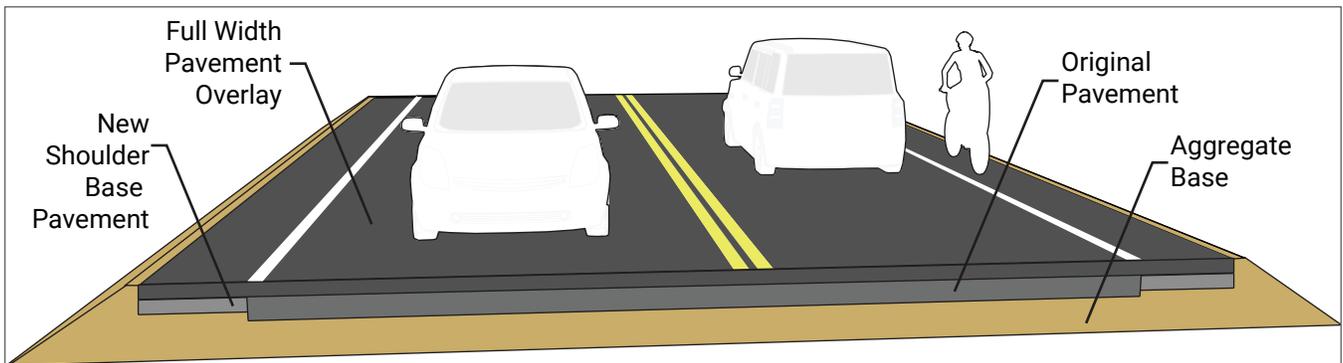


FIGURE 19: Diagram of paving a shoulder during an overlay resurfacing project.

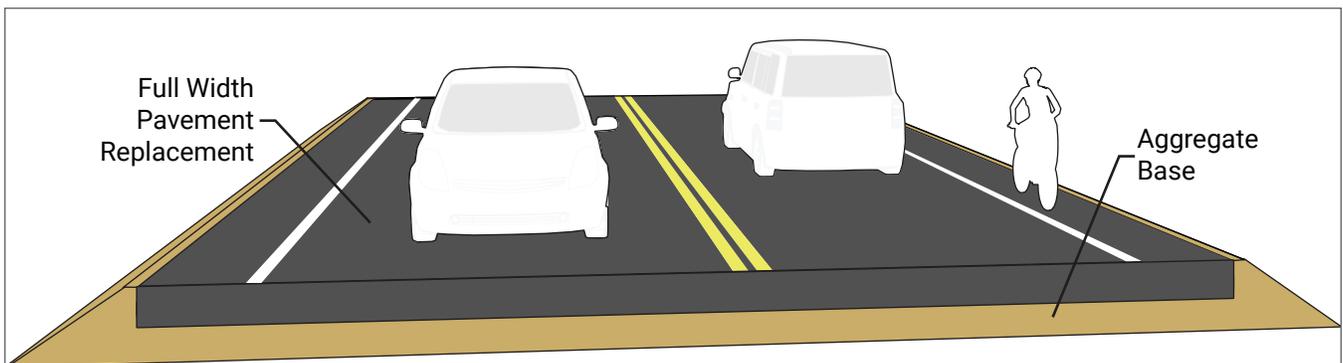


FIGURE 20: Diagram of paving a shoulder during a pavement replacement project.

4.4 | Bikeway Marking Material Considerations

Providing bikeways during a resurfacing project allows the application of marking materials on new pavement. This can result in better marking adhesion to the roadway surface and increased marking longevity. Additionally, installing markings on new pavement may allow for the use of a higher quality and more durable marking material than could be used on older pavement. This section provides an overview of pavement marking materials and some of the benefits and issues surrounding specific marking materials.

Agencies use a variety of different materials for marking bikeways and other roadway markings, including paint (water- or oil-based), epoxy, polyurea, thermoplastic, and preformed marking tape. Often these marking materials are divided into two categories: nondurable (paint) and durable (all other marking materials). Agencies weigh several factors when determining which marking material is most appropriate for particular markings including cost, durability, retroreflectivity, friction coefficient (slipperiness), whether or not the material can be applied using existing agency labor and equipment, and what are the remarking limitations and processes.

Most agencies contacted for this Workbook use thermoplastic for marking bike lane lines, which is

recommended for its longevity. Several agencies use paint initially or will use paint when remarking bike lanes. Epoxy is also used by a number of communities. The communities that use paint typically use city crews and equipment to do the work, while contractors are commonly used to install thermoplastic markings.

Durability and Remarking

The primary maintenance problem with all roadway markings is durability. Heavy traffic volumes, extreme heat during summer months, snow plowing, and the use of abrasives such as sand in the winter all have dramatic impacts on the longevity of pavement markings. Painted markings may need to be reapplied several times a year while other marking materials are more durable, but are also more expensive. In cold weather climates where the roads are salted and sanded, the abrasiveness of these materials will cause more rapid deterioration of the markings. Agencies researched for this Workbook stated that snowplows often damage thermoplastic markings. Several agencies have recessed thermoplastic markings to decrease the likelihood of snowplow damage, but this is expensive; other communities have stopped using thermoplastic markings in part because of this concern.

An issue with thermoplastic markings and some preformed marking tapes is that they sometimes become more slippery with wear, which is an issue



Neil Kopper, City of Austin, TX

New markings are applied to South Lamar Boulevard in Austin, TX.

for bicyclists. Manufacturers of these materials have taken steps to improve the friction coefficient of their materials, but slippery markings may make it necessary to replace the markings even though the retroreflectivity may still be adequate.

Epoxy markings involve a two-part system using a mixture of two bonding components. Epoxy application requires specialized equipment to assure proper blending of the two components and successful application of the markings. In some States, only a handful of private vendors have the equipment necessary for this application which should be a consideration for maintenance for bike lanes.

All marking materials can be applied to new pavement following a resurfacing project. However, remarking over existing durable markings can be problematic. Successful use of preformed thermoplastic relies on applying the material to a dry, clean surface. Sandblasting of pavement is normally required to remove existing materials before reapplying epoxy or thermoplastic markings. Additionally, some epoxies have a relatively long cure time (up to 45 minutes depending on ambient conditions), which requires restricting traffic movements in the work area.

Marking Material Comparison

Table 5 displays characteristics of four common roadway marking materials. Because marking material and labor costs vary widely across the country, costs are only provided on a relative scale from “low” to “high.” Material lifespans are strongly impacted by the volume of traffic passing over the marking and the use of snowplows and abrasives such as salt or sand on

streets. In general, bike lane markings on lower volume roadways with few crossings in temperate climate last much longer than bike lane markings on busy arterials with numerous crossings and long, snowy winters.

The complexity of marking materials and their use is apparent, however, based on focus groups and interviews, agencies appear relatively comfortable with their approaches to markings. The following recommendations are universal to nearly every marking program:

- Use a durable marking for bikeways at the time of repaving using funding from the construction budget for the project.
- To promote a longer lifespan when using paint, a “high build grade” is recommended with glass beads for retroreflectivity.

Sustainability

Agencies implementing bike network improvements during resurfacing projects are strongly encouraged to consider sustainable and low impact development (LID) concepts by looking for opportunities to incorporate environmentally friendly best practices in their system planning, project planning, design, construction, operations, and maintenance activities. Such practices include but are not limited to green infrastructure and recycled material. The FHWA’s INVEST (Infrastructure Voluntary Evaluation Sustainability Tool), is a web-based self-evaluation tool to help transportation agencies integrate sustainability into their programs and projects:

<https://www.sustainablehighways.org>.

TABLE 5: Relative comparison of marking materials based on cost, lifespan, and retroreflectivity.

Material	Initial Relative Cost \$ =Low \$\$\$ \$ =High	Lifespan (months)	Retroreflectivity ● =Low ●●● =High
Paint	\$	3 – 24	●
Epoxy Paint	\$ \$	24 – 48	● ●
Thermoplastic (sprayed)	\$ \$ \$	48 – 72*	● ●
Preformed Tape	\$ \$ \$ \$	36 – 96*	● ● ●

Note: Estimates based on 2014 comparative costs.^{7,8}

* Thermoplastic and tape have shortened lifespans in snowy areas where they are often damaged by snowplows.

4.5 | Bikeway Marking Considerations

This section details considerations when selecting bikeway marking materials.

Life-Cycle Costs

Unit costs for marking materials vary considerably across the country. Given the durability issues previously discussed, life-cycle costs are an essential consideration for any agency. A National Cooperative Highway Research Program (NCHRP) Synthesis 306: *Long-Term Pavement Marking Practices* provides cost comparisons and a life-cycle cost table. In general, thermoplastics provide a usable life of two to three times that of paint for long lines, however, costs average almost five times that of paint. Thus, when life-cycle cost was calculated, paint was half the cost of thermoplastic. It is important to note that costs and durability ranged significantly in this study. There is a clear trade-off between the durability of thermoplastic and the lower cost of paint. Communities that use paint to mark bike lanes often must repaint them every year, whereas thermoplastic markings typically last two to three years.

Agencies should perform life-cycle cost analysis for different materials based on their local product costs,

labor costs, the cost of diverting traffic, and real-world observations of product lifespans, given local maintenance conditions.

Traffic

Traffic has a significant impact on the longevity of roadway markings—the more traffic markings are exposed to, the more quickly they wear and need replacing. Frequently repainting markings in high-traffic areas incurs traffic control costs that agencies should take into account. Products that may be more expensive up front may be less expensive over time if they need to be replaced less frequently.

Equipment and Labor

Costs are dramatically affected by the availability of equipment and labor. For instance, if thermoplastic equipment has already been purchased by an agency and in-house labor is trained and available for marking, costs will be minimized. For communities that want to avoid investment in such equipment, some applications of markings are relatively inexpensive, such as applying cold or heated tapes. Another equipment issue is whether a community commonly uses snowplows. Thermoplastic and preformed tape may not be appropriate in areas using snowplows unless the markings are inlaid in the pavement, which protected the material from the plow blade.



Randy Dittberner, Virginia DOT

Lawyers Road in Fairfax County, VA underwent a four-lane to three-lane Road Diet which allowed the addition of bike lanes.



Bike Lanes were added to Portage Road in Madison, WI, by clearly defining overly wide shared travel/parking lanes.

Pavement Type and Previous Markings

Pavement type—*asphalt or concrete*—and the previous marking material must be considered when selecting a new marking material. The vast majority of resurfacing projects are asphalt projects, but an existing pavement could be replaced with concrete.

In new applications on asphalt surfaces, agencies typically use inlay tapes, hot-applied thermoplastics, or high build grade applications of paint-based markings in order for the markings to be visible. Markings generally last longer on asphalt than concrete, especially for a new surface. Tapes can be rolled in when new asphalt is being rolled; this improves the durability of the tapes during snow plowing. For new concrete surfaces, marking applications are more limited and preparation of the surface is more important than with asphalt surfaces. Grooving concrete for inlay tapes is very expensive, but provides superior durability during the winter months where snowplows are in use.

When it is time to remark a bikeway, one benefit of using paint is that the new paint can be sprayed on top of the old paint after the surface is cleaned and any flaking paint is removed. Liquid thermoplastics can generally be placed over worn paint or liquid-applied thermoplastic markings. However, liquid

thermoplastics cannot be easily applied over tapes unless at least 70 to 90 percent of the former marking material has been removed through grinding or sand blasting. Similarly, tapes cannot be reapplied over existing tapes unless a minimum of 80 to 95 percent of the former tape has been removed through grinding or sand blasting. The performance of marking material is significantly affected by application over existing materials; it is important that agencies communicate with vendors about this issue.

There is a certain economy of scale and simplicity for agencies to use one marking type for all applications, but it may make sense to combine marking types. Traffic volumes, pavement surfacing type, initial marking material, cost, and availability of application equipment will be factors in determining the mix of treatments for marking bikeways. Agencies need to be flexible in their approaches to reapplying bikeway markings. For example, it may be cost effective to use paint for remarking bike lanes on lower volume streets, while expensive preformed thermoplastic material will be used for other long lines in higher volume locations even when the old material has to be ground off for reapplication. In general, the communities contacted while preparing this Workbook were largely settled on the marking materials that they use, and are unlikely to change materials without significant reason to do so.



CASE STUDY

State and Local Coordination

Virginia DOT & Fairfax County, VA

Fairfax County, VA, is just west of Washington, DC, and is the most populous jurisdiction in the metropolitan area. The county ranges from highly urbanized, to suburban, to rural. The Virginia Department of Transportation (VDOT) owns and maintains nearly all of the public roads in Fairfax County. VDOT and Fairfax County coordinate on a process to include bicycle facilities where possible on resurfacing projects. Following provides a brief description of the process throughout a typical year:

Fall

- VDOT produces a list of resurfacing projects for completion the following year; the list is shared with Fairfax County staff.

Winter

- County staff review the list to identify possible opportunities to add or improve bicyclist accommodations, using the 2014 Countywide Bicycle Master Plan as a key resource.
- Field work is performed by County staff to determine if streets included in the bike plan can accommodate bicycle facilities as part of the resurfacing project.
- Conceptual plans are developed for potential projects by County staff, VDOT staff, or consultants.
- Ongoing coordination between VDOT and County staff about the inclusion of bicycle facilities on selected projects as well as any changes to the resurfacing list.

Spring

- Public outreach meetings are held by County staff about projects identified for possible bicycle facilities as part of a resurfacing project.
- County and VDOT staff, in consultation with elected officials, make a decision about whether to implement each project based on public comments received during and after the outreach meetings.

- Final plans are developed for each project, incorporating public input, and delivered to VDOT's paving contractors.

Summer

- Resurfacing is performed and bicycle facilities are installed by VDOT's contractors.

According to Randy Dittberner of VDOT, "The best time to change the markings is when a street is paved, and VDOT is glad to work with counties to add bike facilities to help develop a cycling network. In many cases the new marking patterns help improve safety for all users and are very low cost, which makes the process a big win all around."

In 2015, the use of Lane Diets, Road Diets, and space reallocation allowed the installation of bicycle facilities as a part of 20 different resurfacing projects throughout Fairfax County.



Courthouse Road in Fairfax County, VA, was resurfaced with bike lanes by Virginia DOT with design input from Fairfax County staff.

Randy Dittberner, Virginia DOT



5

Conclusion

This resource for *Incorporating On-Road Bicycle Networks into Resurfacing Projects* provides recommendations for how roadway agencies can integrate bikeways into their resurfacing program. By installing bicycle facilities during resurfacing projects, agencies can create connected networks of bicycle facilities in an efficient and cost-effective manner.

FHWA supports a flexible approach to roadway design that can allow the installation of bicycle facilities on many roadways when they are resurfaced. There should be continued education targeted at design practitioners to emphasize the flexibility that exists within current design guidance, and the strong support of FHWA for using this flexibility to create connected bicycle networks everywhere. These connected bicycle networks provide increased transportation options, enhance access to jobs, schools, and essential services, and increase the utility of our existing transportation network. Providing bicycle facilities when resurfacing roadways is one tool that cities, counties, and States can use to expand their bikeway networks.

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For More Information

Visit http://www.fhwa.dot.gov/environment/bicycle_pedestrian/

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