Maintenance of the Active Transportation Elements of Complete Streets

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Maintenance of the Active Transportation Elements of Complete Streets

by

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16. ABSTRACT

This report surveys the maintenance practices of public entities responsible for active transportation elements of complete streets, with particular emphasis on those elements that serve bicyclists, including both bike lanes and bicycle tracks that are adjacent to roadways and separate shared-use paths. The report identifies the challenges and opportunities associated with designing these facilities for long-term maintenance, describes how leading state and local jurisdictions currently maintain them, and highlights emerging best practices among complete streets leaders. This report does not make recommendations for specific maintenance practices that WSDOT should adopt but does recommend a process for developing maintenance guidance for these facilities.

Developing consistent levels of service and treatment intervals for all the different aspects of active transportation facility maintenance is an emerging practice area. In most areas, maintenance for bicycle and pedestrian pathways is driven by complaints rather than defined service guidance. WSDOT could undertake an iterative process to shift from the existing complaint-based approach to maintenance to a standardized system for maintenance that suits the particular needs and requirements of Washingtonians, given available resources. If funding allows, there is evidence from other jurisdictions to support adopting dedicated teams with dedicated equipment to maintain active transportation facilities. These dedicated teams make active transportation facilities their first priority, which highway maintenance staff cannot do. Bike lanes and pathways often require different equipment and techniques than highway maintenance. Dedicated teams for active transportation facilities can bring the specialization and focus necessary to generate better maintenance outcomes.

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Glossary

Active transportation: Using a human-scale and often human-powered means of travel to get from one place to another; includes walking, bicycling, using a mobility assistive or adaptive device such as a wheelchair or walker, using micromobility devices, and using electrically assisted devices such as e-bikes and e-foot scooters.

Caltrans: California Department of Transportation

Bicycling or Cycling: The use by people of various forms of bicycles and tricycles, both those propelled solely by human power and electrically assisted bicycles/tricycles

CDOT: Connecticut Department of Transportation

Complete streets: An approach to planning, designing, building, operating, and maintaining streets that enables safe access for all people who need to use them, including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities.

Complete Streets: When capitalized in this report, this phrase refers to the legislation and policies adopted by WSDOT to support complete streets.

DDOT: District (Washington, D.C.) Department of Transportation

Facility: In this document the term facility generally refers to transportation-related infrastructure such as bike lanes, sidewalks, trails, and roads.

FHWA: Federal Highway Administration

MassDOT: Massachusetts Department of Transportation

MnDOT: Minnesota Department of Transportation

MDOT: Montana Department of Transportation

NCDOT: North Carolina Department of Transportation

NPRA: Norwegian Public Roads Administration

ODOT: Oregon Department of Transportation

Pedestrian: As defined under Washington state law, “Any person afoot or using a wheelchair (manual or motorized) or a means of conveyance propelled by human power other than a bicycle”. (RCW 46.04.400)

Separation elements: Bollards, flexposts, curbs, vegetated medians, and other vertical (i.e., raised) features that create separation between motor vehicles and bicyclists.

Trails and shared-use paths: A public way constructed primarily for and open to people walking, bicycling, or rolling (and in some locations, riding horses); does not include sidewalks. For certain purposes under Washington state law, a trail/path can also include a widened highway shoulder where that has been made part of a trails plan. WSDOT calls all of these facilities “shared use paths,” but the label varies nationally and non-Washington findings in the report retain some use of “trails.”

USDOT: United States Department of Transportation

WABA: Washington (D.C.) Area Bicyclist Association

WSDOT: Washington State Department of Transportation

Executive Summary

This report surveys the maintenance practices of public entities responsible for active transportation elements of complete streets, with particular emphasis on those elements that serve bicyclists, including both bike lanes and bicycle tracks that are adjacent to roadways and separate shared-use paths. The report identifies the challenges and opportunities associated with designing these facilities for long-term maintenance, describes how leading state and local jurisdictions currently maintain them, and highlights emerging best practices among complete streets leaders. This report does not make recommendations for specific maintenance practices that WSDOT should adopt but does recommend a process for developing maintenance guidance for these facilities.

This report was developed by the University of Washington Sustainable Transportation Lab (UW STL) under contract to the Washington State Department of Transportation (WSDOT). The team kicked off the project by conducting two listening sessions with WSDOT maintenance staff to gain insights into the specific challenges and opportunities associated with maintaining active transportation facilities in Western and Eastern Washington. The research team then reviewed the existing literature on the maintenance of active transportation facilities, including academic papers, industry reports, and government documents. The team also interviewed subject matter experts from other states, cities, and provinces in North America and abroad. This combination of staff interviews, literature review, and expert interviews informed the report's findings and recommendations.

The report is organized into ten sections, each addressing a key topic identified by WSDOT maintenance staff:

1. Design strategies to ensure durability and low maintenance costs
2. Winter maintenance
3. Removal of sand, leaves, and other debris
4. Resurfacing and striping
5. Vegetation and drainage
6. Separation elements, signage, and lighting
7. Equipment
8. Use of dedicated teams
9. Planning and budgeting metrics
10. Coordination among jurisdictions

Maintenance practices for the active transportation elements of complete streets in North America have not been standardized to the degree that they have for roads and highways. Bike lanes, pathways, and pedestrian zones create unique maintenance requirements that are often mismatched to the staff and equipment that most state departments of transportation (DOTs) currently have in place. Developing defined levels of service and treatment intervals for all the different aspects of active transportation facility maintenance is an emerging practice area among those jurisdictions that have embraced complete streets. In most areas, maintenance for bicycle and pedestrian pathways is driven by complaints rather than defined service guidance. Communities with strong commitments to maintaining well-functioning bike lanes and pathways have developed maintenance guidance that varies with the local climate, facility type, and utilization by pedestrians and bicyclists.

The level of maintenance on public facilities reflects the priorities, funding levels, and physical infrastructure of a particular community. The research for this report did not reveal any specific maintenance performance measures that are an obvious fit for the active transportation facilities across the state of Washington. The research did, however, show the methods that WSDOT could adopt to set maintenance guidelines that would appropriately serve communities statewide. The jurisdictions that have adopted policies vary the maintenance they provide with the facility type, the useful life of the materials selected for that facility, the level of utilization by bicyclists and pedestrians, the climate zone, and the amount of snow or debris that accumulates.

WSDOT could undertake an iterative process to shift from the existing complaint-based approach to maintenance to a standardized system for maintenance that suits the particular needs and requirements of Washingtonians, given the available resources. If funding allows, there is evidence from other jurisdictions to support adopting dedicated teams with dedicated equipment to maintain active transportation facilities. These dedicated teams make active transportation facilities their first priority, which highway maintenance staff cannot do. Bike lanes and pathways often require different equipment and techniques than highway maintenance. Dedicated teams for active transportation facilities can bring the specialization and focus necessary to generate better maintenance outcomes.

Introduction and Overview

The Washington State Department of Transportation (WSDOT) recognizes that an inclusive and effective transportation system provides for the needs of all users, not just those in motor vehicles. This commitment is reflected in WSDOT's vision that all travelers have access to a safe, sustainable and integrated multimodal transportation system. In RCW 47.04.035, the Washington state legislature stated that "the department must incorporate the principles of complete streets with facilities that provide street access with all users in mind, including pedestrians, bicyclists, and public transportation users."[1] This law is a paradigm shift in roadway design and maintenance, emphasizing the creation of streets that are safe, comfortable, and accessible for everyone, regardless of their mode of transportation. Whether someone is walking, biking, rolling, taking transit, or driving, complete streets are designed to accommodate them.

This approach is not just about adding bike lanes or sidewalks; it entails a holistic integration of various transportation modes. It means considering the needs of pedestrians at crossings, accommodating people with disabilities, providing safe and convenient access to transit stops, and creating dedicated spaces for bicyclists, including those that are physically separated from vehicular traffic. With the Complete Streets law and supporting policies, WSDOT aims to promote active transportation, reduce reliance on single-occupancy vehicles, and create more livable and sustainable communities.

This report addresses the maintenance of active transportation elements of complete streets, with particular emphasis on those elements that serve bicyclists, including both the bike lanes and cycle tracks that are adjacent to roadways and separate shared-use paths. We focus on bicycling facilities because the maintenance of sidewalks and signage and signals for pedestrians is better established in the literature and in everyday practice. The report identifies the challenges and opportunities associated with designing bicycle and multi-use pathways for long-term maintenance, describes how leading state and local jurisdictions currently maintain them, and explains what is emerging as best practices among complete street leaders.

This report was developed by the University of Washington Sustainable Transportation Lab (UW STL) under contract to the WSDOT. The team conducted two listening sessions with WSDOT maintenance staff at the start of the project to gain insights into the specific challenges and opportunities associated with maintaining active transportation facilities in Washington state. The team then reviewed the existing literature on the maintenance of active transportation facilities, including academic papers, industry reports, and government documents. In addition, the team also interviewed subject matter experts from other jurisdictions to learn about best practices and innovative approaches to maintenance. This combination of maintenance staff

[1] https://wsdot.wa.gov/construction-planning/complete-streets

insights, literature review, and expert interviews informed the report's findings and recommendations.

Research Questions

The objectives of this study, as outlined in the Scope of Work between UW STL and WSDOT, were to answer the following questions:

- What are the most critical active transportation facility questions facing WSDOT maintenance staff?
- How do maintenance considerations affect design and materials selection in high quality active transportation facilities, particularly for vertical elements?
- What active transportation facility design best practices can simplify maintenance?
- What are best practices regarding levels of service for maintenance activities and the desired asset conditions for active transportation facilities?
- What are the equipment and labor needs for active transportation facility maintenance?

This report focuses especially on the fourth and fifth questions, namely, best practice levels of service for maintenance activities and the desired asset conditions for active transportation facilities, and the equipment and labor needed to maintain them.

Listening Sessions with WSDOT Maintenance Staff

To kick off the project, members of the WSDOT complete streets maintenance project team and UW STL convened two on-line video conferences with WSDOT maintenance staff to discuss their views on maintaining the non-automotive elements of complete streets. Appendix A contains a list of the roles of the attendees. The discussion addressed the problems and challenges associated with maintaining sidewalks and pathways over four seasons and what information and resources could help address these issues.

From the set of issues raised by WSDOT maintenance staff during those meetings, UW STL developed a set of research topics to guide the review of the published literature and conversations with national and international practice leaders. The project team organized the research and results regarding Complete Street maintenance under the following key topics identified by WSDOT staff:

1. Design strategies to ensure durability and low maintenance costs
2. Winter maintenance
3. Removal of sand, leaves, and other debris

4. Resurfacing and striping
5. Vegetation and drainage
6. Separation elements, signage, and lighting
7. Equipment
8. Use of dedicated teams
9. Planning and budgeting metrics
10. Coordination among jurisdictions

Published Sources on Complete Streets Maintenance

UW STL queried WSDOT staff, other researchers, and complete streets practice leaders in design and engineering firms and in state and local departments of transportation (DOTs) about reports and studies that they would recommend to inform decision-making on maintenance practices. We reviewed scores of documents and identified the following documents as especially relevant for WSDOT as it develops its maintenance program for pedestrian and bicycle facilities:

- A Guide for Maintaining Pedestrian Facilities for Enhanced Safety (FHWA, 2013)
- Best Practices for Bicycle Trail Pavement Construction and Maintenance in Illinois (2012)
- Best Practices for Cycle Path Winter Maintenance Processes (Karhula, 2014)
- Bicycle Facility Design Manual (MnDOT)
- Bikeway Selection Guide (FHWA 2019)
- Designing and Implementing Maintainable Pedestrian Safety Countermeasures (Veneziano et al., 2023)
- Guide to Bicycle Facilities (AASHTO, 2012)
- Shared Use Paths Inventory and Detailed Maintenance Plan (MDOT, 2019)
- Winter Maintenance Resource Guide (Toole Design Group, 2024).

A complete list of the documents that UW STL reviewed is included in this report's bibliography.

Expert Interviews

Interviews were held with maintenance representatives from across the U.S. and internationally. Please see Appendix B for the interview questions. The research team identified the experts at consultancies, state and local DOTs, and international counterparts, from published reports, through WSDOT project team recommendations, and from professional contacts of the UW STL team. The team contacted potential interviewees at 37 organizations, making at least three attempts by email to schedule a one-hour interview.

In total, 16 interviews were conducted with the following organizations:

- AECOM
- Caltrans
- City of Philadelphia
- City of Kitchener, Ontario, Canada
- City of North Vancouver, British Columbia, Canada
- Connecticut DOT
- Massachusetts DOT
- Minnesota DOT
- Montana DOT
- North Carolina DOT
- Norwegian Public Roads Administration
- Oregon DOT
- Waka Kotahi, New Zealand
- Washington, D.C. DOT
- Watt Consulting Group, Victoria, BC, Canada.

During the interview sessions, the representatives were asked questions about each of the key topics identified from the listening sessions with WSDOT maintenance staff. Key findings from these interviews and the literature review are presented by topic area in the following section.

Maintenance Practice Among Adopters of Complete Streets

1. Design Strategies to Ensure Durability & Low Maintenance Costs

WSDOT Maintenance Perspectives

WSDOT maintenance staff identified several design-related challenges that affect the maintenance of active transportation facilities:

- Lack of design consideration for snow removal on trails and paths, especially over bridges
- Occasions of poor drainage for paths
- Encroaching vegetation adjacent to pathways
- Features of active transportation facilities such as green box paints or plastic bollards that deteriorate and fail quickly in comparison to highway features
- Highway equipment that is often too big and heavy for trail maintenance activities such as plowing, striping, and sweeping
- Lighting on pathways that can be difficult to maintain
- The emergence of new designs to discourage encampments[2].

Published Reports

A comprehensive review of the optimal design and engineering of streets, sidewalks, pathways, intersections, and bridges and their active transportation features was well beyond the scope of this report. Indeed, WSDOT's own design manual runs to more than 1,300 pages[3]. Nevertheless, the core elements of good design and engineering practice for highways certainly apply to active transportation elements:

- Engage maintenance staff in the development of project design alternatives.
- Choose longer lasting, higher quality materials and designs whenever practical.

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[2] https://wsdot.wa.gov/sites/default/files/2024-05/Public-Health-Homeless-Encampments-Report-April2024.pdf

[3] https://wsdot.wa.gov/engineering-standards/all-manuals-and-standards/manuals/design-manual

- Consider lifecycle costs, including annual maintenance in design and material selection.
- Consider the environmental and user benefits, including safety relative to the costs of the design alternatives.

The Federal Highway Administration's (FHWA's) guide for maintaining pedestrian facilities notes that in the U.S., concrete tends to be the most common form of sidewalk pavement material because of its durability and long lifespan (40-80 years)[4]. Asphalt pavement has a shorter lifespan than cement concrete but is significantly cheaper to install, making it less commonly used for sidewalks but the main material for shared-use paths. FHWA recommends building pedestrian facilities with maintenance in mind to reduce maintenance costs. Sidewalks and paths with proper base courses and pavement thickness will last longer, and finished surfaces with slight cross-slopes will improve slip resistance by more easily shedding water. Certain complete streets elements, such as bike ramps and median crossing islands, can cause issues during snow events. These elements are often depressed and close to gutters where ice can accumulate. Localized depressions also create major maintenance problems by being collection points for debris and fallen leaves, which can quickly plug drainage systems during periods of heavy rain. Therefore, additional attention is necessary to control these issues in areas where snow, ice, and leaves accumulate.

Interviews with Complete Streets Practice Leaders

- **Involvement in design processes:** Several interviewees from state DOT maintenance teams reported that they were not included in initial planning and design processes for complete streets or active transportation facilities. More typically, these teams are left to determine how to conduct maintenance during or after construction. Planners and designers often use manuals, such as the AASHTO Green Book, which contributes to greater standardization in design. Several interviewees reported that the design process often does not directly account for maintenance costs or durability, particularly for newer complete streets treatments. However, that is starting to change among complete streets practice leaders. For example, Minnesota DOT (MnDOT) is currently working to include maintenance perspectives before 30 percent design. Oregon DOT's (ODOT's) design guidance includes Maintenance as a key stakeholder, involved in the kick-off and initiation phase of project design.[5] During the design phase, ODOT evaluates the available equipment in the project's region and uses that information to inform some design decisions. The level of involvement may vary with the field knowledge of the maintenance staff that participate.

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[4] FHWA. (2013). *A Guide for Maintaining Pedestrian Facilities for Enhanced Safety*. https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa13037.pdf

[5] OregonDOT. (2004). *Maintenance Guide, Ch. 4: Maintenance Role in ODOT Project Delivery Process*.

- **Design for snow season:** Snow storage is a common challenge during winter. Dedicated areas for snow storage and drainage for bike lanes/shared-use paths should be part of any new facility design. Connecticut DOT noted that certain active transportation designs can be more difficult to maintain during the winter months as well. In particular, splitter islands and medians require specialized equipment for snow clearing and typically are cleared a day or two later. The City of Kitchener, Ontario, in Canada puts asphalt bike lanes directly adjacent to concrete sidewalks at an elevated grade next to its arterials. The two paths together create a three-meter width that is amenable to plowing with a pickup truck, which substantially lowers the cost relative to using smaller equipment. By creating a shared, deep crushed rock base for the adjacent pathways, the city has not had differential settling despite the material differences between cement concrete and asphalt pavement.

- **Separation elements:** Many active transportation designs incorporate the use of vertical elements to delineate and protect bike lanes.

    - Plastic flexposts are relatively inexpensive but not especially durable.

    - Curbs made of concrete and other materials provide greater separation but have higher installation costs.

    - Fixed bollards at the entrances to bikeways will prevent cars from using them but can create obstructions for bicyclists.

- **Paint and striping:** Road and path markings made with paint and striping can be an effective design strategy that designates pedestrian and bicyclist areas, but they are subject to rapid wearing. Newer pavement markings, such as green bicycle boxes delineated with paint, are difficult to maintain as they can wear off within two years. In California, the City of Sacramento has used methyl methacrylate (MMA) for its road markings, which have lasted for five years without any maintenance needs.

- **Path design and materials:** Interviewees identified asphalt pavement as a commonly used, durable, and low-cost pathway material. Some jurisdictions in North Carolina have also used crushed gravel and asphalt in coastal areas because of the lower replacement costs when washouts occur.

- **Vegetation management:** Hardscaping keeps maintenance costs low when it comes to landscaping. Adding vegetation will generally increase maintenance costs and frequency. Philadelphia designs a six-foot clearing to the path edge so riders can see people approaching the pathway and to avoid encroachment by vegetation. The city also uses a wide variety of design elements, from highly maintained shrubbery in city parks to more natural landscaping along riversides.

- **Cost evaluation:** Oregon DOT is starting to evaluate designs on the basis of maintenance costs, but there is no policy yet. The design acceptance phase considers costs, but mostly through anecdotes about what costs could be expected with certain features.

Key Findings

- Develop specific plans for where to put snow when clearing pathways.
- Plan pathway design and snow removal equipment together. The labor costs of snow clearing per lane mile can vary by a factor of ten, depending on the pathway width and the equipment used—and wider lanes can be cheaper to maintain.
- Provide for adequate drainage for all components of the proposed facility, and attend to how road runoff interacts with pathways.
- Involve maintenance personnel early in the design process.
- Consider lifecycle costs—including annual maintenance—in design and material selection.

2. Winter Maintenance

WSDOT Maintenance Perspectives

WSDOT maintenance teams highlighted several challenges specific to snow removal. A primary concern was the limited space available to store plowed snow. Unlike wider highways with shoulders, active transportation facilities tend to lack designated snow storage areas. This leads to difficulties in finding appropriate locations to pile snow without obstructing pedestrian or bicycle traffic. Workers also noted that snow removal on highways is the top priority during the winter to ensure that emergency vehicles can respond to community needs and to allow people and goods to move about and support the local economy. Given these priorities, other activities such as clearing bike lanes are often addressed only in response to complaints. The lack of comprehensive snow removal plans specifically tailored to complete streets creates confusion for crews, who are left to come up with their own solutions.

Published Reports

Preventative measures, such as pre-treating and anti-icing, have proved beneficial in comparison to reactive measures (e.g., de-icing).[6] Pre-treating or anti-icing surfaces can lead to quicker melting, lower melting temperatures, faster salt penetration, and reduced salt loss—saving money and reducing salt-attributed environmental impacts.

[6] Toole Design Group. (2024). *2024 Winter Maintenance Resource Guide*.

Several factors play a role in how quickly after a snowfall the snow and ice are removed from shared use paths:[7]

- Bicyclist and pedestrian demand for the facility: Facilities in high-use areas (e.g., urban settings) see demand throughout the winter and so require more attention than those in remote areas.
- Presence of nearby facilities: If there are no nearby parallel paths to act as an alternative facility, year-round maintenance becomes more important.
- Community support: Some neighborhoods, bicyclists, and pedestrians may want popular facilities to be cleared of snow and ice, evidenced by several maintenance requests for the same facility.
- Connectivity: Paths can be prioritized on the basis of the number of neighborhoods and commercial areas they connect to; the more areas, the more valuable the path is for year-round use.

In 2014, Tampere University of Technology conducted a study on winter bicycle path maintenance best practices across Denmark, Sweden, and Finland.[8] All three countries categorize bicycle path networks between higher and lower priorities. Prioritized networks connect the most important business areas, schools, and city centers to residential areas—thus the maintenance requirements are higher than on other bicycle paths. In Umea, Sweden, prioritized bicycle paths have snow accumulation limits of 4 cm. The city of Copenhagen, Denmark, similarly has snow limits of 2-3 cm. This process ensures access for bicyclists while placing less burden on maintenance crews than lower accumulation limits. Umea also utilizes GPS trackers to continuously monitor maintenance activities and identify problematic areas. Linkoping, Sweden, features a stricter limit of 1 cm on its prioritized bicycle path network and 3 cm on general bicycle paths and roads alike. Linkoping also sets time limits for snow clearing: within six hours after snowfall stops in the city center and within three hours for the public transportation center. Oulu, Finland, sets its snow limits at 2 cm for prioritized bicycle paths and 3 cm during snowfall, whereas the snow limits for lower priority areas are 3 cm and 5 cm during snowfall. Like Umea, Oulu also tracks maintenance activities using GPS trackers.

The province of Ontario, Canada, also established snow clearing standards for bike lanes owned by the municipalities within the province. High-use bicycle facilities must be cleared

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[7] FHWA. (2013). *A Guide for Maintaining Pedestrian Facilities for Enhanced Safety*. https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa13037.pdf

[8] Karhula, K. & Tampere University of Technology. (2014). *Best practices for cycle path winter maintenance processes*.

within eight hours after 2.5 cm of snowfall; lower-use facilities that receive 8 cm or more of snow must be cleared within 24 hours.[9]

A study of complete streets elements for MnDOT noted that bulb outs and short radius curbs that are often an element of pedestrian-friendly sidewalks and bikeways can impede the use of conventional plowing on the adjacent streets. Curbs with a shorter corner radius require smaller plowing equipment.[10]

Interviews

The interviews revealed significant variation in the nature, and even the existence, of guidance for snow removal. Across the interviewed jurisdictions, we found a range of practices, from complaint-based clearing of snow-covered paths to well-defined guidance.

At one end of the spectrum, there are inconsistent schedules for snow removal on active transportation facilities, and maintenance personnel respond to complaints. MassDOT, MnDOT, and DDOT reported that on-street facilities are cleared along with the main road, but there is no guidance for separated or off-street paths. Because of this, the agencies monitor complaints and address issues on a need basis. A subset of highly used bikeways has strong advocates who push for timely snow removal so that it becomes routine. Similarly, NCDOT reported only the general principle that neighborhood facilities tend to be the lowest priority, addressed only after main road segments have been cleared of snow. For DDOT, prioritization is based on equipment availability and the suitability of equipment for different paths, although it aims to develop a more standardized prioritization list.

Formalizing winter maintenance guidance can require significant effort. The City of Philadelphia recently worked with a consultant to develop a three-tiered set of maintenance guidelines However, the city does not yet have a clear classification scheme for its trail network to implement those standards. Similarly, the City of North Vancouver has not set specific maintenance standards but takes a proactive approach to winter maintenance by salting networks ahead of cold weather. While this treatment makes the paths more corrosive to bicycle parts, the benefits of maintaining clear pavement are worth the tradeoff in this community. In some parts of Norway, by contrast, jurisdictions plow the trails but keep a layer of snow on the trails and expect bicyclists to have studded tires in the winter.

The City of Kitchener, Ontario, in Canada provides a model for a fully developed set of winter maintenance standards in North America. As noted in the preceding section, the provincial government of Ontario developed minimum maintenance standards (MMS) five years ago. The MMS set objective time and accumulation-based standards for snow removal and for other maintenance of bike lanes. Similarly, the Norwegian Public Roads Administration's 2014

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[9] https://www.ontario.ca/laws/regulation/020239

[10] Veneziano, John Shaw, and Jonathan Wood, "Designing and Implementing Maintainable Pedestrian Safety Countermeasures."

handbook for standardized maintenance outlines maintenance classes for each pathway, and the maintenance class determines the frequency of maintenance required.

Site-specific factors and constraints may need to be considered when jurisdictions establish standards for a given facility. For example, Connecticut DOT noted that on some bridges, sidewalks are separated by parapets; this makes it difficult to store snow anywhere other than on that sidewalk. Weight restrictions on these bridges can limit the size of equipment that can be used as well. Kitchener's 3-meter-wide combined pedestrian and bike paths can be cleared with pickup truck snowplows; these allow for much faster clearing and therefore lower labor costs than the use of skid steers and shovels that would be required on narrower sidewalks and pathways. These experiences also reinforce the importance of considering maintenance issues during the design phase of a project.

Key Findings

- Complete streets practice leaders have moved away from reactive, complaint-based snow removal to a guidelines-based system that prescribes the maximum time after a snowfall by which the snow must be cleared. Jurisdictions have adopted different criteria for snow clearing that vary by the amount of snowfall, the time interval allowed for clearing, the facility type, and path utilization by bicyclists and pedestrians or utilization of the adjacent general roadway facility.

- Snow removal equipment and snow storage strategies must be tailored to the particular design of the active transportation elements. Some active transportation facility designs and equipment pairings have substantially lower snow removal costs than others. Costs are lower with designs that accommodate wider equipment and when active transportation facilities accommodate standard fleet equipment that can be used throughout the network.

3. Removal of Sand, Leaves, and Other Debris

WSDOT Maintenance Perspectives

Discussions with WSDOT maintenance teams on sweeping and debris removal revealed several challenges related to the size and design of complete streets facilities. Typical width lane sweepers for roads are too large to navigate narrower pathways and bike lanes, hindering any cleaning. Staff reported that smaller sweepers are currently difficult to acquire. Some workers noted attempts to increase collaboration between design and maintenance teams, with discussions aimed at incorporating sweeping and debris removal considerations into the design phase of projects. However, maintenance practices still rely on complaints rather than following a consistent, proactive schedule. One attendee noted that they are exploring an "adopt a trail" program to encourage community involvement in litter pick-up.

Published Reports

In the maintenance guide from FHWA[11], certain active transportation facilities were highlighted as requiring special attention related to sweeping. Curb ramps and low sections of sidewalks and paths produce areas where dirt can settle. When this dirt becomes wet, it creates slippery conditions for users who are vulnerable to falls from loose material on pathways. On all types of paths, broken glass and other debris are troublesome for bicyclists, wheelchair users, and others, and are often unpredictable. Jurisdictions can monitor trail conditions by relying on reports from a path's users or by having staff or contractors conduct regular inspections. FHWA recommends sweeping pathways, or at least closely observing them for sweeping needs, on a weekly or bi-weekly basis in areas with high utilization.

Interviews

Many DOTs take a proactive approach to clearing debris from active transportation pathways. For example, MDOT, DDOT, MassDOT, and Caltrans sweep bike lanes in alignment with the roads' fixed schedules. Still, complaints drive more frequent maintenance because of the concerns posed by sand and debris collecting in bike lanes. MassDOT reported that heavily trafficked bike lanes are swept twice as often as adjacent roads as a result of complaints. DDOT has implemented a 311 system in which calls are systematically assigned to the relevant maintenance department, improving its overall response time. The City of Philadelphia also noted that advocacy groups drive much of its pathway maintenance.

Inspections also influence maintenance schedules in Philadelphia, Ontario, Norway, and New Zealand. In Philadelphia, the frequency and service of inspections are at the discretion of the area manager. In Norway, maintenance contractors meet with NPRA monthly to inspect the work they've completed. Waka Kotahi used to rely on monthly sweeping but has switched to performance-based contracts, using random audits to drive maintenance. This change has reportedly led to more adverse behaviors, with maintenance being delayed until necessary rather than being performed proactively.

Sweeping schedules also vary seasonally. NCDOT reported challenges during the hurricane season since crews are limited and roads receive priority. MDOT also reported that while it relies on roadway schedules for regular maintenance, it makes a pointed effort in the spring and summer to clear extra debris. Similarly, Caltrans advocated for adjusted sweeping schedules based on the season. The City of Kitchener conducts a citywide "blitz" of all paths in spring and fall to clear sand and debris.

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[11] FHWA. (2013). *A Guide for Maintaining Pedestrian Facilities for Enhanced Safety*. https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa13037.pdf

Key Findings

- Complete streets practice leaders combine regularly scheduled sweeping and clearing with unscheduled clearing in response to agency inspections or user complaints.

- The interval for scheduled clearing can range from six months (spring and fall) to weekly, depending on the type of facility and the level of utilization

- Many active transportation elements require specialized sweeping equipment that is sized for the narrower widths of pathways. This equipment can be planned and budgeted for during the design phase.

4. Resurfacing and Striping

WSDOT Maintenance Perspectives

A significant challenge identified by maintenance workers was the lack of appropriate equipment for re-striping bike lanes and pathways. Standard striping equipment is designed for larger roadways, not the narrower dimensions of off-road pathways, making it difficult to apply any kind of striping.

WSDOT maintenance staff during the listening sessions did not raise any particular issues about the current need for and frequency of repairing broken and uneven pathways beyond noting that maintenance of active transportation elements is typically a lower priority for them than maintaining the roadways. However, staff engaged with designing and monitoring active transportation facilities have subsequently reported examples of critical pavement repair needs in WSDOT's Northwest region that presented challenges for maintenance staff.

Published Reports

FHWA[12] identified four repair techniques for paths and sidewalk pavements that typically last between one and five years, although some of these measures can become permanent fixes in certain circumstances.

- Patching: a common and effective repair when small sidewalk corners have broken off or minor gaps have formed between panels. Choosing asphalt as a patching (or wedging) material for concrete sidewalks is seldom done in areas of the U.S. where high sustained temperatures make the materials incompatible.

- Wedging: entails the placement of an asphalt or concrete filler placed in advance of a displaced section of a sidewalk or shared-use path to provide a ramp. Wedging is often

[12] FHWA. (2013). *A Guide for Maintaining Pedestrian Facilities for Enhanced Safety*. https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa13037.pdf

applied where there is a formed or saw joint in the pedestrian walkway that has created a tripping hazard.

- Grinding and horizontal cutting: a set of treatments used for heaved concrete sidewalk and path segments. Americans with Disabilities Act (ADA) draft guidelines allow grinding and cutting displacements of between .25 in. and .5 in. On paths and sidewalks, root pop-ups and minor heaves are often ground down.

- Mudjacking: involves lifting concrete slabs back to their original positions by injecting concrete “mud” material under the sidewalk. Holes can be drilled through the slab to inject grout and raise the concrete slab or fill the voids underneath. The cause of the sunken settlement should be identified and addressed before mudjacking to prevent the mud from being inadvertently pushed into utilities such as storm sewers.

A significant maintenance issue with crosswalk markings is durability. Painted crosswalks may have to be re-striped several times a year, depending on the volume of traffic and severity of the local weather. Other marking materials, such as thermoplastic, are more durable but also more expensive. In cold weather climates, the abrasiveness of salt and sand mixtures causes more rapid deterioration of the markings. Equipment such as snowplows often damages thermoplastic markings as well, unless these markings are recessed.

FHWA recommends regular inspections by volunteers, staff, or contractors to identify issues and establish priorities. The tools that many agencies use to record the condition of pavement on roadways do not work on narrower biking and walking paths. Communities in Iowa and elsewhere have developed modified e-bikes to collect data on concrete and pavement conditions on these pathways.[13]

Table 1 outlines the characteristics of the four repair techniques for paths and sidewalk pavements identified by FHWA.

[13] See https://dmampo.org/project/data-bike/ and https://www.route-fifty.com/infrastructure/2024/07/rough-ride-data-bikes-chart-condition-bike-paths-more-cities/397981/.

Table 1. Maintenance measures for pathway/sidewalk resurfacing

Maintenance Measure	Material	Durability	Characteristics	FHWA Recommendations
Patching	Asphalt, but sometimes a concrete-type filler (mortar or composite material consisting of vinyl or epoxy mix).	Varies significantly based on repair method, material, type of hole/crack, and stresses placed on the sidewalk/path. The patching can be expected to last less than several years.	Hot mix asphalt is easy to use but has a short life. Cold mix asphalt has an even shorter life and is suitable only for a winter to spring seasonal repair. Mortar or concrete-type fillers last longer but are time-consuming to apply.	Recommended as a quick response measure when tripping hazards are reported and only until a permanent repair can be made.
Wedging	Asphalt, but sometimes a concrete-type filler. Cold mix asphalt can be a temporary repair (it often lacks adequate bonding).	Varies depending on the repair method, material, how well the asphalt material is compressed, any continued shifting of the sidewalk pieces, and winter maintenance (e.g., plows running over the wedges).	Asphalt is easy to use as a wedge filler but has a short life. It will also be noticeable because of the mismatch in color and texture with concrete. Cold mix asphalt has an even shorter life and is suitable only for a winter to spring seasonal repair. Mortar or concrete-type fillers last longer but are time-consuming to apply.	Recommended as a quick response measure when tripping hazards are reported. A more permanent repair should be made later in the season or within a year, depending on the slope and integrity of the wedge.
Grinding and horizontal cutting	Most commonly concrete, but asphalt is an option.	Repairs done appropriately and expertly can be considered permanent fixes.	A horizontal cut leaves the appearance of a very smooth cut surface with exposed aggregate. Grinding leaves a rougher texture and shows the grinding pattern used.	Suitable as either a temporary or permanent repair based on the size and angle of displacement. When displacement is between ¼ to ½ in., the measure is considered permanent. Cross-slopes should be maintained at

Maintenance Measure	Material	Durability	Characteristics	FHWA Recommendations
				2% or less. Maintenance teams should make sure not to grind past the minimum recommended thickness.
Mudjacking	Only done to concrete sidewalks and paths. The concrete type “mud” mixture is injected under the concrete slabs.	Repairs done appropriately and expertly can be considered permanent fixes.	Small holes are detectable after mudjacking; otherwise, the repair allows the treated section to match adjacent and untouched sections.	Mudjacking is relatively expensive, nearly matching the cost of sidewalk replacement. Older sidewalk segments should be avoided unless a modest cost can be achieved. Recommended as a permanent measure when the sidewalk has sunk by over ½ in. and the panel can be lifted back into place with the correct side slope.

Maintaining the conspicuity or retroreflectivity of these markings can also be a problem. It is important for crosswalk markings to retain their retroreflectivity during evenings when pedestrians are still active. Retroreflectivity can be accomplished by adding beads or other retroreflective material to the marking material. The reflective quality of the material of crosswalks is often lost first as a result of wear. Table 2 shows a comparison of different crosswalk marking measures. The Manual on Uniform Traffic Control Devices (MUTCD) 11th Edition, published in December 2023, establishes standards for pavement marking retroreflectivity in Section 3A.05

Table 2. Crosswalk marking comparisons (adapted from FHWA, 2013)

Crosswalk Marking Type	Cost	Lifespan	Retroreflectivity
Paint	Lowest	3-24 months	Lowest
Epoxy Paint	Lower	24-48 months	Medium
Thermoplastic (sprayed)	Higher	48-72 months	Medium
Pre-Formed Tape	Highest	36-96 months	Highest

Interviews

Most state DOTs reported that repairing, resurfacing, and striping of active transportation facilities occurs at the same time as the regularly scheduled treatment of the adjacent road or highway. Staff from MassDOT, MnDOT, MDOT, and ODOT each reported that bike facilities were resurfaced on the schedule of the related roadway. If bike facilities had lane stripes, then the road restriping schedule also applied to the pathways. NCDOT, the City of North Vancouver, and the City of Philadelphia described a regular inspection process that flagged cycle facilities for needing repairs that occurred outside of the regular maintenance cycle.

NCDOT has been subject to lawsuits from bicyclists who were injured when they crashed while riding on cracked pathways. As a result, repairing damaged paths has become a priority for the state, even though by state law, cities and towns are supposed to maintain bike paths within their jurisdictions. State crews do a condition assessment and consider all facilities in a given location. Bike paths do not necessarily wear on the same schedule as roads; in particular,

asphalt in pathways may fail before the related roadway if the roadway is made of concrete. The City of Kitchener also noted the emerging issue of potholes on active transportation pathways. Since many micromobility devices have smaller wheels, pothole filling may become a higher priority in the future.

MassDOT, CDOT, CalTrans, and the City of Philadelphia reported experimentation with striping paints and bike box markings to determine which materials are best suited to longer lasting pavement markings. Standard paint wears out very quickly whereas thermoplastic paints have the longest lifespan, as shown in Table 2. The City of Seattle has conducted extensive research on durability and has concluded that preformed thermoplastic panels are the most durable (as well as being easy to install and highly skid resistant), according to conversations with WSDOT design staff.

Key Findings

- Complete streets practice leaders combine regularly scheduled resurfacing and restriping of active transportation facilities with rapid response to cracks and bumps that are identified by inspections or user complaints when they increase the crash risk for bicyclists.

- Materials selection for striping, pavement marking, and nighttime visibility is an area of active experimentation, with practice leaders moving toward materials with greater durability.

5. Vegetation Management

WSDOT Maintenance Perspectives

WSDOT maintenance teams primarily rely on complaints to address overgrown vegetation. Participants in the WSDOT listening sessions emphasized the importance of selecting appropriate plant species during design and construction to minimize future maintenance needs. Invasive species and fast-growing shrubs near pathways were identified as particular issues. Additionally, encroaching tree roots cause damage to pavement on shared-use paths. Some specific species, such as cottonwoods, require more maintenance than others because they drop limbs, fall over, and cause root heaving and settlement. In some cases, regular maintenance involves the active removal of this type of vegetation when it is present. Maintenance personnel also noted that regular vegetation maintenance could help deter encampments by reducing the attractiveness of certain areas.

Published Reports

Adjacent vegetation provides shade for complete streets users, carbon dioxide reduction, increased property value, stormwater control, and visual appeal.[14] However, vegetation growth can encroach on sidewalks and pathways and can create debris on surfaces, necessitating regular maintenance.

City ordinances often provide guidance for tree planting and vegetation management responsibilities. For example, Seattle, Spokane, and Bellevue all have published specific guidance on tree species, size, and care for planting strips next to sidewalks and roadways.[15]

FHWA recommends that municipalities establish and enforce these ordinances to ensure proper maintenance. Toward this effort, some communities rely on the expert opinion of arborists to aid in maintenance directions. FHWA highlights several methods for maintaining vegetation growth: edging, limb trimming, and vegetation debris management. Edging cuts back certain types of grasses and soil from the outer edges of the sidewalk. Limb trimming refers to the trimming of branches or other vegetative objects that protrude into the sidewalks or paths. FHWA specifies that objects should not protrude more than 4 inches into the path and that there should be a vertical clearance of 80+ inches on pedestrian paths and 92+ inches on shared-use paths. Vegetation debris management is related to clearing paths and sidewalks of leaves and other vegetative debris, typically with rakes and leaf blowers.

The City of Arlington, Washington, developed a complete streets plan[16] that includes recommendations for vegetation (mainly tree) management. Near on-street parking, plants should be located at least 3 feet from the curb (away from the door zone) or 3 feet behind the sidewalk. Arlington also uses mulch rings around trees along boulevards because they can retain soil moisture, cool the soil, prevent compaction, and therefore reduce maintenance needs. The City of Arlington maintains at least a 7-ft clearance above sidewalks and a 14-ft clearance above streets. The types of trees planted also play a role in maintenance considerations. Trees with ascending or vase-shaped canopies help alleviate the need for pruning better than broad or pyramidal form trees. Prioritizing trees with strong, undamaged leaders (i.e., the central stem) helps ensure appropriate forms, whereas trees with damaged or split leaders tend to grow horizontally and require more maintenance. The City of Arlington's

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[14] FHWA. (2013). *A Guide for Maintaining Pedestrian Facilities for Enhanced Safety*. https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa13037.pdf

[15] https://www.seattle.gov/trees/planting-and-care/street-trees,

https://my.spokanecity.org/urbanforestry/planting-and-care/, and

https://bellevuewa.gov/city-government/departments/parks/nature-and-environment/street-trees-arterial-landscapes

[16] Heaton, N., Peterson, L., Hayes, M., Lohse, K., de Orvañanos, K. K., Almdale, B., Kachadoorian, C., Leighton, A., Ochiltree, B., & Talich, C. (2018). *Arlington Complete Streets Plan*.

standard maintenance of trees consists of structural pruning—typically every three to five years depending on the type of tree)—and regular inspection by a certified arborist every one to two years.

Interviews

In North Carolina, vegetation management is primarily handled at the division level, since local crews have the most accurate information on when it becomes a priority. The City of Philadelphia also pushes decisions about vegetation management down to area managers, who serve everything from parks with formal gardens that are trimmed and weeded weekly to trails through wooded areas that are trimmed in one seasonal pass. This decentralized approach leads to considerable variation in maintaining plantings, often resulting in staff clearing vegetation only as it encroaches on the right-of-way and when users complain. Similarly, in D.C., the Urban Forestry Division of DDOT handles maintenance related to vegetation management. DDOT contracts with the Washington Area Bicyclist Association (WABA) to manage a Trail Ranger program in which WABA employees systematically patrol pathways, do basic maintenance to keep a passable corridor 2-ft past the trail edge and 10-ft tall as much as practicable, and report maintenance issues that include significant encroaching vegetation. Their maintenance schedule is primarily driven by issues identified by Trail Rangers as well as user complaints, and 311 calls are routed to the appropriate division on the basis of the type of maintenance activity. Montana DOT noted that vegetation management tends to be a seasonal activity, and most maintenance occurs during the summer months.

Key Findings

- Complete streets practice leaders combine regularly scheduled clearing of brush, weeds, and branches with rapid response to encroachment by plants that are identified by inspections or user complaints when they block use and user sightlines of the right-of-way.

- Many cities have adopted guidelines for tree selection and care along streets and pathways to ensure healthy trees, support cost-effective maintenance, and limit pavement damage from root growth.

6. Separation Elements, Lighting, and Signage

WSDOT Maintenance Perspectives

The WSDOT maintenance groups identified several challenges related to maintaining flexposts, lane markers, lighting, and signage. They expressed concerns about the number of light fixtures on complete streets facilities. These numerous fixtures translate into time and resources dedicated solely to their upkeep and repair, especially on routes that can’t be surveyed in motor vehicles. The maintenance staff also discussed the recurring issue of damaged flexposts and explained that they are frequently knocked down and permanently damaged by vehicles. This necessitates additional resources for repair or replacement.

Published Reports

Separation elements: MassDOT recommends conducting regular inspections for damaged or displaced flexposts in street buffers and keeping a supply of flexposts for quick replacement when needed. During winter seasons with significant snow, these vertical objects may be removed to aid snow clearing efforts if safety can be ensured without vertical separators.[17]

Signage**:** Signage is instrumental for wayfinding and regulations but also vulnerable to wear and vandalism. Maintenance teams should check regularly for wear and graffiti and should replace signs as needed. The City of Tacoma recommends replacing or conducting regular maintenance of signage every one to three years.[18] Newer signs are designed to be highly visible but can over time lose retroreflectivity and become more difficult to see at night. AASHTO recommends regular inspections of signs for wear and readability during nighttime hours and replacing any defective or damaged signs as soon as possible.[19] The City of Madison's Public Works makes similar recommendations and adds that repaired or temporary corrections could be used until permanent repairs are ready.[20]

Lighting: The City of Madison's Public Works maintenance program includes schedules for routine repair and replacement of luminaires and fixtures for illuminated signs.

Interviews

In practice, both DDOT and NCDOT rely on complaints to manage lighting repair for active transportation maintenance. In D.C., the 311 calls from contracted Trail Rangers and trail users are directed to the Street Light Division, which is responsible for maintenance as requested. In Minnesota, lighting maintenance for pathways is handled along with the roadway's lighting schedule. The workforce and equipment that MnDOT has are set up to do everything from the truck. Separated/protected lanes mean that the crew must get out of the truck, making lighting replacement more difficult to handle. MnDOT works with local partners and encourages them to come out to take care of these types of elements, but there is no schedule for when they check and repair the vertical elements on pathways.

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[17] MassDOT. (2015). *Separated Bike Lane Planning & Design Guide: Maintenance*. https://www.mass.gov/doc/chapter-7-maintenance/download

[18] City of Tacoma. (2010). *Tacoma Mobility Master Plan: Bicycle and Pedestrian Design Guidelines*. https://cms.cityoftacoma.org/Planning/MoMaP/MoMaPDesignGuidelines_PublicReviewDraft.pdf

[19] AASHTO. (2012). *Guide to Bicycle Facilities, 4th Ed., Ch 7: Maintenance and Operations*.

[20] City of Madison Public Works. (2017). *Bicycle Facilities Maintenance Program*.

Key Findings

- As with trees and vegetation, most of the existing practice leaders primarily rely on user complaints to identify the separation elements, lighting, and signage that need replacement, combined with some program of regular inspections and service

- Choosing the best materials and designs for separation elements, lighting, and bike lane delineation is an active area of experimentation, with a trend toward more durable features. Newer durable designs include poured concrete curbs and bolted wheel stops. Practice leaders also avoid using fixed bollards at path entrances because of the risk of bicyclists crashing into them.

7. Equipment Used

WSDOT Maintenance Perspectives

During the listening sessions with WSDOT, maintenance workers highlighted significant challenges in maintaining bike lanes and pathways because of a mismatch between their existing equipment and the smaller size of these facilities. Maintenance crews primarily work with large equipment designed for highways, which makes tasks such as sweeping, striping, and snow removal difficult or even impossible on narrower sidewalks and shared-use paths, particularly on bridges. The maintenance teams specifically mentioned the lack of appropriately sized sweepers and striping equipment, struggling to find space to pile snow without resorting to loaders, and the overall inadequacy of current vehicles for navigating these new, smaller areas. The general sentiment was a lack of clarity on how to properly maintain complete streets facilities because of the limitations of their current equipment.

Published Reports

The Toole Design Group has highlighted several types of equipment that can be used for winter maintenance: plows, blowers, and brooms.[21] Plows can push aside snow of 2 in. or more to clear roads and paths. Blowers and brooms tend to be attached to smaller pieces of equipment than plows. Blowers can move large amounts of snow (6 inches or more) even when compacted. Brooms can be used after plows or blowers to achieve bare pavement surfaces. Salt and sand spreaders can also be attached to these same vehicles. Some equipment that is typically used in the summer (e.g., mowers) can be repurposed in winter by adding a blower attachment.

FHWA notes that communities often use power-driven, rotating brooms mounted on tractors or skid-steers to keep sidewalks clear.[22] However, snow material is difficult to control and tends to

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[21] Toole Design Group. (2024). *2024 Winter Maintenance Resource Guide*.

[22] FHWA. (2013). *A Guide for Maintaining Pedestrian Facilities for Enhanced Safety*. https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa13037.pdf

just get pushed to another location. For material such as soil or sand, this style of sweeping may be preferred, since the material can be returned to areas (e.g., tree buffers) where it was initially situated. Other efforts include using leaf blowers to collect debris into a pile or windrow to be swept up later.

In a report on pedestrian safety countermeasures[23], Veneziano and colleagues highlighted several maintenance-related best practices case studies across the U.S. and Canada. In Willmar, Minnesota, the city uses several Trackless model MT tractors equipped with 5-ft blade or snow blower attachments to remove snow from sidewalks. For bike paths and trails, crews use Bobcat Toolcat vehicles with wide plows, since the paths are 10 ft wide. In Bloomington, Minnesota, nine sidewalk plow machines are used to cover about 250 miles of sidewalks. These machines typically plow two hours after snow events to avoid battling spillovers from street snow plowing. The sidewalk plows are similar to those used by Willmar, since they are tractors with v-plows or blowers. Trackless brand tractors are used over others because of the strong dealer support in the Twin Cities area; these machines require regular maintenance and get replaced every five years. For .5 to 3 in. of snowfall, the nine machines can remove snow from all sidewalks in the city during a 12-hour shift. For 4-8 in. of snowfall, at least 16 hours are needed. For snowfall of 9 in. or more, around 31 hours are needed. Winnipeg, Manitoba, adjusts the size of its fleet based on the distance to be covered during each shift. The city assumes an operating speed of 1 km/h and accounts for the time required to mobilize equipment and get to the plowing location. Sidewalk snow removal equipment has not been as reliable as the snowplows used for roads, so they also size their fleet so that 30 percent of their plows can be out of service at any given time.

Interviews

Standardized Equipment

Some states rely on standard equipment for active transportation maintenance. For example, Massachusetts uses standard highway plows on adjacent painted bike paths. This approach can cause issues, especially for pathways that are too narrow to be maintained by standardized equipment. In Oregon, this leads to a reliance on local municipalities for maintenance. The rationale is that if local municipalities desire these facilities, they must be able to maintain them if ODOT cannot. If the locals are unwilling to maintain the facility, ODOT redesigns it to be compatible with its equipment. Additionally, according to DDOT, the lack of specialized equipment also affects the prioritization of different activities; facilities with adequate equipment receive priority.

Specialized Equipment

Other DOTs have acquired specialized equipment for maintaining active transportation pathways. Connecticut DOT, for instance, has 13 different specialized machines for

[23] Veneziano, D., John Shaw, & Jonathan Wood. (2023). *Designing and Implementing Maintainable Pedestrian Safety Countermeasures*.

maintenance but still finds this insufficient for its current needs (~60 miles of pathways). The demand for maintenance is expected to grow to 100 miles by the end of 2024. Minnesota DOT also relies on specialized equipment for the winter maintenance of active transportation pathways. Additionally, California is preparing a proposal to acquire specialized equipment for complete streets, although the machines must pass compliance checks with the Department of Equipment, presenting another hurdle. One advantage of specialized or smaller vehicles is that they are lighter and better matched to the weight bearing capacity of a shared-use path. Lighting conduit and other utilities buried under trails typically are often lighter duty to reduce trail construction costs and so can be damaged when heavy equipment drives on trails.

Many interviewees noted that specialized equipment can support multiple attachments, making it suitable for year-round operations. Connecticut DOT has six Steiner hydraulic 4WD tractors with power take-off for multiple attachments. These tractors, which feature bolt-on cabs for the operator, are 40 inches wide and weigh around 2,500 lbs., allowing them to work on narrower strips. CTDOT uses these tractors for mowing, debris removal, snow removal, and sweeping. The maintenance crew appreciates their power, especially in heavy snow, although the canvas-style housing does not retain much heat during snowstorms. Additionally, the crews have six Bobcats with bucket loaders and snow blowers, and a 25-year-old TORO Dingo standing machine with attachments.

Minnesota DOT also has several types of equipment for complete streets maintenance. Its teams use an Ariens Mammoth 850, which features a front broom or plow and can apply salt and brine from the rear. This new machine is still being evaluated for effectiveness. Additionally, it has a small John Deere unit 1585 with various attachments, including a blower, broom, bucket, and plow. Another piece of equipment is the Ventrac 4520, which can use either a blower or broom and has an attachable cab enclosure. Figures 1 and 2 show two of these specialized machines. MnDOT's inventory also includes skid steers with brooms, buckets, or blowers, and walk-behind snow blowers. Besides the Ariens Mammoth 850, crews use handheld spray cans for brine application. MnDOT may also consider setting up pickup trucks with plow blades in the future.

In California, one district rents a Multihog machine[24] for narrow areas on bridges. Montana, D.C., and North Vancouver use Toolcats with blower and sweeping attachments for active transportation maintenance. D.C. also uses electric cargo bicycles for its shared-use path team. The City of Seattle has a number of Mathieu enclosed sweepers that can cover a lot of ground and sweep up the debris into a contained loader rather than just sweeping it aside. It has also begun testing eSwingo sweepers that are all-electric[25].

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[24] https://multihog.com/

[25] https://sdotblog.seattle.gov/2023/09/11/were-launching-the-ebroomer-pilot-program-our-first-test-project-to-replace-carbon-emitting-vehicle-fleet-with-zero-emissions-alternatives/

Figure 1. MnDOT's Ariens Mammoth 850

Figure 2. MnDOT's Ventrac 4520

Key Findings

- Complete streets practice leaders have adopted specialized equipment to maintain shared-use pathways, bike lanes, and cycle tracks. Traditional highway maintenance vehicles won't fit or will damage pathways because of their narrow dimensions and light duty construction.

- Practice leaders typically choose equipment from vendors that have a strong local reputation and can provide timely warranty service, spare parts, and equipment support.

- The physical demands on staff while operating smaller equipment that often lacks cabs with heating and air conditioning is substantially different than those while operating typical highway equipment such as snowplows.

8. Use of Dedicated Teams

WSDOT Maintenance Perspectives

Several WSDOT maintenance workers advocated for the creation of dedicated teams specifically for maintaining complete streets facilities. Several potential advantages were discussed. Having a dedicated team would alleviate the pressure on existing maintenance crews, since they are already stretched thin maintaining the existing state highways. Dedicated crews could be equipped with appropriately sized vehicles and tools, allowing them to perform maintenance tasks more efficiently and effectively than with their current equipment. Furthermore, a dedicated team could develop a deeper understanding of the unique maintenance needs of complete streets, fostering a more proactive approach to upkeep and potentially reducing the need for reactive repairs. WSDOT staff believe their priority is maintaining state highways, and they already lack sufficient resources for that assignment.

Published Reports

Veneziano and colleagues' paper on pedestrian countermeasures[26] included a case study with a breakdown of maintenance team personnel. The Public Works department of the City of Willmar, Minnesota, is responsible for about 135 miles of streets and 25 miles of sidewalks, bike paths, and shared-use paths. Willmar has historically experienced between ten and 15 snow events each year that require plowing. Therefore, the Public Works department is staffed by 22 people for snow and ice removal. While 21 personnel are in charge of streets, only one person is dedicated solely to sidewalks and paths. Four others contribute one-half to two-thirds of their shifts to helping clear snow from sidewalks and paths. With this staffing allocation, it typically takes about ten hours to remove snow from the sidewalks after snowstorms and another ten hours to remove the snow from bike and shared-use paths.

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[26] Veneziano, D., John Shaw, & Jonathan Wood. (2023). *Designing and Implementing Maintainable Pedestrian Safety Countermeasures*.

The Toole Design Group noted an innovative partnership in its winter maintenance resource guide (2024). The City of Rochester in New York has employed private contractors to plow snow on its 878 miles of sidewalks. Many of these private contractors are farmers who add v-blade attachments to their orchard tractors. This agreement has provided employment for the farmers during the winter and utilizes equipment that would otherwise be unused during that time of year (Toole Design Group, 2024).

Interviews

The term “dedicated team for active transportation maintenance” carries several meanings, depending on the context. In many towns, it is common for the parks department to maintain trails, the transportation department to maintain streets, and adjacent property owners to maintain sidewalks. Those responsibilities change depending on local ordinances. City staff in Kitchener, Ontario, Philadelphia, Minneapolis, and Washington D.C., report having dedicated teams of city staff that are responsible for clearing and maintaining bike paths. When maintenance staff at state DOTs discuss “dedicated teams,” they can be referring to cities, contractors, and potentially new teams within the state DOT. Mostly, the state maintenance staff would prefer to focus on highways and not add active transportation facilities to their responsibilities.

As a result, many of the DOTs we interviewed support creating dedicated teams within their agency for maintaining active transportation facilities. Caltrans believes a dedicated team would allow them to focus on complete streets without being diverted to other maintenance activities. However, concerns about labor, staff, and equipment present challenges for establishing such a team. Connecticut is also exploring the feasibility of dedicated teams through a subcommittee on complete streets, which is assessing the required funding, labor, and hours needed. This initiative aims to ensure that facilities receive attention during storms and when maintenance is otherwise needed.

In 2021, DDOT made a seven-fold increase in spending to monitor trail conditions and do basic maintenance through a new contract with the Washington Area Bicyclist Association for the dedicated team of D.C. Trail Rangers employed by WABA on the District’s trail system. Increasing the staffing capacity dedicated to inspecting and reporting on maintenance issues significantly improved the completion and timeliness of repairs. Maintenance requests are now often turned around within 48 hours, leading to increased trust from constituents.

In Oregon, the need for dedicated teams varies by location. Metro areas could benefit significantly from having a dedicated team within ODOT, but other parts of Oregon face staffing and equipment shortages. ODOT’s maintenance staff generally believe that additional funding should prioritize roadways, which are already underfunded, rather than creating new funding burdens. For example, in one district, ODOT handles less than 10 miles of separated bikeways, which would not warrant the creation of a dedicated group for maintenance.

State DOTs often hand off maintenance responsibility to local governments. This can lead to variation in maintenance quality. For example, in North Carolina, paths maintained by larger cities are better cared for, as they can perform maintenance sooner and more effectively,

whereas smaller cities don't have any of the necessary staff or equipment. Similarly, in Montana, there are no specific teams for active transportation because of roadway demands, and most bike lanes and paths fall under local jurisdiction.

Minnesota DOT is facing pressure to maintain active transportation facilities at the same level as roadways. It has considered contracting out the work to local governments, but those local governments typically encounter the same labor challenges as the state. In addition, the union opposes outsourcing because active transportation maintenance has historically provided overtime work for maintenance staff.

In Norway, the maintenance activities of state roads have been outsourced since 2003. While this approach works reasonably well because of the limited number of bicycle lanes on state roads, the lack of a dedicated team can lead to prioritizing main roads over bike lanes.

Key Findings

- Larger cities with dedicated crews for maintaining shared-use pathways, bike lanes, and cycle tracks tend to have better levels of active transportation maintenance than state DOTs that lack dedicated resources

- Dedicated teams for pathway maintenance can be amenable to contracting with private enterprises, which is the norm in parts of Europe and New Zealand. Washington, D.C., contracts for some maintenance functions with a local non-profit.

- Dedicated teams can make active transportation facilities their first priority whereas highway maintenance staff cannot. Dedicated teams can bring the specialization, equipment, and focus necessary to generate better maintenance outcomes.

9. Planning and Budgeting Metrics

WSDOT Maintenance Perspectives

During the listening sessions with WSDOT maintenance crews, some participants expressed interest in establishing level of service criteria for different types of complete streets facilities. As it currently stands, maintenance teams tend to take care of paths at the same time as the road where they are adjacent. Otherwise, they wait until they receive complaints. At the same time, there are no means for tracking active transportation maintenance activities separately from general maintenance activities. WSDOT uses a software system called the Highway Activity Tracking System (HATS) to track specific maintenance activities in the field, but it is not currently set up to distinguish between roadway and active transportation maintenance tasks.

Published Reports

The most detailed published estimates identified by the UW STL team come from the Montana DOT. Its most recent shared use paths maintenance plan[27] estimated that the annual maintenance costs of its 180 miles of shared-use paths totals about $660,000. Because of agreements with local agencies, MDT estimated that its responsibility is only $130,000 of that total cost. Most of these costs are attributed to snow removal: $624,000 of $660,000. To project costs, MDT categorizes general maintenance as monitoring and evaluating path conditions, mowing, drain cleaning, sweeping, and snow removal. MDT estimates that general maintenance costs $263.30 per path mile per year while snow removal costs $3,600 per path mile per year. The MDT report breaks these estimates down further:

- Path evaluation: $2.30 per path mile per year
- Mowing: $40 per path mile per year
- Cleaning drainage structures: $51 per path mile per year
- Sweeping: $85 per path mile per sweep, twice a year
- Snow removal: $180 per path mile per removal, 20 times per year.

Montana DOT also provides an estimate for pavement preservation maintenance. In general, the agency recommends crack seals every four years, fog seals every eight years, and pavement overlays every 25 years. Therefore, in its annual cost estimates, one-quarter of all paths are assumed to be crack sealed, one-eighth are assumed to be fog sealed, and one-twenty-fifth will have an overlay. Using these estimates, MDT puts the pavement preservation costs at around $270,000 per year. MDT broke these estimates down further:

- Minor crack sealing: $1,600 per path mile, every four years
- Major crack sealing: $4,800 per path mile, as needed
- Hand patching: $300 per path mile, as needed
- Machine patching: $3,075 per path mile, as needed
- Fog sealing: $1,100 per path mile, every eight years
- Plant mix surfacing overlay: $29,500 per path mile, every 25 years.

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[27] MDT. (2019). *Shared Use Paths Inventory and Detailed Maintenance Plan*. Montana Department of Transportation. https://www.mdt.mt.gov/other/webdata/external/maint/SUP-Maintenance-Plan.pdf

Interviews

Some DOTs and cities rely on unit-based calculations to estimate budgets. For example, the City of Philadelphia builds budgets using cost per acre of park or per mile of trail based on its estimates for labor and equipment costs. Similarly, the City of Kitchener calculates annual maintenance costs by lane kilometer, with different costs for roadways versus off-street pathways. It has found that off-street paths can be three to ten times more expensive than roadways, depending on whether design requires specialized equipment and hand shoveling. Connecticut estimates maintenance costs per square foot for sidewalks but has not established formal costs metrics to inform budget planning.

Other DOTs have databases to track maintenance expenses and hope to integrate these data into future budget-planning. For instance, Caltrans, DDOT, and Oregon all have databases to track historic maintenance costs, which can be used for budget development. However, both Oregon and Caltrans' databases are not granular enough to differentiate between maintenance costs for active transportation facilities and roadways, causing challenges in integrating these data. Connecticut is also working on building a database to document facility dimensions, characteristics, and equipment needs.

Minnesota is currently working on two projects with consultants to define the associated costs for different facilities. One consultant, Toole Design Group, is working to include not only winter maintenance but also summer for activities such as pavement and crack sealing. As of today, the maintenance crews react to complaints. On-street facilities are handled with the roadway, but separated lanes or off-street paths don't have defined approaches.

Montana's current budgeting is based on contracted costs for roadways, using historical costs from its maintenance management. It uses historical data and rates published by the Federal Emergency Management Agency to match equipment costs and then estimate hours.

Key Findings

- Smaller cities tend to have a better handle on the actual unit costs of different maintenance activities on different facility types. This is because the crews and equipment counts are low, and it is relatively easy for the public works manager to add up costs for a given activity such as plowing and divide that number by the appropriate number of lane miles. That's how the City of Kitchener, Ontario, can provide good data on the costs of plowing its different designs of bicycle paths.

- Several state DOTs are interested in better cost accounting to develop planning metrics for maintenance, but those efforts have just begun.

- Unit costs for different maintenance activities vary with the local costs of labor and equipment, the type of facility, and the maintenance guidelines established for those facilities. One jurisdiction's unit costs may prove to be very different from those for the next.

10. Coordination Among Jurisdictions

WSDOT Maintenance Perspectives

WSDOT maintenance workers noted some challenges in coordinating maintenance activities for complete streets facilities with cities and counties. These challenges seemed to stem from a lack of clarity regarding who is responsible for maintaining what or differing priorities for maintaining active transportation assets. While interlocal agreements on maintenance are a typical feature of most state highways that pass through other jurisdictions, maintenance teams are often left to determine responsibilities on a case-by-case basis. Some WSDOT maintenance staff expressed that they would prefer that local jurisdictions take care of complete streets elements, since they are more likely to have the proper equipment and WSDOT staff are already understaffed to maintain the existing highways.

Published Reports

The winter maintenance best practices report by Karhula et al. (2014) described coordination efforts across different cities in Sweden, Finland, and Norway. For example, in Linköping, Sweden, several contractors are awarded for five years at a time and assigned a specific geographical area. A single contractor is also assigned to maintain the prioritized bicycle and pedestrian path networks. This helps ensure uniform quality throughout the routes and allows contractors to acquire the specialized equipment necessary for their specific area. While the contractors decide when to start maintenance activities, they must notify the city beforehand so that city personnel are aware and can share information with residents. The City of Linköping and the contractors meet regularly to discuss any issues that drivers are experiencing.

Interviews

Across the DOTs and cities we interviewed, there was significant variation in the challenges of managing coordination among jurisdictions. Some DOTs have minimal overlap in jurisdictions, others have well-defined agreements for these cases, and some are still working on solutions for special situations. We summarize the most relevant insights below:

North Carolina: In North Carolina, state law dictates that local governments are responsible for maintaining complete streets facilities developed by the state. The NCDOT flags maintenance issues and passes them to the local jurisdiction for action. Larger cities, such as Raleigh and Charlotte, have their own transportation and parks employees who maintain the state's active transportation facilities within city boundaries. However, small cities and counties lack the staff and equipment necessary for proper maintenance, causing the work to revert back to the state. In these cases, NCDOT often ends up completing the maintenance work to avoid increased liability from poor pavement conditions. The lack of local maintenance capacity in smaller jurisdictions sometimes motivates the state DOT to place pathways at the edges of roads, even if better options are available out of the right-of-way. For example, an on-street lane might be built instead of an off-street pathway if the local government cannot or will not take responsibility for maintaining it. Maintenance agreements are also integral to the project development

process, as seen in North Carolina's Great Trails State Plan, which demonstrates effective collaboration across all 100 counties.

Philadelphia: The city has agreements with PennDOT and typically defines maintenance roles early on. However, even the best-defined agreements have flexibility and are subject to interpretation by day-to-day maintenance staff.

Massachusetts: Sidewalk and pathway maintenance is a topic of ongoing discussion and negotiation among jurisdictions and their elected officials. MassDOT highways pass through 348 cities, each with different ordinances and practices regarding the roles of property owners and local governments.

Kitchener, Ontario: In Ontario, agreements for pathways that cross multiple jurisdictions are handled on a case-by-case basis. This can lead to challenges due to differing priorities and budgets.

Caltrans: Caltrans uses delegated maintenance agreements in which the local maintenance teams are reimbursed for the costs of activities (e.g., landscaping, street design repair, bulb-out areas, crosswalks) on state assets. By and large, this approach has worked well for both sides.

Minnesota: MnDOT enters agreements with local agencies, but locals have recently wanted to remove snow and ice responsibilities from routine maintenance agreements. MnDOT has struggled with establishing clear responsibilities and ensuring follow-through with local maintenance. For example, a bridge in the Minneapolis metro area, which spans a park within the City of Brooklyn on one side and a county trail on the other, falls under MnDOT's responsibility. The county on the north end believes it has no responsibility to clear the trail on its side. MnDOT lacks tools to ensure that everyone meets their responsibilities or to track existing agreements and their limits. There is an ongoing discussion about whether to adopt a more devolved model like Wisconsin’s, in which responsibilities are more localized.

Montana: Montana rarely has paths that span multiple jurisdictions, so its maintenance agreements are usually based on the jurisdiction in which the path is located. However, agreements can be inconsistent across jurisdictions. Best practices suggest developing consistent maintenance agreements with local jurisdictions statewide. A particular challenge is that many local ordinances place maintenance responsibility on adjacent landowners, resulting in inconsistent upkeep. Indian reservations in Montana are also seeking more active transportation investments, posing unique challenges for coordinating maintenance activities.

Connecticut: In Connecticut, regular maintenance of on-street bikeways and off-street pathways is typically handled by local municipalities. Service standards are based on the subjective satisfaction of CTDOT and are largely complaint-based and as needed. Best practices include using standard language in all agreements across the state, providing the right equipment to local areas, and offering design standards to clarify requirements. Special facilities are difficult to maintain because they are not covered by standard state guidelines. CTDOT has not

encountered much resistance to having locals take care of maintenance, as the state provides funding for it.

Oregon: In Oregon, Corvallis has a pathway that crosses both state and local jurisdictions, with an agreement outlining obligations and responsibilities. Recently, reaching agreements has become more difficult, primarily because of funding shortages. When cities want to introduce new active transportation designs, ODOT sets out requirements for building them and asks locals to take responsibility for any components beyond that scope. Clear and early communication during project kickoffs has been crucial for successful collaboration, fostering a direct and transparent approach.

Norway: In Norway, the maintenance of public roads involves three jurisdictions: the state, county, and municipal levels. There are many areas where the state is responsible for the road while the municipal government maintains the bike lane. In such cases, it is the responsibility of the contractors to coordinate maintenance activities. However, this can lead to issues such as snow being shuffled back and forth between the road and the bike lane.

Key Findings

- Responsibility for maintaining pathways can reside with the state or province, the county, the city, adjacent property owners, or private contractors for those parties. There is no agreed upon policies for allocating maintenance roles and responsibilities for these facilities in North America.

- Often maintenance agreements for pathways that travel through multiple jurisdictions are worked out through time-consuming negotiations that require frequent updates.

- Maintenance staff on the ground are not always aware of or have access to agreements negotiated by other programs in their organization. In ideal situations, crews from neighboring jurisdictions know each other, understand their own agreements, and do their best to be reasonable while responding to their constituents' priorities.

- Appropriate detail, proactive drafting, direct collaboration with maintenance staff, and practical implementation of maintenance agreements are key to jurisdictional collaboration.

- Most transportation departments at the state, county, and city levels feel financially constrained in their mandate to maintain the roads and would be happy to move responsibility for trail and pathway maintenance to another entity.

Conclusion

Maintenance practices for the active transportation elements of complete streets have not been codified as they have for roads and highways. Bike lanes, pathways, and pedestrian zones create unique maintenance requirements that are often not well suited to the staff and

equipment that most state DOTs already have in place. Developing maintenance levels of service and treatment intervals for all the different aspects of facility maintenance is an emerging practice area among those jurisdictions that have embraced complete streets. In most areas, maintenance for bicycle and pedestrian pathways is driven by complaints rather than defined performance measures. Communities with strong commitments to maintaining well-functioning bike lanes and pathways have developed maintenance guidance that vary with the local climate, facility type, and utilization by pedestrians and bicyclists.

Level of service criteria reflect the priorities, funding levels, and physical infrastructure of a particular community. The research for this report did not reveal any specific maintenance guidance that could be easily applied to active transportation facilities across the state of Washington. The research did, however, show the methods that WSDOT could adopt to set maintenance guidance that would appropriately serve communities statewide.

The first step is to track the costs of current maintenance activities on active transportation facilities. WSDOT has an existing Highway Activity Tracking System (HATS) to document daily maintenance activities in the field and provide a clearer understanding of asset conditions. This system could be modified to differentiate among the active transportation elements in the state highway system to generate cost and performance data to inform the development of maintenance guidance.

Most jurisdictions that adopt policies vary the maintenance they provide with the facility type, the useful life of the materials selected for that facility, the level of utilization by bicyclists and pedestrians, the climate zone, and the amount of snow or debris that accumulates. For example, cities in Ontario, Canada, must clear bike lanes with high utilization within eight hours after a snowfall of 2.5 centimeters.

With data on actual costs for maintenance activities related to active transportation, WSDOT could better estimate the costs of adopting different maintenance standards. Data on actual costs for different facility types would help inform better design decisions. The City of Kitchener, Ontario, noted that the cost of snow removal on narrow paths was ten times the cost of snow removal on paths that could be plowed with a pickup truck with a snow blade. Facility design and material decisions have a large impact on maintenance costs.

WSDOT could undertake an iterative process to shift from the existing complaint-based system to one that applies maintenance guidance that suit the particular needs and requirements of Washington citizens, given the available resources.

The steps to developing such a system include the following:

1. Identify any minimum standards in the Americans with Disabilities Act, the FHWA's Public Right-of-Way Accessibility Guidelines, and existing federal and state policy.

2. Define low, medium, and high service levels for the key maintenance activities related to active transportation facilities in a manner that's consistent with state and federal policy guidance. For example (ordered from low to high),

    a. Clearing 2 in. of snow on pathways within 48, 24, and eight hours

    b. Sweeping sand and debris every 12, six, or two weeks

    c. Cutting back encroaching vegetation every 12, six, or three months.

3. Estimate the costs of adopting the three different service levels in a particular geographic area in coordination with the staff from the area who would be tasked with the work.

4. Engage policymakers and budget developers in selecting appropriate service levels for the maintenance activities on the active transportation assets in that area.

5. Implement the maintenance activities for one budget period.

6. Update the budgeted cost models for maintenance, given the actual personnel and equipment costs in the field.

7. Expand the number of areas with the state that shift from complaint-based to guidelines-based maintenance.

8. Revisit the maintenance performance guidance on a regular basis and update them to reflect greater experience with complete streets maintenance, public preferences, and the agency's fiscal resources.

9. Use data from the actual maintenance experience across the state along with maintenance staff input to inform future designs early in the design process and to improve the efficiency of regular maintenance activities.

If funding allows, there is evidence from other jurisdictions to support adopting dedicated teams with dedicated equipment to maintain active transportation facilities. These dedicated teams make active transportation facilities their first priority, which highway maintenance staff cannot. Bike lanes and pathways often require different equipment and different skills than highway maintenance. Dedicated teams for active transportation facilities can bring the specialization and focus necessary to generate better maintenance outcomes.

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Appendix A - WSDOT Maintenance Listening Session Attendees

Eastern Washington Session (14 staff)

- South Central

    - Maintenance Superintendent
    - Maintenance Superintendent
    - ARA of Maintenance and Operations
    - Assistant Maintenance Superintendent
    - Maintenance Superintendent

- Eastern

    - Eastern Region Maintenance and Operations ARA
    - Eastern Region Maintenance Manager
    - Eastern Region Maintenance Superintendent

- North Central

    - Maintenance Manager
    - Incident Response
    - Maintenance Superintendent
    - Highway Maintenance Supervisor

- Statewide

    - Winter Maintenance and Training Manager
    - Maintenance Accountability Process Team Lead

Western Washington Session (11 staff)

- Northwest

    - Assistance Maintenance Superintendent
    - Maintenance and Operations Manager
    - Assistant Superintendent
    - ARA of Maintenance
    - Maintenance and Operations Superintendent
    - Maintenance and Operations Superintendent
    - Maintenance and operations Superintendent

- Assistant Maintenance and Operations Superintendent

- Southwest

- Maintenance Manager

- Olympic

- Assistant Maintenance Superintendent

- Statewide

- Maintenance Innovation and Operation Manager

Appendix B - Interview Questions on Maintenance of Complete Streets

Ask follow up questions regarding documents

Ask to record sessions and make transcriptions.

1. What design strategies help ensure durability & low maintenance costs?
    a. Do you evaluate construction + maintenance costs for different designs?
    b. Do you have examples of designs or materials that do and don't meet your standards for durability?
2. How does your jurisdiction set priorities & treatment intervals for regular maintenance of:
    a. On-street bikeways
        i. Path clearing
            1. Snow
            2. Other material
        ii. Lighting repair
        iii. Striping
        iv. Resurfacing
        v. Vegetation management
    b. Off-street pathways (if different)
        i. Path clearing
            1. Snow
            2. Other material
        ii. Lighting repair
        iii. Striping
        iv. Resurfacing

v. Vegetation management

3. Do you have service standards for each of the above activities? Do they vary by utilization?

4. What make and model of equipment do you use for:

    a. Snow clearing

    b. Debris removal

    c. Striping

    d. Resurfacing

5. Do you use any planning metrics for calculating maintenance costs per mile or km of pathway for planning and budgeting? Labor hours? Equipment hours? Materials consumption, e.g. snow melting agent?

    a. Can you share any data on these metrics for different facility types?

6. What do you view as the pros and cons of having a dedicated team and equipment for bike lanes and pathways?

7. What do you view as best practices for maintenance of pathways that cross multiple jurisdictions?

    a. What examples of success in this area stand out for you?

    b. Do you have examples of inter-jurisdictional agreements that you think provide a good model for collaboration on trail maintenance?

Appendix C - Interview Participants

All interviews were conducted in spring and summer of 2024. Dates in parenthesis

1. AECOM (3/26)
    a. Derek Chisholm, Associate Vice President
2. Caltrans (4/30)
    a. Vu Nguyen, Chief, Office of Special Programs, Caltrans Division of Maintenance
    b. Delia Aguirre, Complete Streets Coordinator, Office of Special Programs, Caltrans Division of Maintenance
3. City of Philadelphia (4/17)
    a. Josh Bell, Park Manager 2 at Philadelphia Parks and Recreation
4. City of Kitchener, Ontario (4/24)
    a. Barry Cronkite, Director of Transportation Services
5. City of North Vancouver (09/03)
    a. Richard Parker, Supervisor of Engineering, Parks & Environment – Turf, Trails & Cemetery
6. Connecticut DOT (5/17)
    a. Eric Belanger, Transportation Maintenance Manager, Central Maintenance Planning
7. Massachusetts DOT (4/25)
    a. Mark Goldstein, Lead Statewide Snow & Ice Engineer
    b. Scott Wilson, Deputy Chief of Highway Operations and Maintenance
    c. John Gendall, Director of Highway Operations
8. Minnesota DOT (5/1)
    a. Nissa Tupper, Transportation and Public Health Planning Director
    b. Todd Stevens, Twin Cities area, Maintenance Engineer

    c. Jaime Hukriede, Assistant District Engineer for Maintenance in District 3

9. Montana DOT (5/2)

    a. Doug McBroom, Maintenance Operations Manager

10. North Carolina DOT (4/18)

    a. Joe Furstenberg, Complete Streets Program Manager

11. Norwegian Public Roads Administration (6/27)

    a. Torgeir Vaa, Senior Principal Engineering

12. Oregon DOT (6/11)

    a. Brian Morey, District 4 Manager in Corvallis, OR

13. Waka Kotahi, New Zealand (7/11)

    a. Jessica Rattray, Team Leader Safe System, Road Safety

14. Washington DC DOT (7/8)

    a. Michael Alvino, Active Transportation Branch Manager, Planning and Sustainability Division of District Department of Transportation

15. Watt Consulting Group, Victoria BC (6/13)

    a. Andy Kading, Senior Transportation Engineer

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