

Bicycle and Pedestrian Gap Analysis – Final Report

City of Bozeman, Montana

BOZEMAN^{MT}

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HIGH STREET



Contents

Introduction	3
Gap Definition	3
Spot Gaps	4
Linear Gaps	4
Gap Inventory	6
Gap Criteria & Prioritization Methodology	6
Case Study Criteria	7
Case Study Methodologies.....	7
Scoring Methodology	8
Final Criteria & Scoring Metrics	9
Criteria	9
Scoring Metrics	10
Criteria Weights	11
Automated Scoring Tool	12
Prioritized Gaps	12
Conclusion	12

Introduction

Bozeman remains one of the fastest growing cities in the United States. Over the past couple of decades, the City has significantly expanded its network of sidewalks, bikeways, and trails. This has primarily been accomplished through:

- City and Montana Department of Transportation (MDT) roadway reconstructions projects
- City and developer constructed new roadways
- Sidewalks, trails, and parks through new development
- Specific funded projects to expand the trail or bikeway network

While the City's network completeness has improved, there remain gaps in the network that prevent access to many destinations and limit route and modal choice among residents.

This Bicycle and Pedestrian Gap Analysis Project builds upon previous planning efforts by identifying a comprehensive list of gaps and creating a methodology to prioritize them based on each gap's attributes evaluated against a consistent set of evaluation criteria.

This is the final report that summarizes the evolution of the project and is organized into the following sections:

1. Gap Definition
2. Gap Inventory
3. Gap Criteria & Prioritization Methodology
4. Final Criteria & Scoring Metrics
5. Prioritized Projects
6. Conclusion

Gap Definition

Prior to any analysis, a common understanding of the types of gaps and the definitions of each type of gap needed to be created. In July 2024, a memo entitled "Bicycle and Pedestrian Gap Definitions" was submitted with a number of identified gap types and definition. As the project progressed, these types were consolidated into the following:

- **Spot Gap** - Key focal points, such as crossings or intersections that lack appropriate accommodations for comfortable pedestrian or bicycle travel. It should be noted that while any intersection could be improved for comfort or safety, only ones with obvious deficiencies were selected.
- **Linear Gap** - Sections of missing segments of sidewalk, trail, bicycle lane, or shared use path that create gaps between existing built facilities.
 - Linear gaps can be experiential, where the experience is insufficient for the intended purpose, such as a conventional bike lane on a busy high-speed arterial.
 - Linear gaps can also be "planning gaps" where strategic extensions of the network to destinations could also qualify as a gap.

What is a gap?

A gap is a section of missing active transportation facilities between existing built facilities, or extensions thereof to a logical destination.



Examples of a “Spot Gap” (left) where neighborhood sidewalk connectors do not include a crossing across Durston Road and a “Linear Gap” (right) where a section of sidewalk is missing along Cottonwood Road

From a practical user perspective, these gaps would be identified as locations needing a crosswalk, sidewalk, natural surface path, paved path, bicycle lane or other on-street bicycle facility, or enhanced crossing to improve network connectivity and user experience.

Spot Gaps

Spot gaps may include:

- Missing crosswalk on one or more legs of intersection
- Natural surface trail terminates into the street without a continuation
- Existing crosswalk on a busy street that really should have additional improvements (e.g. geometric or beacon/signal enhancements)
- Crossing at uncontrolled intersection necessary to facilitate a designated route such as a shared use path or bicycle boulevard
- New bridge/tunnel to overcome barrier such as major road/creek, etc.
- Desired crossing within long road corridor far from existing crossings

Linear Gaps

Linear gaps may include:

- Missing segments of sidewalks on local streets and within subdivisions
- Missing segments of sidewalk along collector / arterial roadways
- Missing trail between existing segments such as the Gallagator trail from Kagy Boulevard to south through the Museum of the Rockies campus
- A shared use path that is interrupted by missing segments along a street

Maintenance Gaps

This study has also identified the existence of **maintenance gaps** caused by overgrown vegetation, low hanging branches (especially when branches are snow-loaded in winter), severe buckling due to tree roots, or unshoveled winter snow. These gaps are outside of the scope of this project. Numerous such gaps were reported in the public survey. These gaps are within the purview of the city’s Code Enforcement division, but code enforcement is predominantly complaint driven and many maintenance gaps are never reported. Many cities maintain a 311-phone hotline that allows residents to report maintenance issues. The City is recommended to develop strategies for proactively addressing maintenance gaps.

- Terminations or gaps in bicycle lanes, sometimes indicated by “Bike Lane Ends” sign
- Absence of bike lane or shared use path along a collector or arterial road
- Segments that degrade the experience between higher quality facilities
- Potential connections between land uses such as parks, open spaces, schools, shopping areas, etc.

Gap Inventory

This effort began with the project team receiving Geographic Information System (GIS) data from the City of Bozeman as well as gathering other data from external sources. A project base map could then be created and updated based on:

1. Automated analysis and screening. Complete sidewalk and bike lane inventories were produced from the City's 2023 aerial imagery processed by Ecopia AI. These GIS layers were provided to the City as part of Task 1. This inventory was compared against Strava activity data to identify areas with frequent bicycle and pedestrian activities recorded on Strava in places without existing sidewalks or bicycle facilities.
2. Review of proposed projects in previous planning documents such as:
 - a. The Bozeman Parks Recreation and Active Transportation (PRAT) plan (<https://engage.bozeman.net/pratplan>) Adopted 2023
 - b. The Triangle Trails Plan (https://gallatincomt.virtualltownhall.net/sites/g/files/vyhlf606/f/pages/triangle_trails_plan_adopted_112321.pdf) Adopted 2021
 - c. The Bozeman Transportation Master Plan (https://mdt.mt.gov/publications/docs/brochures/bozeman_tranplan_study.pdf) Adopted 2017
3. Field review of the City by bike and foot.

Gap Criteria & Prioritization Methodology

Many communities within Montana, the region, and nationally have developed customized prioritization methodologies that meet their unique needs. For this project, a methodology is not created to rank all projects within a transportation plan, but active transportation gaps that have been identified as part of this separate planning process. This is a key distinction as many prioritization methodologies for larger scale planning projects include metrics to rate a project's ability to close a gap.

In August 2024 a memo entitled "Gap Prioritization Methodology Memo" was submitted to the City of Bozeman. This memo reviewed peer community experience in Teton County, WY; Billings, MT; Boise, ID; Durango, CO; and San Luis Obispo, CA. These case studies were used to both identify applicable potential criteria with which to use within a scoring methodology and review various qualitative and quantitative methodologies that could be used in Bozeman.

A successful approach for Bozeman is based on the following principles:

- **Be objective based** – prioritization should help identify gaps that meet the objectives of the exercise. In this instance, the methodology should provide a means of identifying the most beneficial spot and lineal gaps in the system. These gaps may differ from a potential larger methodology that would rank all planned active transportation gaps in the city without focusing specifically on gaps.
- **Be quantitative** – prioritization is fundamentally an attempt to measure expected benefits that would result for each of the identified gaps. It is rare for a single measure to capture how a gap impacts the community. This prioritization process should consider multiple metrics, and be given a formulaic score to understand the benefits of filling the gap.

- **Focus on understanding meaningful differences** - especially in measurement-heavy approaches to prioritization, it can become easy to be lost in the numbers. Any prioritization process should consider what is a truly meaningful change, not just a measurable change. Setting thresholds with meaning is challenging, but critical, to help ensure that filling a gap has real benefits.
- **Be transparent** – The process should follow a very clear logic such that both City staff and the public can understand why the highest rated gaps rank above others.

Case Study Criteria

Each of the case study communities contained both similarities in terms of the criteria that the community’s found important, but also key differences in terms of the way they scored and weighted each criterion. Table 1 summarizes the different criteria that were considered in each of the case study cities. Note that these case studies featured overall network prioritization, as opposed to being specifically focused on gaps.

Table 1: Case Study City Criteria Summary

Prioritization Criteria	Bozeman*	Teton County WY	Billings MT	San Luis Obispo CA	Boise ID	Durango CO
Safety	X	X		X		X
Equity	X		X	X	X	
Public Input	X	X	X	X	X	
Comfort		X				
Ease of Implementation	X	X	X			X
Project Cost						X
Maintenance	X					
Network Connectivity	X	X	X		X	X
Activity Centers	X	X	X	X	X	
Downtown Projects		X	X	X		
School Connectivity		X	X	X	X	X
Park/Open Space				X	X	X
Transit Connectivity					X	
Affordable/Senior Housing				X		X
Ridership/Usage Potential				X		
Level of Traffic Stress				X		
Roadway Classification						X
Speeding History						X
Project funding status						X

*Note: prior to the project, the City of Bozeman had suggested criteria for consideration developed by the Transportation Advisory Board.

Case Study Methodologies

The case study cities also had a variety of prioritization methodologies to consider. While most are considered quantitative, meaning that they involved mathematically measurable processes, often these processes involved a person subjectively assigning numerical values to each gap. Points are assigned based on how well a gap meets the metrics for each criterion. The gaps are

then sorted according to the number of awarded points. A ranked list of gaps is produced in order from highest to lowest priority. Often the points are also weighted based on an assessment of the relative importance of each criterion.

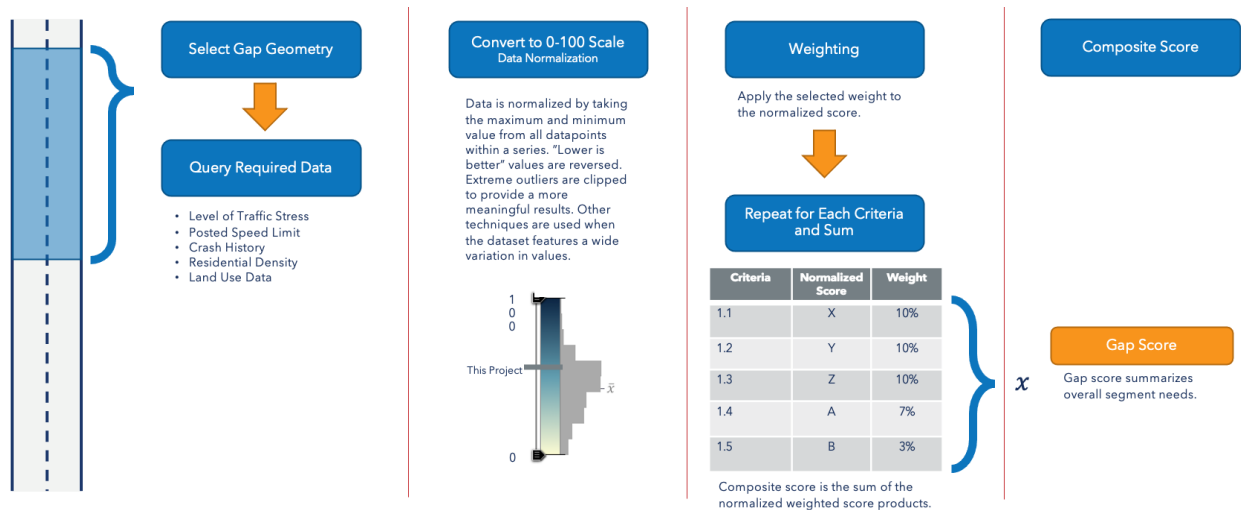
One key disadvantage is that for a newly identified gap to be added to the prioritization list, it typically must be manually scored before being added to the list. Often this will involve City staff needing to be aware of the specifics of the process to do so accurately. In some cases, the points assigned to a gap may vary by who is assigning the points.

Scoring Methodology

A series of metrics were defined to prioritize the identified gaps. To score and prioritize over 500 gaps, the scoring was automated, using methods and tools commonly applied for performance-based planning and programming. The scoring methodology is as follows:

1. Each gap is scored for each metric. To score a given metric, a corresponding source data layer for the same location is queried using GIS, and the appropriate logic (sum, minimum, maximum, straight average, length-weighted average, etc.) is applied.
2. Each metric score is normalized to a 0 – 100 range. To provide an apples-to-apples comparison between metrics, metric values are scaled to a standardized range where, for a given metric, 0 corresponds to the lowest score among all gaps and 100 corresponds to the highest score. In some cases, e.g. Metric 2.3 “Inverse of the total length of sidewalk and bicycle facilities within a half-mile buffer” the metric scores are inverted such that higher scores correspond to higher priority.
3. Normalized scores are weighted and combined. For a given gap, each normalized metric score is multiplied by the metric weight. These weighted scores are summed to produce a composite score for the gap.
4. Gaps are ranked by composite score.

This process is summarized in the diagram below.



Linear gaps and spot gaps are scored separately (primarily due to GIS limitations that require points and lines to be stored separately). The results from the two separate processes can be combined into a single consolidated gap list.

Final Criteria & Scoring Metrics

The City of Bozeman has a robust Geographic Information System (GIS) department with several full-time staff and regularly maintains and updates key spatial data that are relevant to any scoring process. For this reason, a methodology was desired that would utilize the existing staff and data resources available, allowing the process to be consistent and repeatable. For these reasons the desired methodology is:

- Based on existing and regularly maintained GIS based data sources
- Based on City, County, State or external data sources
- Simple to re-run as the city grows and changes
- Repeatable through the process without individual subjectivity
- Able to conform to the desired evaluation criteria to the degree possible while still conforming to the above needs.

Criteria

The following are the final criteria selected for use in Bozeman for gap scoring to create the final lists of prioritized projects. Note that some of these criteria combine themes from the case study cities.

1. **Safety & Comfort** – Projects that improve conditions along or across higher stress roadways, projects that improve user comfort
2. **Equity** – Projects that exist in areas of the city where various types of equity can be improved. E.g., areas of lower transportation equity (fewer options) or economic equity (lower incomes).
3. **Public Input** – Projects that have been noted through public feedback in this, and previous Bozeman transportation planning projects
4. **Connections to Activity Centers** – Areas with dense residential, commercial land uses would be elevated. Areas near parks, schools or Downtown Bozeman would also be amplified.

Note, several criteria were dropped from consideration. These include:

Ease of implementation – Typically this criterion includes either public support considerations, cost, or jurisdictional challenges. As an alternative to including this as a separate scoring criterion, the city may sort or omit projects that exist within Gallatin County inholdings, or streets that are maintained by the Montana Department of Transportation (MDT). Additionally cost of the projects is not known and subject to change as material and labor costs change.

Maintenance – This criterion is sometimes used by communities to influence the scoring by penalizing projects where maintenance will be costly or bourn by the City. It was felt that projects should be prioritized based on their merit, without regard to their maintenance obligations.

Network Connectivity – Many prioritization schemes in other communities rate a project's connectivity with other projects. As all gaps in this project are already improving connectivity by definition, this criterion was not pursued, instead the Connections to Activity Centers criterion was used.

Capital Improvement Project Compatibility – Projects that overlap with existing planned capital projects in the City of Bozeman.

Scoring Metrics

Tables 2 through 6 provide a more detailed account of the individual metrics used in the scoring methodology and their data sources.

Table 2 – Scoring Metrics for Criteria 1 – Safety & Comfort

Automated Scoring Metric	Data Source(s)
1.1 Level of Traffic Stress (1 – 4)	Level of Traffic Stress (LTS) Source: City of Bozeman
1.2 Count of severe or fatal crashes within a 500-foot buffer	High Severity Crashes. Source: City of Bozeman
1.3 Posted speed limit	Posted Speed Limits. Source: City of Bozeman
1.4 Maximum AADT intersecting within 100-foot buffer	Bozeman streets Average Annual Daily Traffic Counts (AADT) Source: MDT
1.5 Maximum Lane count	Multilane Streets Layer. Source: City of Bozeman
1.6 Sum of Strava activities within 500-foot buffer	Strava Activity Counts (2023). Source: Strava

Table 3 – Scoring Metrics for Criteria 2 – Equity

Automated Scoring Measure	Data Source(s)
2.1 Median income among intersecting census block (inverted scale)	2020 Census Data - Household Income by Census Block. Source: US Census
2.2 Location is within a quarter-mile buffer of existing transit stop	Streamline Transit Stops. Source: City of Bozeman
2.3 Inverse of the total length of sidewalk and bicycle facilities within a half-mile buffer	"Bicycle & Shared Use Facilities from this study Sidewalks layer from this study" Source: City of Bozeman
2.4 Percent of gap within a quarter-mile buffer of commercial zoning	Zoning Layer. Source: City of Bozeman

Table 4 – Scoring Metrics for Criteria 3 – Public Input

Automated Scoring Measure	Data Source(s)
3.1 Percent overlap with buffered PRAT aspirational network or Triangle Trails Plan layer.	"PRAT Network, Triangle Trails Plan Network." Source: City of Bozeman
3.2 Count of public comment points within 500' of gap	

Table 5 – Scoring Metrics for Criteria 4 – Activity Centers

Automated Scoring Measure	Data Source(s)
4.1 Sum of dwelling units within quarter-mile buffer	Address Data Layer. Source: City of Bozeman
4.2 Percent of gap within a quarter-mile buffer of commercial zoning (same as 2.5)	Zoning Layer. Source: City of Bozeman
4.3 Count of parks within a quarter-mile buffer	Parks Layer. Source: City of Bozeman
4.4 Count of schools within a quarter-mile buffer	Schools Layer
4.5 Gap within a half-mile of Downtown (B-3 zoning)	Zoning Layer. Source: City of Bozeman

Criteria Weights

In December 2024, a weighting workshop was undertaken with City of Bozeman Staff. Weighting occurred at two levels. For the macro level, participants were given a limited number of tokens to spend on each of the overall criteria to determine the relative perceived importance of each. At the micro level, each of the sub metrics identified in Tables 2 through 6 were also weighted within each overall metric. This weighting proportionally emphasized or deemphasized the sub metrics with the overall points available for each staying constant.

The weights used for project scoring are presented in Table 1 below.

Table 1 Adopted Metric Weights

Criteria 1: Safety & Comfort	48%
1.1 Level of Traffic Stress	11%
1.2 Count of severe or fatal bicyclist or pedestrian crashes within a 500-foot buffer	11%
1.3 Posted speed limit	11%
1.4 Maximum AADT intersecting within 100-foot buffer	7%
1.5 Maximum lane count	7%
1.6 Sum of Strava activities within 500-foot buffer	3%
Criteria 2: Equal Mobility Options for Everyone	15%
2.1 Median income among intersecting census block (inverted scale)	4%
2.2 Location is within a quarter-mile buffer of existing transit stop	6%
2.3 Inverse of the total length of sidewalk and bicycle facilities within a half-mile buffer	3%
2.4 Percent of gap within a quarter-mile buffer of commercial zoning	2%
Criteria 3: Public Input	11%
3.1 Percent overlap with PRAT aspirational network or Triangle Trails Plan layer	9%
3.2 Count of public comment points within 500' of gap	2%
Criteria 4: Connections to Activity Centers	26%
4.1 Sum of dwelling units within quarter-mile buffer	7%

4.2 Percent of gap within a quarter-mile buffer of commercial zoning	5%
4.3 Count of parks within a quarter-mile buffer	3%
4.4 Count of schools within a quarter-mile buffer	8%
4.5 Gap within a half-mile of downtown	3%

Automated Scoring Tool

The consultant team implemented a GIS-based scoring tool to automatically score and weight all gaps. This tool, implemented as a series of geoprocessing tools within ArcGIS Pro, provides a repeatable and scalable framework for gap scoring. The tool has been provided as a supplemental deliverable to enable the City to re-run the prioritization process as existing conditions change, gaps are filled, or with alternative sets of weights.

Prioritized Gaps

Identified spot and linear gaps were run through the prioritization methodology automated tool to provide scores.

Conclusion

In total, this project identified and prioritized more than 500 gaps in the City of Bozeman's active transportation networks.

The Bicycle and Pedestrian Gap Analysis Project provides the City with a dynamic tool that can be run at any time to update the relative importance of gaps within the City limits. The tool is not intended to be a rigid prescriptive list that mandates the city to implement projects in the same order as gaps are ranked. Rather, it is a tool that can help inform decision making and help guide the City to target limited financial resources. Actual project implementation may be informed on the tool, but will also be impacted by funding sources, possible inclusion within larger city projects and whether the gap lies within an MDT or Gallatin County inholding area. Additional considerations may include public desire, any recent safety concerns such as crashes, etc.

With this prioritization tool, the City of Bozeman should still be opportunistic in its approach to project implementation, and should explore strategies such as integrating lower priority gaps into existing roadway or maintenance projects in order to implement the largest number of projects as expeditiously as possible.

As Bozeman continues to grow and evolve, changes to the City including posted speed limits, roadway additions or reconstructions, and improved active transportation facilities may indicate a need to run the tool again, which can quickly provide an updated prioritization list. Gaps should be removed from the list as they are completed.