Appendix B

Active Transportation Plan network development methodology

DRCOG Planning Region, 2024

October 2025

The regional active transportation network is a key component of the Denver Regional Council of Governments Active Transportation Plan update. Separate analyses were used to identify pedestrian focus areas, short-trip opportunity zones, and regional active transportation corridors. Key steps and inputs are described below for each item.

The update also included a preliminary crossing gap analysis using geospatial data to identify crossings throughout the region that were not supplemented with safety countermeasures sufficient for the speed and volume of traffic on our roadways. The methodology to conduct this analysis is also included in this memo.

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Pedestrian focus areas

Pedestrian focus areas are areas where a high level of pedestrian activity is occurring or is expected to occur based on destination attractors, and where there may be a higher level of need based on pedestrian crash history and demographic factors. Pedestrian focus areas were identified through a data-driven process to incorporate various factors shown in the table below and translate these values into a hex-grid to visualize the draft areas. The pedestrian focus areas identified as part of the overall regional active transportation network provide guidance on where investment in the pedestrian environment may have the most significant impact, such as an increase in the number of walking trips, a shift to walking from more polluting modes of transport, and/or a decrease in the frequency and severity of pedestrian crashes in the area. An estimated 125 square miles (2.3% of the region) were designated as pedestrian focus areas. Approximately 710,000 people currently live in a pedestrian focus area (21% of the region's population).

The process included the following steps:

1. The current network of streets, trails, and present and absent sidewalks and crosswalks was compiled (Figure 1). Data was compiled from DRCOG's open data portal, Longitudinal Employer-Household Dynamics (LEHD), and internal data provided by DRCOG. See for a complete list of inputs, values, and sources.
2. Facilities that generate pedestrian trips, like schools, parks, trail crossing points, and transit stops were overlaid onto the network.
3. Walksheds, or paths of travel, were generated using the facilities and street segments.
4. After walksheds were created, the network of street segments was scored based on Table 1.
5. A hex-grid was created for the Denver region. 0.25-mile hexagons were overlaid over the pedestrian network.

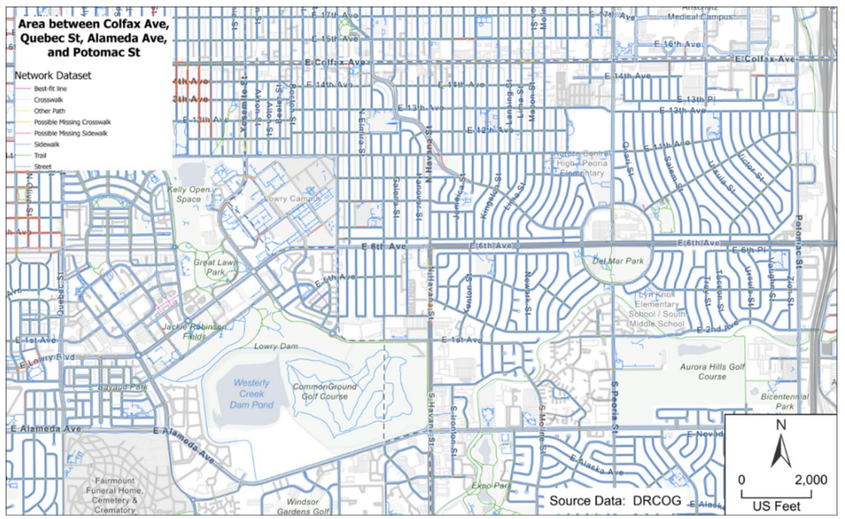

Figure 1 Network Dataset Example

6. After hex-grids were created, the total network segment scores were summarized for each hexagon. If a segment overlapped multiple hexagons, the segment's score was divided proportionally across hexagons. For example, if 1/4 of a segment was in a hexagon, only 1/4 of the score for that segment was assigned to the hexagon. This avoided double counting or over-emphasizing certain segments or factors. Lower scores indicated fewer pedestrian-related factors, while higher scores indicated more pedestrian factors.
7. Five natural breaks (Jenks breaks) were assigned. Values equal to or greater than the top 1.5 Jenks (which includes the top half of the medium category, the medium high category, and the high category) were selected as potential draft pedestrian focus areas.
8. A manual check was used to review areas against those identified as pedestrian focus areas in the previous Active Transportation Plan analysis.
9. The top 5% of hex grids in DRCOG member counties were added if not already included in analysis. These may show up as low or medium-scoring hexagons.
10. After draft pedestrian focus areas were identified, the Active Transportation Advisory Group members provided comment on pedestrian focus areas.
11. The project team reviewed comments and manually removed or added pedestrian focus areas based on local knowledge, Colorado House Bill 1313 , and DRCOG's system optimization plan to finalize the pedestrian focus areas for the active transportation network.

Table 1 Pedestrian Focus Area Data Factors

Input	Description	Range	Data Source
Schools	Street segments within a ¼ mile walkshed around schools.	0-1	Schools, 2024 (DRCOG).
Parks	Street segments within a ¼ mile walkshed around parks.	0-1	Parks, recreation, and open space, 2022 data (DRCOG).
Transit stops and facilities	Street segments within a ¼ mile walkshed around bus stops or within a ½ mile walkshed around light rail and park and ride.	0-1	System Optimization Plan, 2022 (Regional Transportation District)..
Trails	Street segments within a ½ walkshed around trail crossing points.	0-1	Bicycle Facility Inventory, 2024 (DRCOG).
Demographic factors	Denver Regional Council of Government Index scores for each Census tract, based on percentile.	0.2-1	Equity Index Census Tracts, 2023 (DRCOG).
Job density	Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics employment data, number of jobs per acre for each job zone.	0.2-1	LEHD LODES Total Jobs 2021 (retrieved by Nelson\ Nygaard).
Area type	Street segments in an urban area (1). Street segments in a suburban area (1.33). Street segments in a rural area (1.67).	1-1.67	Area type shapefile (DRCOG, Taking Action on Regional Vision Zero).
Crashes	Street segments within 100 feet of fatal and severe injury pedestrian crashes (1.5). Street segments within 100 feet of injury-only pedestrian crash (1).	0-1.5	Pedestrian crashes 2018-2022 (DRCOG).
High injury network	Street segments on the Denver Regional Council of Governments high injury network (1). Street segments that intersect the Denver Regional Council of Governments high injury network (.67). Street segments that intersect the Denver Region Council of Governments high injury network (.33).	0-1	High injury network and critical corridors feature class from transportation infrastructure geodatabase (DRCOG).
Urban centers	Street segments in Denver Regional Council of Governments-defined existing or emerging urban centers.	0-1	Urban centers 2019 shapefile (DRCOG).

Short trip opportunity zones

Short trip opportunity zones are areas where a high concentration of trips two miles or less in length by all modes are occurring and where investment in high-comfort, safe active transportation facilities may shift trips to walking and bicycling. Short trips currently make up 35% of all trips within the DRCOG region. Short trip opportunity zones illuminate where short distance trips occur in a high concentration (generally defined as transportation analysis zones with the top 20% of aggregate short trip densities), which can help to focus analysis and investment of improvements across the region. Short trip opportunity zones were identified using data from the Denver Regional Council of Governments travel demand model. The process to identify the draft zones included the following steps:

1. Review of the Denver Regional Council of Governments travel demand model data. The model estimates short trips made in each transportation analysis zone for drive-alone trips, shared ride, shared-ride with three or more people, walking or biking.
2. Calculate density of short trips per square mile per mode per transportation analysis zone.
3. Convert density scores to a percentile.
4. Incorporate proximity to regional parks included in previous short trip opportunity zone analysis (score of 0 or 1, or manually selected).
5. Combine the percentile scores for each mode and park score per transportation analysis zone to create a composite score of short trip opportunities per zone. A higher composite score signals more short trips made per zone by any mode.
6. Visualize short trip opportunity zones by transportation analysis zone using a quantile classification with five breaks and define a query to keep only the transportation analysis zones in the highest quintile/break.
7. After the draft short trip opportunity zones were created, the Active Transportation Advisory Group members and member agencies provided comment on the short trip opportunity zones.
8. The project team reviewed comments and manually removed or added short trip opportunity zones based on local knowledge to finalize the short trip opportunity zones for the active transportation network.

Regional Active Transportation Corridors

Regional active transportation corridors are regionally significant multimodal linear routes where people walking, bicycling, and using other active modes should expect a high level of comfort and substantive safety. These routes provide connections within and between communities in the Denver region, increasing opportunities for recreation and utilitarian active travel.

Regional active transportation corridors were identified through the following steps:

1. The 2019 Active Transportation Plan active transportation corridor analysis was used as the starting point for the current map.
2. DRCOG's bicycle facilities database was updated with the most recent local bike network plans.
3. Area types developed for Vision Zero planning were used to set the general network density and usage criteria (Table 2).
4. After draft active transportation corridors were created, the Active Transportation Advisory Group members and member agencies provided comment on the active transportation corridors.
5. The project team reviewed comments and manually removed or added active transportation corridors based on local knowledge to finalize the active transportation corridors for the active transportation network.

Table 2 Regional Active Transportation Corridor Density and Usage Criteria by Area Type

Area Type	Network Density and Usage Criteria
Urban	Approximately 1 to 1.5 mile linear spacing between corridors (with urban core areas more dense at ~0.5-mile); intended primarily for functional travel. Design for high capacity.
Suburban	Approximately 2 to 3 mile linear spacing between corridors; primarily regional trails or major roadways. Design for moderate to high capacity.
Rural	Approximately 3 to 5 mile linear spacing; may be functional, but key use is often recreational or bike tourism related. Design for moderate to high capacity.

High-Comfort Crossing Gaps Analysis

Sidewalks and other walkways are only one part of the pedestrian travel experience. The quality of crossings and the distance between high quality crossings are important elements that affect the level of comfort and safety for people walking and rolling. When people have to travel long distances between high quality crossings they may take larger risks to cross the street with a shorter path of travel.

The Active Transportation Plan includes a preliminary crossing gap analysis using geospatial data to identify crossings throughout the region that were not supplemented with safety countermeasures sufficient for the speed and volume of traffic on our roadways.

Analysis approach

To conduct the preliminary high-comfort crossing gaps analysis, the project team's goal was to leverage existing or easily collected data to conduct a regional scale assessment of where existing crossing treatments provide a sufficient facility for pedestrians, and on a given road segment how far is a pedestrian situtated from a sufficient crossing. The analysis is primarily based in two geospatial datasets: Colorado DOT's All Roads Linear Referencing System and DRCOG's Planimetric Sidewalk Centerlines.

The analysis was conducted in three steps:

1. Determine crossing sufficiency at each intersection across the region.
2. Calculate average distance to a sufficient crossing on every street segment.
3. Assign a designation based on average distance to a sufficient crossing based on area type.

This section describes the technical criteria used for determining and classify sufficient or "high-comfort" crossings across the region.

Determining crossing sufficiency

While "comfort" for people walking especially is subjective and personal based on an individual's stress threshold and the characteristics of the trip itself (i.e., people may have differing levels of comfort by time of day, whether they are walking with children, or whether they are carrying cargo or pushing a cart for instance), the Crossing Gaps Analysis is girded by the FHWA 2005 report **Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations**. In this report, researchers studied pedestrian crash risk by roadway context to develop a set of recommended criteria for judging crossing sufficiency, which are shown in Table 3. In the report, the authors emphasize the importance of providing a sufficient pedestrian facility:

> *“Marked crosswalks are one tool used to direct pedestrians safely across a street. When considering marked crosswalks at uncontrolled locations, the question should not be simply, ‘Should I provide a marked crosswalk or not?’ Instead, the question should be, ‘Is this an appropriate tool for directing pedestrians across the street?’ Regardless of whether marked crosswalks are used, there remains the fundamental obligation to get pedestrians safely across the street.”*

The High-Comfort Crossing Gaps Analysis is based in this imperative to provide safe and sufficient crosswalks and enhancements per context.

Table 3 Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations (**Zegeer et al, 2005**)

Roadway type	Vehicle ADT ≤ 9,000			Vehicle ADT 9,000 to 12,000			Vehicle ADT 12,000 to 15,000			Vehicle ADT > 15,000		
	Speed Limit											
	30	35	40	30	35	40	30	35	40	30	35	40
Two lanes	C	C	P	C	C	P	C	C	N	C	P	N
Three lanes	C	C	P	C	P	P	P	P	P	P	N	N
Multilane (four or more) with raised median	C	C	P	C	P	N	P	P	N	N	N	N
Multilane (four or more) without raised median	C	P	N	P	P	N	N	N	N	N	N	N

*C = Candidate for marked crosswalk; P = Possible increase in pedestrian crash risk if crosswalks are added without other pedestrian facility enhancements; N = Marked crosswalks alone are insufficient, since pedestrian crash risk my be increased by providing marked crosswalks alone.

Building on the FHWA report's criteria, the project team developed a set of criteria based on roadway characteristics identified in available data to assess each intersection's sufficiency based on its weakest link. Using CDOT's All Roads Linear Referencing System dataset, the team was able to identify the following factors for the analysis:

- **Vehicular speed limit:** highest speed using speed limit data from centerline data set as updated for the Regional Roadway System by DRCOG in 2025.
- **Crossing width and number lanes:** number of entering lanes as a sum of through, right, left, and auxiliary lanes in both directions.
- Presence of **curbed median** based on data about the presence or width of a raised median.
- **Volume** of segment being crossed, using provided Average Annual Daily Traffic.
- **Functional Classification,** limited to arterial and collector streets as classified by State data.

This analysis excluded roadways classified as interstate highways or limited-access state highways since there are not pedestrians anticipated to becrossing those roadways at grade. Additionally, the decision was made to not assess "Local" roadways (i.e., roads functionally classified as "Local" rather than roads operated by local jurisidctions) for two reasons: first, "Local" classified streets were frequently missing necessary data, and second, that these local-to-local intersections are often likely to meet a "sufficient" crossing designation due to low vehicle volumes and posted speed limits.

Using DRCOG's Planimetric Sidewalk Centerlines data, the team was also able to identify marked crosswalk locations for much of the Denver region. While the Planimetric dataset does not cover DRCOG's entire planning geography, it encompasses most of the urbanized area and is useful for this level of analysis. DRCOG's Traffic Signal dataset was also leveraged to

identify signal-controlled locations, which includes full traffic signals, school crossing signals, and pedestrian hybrid beacons. Based on FHWA's STEP Guide and consultation with the Active Transportation Advisory Group, the project team set the following criteria for when an intersection is judged to be sufficient:

- **Full traffic signal** with marked crosswalks present. While actual pedestrian comfort and safety conditions vary widely by signalized location, for this analysis a signalized crossing was judged to be comfortable for the typical user. Future expansion of the analysis could gather more site-specific data to better assess comfort at signalized locations.
- **Pedestrian hybrid beacons or school crossing signals** with marked crosswalks present. While site-specific conditions may vary, if a pedestrian hybrid beacon has been installed the project team assumes that it is coupled with the necessary enhancements to meet a high-comfort threshold.
- **Unsignalized locations** under the conditions identified in Table 4.

Table 4 Marked crosswalk are sufficient at unsignalized locations meeting the following conditions

Travel Lanes	Vehicle volume	Posted speed limit
2	≤ 15,000 ADT	≤ 35 MPH
2	9,000 - 15,000 ADT	≤ 30 MPH
3, with raised median	≤ 15,000 ADT	≤ 30 MPH
3, without raised median	≤ 9,000 ADT	≤ 30 MPH
4, with raised median	≤ 9,000 ADT	≤ 30 MPH
4, without raised median	Never	Never

Using these criteria, the project team developed a GIS dataset of intersection nodes (Figure 2) in a multistep process to compare whether the expected crossing treatment for the intersection meets the observed crossing treatment. The expected crossing treatment was calculated as that which would be expected for the intersection based on the highest stress combination of motor vehicle volume, posted speed, raised median presence, traffic control device and number of travel lanes in both directions. At each intersection node, if the combined maximum speed, volume, and travel lanes is in excess of the threshold for supplementing the crossing with a signal or a pedestrian hybrid beacon and there is no signal or pedestrian hybrid beacon within 100 feet of the intersection, the intersection is defined as insufficient.

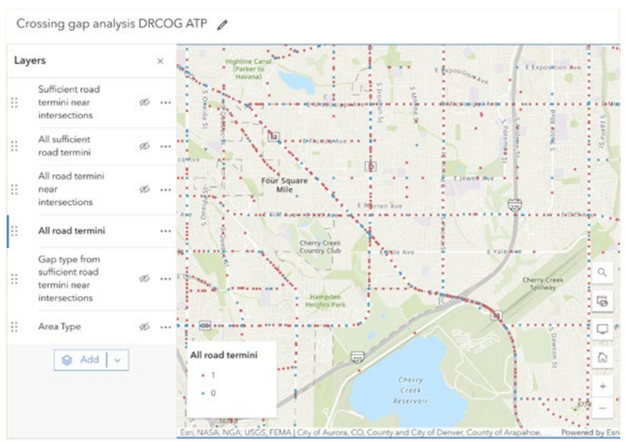

Figure 2 Intersection nodes output dataset

Identifying gaps between sufficient intersections

Once crossing sufficiency was calculated at the intersection level, the project team used the CDOT All Roads dataset to calculate the mean distance along each line segment to the nearest sufficient crossings. Based on consultation with the Active Transportation Advisory Group, the project team set thresholds for "acceptable" distance to the nearest sufficient crossing based on area type to symbolize the map outputs and categorize street segments based on their proximity to high-comfort crossings. The thresholds are described in Table 5.

Table 5 Distance to high-comfort crossing thresholds by area type

Area Type	Acceptable distance	Excessive distance	Critical distance
Urban	< 660 feet	660 – 1,320 feet	> 1,320 feet
Suburban / Compact Community	< 660 feet	660 – 1,320 feet	> 1,320 feet
Rural	< 1,320 feet	1,320 – 2,640 feet	> 2,640 feet

Segments were split at sufficient crossings to determine the distance between these locations (Figure 3). The resulting centerline segments were symbolized by length, differentiated as to whether the calculation was completed in an urban, suburban, or rural area.

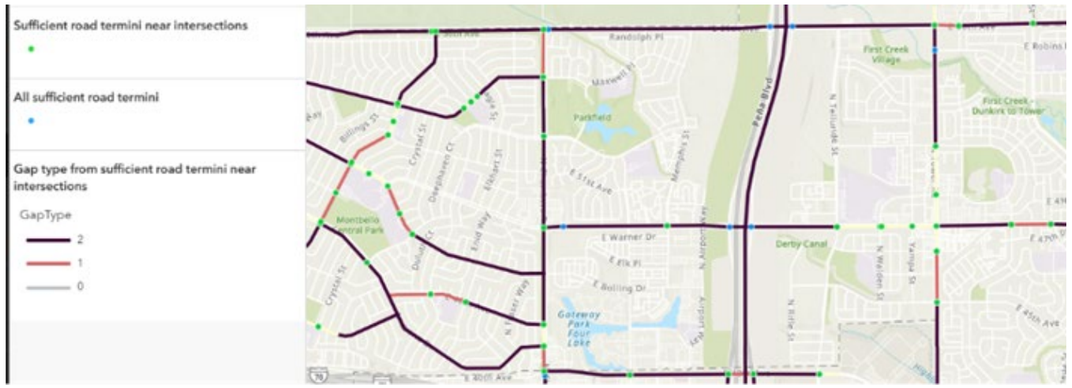

Figure 3 Crossing Gaps between sufficient intersections before screening for intersection proximity

Opportunities for Advancing Methodology

This analysis is intended as a first-step planning tool to aid DRCOG and its members and partners in understanding pedestrian needs and gaps across the Denver region. Beyond the development and adoption of the Active Transportation Plan, DRCOG has the option to build on, refine and advance the methodology to better represent real world conditions and identify opportunities for improvement. Some considerations for possible next steps include:

1. This analysis was undertaken while CDOT was undertaking a data collection project that would provide more information at the intersection level. Therefore, the intersections and their associated infrastructure had to be estimated. A future analysis should include updated

traffic control information specifically for the intersection level, as opposed to in close proximity of potential intersections.

2. There are some locations where there the distance between sufficient intersections was miscalculated because the distance from the centerline segment to the existing enhancement was in excess of 100'. This can be resolved by splitting all lines at the existing enhancements in addition to at the intersections.
3. Line features in the dataset are segmented based on where the following attributes change:
   - Route name.
   - Number of lanes.
   - Speed.
   - AADT.
   - Median.
   - Functional class.
   - Other attributes related to functional class or ownership.

This segmentation choice means that line features are not necessarily segmented where crosswalks and signals exist today, and this doesn't get captured when the lines are turned to termini (i.e. there are not always termini for existing signals and crosswalks) (Figure 14). A potential solution for this challenge is to post process the centerline data an additional time by splitting the lines again by the crosswalks and signals. These points can be processed for sufficiency independently of the steps conducted for this analysis based on the same FHWA standards.

Updating the crossing gaps analysis

This analysis is a launching point for future process improvements and updates as intersection crossings are updated or as agencies provide additional data about intersections currently designated as potentially deficient. DRCOG has the option and opportunity to periodically update this analysis as intersections are enhanced, street segments are modified or as new or improved data becomes available.