Appendix: Pedestrian Experience Index (PEI) Methodology Memorandum

Fort Worth Active Transportation Plan

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Fort Worth

North Central Texas Council of Governments

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MEMORANDUM

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Project: Fort Worth Active Transportation Plan

Re: Pedestrian Experience Index Methodology

This memorandum describes the Pedestrian Experience Index (PEI) analysis conducted as part of the Fort Worth Active Transportation Plan. The results of this analysis are available online at http://fortworthtexas.gov/atp/**.** This memo includes six major sections:

Background (page 2) provides context for the PEI analysis.

Summary of Variables (page 2) outlines the input data and their sources for the PEI analysis.

Segment PEI Variable Descriptions (page 3) details the scoring criteria for the segment PEI analysis.

Intersection PEI Variables (page 8) presents the scoring criteria for the intersection PEI analysis.

Scoring Approach (page 9) documents the process by which road segments and intersections were scored.

Limitations (page 13) discusses data and methodology limitations and offers recommendations for future analyses.

Background

The Pedestrian Experience Index is a pedestrian complement to the Bicycle Level of Traffic Stress analysis. It incorporates infrastructure and built environment data to quantify the quality of the pedestrian experience for each block face (one side of the street between intersections) and each intersection in Fort Worth. While this analysis is unique to Fort Worth, it relies on factors well-known in the transportation and urban design literature for their connection to walkability and pedestrian comfort.[1] The output is a PEI score for each block face. A score of 1 indicates a more comfortable pedestrian environment, while a score of 4 indicates a less comfortable pedestrian environment. PEI scores can be used to help prioritize pedestrian improvements or to evaluate progress toward improving pedestrian comfort over time.

Summary of Variables

Variables for the PEI segment analysis are divided into two categories: infrastructure and built environment. Table 1 presents the PEI segment variables and GIS data sources for each category. Table 2 presents the variables for the PEI intersection analysis.

Table 1. Segment PEI Variables

Category	Variable	Source (GIS Layer Name)	Year Updated
Infrastructure	Sidewalk Condition	Sidewalks	2017
	Number of Adjacent Travel Lanes	PMAStreets	2017
	Adjacent Bike Lane Presence	BIKE_ROUTES	2018
	Adjacent Parking Lane Presence	Street_Parking	2017
	Posted Travel Speed	City correspondence	2018
Built Environment	Block Length and Mid-Block Crossings	PMAStreets/ RAMPS	2017
	Building Setbacks	BLDG_FOOTPRINTS	2018
	Driveways	EDGE_OF_PAVEMENT/SIDEWALKS	2017
	Number of Addresses	Address_Points	2018

[1] Clifton, Kelly J., et al. "The Development and Testing of an Audit for the Pedestrian Environment." Landscape and Urban Planning, vol. 80, no. 1-2, 2007, pp. 95–110., doi:10.1016/j.landurbplan.2006.06.008.

Table 2. Intersection PEI Variables

Variable	Source	Year Updated
Number of Lanes to Cross	PMAStreets	2017
Speed Limit of Street to Cross	City correspondence	2018
ADA-Compliant Curb Ramps Existing/Expected	RAMPS	
Crosswalks	BICYCLE_FACILITIES_AND_CROSSWALKS	
Signalization/All-Way Stops	HAWKs_PHB_SIGNALS, PEDandFLASHER_SIGNALS, SIGNALIZED_INTERSECTIONS, STOP_SIGNS	2017

Segment PEI Variables

Sidewalk Condition

Sidewalks contribute to a comfortable pedestrian environment in urban areas. In locations without sidewalks, people using wheelchairs either cannot travel on that street or may make the high-risk choice to mix with motor vehicles in a travel lane. In addition, sidewalk condition affects the utility of the facility and the walking experience. For example, sidewalks with heaved or cracked panels may be only marginally more useful for people using wheelchairs than not having a sidewalk at all.

Using City-provided sidewalk condition data, the PEI analysis assessed the condition of different sidewalk elements along each block face. The worst sidewalk element determined the condition of each block face [**n/a** (missing), **Good**, **Fair**, and **Poor**]. Condition-specific scores are described in the following sections.

Number of Adjacent Travel Lanes

The number of travel lanes affects the pedestrian experience.[2] Roads with more lanes are wider than roads with fewer lanes and are more uncomfortable to walk along, even when there are adequate sidewalks. They also take longer to cross than narrower streets, increasing exposure to motor vehicle traffic for crossing pedestrians. The number of travel lanes for each road was derived from the City's *PMA_Streets* dataset. Roads with fewer lanes score better than those with more.

[2] Dixon, L. 1996. Bicycle and pedestrian level of service performance measures and standards for congestion management systems. Transportation Research Record 1538: 1-9.

Posted Travel Speed

Intuitively, we understand that walking next to fast-moving cars is uncomfortable and potentially dangerous. Actual and perceived pedestrian safety suffers when people walk in close proximity to moving motor vehicles.[3] In the absence of readily available observed travel speeds, City-provided speed limit data was used to calculate the speed limit along each block face. Block faces on roads with higher speed limits score worse than those with lower speed limits.

Block Length and Mid-Block Crossings

Walkability and the pedestrian experience are affected by block length in several ways. Longer blocks mean fewer direct routing options for pedestrians. Longer blocks mean there are fewer streets and each street carries more traffic, reducing pedestrian comfort. Longer blocks allow motorists to travel at higher speeds. To carry the traffic, streets are wider and take longer for pedestrians to cross. With shorter blocks, it is easier for pedestrians to cross to the other side of the street to access destinations. Research indicates that block lengths around 300 feet are ideal, but block lengths up to 400 or 500 feet are also acceptable.[4] The PEI assigns block faces closer to the ideal length a better score than those "superblocks" that may be many times longer. Blocks within and along parks were given the shortest block length score because comfort walking in and along a park is assumed to be unaffected block length. Greater block lengths yield a less favorable pedestrian experience.

Table 3. Scoring by Block Length

Block Length	Score
<300 feet	0
400-500 feet	20
>500 feet	40

One strategy to mitigate the detrimental impact of long block lengths on walkability is to make it easier for pedestrians to cross the street at mid-block locations. This can improve direct routing and make it easier for pedestrians to access destinations on the other side of the street. Based on City-provided data on mid-block crossing locations, the PEI analysis scored block faces with mid-block crossings according to the table below in locations where there are two or fewer travel lanes. These scores were used to mitigate the scoring "penalty" of long blocks. In other words, if there is a long block and a mid-block crossing, the penalty for having a long block is reduced, but not eliminated.

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[3] Jaskiewicz, Frank. "Pedestrian level of service based on trip quality." Transportation Research Circular, TRB (2000).
[4] Ewing, Reid. Pedestrian and Transit-Friendly Design: A Primer for Smart Growth. https://www.epa.gov/sites/production/files/documents/ptfd_primer.pdf

Table 4. Scoring by Block Length with Mid-Block Crossings

Block Length	Score
<300 feet	0
400-500 feet	15
>500 feet	35

Building Setbacks

Several streetscape elements relate to the urban design concept of “enclosure,” the extent to which a street feels like an outdoor living space for pedestrians. A building setback—the distance between a building and the street—influence enclosure. Buildings that are far away from the street create a sense of openness and expanse that can be uncomfortable for pedestrians.[5] For example, parking lots between a building and sidewalk indicates the prioritization of driving over walking. Conversely, buildings that are closer to the street create a street wall that “encloses” the streetscape, provides engaging frontages and sidewalk shade, which is especially important for communities with warmer climates such as Fort Worth. Figure 1 shows an example of how the PEI analysis calculated building setbacks using the City’s building footprint data and street centerline data. The calculation included subtracting half the street width to exclude the distance between the centerline and the curb.

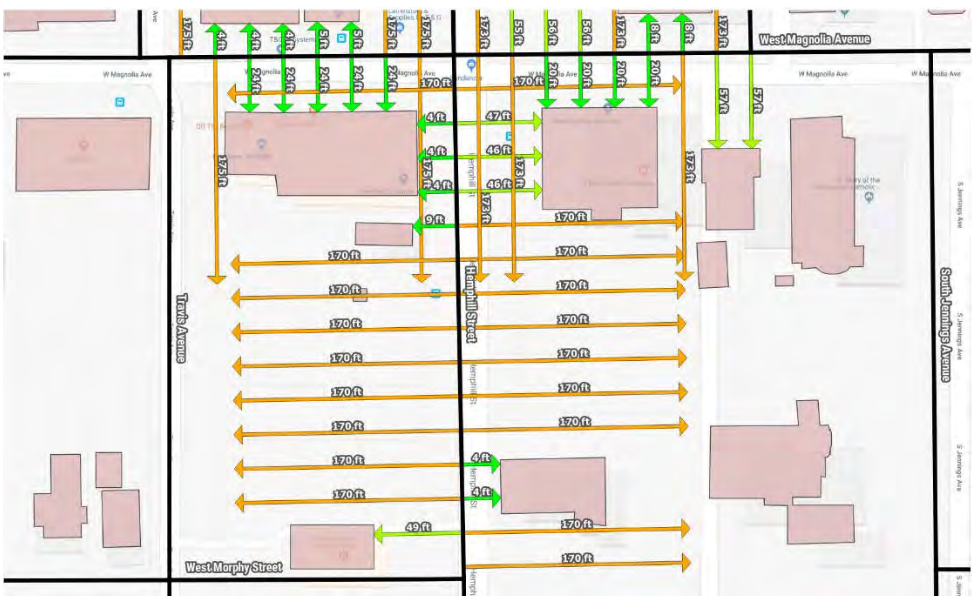

Figure 1. Building Setback Calculation Example

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[5] Institute of Transportation Engineers. A Framework for Walkable Urban Thoroughfare Design. Chapter 4. https://www.ite.org/css/online/DWUT04.html

Several equally-spaced building setback measurements were made for each block face. Based on a review of the data and experimenting with different values, four categories were established for setback scoring, as shown in Table 5.

Table 5. Grouping by Building Setback

Group	Building Setback
1	<= 25 feet
2	>25 feet and <= 35 feet
3	>35 feet and <= 50 feet
4	>50 feet

For each block face, the setback score was determined based on the percentage of total measurements along a roadway that were in each group. For example, if 100 percent of the measurements on a block face were in Group 1, that block received the best setback score.

In many cases in Fort Worth, deep setbacks result from parking lots adjacent to the sidewalk. In other cases, deep setbacks result from parks or other green spaces. For block faces adjacent to parks or green spaces, the block face is given the best building setback score possible because walking along a park is assumed to be much more comfortable than walking along a parking lot.

Driveways

Driveways create conflict points between pedestrians and motorists accessing residences and businesses across the sidewalk. Motorists, especially those turning left across oncoming traffic to access a driveway, may not see or look for pedestrians on the sidewalk. In many cases, driveways also increase sidewalk cross-slope, decreasing pedestrian accessibility. The PEI analysis calculated the number of commercial driveways on each block face that intersect the sidewalk by comparing City-provided sidewalk condition data with City-provided edge of pavement data. Block faces with more driveways score worse than those with fewer driveways.

Adjacent Bike Lane

Bike lanes benefit pedestrians by increasing the buffer space between sidewalks and general travel lanes. Block faces score better if they are next to a bike lane.

Adjacent Parking Lane

Parking lanes benefit pedestrians by increasing the buffer space between sidewalks and general travel lanes and providing physical separation when motor vehicles are parked in the parking lane. Block faces score better if they are next to a parking lane.

Number of Addresses

Blocks that are more visually interesting, are dense with businesses, and have more attractions to draw pedestrians are more likely to be pedestrian-friendly than those with fewer frontages and businesses.[6] The number of addresses on a block face is a proxy for its attractiveness for pedestrian activity. City-provided address point data was used to assign block faces with more addresses better scores than those with fewer addresses.

Parking Lot Adjustment

The Built Environment scores for blocks covered entirely with surface parking were adjusted. Sidewalks next to large parking lots are generally uncomfortable pedestrian environments, even if there are few driveways or short block lengths. The worst score for each Built Environment factor was applied to these blocks.

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[6] Campoli, Julie. Made for Walking: Density and Urban Form. 31.

Intersection PEI Variables

Number of Lanes to Cross

The more lanes pedestrians must traverse to cross at an intersection, the more uncomfortable and unsafe. This analysis used the PMAStreets layer to calculate the number of lanes to cross for the widest street at an intersection.

Speed Limit of Road to Cross

All else being equal, a street with faster motor vehicle traffic will be more uncomfortable to cross as a pedestrian. City-provided speed limit data guided the identification of the highest speed limit at every intersection in Fort Worth.

Traffic Control and Crosswalk Presence

Signalization and marked crosswalks greatly improve pedestrian crossing comfort. Using City-provided traffic control and crosswalk data, at intersections with traffic control (full signalization, RRFBs, HAWKs, all-way stop signs) and crosswalks, this analysis improves the PEI score of both the **Number of Lanes to Cross** score and **Speed Limit of Road to Cross** score. This does not affect the intersection's ADA score.

ADA Ramps

The analysis assumes that each corner of an intersection should have at least one Americans with Disabilities Act (ADA)-compliant curb ramp. Each corner was examined to determine if a curb ramp was present. Score were calculated for intersections based on if there were curb ramps on zero, one-to-three, or four-or-more corners. See Figure 2 for examples. In the table, 1 is the best and 4 is the worst.

Figure 2. ADA Curb Ramp Example

Intersection Characteristics	Score
Zero curb ramps	4
Between 1 and 3 corners with a curb ramp	3
4 or more corners with a curb ramp	1

Scoring Approach

Segment PEI Scoring

Each block face receives an infrastructure score and a built form score. The weights for each element of the category score are shown in Table 6 and Table 7.

Table 6. Segment PEI Scoring by Infrastructure Factor

Infrastructure		
Factor	**Scoring Criteria**	**Score**
Sidewalk Condition	Good	30
	Fair	15
	Poor	5
	Missing	0
Speed Limit	30	25
	35-40	10
	>40	0
Number of Adjacent Lanes	<=2	25
	3-4	10
	>4	0
Adjacent Bike Lane	Yes	10
	No	0
Adjacent Parking Lane[7]	Yes	10
	No	0
Total		**100**

[7] Based on the *Street_Parking* layer provided by the City

Table 7. Segment PEI Scoring by Built Form Factor

Built Form		
Factor	**Scoring Criteria**	**Score**
Block Length (without Midblock Factor)[8]	<300 ft	0
	300-500 ft	20
	>500 ft	40
Building Setbacks	>= 66% in Narrowest Quartile	0
	33% - 65.99% in Narrowest Quartile	25
	<33% in Narrowest Quartile	50
Driveways	Relative number of driveways	20
# of Addresses	Relative Number of Addresses	10
Total		**100**

Table 8. Block Length Scoring Adjustments for Mid-Block Crossings

Block Length Score Adjustment		
Factor	**Scoring Criteria**	**Score**
Mid-block crossing present and number of travel lanes is two or fewer	<300 ft	0
	300-500 ft	15
	>500 ft	35

For each block face, the infrastructure and built form scores are summed and broken into quartiles with 1 being the best and 4 being the worst.

Intersection PEI Scoring

Each intersection is scored using a "weakest link" approach similar to that used in the Bicycle Level of Traffic Stress (LTS) analysis. The worst intersection approach determines the overall PEI score for the intersection. For example, the following scenarios would result in intersection PEI scores of 4:

[8] Blocks in and along parks were assigned scores for short blocks.

- The widest intersection approach has 2 travel lanes, a speed limit less than 35 mph, but no ADA-compliant curb ramps.
- The widest intersection approach has 4 travel lanes, a speed limit less than 35 mph, and all ADA-compliant ramps.
- The widest intersection approach has 5 or more travel lanes, a speed limit of greater than 40 mph, and all ADA-compliant ramps. However, the PEI score would be 3 if the approach was signalized and/or included a crosswalk, because both the number of lanes score and the speed limit score would be improved by one.

Intersection PEI scores are described in Table 9. Table 10 presents the approach for Intersection PEI scoring.

Table 9. Intersection PEI Score Descriptions

Intersection PEI Score	Description
1	These intersections are comfortable and accessible for everyone old enough to cross streets independently. All approaches have ADA-compliant curb ramps. Pedestrians need only cross two travel lanes at most without the aid of a traffic signal.
2	These intersections are mostly comfortable, but there may be more travel lanes to cross and traffic speeds may be higher. All approaches have ADA-compliant curb ramps. Parents may not be at ease with children crossing unaccompanied. Pedestrians may have to cross three lanes at most without the aid of a traffic signal.
3	Higher traffic speeds and more travel lanes to cross make for a pedestrian experience less comfortable than PEI 2. There may not be ADA-compliant curb ramps on all approaches, so some intersection legs may not be accessible to those using wheelchairs or other mobility devices.
4	These intersections tend to be both wide and fast and/or lacking accessible curb ramps entirely. These intersections are uncomfortable and potentially unsafe for pedestrians to cross. Intersections with PEI scores of 4 can be major barriers for people walking.

Table 10. Intersection PEI Scoring by Factor

Factor	Scoring Criteria	Score
Number of Lanes to Cross	1-2	1
	3	2
	4	3
	5+	4
Speed to Cross	< 35	1
	35	2
	40	3
	> 40	4
ADA Ramps Existing/Expected	All	1
	Partial	3
	None	4
Signalization /All-Way Stop (Traffic Light/RRFB/HAWK) /Crosswalk Presence	Present	-1 from highest (Number of Lanes to Cross and/or Speed to Cross scores)
	None	Nothing

Limitations

Data Limitations

Limitations exist for several variables in the segment and intersection PEI analysis.

Because the *building setback* variable is calculated using regularly-spaced measurements into the block face, measurements that land in the narrow space between buildings may skew the score for that block face. Also, setback calculations can be inaccurate in dense areas where there are multiple acute intersections. Additionally, because the actual setback is calculated by subtracting half of the street width from the centerline data, if the centerline data is not located exactly on the center of the roadway, the calculation will be inaccurate.

The *number of addresses* variable may not separate different ground-level storefronts into different addresses due to the data provided.

The *mid-block crossing* variable is derived from the location of ADA-compliant ramps at mid-block locations. It is possible that this calculation included intersection locations at the top of "T" intersections. This measure also doesn't include mid-block crossings that may not have ADA-compliant ramps at all.

The *driveways* variable was calculated by overlaying the “commercial driveway” and “parking lot” data from the City-provided pavement data on top of the City’s sidewalk condition data. Incorrect sidewalk geometry can result in the overestimation of the number driveways.

Methodology Limitations

The PEI approach to quantifying the pedestrian experience is unique. There has been significant urban design scholarship about factors that make walking comfortable and enjoyable, but none have been geared toward quantifying the experience by block face for an entire city. The development of a measure that is appropriate for Fort Worth was based on urban design literature and the City's existing data. Future ground-truthing could help adjust variable weights to improve PEI analysis results.

While scoring criteria for several variables are in absolutes (speed limit thresholds, block length, etc.), factors like building setbacks, number of addresses, and driveways are scored relative to all other block faces in the City. For building setbacks, the appropriate setback for walkability is dependent on land use and other factors that this analysis did not consider. For number of addresses and driveways, the literature is not clear on what thresholds are appropriate for absolute scoring criteria, so relative values were used. In the long term, the implication of using relative values is that as block faces improve in absolute terms, they may not improve in relative terms if other block faces improve more.

Future Improvements

Field measurements of building setbacks, completion of the City’s tree canopy dataset, and considering absolute measures instead of relative measures would improve the PEI analysis in the future.