APPENDIX C: Crosswalk Improvement Evaluation Details

At existing or proposed crosswalks without existing stop sign or signal control, potential improvements were evaluated based on guidance in the Federal Highway Administration's (FHWA) recent publication, "Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations", dated July 2018. Table 1 of this publication, reproduced herein also as **Table C1**, includes enhanced guidance on countermeasures that can or should be considered for uncontrolled crosswalks with various combinations of vehicular speed, traffic flow, and number of lanes to be crossed. This appendix describes how the consultant team used Table C1 to produce consistent recommendations for crosswalk improvements, as well as how roadway speed and daily traffic volume data required as inputs to the process were estimated where otherwise unavailable.

In the reproduction of Table 1, red boxes have been added to highlight an example crosswalk to illustrate how the table was used for each evaluation. In the example, four-lane undivided roadways with average annual daily traffic (AADT) over 15,000 vehicles/day and speeds greater than 40 miles per hour have up to six potential countermeasures recommended for possible consideration, as indicated by the six one-digit numbers in the lower right cell of the table. The strongest recommendations are indicated by white numbers in solid black circles. The number "1" inside an outlined circle denotes that marked and signed crosswalks should always occur in conjunction with other listed countermeasures. Numbers without circles around them indicate other improvements which may optionally be considered.

In the example, the number "1" in the lower right cell of the table indicates that high visibility crosswalk markings, parking restrictions on the crosswalk approach, adequate lighting levels, and crossing warning signs should all be employed to create a high visibility crosswalk wherever significant pedestrians demand exists or may be anticipated. But the outlined circle around the number "1" in the table indicates that implementation of these countermeasures alone is insufficent due to the high traffic volumes, high speeds, and large number of lanes to be crossed. One or more of the other options should always therefore be implemented.

The other options to be given strong consideration (based on the white number in the dark circle legend) include "Advance Yield Here for Pedestrian" signs (#3), a median pedestrian refuge island (#6), or a pedestrian hybrid beacon (#9). Other candidate countermeasures that may also be considered include curb extensions (#5) and a road diet (#8).

Note that the unavailable options for these circumstances include a raised crosswalk (#2), in-street pedestrian crossing signs (#4), and rectangular rapid-flashing beacons (RRFB's/#7). Where options such as the RRFB are listed as incompatible with context, research had demonstrated that the combination of speed, volume, or crossing distance would render the treatments less than acceptably effective. The footnotes indicate that some options are mutually exclusive of others.

A Microsoft Excel spreadsheet was created to automate Table 1 as a lookup table and quickly produce the list potentially recommended improvements given the inputs entered for each candidate crosswalk improvement location to be considered for the project. The analyst in each case still used engineering judgment to select which countermeasure options would ultimately be recommended, as indicated by the red boxes around items #1, #3 and #9 (but not #6) in the bottom right corner of the table. Notes as to the rationale for each improvement were made. The inputs, options, recommendations, and notes are tabulated in tables found in **Appendix D**.

Table C1: Application of Pedestrian Crash Countermeasures by Roadway Feature

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	❶ 2 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6 7 9	① 5 6 7 9	① 5 6 ❾
3 lanes with raised median (1 lane in each direction)	❶ 2 3 4 5	❶ ❸ 5 7 9	① ❸ 5 ❼ ❾	① 3 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❼ ❾	① ❸ 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❾
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	❶ 2 3 4 5 6 7 9	❶ ❸ 5 6 7 9	① ❸ 5 6 ❾	① 3 4 5 6 7 9	① ❸ 5 6 ❼ ❾	① ❸ 5 6 ❾	① ❸ 4 5 6 7 9	① ❸ 5 6 ❾	① ❸ 5 6 ❾
4+ lanes with raised median (2 or more lanes in each direction)	❶ ❸ 5 7 8 9	❶ ❸ 5 7 8 9	① ❸ 5 8 ❾	① ❸ 5 7 8 9	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 8 ❾
4+ lanes w/o raised median (2 or more lanes in each direction)	❶ ❸ 5 6 7 8 9	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 8 ❾

Given the set of conditions in a cell,

- \# Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1. High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2. Raised crosswalk
3. Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4. In-Street Pedestrian Crossing sign
5. Curb extension
6. Pedestrian refuge island
7. Rectangular Rapid-Flashing Beacon (RRFB)**
8. Road Diet
9. Pedestrian Hybrid Beacon (PHB)**

*Refer to Chapter 4, 'Using Table 1 and Table 2 to Select Countermeasures,' for more information about using multiple countermeasures.

**It should be noted that the PHB and RRFB are not both installed at the same crossing location.

This table was developed using information from: Zegeer, C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey, J. Feaganes, and B.J. Campbell. (2005). Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines. FHWA, No. FHWA-HRT-04-100, Washington, D.C.; FHWA. Manual on Uniform Traffic Control Devices, 2009 Edition. (revised 2012). Chapter 4F, Pedestrian Hybrid Beacons. FHWA, Washington, D.C.; FHWA. Crash Modification Factors (CMF) Clearinghouse. http://www.cmfclearinghouse.org/; FHWA. Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE). http://www.pedbikesafe.org/PEDSAFE/; Zegeer, C., R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, J. Zegeer, C. Lyon, E. Ferguson, and R. Van Houten. (2017). NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. Transportation Research Board, Washington, D.C.; Thomas, Thirsk, and Zegeer. (2016). NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways. Transportation Research Board, Washington, D.C.; and personal interviews with selected pedestrian safety practitioners.

The inputs to the spreadsheet analysis of crosswalk improvements were straightforward for the number of lanes in each case. Posted speed limit was also generally straightforward, though in a few cases with low posted speed limits and high number of lanes (for example, six-lane divided roadways with posted speed limits of 35 mph) a higher prevailing speed was assumed based on engineering judgment and substituted for the posted speed limit.

In many cases, recent AADT volumes for the subject roadways for the crosswalks being evaluated were available from City or TxDOT data. Historic AADT volumes were grown at 2% annually to 2019 and used directly as inputs for the crosswalk countermeasure selection analysis.

In other cases where AADT data was not already available, particularly on collector streets, a "short-cut" method for estimating AADT without collecting new 24-hour traffic counts was developed to balance accuracy with the large amount of data to be collected and the lack of precision necessary to select the appropriate sets of columns in Table C1.

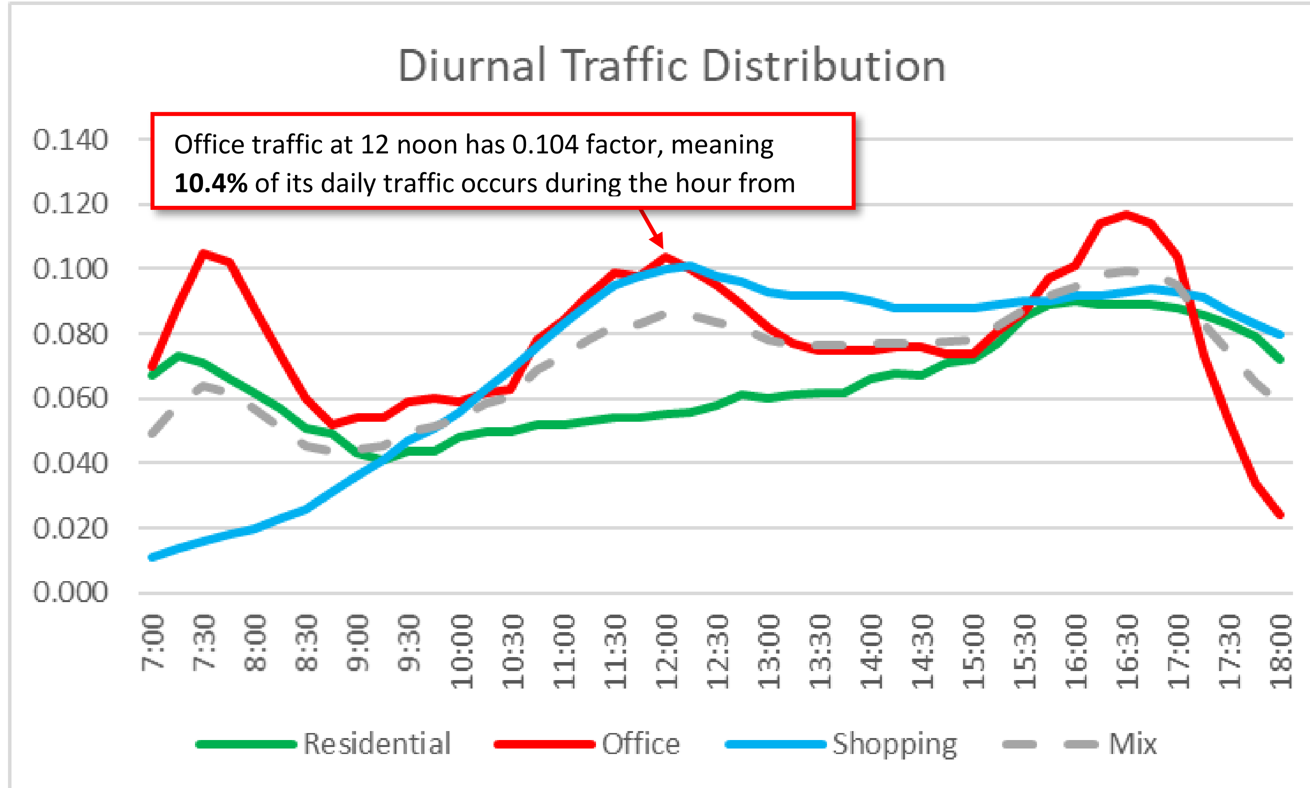
Short two-minute traffic counts were collected by consultant staff in the field at crosswalks that had been pre-selected as candidates for improvements. A two-minute time period was selected to account for the cycle length of most signalized intersections that might be nearby and therefore affect the distribution of traffic volumes. The count could be taken anytime during daylight hours to maximize field work efficiency for multiple locations.

These two-minute volumes were factored by the Excel spreadsheet program to represent approximate AADTs. The two-minute volumes are expanded to hourly volumes by multiplying by 30. The hourly volumes are then expanded to daily volumes using a lookup table based on the 15-minute period during the day that the two-minute count was taken, the adjacent land use category noted by data collection staff, and factors that were derived from data in the Institute of Transportation Engineers' (ITE) *Trip Generation Manual*, 10th Edition for the percentage of traffic generated by different land uses at different times of day.

For each crosswalk, the analysis characterized the land use contributing to traffic at a particular crosswalk as residential, office, shopping center, or a mix of the three. **Figure C1** identifies the hourly-to-daily converstion factors derived for each land use by time of day. The "mix" category was computed by averaging the values from the other three land uses.

Note that office traffic has the most distinct "peaks" with the largest percentage of its traffic occuring near morning arrival, lunch hour, and afternoon departure times. Residential traffic peaks in the morning and afternoon without the distinct lunch peak, while generally increasing in the afternoon. Shopping center traffic is very low in the morning, with higher levels in the afternoon and evening.

Figure C1: Hourly to Daily Traffic Conversion Factors, by Land Use & Time of Day



To convert from hourly to daily traffic, the hourly total was divided by the selected conversion factor to get a daily traffic estimate. For example, a two-minute count of 40 vehicles taken at noon across an uncontrolled crosswalk near a large office building would first be converted to an hourly volumes of 1,200 vehicles/hour (=40 x 30). Then, the hourly volume would be converted to a daily volume by dividing 1,200 vehicles/hour by the 0.104 factor selected from Figure 7 to yield ~11,540 vehicles/day.

Note that daily traffic volume estimates derived in this way are not assumed to be accurate enough for most traffic analysis purposes, but were assumed to be valid for planning-level purposes such as selection of the appropriate columns in Table C1.

In cases where road diets were recommended, the consultant team compared the City/TxDOT AADT or estimated daily volume and the proposed number of lanes for the roadway with the maximum service volumes assumed per lane in NCTCOG's Dallas-Fort Worth Regional Travel Model, shown in **Table C2**. Road diets were only recommended if roadways would likely still have excess capacity after the lane reductions.

Table C2: NCTCOG Roadway Capacity for Divided or One-way Roads

Area Type	Functional Class						
	Freeway	Principal Arterial	Minor Arterial	Collector	Ramp	Frontage Road	HOV
	Hourly Service Volume Per Lane						
CBD	2,050	725	725	475	1,250	725	2,050
Fringe	2,125	775	775	500	1,375	775	2,125
Urban Residential	2,150	850	825	525	1,425	850	2,150
Suburban Residential	2,225	925	900	575	1,600	900	2,225
Rural	2,300	1,025	975	600	1,725	975	2,300