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MEMORANDUM

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To: Chris Comeau, AICP-CTP
Organization: City of Bellingham
From: Michael Hintze, AICP, Brian Almdale
Project: Bellingham Bicycle and Pedestrian Master Plan

Re: Pedestrian Network Analysis Approach

Pedestrian Network Analysis

Toole Design analyzed the existing pedestrian network to measure pedestrian network connectivity throughout the City of Bellingham by conducting a pedestrian Level of Traffic Stress analysis (PLTS) at crossings and a pedestrian network access analysis. Key pedestrian network gaps and barriers will be identified using the results of these analyses and will inform the selection of important network features that will improve pedestrian safety and access to key destinations. This memo provides a brief overview of the two analyses.

Pedestrian Crossing Analysis

The Oregon Department of Transportation (ODOT) has developed a methodology for evaluating the suitability of pedestrian crossings. The framework applies simple logic similar to Bicycle Level of Traffic Stress to the pedestrian environment. The methodology considers basic details including the speed of cross traffic, crossing distance, and mitigating features like signals and refuge islands. The thresholds identified by ODOT result in a PLTS score from PLTS 1 through PLTS 4 representing the following conditions, as described in ODOT's *Analysis Procedures Manual*[1] (PLTS descriptions quoted directly from the manual):

- **PLTS 1**- Represents little to no traffic stress and requires little attention to the traffic situation.
- **PLTS 2**- Represents little traffic stress but requires more attention to the traffic situation than of which young children (defined by ODOT as 10 years of age or older) may be capable.
- **PLTS 3**- Represents moderate stress and is suitable for adults. An able-bodied adult would feel uncomfortable but safe using this facility.
- **PLTS 4**- Represents high traffic stress. Only able-bodied adults with limited route choices would use this facility.

ODOT's manual identifies PLTS 2 as a reasonable target for most situations.[2] The vast majority of residential/local streets will score as PLTS 1. As such, it's recommended that locations at/along collector and arterial roadways are the focus of this analysis.

The criteria to measure PLTS at every crossing (marked and unmarked) for the City of Bellingham will include some modifications to the original ODOT PLTS criteria to better reflect conditions in the Bellingham. As with the

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[1] https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx see Chapter 14 section 5
[2] https://www.oregon.gov/ODOT/Planning/Documents/APMv2_Ch14.pdf section 14.5.3 (page 14-37)

original ODOT methodology, these modifications are informed by FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations and FHWA's Crash Modification Factors (CMF) Clearinghouse.

Key inputs to measure PLTS:

- Street centerline
- Vehicle volumes
- Traffic signals
- Stop signs
- Number of lanes
- Prevailing vehicle speed or posted speed limit
- Pedestrian crossing/refuge islands
- Functional Classification
- RRFBs

Key outputs:

- Map displaying PLTS for every marked and unmarked crosswalk.
- Distance between high-stress crosswalks to the nearest low-stress crosswalk along the same street.

PLTS Assignment Methodology

Unsignalized Crossings

The comfort and safety of a crossing is different for an unsignalized intersection compared with a signal-controlled intersection. The presence of a median refuge, additionally, can impact the comfort and safety of an intersection. The rating tables proposed for this project for unsignalized intersections are separated depending on whether there is a median refuge or not to account for the safety and comfort differentials for users.

Each of the three Base PLTS tables below are based on no additional existing countermeasures at partially-controlled intersections (e.g., the intersecting street is stop-controlled but the street being crossed is not).

Base PLTS for Unsignalized Crossing with No Median Refuge

Prevailing Speed or Speed Limit	Total Lanes Crossed (Both Directions)						
	2 Lanes			3 Lanes			4+ Lanes
	<5,000 vpd[3]	5,000-9,000 vpd	>9,000 vpd	<9,000 vpd	9,000-15,000 vpd	>15,000 vpd	any
25 or less	1	2	3	3	3	4	4
30	2	3	3	3	3	4	4
35	3	3	4	4	4	4	4
40 or more	3	4	4	4	4	4	4

Base PLTS for Unsignalized Crossing with Median Refuge[4]

Prevailing Speed or Speed Limit	Total Lanes Crossed (Both Directions)						
	2/3 Lanes			4/5 Lanes			6+ Lanes
	<5,000 vpd	5,000-9,000 vpd	>9,000 vpd	<9,000 vpd	9,000-15,000 vpd	>15,000 vpd	Any
25 or less	1	2	2	2	3	3	4
30	2	2	2	2	3	3	4
35	2	2	3	3	3	4	4
40 or more	3	3	4	3	4	4	4

[3] VPD = Vehicles Per Day

[4] Note: crosswalk markings and roadside signage are assumed to be included with median refuge.

Base PLTS for Unsignalized Crossing for One-Way Streets

Prevailing Speed or Speed Limit	Maximum Lanes Crossed (per direction)							
	1 Lane	2 Lanes			3 Lanes			4+ Lanes
	any	<5,000 vpd	5,000-9,000 vpd	>9,000 vpd	<9,000 vpd	9,000-15,000 vpd	>15,000 vpd	any
25 or less	1	1	2	2	2	2	3	4
30	2	2	2	2	2	2	3	4
35	2	2	2	3	3	3	4	4
40 or more	3	3	3	4	4	4	4	4

PLTS Adjustments for Unsignalized Crossings

The base PLTS scores account for common countermeasures by applying a downward adjustment depending on the countermeasure. This table should not be interpreted as recommendations for how to treat high stress crossings. These are assumptions that will be used to estimate the likely stress of intersections across the city. This estimation is intended to identify high priority treatment locations. The treatments themselves should be determined by a more in-depth engineering evaluation of an individual intersections.

Treatment	Adjustment
RRFB Assumes high-visibility crosswalk markings and advance yield markings (if appropriate based on FHWA countermeasure guidance) are also provided.	-1
Raised crosswalk Only appropriate on streets that are <30 MPH and <9,000 vpd.	-1
Stop control On the street being crossed. Stop line (stop bar) GIS data can be used to identify these locations. It can be assumed that any street that intersects a street with a higher Street Level classification will be stop-controlled if there is no signal present. For example, where a Street Level 2 intersects a Street Level 3, it is assumed the Level 2 street is stop-controlled and the 1 point deduction to the PLTS score is applied.	-1

Countermeasures can only improve the score by 1 point to a minimum of PLTS 2 regardless of how many are applied. In addition, crosswalk markings and roadside signage are assumed to be included with median refuge and RRFB installations so those adjustments don't apply as separate items. City staff may also apply a manual override at locations where crossings have been improved using other appropriate countermeasures as identified in FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations.

Signalized Crossings

The ODOT methodology does not include detailed guidance for signalized intersections. Following the general principles for unsignalized intersections, the project team proposes to apply ratings to signalized crossings as well.

Because cross traffic is stopped by the signal, the speed and volume of traffic on the street that is being crossed has less influence on the comfort of a signalized crossing. Instead, roadway width and interactions with turning traffic are the primary drivers of safety and comfort at signalized intersections. Presence of turn lanes on the street being crossed and on the intersecting street, permissiveness or prohibition of right-turn-on-red, permissiveness or protection of left turns, and the speed and volume of tuning traffic from the intersecting street are all factors. However, data and computational limitations may prevent many of these nuances from consistently being incorporated into a citywide analysis of this scale.

Base PLTS for Signalized Crossings

Configuration of the intersecting street*	Total Lanes Crossed*				
	2 Lanes	3 Lanes	4 lanes	5 lanes	6+ Lanes
PHB/HAWK at midblock location	1	2	3	3	3
2 Lanes	2	2	3	3	4
3 Lanes	2	3	3	3	4
4 Lanes	2	3	3	4	4
5 Lanes	3	3	4	4	4
6+ Lanes	3	4	4	4	4

The Base PLTS for Signalized Crossings assumes all crossings have pedestrian countdown timers, but DO NOT have refuge islands, no right turn on red restrictions, have protected left turn phases, or leading pedestrian intervals.

The number of lanes includes any turning lanes being crossed. However, the accuracy of this is highly dependent on the quality of data. The CTN has the most complete information about cross sections of all the available street centerline datasets, but information about auxiliary lanes appears to be incomplete. This will impact the accuracy of results. In its place, the assumptions in the Street Configuration Assumptions table at the beginning of this memo will be used to estimate number of lanes at intersections based on Street Level classification. Manual edits may be made by City staff at a later point.

PLTS Adjustments for Signalized Crossing

Treatment	Adjustment	Notes
Pedestrian refuge (island or within median)*	-0.5 (-1 for PHB crossings)	CRF of 31.5% for vehicle-pedestrian crashes.
All-red signal phase**	-1	
No right turn on red**	-0.25	Not well studied from a crash reduction perspective, but believed to decrease stress
Leading Pedestrian Interval**	-0.5	CRF of 13% for vehicle-pedestrian crashes.
Tightened corner radius**	-0.5	Decreases turning speeds.
>20 degree crossing angle**	+0.25	Lengthens crossing.
Protected Left Turn**	-0.5	CRF of 33% for vehicle-pedestrian crashes.

* Data is available and was included in Toole Design's analysis.

** Data availability unknown. Assume this is a manual adjustment available for City staff for later adjustments to the evaluation.

The Base PLTS is adjusted for crossings at signalized intersections that contain certain features that either have demonstrated crash reduction factors (CRFs) or are otherwise considered best practices to lower stress at intersections. These adjustment factors are applied to the base score and use the following protocol:

1. PLTS scores are rounded up. For example, a street with a base PLTS score of 3 that has a leading pedestrian interval will receive a score of 2.5, which would round back up to PLTS 3. To achieve PLTS 2, that crossing would need an additional treatment(s).
2. PLTS scores at signalized intersection can be adjusted a maximum of two points (e.g., the best possible score for an intersection with a base PLTS score of 4 that has all of the treatments listed above) is PLTS 2.

Pedestrian Access Analysis

Pedestrian access was analyzed using the results of the pedestrian crossing analysis, existing trails, sidewalks, and streets without sidewalks that are considered suitable for pedestrians to walk along[5], key destinations, and parcel data. Pedestrian access between every parcel to key destinations will be measured using two routable GIS-based pedestrian networks:

1. **Existing Network** – this represents the existing pedestrian network consisting of sidewalks, trails, and low-stress crossings (results from crossing analysis).
2. **Planned Network** – this represents all features from the existing network and plus the planned pedestrian improvements from the 2012 Pedestrian Master Plan. Crossing improvements from the 2012 PMP were assumed to be low-stress crossings.

Access was measured for both of these networks by determining if parcels are connected to key destinations within a specified network distance. Routing was conducted using the pedestrian network to more accurately measure pedestrian access on each side of the street, rather than using a generalized street centerline.

The analysis calculated how far a pedestrian could travel using the parts of the pedestrian network that are considered accessible under the existing and planned scenarios for each key destination type (urban village, school, high-frequency transit, and all transit). The difference between the existing and planned network distances will be calculated for each parcel to highlight parcels that have significant route detours due to sidewalk gaps, unconstructed trails, and high-stress crossings. A detour was considered if the following criteria were met:

- Parcel was connected under existing and planned scenarios
- Trip length under existing scenario was at least 500 feet in length
- Percent difference between trip lengths under existing and planned scenarios was at least 25%

This analysis will help highlight the impact crossing barriers and missing sidewalks have on pedestrian accessibility to key destinations.

Origins:

- Parcels

Destinations:

- Urban villages (1/2 mile)
- Public Schools (1/2 mile)
- High-Frequency Transit Stops (1/4 mile)
- All Transit Stops (1/4 mile)

Pedestrian Routing Factors

- Presence of sidewalk (existing and planned facilities from 2012 Pedestrian Master Plan)
- Trails/shared-use paths
- Crosswalks (low-stress)
- Planned crossing improvements from 2012 Pedestrian Master Plan
- Unimproved rights of way
- Pathways connecting school entrances to nearby sidewalks

Key Outputs:

- Map for each key destination type displaying pedestrian walksheds measuring existing and planned network accessibility. Key information displayed here will highlight the following:

[5] These roadway types will need to be determined or specific streets that are considered suitable will need to be provided to Toole Design.

    - Parcels accessible to key destinations under existing network
    - Parcels accessible to key destinations under planned network
    - Parcels accessible to key destinations under existing network but require significant detour
- Calculated network distance between parcels and key destinations under existing and planned scenarios assigned to every parcel for each destination type to allow for refining distance thresholds and using various cartographic approaches to convey the results of this analysis.