The City of Hamilton

Hamilton LINC and RHVP Speed Study

Final Report
October 2018

B000915

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Project No. B000915

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1. Background and Introduction

1.1. Background

Lincoln M. Alexander Parkway (LINC) and Red Hill Valley Parkway (RHVP) provide key commuter routes for the movement of people and goods within and across the City of Hamilton. These two highways are prone to congestion and lane-to-lane speed differentials resulting in incidents directly affecting safety and traffic mobility. In addition, the two highways have unique characteristics, being part of the urban arterial highway system, with challenging roadway geometries, including a sequence of curves of relatively small radii along the RHVP, as well as closely spaced interchanges along the LINC. Recently, the City completed a safety and operational performance review of both the LINC and RHVP to identify measures that could potentially improve performance and reduce the number and/or the severity of collisions. One of the recommendations derived from the study was an in-depth review of the operating speed along these highways along with a review of the posted speed limits on the LINC and RHVP.

1.2. Scope of Work

The City initiated this project to establish a reasonable and safe speed limit along both the LINC and RHVP. Road safety can be enhanced through credible posted speed limits that are consistent with the expectations of motorists for a given roadway and surrounding environment. To that end, the following major tasks were undertaken:

- Collect the speed data along the LINC and RHVP;
- Review and evaluate the methodologies for setting speed limits; and
- Select the preferred approach and provide recommendations for posted speed limits based on the observed traffic along the two highways.

A critical component of this project was to review the most recent industry standards, research and best practices relevant to proper speed limit setting, with careful consideration of the specific function, geometry, collision history, and surrounding environment of these two highways. This report summarizes the steps taken to identify recommended speed limits and is structured as follows: first, a literature review was conducted to identify different methodologies for setting posted speed limits. The findings of this review are presented in Section 2 of the report. A tabulated summary of each methodology, including data requirements as well as advantages and disadvantages to each approach is discussed in Section 3. Section 4 presents the recommendations for setting posted speed limits. This is followed by a description of speed data collection and analysis in Section 5. Finally, the recommended speed limits derived from the selected methodologies and field observations is presented in Section 5.4.

2. Methodologies for Setting Speed Limits

The posted speed limit is one of the most popular tools used by traffic engineers and practitioners to manage travel speeds and improve roadway safety. Despite this use, there is no consensus in the traffic engineering community on a single methodology to identify the optimum posted speed limit. A review of the best practices revealed the following four prevalent approaches[1,2]:

- Engineering approach;
- Expert system approach;
- Optimization approach; and
- Safe system approach.

2.1. Engineering Approach

Engineering approaches are widely used in North America and typically involve a two-step process where:

- An initial reference speed is set by considering the 85th percentile speed, the design speed, and/or other criteria; and
- The reference speed is adjusted according to several other factors depending on the methodology used.

Policy on Establishing and Posting Speed Limits on the State Highway System by the Illinois Department of Transportation (IDOT)[3], the Northwestern Speed Zoning Technique[4] and Road Risk Method outlined by Transportation Association of Canada's (TAC) *Canadian Guidelines for Establishing Posted Speed Limits*[5] are the three methodologies mostly used in North America.

2.1.1. Operating Speed Method

Most engineering approaches for identifying an optimum speed limit are based on the 85th percentile speed, expressed as the speed at which 85% of vehicles do not exceed. The procedure is to set the speed limit at or near the 85th percentile speed of the traffic. Adjustments to either increase or decrease the recommended speed limit may be made depending on infrastructure, traffic conditions, roadway safety, and engineering judgment.

The 85th percentile speed approach has widely been used by both agencies and researchers for setting the speed limit because it reflects the collective judgment of majority of drivers as to what a reasonable speed for a given traffic and roadway condition should be[6]. This is aligned with the general policy sentiment that speed limits should not make people acting reasonably into law-breakers. The use of the 85th percentile speed concept is based on the theory that most drivers are

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[1] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).
[2] J.G. Milliken, F.M. Council, et al. (1998). Special Report 254: Managing Speed: Review of Current Practice for Setting and Enforcing Speed Limits [Report], Transportation Research Board, National Research Council, National Academy Press, Washington, DC.
[3] Policy on Establishing and Posting Speed Limits on the State Highway System (2014). Illinois Department of Transportation, Illinois, USA.
[4] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).
[5] Law, V., & Zein, S. (2009). Canadian Guidelines for Establishing Posted Speed Limits, Transportation Association of Canada, Ottawa, Canada.
[6] Forbes, G. (2012). Global Approaches to Setting Speed Limits. In 2012 Conference and Exhibition of the Transportation Association of Canada, Transportation: Innovations and Opportunities.

reasonable and prudent, would like to stay away from collisions, and desire to reach their destination in the shortest possible time[1].

Under the operating speed method, the first step is to set the speed limit at the 85th percentile speed. According to the Manual on Uniform Traffic Control Devices (MUTCD), the speed limit should be within 5 mph (8 km/h) of the 85th percentile speed[2].

While the MUTCD recommends setting the posted speed limits near the 85th percentile speed, the common practice in many jurisdictions is to use engineering judgement through experience with similar roadway conditions to adjust the 85th percentile speed. The following factors can be considered as adjustments[3,4,5]:

- Road characteristics, shoulder condition, grade, alignment, and sight distance;
- The average speed;
- Parking policies and pedestrian activity;
- Access density;
- Roadside development and environment; and
- Reported collision history for at least a 12-month period.

For example, if the collision analysis identifies a roadway segment with a higher than average collision history compared to other similar segments, a reduction in the posted speed limit or other engineering countermeasures should be considered. Another example would be the adjustment due to a limited stopping sight distance. When the stopping sight distance is found shorter than the required minimum value, the observed 85th percentile speed should be adjusted for the purposes of identifying an optimum posted speed limit[6].

Once the adjustments are made on the 85th percentile speed, some jurisdictions recommend that several test runs be made through the area in both directions of travel driving at the selected speeds. These tests highlight any irregularities that may need correction before the speed limit is implemented[7].

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[1] Rawson, C.T. (2015). Procedures for Establishing Speed Zones. Texas Department of Transportation, Texas.
[2] Manual on Uniform Traffic Control Devices. (2009). US Department of Transportation, Federal Highway Administration, Washington DC.
[3] K. Fitzpatrick, P. Carlson, M.A. Brewer, M.D. Wooldridge, and S.P. Miaou. (2003). Design Speed, Operating Speed and Posted Speed Practices, Transportation Research Board of the National Academies, National Cooperative Highway Research Program Report 504, Washington, DC.
[4] Minnesota Department of Transportation. (2012). Methods for Setting Posted Speed Limits, Transportation Research Synthesis, Minnesota.
[5] Establishing Realistic Speed Limits, Michigan Department of Transportation, https://www.michigan.gov/documents/Establishing_Realistic_Speedlimits_85625_7.pdf
[6] Yang, Y. (2006). Optimal speed limit for shared-use roadways, Ph.D. Thesis, New Jersey Institute of Technology, New Jersey, NJ.
[7] Rawson, C.T. (2015). Procedures for Establishing Speed Zones. Texas Department of Transportation, Texas, TX.

The operating speed method has the advantage that a properly set speed limit will provide a realistic expectation of actual vehicular speeds on the roadway. However, the following criticisms were noted in the literature on using the operating speed method[1,2,3]:

- This approach is built with an assumption that the majority of drivers are aware of and select the safest speed. In other words, the safety impact of the operating speed on other road users is not considered and may create an inequity in the safety of different road users and residents; and
- This practice may lead to an upward drift or creep in average operating speeds over time.

Despite wide-spread use of the operating speed method for setting speed limits in North America, there are few jurisdictions that have quantitative criteria for the adjustments to the 85th percentile speed. For example, how much should a speed limit be reduced if there is a high volume of pedestrian traffic on the street? For the most part, the analyst is to use “engineering judgment” to make such valuations. Two notable exceptions to the qualitative procedures are the Policy on Establishing and Posting Speed Limits on the State Highway System by the Illinois Department of Transportation (IDOT), and the Northwestern Speed Zoning Technique, which is a procedure used by several municipalities. These approached are discussed in the following sections.

2.1.2. Illinois Department of Transportation (IDOT)

IDOT has developed the *Policy on Establishing and Posting Speed Limits on the State Highway System*[4], as an engineering guideline to analyze the observed speed distribution of traffic and assist practitioners and local agencies in setting the speed limits on both arterial and highway corridors. The procedure is comprised of the following steps:

Step 1: Establish the Prevailing Speed

The first step in the Illinois methodology is to establish the prevailing speed, as the average of the following three metrics, measured during free-flow traffic conditions:

- 85th percentile speed;
- Average speed; and
- Upper limit of 10 mph (16 km/h) pace. The 16 km/h pace is defined as the 16 km/h range containing the most vehicles.

The prevailing speed is to be rounded to the nearest 5 mph increment, or 10 km/h in the metric system. The prevailing speed can be directly used as the preliminary speed limit. However, in certain cases, a lower altered speed limit may be justified for uninterrupted traffic flow facilities based on the following supplementary investigation.

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[1] Forbes, G. (2012). Global Approaches to Setting Speed Limits. In 2012 Conference and Exhibition of the Transportation Association of Canada, Transportation: Innovations and Opportunities.
[2] Commonwealth of Massachusetts. (2005). Massachusetts Highway Department, Procedures for Speed Zoning on State and Municipal Roadways.
[3] E. Hauer. (2009). Speed and Safety, Transportation Research Record 2103, Transportation Research Board of the National Academies, pp. 10–17.
[4] Policy on Establishing and Posting Speed Limits on the State Highway System (2014). Illinois Department of Transportation, Illinois, USA.

Step 2: Conduct Supplementary Investigations (Optional)

Non-State Highways

For non-state highways, IDOT uses qualitative procedures to make further adjustments. The adjustments consider factors such as high-collision locations, access control, pedestrian, parking presence, and other factors based on engineering judgement. Since both LINC and RHVP are uninterrupted traffic flow facilities, the reduction factors for access control, pedestrians, and parking presence were excluded from this section. The other factors are as follows:

- If the study area is determined to be a high-collision area based on historical collision analysis, the prevailing speed may be reduced by 10%; and
- Normally, isolated curves and turns, areas of restricted sight distances, and no-passing zones, should not to be considered as the basis for alteration of speed limits.

The adjustment factors from the above-note factors are added together to produce a single percentage adjustment.

Interstate Highways

IDOT recommends reviewing the following conditions for interstate highways between 3 km (2 miles) and 16 km (10 miles) to identify potential reductions in speed limit:

1. Locations with a high number of collisions based on historical collision analysis;
2. Segments with an access density of 3 points per 1.6 km (3 points/mile), covering a minimum of two interchanges within the study area. Access density captures the effect of entry and exit ramps for the interchanges along the study area;
3. Segments with the Average Daily Traffic (ADT) above the following thresholds:

Number of Lanes (Both Directions)	Minimum ADT
4 lanes	50,000
6 lanes	75,000
8 lanes	100,000
10 lanes	125,000
12 lanes	150,000
14 lanes	175,000

4. A location with the advisory speed of 30 mph (50 km/h) or less on the exit ramps, where the traffic routinely slows down on the mainline interstate while approaching the exit point;
5. A location where the traffic on exit ramp queues back onto the mainline segment and implementing alternative countermeasures was not successful; and
6. A segment where the travelling speed is less than 40 mph (70 km/h) for at least 4 hours a day[1].

Based on the above conditions, the following adjustment factors are to be considered for interstate highways:

- If conditions 1 **and** 2 are met, a **0.90** adjustment factor may be applied;
- If conditions 1 **or** 2 are met, a **0.95** adjustment factor may be applied; and

[1] This condition should be interpreted with cautious as the posted speed on Illinois interstate highways is 112 km/h (70 mph), which is higher than the posted speed limit of 90 km/h along the LINC and RHVP

- A **0.975** adjustment factor may be applied for each of conditions 3 through 6 that are met.

Step 3: Select Preliminary Speed Limit

The preliminary speed limit is either the calculated prevailing speed (from Step 1), or if the optional investigation was undertaken, it is the prevailing speed, altered by the adjustment factors discussed above (Step 2). Either way, the following rules should be considered for the selection of the preliminary posted speed limit:

- The preliminary posted speed limit is to be rounded to the nearest 5 mph increment, or 10 km/h in the metric system;
- For non-interstate highways, the preliminary speed limit should be within 9 mph (15 km/h) of the prevailing speed or 20% difference, whichever is less; and
- For interstate highways, the preliminary speed limit should be within 15 mph (25 km/h) of the prevailing speed or 25% difference, whichever is less.

Step 4: Violation Check

The final step in the IDOT approach is to review the violation rate due to imposing the preliminary speed limit. To do so, using the collected speed data in Step 1, the 50^{th} percentile speed (i.e. speed median) should be calculated. The proposed speed limit should be either the preliminary posted speed limit or the 50^{th} percentile speed, whichever is greater. In other words, the violation rate based on the proposed speed limit should be less than 50%.

It is noted that differences in posted speed limits between adjacent speed zones should not be more than 10 mph (16 km/h). However, the IDOT policy allows a larger difference provided that adequate speed reduction signs are posted.

2.1.3. The Northwestern Speed Zoning Technique

The Northwestern Speed Zone Methodology[1], developed by the Northwestern University, has been extensively used by several municipalities in North America, including Peel Region[2] and Nova Scotia Department of Transportation and Infrastructure Renewal[3]. The procedure is like the IDOT methodology discussed above, but it considers a wider range of traffic and infrastructure factors including presence of a median, lane widths, vertical alignment, etc.

The procedure consists of two parts: a) minimum speed study, and b) a detailed study. The minimum study is the first step and is always carried out; the detailed analysis is undertaken when unique road or land use characteristics are present along the corridor, necessitating adjustments to the speed limit derived from the minimum study. The details of the procedure are discussed in the followings.

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[1] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).

[2] Labrecque, D. (2011). Speed Limit Revision on Regional Road 50 (Highway 50), 120 Metres North of Bolton Heights Road to Columbia Way - Town of Caledon -Ward 5, Peel Region, http://www.peelregion.ca/council/agendas/pdf/rc-20110908/report-pw-c1.pdf , Accessed 17 June 18, 2018.

[3] Low Posted Speed Limit Study. (2013). Nova Scotia Transportation and Infrastructure Renewal, Nova Scotia, Canada.

Minimum Speed Study

The objective of the minimum speed study is to identify a preliminary speed limit based on the collected speed data, considering physical features of the corridor. This study is comprised of the following steps:

- Determine 85th percentile speed, upper limit of the 15 km/h pace, and the average speed using the collected speed data along the study area.
- Select the justified speed for each of the above three measurements using the values presented in Table 1.

Table 1: Justified Speed Limit based on Speed Data

85th Percentile Speed (km/h)	Upper Limit of the 15 km/h Pace	Average Speed (km/h)	Justified Speed Limit (km/h)
< 34	< 33	< 30	30
34 – 44	33 – 42	30 – 38	40
45 – 54	43 – 52	39 – 48	50
55 – 64	53 – 62	49 – 56	60
65 – 74	63 – 72	57 – 65	70
75 – 84	73 – 80	66 – 75	80
85 – 94	81 – 88	76 – 85	90
95 – 104	89 – 96	86 – 94	100
> 104	> 96	> 94	110

- Compute a weighted average speed limit (SL), using the following equation and round down to the nearest 10 km/h:

$$SL = \frac{3SL_{85} + 3SL_{pace} + 4SL_{ave}}{10} \tag{1}$$

Where:

SL_{85}: Justified speed limit using the 85th percentile speed from Table 1
SL_{pace}: Justified speed limit using the upper limit of 15 km/h pace from Table 1
SL_{ave}: Justified speed limit using the average speed from Table 1

- Select the maximum speed limit (MSL) from Table 2 that will satisfy all three conditions of the design speed, average distance between interchanges, and length of the proposed speed zone.

Table 2: Maximum Speed Limit based on Road Parameters

Design Speed (km/h)	Average Distance Between Interchanges (m)	Length of Proposed Zone (km)	Maximum Speed Limit (km/h)
110	400	1.5	110
100	300	1.0	100
90	250	0.8	90
90	175	0.7	80
70	125	0.6	70
70	100	0.5	60
50	75	0.4	50
50	60	0.3	40
30	45	0.2	30

- The recommended speed limit is the lower of the weighted average (SL) and the maximum speed limit (MSL).

Detailed Analysis

As noted above, the detailed analysis method makes further adjustments to the recommended speed limit derived from the minimum speed study. The analysis is comprised of the following steps:

- Identify the adjustment factors for the following traffic and roadway characteristics from the table listed in **Appendix A**.
  - Access density;
  - Land width;
  - Functional classification;
  - Median type;
  - Shoulder type;
  - Pedestrian activity and sidewalk location;
  - Parking activity;
  - Vertical roadway alignment and number of curves; and
  - Collision rate.
- Add all the adjustment factors together to obtain an Overall Adjustment Factor (OAF).
- Calculate the Multiplier Factor (MF) using the following equation:

$$MF = \frac{100+OAF}{100} \quad (2)$$

- If the MF is greater than 1.25 or less than 0.75, set the value to 1.25 or 0.75, respectively.
- Multiply the recommended speed limit from the minimum speed study by the MF and round to the nearest 10 km/h to produce the recommended speed limit.

2.1.4. TAC Road Risk Method

The road risk method considers the risks associated with the physical design of the road and the expected traffic conditions. The road risk method is like the operating speed method in that a base speed limit is being adjusted by various factors to determine the recommended speed limit. However, the main difference between the two engineering methods is that the operating speed approach uses the 85th percentile speed as the starting point, while the road risk method uses a starting speed limit that is based on the functional classification of the road and land use characteristics.

In Canada, the *Canadian Guidelines for Establishing Posted Speed Limits*[1] published by Transportation Association of Canada's (TAC) is one of the major resources that provides a systematic, consistent, and repeatable process for establishing posted speed limits. According to the guidelines, the recommended posted speed limit evaluation methodology meets the following objectives:

- The posted speed limit is a function of the road classification, function, physical characteristics and engineering factors that influence the level of risk;
- It is applicable to all types of roadways across Canada;
- It is systematic, consistent and repeatable; and

[1] Law, V., & Zein, S. (2009). Canadian Guidelines for Establishing Posted Speed Limits, Transportation Association of Canada, Ottawa, Canada.

- It is simple to use.

The TAC evaluation methodology is illustrated in Figure 1.

Steps in the Evaluation	**Road Classification**					
	Freeway	Expressway	Highway[1]	Arterial	Collector	Local
Identify land use: Urban or Rural	✓	✓	✓	✓	✓	✓
Identify median separation: Divided or Undivided	✓ [2]	✓	✓	✓	✓	✓
Identify road hierarchy: Major or Minor	Not applicable		✓	✓	✓	Not applicable
Identify number of through lanes per travel direction: 1 lane or 2+ lanes	✓ [3]	✓	✓	✓	✓	✓
Identify length of corridor	✓	✓	✓	✓	✓	✓
Identify design speed	✓	✓	✓	Not applicable		
Identify risk level for each evaluation criteria: - Horizontal geometry - Vertical geometry - Average lane width - Roadside hazards - Pedestrian exposure - Cyclist exposure - Pavement surface - Intersection density - Access density - Interchange density - On-street parking	✓	✓	✓	✓	✓	✓
Posted Speed Limit Recommended based on Characteristics of Roadway						

(1) The Highway road class is currently not defined by the GDGCR, (TAC, 1999). It is included in these guidelines to accommodate the practical use of this road class across Canada. More discussion is included in Section 6.3.

(2) It is expected that all freeways are divided.

(3) It is expected that all freeways have 2+ lanes per direction.

Figure 1: TAC Speed Limit Evaluation Process

Starting Speed Value and Risk Score

The TAC methodology establishes a "starting speed value" for each combination of road classification, land use, median separation, hierarchy and number of lanes, and calculates a "risk score" based on several physical characteristics such as road geometry, lane width, pedestrian and cyclist exposure, intersection and access density, etc. The starting speed value is then reduced by increments of 10 km/h depending on the total risk score (i.e. the combination of the risk scores of all physical characteristics). Table 3 provides the base speed limits for different land use and roadway classifications.

Table 3: Base Speed Limits for the Classification and Land Use Combination

Classification	Land Use							
	Rural				Urban			
	Undivided		Divided		Undivided		Divided	
	1 lane per direction	2+ lanes per direction	1 lane per direction	2+ lanes per direction	1 lane per direction	2+ lanes per direction	1 lane per direction	2+ lanes per direction
Freeway	Freeways are typically divided	Freeways are typically divided	A divided freeway typically has 2+ lanes in each direction	Design speed	Freeways are typically divided	Freeways are typically divided	A divided freeway typically has 2+ lanes in each direction	Design speed
Expressway	Design speed	Design speed	Design speed	Design speed	Design speed	Design speed	Design speed	Design speed
Highway	Design speed	Design speed	Design speed	Design speed	Design speed	Design speed	Design speed	Design speed

Road Classification, Land Use and Hierarchy

The road classification referenced in the TAC's posted speed limit guideline is generally consistent with the TAC Geometric Design Guide[1]. From road classification (public lanes, locals, collectors, arterials, expressway and freeways), land use (residential, commercial and industrial) and road hierarchy (major and minor), a facility can be categorized into one of the following groups:

- Urban roads
  - Public lanes (residential or commercial);
  - Locals (residential or commercial/industrial);
  - Collectors (residential or commercial/industrial);
  - Arterials (minor or major);
  - Expressways; and
  - Freeways.
- Rural roads
  - Rural locals;
  - Rural collectors;
  - Rural arterials; and
  - Rural freeways.

The detailed characteristics of each facility in terms of typical traffic volume, design speed, access, vehicle type, average running speed, and other characteristics are provided in the TAC guideline.

Median Separation, Number of Lanes and Length of Corridor

The presence of a median and the number of lanes is another consideration in setting the speed limit. Where the geometric characteristics change through the study segment, those characteristics present for 50% or more of the study segment should be considered.

For a continuously divided roadway, the evaluation methodology can be applied separately for each direction of travel, if there is an interest in possibly posting different speed limits in each

[1] Transportation Association of Canada (TAC). (2017) *Geometric Design Guide for Canadian Roads*. Ottawa, Canada.

direction. This may also be useful in the case where a divided roadway provides one lane in one travel direction and more than one lane in the other direction, or significantly different access conditions or roadside hazards in one direction.

Frequent speed limit changes may overwhelm the ability of drivers and react. It is recommended that a minimum speed zone length of 1,000 m be provided for posted speed limits of 70 km/h or higher.

Evaluation Criteria

As noted in Figure 1, the TAC guideline considers eleven evaluation criteria related to the physical and road-user characteristics of the roadway. In general, the guideline assigns three qualitative risk levels (lower, medium, higher) for most of the evaluation criteria, although it provides quantitative references to assist in the determination of the risk levels. The guideline states that "*the data requirements are intended to be easy to collect and […] detailed counts and a high level of precision are not required and will not add value in the determination of the recommended posted speed limit*". The detailed evaluation criteria, including risk levels and their descriptions are provided in **Appendix B**.

Other Provisions in the TAC Guidelines

The TAC guidelines include the following set of provisions in addition to the core methodology (i.e. starting speed limit and risk score):

- *Speed zone length:* as noted above, a minimum length of 1,000 m is recommended for speed zones at a speed limit of 70 km/h or higher. For slower speeds, speed zone lengths shorter than 500 m should be avoided;
- *Operating speeds:* if there is a significant discrepancy[1] between the recommended posted speed limit and the operating speeds, the reasons for the discrepancy should be identified, reviewed and rectified. A significant discrepancy is usually a result of a road where the risks are not apparent to the driver. Typical causes for this include:
  - the road is being used for a different function than its original intention;
  - the speed limit has been set by a policy (not consistent with the characteristics of the road);
  - the risks that are present along the road have been over-stated;
  - the road has been over-designed compared to its function and the surrounding land use; or
  - the function of the road and its surrounding land use are inconsistent.
- *Transitional speed limits:* the guidelines recommend that the posted speed limit always be consistent with the characteristics of the road. The physical characteristics in the transition zone should be self-explanatory in guiding drivers to lower their speeds; and
- *Engineering judgement:* the decision to adjust posted speed limits based on these guidelines rests with individual road agencies, and sound engineering judgement should always be applied.

[1] For roads posted 70 km/h or less, the 85th percentile speed should be within +/- 10 km/h of the posted speed. For posted speeds 80 km/h or more, the 85th percentile should be within +/- 20% of the posted speed.

2.1.5. New Zealand's Road Risk Method

The Speed Limits New Zealand (SLNZ) method is based on the road risk approach[1] for calculating the speed limits on public roads. The speed limit is calculated using the following information:

- The existing speed limit;
- The character of the surrounding land environment (e.g., rural, fringe of city, fully developed);
- The function of a road (i.e., arterial, collector, or local);
- Detailed roadside development data (e.g., number of houses, shops, schools, etc.);
- The number and nature of side roads;
- Roadway characteristics (e.g., median divided, lane width and number of lanes, road geometry,
- Street lighting, sidewalks, cycle lanes, parking, setback of fence line from the road);
- Vehicle, bicycle, and pedestrian activity;
- Collision data; and
- Speed survey data.

The New Zealand Transport Agency also developed a computer program that is based on the same procedure as the SLNZ.

Like the TAC procedure, the SLNZ method does not consider the operating speed to be a major consideration factor[2]. However, the recommended speed limit based on the road risk method should be consistent with the operating speeds. If the mean speed is over the posted speed and 85th percentile speed is over the posted speed by 10 km/h, additional engineering, enforcement, or educational countermeasures are recommended to reduce the operating speed.

In the SLNZ method, the roadway and roadside data listed above are used to calculate the development and roadside ratings. These ratings are used as inputs to a flow chart to determine the appropriate speed limit. The following steps summarize the SLNZ procedure.

- Step 1: Development Rating:
  - The development rating is based on the frontage development types available on the road segment. For example, an access point with 1 or 2 dwellings has a rating unit of 1 and a hospital has a rating unit of 4. Summation of rating units on all access points for each 100 m section of the road is determined to be the development rating. Readers are referred Table C-1 in **Appendix C** for the development rating units.
- Step 2: Side Road Development Rating:
  - The side road development rating is based on the traffic volume on the side road and the development rating found in Table C-1 on the first 500 m of the side road. The side road rating can be found in Table C-2 in **Appendix C**.
- Step 3: Roadway Rating:

[1] NZ Transport Agency (2003). *Speed Limits New Zealand (SLNZ), Guidelines for Setting Speed Limits and Procedures for Calculating Speed Limits*.
[2] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).

- Roadway rating is calculated by summing the ratings related to pedestrian facilities, cycling facilities, parking facilities, roadway geometry, traffic control type, road classification and land use development. Tables C-3 to C-8 in **Appendix C** present the rating for each of the above-noted criterion.
- Step 4: Average Rating
  - The average rating is calculated by adding the total development and roadway rating for the length of the road being assessed and then dividing by the number of 100 m sections of road.
- Step 5: Speed Limit:
  - In the final step, the speed limit can be determined using the flow charts presented in Appendix C. Three separate charts are available depending on surrounding land use environment, including rural, suburban, and urban settings.

2.2. Expert System

An expert system is developed through the collective knowledge and experience of experts to establish a uniform system for setting speed limit[1]. Typically, an expert system is a computer-based program that contains the accumulated knowledge and experience (knowledge base), and a set of rules for applying the knowledge to each situation (the inference procedure)[2].

The expert system approach includes all the factors covered in the engineering study method. The main difference is the process. The expert system approach makes the factors and the decision rules involved in determining an appropriate speed limit more explicit[3]. The following sub-sections discuss the most common expert systems for setting speed limits.

2.2.1. Victoria Limits (VLimits)

The original expert system for setting speed limits was developed by the Australian Road Research Board (ARRB), for the State of Victoria, Australia. The field data from more than 60 locations were reviewed by a panel of experts to elicit decision rules for determining appropriate speed limits for various road classes and traffic conditions. This expert judgment was reduced to a computer program, VLimits 3.0, which leads the user through a series of question-answer menus that ultimately results in a recommended speed limit for a roadway section. One of the caveats of this approach is that the Australian expert system is hard coded, and the system does not learn with previous experience[4].

Several factors are coded in the VLimits when determining what speed limit might be appropriate for a road section. These criteria include[5,6]:

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[1] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).
[2] Minnesota Department of Transportation. (2012). Methods for Setting Posted Speed Limits, Transportation Research Synthesis, Minnesota.
[3] Committee for Guidance on Setting and Enforcing Speed Limits National Research Council. (1998). Managing speed: review of current practice for setting and enforcing speed limits. National Academy Press
[4] Minnesota Department of Transportation. (2012). Methods for Setting Posted Speed Limits, Transportation Research Synthesis, Minnesota.
[5] Traffic Engineering Manual Volume 3 - Speed Zoning Guidelines. (2017). Victoria State Government, Australia.
[6] Setting speed limits in Victoria, VicRoads, http://vlimits.com.au/, Accessed 27 June 27, 2018.

- Road and road environment, including classification; presence and width of median; presence of service roads; number and type of intersections; vertical and horizontal alignment;
- Surrounding developments, including nature and density of abutting development (i.e. rural, fully or partially built-up, etc.); type of development (e.g. houses, shops, schools, etc.); type and volume of traffic generated;
- Nature and level of road user activity, such as traffic volume; presence and type of public transport; presence of pedestrians and cyclists; heavy vehicles; presence of recreational traffic;
- Collision history;
- Existing operating speeds (i.e. 85th percentile speed); and
- Speed limits on adjacent road sections.

VLimits is a tool to determine a suggested speed limit based on the inputs listed above. New South Wales and Queensland also developed similar version called NLimits and QLimits[1]. Adjustments to the suggested speed limit will generally need to be made to reflect local issues and conditions, including consideration of lower speed limits in areas with pedestrian activity.

Lowering of speed limits should not be used to compensate for sub-standard road infrastructure. The primary response for locations with a high collision frequency and severity should be to identify and implement infrastructure measures that address the specific safety problem. However, where infrastructure improvement options have been exhausted or are not feasible in the short term and current risks are unacceptably high, a reduced speed limit may be appropriate[2].

The most recent version of the system, VLimits v3.0, starts with selecting the land use environment (i.e. fully built-up, partially built-up etc.) and adjust the default speed limit[3] based on the criteria listed above. The flowcharts of the VLimits system for setting the speed limits are presented in **Appendix D**.

In practice, on higher-speed roads, the VLimits system recommends a speed limit that is close to the 85th percentile speed in most cases[4]. The system appears to be most useful on roads where the 85th percentile speed is seen as an inappropriate basis for setting speed limits. Heavily trafficked urban areas with a mix of road users, including cyclists and pedestrians, with heavy roadside activity (e.g., parking, access to businesses) fall into this category. In such cases, the system is likely to recommend a lower speed limit, which is more compatible with the needs of all road users.

[1] Committee for Guidance on Setting and Enforcing Speed Limits National Research Council. (1998). Managing speed: review of current practice for setting and enforcing speed limits. National Academy Press.
[2] Setting speed limits in Victoria, VicRoads, http://vlimits.com.au/, Accessed 27 June 27, 2018.
[3] The default speed limit is 50 km/h in built-up areas and 100 km/h for the outside of built-up areas.
[4] Coleman, J. A., Paniati, J., Cotton, R. D., Parker Jr, M. R., Covey, R., Pena Jr, H. E., ... & Morford, G. (1996). FHWA study tour for speed management and enforcement technology. US Department of Transportation, Washington, DC.

2.2.2. USLIMITS2

In 2012, the Federal Highway Administration's (FHWA) Office of Safety released an updated version of USLIMITS2, a web-based software program designed to assist State and local agencies in setting appropriate speed limits, defined as safe, credible, consistent, and enforceable[1].

The core of USLIMITS2 is a set of decision rules developed with the help of two selected groups of experts: an expert panel that participated in meetings and conferences and a larger expanded panel that responded to questionnaires and surveys. These groups included traffic engineers; law enforcement officials; road safety professionals; and other experienced officials familiar with the setting, enforcement, and adjudication of speed limits for speed zones[2].

Like VLimits, USLIMITS2 was built with the idea of providing a consistent and systematic procedure for setting a speed limit. What differs between VLimits and USLIMITS2, is that USLIMTS2 incorporated lessons learned from previous generation of expert systems in addition to previous research, expert's input from hypothetical case studies, and panel meetings[3].

For the limited access freeways, the USLIMITS2 would require the following input variables[4]:

- Operating Speed: 85th and 50th percentile speeds;
- Section length;
- Annual Average Daily Traffic (AADT);
- Presence/absence of vertical and/or horizontal alignments;
- Current statutory speed limit for this type of road;
- Terrain (i.e. level/flat, rolling, or mountainous);
- Is this section transitioning to a non-limited access highway?
- Number of Interchanges within this section; and
- Historical collision rates, per 100 million Vehicle Miles Travelled (VMT).

The USLIMITS2 program (https://safety.fhwa.dot.gov/uslimits) calculates a recommended speed limit using two approaches, based on a) safety surrogates using roadway characteristics, and b) operating speeds and collisions history. The lower value of the speed limit from the two approaches is reported as the recommended speed limit in the output window. A brief description of these approaches is presented below. The decision rules and algorithm are illustrated in the **Appendix E**.

Approach 1: Safety Surrogates

Safety surrogates are indicators that are associated with any safety hazards on the road segments. For the first approach, the expert panel identified designated ranges of selected characteristics of a

[1] USLIMITS2: A Tool to Aid Practitioners in Determining Appropriate Speed Limit Recommendations, https://safety.fhwa.dot.gov/uslimits, Accessed 28 June 2018.
[2] University of North Carolina. Highway Safety Research Center. (2007). An Expert System for Recommending Speed Limits in Speed Zones. Transportation Research Board. Research Results Digest 318.
[3] Forbes, G. (2012). Global Approaches to Setting Speed Limits. In 2012 Conference and Exhibition of the Transportation Association of Canada, Transportation: Innovations and Opportunities.
[4] User Guide for USLIMITS2. (2017). Federal Highway Administration (FHWA), https://safety.fhwa.dot.gov/uslimits/documents/appendix-l-user-guide.pdf, Washington D.C.

roadway segment as the surrogates. For freeways, safety surrogates include interchange spacing and AADT. The recommended speed limit for limited accessed freeways are as follows[1]:

- If AADT is higher than 180,000 and the average interchange spacing is between 0.5 and 1-mile (800 m and 1.6 km), the recommended speed limit from this approach will be the 5 mph (10 km/h in the metric system) multiple obtained by rounding down the 85th percentile speed.
- If AADT is higher than 180,000 and the average interchange spacing is less than 0.5 mile (800 m), the recommended speed limit is the 5 mph (10 km/h) multiple closest to the 50th percentile speed.
- For other situations in freeways, the recommended speed limit from this approach will be the 5 mph (10 km/h) multiple closest to the 85th percentile speed.

Approach 2: Collision Modules

Collision module is based on collision frequency and severity of the roadway. First, the user is asked to enter the frequency of total and injury collisions. In addition, the user is also asked to enter the average collision rate and the average rate of injury and fatal collisions for similar sections in the same jurisdiction. If data on average rates are not available, the program makes use of average rates calculated with data from 8 States in the US that are part of the Highway Safety Information System (HSIS). Using the average collision rate and the average rate of injury and fatal collisions, the program calculates the following critical collision rate and critical injury rate[2]:

$$R_C = R_a + K\sqrt{\frac{R_a}{M}} + \frac{1}{2M} \tag{3}$$

Where:

$\boldsymbol{R_C}$: critical collision rate

R_a: average collision rate

K: constant associated with the confidence level (1.645 for 95% confidence)

M: 100 million vehicle miles travelled

If the collision or injury rate is higher than the corresponding critical rates or at least 30% higher than the corresponding average rates, the user is asked to indicate if traffic and geometric measures can reduce the total collision and/or injury rate in this section. If the user answers “Yes” to this question, the recommended speed limit from this module will be the 5 mph (10 km/h) multiple closest to the 85th percentile speed. If the user answers “No” or “Unknown”, the recommended speed limit from this module will be the 5 mph (10 km/h) increment obtained by rounding-down the 85th percentile speed (if collision or injury rate is at least 30% higher than the average rate) or closest to the 50th percentile speed (if the collision or injury rate is higher than the critical rate).

As noted above, the expert system does not recommend speed limits higher than the 5 mph (10 km/h) increment closest to the 85th percentile speed; it also does not recommend speed limits

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[1] Bared, J.G., Edara, P., and Kim, T. (2006). Safety Impact of Interchange Spacing on Urban Freeways, Presented at the 2006 Annual Meeting of the Transportation Research Board, Washington, D.C.

[2] Zegeer, C.V., and Deen, R.C. (1977). Identification of Hazardous Locations on City Streets, Traffic Quarterly, Vol. 31(4), pp. 549-570

lower than the 5 mph (10 km/h) increment closest to the 50th percentile speed. The system also provides warnings if the 85th percentile speed is unusually low or high for a road type. The final output window warns the users of any minimum requirements to be advised of such as section length, statutory limit, geometric alignment, collision rate and injury and fatal collision rate.

2.3. Optimal speeds

One scheme to control the societal cost of travel in a transportation network is to identify the optimal speed limit that minimizes the total cost of transportation, including costs of collisions, travel time, as well as fuel consumption, and vehicle emissions[1].

Each of these cost variables was defined as a function of the posted speed limit. Various mathematical models were developed in the literature to formulate the relationship between the cost of collisions and the posted speed limit, including linear regression, Poisson, and Negative binomial models[2]. Also, in the absence of fuel consumption and vehicle emission data, traffic simulation models were developed to estimate the correlation between these parameters and the posted speed limit. Finally, the optimal speed limit was set as the point with the minimum total cost of transportation. This process is visually shown in Figure 2[3]. As shown in this graph, the cost of each societal factor was developed through a mathematical function from available data and the most optimal speed limit is determined through mathematical optimization.

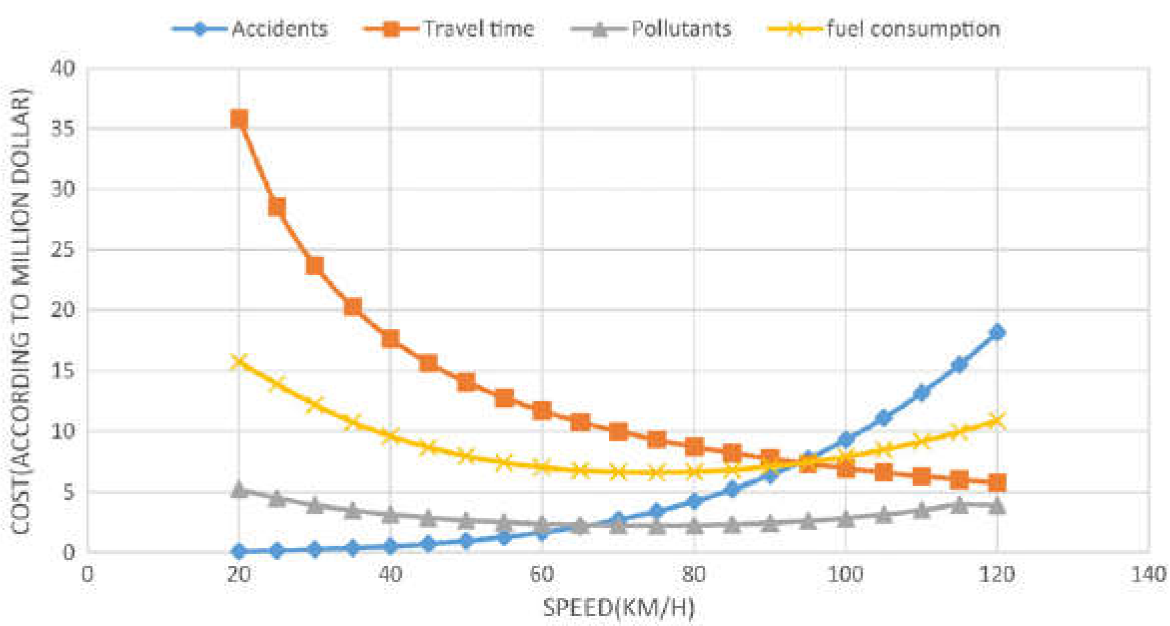


Figure 2: Societal Costs of Travelling in Different Speeds (Optimal Speed: 82 km/h)

[1] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).
[2] Yang, Y. (2006). Optimal Speed Limit for Shared-Use Roadways, Ph.D. Thesis, New Jersey Science and Technology University, Vol. 69, No. 10.
[3] Hosseinlou, M. H., Kheyrabadi, S. A., & Zolfaghari, A. (2015). Determining optimal speed limits in traffic networks. IATSS research, 39(1), 36-41

This method of setting the speed limit was used in the Netherlands, Spain, and Sweden to improve air quality of NO_x and PM_{10} along the freeways[1,2,3]. However, the optimal speed method has been rarely used due to the difficulty in quantifying key variables and the overall complexity of the process. In addition, the optimization models would require a significant amount of data for the development or calibration of various models that are at the core of the system.

2.4. Safe System Approach

The Safe System approach aspires to create a road system in which human error does not result in death or serious injury. The approach accepts that humans will make errors, so collisions will continue to occur. However, humans are physically vulnerable and are only able to absorb limited kinetic energy during a collision before serious injury or death occurs. In other words, vehicles cannot legally travel at speeds where, in the event of a collision, the release of kinetic energy can produce a serious or fatal injury[4].

Australian Transport Council launched the Safe System in 2004 across all state and territory authorities[5]. The approach is composed of four essential and interlinked pillars, including road and roadside infrastructure; vehicles; road users; as well as travel speeds to minimize death and serious injury because of a collision. These pillars form the areas of strategic focus and ongoing improvement. Figure 3 presents an example of a Safe System diagram[6].

Figure 3: Components of the Safe System Approach

[1] M.P. Keuken, S. Jonkers, I. Wilmink, J. Wesseling (2010). Reduced NO_x and PM_{10} Emissions on Urban Motorways in The Netherlands by 80 km/h Speed Management, Sci. Total Environ. 408 (12), pp. 2517–2526.
[2] J.M. Baldasano, M. Gonçalves, A. Soret, P. Jiménez-Guerrero (2010) Air pollution Impacts of Speed Limitation Measures in Large Cities: The Need for Improving Traffic Data in a Metropolitan Area, Atmos. Environ. 44 (25), pp. 2997–3006.
[3] J.M. Baldasano, L.P. Güereca, E. López, S. Gassó (2008). Development of a High-Resolution Emission Model for Spain: The High-Elective Resolution Modelling, Atmos. Environ. 42, pp. 7215–7233 (31).
[4] Langford. (2006). Setting Speed Limits for a Safe System, Monash University Accident Research Centre, http://www.whiteandblack.co.nz/wp-content/uploads/2010/06/9._Setting_speed_limits__16_Nov_06_.pdf, Accessed 3 July 2018.
[5] Jurewicz, C. (2014). Model national guidelines for setting speed limits at high-risk locations. In ARRB Conference, 26th, 2014, Sydney, New South Wales, Australia, No. 1.4.
[6] The Safe System Approach, Safer Roads, Safer Queensland: Queensland's Road Safety Strategy 2015–21, http://roadsafety.gov.au/nrss/safe-system.aspx, Accessed 29 June 2018.

Through a combination of the components in Figure 3 , the Safe System approach aims to design and build a transport system that will protect road users and reduce the number of deaths and serious injuries. This approach shares principles in common with well-known international strategies such as Sweden's Vision Zero and Netherlands' Sustainable Safety approaches[1]. Like the Vision Zero, the Safe System approach requires significant cultural and legislative changes towards traffic and road safety, road design, enforcement, and the education of road users.

A four-step procedure was proposed in the literature to identify the speed limits following the Safe System approach[2,3,4]. The process involves the following four steps:

- Identify the speed limit based on road classification and function in the subject jurisdiction;
- Identify the speed limits, derived from the Safe System principles. Within this context, several studies summarised the biomechanical tolerances of humans for different collision types[5,6,7]. Table 4 presents the maximum survivable impact speeds for various collision types. These human tolerances need to be considered in the management of speed to ensure that in the event of a collision, no road users are killed or seriously injured.

Table 4: Proposed Maximum Travel Speed Based on Biomechanical Tolerance

Type of Collisions	Impact Speed (km/h)
Locations with potential conflicts between pedestrians and vehicles	30
Locations with potential side impacts between vehicles	50
Locations with potential head-on impacts between vehicles	70
Impact with road infrastructure only (roads with no possibility of a side impact or head-on collisions)	100+

The speeds from the assessment above will likely form the lower end of the speed limit. A significant gap may be evident from these first two steps. In other words, the Safe System assessment may suggest that a much lower speed is required than the assessment based on road classification and function.

[1] Vision Zero was introduced recently in North America with several jurisdictions adopting the approach, including Toronto, Peel, Durham, London, Halifax, Kingston, Edmonton, New York, and Washington D.C., and the early results have been very promising.
[2] Jurewicz, C. (2014). Model national guidelines for setting speed limits at high-risk locations. In ARRB Conference, 26th, 2014, Sydney, New South Wales, Australia, No. 1.4.
[3] Turner, B. (2013). Implementing the safe system approach to road safety: Some examples of infrastructure related approaches. In 16th International Conference Road Safety on Four Continents. Beijing, China (RS4C 2013). 15-17 May 2013.
[4] Tingvall, C., & Haworth, N. (2000). Vision Zero: an ethical approach to safety and mobility. In 6th ITE International Conference Road Safety & Traffic Enforcement: Beyond (Vol. 1999, pp. 6-7).
[5] Austroads. (2005). Balance between harm reduction and mobility in setting speed limits: a feasibility study, APR272/05, Austroads, Sydney, NSW.
[6] Tingvall, C., & Haworth, N. (2000). Vision Zero: an ethical approach to safety and mobility. In 6th ITE International Conference Road Safety & Traffic Enforcement: Beyond (Vol. 1999, pp. 6-7).
[7] J. Langford. (2006). Setting Speed Limits for a Safe System, Monash University Accident Research Centre, http://www.whiteandblack.co.nz/wp-content/uploads/2010/06/9._Setting_speed_limits__16_Nov_06_.pdf, Accessed 3 July 2018.

- The third step involves an assessment of a current or future road infrastructure that could be utilized to minimize the risk of collisions. This may involve an improvement or provision of new infrastructure or a lower speed to meet the objectives of the Safe System.
- The final stage of the assessment involves managing political and social impacts, including driver perception of the road environment and the new speed limit strategy. If the operating speed is noticeably higher than the posted speed limit, engineering, educational, or enforcement countermeasures should be implemented to provide incremental safety improvements and support the new speed limit. This might require additional speed management strategies (e.g. narrower traffic lanes, gateway treatments, oversized posted speed signs) to reduce the operating speeds, in combination with a higher presence of enforcement.

The Safe System approach to speed limit setting would result in lower posted speed limits than those traditionally used in most Canadian jurisdictions, as generally set by engineering and expert system methods. Thus, implementing a Safe System approach to the speed limits would be challenging at first due to the likely substantial reductions in posted speed limits. At least in the short to medium term, it is likely that the new posted speed limits will meet with considerable resistance, which in turn will give rise to major compliance issues. Some opposition can also be expected especially from commercial freight operators who are likely to associate any reduced speeds with increased travel times and hence disruptive to existing freight schedules.

To increase drivers' compliance with the new posted speed limits, the following strategies can be followed[1,2]:

- Build a case over time for a new paradigm as to what is regarded and legislated as a safe speed limit for the roadway network;
- Prolonged political and community support will be critical if this new approach is to overcome the issues listed above and is to have an impact on speed setting practices; and
- Education programs alerting motorists to the dangers of speeding may have a role in promoting the benefits of reduced speeds and encouraging more compliance without the need for sustained intensive enforcement.

[1] Forbes, G. (2012). Methods and practices for setting speed limits: An informational report (No. IR-133). Federal Highway Administration (FHWA).
[2] Langford. (2006). Setting Speed Limits for a Safe System, Monash University Accident Research Centre, http://www.whiteandblack.co.nz/wp-content/uploads/2010/06/9._Setting_speed_limits__16_Nov_06_.pdf, Accessed 3 July 2018.

3. Evaluation of Methodologies

Table 5 summarizes each methodology discussed in this report for setting posted speed limits, including the data requirements, advantages, and disadvantages of each approach.

Table 5: Summary of Methodologies for Setting the Speed Limit

Approach	Basic Premise	Data Required	Advantages	Disadvantages
Operating Speed	The speed limit is based on the 85th percentile speed and may be slightly adjusted based on road and traffic conditions and collision history.	• Observed speed data • Road characteristics, shoulder condition, grade, alignment, and sight distance • Parking policies and pedestrian activity • Access density • Reported collisions	• 85th percentile speed reflects the collective judgement of most drivers as to a reasonable speed for given traffic and roadway condition. • ensures that the speed limit does not place a burden on enforcement.	• This practice may lead to an upward drift or creep in average operating speeds over time. • Drivers may not be aware of the impact of their actions and select the most appropriate speed. • Selection of the speed limit based on the 85th percentile speed assumes that most drivers select the safest speed. • Lack of quantitative criteria for the adjustments to the 85th percentile speed.
Illinois DOT	The base speed limit is the rounded average of 85th percentile speed, average speed, and 10 mph pace. The base speed limit may be slightly adjusted based on road and traffic conditions and collision history.	• Observed speed data • Road classification • Traffic volumes • Access density • Collision history	Easy to calculate the quantitative criteria as the adjustments to the 85th percentile speed.	• This method does not consider the roadway geometries such as median presence, lane width and horizontal/vertical alignment in the process. • Selection of the speed limit based on the 85th percentile speed assumes that most drivers select the safest speed.
The Northwestern Zoning Technique	The speed limit is determined through a two-step process where a minimum study determines the base speed and the detailed analysis makes adjustments to the	• Observed speed data • Design speed • Distance between interchanges • Access density	• Using the 85th percentile speed ensures that the speed limit does not place an undue burden on enforcement and provides residents and businesses	• Selection of the speed limit based on the 85th percentile speed assumes that most drivers select the safest speed.

Approach	Basic Premise	Data Required	Advantages	Disadvantages
	speed limit based on the road and traffic characteristics.	• Land width • Functional classification • Median and shoulder type • Vertical roadway alignment and number of curves • Collision history	with valid indication of actual travel speeds. • Comparing to the Illinois DOT method, this approach considers a wider range of traffic and infrastructure factors including the presence of a median, lane width, vertical alignment, etc. • Well-established methodology for setting the speed limit in North America.	
Road Risk Method – TAC	The road risk method considers the risks associated with the physical and road-user characteristics of the roadway without factoring in the operating speed of the facility.	• Road Classification • Land use • Median separation • Road hierarchy • Number of lanes • Length of corridor • Design speed • Road geometry • Pedestrian/cyclist exposure • Pavement surface • Access, interchange and intersection density • Parking presence	• This method aligns the recommended speed limit with the function and design of the road. • It is applicable to all types of roadways. • The automated spreadsheet is simple to use.	• The road risk methods may result in speed limits that are well below the 85th percentile speeds, resulting in a reduced compliance. • No clear direction is provided if there is a substantial discrepancy between the recommended posted speed limit and the operating speeds.
Road Risk Method – Speed Limits New Zealand (SLNZ)	The speed limit policy in New Zealand is a national policy that aims to balance mobility and safety by setting speed limits that are safe, appropriate, and credible for the level of roadside development and the category of road.	• Current speed limit • Observed speed data • The surrounding land environment • Road classification • Roadside development data • Side road characteristics • Vehicle, cycle and pedestrian activity • Collision data	SLNZ is considered beneficial for road segments with a high number of access points to ensure the interruption of traffic flow on mainline is considered.	Highly focused on the roadside development and road environment, meaning this approach best used for urban roadways and rural local and arterial roads. The SLNZ may not be suitable for highways, freeways and expressways.

Approach	Basic Premise	Data Required	Advantages	Disadvantages
Expert System – VLIMITS	As an expert system, the procedure is built as a computer program. A panel of experts reviewed field data to come up with decision rules for appropriate speed limits for different types of roads and traffic conditions.	• Road and road environment • Surrounding developments • Traffic volume • Collision history • Existing operating speeds • Speed limits on adjacent road sections	The system appears to be most useful on roads where the 85th percentile speed is seen as an inappropriate basis for setting speed limits. Heavily trafficked urban areas with a mix of road users, including cyclists and pedestrians, with heavy roadside activity (e.g., parking, access to businesses) fall into this category.	• The assumptions of the VLIMITS are hard coded and users cannot change the coded parameters in the program based on newly available data. • Practitioners may need to rely on output from the expert system without applying a critical review of the results.
Expert System – USLIMITS2	USLIMITS2 is a web-based software program developed by FHWA to assist agencies in setting appropriate speed limits based on results of previous research studies, best practices, and inputs from a panel of experts.	• Operating Speed: 85th and 50th percentile speeds • Section length • AADT • Presence/absence of vertical and/or horizontal alignments • Current statutory speed limit for this type of road • Terrain • Number of Interchanges within this section • Historical collision rates	• USLIMITS2 is easy and simple to use. • Any violation of parameters is noted and shown as a warning message. • Unlike VLIMITS, USLMTS2 incorporated lessons learned from previous generations of expert systems in addition to previous research, expert's input from hypothetical case studies, and panel meetings. • USLIMITS2 considers not only roadway geometry and traffic characteristics in setting the speed limits, but also the observed speed profiles and historical collision data.	• This program does not provide maximum safe speed warnings for adverse alignments. • Based on the information gathered from experts in the US, this program does not recommend speed limits higher than 75 mph.
Optimal Speed Limit	The optimal speed limit is a speed threshold that minimizes the total cost of transportation, including cost of collisions, travel time, as	• Cost model • Collision history • Air pollution data • Delay data • Pedestrian and cycling activity	Provides a balanced approach to setting speed limits that considers different aspects of transportation and the environment as well as	• This method of setting speed limits is rarely used due to the difficulty in quantifying key variables, as well as collecting the required data and

Approach	Basic Premise	Data Required	Advantages	Disadvantages
	well as fuel consumption, and vehicle emissions.		non-motorized road users in setting the speed limit.	developing the prediction models. • Different prospective of optimal speed between drivers and road authorities • The benefits derived from the optimal speed limit may not be evident to all road users.
Safe System	The Safe System approach advocates for a safe road system, better adapted to the physical tolerance of the users. Speed limits are set according to the collision types that are likely to occur, the impact forces that result, and the tolerance of the human body to withstand these forces.	• Collision types for the subject road • Survivability rate for different operating speeds • Roadway classification	• This approach places a high priority on road safety. • The approach considers road and roadside infrastructure, vehicles, road users, as well as travel speeds to minimise death and serious injury collisions. • The Safe System approach is successfully implemented in Sweden and Netherlands.	• Mostly beneficial in urban arterial environments with shared road users including pedestrians and cyclists. • implementing a Safe System approach to speed limits would be controversial and challenging at first due to substantial reductions in speed limits on some roads. • This approach may suggest a speed limit that is not in line with drivers' expectations, and consequently result in reduced compliance.

4. Preferred Methodologies

As noted earlier in this report, there is no consensus in the traffic engineering community on a single methodology for setting posted speed limits. This is evident from the summary of the methodologies listed in Table 5. With careful consideration of the specific functions of the LINC and RHVP, the following conclusions and recommendations were made for selecting a speed limit methodology:

- Optimal Speed Limit:
  - As discussed above, this method for setting the speed limit was used in a few cases in the Europe, aiming to improve the air quality along the freeways. However, due to difficulties in quantifying key variables, as well as collecting the required data and developing the prediction models, this method was not recommended for this project.
- Safe System:
  - The Safe System places a high priority on road safety, and shares principles with the concept of Vision Zero. However, this approach was found to be more beneficial in urban arterial environments with shared road users. It is also noted that the implementation of a Safe System would be challenging in the short-term, due to a substantial difference between the drivers' expectations and the new posted speed limit. Finally, this approach was utilized in a few instances in the Europe, with no examples in the North America. Therefore, the Safe System is not recommended for setting the speed limits on the LINC and RHVP.
- Road Risk Methods:
  - The Speed Limits New Zealand (SLNZ) is not suitable for the LINC and RHVP and this approach was best used for urban roadways and rural local and arterial roads.
  - The TAC approach was simple to use and aligned the recommended speed limit with the function and design of the road. Given the extensive application in different Canadian jurisdictions, the TAC method is selected as one of the methodologies for setting posted speed limits on the LINC and RHVP.
- Operating Speed Methods:
  - Among the three approaches based on operating speed (i.e. the 85^{th} percentile speed method, IDOT, and the Northwestern Zoning Technique), the Northwestern method was found to be more comprehensive, while considering a wider range of traffic and infrastructure factors. In addition, it is a well-established methodology for setting the speed limit in North America. Therefore, the Northwestern method is one of the recommended methodologies.
- Expert System Methods:
  - The VLIMITS expert system was found to be outdated with hard coded assumptions. Instead, the USLIMITS2 was noted in the literature as an easy-to-use tool, while considering roadway geometry and traffic characteristics, as well as speed profiles and historical collision data. This approach was derived from extensive research studies and expert's inputs from hypothetical case studies, as well as panel meetings. Therefore, this method is another recommended method for comparison with the the Northwestern and TAC methods.

In summary, the Northwestern, TAC, and USLIMITS2 methods are chosen as the selected approaches for setting the speed limit. The next section of this report discusses the speed data collection and analysis, followed by the recommended speed limit derived from the three selected approaches.

5. Data Collection and Analysis

5.1. Data Collection

To carry out the speed limit review, traffic data is required along the LINC / RHVP. Figure 4 shows the proposed locations for the speed data collection, following by the justification for these locations as listed in Table 6. The main criteria for the selection of these locations include collision history, geometry of the highway, and our observations in previous projects.

Figure 4: Proposed Locations for the Speed Data Collection

Table 6: Justifications for Selecting the Locations for the Speed Study

Highway	No.	Location	Direction	Justification
LINC	1	At 550 m east of Upper Ottawa Overpass	EB and WB	Start / End of the LINC and outside the interchange influence.
	2	At Upper Wellington Street Overpass	EB and WB	Collisions are broadly distributed along the LINC in both directions. Distance between interchanges is approximately 1.7 km. This location presents the midpoint between Upper James Street and Upper Gage Avenue interchanges.
	3	At 450 m west of Upper Paradise Road Overpass	EB and WB	Area outside the interchange influence

Highway	No.	Location	Direction	Justification
RHVP	1	At 700 m North of Queenston Road interchange	NB and SB	One of the locations with highest collision frequencies along the RHVP, outside the weaving sections.
	2	At 350 m South of King Street East interchange	NB and SB	One of the locations with highest collision frequencies along the RHVP, outside the weaving sections.
	3	At 1400 m south of Greenhill Avenue interchange	NB and SB	Area outside the interchange influence and before the downhill / uphill.

Upon conformation of the locations with the City's project team, the 24-hour traffic data collection was completed using Automatic Traffic Recorder (ATR), placed at 14 selected locations, each associated with one lane of traffic, as shown in Figure 4. The data collection efforts lasted 7 days (including a weekend) from May 24th to May 31st, 2018 and ran continuously at each location. The data includes traffic characteristics such as speed, vehicle classification, and traffic volume. Readers are referred to **Appendix F** for the data summary reports, describing the detailed data collection efforts, including the start and end times, traffic volumes, headway, weather information, as well as average and 85th percentile speeds for each lane of traffic.

5.2. Analysis

In the next step, the acquired traffic data was thoroughly reviewed to ensure compliance with the study dates and locations. As discussed in Section 2, most engineering approaches for identifying optimum posted speed limits are based on the 85th percentile speed during the free-flow traffic conditions. Therefore, the next step of the data analysis was to identify and exclude the peak-period traffic conditions from the original dataset. To do so, it was essential to plot the speed-flow diagrams for each location, during weekdays. Figure 5 provides a schematic speed-flow diagram. In this figure, the purple dashed line represents the approximate fitted curve with the speed-flow data.

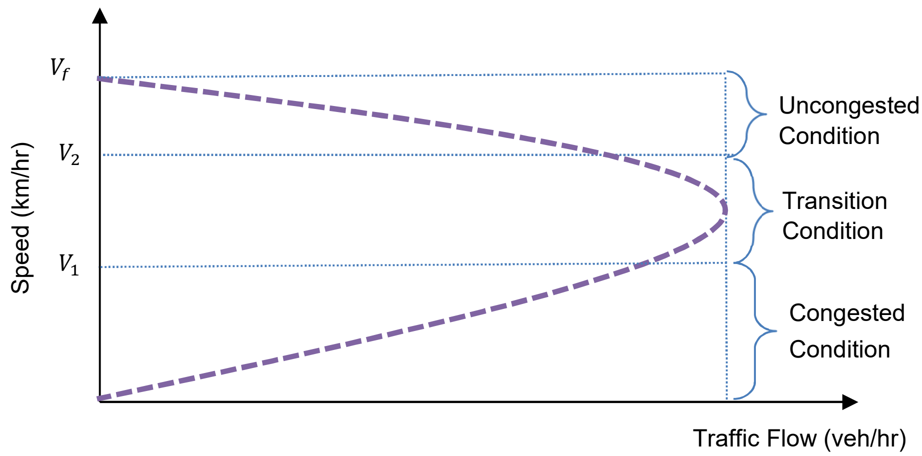


Figure 5: Congested, Transition and Uncongested Traffic Conditions

As shown in Figure 5, the traffic congestion occurs under the following three regimes:

- Congested conditions, when standing queues were present;
- Uncongested conditions, when traffic was travelling at or near free-flow speeds (from V_2 to V_f); and
- Transition conditions, when traffic flow conditions were moving between the congested and uncongested conditions or where queues were repeatedly forming and dissipating.

In this project, the speed-flow diagrams were plotted for each location. The uncongested traffic condition was then visually set as the threshold where slight increases in the traffic volume results in noticeable changes in the traffic speed. As an example, Figure 6 presents the speed-flow diagram for one of the ATR locations on the RHVP. According to this figure, the threshold speeds for the congested and uncongested conditions are approximately 40 km/h and 80 km/h, respectively. Based on these speed values, the uncongested traffic conditions were separated and carried forward for further analysis.

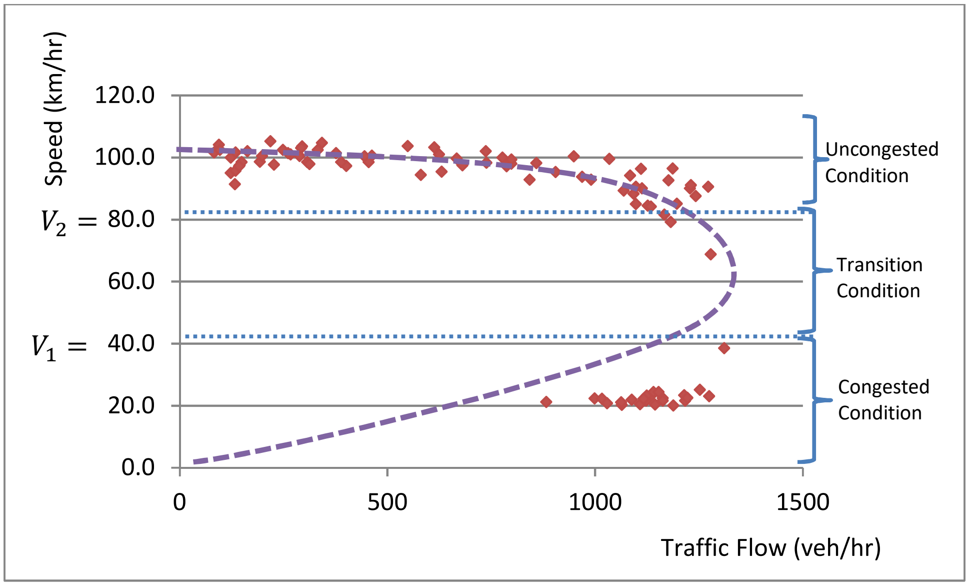


Figure 6: Example Speed-Flow Diagram

Based on the approach discussed above, the 85th percentile speed, average speed, and 10 km/h pace were calculated for each location and direction of traffic (Table 7).

Table 7: Summary of Speed Data During Free-Flow Traffic Conditions

Highway	No.	Location	Direction	85th % Speed	Average Speed	10 km/hr Pace
Lincoln Alexander Pkwy	#1	West of Dartnall Rd	EB	92	89	80 – 90
			WB	93	90	80 – 90
	#2	West of Upper Wentworth St	EB	94	91	84 – 94
			WB	92	90	82 – 92
	#3	West of Upper Paradise Rd	EB	95	92	82 – 92
			WB	91	88	78 – 88
Red Hill Valley Pkwy	#1	South of Barton St	NB	90	88	80 – 90
			SB	92	90	82 – 92
	#2	South of King St	NB	97	95	86 – 96
			SB	95	93	84 – 94
	#3	North of Mud St	NB	103	100	92 – 102
			SB	99	96	88 – 98

As is apparent from Table 7, the average and 85th percentiles speed values were found to be close to one another during off-peak periods. Furthermore, as noted in the TAC Guideline for Defining and Measuring Traffic Congestion[1], many jurisdictions in Canada select the posted speed limit plus 10 km/h an as indication of free flow speed. A review of the speed data in Table 7 confirms similar observations for these two highways. In other words, one can conclude that the traffic was traveling at, or slightly above, the posted speed limit of 90 km/h along both highways. Having said that, it is essential to apply the selected approaches for setting the speed limit and identify the recommended posted speed limit based on other adjustment factors.

5.3. Study Findings

The objective of this section of the report is to present the recommended speed limit values derived from each of the three selected methodologies, namely TAC, Northwestern, and USLIMITS2.

5.3.1. TAC Road Risk Method

As discussed in Section 2.1.4, the posted speed limit from the TAC method is a function of the road classification, function, physical characteristics and engineering factors that influence the level of risk. As shown in Table 3, this method is heavily based on the design speed, as the starting point. For both LINC and RHVP, the design speed is 110 km/h, with the estimated total risk score of 19 and 25 for the LINC and RHVP, respectively. The TAC automated spreadsheet assigned a weighting factor to each of the evaluation elements listed in Figure 1. Based on the calculated level of risks, the posted speed limit of 110 km/h was recommended from the TAC methodology. The outputs of the TAC method and the risk levels are presented in **Appendix G**.

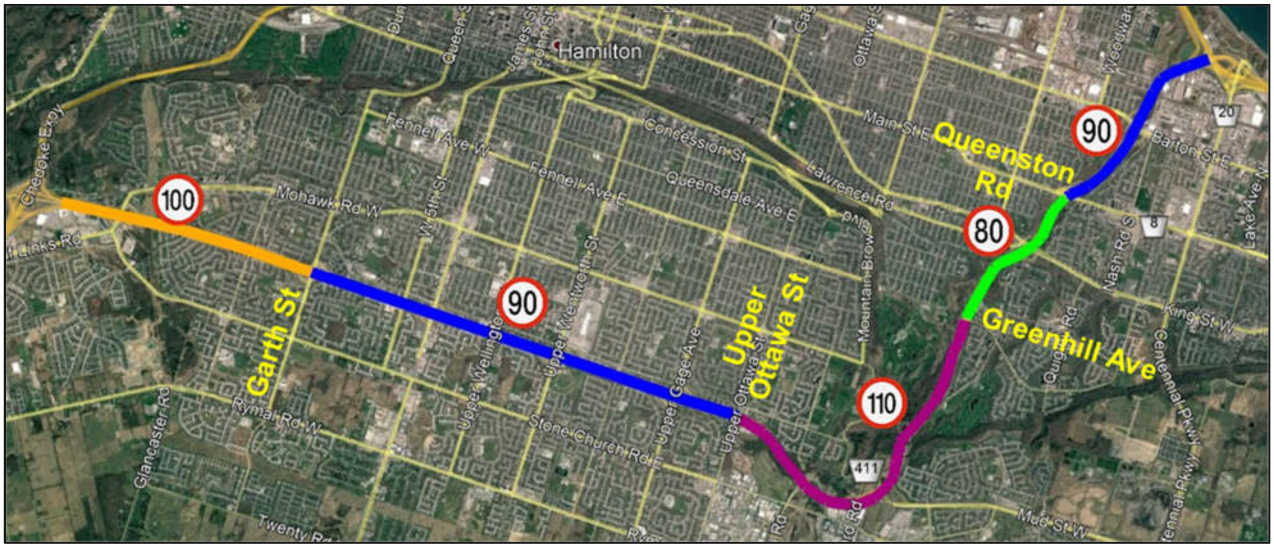
The above observations were as expected from this approach since the observed traffic data is not one of the input variables. In addition, the existing physical characteristics of these two highways did not impose any high level of risks, based on risk descriptions provided in the TAC guidelines.

5.3.2. The Northwestern Speed Zoning Technique

The Northwestern approach identified the speed limit through a two-step process where a minimum study determines the base speed and the detailed analysis makes adjustments based on the road and traffic characteristics. The input parameter and the adjustment factors can be found in **Appendix H** for all study locations. Figure 7 shows the proposed speed limits along the study corridors.

[1] Guidelines for Defining and Measuring Urban Congestion. (2017). Transportation Association of Canada (TAC), Ottawa, Canada

Figure 7: Proposed Speed Limits from Northwestern Speed Zoning Technique



The following observations are based on the results shown in Figure 7:

- On the RHVP, the recommended posted speed limit is 90 km/h from the QEW to Queenston Rd. The lower speed limit of 80 km/h from Queenston Rd to Greenhill Ave was due to high number of fatal and injury collisions compared to other highways with similar characteristics. As expected, due to a higher traffic speed from Greenhill Ave to Upper Ottawa St, and with the addition of the third lane in the southbound direction, the Northwestern approach proposed an increase in the posted speed limit for this section.
- On the LINC, the Northwestern approach confirmed the prevailing posted speed of 90 km/h for most highway sections, except from Garth St to Hwy 403 with the proposed speed limit of 100 km/h. The increase of the speed limit for this section was due to a lower collision rate compared to other similar facilities in Ontario.

5.3.3. USLIMITS2

Based on the input parameters listed in Section 2.2.2, the online tool provided the proposed posted speed limits for different sections of the highways. **Appendix I** presents the speed zoning reports generated for the entire length of both highways. Similar reports were also prepared for the smaller speed zones, as shown in Figure 8.

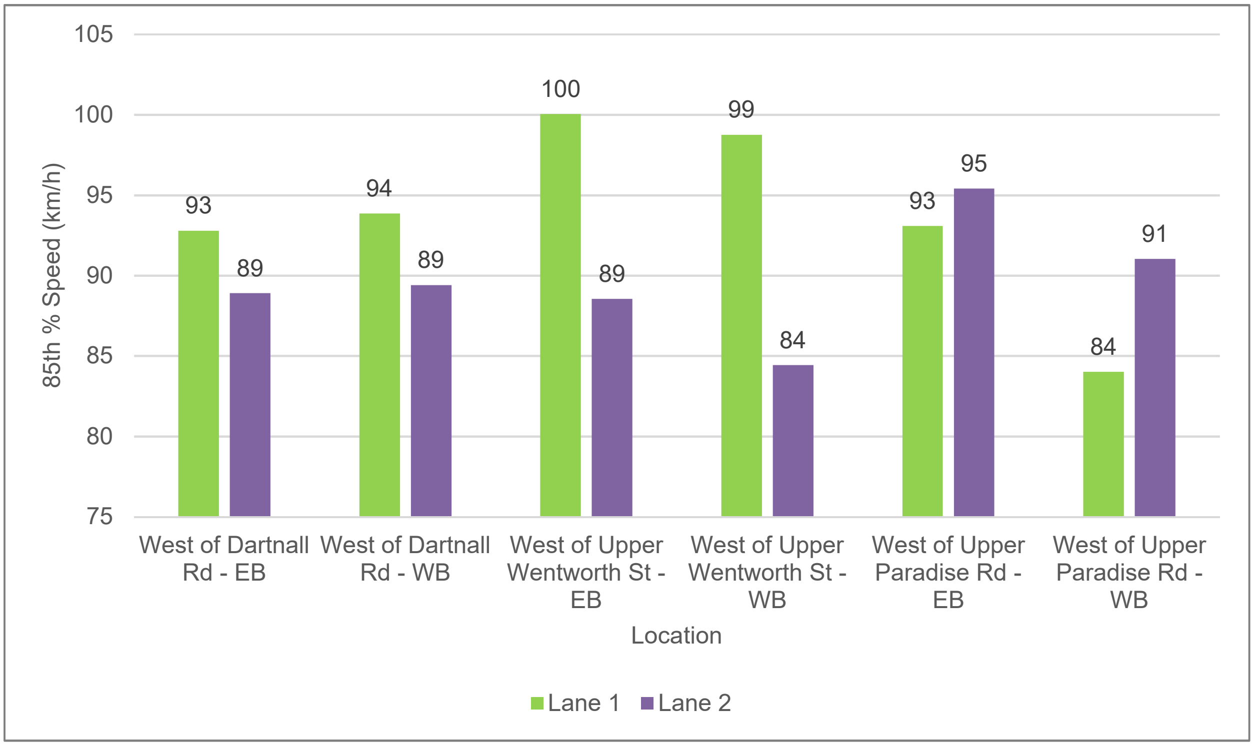
Figure 8: Proposed Speed Limits from USLIMITS2

The following observations are based on the results shown in Figure 8:

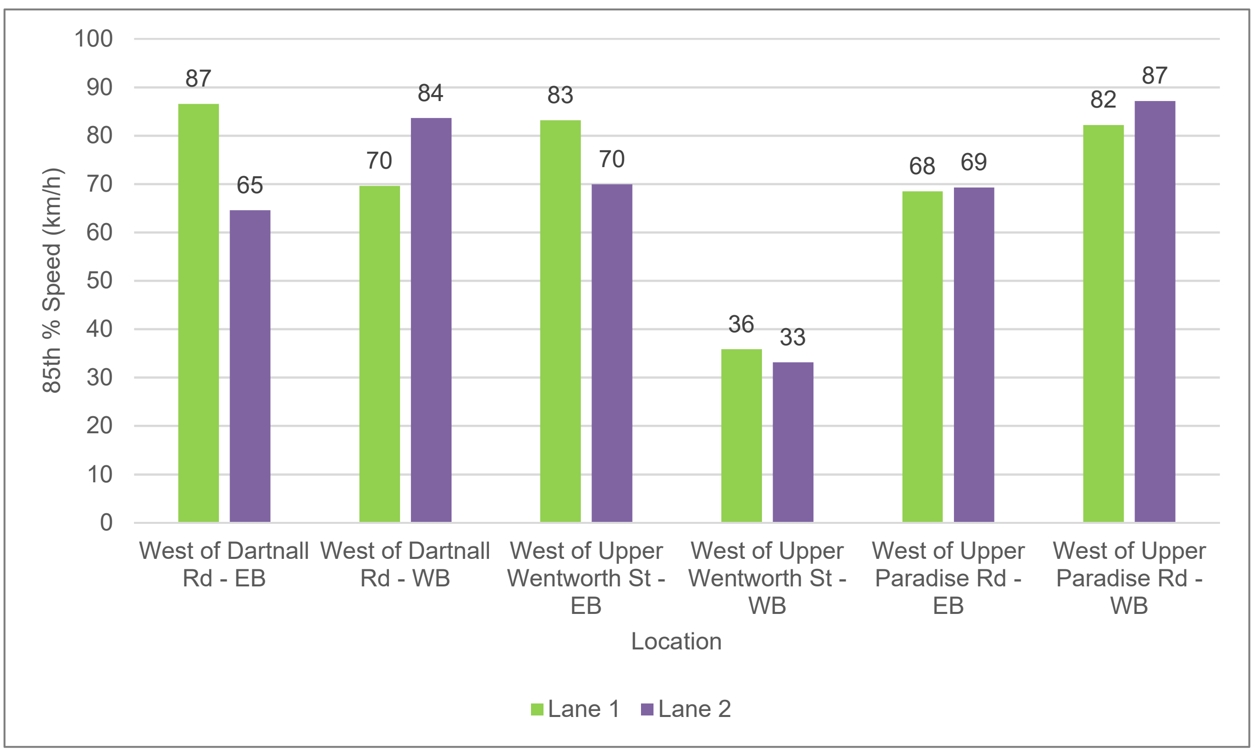
- On the RHVP, the recommended posted speed limit is 90 km/h from the QEW to Greenhill Ave. Like the Northwestern approach, the USLIMTS2 assigned a higher speed from Greenhill Ave to the LINC.
- On the LINC, the USLIMTS2 approach increased the posted speed limit to 100 km/h, except from Dartnall Rd to Upper Gage Ave with the speed limit of 90 km/h.
- In addition to running the online tool for different speed zones, the USLIMITS2 was run for the entire length of the both highways (**Appendix I**). The recommended speed limit was found to be 90 km/h and 100 km/h for the RHVP and LINC, respectively.

5.4. Speed Differentials between Lanes

One of the essential benefits of an optimum posted speed limit is a reduction in speed differentials between traffic lanes, while considering the safety of all drivers. This assessment should be included in setting the speed limit for the two subject highways. Figure 9 and Figure 10 present the lane-by-lane 85th percentile speed values for the peak periods along the LINC and RHVP, respectively. It is noted that the speed differentials analysis was conducted for the AM and PM peak periods, which was found to be more evident when comparing to off-peak periods.

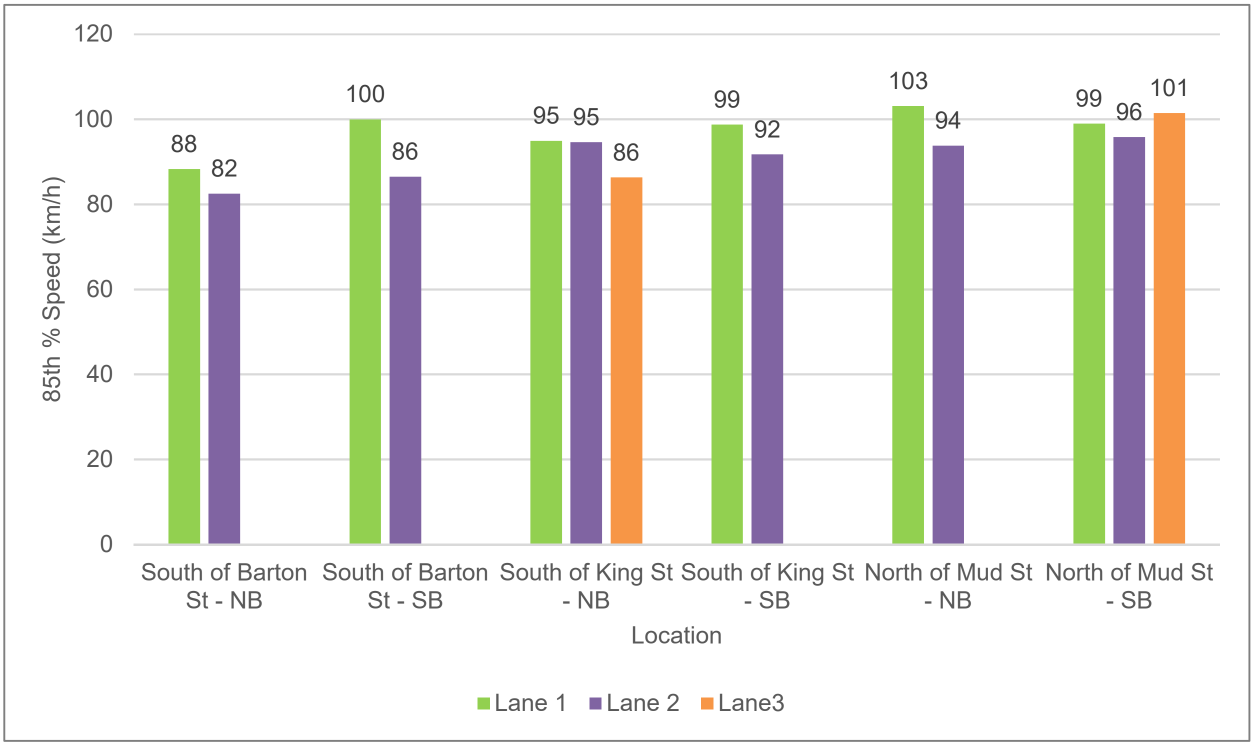


a) AM Peak

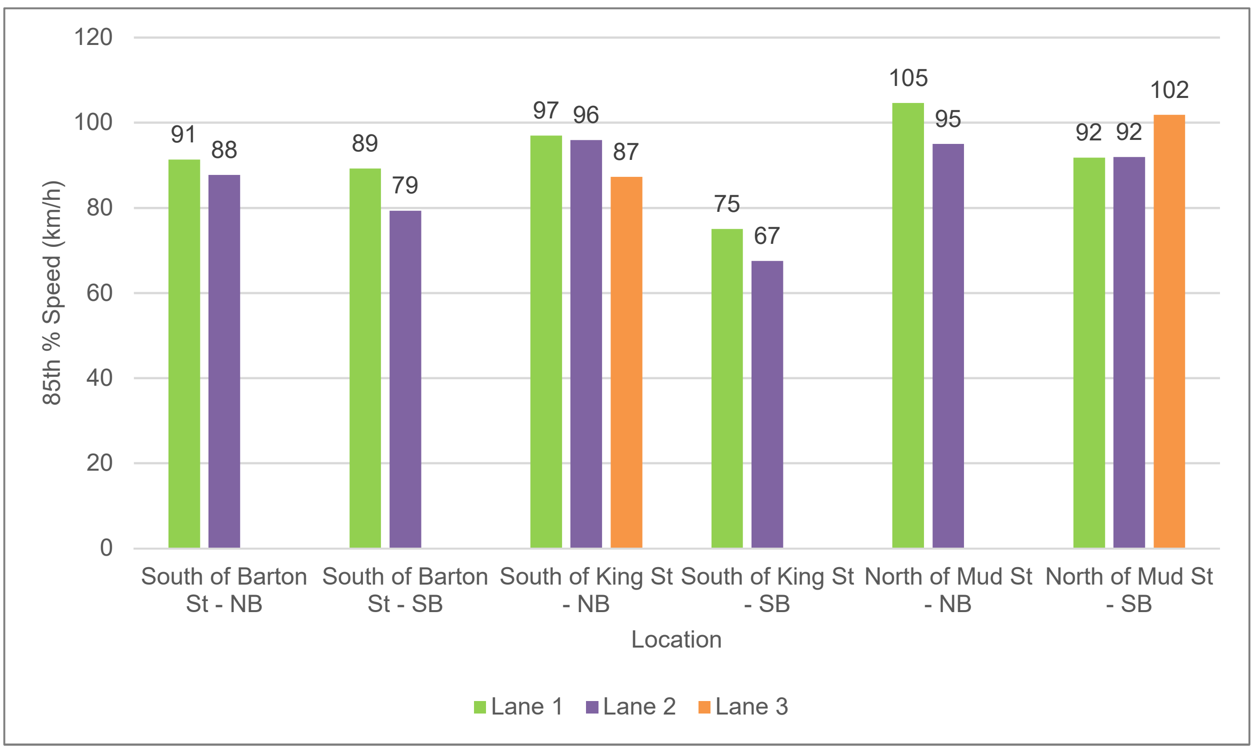


b) PM Peak

Figure 9: Speed Differential between Lanes along the LINC



a) AM Peak



b) PM Peak

Figure 10: Speed Differential between Lanes along the RHVP

In summary, the following observations were made from the above figures:

- During the AM peak period, the speed differentials between the two lanes of traffic were found to be noticeable, especially west of Upper Wentworth St and west of Dartnall Rd for both directions of travel. The speed differentials were less evident for the PM peak period;
- The speed differentials between the traffic lanes were found to be less evident when comparing the RHVP to the LINC, except for the south of Barton St in the southbound direction of travel; and
- The traffic compliance with the existing posted speed was found to be high for the LINC and RHVP, during both peak periods and directions of travel.

The above-noted observations along with the findings on of the speed study listed in Table 7 confirm that drivers along these two highways complied with the posted speed limit. In addition, the speed differential between traffic lanes along the LINC highlight the current challenges for drivers, including closely-spaced interchanges and short acceleration and deceleration lanes, which can cause significant speed differentials between the two lanes of traffic. In addition, any increase in the posted speed limit may create a greater gap in the observed speed between the two lanes, which can consequently increase the risk of collisions along this corridor. A more detailed discussion, leading to the recommended speed limit is provided in the next section.

6. Summary and Recommendation

The purpose of this assignment was to conduct a detailed review of the operating speed along the LINC and RHVP and recommend a safe posted speed, consistent with drivers' expectations. To achieve this objective, a comprehensive literature review was conducted to identify the best approaches for setting posted speed limits. With careful assessment and consideration of the specific function of the LINC and RHVP, three methodologies were selected for setting the speed limit: TAC, Northwestern, and USLIMITS2.

In parallel to the literature review, 24-hour speed traffic data were collected continuously for one week to evaluate the prevailing traffic conditions. A preliminary review of these speed data along both highways revealed that the traffic was traveling at, or slightly above, the posted speed limit of 90 km/h. Similar observations were made during peak and off-peak periods. Having said that, the speed differentials between the travel lanes along the LINC were found to be significant. Consequently, any increase in the posted speed limit may increase the speed differentials and create a bigger safety concern.

The above-noted observations were coupled with the following findings from each of the three selected methodologies:

- The proposed speed limit from the TAC road risk method is 110 km/h for both highways. However, having the same posted and design speed for a corridor would be an uncommon and controversial policy, while creating several operational and safety issues. First, the posted speed limit of 110 km/h is noticeably higher than the operating speeds listed in Table 7, which would be inconsistent with existing drivers' expectations. Second, the posted speed limit of 110 km/h will lead to upward creep in average operating speeds over time. Some drivers will eventually travel faster than the posted speed limit (i.e. design speed), which consequently will impose significant safety concerns to all drivers. It is noted the TAC guidelines acknowledges several provisions to the core methodology, including engineering judgement, which allows roadway agencies to evaluate the recommended speed limit against the prevailing traffic condition and roadway safety.

- On the RHVP, the proposed speed limits from the Northwestern approach suggests zones of 90 km/h, 80 km/h, and 110 km/h (Figure 7). In the USLIMITS2, the recommended speed limits are in zones of 90 km/h and 100 km/h (Figure 8). As discussed above, the speed limit of 110 km/h is not recommended along these two highways. In addition, the variable speed limit zones will create enforcement, operational, and safety issues along both the LINC and RHVP. It is also noted that the proposed speed limit from both approaches were close to the existing 90 km/h. Based on these observations, it was recommended the existing posted speed limit of 90 km/h for the RHVP be maintained.
- Based on Northwestern approach, the proposed speed limit along the majority of the LINC is 90 km/h (Figure 7), while the USLIMITS2 proposes a slightly higher speed limit of 100 km/h (Figure 8). As discussed above, increasing the speed limit on the LINC may increase the speed differentials between the two lanes and create safety concerns. In addition, the traffic was moving at or slightly above the existing posted speed limit. Therefore, and for consistency with the RHVP, it is recommended to keep the speed limit along the LINC as 90 km/h.

A

Appendix A: Northwestern Speed Zoning Technique

The detailed analysis of the Northwestern Speed Zoning Technique requires adjustments to the posted speed limit, based on the following traffic and roadway characteristics:

Access density;
Land width;
Functional classification;
Median type;
Shoulder type;
Pedestrian activity and sidewalk location;
Parking activity;
Vertical roadway alignment and number of curves; and
Collision rate.

Table A-1: Adjustment Factors for Access Density

No. of Driveways per kilometer		Speed Limit from Minimum Study (km/h)								
Non-Commercial	**Commercial**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**
0 – 3	0	+15	+15	+15	+10	+10	+5	+5	0	0
4 – 6	0	+10	+10	+10	+5	+5	0	0	0	-5
7 – 12	1	+10	+10	+5	+5	0	0	0	-5	-5
13 – 21	2 – 3	+5	+5	0	0	0	-5	-5	-10	-10
22 – 30	4 – 5	+5	0	0	0	-5	-10	-10	-15	-15
> 30	> 5	0	0	-5	-10	-10	-15	-15	-20	-20

Table A-2: Adjustment Factors for Lane Width

Lane Width (m)	Speed Limit from Minimum Study (km/h)								
Commercial	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**
< 2.8	0	0	0	-5	-5	-10	-10	-10	-15
2.8 – 3.2	+5	+5	0	0	0	-5	-5	-5	-10
3.3 – 3.5	+10	+10	+5	+5	0	0	0	0	-5
> 3.5	+15	+15	+10	+10	+5	+5	+5	0	0

Table A-3: Adjustment Factors for Functional Classification

Functional Classification (Urban Areas Only)	Speed Limit from Minimum Study (km/h)								
	30	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**
Local	0	0	0	-5	-10	-10	-15	-15	-20
Collector	+5	0	0	0	-5	-5	-10	-10	-15
Arterial	+10	+5	+5	0	0	0	-5	-5	-10
Expressway	+15	+10	+10	+5	0	0	0	0	-5
Freeway	+25	+20	+15	+10	+5	+5	0	0	0

Table A-4: Adjustment Factors for Median Type

Functional Classification	Median								
	None	Flush or Painted		Mountable		Barrier		Depressed Unpaved	
		0.6m – 1.8m	> 1.8m	0.6m – 1.8m	> 1.8m	0.6m – 1.8m	> 1.8m	1.8m – 6.0m	> 6.0m
Local	0	+5	+10	—	—	—	—	—	—
Collector	0	+5	+5	+10	+15	—	—	—	—
Arterial	-10	0	0	+5	+10	+15	+20	—	—
Expressway	—	-10	-5	0	0	+5	+10	+15	+20
Freeway	—	—	-10	-10	-5	0	0	0	0

Table A-5: Adjustment Factors for Shoulder Type and Width

Functional Classification	Shoulder Type			
	None	Turf or Gravel	Stabilized	Paved
Local	0	+5	+10	+20
Collector	0	0	+5	+10
Arterial	-5	0	0	+5
Expressway	-10	-5	0	0
Freeway	+25	+20	+15	+10

Table A-6: Adjustment Factors for Pedestrian Activity

Pedestrian Activity	Sidewalk Setback from Edge of Pavement (m)				
	None	0 – 0.5	0.6 – 2.5	2.6 – 4.5	> 4.5
Age <12					
Heavy	-25	-20	-15	-10	-5
Medium	-20	-15	-10	-5	0
Light	-15	-10	-5	0	0
Age >12 (If none, consider ages over 12)					
Heavy	-10	-5	0	0	0
Medium	-5	0	0	0	0
Light	-5	0	0	0	0
None	0	0	0	0	0

Table A-7: Adjustment Factors for Parking Activity

Functional Classification	Parking Activity			
	No Parking	Low Turnover	Medium Turnover	High Turnover
Local	+10	0	-10	-10
Collector	+10	0	-10	-15
Arterial	+15	0	-10	-15
Expressway	0	-10	-15	-20

Table A-8: Adjustment Factors for Roadway Alignment

Number of Curves per KM with Advisory Speed < Speed Limit from Minimum Study	Vertical Alignment			
	Level	Rolling	Hilly	Mountainous
0	+10	+5	0	0
1	0	0	-5	-5
2	-10	-10	-10	-10
> 2	-20	-20	-20	-20

Table A-9: Adjustment Factors for Collision Rate

Collision Rate as a Percent of Area-wide Rate for Similar Facilities	Adjustment
< 75%	+10
76% – 125%	0
126% – 200%	-10
> 200%	-20

B

Appendix B: TAC Evaluation Criteria

Table B-1: TAC Evaluation Criteria

Evaluation Criteria	Risk Level	TAC Guidelines
Horizontal Alignment (number of curves per km)	Lower	R: < 3; U: < 2
	Medium	R: 3-6; U: 2-4
	Higher	R: > 6; U: > 4
Vertical Alignment (Steep grades on 50% of the road section or more)	Lower	6% grades or more
	Medium	4% grades or more
	Higher	Moderate or flat
Average Lane Width (Comparison to typical roads with same classification)	Lower	Wide lane widths
	Medium	Similar lane widths
	Higher	Narrow lane widths
Roadside Hazards (Frequency of hazards within clear zone)	Lower	R: < 2; U: < 5
	Medium	R: 2-5; U: 5-9
	Higher	R: > 5; U: > 9
Pedestrian Exposure (Usage and facilities)	Lower	Used and separated, or negligible demand
	Medium	Used and adjacent to the road
	Higher	Used and no facilities provided
Cyclist Exposure (Usage and facilities)	Lower	Used and designated facility is provided, or negligible demand
	Medium	Used and wide curb lane/shoulder provided
	Higher	Used and no facilities provided
Pavement Surface (General condition of pavement)	Lower	Good or smooth
	Medium	Fair or rough
	Higher	Poor or unpaved
Number of intersections with public roads	Density of intersections/driveways per kilometer (number of occurrences divided by segment length).	
Number of intersections with private driveways		
Number of interchanges		
On-street parking (Level of permission and/or utilization)	N/A	Prohibited
	Lower	Permitted and rarely utilized
	Medium	Permitted during part of the day
	Higher	Permitted all day
Legend: R: Rural; U: Urban; N/A: Not Applicable		

C

Appendix C: New Zealand Speed Limit Methodology

The detailed analysis of the New Zealand Speed Limit Methodology requires adjustments to the posted speed limit, based on the following criteria:

- Frontage development;
- Side road development;
- Pedestrian facilities;
- Cycling facilities;
- Parking facilities;
- Roadway geometry;
- Traffic control type;
- Road classification; and
- Land development.

Table C-1: Frontage Development Rating Units

Development Type	Frontage Development Description	Rating Unit
A	Property or access point[1] with 1 or 2 dwellings[2]; church; small hall; playground; beach; sports ground; camping ground; holiday cabins; cycle path or pedestrian way that intersects with the roadway	1
B	Property or access point[1] with 3 or 4 dwellings[2]; business or office with fewer than ten employees; small shop; large hall; cinema; small public swimming pool	2
C	Property or access point[1] with 5 or more dwellings[2]; business or office with 10 to 30 employees; general store; takeaway shop; bank; service station; cinema complex; hotel; restaurant; large swimming pool	3
D	Business or office with more than 30 employees; large shop; post office; hospital; tertiary education establishment	4
E	Access point[1] serving two or more developments	1 or 4[3]
F	Primary school or kindergarten	1 for every 15 pupils
G	Secondary School	1 for every 30 pupils

[1] An access point includes a private driveway and a public entrance or exit.
[2] A dwelling includes a house, a home unit in a block, a semi-detached home unit and a motel unit. Each unit in a block of units counts as one dwelling.
[3] When two or more developments other than dwellings, or if dwellings and other developments share a common access point or service road, the correct rating is the greatest of:

(1) the rating for a development type A, B or C according to the number of dwellings served by the access point; or
(2) the highest rating for any one development, other than dwellings, served by the access point; or
(3) the rating determined by treating the access point as a side road and allocating the rating specified in Table C-2.

Table C-2: Side Road Development Rating Unit

Traffic flow on side road (V = vehicles per day)	Side road development rating units according to the frontage development rating (R) on the first 500 m of the side road		
	R < 8	8 ≤ R < 20	R ≥ 20
V < 4000	1	2	3
V ≥ 4000	2	3	4

Table C-3: Pedestrian Facility Roadway Rating

Pedestrian facilities	Pedestrian volume less than 200 per day	Pedestrian volume 200 per day or more
Footpaths behind grass berms or no pedestrian access	0	0
Footpaths adjacent to roadway	0	1
No footpath but useable shoulder	1	2
Pedestrians must walk on roadway	1	3

Table C-4: Cycling Facility Roadway Rating

Cycling facilities	Cyclist volume less than 200 per day	Cyclist volume 200 per day or more
Cycleway behind berms or fence or no cycle access	0	0
Wide road, cycles clear of moving traffic	0	1
Narrow road, cycles impede moving traffic	1	2

Table C-5: Parking Facility Roadway Rating

Parking facilities	Normally two parked vehicles or fewer per 100 metres	Frequent parking on both sides, long duration	Frequent parking on both sides, short duration
Vehicles can park 2 metres from moving traffic	0	0	1
Vehicles park close to moving traffic but do not obstruct it	1	2	3
Parked vehicles obstruct moving traffic, i.e., remaining traffic lane 3 metres or less	2	3	4

Table C-6: Roadway Geometry Rating

Type of Roadway	Shoulder Type		
	Open Visibility	Average Visibility	Limited Visibility
Divided carriageway (solid median or barrier) or one way	0	0	0
4 or more lanes (flush median or undivided)	0	1	1
2 or 3 lanes (flush median or undivided)	0	1	2
1 lane (two way)	3	4	5

Table C-7: Traffic Control Roadway Rating

Traffic control (Applying to traffic on the road surveyed)	Rating units
Pedestrian crossing	3
'Stop' control	3
'Give Way' control	2
Traffic signals	2
Railway level crossing	1

Table C-8: Development Rating

Type of Development	Status of Road		
	Local Road	Collector Road	Arterial Road
Residential	2	1	0
Industrial	1	0	0
Commercial	0	0	0
Rural Residential	1	0	0
Rural	0	0	0

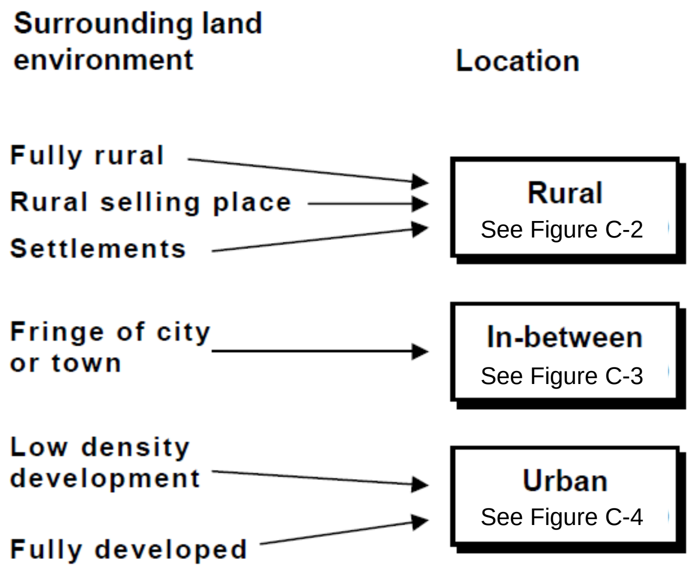


Figure C-1: Determination of Speed Limit Based on Surrounding Land Use

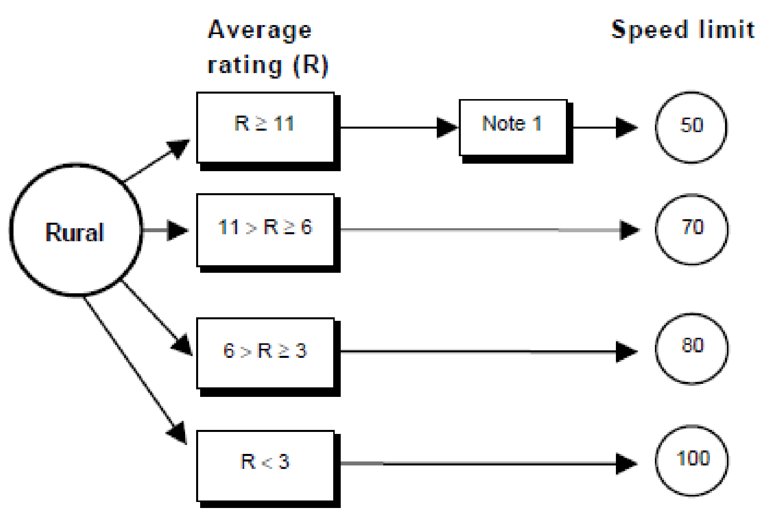


Figure C-2: Speed Limit Flow Chart – Rural

Note 1. The level of development is not consistent with the location of this road. Please check you have used the correct flow chart for the location (see Figure C-1).

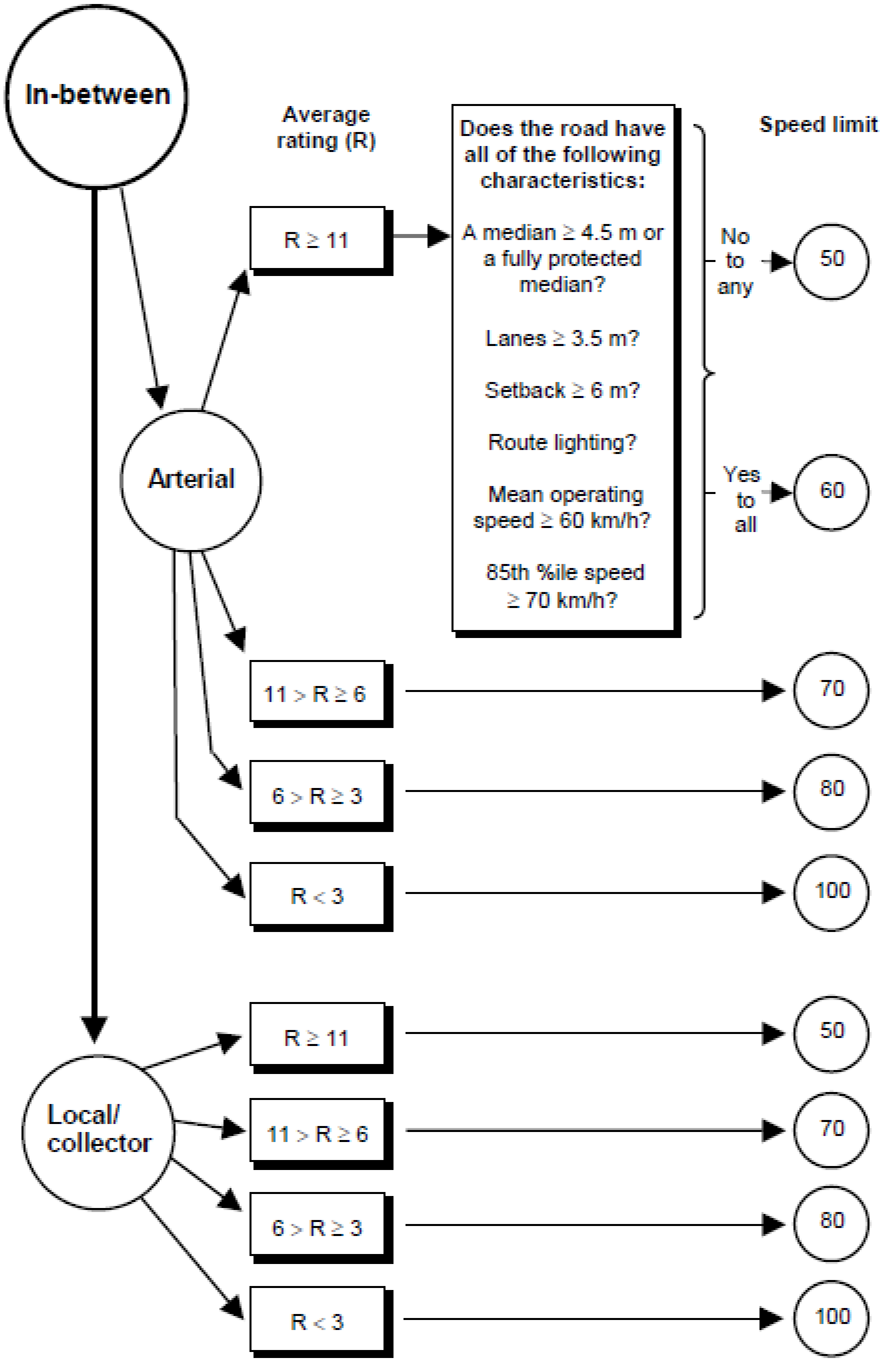


Figure C-3: Speed Limit Flow Chart – In-Between

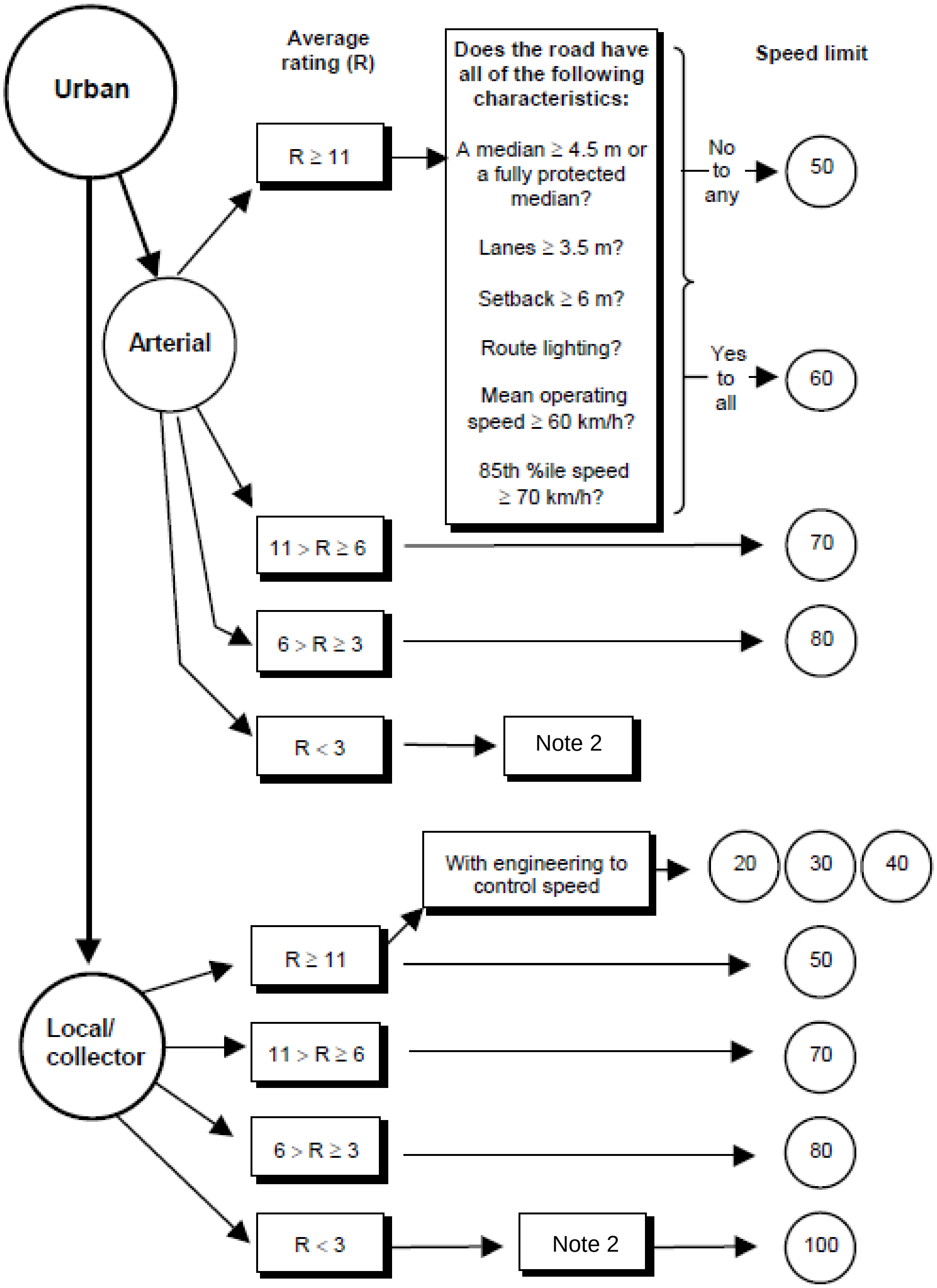


Figure C-4: Speed Limit Flow Chart – Urban

Note 2. The level of development is not consistent with the location of this road. Please check you have used the correct flow chart for the location (see Figure C-1).

D

Appendix D: VLIMITS Process

This appendix was derived from the Traffic Engineering Manual published by VicRoads, the Victoria's Road and Traffic Authority. A summary of the VLimits process are outlined in the followings.

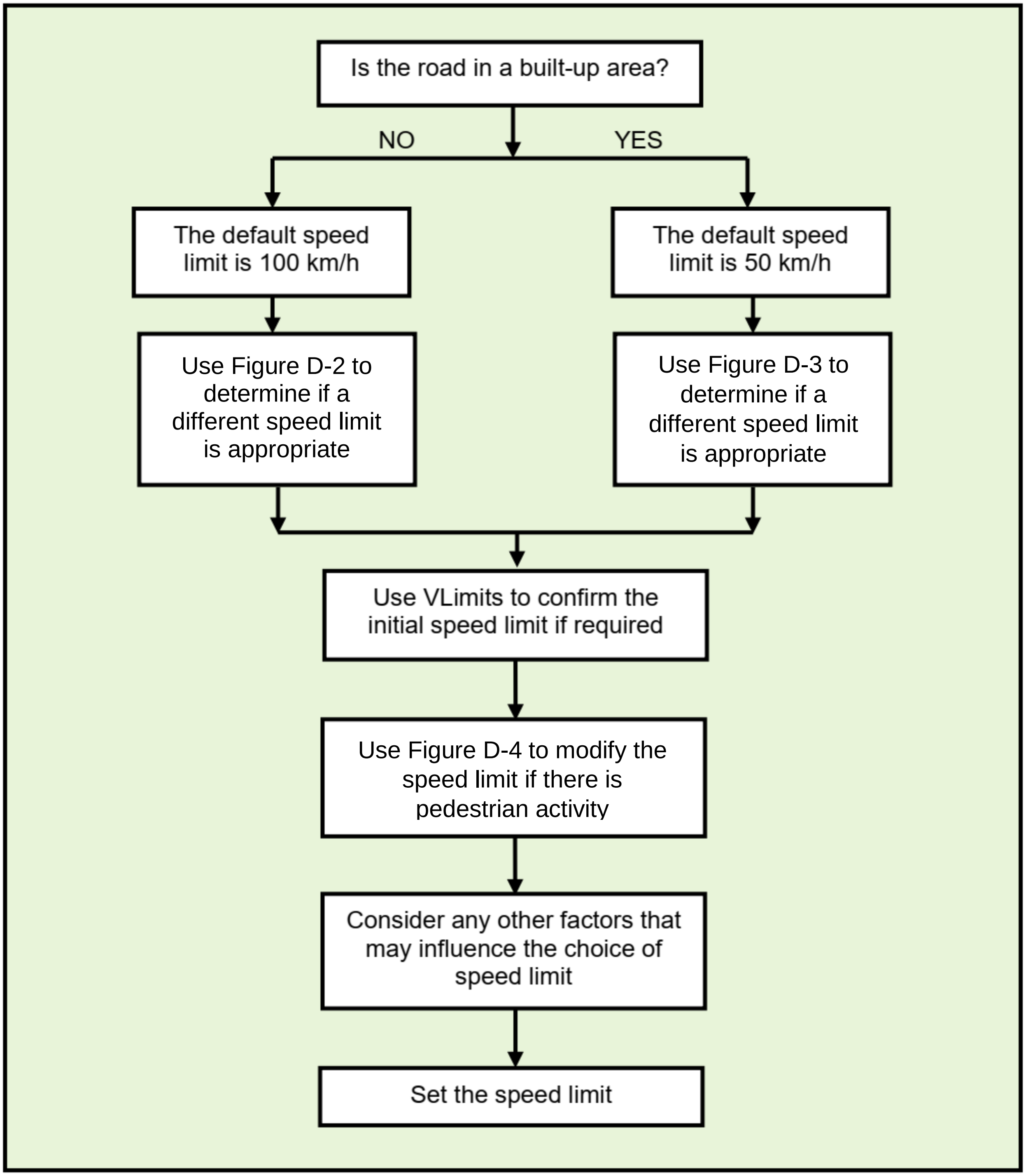


Figure D-1: The overview of Process for Determining Speed Limits Using VLIMITS

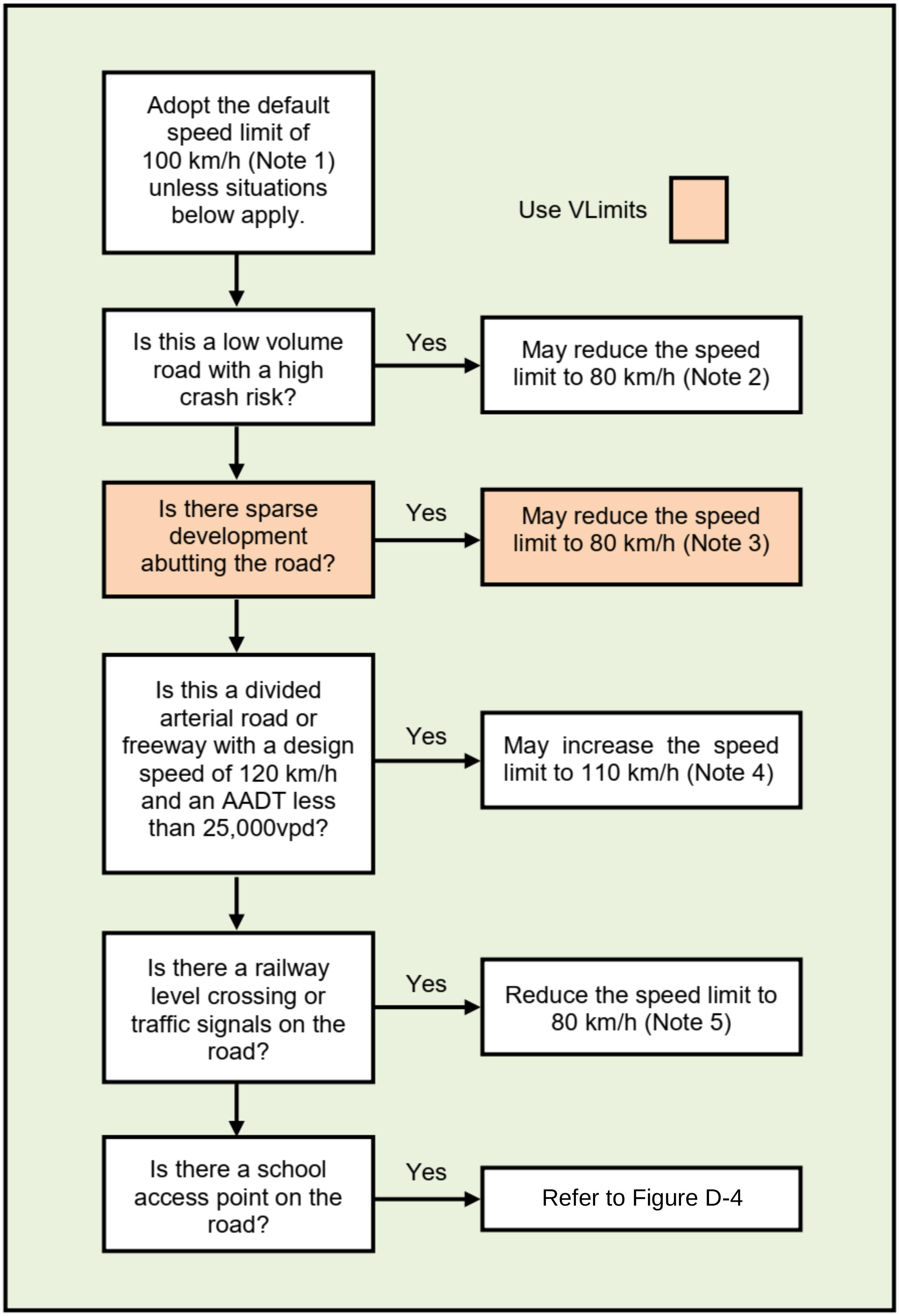


Figure D-2: Process for Determining Speed Limits Outside Built-Up Areas

Notes for Figure D-2

1. The default limit of 100 km/h applies to rural roads with undeveloped abutting land or abutting farmland and no sign-posted speed limit.

   If operation becomes unsatisfactory (i.e. the collision rate is high) and warning signs such as advisory speed signs on curves fail to correct the problem, sections with low standard of alignment and cross-section can be:

   - Investigated for permanent improvements to curve alignment, cross-section, delineation and shoulders
   - Speed limited to a lower value if infrastructure improvements are not possible or practical in the short term.
2. On rural roads, a speed limit of 80 km/h maybe applicable in the following situations:
   - The road carries a low volume of traffic AND
   - Has a low standard alignment and / or cross section AND
   - Has a high collision rate or demonstrated high collision risk but is unlikely to attract funding to make it safer.
3. A speed limit of 80 km/h may also apply to:
   - Undivided arterial roads or local roads in sparsely built-up areas (typically the outer urban / rural fringe) OR
   - Divided or undivided roads in rural areas that have an alignment standard that is just less than 100 km/h and unsatisfactory operation is being experienced (i.e. the collision rate is high) OR
   - Divided or undivided roads in areas of sparse development where traffic signals have been installed (where the default speed limit of 100 km/h would otherwise apply) OR
   - Roads that pass through a hamlet – a small rural settlement with sparsely built-up development.
4. A speed limit of 110 km/h can generally only be applied to the highest standard rural roads. To be eligible, a road must satisfy ALL the following criteria:
   - Perform an interstate or inter-regional transport function AND
   - Be a divided arterial road with a design speed of 120 km/h AND
   - Have full access control AND
   - Have sealed shoulders (highly desirable) and appropriate roadside clear zones AND
   - Have a collision rate not greater than 0.50 fatal collisions per km/year for the latest three years (minimum) to 5 years (desirable).

   Each individual criterion should not be viewed as an absolute warrant but should be considered in combination with others in judging the suitability of road sections for the higher limit.

   An isolated curve that has a 100 km/h design speed would not preclude a section being signposted at 110 km/h, provided that the shoulders are sealed, the curves are adequately signposted and delineated, and the collision history does not indicate a safety problem.

   Some permitted points of access may exist (generally not more than two per km). In general, entry and exit will be by well-spaced interchanges, and ramps signposted to interchange standards in the case of service centres and rest areas. However, some well-spaced, low volume (< 100 vpd) at-grade intersections would not exclude the section if the collision history is satisfactory.

Any hazard (including rigid objects) within the roadside recovery area must be frangible or be shielded by crash barriers.

A 110 km/h speed limit is not appropriate for sections of freeways in or around the general built-up areas of Melbourne or provincial cities where there is a high proportion of commuter trips, relatively closely spaced interchanges (typically < 3 km) leading to complex traffic maneuvers or traffic volumes generally in excess of 25,000 vpd (two-way).

5. Applies at railway level crossings on sealed roads in rural areas. A speed limit of 80 km/h shall generally apply for minimum distances of 400 m on the approach to a level crossing and 100 m on the departure.

   Also applies if there are isolated traffic signals on a rural road. A speed limit of 80 km/h shall generally apply for minimum distances of 400 m on the approach to the traffic signals and 100 to 200 m on the departure.

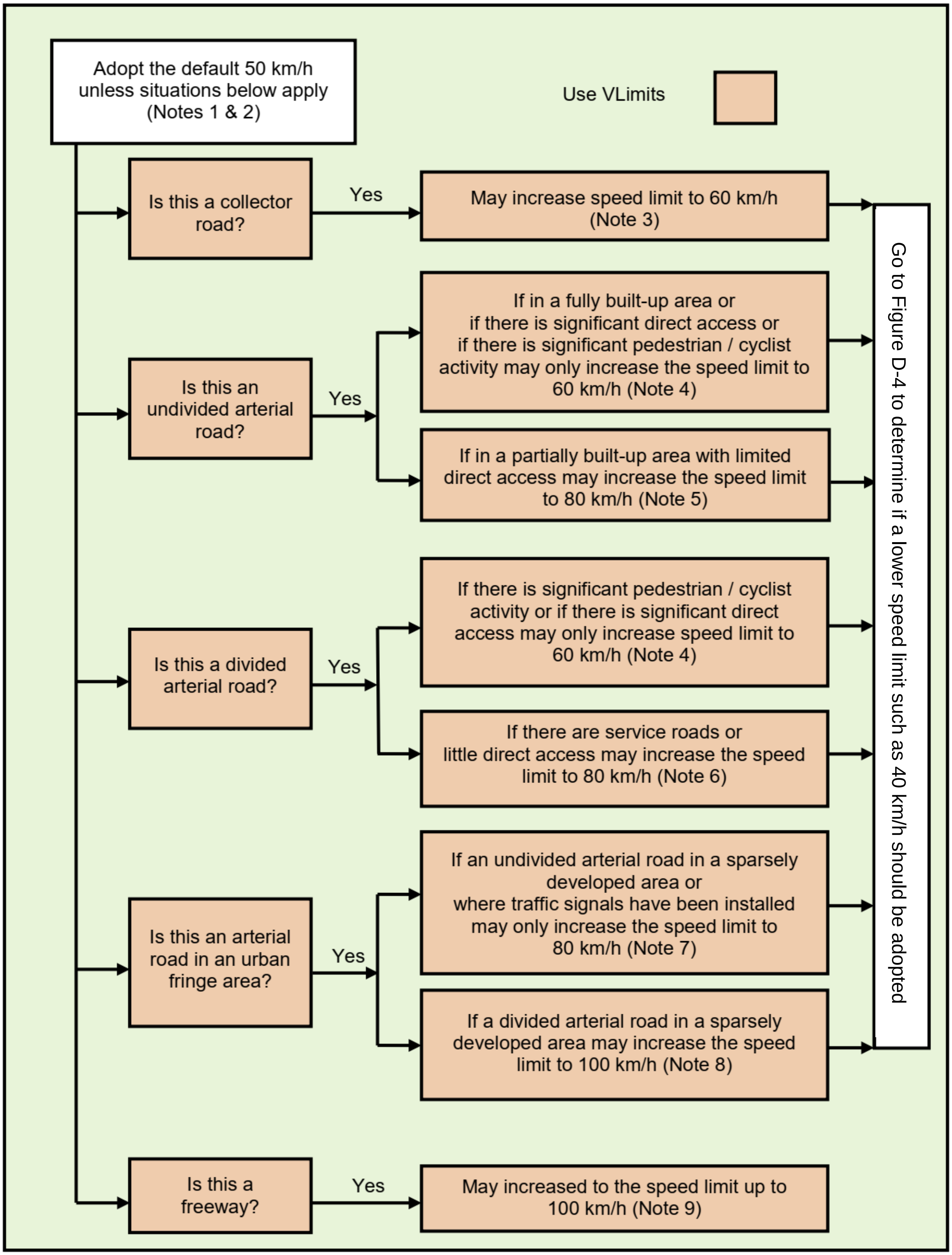


Figure D-3: Process for Determining Speed Limits in Built-Up Areas

Notes for Figure D-3

1. A signposted 50 km/h speed limit should always be used in service roads where the through highways are signposted at a higher level. The signs should be placed on the left side of the service road so that they are not associated with the through highway. However, if signing a service road is likely to cause confusion on the main highway, a 'SERVICE ROAD' supplementary plate should be added below the service road speed limit sign.
2. For the purposes of determining speed limits in built-up areas, a local road that is designated by the relevant municipal council as a traffic route (i.e. a road that performs a traffic function like an arterial road) may be categorized as an arterial road when using Figure D-3 and VLimits.
3. A speed limit of 60 km/h may be appropriate on a collector road (or equivalent higher order local road if this term is not used by a local council) in a built-up area where ALL the followings apply:
   - Appropriate standard of road design and visibility AND
   - Low level of pedestrian and / or cyclist activity AND
   - Insignificant collision history, especially related to pedestrians and cyclists AND
   - Support of the local community and council.

   It is also desirable that the frequency of direct access to properties is less than is generally the case for local streets.

4. A speed limit of 60 km/h applies to undivided arterial roads:
   - In fully built-up areas OR
   - In partially built-up areas where there is a significant level of direct access to the road from abutting properties OR
   - In fully or partially built-up areas where there is a significant level of pedestrian and / or cyclist activity or if there is a history of collisions involving pedestrians and / or cyclists.

   A significant level of pedestrian activity means that there are regular movements of pedestrians across the road such that on most trips a driver would expect to see pedestrians crossing the road. Typical lengths of road include those with abutting land uses that generate significant pedestrian movements but are not continuous or at a density that would justify a 40 km/h zone, those with closely spaced, well patronized bus stops and along tram routes with curbside stops. Lengths of road where pedestrian movements regularly occur away from controlled pedestrian crossings would have a higher priority.

   A significant level of cyclist activity means that on most trips along the road a driver would encounter cyclists that share the road space and may include locations where there is an on-road bicycle lane.

   A speed limit of 60 km/h also applies to divided arterial roads in fully or partially built-up areas where the conditions for a speed limit of 80 km/h are not satisfied (see Note 6).

5. A speed limit of 80 km/h may be appropriate for an undivided arterial road in a partially built-up area where direct access is limited because of the nature and / or density of abutting development or because of access controls. In addition, the level of pedestrian and / or cyclist activity must be low.
6. A speed limit of 80 km/h applies to divided arterial roads in fully developed or partially developed areas if ALL the following conditions exist:
   - A limited number of points of access or controlled access on one or both sides (usually via service roads) AND

- Exclusive right turn lanes at median openings AND
- Little or no pedestrian or cyclist activity.

Also applies in partially developed areas if there is little or no pedestrian or cyclist activity AND:

- There is no access control on either side of the road but there are exclusive turning lanes at all median openings OR
- There is controlled access on one or both sides (usually via service roads), there is partial or no protection for right turn or crossing traffic, and the number of right turn and crossing movements is relatively low OR
- There is a narrow median with few points of access to the main carriageways.

May also apply in fully developed areas where the median is narrow and there is partial or no protection for right turn and crossing traffic provided that:

- There are few points of access to the main highways or there is control of direct access on both sides of the road (usually via service roads) AND
- At unprotected median openings the number of right turn and crossing movements is low.

7. In sparsely built-up areas (typically the outer urban / rural fringe) a speed limit of 80 km/h may apply to:
    - Undivided arterial roads OR
    - Divided or undivided roads where traffic signals have been installed (where the default speed limit of 100 km/h would otherwise apply). In such cases, a speed limit of 80 km/h shall generally apply for minimum distances of 400 m on the approach to the traffic signals and 100 to 200 m on the departure. Note that split speed zones are permitted in these instances (i.e. the start and finish of the 80 km/h speed zone do not coincide for each direction of traffic).
8. A speed limit of 100 km/h will generally apply to divided arterial roads in sparsely built-up areas (typically the outer urban / rural fringe), subject to a satisfactory safety record.
9. Applies to urban freeways with full access control, well spaced interchanges and high design standards. Lower speed limits may be appropriate on a permanent or variable basis to address geometric and operational concerns on specific sections such as:
    - A low standard of alignment or reduced sight distance for a significant length OR
    - Closely spaced interchanges and complex weaving manoeuvres OR
    - High levels of congestion OR
    - Turning roadways or ramps at interchanges OR
    - Tunnels with confined cross-sections OR
    - At freeway terminals OR
    - Congestion and driver behaviour at incidents OR
    - A poor crash history which cannot be addressed through improvements to the road infrastructure in the short-term OR
    - Sections that are subject to severe levels of wind or adverse weather, such as elevated roadways (generally variable speed limits would apply, dependent on the conditions) OR
    - High traffic volumes where a lower speed limit would optimise traffic flow.
    - Where variable speed limits exist on freeways or are proposed, practitioners should investigate opportunities to use variable message signs to advise motorists of the reason for the reduction in speed limit (e.g. congestion ahead, incident ahead).

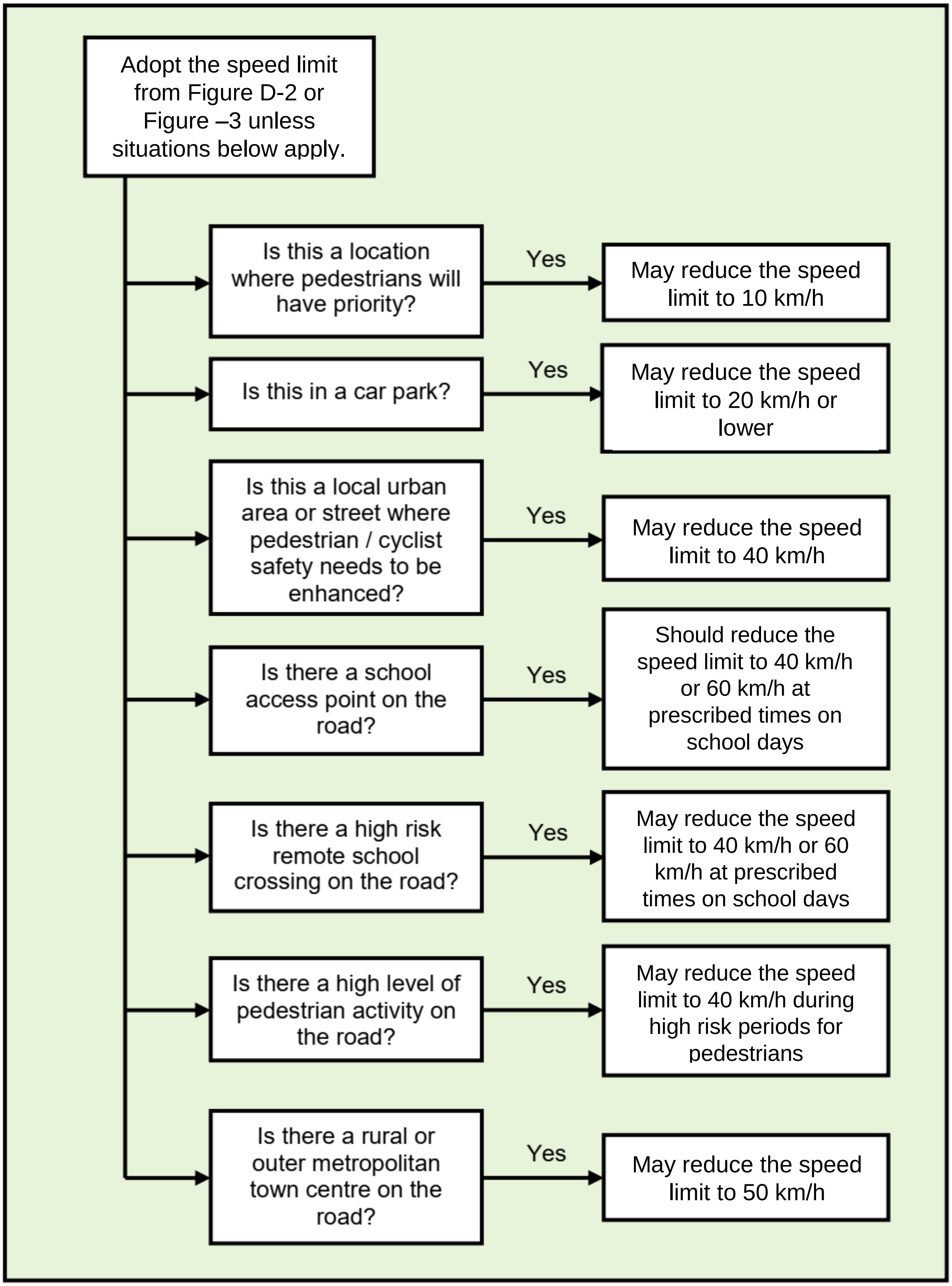


Figure D-4: Process for Determining Speed Limits in Pedestrian Activity Areas

E

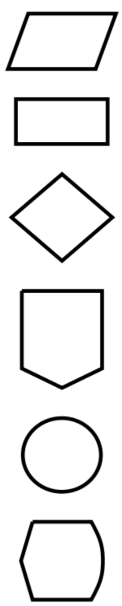
Appendix E: USLIMITS Process

This appendix contains flow charts describing the decision rules for the USLIMITS expert system applicable for limited access freeways.

Terms:

- **Closest 85th:** This is the 5 mph increment that is closest to the 85th percentile speed (e.g., if the 85th percentile speed is 63 mph, the Closest_85th will be 65 mph)
- **Rounded-down 85th:** This is the 5 mph increment obtained by rounding down the 85th percentile to the nearest 5 mph increment (e.g., if the 85th percentile speed is 63 mph, the Rounded-down_85th will be 60 mph)
- **Closest 50th:** This is the 5 mph increment that is closest to the 50th percentile speed (e.g., if the 50th percentile speed is 58 mph, the Closest_50th will be 60 mph)
- **SL_1:** Speed limit calculated using safety surrogates
- **SL_2:** Speed limit calculated using crash data from the crash module
- **SL:** Recommended speed limit
- **L.A.F.:** Limited Access Freeway

Keys:



Input or Output
Computation or Process
Decision and Branching
Off-page Connector
Connector
Display

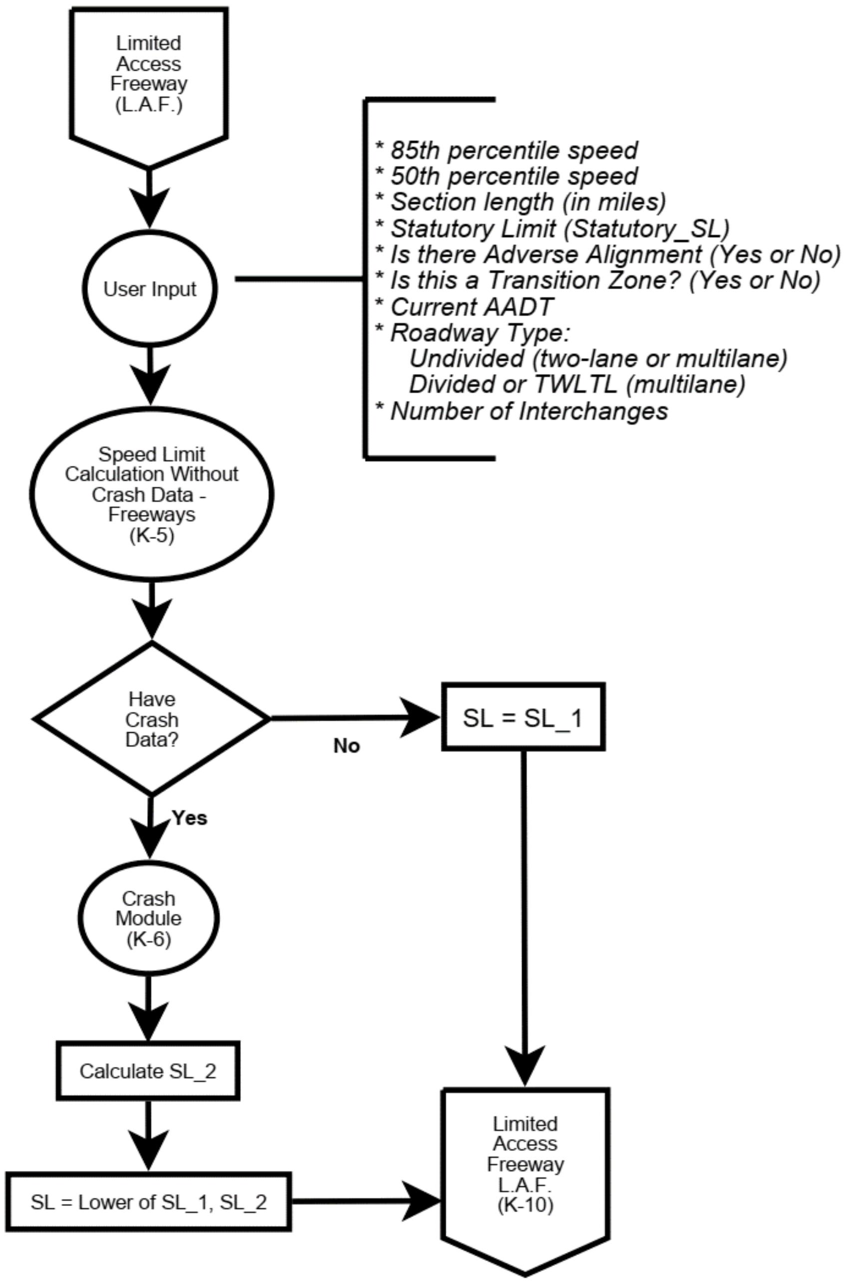


Figure E-1: Overall Process of USLIMITS for Limited Access Freeways (LAF)

Speed Limit Calculation Without Crash Data (to calculate SL_1) (Limited Access Freeway)

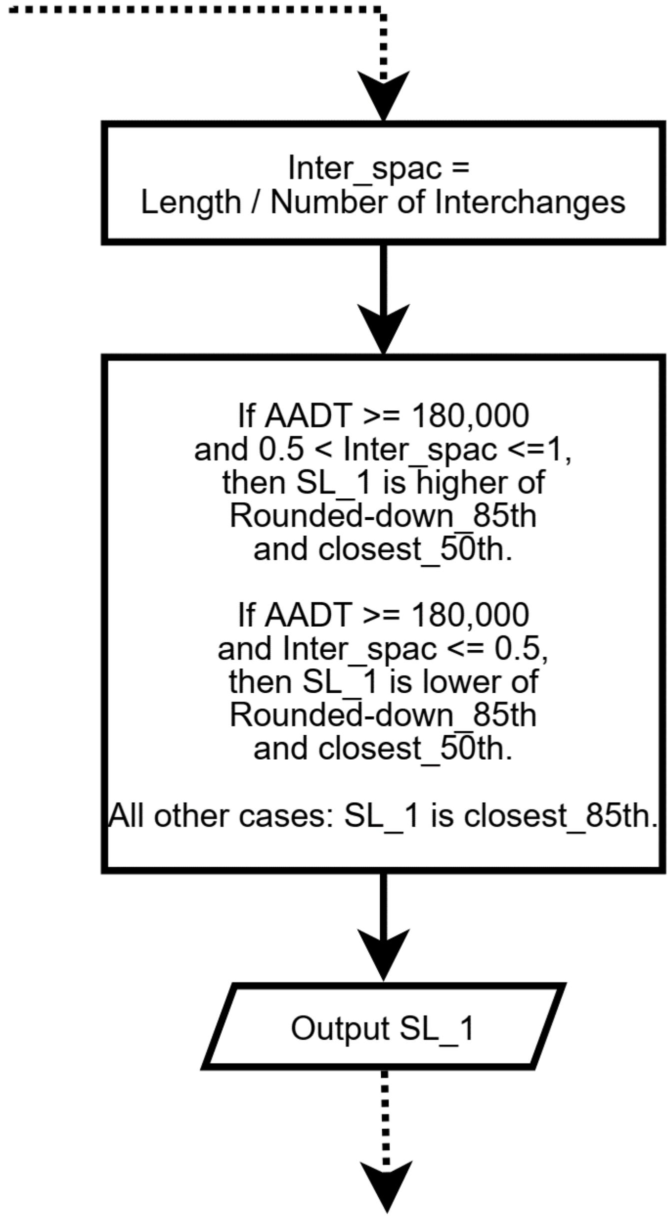


Figure E-2: Speed Limit Calculation Using Safety Surrogates (SL_1)

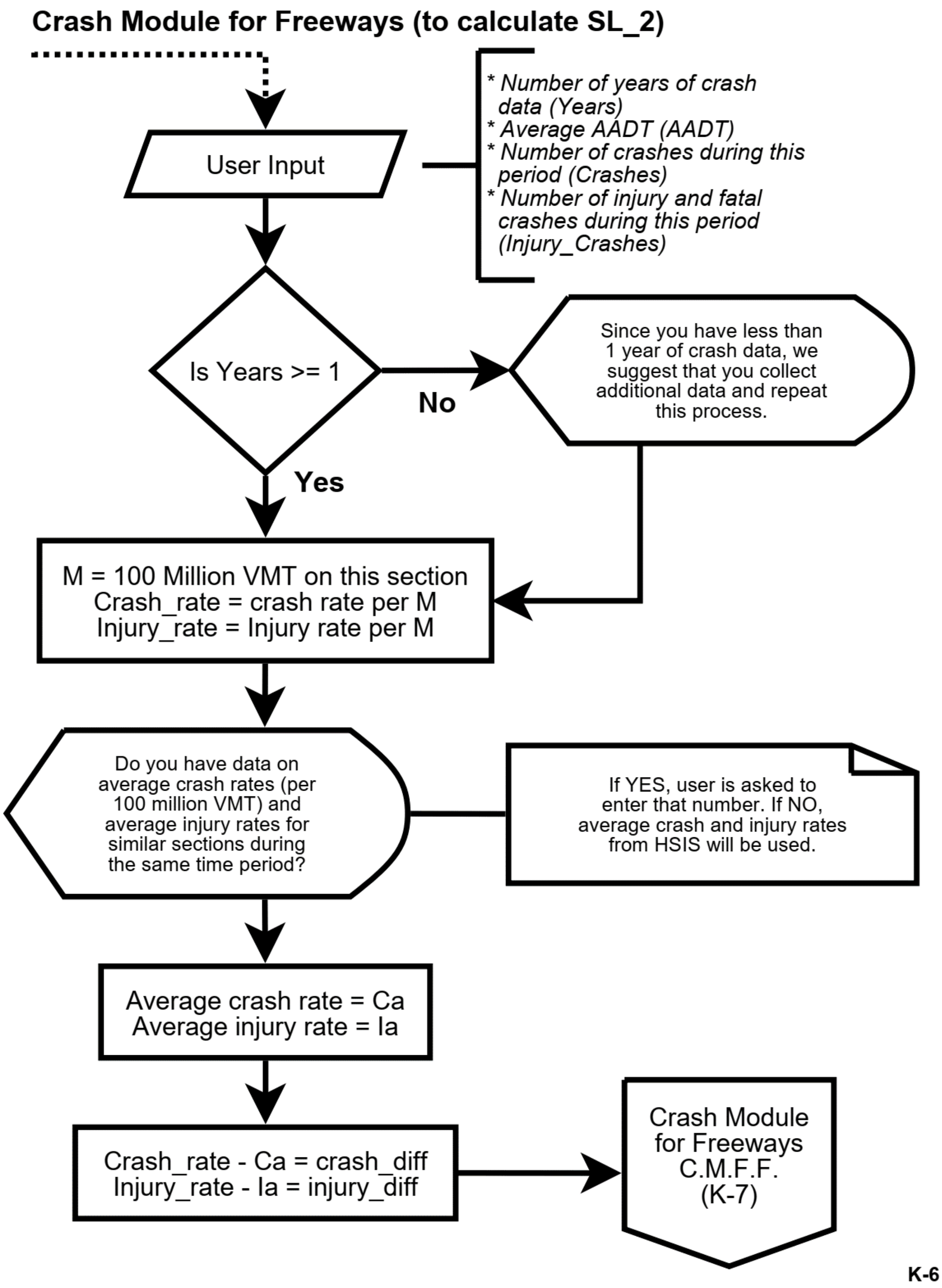


Figure E-3: Speed Limit Calculation Using Crash Module (SL_2: Step 1)

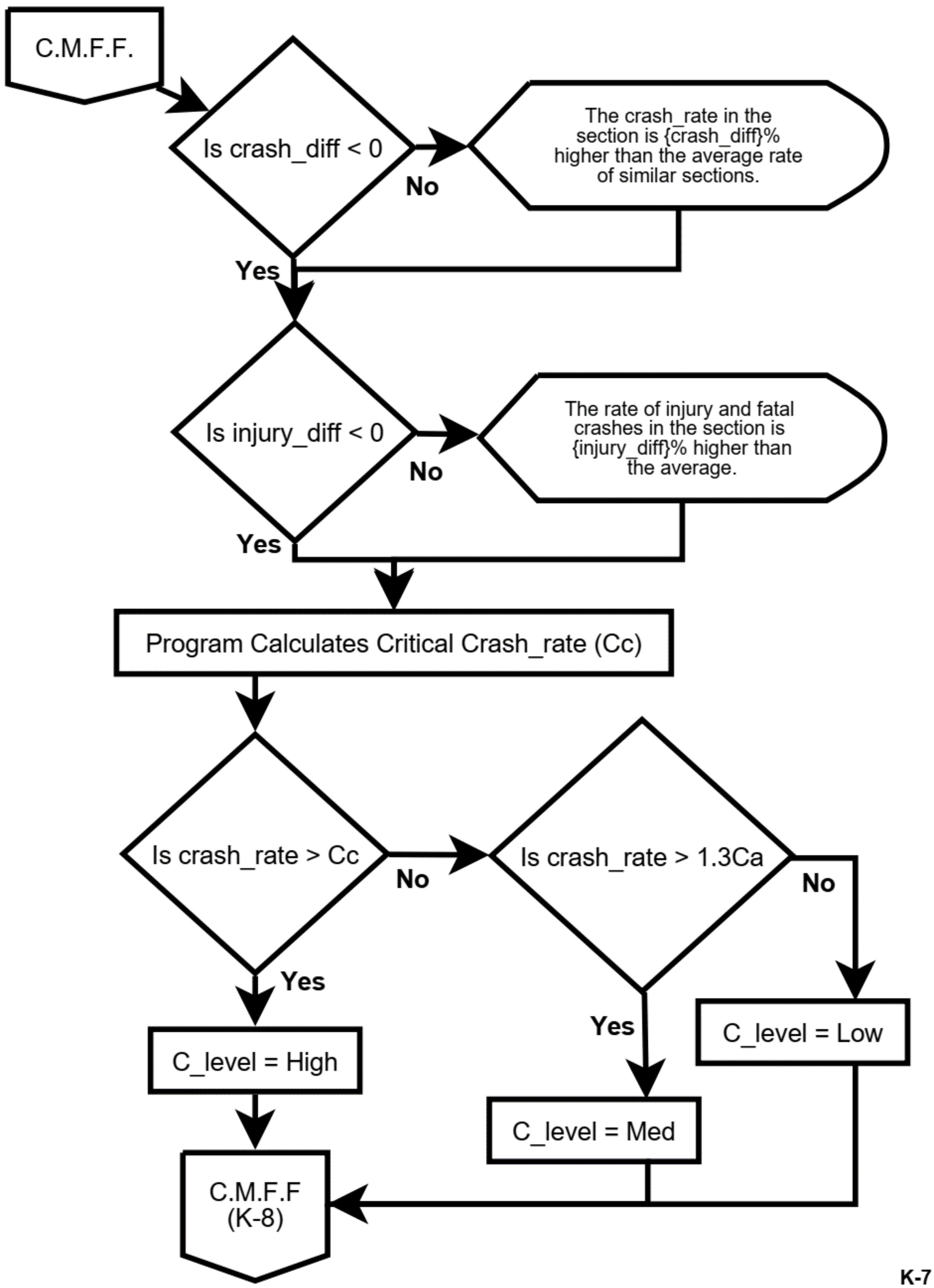


Figure E-4: Speed Limit Calculation Using Crash Module (SL_2: Step 2)

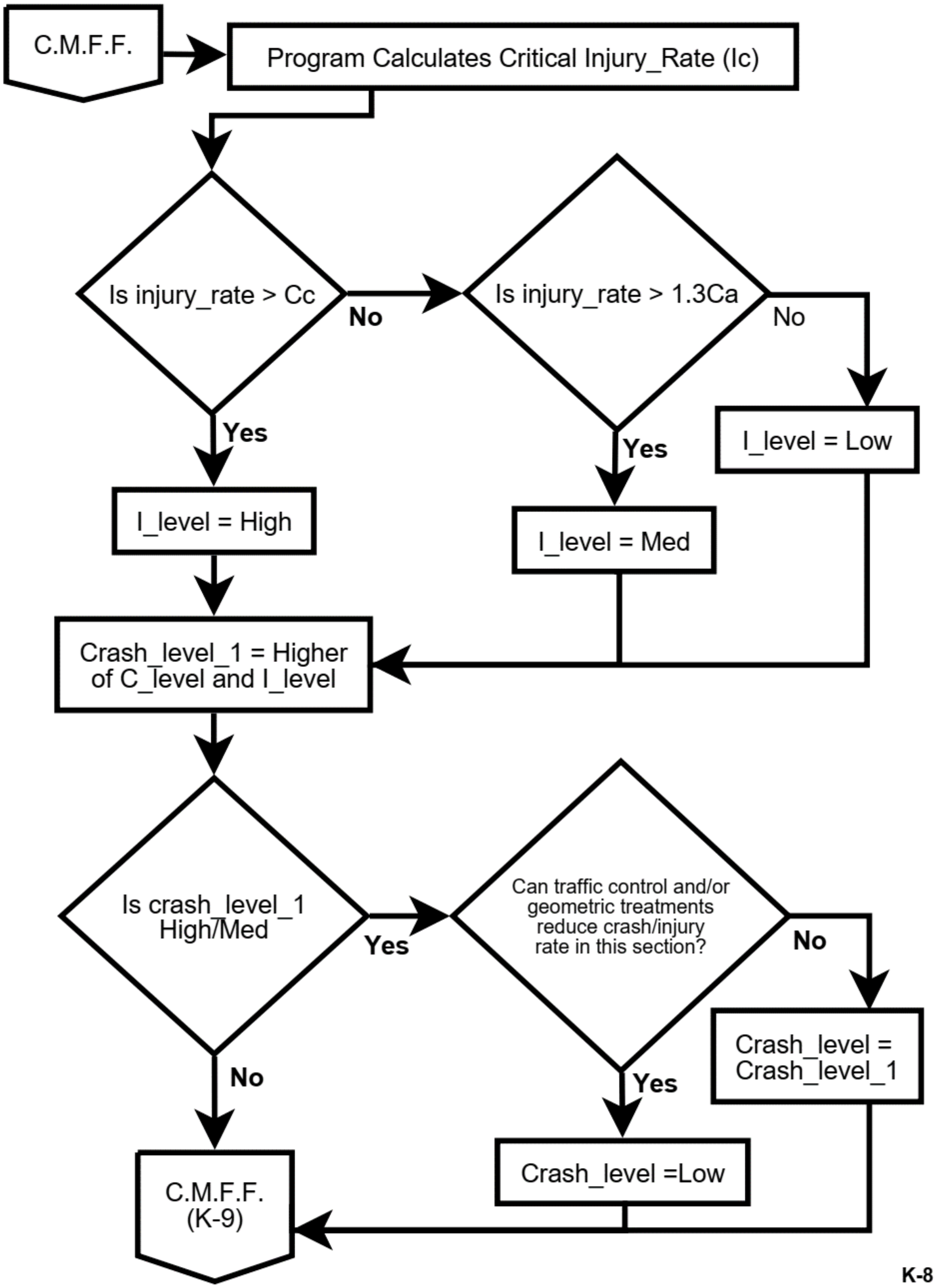


Figure E-5: Speed Limit Calculation Using Crash Module (SL_2: Step 3)

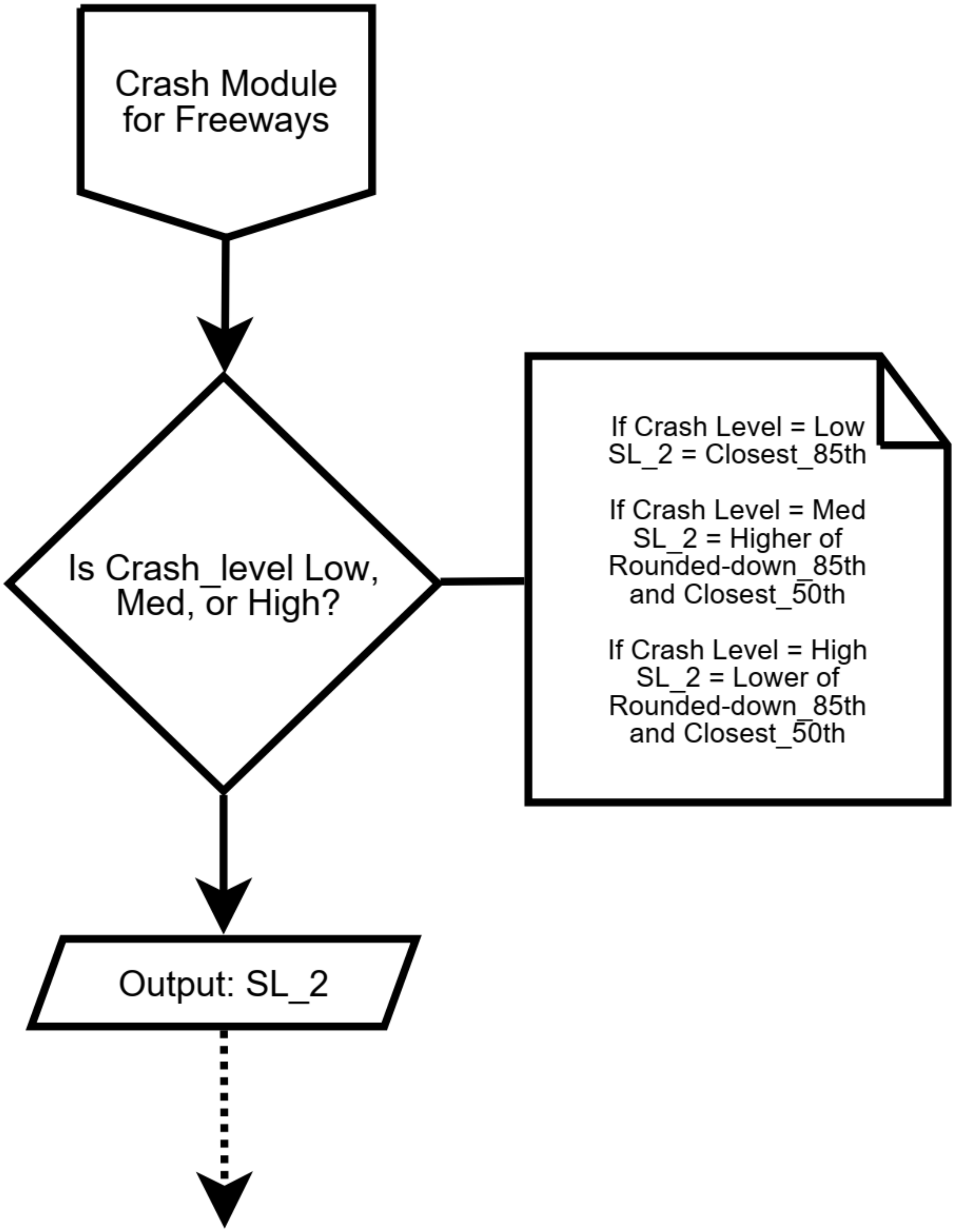


Figure E-6: Speed Limit Calculation Using Crash Module (SL_2: Step 4)

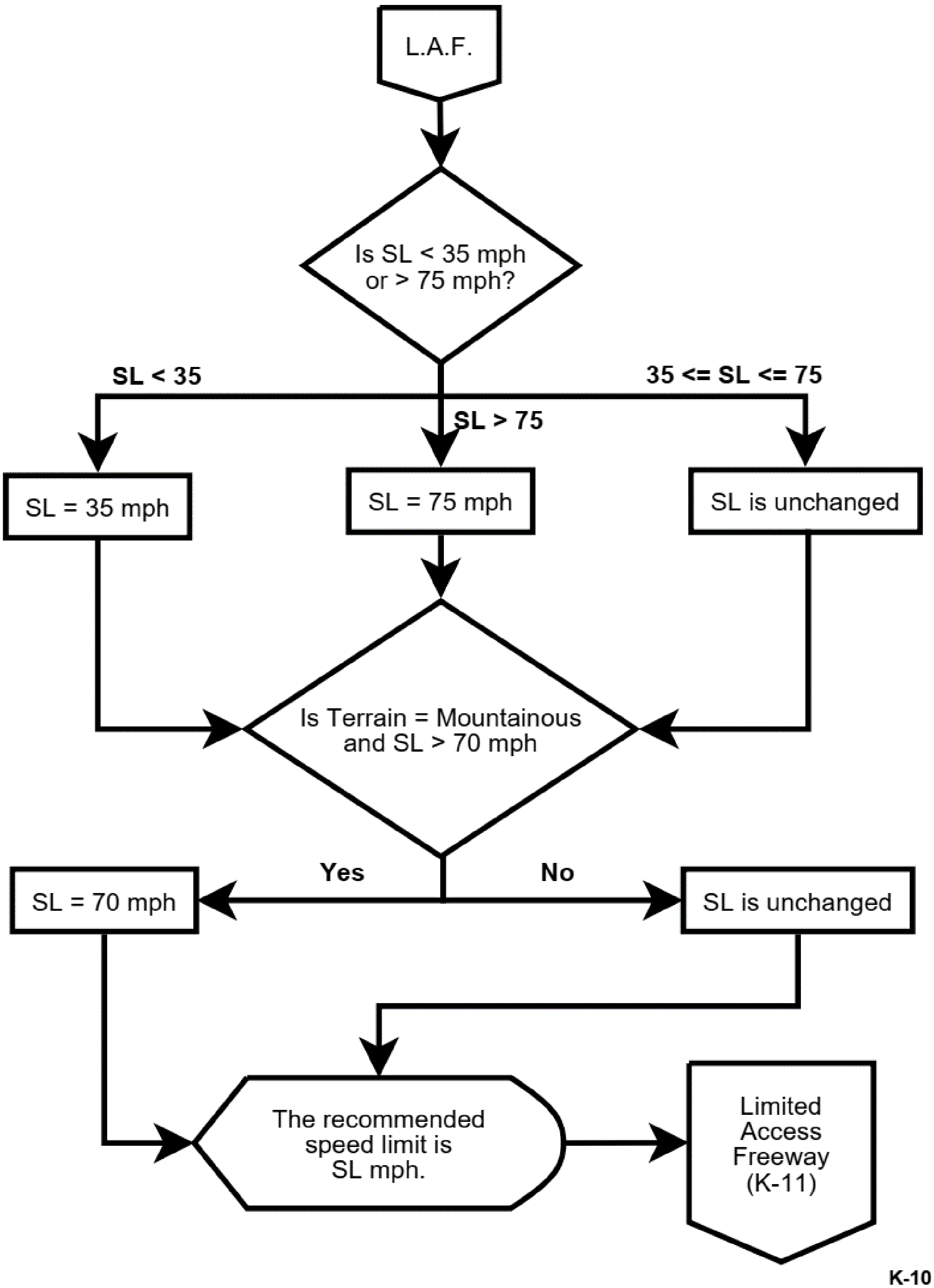


Figure E-7: Recommended Speed Limit Considering Terrain

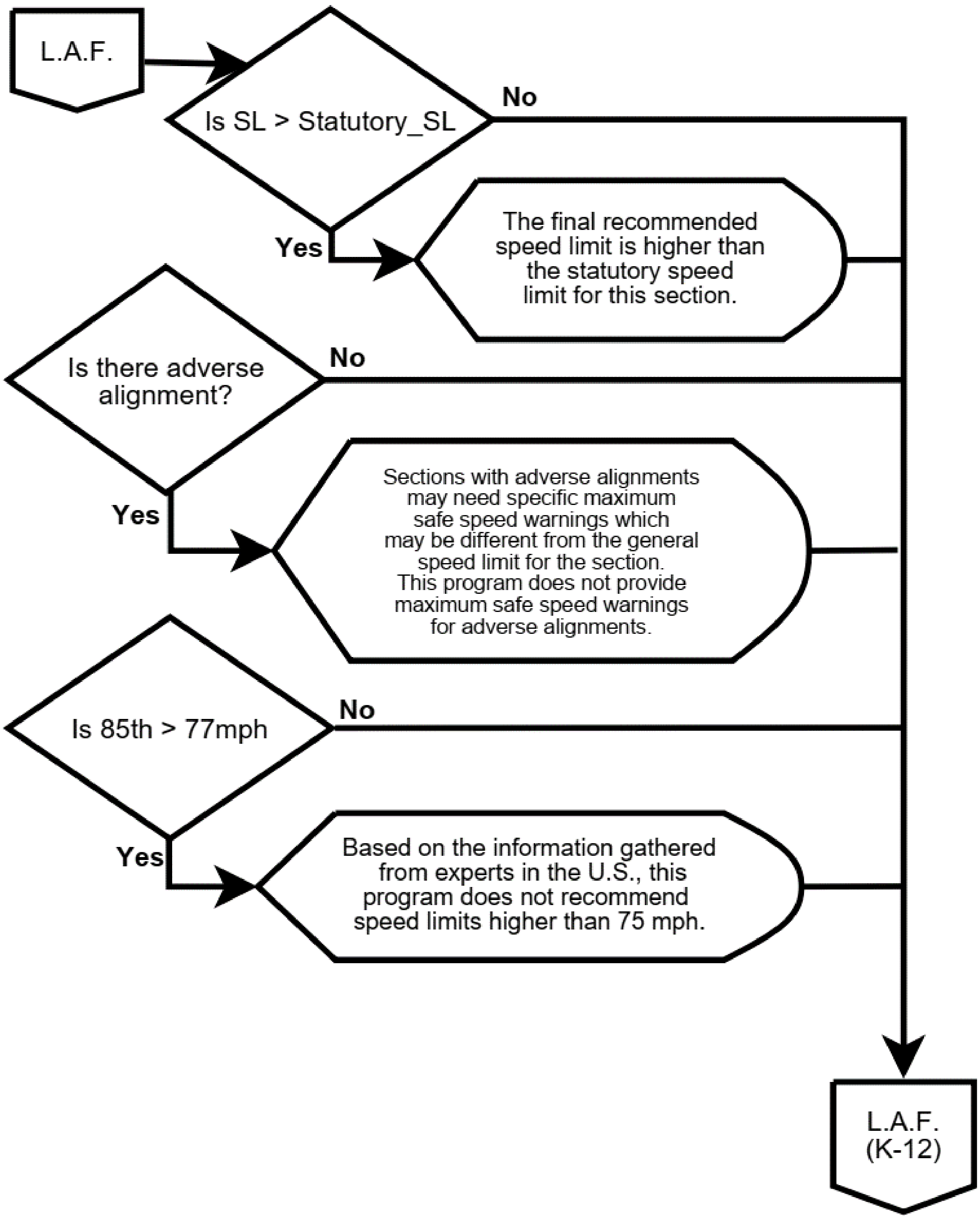


Figure E-8: Recommended Speed Limit Considering Adverse Alignment

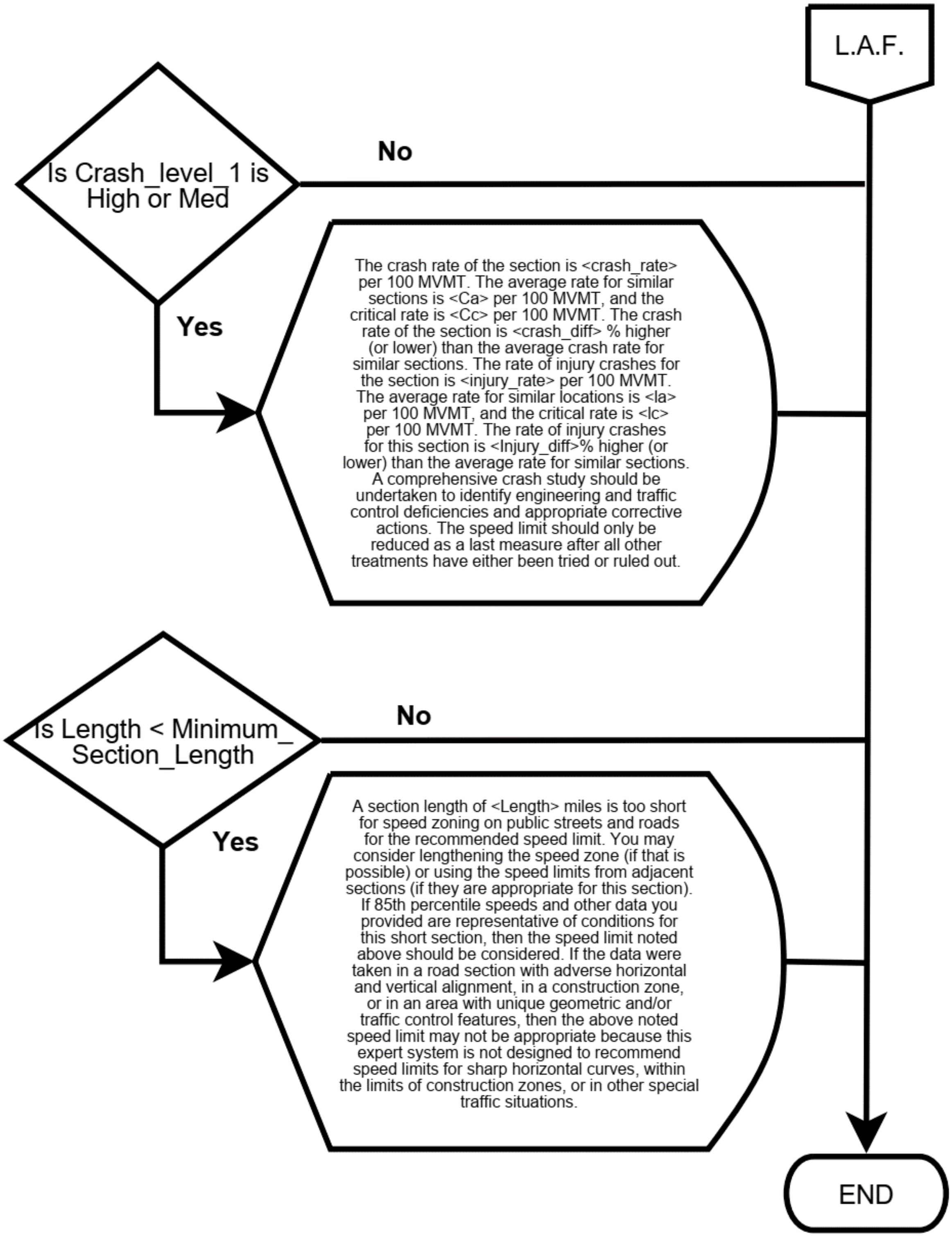


Figure E-9: Recommended Speed Limit Considering Crash Level

F

Appendix F: Speed Data Summary Report

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Lincoln Alexander Pkwy - EB
Location: 1

A study of vehicle traffic was conducted with the device having serial number 132476. The study was done in the EB lane at Lincoln Alexander Pkwy - EB in City of Hamilton, ON in west of Dartnall Rd county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 306,082 vehicles passed through the location with a peak volume of 3269 on 2018-05-24 at [04:00 PM-05:00 PM] and a minimum volume of 122 on 2018-05-28 at [03:00 AM-04:00 AM]. The AADT count for this study was 43,726.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 84 KM/H with 39.73% vehicles exceeding the posted speed of 90 KM/H. 71.10% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 98.20 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
12956	11300	17448	45415	94538	90879	17972	6056	1878	970	826	429	277	136	349

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 282554 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 4720 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 5480 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 8675 which represents 3 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
167136	115418	4720	5480	1815	2761	2768	1331							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-24 at [04:00 PM-05:00 PM] the average headway between vehicles was 1.101 seconds. During the slowest traffic period, on 2018-05-28 at [03:00 AM-04:00 AM] the average headway between vehicles was 29.268 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 42.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Lincoln Alexander Pkwy - WB
Location: 1

A study of vehicle traffic was conducted with the device having serial number 135572. The study was done in the WB lane at Lincoln Alexander Pkwy - WB in City of Hamilton, ON in west of Dartnall Rd county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 318,353 vehicles passed through the location with a peak volume of 3426 on 2018-05-28 at [08:00 AM-09:00 AM] and a minimum volume of 147 on 2018-05-28 at [02:00 AM-03:00 AM]. The AADT count for this study was 45,479.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 85 KM/H with 39.11% vehicles exceeding the posted speed of 90 KM/H. 68.72% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 99.09 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
13318	12377	20148	50865	91573	82016	22726	7475	3190	1692	1406	866	604	290	672

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 291275 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 5262 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 5653 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 7028 which represents 2 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
174223	117052	5262	5653	1435	1996	2609	988							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-28 at [08:00 AM-09:00 AM] the average headway between vehicles was 1.05 seconds. During the slowest traffic period, on 2018-05-28 at [02:00 AM-03:00 AM] the average headway between vehicles was 24.324 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 43.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Lincoln Alexander Pkwy - EB
Location: 2

A study of vehicle traffic was conducted with the device having serial number 132657. The study was done in the EB lane at Lincoln Alexander Pkwy - EB in City of Hamilton, ON in west of Upper Wentworth St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 338,414 vehicles passed through the location with a peak volume of 3625 on 2018-05-28 at [03:00 PM-04:00 PM] and a minimum volume of 150 on 2018-05-28 at [02:00 AM-03:00 AM]. The AADT count for this study was 48,345.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 85 KM/H with 38.99% vehicles exceeding the posted speed of 90 KM/H. 66.78% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 99.20 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
7113	13053	31298	59454	92776	87073	28248	8920	2705	1140	815	443	313	159	365

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 316544 which represents 95 percent of the total classified vehicles. The number of Small Trucks in the study was 4841 which represents 1 percent of the total classified vehicles. The number of Trucks/Buses in the study was 5321 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 7169 which represents 2 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
174267	142277	4841	5321	1457	2212	2523	977							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-28 at [03:00 PM-04:00 PM] the average headway between vehicles was 0.993 seconds. During the slowest traffic period, on 2018-05-28 at [02:00 AM-03:00 AM] the average headway between vehicles was 23.841 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 21.00 and 42.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Lincoln Alexander Pkwy - WB
Location: 2

A study of vehicle traffic was conducted with the device having serial number 134636. The study was done in the WB lane at Lincoln Alexander Pkwy - WB in City of Hamilton, ON in west of Upper Wentworth St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 265,945 vehicles passed through the location with a peak volume of 3026 on 2018-05-28 at [08:00 AM-09:00 AM] and a minimum volume of 116 on 2018-05-28 at [03:00 AM-04:00 AM]. The AADT count for this study was 37,992.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 78 KM/H with 36.56% vehicles exceeding the posted speed of 90 KM/H. 61.66% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 99.04 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
42021	6302	12471	38736	65141	61895	22526	6103	1998	791	638	354	225	114	273

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 243995 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 4144 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 4427 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 7022 which represents 3 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
149713	94282	4144	4427	1402	2604	2290	726							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-28 at [08:00 AM-09:00 AM] the average headway between vehicles was 1.189 seconds. During the slowest traffic period, on 2018-05-28 at [03:00 AM-04:00 AM] the average headway between vehicles was 30.769 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 21.00 and 46.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Lincoln Alexander Pkwy - EB
Location: 3

A study of vehicle traffic was conducted with the device having serial number 134751. The study was done in the EB lane at Lincoln Alexander Pkwy - EB in City of Hamilton, ON in west of Upper Paradise Rd county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 298,666 vehicles passed through the location with a peak volume of 3336 on 2018-05-28 at [03:00 PM-04:00 PM] and a minimum volume of 104 on 2018-05-28 at [03:00 AM-04:00 AM]. The AADT count for this study was 42,667.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 85 KM/H with 41.71% vehicles exceeding the posted speed of 90 KM/H. 73.80% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 98.80 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
16317	8806	13862	37384	93533	88432	20386	6329	2361	1262	998	613	458	235	513

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 275307 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 4322 which represents 1 percent of the total classified vehicles. The number of Trucks/Buses in the study was 5166 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 6694 which represents 2 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
155317	119990	4322	5166	1342	1827	2493	1032							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-28 at [03:00 PM-04:00 PM] the average headway between vehicles was 1.079 seconds. During the slowest traffic period, on 2018-05-28 at [03:00 AM-04:00 AM] the average headway between vehicles was 34.286 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 45.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Lincoln Alexander Pkwy - WB
Location: 3

A study of vehicle traffic was conducted with the device having serial number 135168. The study was done in the WB lane at Lincoln Alexander Pkwy - WB in City of Hamilton, ON in west of Upper Paradise Rd county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 309,342 vehicles passed through the location with a peak volume of 3256 on 2018-05-25 at [03:00 PM-04:00 PM] and a minimum volume of 109 on 2018-05-30 at [02:00 AM-03:00 AM]. The AADT count for this study was 44,192.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 85 KM/H with 31.35% vehicles exceeding the posted speed of 90 KM/H. 70.61% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 97.03 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
7386	4984	14366	62189	118779	70339	15908	3633	1744	906	793	548	389	183	409

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 287118 which represents 95 percent of the total classified vehicles. The number of Small Trucks in the study was 4484 which represents 1 percent of the total classified vehicles. The number of Trucks/Buses in the study was 4364 which represents 1 percent of the total classified vehicles. The number of Tractor Trailers in the study was 6590 which represents 2 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
191015	96103	4484	4364	1418	2828	1819	525							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-25 at [03:00 PM-04:00 PM] the average headway between vehicles was 1.105 seconds. During the slowest traffic period, on 2018-05-30 at [02:00 AM-03:00 AM] the average headway between vehicles was 32.727 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 21.00 and 42.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Red Hill Valley Pkwy - NB
Location: 1

A study of vehicle traffic was conducted with the device having serial number 134401. The study was done in the NB lane at Red Hill Valley Pkwy - NB in City of Hamilton, ON in south of Barton St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 262,540 vehicles passed through the location with a peak volume of 3686 on 2018-05-25 at [07:00 AM-08:00 AM] and a minimum volume of 109 on 2018-05-28 at [02:00 AM-03:00 AM]. The AADT count for this study was 37,506.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 80 - 90 KM/H range or lower. The average speed for all classifed vehicles was 86 KM/H with 37.48% vehicles exceeding the posted speed of 90 KM/H. 74.12% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 80KM/H and the 85th percentile was 98.37 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
6095	3614	10907	45932	94229	69102	16516	5589	2078	1026	863	470	283	150	326

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 241256 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 5048 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 4125 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 6751 which represents 3 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
163127	78129	5048	4125	1619	2796	1648	688							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-25 at [07:00 AM-08:00 AM] the average headway between vehicles was 0.976 seconds. During the slowest traffic period, on 2018-05-28 at [02:00 AM-03:00 AM] the average headway between vehicles was 32.727 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 45.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Red Hill Valley Pkwy - SB
Location: 1

A study of vehicle traffic was conducted with the device having serial number 135166. The study was done in the SB lane at Red Hill Valley Pkwy - SB in City of Hamilton, ON in south of Barton St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 275,309 vehicles passed through the location with a peak volume of 3352 on 2018-05-30 at [03:00 PM-04:00 PM] and a minimum volume of 120 on 2018-05-28 at [03:00 AM-04:00 AM]. The AADT count for this study was 39,330.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 90 - 100 KM/H range or lower. The average speed for all classifed vehicles was 86 KM/H with 46.46% vehicles exceeding the posted speed of 90 KM/H. 75.10% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 90KM/H and the 85th percentile was 99.92 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
13043	7008	12236	35558	78006	86388	28503	8255	1728	639	420	235	149	80	173

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 255641 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 4816 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 4860 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 7104 which represents 3 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
157504	98137	4816	4860	1517	2421	2470	696							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-30 at [03:00 PM-04:00 PM] the average headway between vehicles was 1.074 seconds. During the slowest traffic period, on 2018-05-28 at [03:00 AM-04:00 AM] the average headway between vehicles was 29.752 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 46.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Red Hill Valley Pkwy - NB
Location: 2

A study of vehicle traffic was conducted with the device having serial number 135173. The study was done in the NB lane at Red Hill Valley Pkwy - NB in City of Hamilton, ON in south of King St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 324,807 vehicles passed through the location with a peak volume of 4084 on 2018-05-29 at [08:00 AM-09:00 AM] and a minimum volume of 124 on 2018-05-29 at [02:00 AM-03:00 AM]. The AADT count for this study was 46,401.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 90 - 100 KM/H range or lower. The average speed for all classifed vehicles was 94 KM/H with 66.49% vehicles exceeding the posted speed of 90 KM/H. 88.01% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 90KM/H and the 85th percentile was 106.79 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
3911	3348	6968	23635	67926	127353	51877	16581	6082	2674	2099	1236	818	372	819

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 295102 which represents 93 percent of the total classified vehicles. The number of Small Trucks in the study was 5831 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 6581 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 8185 which represents 3 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
152939	142163	5831	6581	1824	1701	2746	1914							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-29 at [08:00 AM-09:00 AM] the average headway between vehicles was 0.881 seconds. During the slowest traffic period, on 2018-05-29 at [02:00 AM-03:00 AM] the average headway between vehicles was 28.8 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 47.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Red Hill Valley Pkwy - SB
Location: 2

A study of vehicle traffic was conducted with the device having serial number 134395. The study was done in the SB lane at Red Hill Valley Pkwy - SB in City of Hamilton, ON in south of King St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 317,824 vehicles passed through the location with a peak volume of 3847 on 2018-05-29 at [05:00 PM-06:00 PM] and a minimum volume of 128 on 2018-05-28 at [03:00 AM-04:00 AM]. The AADT count for this study was 45,403.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 90 - 100 KM/H range or lower. The average speed for all classifed vehicles was 88 KM/H with 56.73% vehicles exceeding the posted speed of 90 KM/H. 78.46% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 90KM/H and the 85th percentile was 102.97 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
14287	11075	14079	27839	67898	117735	42521	9646	3041	1480	1062	613	443	217	449

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 292564 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 5851 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 6398 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 7572 which represents 2 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
140822	151742	5851	6398	1751	1875	2765	1181							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-29 at [05:00 PM-06:00 PM] the average headway between vehicles was 0.936 seconds. During the slowest traffic period, on 2018-05-28 at [03:00 AM-04:00 AM] the average headway between vehicles was 27.907 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 45.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Red Hill Valley Pkwy - NB
Location: 3

A study of vehicle traffic was conducted with the device having serial number 130995. The study was done in the NB lane at Red Hill Valley Pkwy - NB in City of Hamilton, ON in north of Mud St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 228,527 vehicles passed through the location with a peak volume of 2697 on 2018-05-29 at [08:00 AM-09:00 AM] and a minimum volume of 103 on 2018-05-28 at [02:00 AM-03:00 AM]. The AADT count for this study was 32,647.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 90 - 100 KM/H range or lower. The average speed for all classifed vehicles was 97 KM/H with 77.58% vehicles exceeding the posted speed of 90 KM/H. 89.99% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 90KM/H and the 85th percentile was 113.09 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
7911	1891	2929	9721	27809	68311	62982	29141	8023	2502	1354	635	396	227	368

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 207877 which represents 93 percent of the total classified vehicles. The number of Small Trucks in the study was 4832 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 4902 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 6589 which represents 3 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
91936	115941	4832	4902	1308	1796	2371	1114							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-29 at [08:00 AM-09:00 AM] the average headway between vehicles was 1.334 seconds. During the slowest traffic period, on 2018-05-28 at [02:00 AM-03:00 AM] the average headway between vehicles was 34.615 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 43.00 degrees C.

MH Corbin Traffic Analyzer Study
Computer Generated Summary Report
City: City of Hamilton
Street: Red Hill Valley Pkwy - SB
Location: 3

A study of vehicle traffic was conducted with the device having serial number 133546. The study was done in the SB lane at Red Hill Valley Pkwy - SB in City of Hamilton, ON in north of Mud St county. The study began on 2018-05-24 at 12:00 PM and concluded on 2018-05-31 at 12:00 PM, lasting a total of 168.00 hours. Traffic statistics were recorded in 60 minute time periods. The total recorded volume showed 337,758 vehicles passed through the location with a peak volume of 4018 on 2018-05-30 at [03:00 PM-04:00 PM] and a minimum volume of 129 on 2018-05-28 at [03:00 AM-04:00 AM]. The AADT count for this study was 48,251.

SPEED

Chart 1 lists the values of the speed bins and the total traffic volume for each bin. At least half the vehicles were traveling in the 90 - 100 KM/H range or lower. The average speed for all classifed vehicles was 96 KM/H with 67.94% vehicles exceeding the posted speed of 90 KM/H. 89.53% percent of the total vehicles were traveling in excess of 89 KM/H. The mode speed for this traffic study was 90KM/H and the 85th percentile was 108.72 KM/H.

< to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	130 to 139	140 to 149	150 to 159	160 to 169	170 to 179	180 to >
1327	2098	6531	24741	71506	123096	59994	25884	8538	3078	1949	960	628	310	641

CHART 1

CLASSIFICATION

Chart 2 lists the values of the classification bins and the total traffic volume accumulated for each bin.
Most of the vehicles classified during the study were Passenger Vehicles. The number of Passenger Vehicles in the study was 310548 which represents 94 percent of the total classified vehicles. The number of Small Trucks in the study was 5758 which represents 2 percent of the total classified vehicles. The number of Trucks/Buses in the study was 6778 which represents 2 percent of the total classified vehicles. The number of Tractor Trailers in the study was 8197 which represents 2 percent of the total classified vehicles.

< to 4.9	5.0 to 8.4	8.5 to 9.9	10.0 to 12.9	13.0 to 15.9	16.0 to 18.9	19.0 to 22.4	22.5 to >							
145634	164914	5758	6778	1901	1676	2908	1712							

CHART 2

HEADWAY

During the peak traffic period, on 2018-05-30 at [03:00 PM-04:00 PM] the average headway between vehicles was 0.896 seconds. During the slowest traffic period, on 2018-05-28 at [03:00 AM-04:00 AM] the average headway between vehicles was 27.692 seconds.

WEATHER

The roadway surface temperature over the period of the study varied between 20.00 and 43.00 degrees C.

G

Appendix G: Outputs of the TAC Approach

Automated Speed Limit Guidelines

FORM A - Automated Speed Limit Guidelines Spreadsheet

Version: 10-Apr-09

Name of Corridor:	Lincoln Alexander Parkway				
Segment Evaluated:	Highway 403	to	Red Hill Valley Parkway		
Geographic Region:	City of Hamilton				
Road Agency:	City of Hamilton				
Road Classification:	Expressway	Length of Corridor:		9,900	m
Urban / Rural:	Urban	Design Speed: (Required for Freeway, Expressway, Highway)		110	km/h
Divided / Undivided:	Divided	Current Posted Speed: (For information only)		90	km/h
Major / Minor:	Major	Prevailing Speed: (85th Percentile - for information only)		93	km/h
# Through Lanes Per Direction:	2+ lanes	Policy: (Maximum Posted Speed)		No policy	

		RISK	Score
A1	**GEOMETRY (Horizontal)**	Lower	3
A2	**GEOMETRY (Vertical)**	Lower	3
A3	**AVERAGE LANE WIDTH**	Medium	4
B	**ROADSIDE HAZARDS**	Lower	2
C1	**PEDESTRIAN EXPOSURE**	N/A	0
C2	**CYCLIST EXPOSURE**	N/A	0
D	**PAVEMENT SURFACE**	Lower	1
E1	**NUMBER OF INTERSECTIONS WITH PUBLIC ROADS**	*Number of Occurrences*	0
	STOP controlled intersection	0	
	Signalized intersection	0	
	Roundabout or traffic circle	0	
	Crosswalk	0	
	Active, at-grade railroad crossing	0	
	Sidestreet STOP-controlled or lane	0	
E2	**NUMBER OF INTERSECTIONS WITH PRIVATE ACCESS DRIVEWAYS**	*Number of Occurrences*	0
	Left turn movements permitted	0	
	Right-in / Right-out only	0	
E3	**NUMBER OF INTERCHANGES**	*Number of Occurrences*	6
	Number of interchanges along corridor	5	
F	**ON-STREET PARKING**	N/A	0

Total Risk Score:

19

Recommended Posted Speed Limit (km/h):

As determined by road characteristics

110

As determined by policy

No policy

The recommended posted speed limit may be checked against the prevailing speeds of the roadway and the road's safety performance.

Comments:

Automated Speed Limit Guidelines

FORM A - Automated Speed Limit Guidelines Spreadsheet

Version: 10-Apr-09

Name of Corridor:	Red Hill Valley Parkway			
Segment Evaluated:	Lincoln Alexander Parkway	to	Queen Elizabeth Way	
Geographic Region:	City of Hamilton			
Road Agency:	City of Hamilton			
Road Classification:	Expressway	Length of Corridor:	3,000	m
Urban / Rural:	Urban	Design Speed: (Required for Freeway, Expressway, Highway)	110	km/h
Divided / Undivided:	Divided	Current Posted Speed: (For information only)	90	km/h
Major / Minor:	Major	Prevailing Speed: (85th Percentile - for information only)	96	km/h
# Through Lanes Per Direction:	2+ lanes	Policy: (Maximum Posted Speed)	No policy	

		RISK	Score
A1	**GEOMETRY (Horizontal)**	Lower	3
A2	**GEOMETRY (Vertical)**	Medium	6
A3	**AVERAGE LANE WIDTH**	Medium	4
B	**ROADSIDE HAZARDS**	Lower	2
C1	**PEDESTRIAN EXPOSURE**	N/A	0
C2	**CYCLIST EXPOSURE**	N/A	0
D	**PAVEMENT SURFACE**	Lower	1
E1	**NUMBER OF INTERSECTIONS WITH PUBLIC ROADS**	*Number of Occurrences*	0
	STOP controlled intersection	0	
	Signalized intersection	0	
	Roundabout or traffic circle	0	
	Crosswalk	0	
	Active, at-grade railroad crossing	0	
	Sidestreet STOP-controlled or lane	0	
E2	**NUMBER OF INTERSECTIONS WITH PRIVATE ACCESS DRIVEWAYS**	*Number of Occurrences*	0
	Left turn movements permitted	0	
	Right-in / Right-out only	0	
E3	**NUMBER OF INTERCHANGES**	*Number of Occurrences*	9
	Number of interchanges along corridor	6	
F	**ON-STREET PARKING**	N/A	0

Total Risk Score:

25

Recommended Posted Speed Limit (km/h):

As determined by road characteristics

110

As determined by policy

No policy

The recommended posted speed limit may be checked against the prevailing speeds of the roadway and the road's safety performance.

Comments:

H

Appendix H: Outputs of the Northwestern Approach

Northwestern Approach		Lincoln Alexander Parkway			Red Hill Valley Parkway		
		Location #1	Location #2	Location #3	Location #1	Location #2	Location #3
Input data	85th Percentile Speed (km/h)	93	93	93	91	96	101
	15 km/h Pace (km/h)	92	95	92	93	97	102
	Average Speed (km/h)	90	91	90	89	94	98
	Design Speed (km/h)	110	110	110	110	110	110
	Interchange Spacing (km)	2.1	1.7	2.6	1.3	1.3	2.5
	Length of Proposed Speed Zone (km)	2.1	1.7	2.6	1.3	1.3	2.5
Speed Limit Justified by Speed Data	85th Percentile Speed (km/h)	90	90	90	90	100	100
	15 km/h Pace (km/h)	100	100	100	100	110	110
	Average Speed (km/h)	100	100	100	100	100	110
Weighting Factors	85th Percentile Speed (km/h)	3	3	3	3	3	3
	15 km/h Pace (km/h)	3	3	3	3	3	3
	Average Speed (km/h)	4	4	4	4	4	4
Weighted Values	85th Percentile Speed	270	270	270	270	300	300
	15 km/h Pace	300	300	300	300	330	330
	Average Speed	400	400	400	400	400	440
	Sum	970	970	970	970	1030	1070
	Weighted Average	97	97	97	97	103	107
	Suggested Speed Limit (km/h)	90	90	90	90	100	100
Max. Sppedd Limit Based on	Design Speed (km/h)	110	110	110	110	110	110
Major Physical Features:	Interchange Spacing (km/h)	Over 400 m	Over 400 m	Over 400 m	Over 400 m	Over 400 m	Over 400 m
	Length of proposed speed zone (km/h)	Over 1.5 km	Over 1.5 km	Over 1.5 km	Over 1.5 km	Over 1.5 km	Over 1.5 km
	Maximum Speed Limit (km/h)	110	110	110	110	110	110
	Suggested Speed Limit (km/h)	90	90	90	90	100	100
Detailed Analysis:	Functional Classification	Freeway	Freeway	Freeway	Freeway	Freeway	Freeway
	Number of non-commercial driveways	N/A	N/A	N/A	N/A	N/A	N/A
	Number of commercial driveways	N/A	N/A	N/A	N/A	N/A	N/A
	Lane width	> 3.5 m	> 3.5 m	> 3.5 m	> 3.5 m	> 3.5 m	> 3.5 m
	Median	Mountable, > 1.8 m	Mountable, > 1.8 m	Mountable, > 1.8 m	Depressed, > 6 m	Depressed, > 6 m	Barrier, > 1.8 m
	Shoulder	Paved	Paved	Paved	Paved	Paved	Paved
	Pedestrian activity	None	None	None	None	None	None
	Parking	No Parking	No Parking	No Parking	No Parking	No Parking	No Parking
	Terrain	Level	Level	Level	Hilly	Hilly	Hilly
	Collision rate	0.81	0.74	0.60	1.11	2.10	0.65
Adjustment Factors	Functional Classification	0	0	0	0	0	0
	Number of non-commercial driveways	-	-	-	-	-	-
	Number of commercial driveways	-	-	-	-	-	-
	Lane width	5	5	5	5	0	0
	Median	-5	-5	-5	0	0	0
	Shoulders, curb	0	0	0	0	0	0
	Pedestrian activity	0	0	0	0	0	0
	Parking	0	0	0	0	0	0
	Terrain	10	10	10	0	0	0
	Collision rate	0	0	10	0	-20	10
	Overal Adjustment Factor	10	10	20	5	-20	10
	Multiplier	1.10	1.10	1.20	1.05	0.80	1.10
Recommended Speed Limit (km/h)		90	90	100	90	80	110

Appendix I: Sample Outputs of the USLIMITS2 Method

USLIMITS2 Speed Zoning Report

Project Name: LINC

Analyst: CIMA+

Date: 07-13-2018

Basic Project Information
Project Number: B000915
Route Name: LINC (Entire highway)
From: Highway 403
To: RHVP
State: Arizona
County: Apache County
City: LINC
Route Type: Limited Access Freeway
Route Status: Existing

Roadway Information
Section Length: 6.4 mile(s)
Statutory Speed Limit: None
Existing Speed Limit: 55 mph
Adverse Alignment: No
Terrain: Flat
Interchanges: 5
Transition Zone: No

Crash Data Information
Crash Data Years: 5.00
Crash AADT: 75730 veh/day
Total Number of Crashes: 286
Total Number of Injury Crashes: 166
Section Crash Rate: 32 per 100 MVM
Section Injury Crash Rate: 19 per 100 MVM
Crash Rate Average for Similar Roads: 46
Injury Rate Average for Similar Roads: 20

Traffic Information
85th Percentile Speed: 58 mph
50th Percentile Speed: 56 mph
AADT: 75730 veh/day

Recommended Speed Limit: **60 mph**

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Equations Used in Crash Data Calculations

Exposure (M)
M = (Section AADT * 365 * Section Length * Duration of Crash Data) / (100000000)
M = (75730 * 365 * 6.4 * 5.00) / (100000000)
M = 8.8453

Crash Rate (Rc)
Rc = (Section Crash Average * 100000000) / (Section AADT * 365 * Section Length)
Rc = (57.20 * 100000000) / (75730 * 365 * 6.4)
Rc = 32.33 crashes per 100 MVM

Injury Rate (Ri)
Ri = (Section Injury Crash Average * 100000000) / (Section AADT * 365 * Section Length)
Ri = (33.20 * 100000000) / (75730 * 365 * 6.4)
Ri = 18.77 injuries per 100 MVM

Critical Crash Rate (Cc)
Cc = Crash Average of Similar Sections + 1.645 * (Crash Average of Similar Sections / Exposure) ^ (1/2) + (1 / (2 * Exposure))
Cc = 45.98 + 1.645 * (45.98 / 8.8453) ^ (1/2) + (1 / (2 * 8.8453))
Cc = 49.79 crashes per 100 MVM

Critical Injury Rate (Ic)
Ic = Injury Crash Average of Similar Sections + 1.645 * (Injury Crash Average of Similar Sections / Exposure) ^ (1/2) + (1 / (2 * Exposure))
Ic = 20.25 + 1.645 * (20.25 / 8.8453) ^ (1/2) + (1 / (2 * 8.8453))
Ic = 22.80 injuries per 100 MVM

USLIMITS2 Speed Zoning Report

Project Name: RHVP (Entire highway)

Analyst: CIMA+

Date: 07-13-2018

Basic Project Information
Project Number: B000915
Route Name: RHVP (Entire highway)
From: LINC
To: QEW
State: Arizona
County: Apache County
City: RHVP (Entire highway)
Route Type: Limited Access Freeway
Route Status: Existing

Roadway Information
Section Length: 5.01 mile(s)
Statutory Speed Limit: None
Existing Speed Limit: 55 mph
Adverse Alignment: Yes
Terrain: Rolling
Interchanges: 5
Transition Zone: No

Crash Data Information
Crash Data Years: 5.00
Crash AADT: 57117 veh/day
Total Number of Crashes: 306
Total Number of Injury Crashes: 134
Section Crash Rate: 59 per 100 MVM
Section Injury Crash Rate: 26 per 100 MVM
Crash Rate Average for Similar Roads: 46
Injury Rate Average for Similar Roads: 20

Traffic Information
85th Percentile Speed: 59 mph
50th Percentile Speed: 58 mph
AADT: 57117 veh/day

Recommended Speed Limit: 55 mph

Note: Sections with adverse alignments may need specific 'advisory speed warnings' which may be different from the general speed limit for the section. See Procedures for Setting Advisory Speeds on Curves, Publication No. FHWA-SA-11-22, June 2011, for more guidance.

Note: The section crash rate of 59 per 100 MVM is above the critical rate (51). The injury crash rate for the section of 26 per 100 MVM is above the critical rate (24). A comprehensive crash study should be undertaken to identify engineering and traffic control deficiencies and appropriate corrective actions. The speed limit should only be reduced as a last measure after all other treatments have either been tried or ruled out.

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Equations Used in Crash Data Calculations

Exposure (M)
M = (Section AADT * 365 * Section Length * Duration of Crash Data) / (100000000)
M = (57117 * 365 * 5.01 * 5.00) / (100000000)
M = 5.2224

Crash Rate (Rc)
Rc = (Section Crash Average * 100000000) / (Section AADT * 365 * Section Length)
Rc = (61.20 * 100000000) / (57117 * 365 * 5.01)
Rc = 58.59 crashes per 100 MVM

Injury Rate (Ri)
Ri = (Section Injury Crash Average * 100000000) / (Section AADT * 365 * Section Length)
Ri = (26.80 * 100000000) / (57117 * 365 * 5.01)
Ri = 25.66 injuries per 100 MVM

Critical Crash Rate (Cc)
Cc = Crash Average of Similar Sections + 1.645 * (Crash Average of Similar Sections / Exposure) ^ (1/2) + (1 / (2 * Exposure))
Cc = 45.98 + 1.645 * (45.98 / 5.2224) ^ (1/2) + (1 / (2 * 5.2224))
Cc = 50.96 crashes per 100 MVM

Critical Injury Rate (Ic)
Ic = Injury Crash Average of Similar Sections + 1.645 * (Injury Crash Average of Similar Sections / Exposure) ^ (1/2) + (1 / (2 * Exposure))
Ic = 20.25 + 1.645 * (20.25 / 5.2224) ^ (1/2) + (1 / (2 * 5.2224))
Ic = 23.58 injuries per 100 MVM

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