Project: *3957-03 AT Red Light Camera Site Selection Methodology*

Date: *18 October 2012* **Revision:** *A*

Author: *Paul Durdin* **Reviewer:** *Dave Smith*

Our Ref: *pd03 3957-03 at red light running site selection methodology*

Title: *Red Light Camera Site Selection Methodology – Technical Analysis*

1 Introduction

1.1 Auckland Transport (AT) on behalf of the TrafiNZ Executive Technical Working Group Committee has commissioned Ably Transportation Consultants Limited (Ably) to develop a site selection methodology for identifying intersections that may benefit from the installation of a red light camera. The assistance of Ably has been sought because of our involvement in the development of technical content for the High-Risk Intersection Guide (HRIG) and the Intersection Intervention and Prioritisation Studies carried out for the Auckland, Hastings, Wellington and Christchurch regions over the past two years.

1.2 The technical note describes:

- The technical analysis undertaken;
- The findings of the technical analysis; and
- The development of the site selection methodology.

1.3 The site selection methodology is based on the identification of sites where there is an established crash record arising from red light running behaviour. However, the identification of a site as being a potential candidate for a red light camera does not necessarily mean that the installation of a red light camera is the most effective treatment of the crash problem at the intersection.

1.4 Prior to finalising any intersection as an appropriate site for a red light camera, it is recommended that an intersection audit be undertaken in conjunction with a crash reduction study process. This will help ensure that all other options available have been considered to mitigate potential risks associated with red light running and that the selection of a red light camera is considered to be the last resort.

2 Technical Analysis – Nationwide Data

2.1 The technical analysis undertaken for this study embodies the general approach to identifying high-risk intersections as presented in the HRIG. This involves using a combination of 'actual' reported fatal and serious crashes, and using all injury crashes to 'predict' the risk of fatal and serious crashes occurring.

2.2 The first part of the analysis involves the derivation of severity indices for crashes involving red light running. A severity index is a prediction of the number of fatal and serious crashes based on all observed injury crashes at a site.

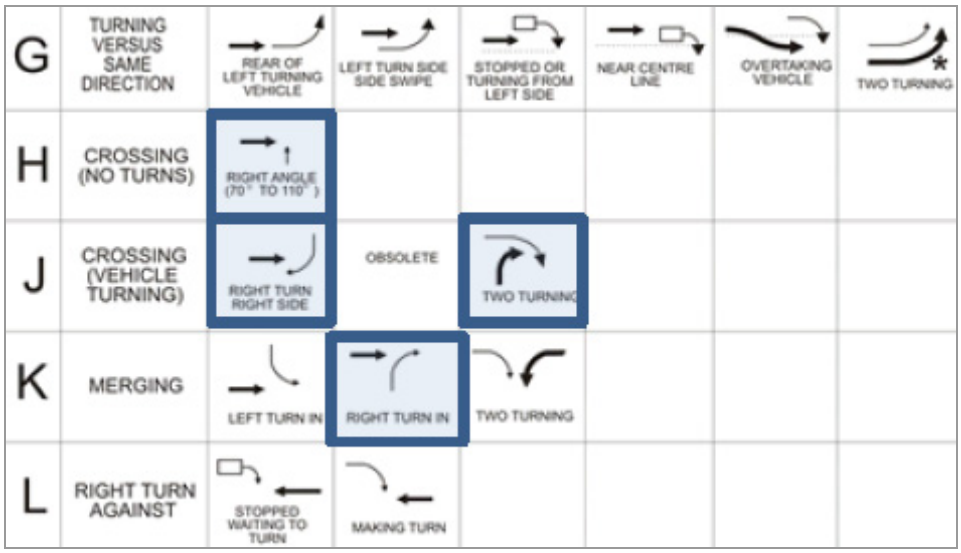
2.3 For this study, the severity indices are calculated for a number of key crash movement types for both signalised 'T' and 'X' intersections in urban and rural speed environments. The severity indices used in this study are casualty based, at the request of AT, which is different from the severity indices application in the HRIG which are crash based.

2.4 The severity outcome of any crash is known to vary substantially depending on the type of conflict, type of intersection and collision speed. The police record all of these aspects for each crash they attend. This information is then entered into the Crash Analysis System (CAS). CAS used in this study is for the 5-year period from 2007 to 2011 inclusive, except where otherwise noted.

2.5 Crashes that involve red light running should be coded in CAS with Cause Code 322 'Did not stop at a steady red light' or 323 'Did not stop at a steady red arrow'. However, analysis of CAS data shows that some crashes are not coded with either of the above Cause Codes, but almost certainly involved a vehicle running a red light.

2.6 Those crash movement types that must involve a red light running movement at a signalised intersection are highlighted in **Figure 1**.

Figure 1: Movement Types that must involve Red Light Running at a Signalised Intersection



2.7 Accordingly, the severity indices developed for this study are based on all crashes with Cause Code 322 or 323 or Movement Types HA, JA, JC and KB at signalised intersections. Two crash queries; one capturing crashes with Cause Code 322 and 323, and one capturing Movement Types HA, JA, JC and KB at signalised intersections, were combined in CAS. Duplicate entries were removed automatically by CAS as part of the combination process. Entries without an intersection type were removed manually.

2.8 The CAS analysis indicates that 4,347 crashes were reported in NZ in the 5-year period that met the Cause Code or Movement Type criteria described above. Of these, 2,883 (66.3%) were non-injury, 1,264 (29.1%) were minor injury and 200 (4.6%) resulted in serious injury or death. There were 249 serious injuries and fatalities as a result of the 200 fatal and serious crashes, which equates to 1.25 casualties for each crash.

2.9 Overall, red light running crashes account for approximately 34% of all signalised intersection injury crashes.

2.10 A summary of red light running crashes and casualties for different signalised intersection types and speed environments is shown in **Table 1**.

Table 1: Red Light Running Crash and Casualty Data for all Signalised Intersections

Intersection Type	Number of Minor Injury Crashes	Number of Fatal and Serious Crashes	Number of Fatal and Serious Casualties
Urban T	283	44	54
Urban X	923	148	184
Rural T	22	2	2
Rural X	36	6	9
Total	**1264**	**200**	**249**

2.11 Table 1 shows crashes arising from red light running crashes are most prevalent in urban areas and particularly at signalised crossroads. The low numbers of red light running crashes in rural speed environments (speed limit greater than or equal to 80km/h) is most likely a reflection of the low number of high-speed signalised intersections rather than an indication that these intersections have a better crash performance from a red light running perspective.

2.12 The following tables show the severity indices that have been derived for the most common crash movement types at each of the intersection types and speed environments. With the exception of 'N (all)', which is a crash involving a pedestrian, the crash movement types are defined in Figure 1.

Table 2: Severity Indices for Urban T-Intersections

Key Movement Types	Number of Injury Crashes	Fatal and Serious Crashes / Injury Crash	Fatal and Serious Casualties / Injury Crash
JA & JC	161	0.09	0.09
KB	17	0.00 *	0.00 *
LB	88	0.20	0.30
N (all)	24	0.25	0.25
Total	**290**	**0.13**	**0.16**

* The Severity Indices used in subsequent analysis are the average rates for this intersection type (from Table 1) due to the low sample of observed crashes.

Table 3: Severity Indices for Urban Crossroads

Key Movement Types	Number of Injury Crashes	Fatal and Serious Crashes / Injury Crash	Fatal and Serious Casualties / Injury Crash
HA	779	0.15	0.19
JA & JC	101	0.07	0.08
KB	21	0.05	0.05
LB	142	0.11	0.15
N (all)	32	0.19	0.22
Total	**1075 ****	**0.14**	**0.17**

* The Severity Indices used in subsequent analysis are the average rates for this intersection type (from Table 1) due to the low sample of observed crashes.

** The total number of injury crashes is more than reported in Table 1 due to some 'HA' type crashes being mistakenly coded as occurring at a T-intersection instead of a X-intersection.

2.13 Tables 2 and 3 show that:

- 'HA' type crashes, which only occur at crossroads, have a severity index of 0.19.
- 'J' Type crashes have a low severity index, less than 0.10 compared to other crash movement types.
- There has been only one reported merging 'KB' type crashes at urban signalised intersections that have resulted in serious injury or death in the past five years. This is not unexpected given the impact forces of vehicles colliding at shallow angles.
- The severity index of 'LB' type crashes varies significantly by intersection type. At T-intersections the index is very high at 0.30 fatal or serious casualties for every one injury crash and double that which is observed (0.15) at crossroads.
- Crashes involving pedestrians (Type N) typically have a severity index above 0.20.
- The severity indices for the key movement types at urban signalised T-intersections (0.16) are similar to crossroads (0.17).
- The severity indices show that on average one serious injury or death results for approximately every six observed injury crashes involving red light running.

Table 4: Severity Indices for Rural T-Intersections

Key Movement Types	Number of Injury Crashes	Fatal and Serious Crashes / Injury Crash	Fatal and Serious Casualties / Injury Crash
JA & JC	7	0.14 *	0.14 *
KB	1	0.00 *	0.00 *
LB	14	0.07 *	0.07 *
N (all)	0	0	0
Total	**22**	**0.09**	**0.09**

* The Severity Indices used in subsequent analysis are the average rates for this intersection type (from Table 1) due to the low sample of observed crashes.

Table 5: Severity Indices for Rural Crossroads

Key Movement Types	Number of Injury Crashes	Fatal and Serious Crashes / Injury Crash	Fatal and Serious Casualties / Injury Crash
HA	14	0.00 *	0.00 *
JA & JC	5	0.20 *	0.40 *
KB	2	1.00 *	1.50 *
LB	18	0.17 *	0.22 *
N (all)	0	0	0
Total	**39**	**0.15**	**0.23**

* The Severity Indices used in subsequent analysis are the average rates for this intersection type (from Table 1) due to the low sample of observed crashes.

2.14 The figures presented in Tables 4 and 5 show significant variations in the crash type severity indices. However, because the figures are based on a low number of observations their use needs to be treated with caution. Accordingly, severity indices of the intersection as a whole have been adopted for all subsequent analysis.

3 Technical Analysis – Metropolitan Case Studies

3.1 Abley has utilised previous citywide intersection studies undertaken for AT and the Wellington City Council to gauge the extent of the red light running problem at intersections in NZ and to inform the development of the site selection methodology for red light cameras. This has been supplemented by ongoing work for the NZTA that involves the calculation of the Collective Risk rating for every intersection along the State Highway network.

Auckland

3.2 The study undertaken for AT, which excludes State Highway intersections, includes some 575 signalised intersections. It is based on crash data for the 5-year period from July 2006 to June 2011 inclusive.

3.3 Interrogation of this data shows there have been at least one injury crash resulting from red light running at 277 (48.2%) of these intersections in the past 5 years. At 48 (8.3%) intersections a serious injury or death has resulted from red light running behaviour.

3.4 In urban areas, red light running crashes resulting in injury have been observed at 130 (40.0%) of all T-intersections and 140 (58.6%) of all crossroads. Fatalities and serious injuries have been observed at 21 (6.5%) of all T-intersections and 25 (10.5%) of all crossroads. This indicates the red light running problem is more pronounced at urban crossroads than urban T-intersections.

3.5 In rural areas, red light running crashes resulting in injury have been observed at 3 (42.9%) of all T-intersections and 4 (100.0%) of all crossroads. Fatalities and serious injuries have been observed at none of the 7 T-intersections and at 2 (50.0%) of the 4 crossroads. Again, this indicates the red light running problem is more pronounced at crossroads; however because of the low number of intersections these results need to be treated with caution.

3.6 In Auckland, there are only 12 (2.1%) intersections where multiple fatalities or serious injuries have been observed as a result of red light running behaviour, and only 4 of these had 3 or more casualties.

Wellington

3.7 The study undertaken for Wellington City Council, which excludes State Highway intersections, includes some 84 signalised intersections. It is based on crash data for the 5-year period from 2006 to 2011 inclusive.

3.8 There have been at least one injury crash resulting from red light running at 31 (36.9%) of these intersections in the past 5 years. At 11 (13.1%) intersections a serious injury or death has resulted from red light running behaviour.

3.9 In urban areas, red light running crashes resulting in injury have been observed at 10 (27.8%) of all T-intersections and 21 (43.8%) of all crossroads. Fatalities and serious injuries have been observed at 5 (13.9%) of all T-intersections and 6 (12.5%) of all crossroads. This indicates the red light running problem is more pronounced at urban crossroads in terms of injuries and similar in terms of fatalities and serious injuries.

3.10 In Wellington, there is only 1 (1.2%) intersection where multiple fatalities or serious injuries have been observed as a result of red light running behaviour. This is a significantly lower incidence than observed in Auckland.

State Highways

3.11 The calculation of the Collective Risk rating for every intersection along the State Highway network is part of the SafetyNET project. It is based on crash data for the 5-year period from 2007 to 2011 inclusive.

3.12 Preliminary analysis of this data shows there has been at least one injury crash resulting from red light running at 138 (52.7%) of the signalised intersections in the past 5 years. At 26 (9.9%) intersections a serious injury or death has resulted from red light running behaviour.

3.13 In urban areas, red light running crashes resulting in injury have been observed at 36 (47.4%) of all T-intersections and 91 (58.3%) of all crossroads. Fatalities and serious injuries have been observed at none of the 76 signalised T-intersections and at 24 (15.4%) of all crossroads. This indicates the red light running problem is more pronounced at urban crossroads, especially in terms of fatalities and serious injuries.

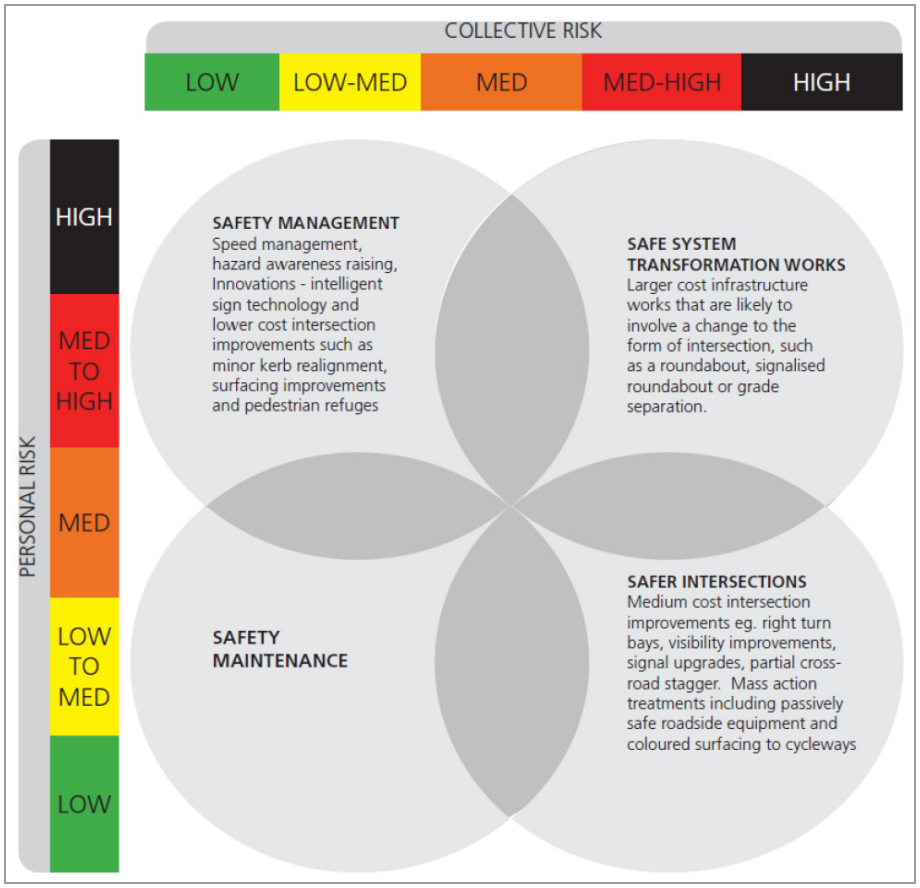
3.14 In rural areas, red light running crashes resulting in injury have been observed at 6 (37.5%) of all T-intersections and 4 (44.4%) of all crossroads. Fatalities and serious injuries have been observed at 1 (6.3%) of the 16 T-intersections and at none of the 9 crossroads.

3.15 On the State Highway network, there are only 6 (2.3%) intersections where multiple fatalities or serious injuries have been observed as a result of red light running behaviour, and only 2 of these had 3 or more casualties. This is very similar to the Auckland findings.

4 Development and Testing of Site Selection Methodology

4.1 The High-Risk Intersections Guide provides guidance to practitioners on the treatment philosophy likely to be most appropriate for an intersection based on its calculated Collective Risk and Personal Risk profile, as shown in **Figure 2**.

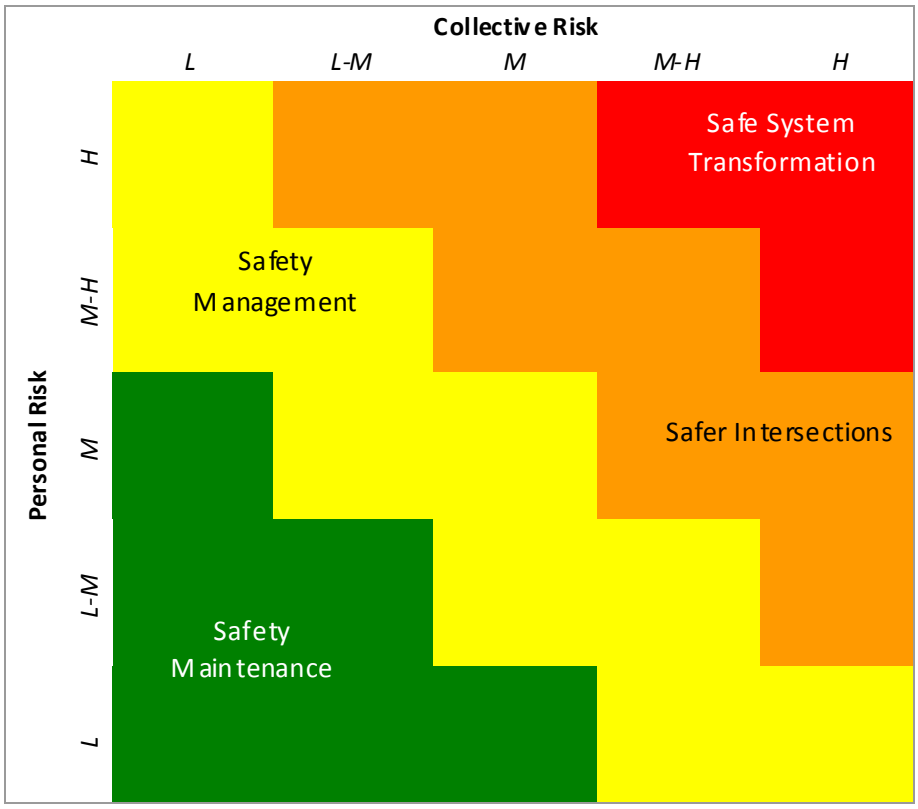
Figure 2: Intersection Treatment Philosophy (reproduced from the High-Risk Intersection Guide)



4.2 It is considered that the use of a red light camera would best be aligned with the treatment philosophy category of 'Safety Management' although it could also form part of a 'Safer Intersection' treatment philosophy. Certainly any intersection that is identified as requiring a 'Safe System Transformation' is unlikely to be a suitable candidate for the installation of a red light camera because the safety issues that contribute to the high Collective and Personal Risk profile are likely to be more fundamental than a red light running problem alone. Further, given the cost of red light cameras, it is also recommended that red light cameras should not be considered for any intersection where 'Safety Maintenance' is the indicative treatment philosophy.

4.3 Further work undertaken by Abley in conjunction with the NZTA (focused around the High-Risk Rural Roads Guide) suggests that the four quadrant treatment philosophy figure is overly simplistic and the shape of the figure is more likely to mirror that shown in **Figure 3**.

Figure 3: Refined Intersection Treatment Philosophy



4.4 Of the 12 intersections in Auckland with multiple observed fatal and serious casualties arising from red light running crashes:

- 2 are classified as Safe System Transformation;
- 3 are classified as Safer Intersections;
- 3 are classified as Safety Management; and
- 4 are classified as Safety Maintenance.

4.5 This suggests that 6 of these intersections (those classified as Safer Intersections or Safety Management) may be appropriate candidates for a red light camera. [1]

[1] This technique could not be applied to intersections on the State Highway network because at the time of preparing this Technical Note the Treatment Philosophy had not been calculated.

4.6 The severity indices described in Section 2 of this Technical Note have been applied to the 575 signalised intersections in Auckland and the 262 signalised intersections on the State Highway network. Abley has analysed the results of this application and developed predicted fatal or serious casualty thresholds for red light running crashes, as shown in **Table 6**. For comparison the Collective Risk levels for all crash types published in the HRIG is also shown.

Table 6: Fatal and Serious Casualty Thresholds for Red Light Running Crashes

Risk Classification	Predicted Number of Fatal and Serious Casualties (Red Light Running)	Predicted Number of Fatal and Serious Casualties (All Crash Types)
Low	< 0.35	< 0.5
Low Medium	0.35 – 0.60	0.50 – 0.85
Medium	0.60 – 0.80	0.85 – 1.20
Medium High	0.80 – 1.10	1.20 – 1.60
High	> 1.10	> 1.60

4.7 In developing the thresholds the typical proportion of injury crashes that result from red light running behaviour has been taken into account. Specifically, the average ratio of red light running injury crashes to all intersection injury crashes (approximately 0.35) has been doubled and multiplied by the mid-point of the HRIG thresholds. This means the thresholds are set at a level where the predicted number of fatal and serious casualties resulting from red light running crashes is twice that of the average red light running rate.

4.8 In Auckland there are 4 intersections that have a 'High' predicted number of fatal or serious casualties based on all red light running injury crashes and a further 9 intersections that would be classified as 'Medium High'.

4.9 Of these 13 Auckland intersections assessed as having a 'High' or 'Medium High' classification:

- none are classified as Safe System Transformation;
- 4 are classified as Safer Intersections (of which 3 were already included from actual observations);
- 8 are classified as Safety Management (of which 1 was already included from actual observations); and
- 1 is classified as Safety Maintenance.

4.10 This suggests that 8 further intersections (those classified as Safer Intersections or Safety Management) may also be appropriate candidates for a red light camera.

4.11 Based on these thresholds, there are 14 intersections (6 based on actual crash observations and 8 based on predicted casualties) in Auckland that may be appropriate candidates for a red light camera. A list of these intersections is shown in **Table 7**. However, as noted in Paragraph 1.4, prior to finalising any intersection as an appropriate site for a red light camera, it is recommended that an intersection audit be undertaken in conjunction with a crash reduction study process. This will help ensure that all other options available have been considered to mitigate potential risks associated with red light running and that selection of a red light camera is considered to be the last resort.

Table 7 Candidate Red Light Camera Intersections in Auckland

Intersection	Number of Fatal and Serious Casualties	Number of Fatal and Serious Crashes	Number of Injury Crashes	Indicative Treatment Philosophy	Predicted Fatal and Serious Casualties
Great South / Penrose	6	2	4	Safer Intersections	0.98
Te Irirangi / Smales	3	2	8	Safer Intersections	1.85
Accent / Chapel / Stancombe	3	2	5	Safer Intersections	0.89
Great South / Redoubt	3	2	4	Safety Management	0.93
Dawson / Te Irirangi	2	1	4	Safety Management	0.67
Golf / Mangere / Walmsley	2	1	3	Safety Management	0.40
Botany / Chapel / Te Irirangi	0	0	11	Safety Management	1.56
Ormiston / Te Irirangi	0	0	7	Safer Intersections	1.38
Ash / Rosebamk	1	1	7	Safety Management	1.26
Henwood / Massey / Robertson	0	0	7	Safety Management	1.01
Reeves / South Eastern / Ti Rakau	0	0	6	Safety Management	0.89
Lincoln / Universal	0	0	6	Safety Management	0.85
Aviemore / Bucklands Beach / Pakuranga	0	0	5	Safety Management	0.82
Balmoral / Sandringham / St Lukes	0	0	5	Safety Management	0.82

4.12 In Wellington, none of the 84 signalised intersections would have a 'High' or 'Medium High' classification based on the above thresholds. This is unsurprising given that only 3 intersections have only 3 observed injury crashes resulting from red light running and a further 7 intersections have only 2 observed injury crashes.

4.13 In Wellington, the only intersection where 'actual' multiple fatalities or serious injuries have been observed as a result of red light running behaviour has Low Collective Risk and Medium Personal Risk profile, which translates to a Safety Maintenance treatment philosophy. Accordingly, there are no intersections in Wellington that would be considered as candidates for red light cameras based on the past 5 years of crash data.

4.14 On the State Highway network, one of the intersections has a 'High' predicted number of fatal or serious casualties based on all red light running injury crashes and a further three intersections would be classified as 'Medium High'. Of these four intersections, two had multiple observed serious injuries or deaths resulting from red light running behaviour.

5 Description of the Site Selection Criteria

5.1 The site selection criteria for identifying those signalised intersections that may be an appropriate candidate for a red light camera is:

- Any intersection that has 2 or more observed serious injuries or deaths resulting from red light running behaviour; or
- Any intersection that has 0.80 or more predicted fatal and serious casualties derived by multiplying each red light running injury crash type by the applicable severity index.

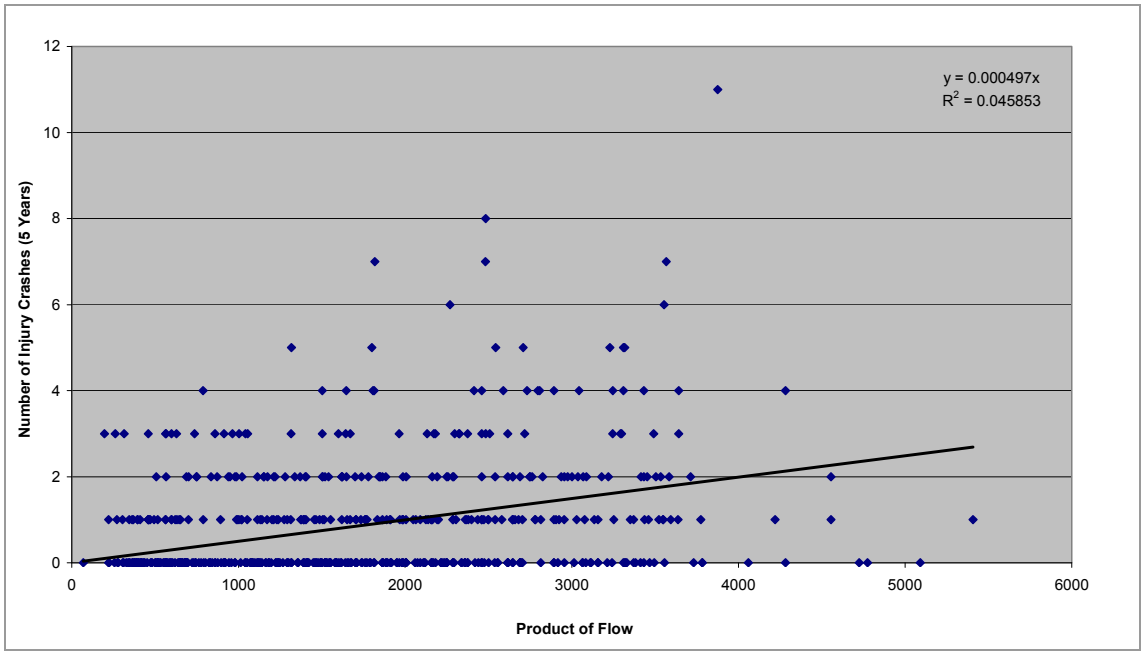
5.2 Only those intersections that have a Collective and Personal Risk profile that corresponds to a 'Safer Intersection' or 'Safety Management' treatment philosophy, as defined by Figure 3 of this Technical Note, shall be considered as appropriate candidates.

6 Discounted Criteria Techniques

6.1 As part of this study, Abley has also explored whether a relationship exists between red light running crashes and traffic flows passing through an intersection. The relationship between crashes and traffic flow is well established for all intersection crashes; however a similar relationship does not exist for red light running crashes.

6.2 **Figure 4** shows a plot of the number of injury crashes resulting from red light running in Auckland over a 5-year period against the Product of Flow (the same variable used in the HRIG).

Figure 4: Relationship between Red Light Running Injury Crashes and Traffic Flow



6.3 Whilst Figure 4 shows there is a positive relationship between red light running crashes and traffic flow, the relationship is very weak (R^2 = 0.046).

7 Extent of the Issue

7.1 The technical analysis indicates that 14 of the 659 Auckland case study signalised intersections investigated would meet the site selection criteria to suggest that an intersection may be an appropriate candidate for a red light camera. This represents only 2.1% of the case study intersections.

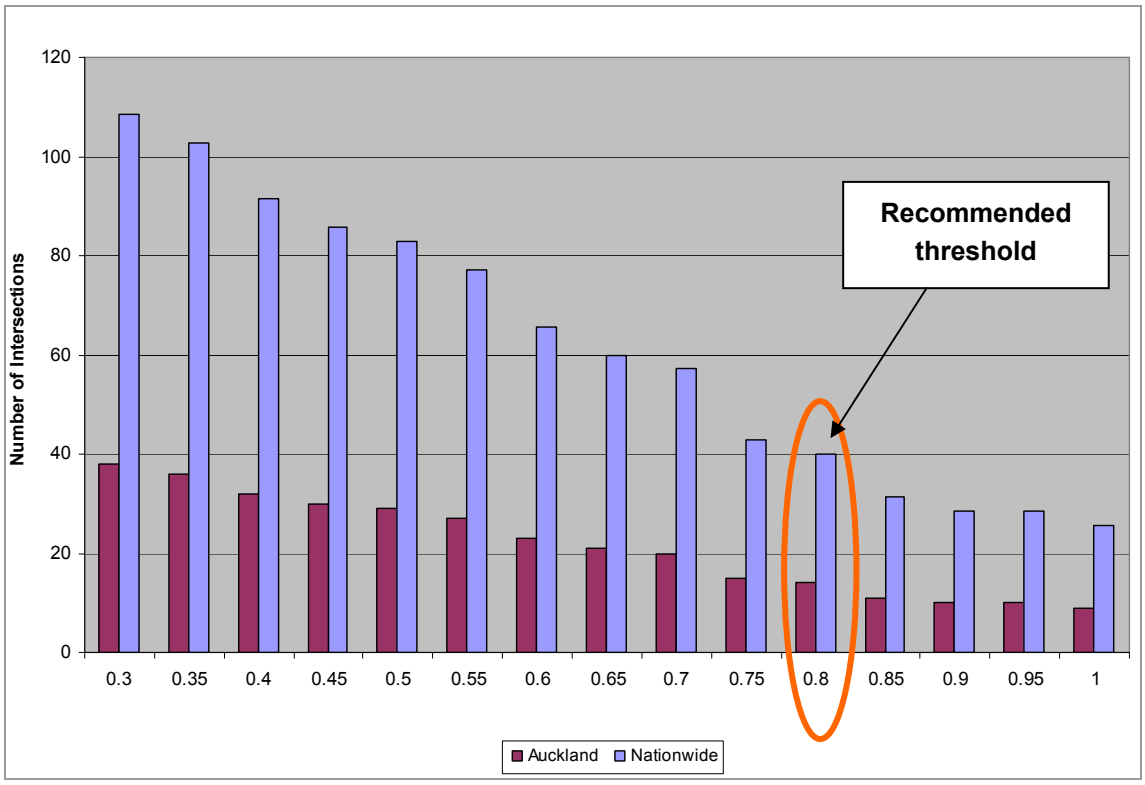
7.2 Further analysis of CAS data has been undertaken to estimate the nationwide number of intersections that would meet the site selection criteria. This analysis suggests that there could be in the order of another 30 additional intersections outside of Auckland, Wellington and the State Highway network that would be likely to exceed the site selection criteria. Based on the Auckland and Wellington sites alone, two thirds of these could be expected to have either a 'Safer Intersection' or 'Safety Management' treatment philosophy.

7.3 Overall, we anticipate that there would be in the order of 35 to 40 intersections that would meet the site selection criteria to suggest that an intersection may be an appropriate candidate for a red light camera. It is unknown what proportion of these sites would then benefit from the installation of a red light camera; however the author of this report would not expect this to be more than half of these sites.

8 Sensitivity of Thresholds

8.1 The sensitivity of the site selection criteria threshold presented in Section 5 of this Technical Note has been evaluated. **Figure 5** shows how the number of intersections meeting the site selection criteria could be expected to vary with a different site selection threshold for the number of predicted fatal and serious casualties based on all injury crashes.

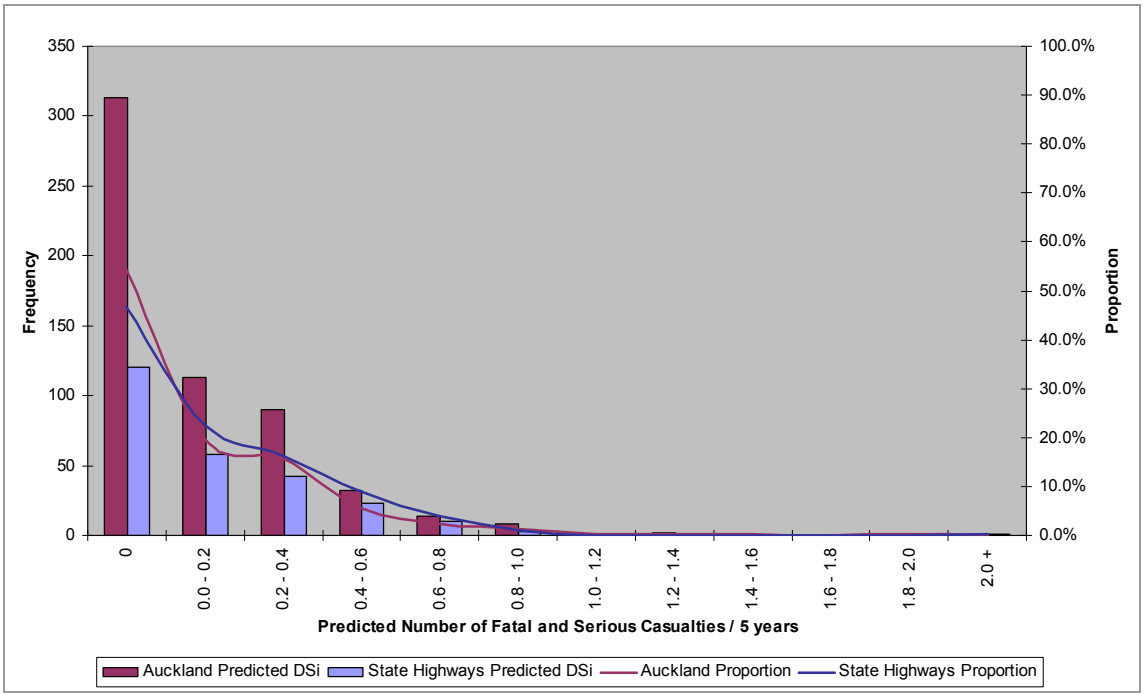
Figure 5: Sensitivity of Site Selection Criteria Threshold for the Number of Predicted Fatal and Serious Casualties



8.2 Figure 5 shows that reducing the threshold from 0.8 predicted fatal and serious casualties to 0.5 predicted fatal and serious casualties would approximately double the number of sites meeting the site selection criteria. The relationship between the number of sites in Auckland and nationwide is proportional to the estimates contained in Section 7 of this Technical Note.

8.3 The representativeness of the Auckland intersections as a proxy for the nationwide extent of the problem has been evaluated by comparing the number and proportion of intersections with a predicted number of fatal and serious casualties with State Highway intersections, as shown in **Figure 6**.

Figure 6: Comparison of Auckland and State Highway Intersections



8.4 Figure 6 shows a very similar trend between the Auckland and State Highway intersections. This suggests the use of Auckland intersections as a case study for informing the development of the thresholds is appropriate.

9 Estimate of Effectiveness

9.1 The following points outline the extent of red light running crashes in New Zealand and provides an estimate of the effectiveness of installing red light cameras to reduce the number of fatal and serious casualties occurring at signalised intersections:

- Injury crashes at signalised intersections account for 25.5% of all injury crashes at intersections. Red light running behaviour accounts for 8.7% of all injury crashes at intersections.
- Fatal and serious casualties at signalised intersections account for 20.8% of all fatal and serious casualties at intersections. Red light running behaviour accounts for 7.6% of all fatal and serious casualties at intersections.
- The HRIG indicates that 38% of all injury crashes occur at intersections. On this basis, red light running behaviour is expected to account for approximately 3% of all injury crashes on New Zealand's roads.
- Adopting the site selection criteria described in Section 5 of this Technical Note would mean approximately 40 signalised intersections are likely to be appropriate candidates for investigating if a red light camera would be a suitable measure to address red light running behaviour.
- The HRIG indicates that red light cameras have an average crash reduction of 69% of red light running crashes on the intersection approach they cover. Based on the average number of injury crashes at Auckland intersections resulting from red light running behaviour and assuming that half of the red light running crashes occurs on the approach covered by the red light camera then the red light camera initiative could be expected to address approximately 2 red light running crashes that result in injury over a five year period at each intersection subject to a red light camera.

- As one serious injury or death arises from approximately every 6 injury crashes resulting from red light running behaviour, then one death or serious injury could be expected to be saved over a five year period for every three intersections covered by a red light camera.