ŌTAKI TO NORTH OF LEVIN PFRs

Report No. 7: Levin Signals

Prepared for NZ Transport Agency

February 2013

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Executive Summary

This report is one of a number of reports being undertaken to determine the package of improvements that should be implemented to improve the safety and efficiency of the highway between Ōtaki and north of Levin as part of the Wellington Northern Corridor Road of National Significance (RoNS).

The purpose of this report is to determine the capacity of the existing coordinated traffic signals on SH1 in Levin to accommodate predicted medium to long term future traffic flows, and to ascertain and assess what measures might be necessary to do so.

SIDRA (version 5.1.12) was used to assess the existing and future flows for the critical PM peak. The existing flows (and peak flow factors) were based on the classified turning count surveys undertaken on Thursday 12 May 2011, and the existing phasing based on SCATS data downloaded at the same time.

Future flows were based on the Otaki to Levin SATURN transport model forecast average weekday PM peak flows for 2011, 2016 and 2041. In addition the higher Friday peak future flows were derived and analysed based on the mid May SCATS detector flow data and the SH1 and SH57 link flow data.

At present the weekday PM peak operates with a common 70 second cycle (Queen Street is 2 phase, Bath Street is 3 phase) and capacity level of service (LoS) B or C. The worst movement LoS is D.

The analysis of the 2041 weekday PM peak indicates that the intersections can continue to operate satisfactorily, with a common 80 second cycle and at the same level of service, albeit it with a modest increase in delay and queue lengths.

The analysis of the 2041 Friday PM peak indicates that the existing intersections can continue to operate satisfactorily, with a common 70 second cycle and intersection LOS C with the worst movements operating at LoS D. This indicates that it can be concluded that there is no perceived need at the present time to proceed with considering modifications to the signals for the purpose of improving capacity in the short to medium term.

An assessment of the safety of the intersections including the short length in between was also undertaken for the past five years. A safety assessment of the signals was made with respect to the High-Risk Intersection Guide. The safety examination and analyses indicated that while the signals have a low or medium safety risk, and operate with a level of safety service of I or II, nevertheless the crash history indicates safety concerns relating to elderly pedestrians in particular.

It is recommended that a low cost safety improvement is made at the Bath Street signals by way of providing a splitter island and left slip turn on the New World corner that was widened in 2009. This could be implemented as part of the Minor Improvements Programme.

NZ Transport Agency

Report 7: Levin Signals

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1 Introduction and Background

Using the outcomes of the Ōtaki to North of Levin Scoping Report and addendum, the NZTA decided that the most appropriate strategy for the highway between Ōtaki and North of Levin is to upgrade the existing highways as the first stage of a long term strategy. This allows the NZTA to realise important safety benefits in the short to medium term whilst deferring the need to construct four lanes for the time being.

This report is one of a number of reports being undertaken to determine the package of improvements that should be implemented to improve the safety and efficiency of the highway between Ōtaki and north of Levin as part of the Wellington Northern Corridor Road of National Significance (RoNS).

The objectives of the Wellington Northern Corridor RoNS, which runs from Wellington Airport to north of Levin, are:

- To enhance inter regional and national economic growth and productivity;
- To improve access to Wellington's CBD, key industrial and employment centres, port, airport and hospital;
- To provide relief from severe congestion on the state highway and local road networks;
- To improve the journey time reliability of travel on the section of SH1 between Levin and the Wellington Airport; and
- To improve the safety of travel on state highways.

For the Ōtaki to north of Levin section; the objectives are:

- To provide best value solutions which will progressively meet (via a staged approach) the long term RoNS goals for this corridor of achieving a high quality four lane route;
- To provide better Levels of Service, particularly for journey time and safety, between north of Ōtaki and north of Levin;
- To remove or improve at-grade intersections between north of Ōtaki and north of Levin;
- To engage effectively with key stakeholders; and
- To lodge Notices of Requirement and resource consents as appropriate with the relevant consent authorities for the first individual project by the 2013/14 financial year.

The projects that are being developed to help meet these objectives are presented in Section 2.

The purpose of this report is to determine the capacity of the existing coordinated traffic signals on State Highway 1 (SH1) in Levin to accommodate predicted medium to long term future traffic flows, and to ascertain and assess what measures might be necessary to do so.

The outcome of this report will be considered alongside the outcomes of the other investigations and used to determine the best package of works to progress as the first stage of the long term strategy.

2 Projects Currently Being Investigated

The projects that are currently being investigated to meet the short to medium term objectives of the Ōtaki to north of Levin RoNS project are presented in the figure below.

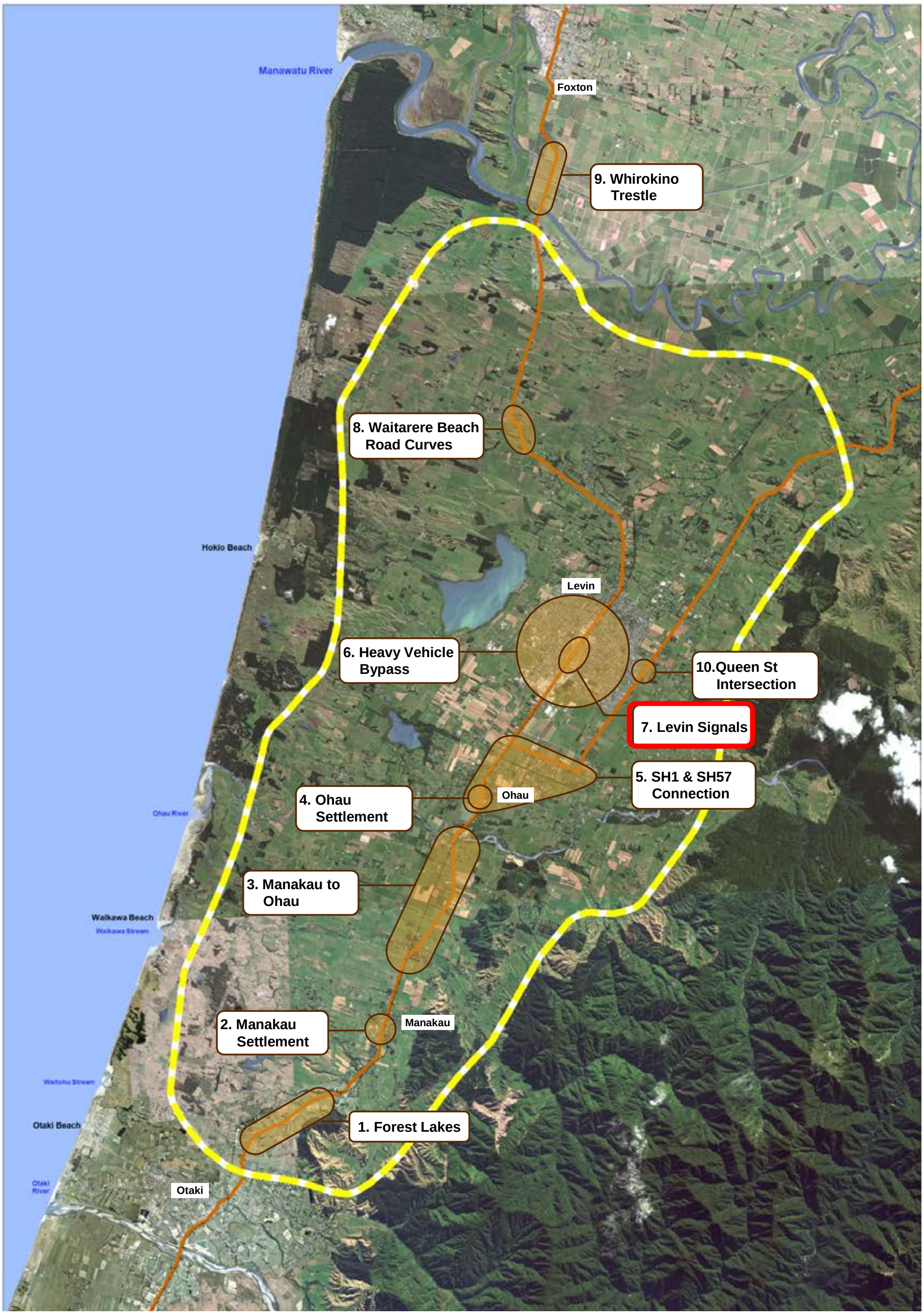


Figure 2-1: Projects Currently Being Investigated

In addition to the above PFRs, reports are also being undertaken on Route Improvements (i.e. edge treatments, passing lanes, walking and cycling, side friction etc; Report No. 11) and on a Four Lane Alignment).

3 Description of Problem

3.1 Ōtaki to North of Levin

State Highway 1 (SH1) and State Highway 57 (SH57) through the study area have a number of deficiencies, resulting in a poor crash history and a number of locations where the free flow of vehicles is restricted by the physical characteristics of the highway.

State Highway 1 currently follows the historic route established in the late 19th and early 20th centuries. As a consequence it is constrained by a now substandard alignment, towns and settlements, narrow curved bridges and significant side friction caused by local roads, commercial frontages and property accesses for the entire stretch.

3.2 Central Levin

While the existing traffic signals do not necessarily have any major deficiencies, there is a perception that the current arrangement will not be able to perform safely and efficiently in the medium to long term. This is particularly due to the decision to upgrade the existing highway(s) and defer plans for a new four lane expressway bypass of Levin.

The section of SH1 through central Levin has a single through lane in each direction. Solid and flush medians are provided and both parallel and angled car parking along the commercial frontages. Pedestrians cross SH1 not only at the signalised (parallel) pedestrian crossings but also between the signals and elsewhere. There is also considerable side-friction from parking manoeuvres which contribute to the perception that SH1 is inhibited in its primary function of catering for through traffic.

The location of the North Island Main Trunk (NIMT) rail line and the service lane to the east of SH1 results in short block lengths. While this might potentially contribute to less than desirable driver behaviour (particularly at times when there might be insufficient length for motorists' vehicles to queue without obstructing other motorists) this is not a present matter of concern. The location of the rail line also has the potential to effect the operation of the highway. However this concern has been addressed as the control of the traffic signals is linked with the operation of the railway barrier arms.

4 Site Description

The project area consists of the 350 m section of SH1 Oxford Street from 50 m north of the Queen Street signals to 50 m south of the Bath Street signals (RP 967 / 13.706 to 14.056) and including the Queen Street and Bath Street approaches to the traffic signals.

The section of road is a wide two lane undivided carriageway. Effective lane widths vary considerably depending on the type of parking and provision of a median. The posted speed limit is within central Levin is 50 km/h with terrain that is generally flat. There are currently no cycle lanes along this urban section of SH1. To the west of SH1 are land use activities attracting significant levels of traffic, including the main supermarkets and the Levin Mall. Consequently there are considerable volumes of cross-traffic and a variety of traffic patterns.

At the two sets of signalised crossroad intersections, on SH1 Oxford Street three approach lanes are provided and one exit lane. The signals are coordinated ("flexilink") and are connected to the Wellington region SCATS network. Currently they operate with simple 2 and 3 phasing and relatively short 70 second cycle throughout the day.

Appendix A shows an aerial of SH1 Oxford Street, while various photos are provided in Appendix B.

5 Traffic Statistics

The Annual Average Daily Traffic (AADT) flow at the NZTA count site on Oxford Street (ID: 01N00981, RP 967/13.58) was 13,600 vehicles per day (2011) with the proportion of Heavy Commercial Vehicles (HCVs) at 7 % (the current site is stated as being dual loop).

The traffic growth rate at the count site is estimated to be 1.3%,based on the Ohau Telemetry Site, using data from 1992 to 2011.

The estimated AADT for SH1 in central Levin is;

- Oxford St north of Queen Street: 15,200
- Oxford St between Queen and Bath: 15,500
- Oxford Street south of Bath Street: 14,800

Side road traffic daily volumes were estimated as follows:

- Queen Street East: 13,300
- Queen Street West: 11,600
- Bath Street (east): 8,700
- Bath Street (west) 8,400

Further traffic information can be found in Appendix E.

6 Crash History

6.1 Crash Data

A review of NZTA's CAS database over the five-year period from July 2007 to June 2012 revealed a total of 43 crashes along the 350 m section of highway (SH1 RP 967/13.706 – RP 967/14.056).

The following tables provide a summary of the CAS output data.

Table 6-1: Annual Distribution of Crashes: At or within 50 m of SH1 Oxford Street / Queen Street

Year	Fatal	Serious	Minor	Non-Injury	Total	DSi*
July - Dec 2007	-	-	1	1	**2**	-
2008	-	-	-	-	**-**	-
2009	-	-	1	2	**3**	-
2010	-	-	-	2	**2**	-
2011	-	-	1	5	**6**	-
Jan – June 2012	-	-	1	2	**3**	-
Total	**-**	**-**	**4**	**12**	**16**	**-**

* Death and Serious injury casualties. Two of the non-injury crashes occurred on Queen Street.

Table 6-2: Annual Distribution of Crashes: At or within 50 m of SH1 Oxford Street / Bath Street

Year	Fatal	Serious	Minor	Non-Injury	Total	DSi
July - Dec 2007	-	1	1	3	**5**	1
2008	-	-	-	3	**3**	-
2009	-	-	2	3	**5**	-
2010	-	1	-	2	**3**	1
2011	-	-	-	5	**5**	-
Jan – June 2012	-	-	-	2	**2**	-
Total	**-**	**2**	**3**	**18**	**23**	**2**

* Death and Serious injury casualties. One of the non-injury crashes occurred on Bath Street

Table 6-3: Annual Distribution of Crashes: SH1 Oxford Street between Queen St and Bath St

Year	Fatal	Serious	Minor	Non-Injury	Total	DSi
July - Dec 2007	-	-	-	-	**-**	-
2008	-	-	-	2	**2**	-
2009	-	-	4	-	**4**	-
2010	-	-	1	-	**1**	-
2011	-	-	-	-	**-**	-
Jan – June 2012	-	-	-	-	**-**	-
Total	**-**	**-**	**5**	**2**	**7**	**-**

* Death and Serious injury casualties

Table 6-4: CAS Crash Type

Crash Type	Number of Reported Injury Crashes	Percentage of Reported Injury Crashes
Overtaking Crashes	-	0%
Straight Road Lost Control/Head On	-	0%
Bend – Lost Control/Head On	-	0%
Rear End / Obstruction	4	29%
Crossing / Turning	1	7%
Pedestrian Crashes	9	64%
Miscellaneous Crashes	-	0%
Total	**14**	**100%**

The following two tables outline the crash types at the two intersections being considered.

Table 6-5: HRIG[1] Injury Crash Types – SH1 Oxford Street / Queen Street Intersection

Crash Type	Number of Reported Injury Crashes	Percentage of Reported Injury Crashes
Manoeuvring (M Type)	1	25%
Pedestrian Crossing (N Type)	3	75%
Total	**4**	**100%**

Table 6-6: HRIG Injury Crash Types –SH57 Oxford Street / Bath Street Intersection

Crash Type	Number of Reported Injury Crashes	Percentage of Reported Injury Crashes
Crossing no turn (H Type)	1	20%
Pedestrian Crossing (N Type)	4	80%
Total	**5**	**100%**

[1] High-Risk Intersections Guide (HRIG), NZTA, draft for consultation, March 2012

Table 6-7: Crash Causation Factors of Reported Injury and Non-Injury Crashes

Causation	Number of Reported Injury Crash Causation Factors	Number of Reported Non-Injury Crash Causation Factors
Alcohol	1	2
Too fast	1	1
Failed to give way/stop	4	8
Overtaking	-	3
Incorrect lane/position	-	11
Poor handling	1	3
Poor observation	8	28
Poor judgement	1	11
Pedestrian factors	4	4
Vehicle factors	2	3
Road factors	-	3
Weather	-	1
Other	-	3

Table 6-8: Environmental Factors

	Wet	Dry		Night	Day		Weekend (Fri 6:00PM to Monday 5:59AM)	Weekday
No.	6	40		7	39		12	34
%	13	87		15	85		26	74

Of the crashes occurring at and between the signalised intersections:

- None were fatal, two were serious, twelve were minor and 32 were non-injury. Both serious crashes occurred at Bath Street, one a right angle crash (red light running) and one a crash involving an elderly pedestrian.
- The vast majority (10 out of 14) of injury crashes involved vulnerable road users Six of these involved elderly (aged 73-89) pedestrians, three others involved adult pedestrians and one an adult cyclist struck by a manoeuvring car.
- Four[2] of the pedestrian crashes involved motorists not stopping for the red light or failing to give way to pedestrians at the traffic signals.
- Five pedestrian crashes occurred mid-block, four 50-100 m south of Queen Street and one within 20 m of Bath Street (hence pedestrian jay walked)
- A large proportion of the non-injury crashes were rear end (predominantly at the intersections) and manoeuvring (predominantly mid-block associated with parking).
- The main crash causation factors included poor observation, poor judgement, failed to give way, pedestrian factors and incorrect lane position.

[2] The primary fault for the serious pedestrian crash at Bath Street (crash id 201013735) was attributed by the Police to the elderly pedestrian but this is arguably unlikely to be so, in which case five motorists would be at fault.

6.2 Crash Risk

This section of SH1 has been analysed using the High Risk Intersection Guide (HRIG) has been utilised to calculate crash risk at this intersections of SH1 Oxford Street / Queen Street and SH1 Oxford Street / Bath Street.

HRIG identifies that crash risk can be defined in two specific ways:

- Collective Risk, also known as Crash Density, is measured as the number of fatal and serious (F&S) crashes per intersection in a crash period
- Personal risk or crash rate is measured in terms of the number of F&S crashes per 100 million vehicles using an intersection

6.2.1 Crash Risk: SH1 Oxford Street / Queen Street Intersection

In terms of collective crash risk for the intersection of SH1 Oxford Street / Queen Street, there are two methods of calculation

- Reported F&S Crashes: Over the 5 year assessment period: there have been zero F&S crashes.
- Estimated F&S Crashes: The second method involves the estimation of F&S crashes that have occurred at an intersection using all injury crashes that have occurred during the crash period. This method take into account the crash movement type, intersection form and control, and collision speed on crash severity outcomes. The estimated collective crash risk is calculated at 0.84 F&S crashes for a 5 year period. This is presented in the table below:

Table 6-9: Estimation of F&S Collective Risk Using Severity Index SH1 Oxford Street / Queen Street Intersection

Crash Type	Number of Reported Injury Crashes	Adjusted F&S crashes / All injury crashes[3]	Estimated Number of F&S Injury Crashes
Manoeuvring	1	0.21	0.21
Pedestrian Crossing	3	0.21	0.63
Total	**4**		**0.84**

Therefore, according to HRIG[4] and using the Estimated F&S method of calculation, this intersection is a low medium (0.50-0.85) collective risk level.

When considering personal risk, a calculation is performed which considers the major and minor road traffic volumes to determine the product of flow to standardise the number of potential conflicts that could occur at an intersection. The SH1 Oxford Street / Queen Street intersection is calculated as having a personal classed as low.

The Level of Safety Service (LoSS)[5] for this intersection is category I[6] which demonstrates excellent safety performance.

6.2.2 Crash Risk: SH1 Oxford Street / Bath Street Intersection

For Collective Crash Risk:

- Reported F&S Crashes: Over the 5 year assessment period, there has been 2 F&S crashes.

[3] HRIG, Table 8.1
[4] HRIG, Table 4-1
[5] Level of Safety Service, as defined by HRIG, is a method of categorising the safety performance of an intersection compared to other intersections of that type.
[6] LoSS categories range from I (one) to V (five) where intersections classified as LoSS I have a safety performance that is better than other intersections of that type, in the same speed environment and with similar traffic flows. For intersections of Category V, the converse is true.

- Estimated F&S Crashes: The estimated collective crash risk is calculated at 0.99 F&S crashes for a 5 year period. This is presented is the table below:

Table 6-10: Estimation of F&S Collective Risk Using Severity Index SH1 Oxford Street / Bath Street Intersection

Crash Type	Number of Reported Injury Crashes	Adjusted F&S crashes / All injury crashes[7]	Estimated Number of F&S Injury Crashes
Crossing (No Turns)	1	0.15	0.15
Pedestrian Crossing	4	0.21	0.84
Total	**5**		**0.99**

Therefore, according to HRIG, using Estimated F&S method of calculation, this intersection is medium (0.85-1.2) collective risk level. Whilst using the actual F&S crash numbers this intersection is considered high risk.

The SH1 Oxford Street / Bath Street intersection is calculated as having a personal classed as low.

This intersection is determined to be near the LoSS I / II category boundary, which represents a good safety performance level relative to similar intersections.

However, while the two signalised intersections are operating reasonably safely, as noted in the crash history there appears to be problems with elderly pedestrians in particular both at the intersections and in the relatively short block in between where parking manoeuvres add to crossing difficulties.

Further crash data can be found in Appendix G.

7 Capacity Analysis of the existing signals

The Do Minimum has been assumed to be the continued maintenance and operation of the existing traffic signals and current layout.

The critical period for capacity is the PM peak. From inspection of the available traffic data, this was taken to be 4:15-5:15 pm which is slightly higher overall than the 4:30-5:30 pm hour.

Examination of the SCATS detector flows for a week indicated that the Friday PM peak appeared to be significantly greater than the Monday to Thursday averages. Accordingly the observed turning count values for the classified survey undertaken on Thursday 12 May 2011 as part of the earlier work were used for modelling the average weekday PM peak, and growth factors applied to them to represent the Friday PM peak.

SIDRA version 5.1.12 was used for a one hour analysis period and 15 minutes peak flow period (PFP) recognising the sharp 5:00-5:15 pm peak quarter hour. The peak flow factors (PFF) were set for each movement (to the nearest 1%) and the light and heavy vehicle flows were entered rounded to the nearest 5 vph, with the model setting changed to include the effect of all heavy vehicles. Lane widths were set at the default 3.3 metres except for the wide left turn lanes.

The SIDRA phasing options were run in a variety of ways to check calibration with the observed phase times, which reflect that the pedestrian demand appears not to be called every cycle. The minimum green times, amber and red intergreen settings were set as per the Contoller Information Sheets (CIS, refer Appendix C). The pedestrian green man and clearance times were also set as per the CIS but the late starts were reduced to reflect that the pedestrian sub-phases appear not to be called every cycle (and the long clearance times for the SH1 crossing had also to be adjusted later to enable SIDRA to run at the average observed phase time for the Bath Street phase). The pedestrian crossing widths were specified and default 1.2 m/s crossing speed used (adjusted to 1.3 m/s if need be).

The SIDRA lane results are included in Appendix F.

[7] HRIG, Table 8.10

7.1 Existing PM peak traffic capacity

For the Queen Street two phase intersection, when specifying a 70 second cycle time the resulting SIDRA derived phase times were consistent with those observed (refer Appendix D). It was noted however that selecting optimum cycle time resulted in a 54 second cycle.

For the Bath Street three phase intersection, specifying a 70 second cycle resulted in SIDRA allocating shorter Oxford Street and longer Bath Street phase times so it proved necessary to instead specify the observed phase times.

For the Queen Street intersection, the overall intersection delay was 19 seconds per vehicle (LoS B) with the worst movement delay for the right turn movements of 32 seconds (LoS C). SH1 Oxford Street through movements operated at LoS B.

For the Bath Street intersection, the overall intersection delay was 22½ seconds per vehicle (LoS C) with the worst movement delay for the right turn movements of 46½ seconds (LoS D). SH1 Oxford Street through movements operated at LoS B (southbound at LoS A).

7.2 Future PM peak traffic capacity

The future traffic was estimated based on the Ōtaki to Levin SATURN Transport Model flows for the base ('Business As Usual') case for 2011, 2016, 2026 and 2041. These indicated that low growth is expected for SH1 traffic and minimal growth for the side road traffic.

The design year chosen was 2041 (30 years from the 2011 base) with the SH1 Oxford Street approach (arithmetic) traffic growth set as 1.0% per annum (slightly higher than present predictions) and that for Queen Street and Bath Street as 0.5% per annum.

For modelling of the 2041 situation, maintaining a 70 second cycle time resulted in too great a delay for the Bath Street eastern approach; however an 80 second cycle time was adequate. With it being necessary for both signals to operate at the same common cycle time, specifying an 80 second cycle at Queen Street resulted in a 43 seconds Oxford Street and 37 seconds Queen Street phasing split (compared to 38 seconds and 32 seconds as modelled for the base year 2011 flows). Currently the average phase time for Oxford Street at Bath Street during the PM peak is about 5 seconds longer than at Queen Street. Adjusting the phase splits at Bath Street to 48, 21 and 11 seconds (80 second cycle) resulted in the best phasing split consistent with SCATS operation.

For the Queen Street intersection, the overall intersection delay was 23 seconds per vehicle (LoS C) with the worst movement delay for the right turn movements of 41½ seconds (LoS D). SH1 Oxford Street through movements operated at LoS B.

For the Bath Street intersection, the overall intersection delay was 24½ seconds per vehicle (LoS C) with the worst movement delay for the right turn movements of 49½ seconds (LoS D). SH1 Oxford Street through movements operated at LoS B.

7.3 Future Friday PM peak traffic capacity

The Friday peak future traffic flows were based on an equivalent of 44 years of traffic growth representing that the base Friday flows for SH1 are about 20% higher and adding 30 years of growth at a 0.8 percent per annum (that is 24 %). With a base model growth rate of 1.0% as previously used the total of 44 % for SH1 amounts to specifying a 44 year design life in SIDRA. As the difference in Friday PM flows compared to average weekday PM peak flows is typically less for local roads than for state highways, the presumed overall equivalent 22 % increase for the side roads seems reasonable (15% for average weekday PM peak).

For the future Friday peak the option to specify the cycle time was chosen not just for the Queen Street intersection but also for the Bath Street intersection to reflect the likely better alignment of the SCATS phase split plans with those required as derived by SIDRA. The optimum cycle time for the Queen Street intersection was 70 seconds with 38 seconds for the SH1 Oxford Street phase (and 32 seconds for Queen Street). For the Bath Street intersection the equivalent for its Oxford Street was 40 seconds which means coordination will still be effective.

For the Queen Street intersection, the overall intersection delay was 24 seconds per vehicle (LoS C) with the worst movement delay for the right turn movements of 48½ seconds (LoS D). SH1 Oxford Street through movements operated at LoS B or C.

For the Bath Street intersecion, the overall intersection delay was 27 seconds per vehicle (LoS C) with the worst movement delay for the right turn movements of 46 seconds (LoS D). SH1 Oxford Street through movements operated at LoS B or C.

7.4 Comments

It is evident that the existing signals are operating well and can continue to do so for the medium to long term without any changes being necessary. From the high level analysis undertaken, there appears to be considerable spare capacity to sufficiently cope for additional demand by changing the phase splits and/or increasing the cycle lengths.

This might be useful since it would appear that the current Bath Street phase is operating shorter than is desired and there is only about 55 metres of queuing space between the limit lines at SH1 and the rail crossing limit lines. However, like other traffic signal controlled intersections on SH1 close to an active (barrier arms) railway crossing on the side road, there is a special SCATS routine for when the railway crossing is closed (same applies at Queen Street).

That only an 80 second cycle is needed for the future PM peak is useful to ensure that the pedestrian level of service provided at the traffic signals is good, so that pedestrians will be less likely to jay walk.

7.5 Other Aspects

It is noted that half of the pedestrian crossings at the two intersections do not comply with current requirements that there be at least a one metre separation at the kerb between them.

At Queen Street there are two bollards at every corner except for the single bollard at the eastern Lotto shop corner and at this corner the drop kerb is contiguous for both the northern crossing of Oxford Street and the eastern crossing of Queen Street.

At Bath Street there is no separation between the crossings except at the southern corner. The latter probably resulted from shifting the southern crossing of Oxford Street slightly south when road widening was undertaken in 2009 along the New World frontages (for both Oxford Street and Bath Street).

It would seem that the northbound through lane for the southern approach at Bath Street is too narrow, although the left turn bay by New World is very wide (presumably for tracking path requirements for supermarket servicing vehicles in particular, given also the wide departure lane on Bath Street).

The pedestrian crossing on the Bath Street west approach is angled, presumably also as a result of the widening by New World. A sketch of a possible low cost pedestrian (and cyclist) improvement option is provided in Appendix H. This reduces the pedestrian crossing distances, which is important given the crash history. It also enables a cyclist holding bay to be provided and possible short cycle lane at the signals for the northbound approach. Furthermore the left turn could then revert from being signalised to become a give way movement resulting in less traffic delay.

8 Conclusions and Recommendations

It is concluded that there is no foreseeable need to improve the existing set of signalised intersections on capacity ground.

It is recommended that a low cost pedestrian (and cyclist) improvement project at the Bath Street signals proceed to the next stage to help address the pedestrian crash history.

Appendix A Site Location

Queen Street

Bath Street

Appendix B Photographs

View east along Queen Street East

View west along Queen Street West

View north along Oxford Street (note lack of separation of the ped. crossings by the single bollard)

View south along Oxford Street

View south along Oxford Street

View east along Bath Street East

View west along Bath Street West

View north along Oxford Street

View north along Oxford Street


View south along Oxford Street (the n/b through lane appears to be too narrow)


View south along Oxford Street (note the wide left turn lane that was widened in 2009)

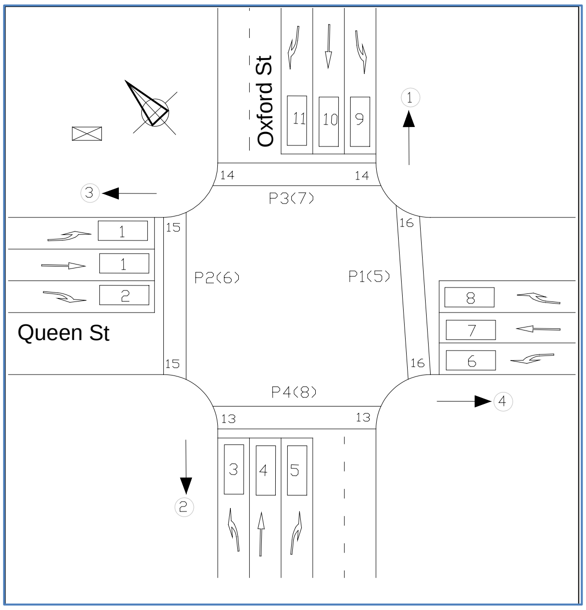
View south along Oxford Street between Queen and Bath Streets
(note the parked car reversing out and the waiting car which the red car has passed while using the flush median)

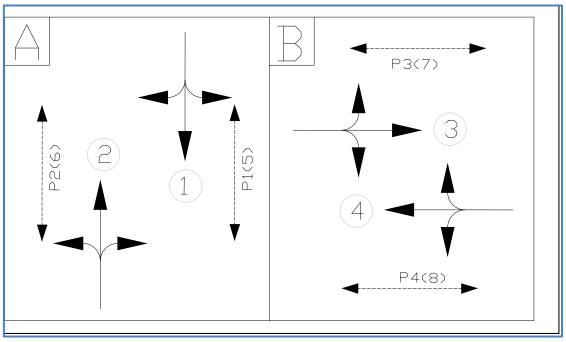
View south along Oxford Street between Queen and Bath Streets
(note the two pedestrians walking along the road, the bicycle lying on the road and the double parked car)

View north along Oxford Street between Bath and Queen Streets
(note the pedestrians waiting to cross and the double parked delivery truck)

Appendix C Controller Information Sheets

Queen Street (#5602, 2 phase)

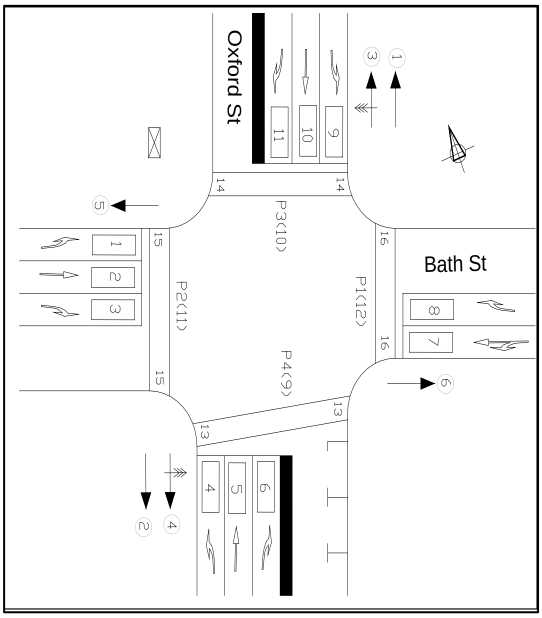




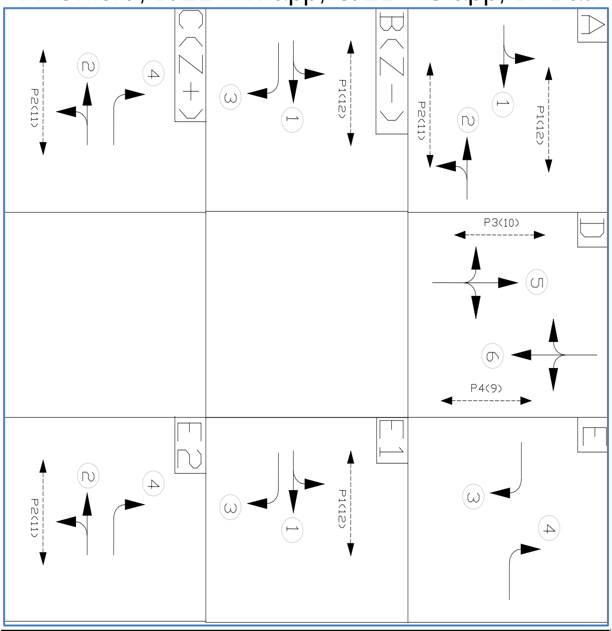
Ped No	Table No	Ped Operates in Phases	Callaway Phase	SG No	Delay Time	Cross	Clear 1	Clear 2	Ped Protection Y/N
1	P1	A	B	5		6	14	4.0	Y
2	P1	A	B	6		6	12	4.0	Y
3	P1	B	A	7		6	12	4.0	Y
4	P1	B	A	8		6	13	4.0	Y

PHASE	LS	LS SG	MG	MAX	YEL	RED	SRED
A	3	1,2	5	90	4.0	2.0	0.0
B	3	3,4	5	40	4.0	2.0	0.0

Bath Street (#5601, 3 phase)



A=Oxford; B/E1 = N app; C/E2 = S app; D=Bath



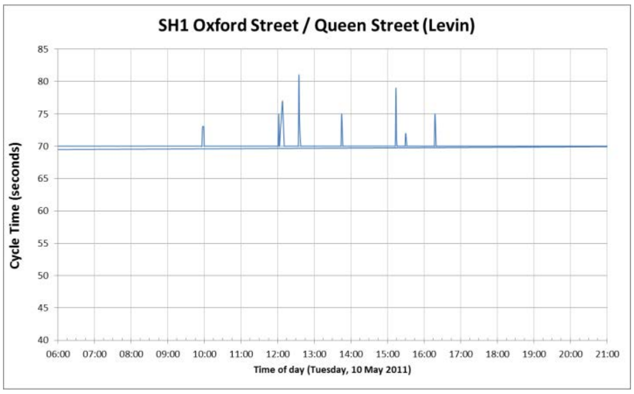
Ped No	Table No	Ped Operates in Phases	Callaway Phase	SG No	Delay Time	Cross	Clear 1	Clear 2	Ped Protection Y/N
1	DO	ABE1	D	12		6	8	3.5	Y
2	DO	ACE2	D	11		6	14	3.5	Y
3	P1	D	A	10		6	12	3.5	Y
4	P1	D	A	9		6	17	3.5	Y

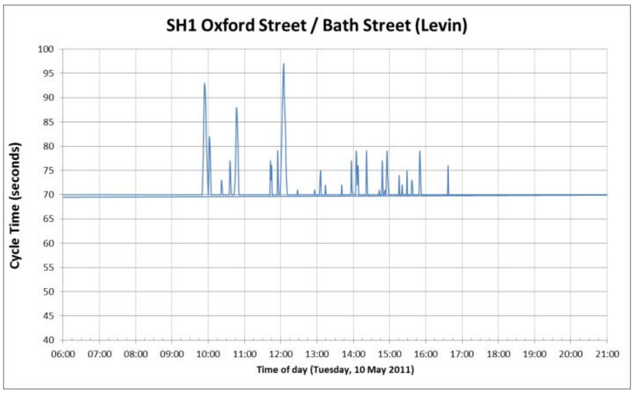
PHASE	LS	LS SG	MG	MAX	YEL	RED	SRED
A	5	1,2,3,4	5	40	4.0	1.5	0.0
B(Z+)	5	1	5	15	4.0	1.5	0.0
C(Z+)	5	2	5	15	4.0	1.5	0.0
D	5	5,6	5	30	4.0	1.5	2.5
E		1,2	5	20	4.0	1.5	0.0

These controller information sheets (CIS) dated 11/4/11 (by Ross Thomson). Flexilink operates.

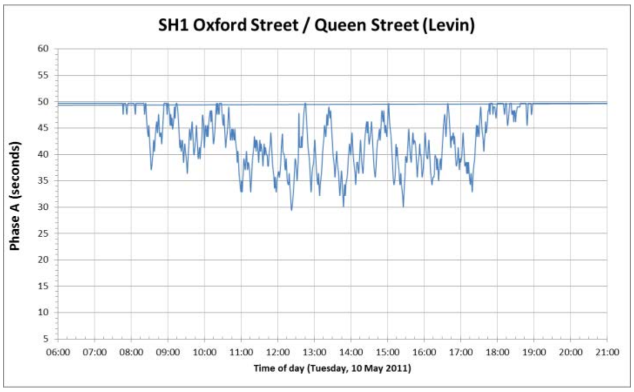
Appendix D Cycle and Phasing output

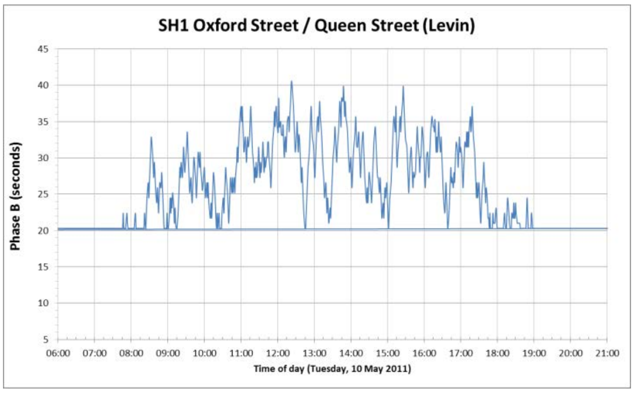
Tuesday 10 May 2011

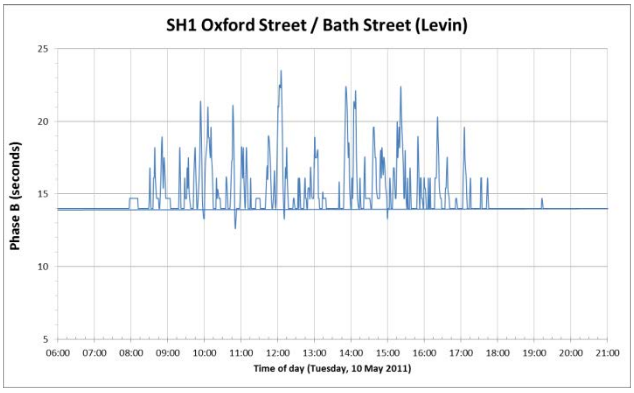




A phase is SH1 Oxford St, B / B (D) phase Queen / Bath St, C (E) phase SH1 Oxford right turns







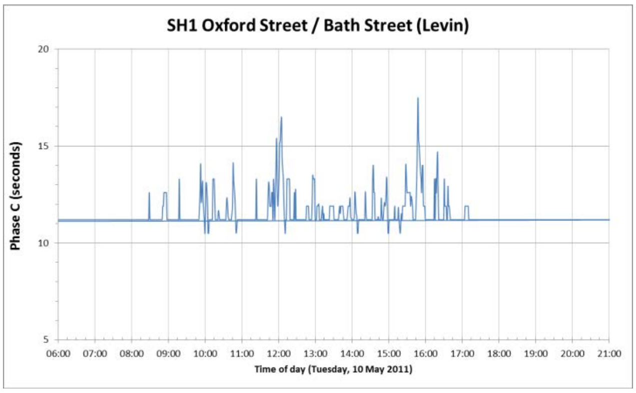
Average Phase times: 4-6 pm

16:00	16:30	38.6	31.6
16:30	17:00	42.8	27.2
17:00	17:30	39.1	30.9
17:30	18:00	46.8	23.2

Queen St (2 phase)

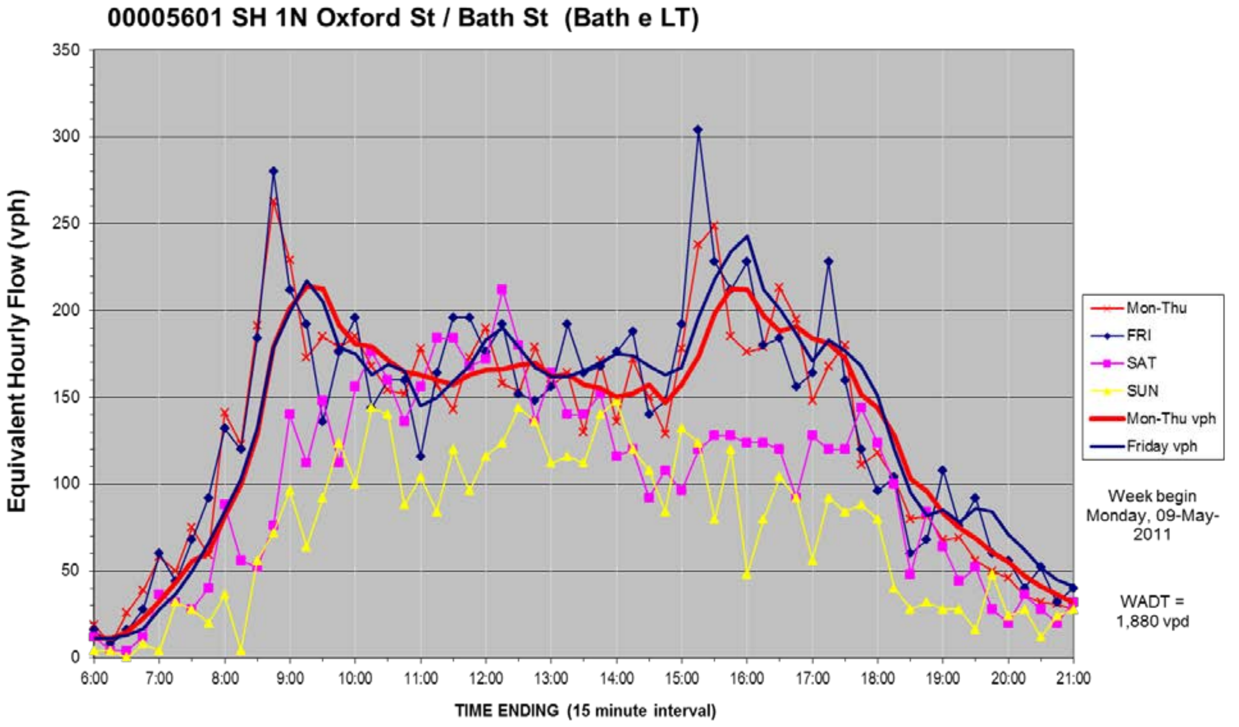
16:00	16:30	43.0	15.4	11.6
16:30	17:00	44.3	14.5	11.4
17:00	17:30	43.8	14.8	11.3
17:30	18:00	44.5	14.3	11.2

Bath Street (3 phase)

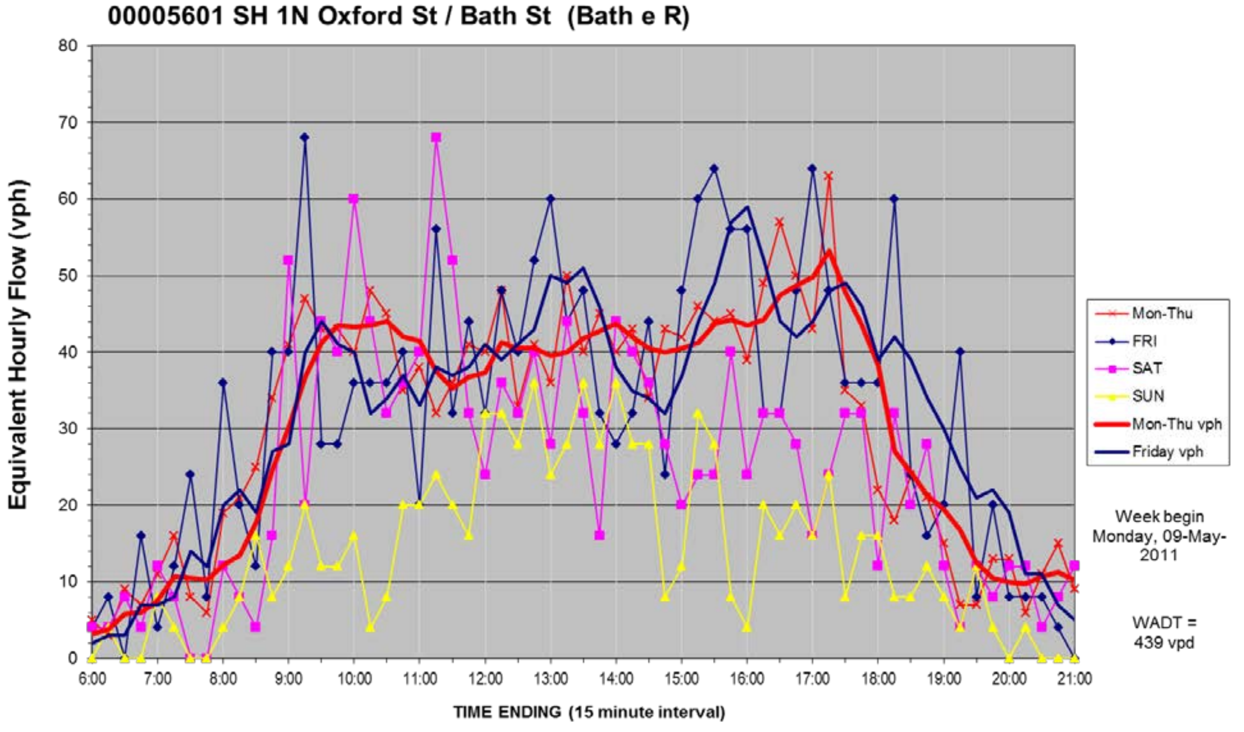


Appendix E Traffic Data

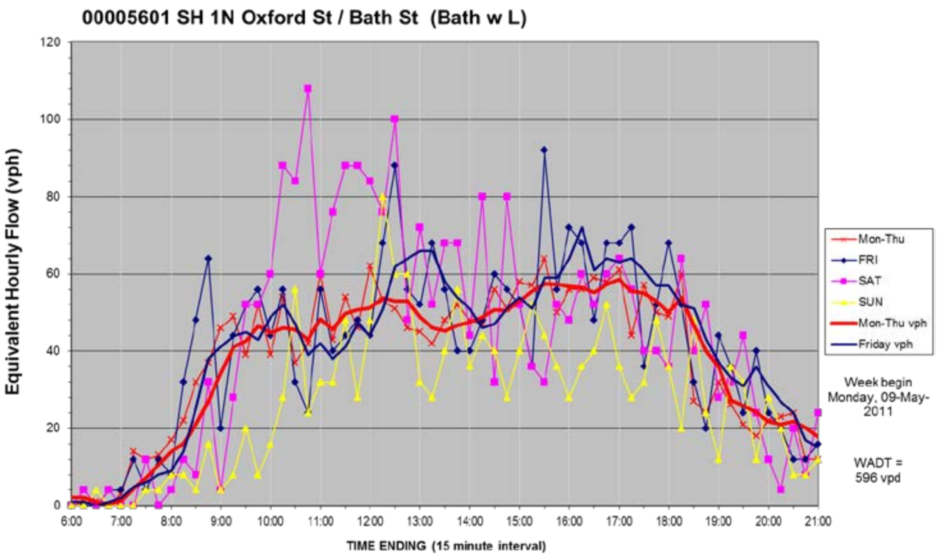
1: SCATS detector flows at Bath Street (5601) for 9-16 May 2011



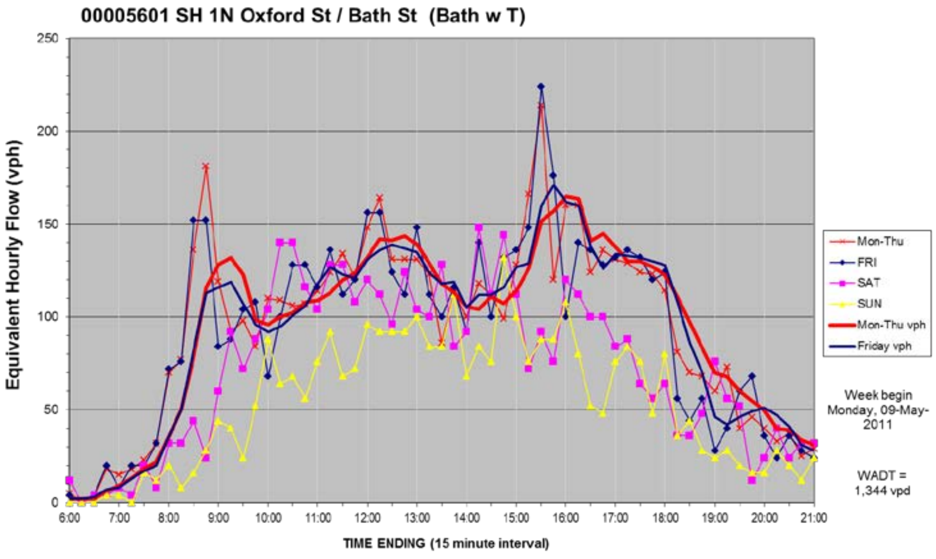
Shared left/through lane for the Bath Street eastern approach



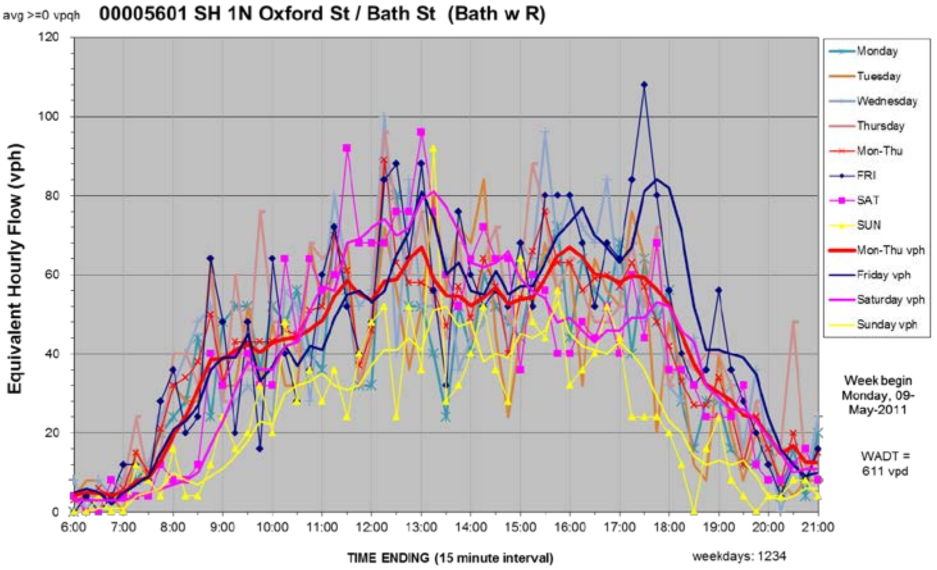
Right turn bay for the Bath Street eastern approach



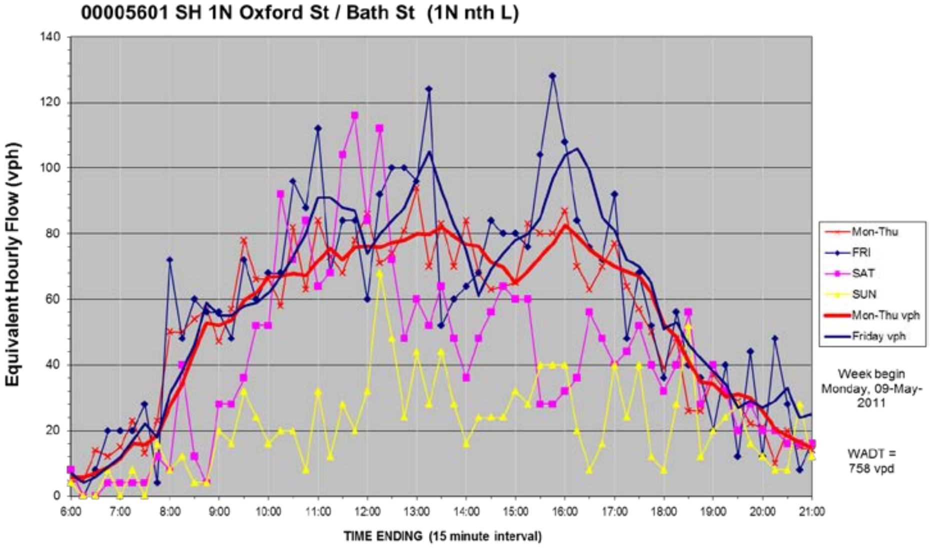
Left lane for the Bath Street western approach



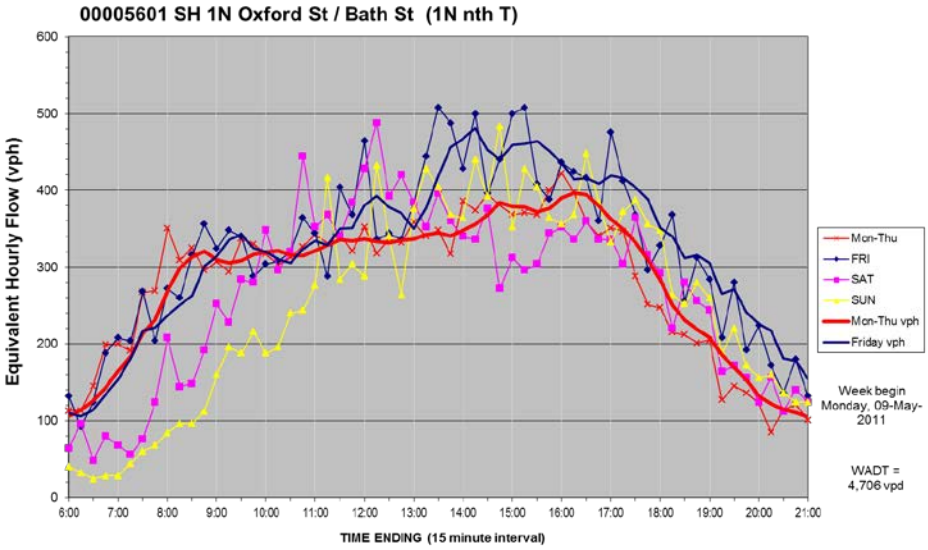
Through lane for the Bath Street western approach



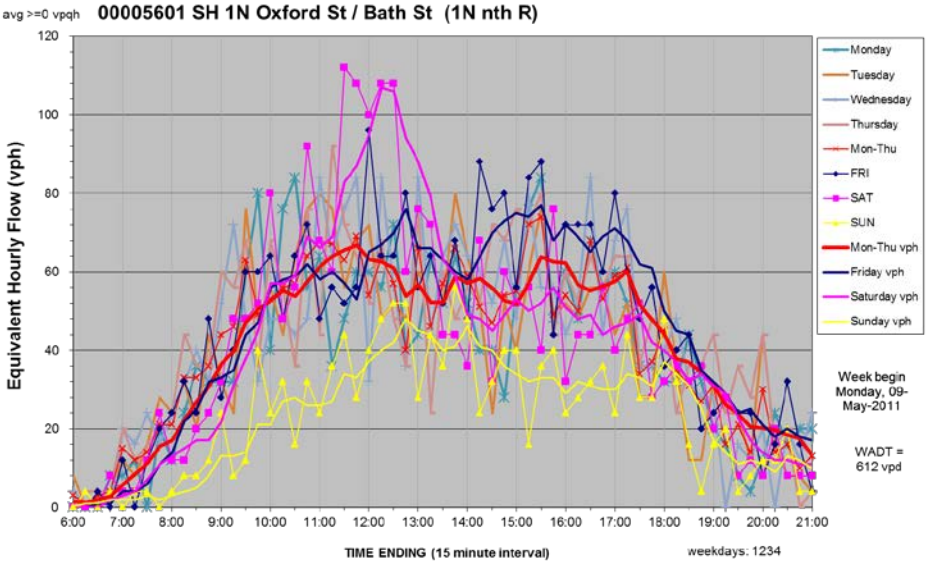
Right lane for the Bath Street western approach



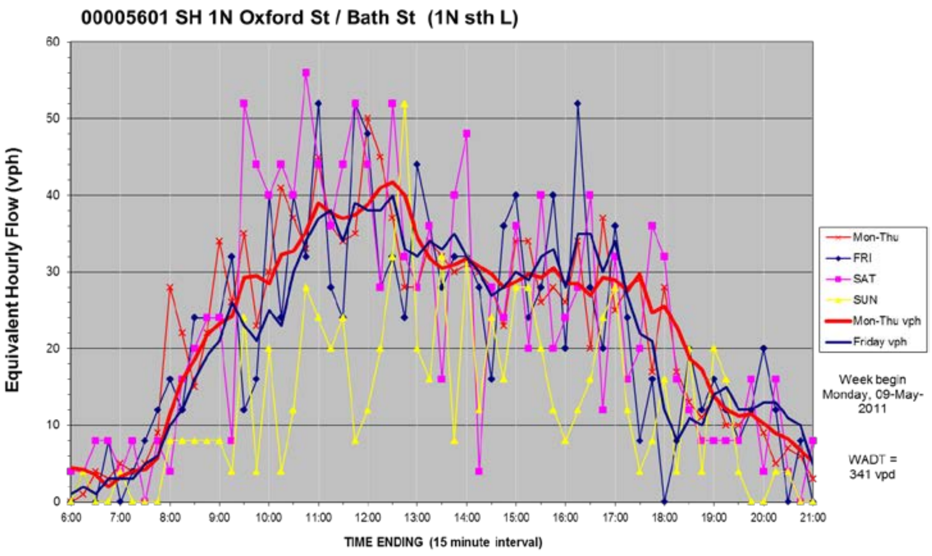
Left lane for the Oxford Street northern approach



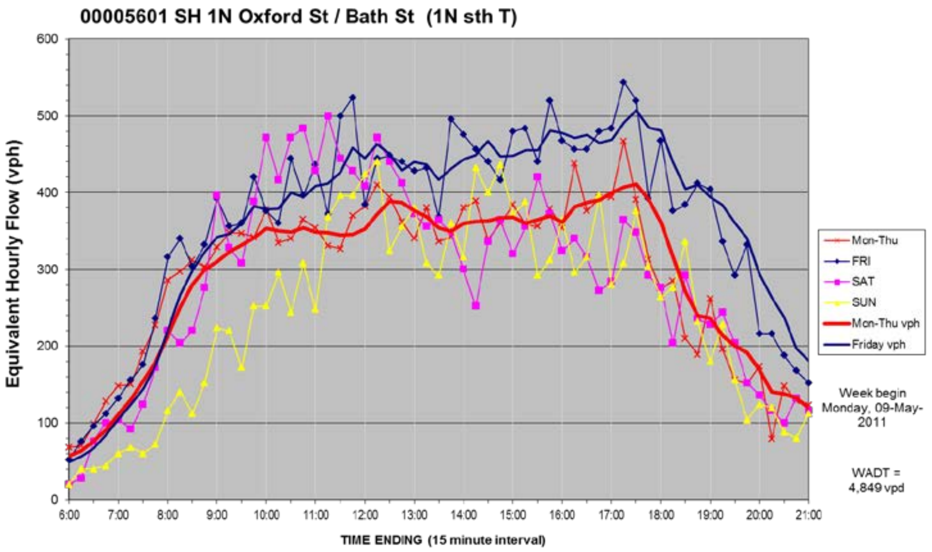
Southbound through lane for the Oxford Street northern approach



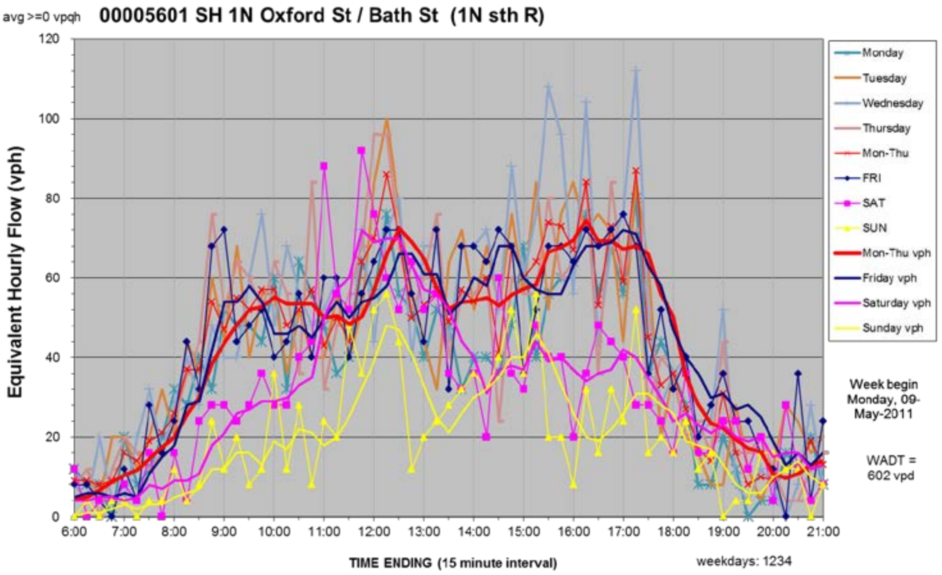
Right lane for the Oxford Street northern approach



Left lane for the Oxford Street southern approach (Friday 4:15-5:15 PM about the same)



Northbound through lane for the Oxford Street southern approach (Friday PM higher)



Right lane for the Oxford Street southern approach (Friday PM about the same)

2: Classified turning count survey: Thursday 12 May 2011

SH1 Oxford Street / Queen Street

Queen St/ SH 1 Thurs 12/05/11 Weather rain on and off for most of the day

	SH 1 North			SH 1 North			SH 1 North			Queen St East			Queen St East			Queen St East			SH 1 South			SH 1 South			SH 1 South			Queen St West			Queen St West			Queen St West						
	Left into Queen St			Straight into SH 1 St			Right into Queen St			Left into SH 1			Straight into Queen			Right into SH 1			Left into Queen St			Straight into SH 1 N			Right into Queen St			Left into SH 1			Straight into Queen			Right into SH 1						
Time	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses				
7:00	5	5		44			5			8			9			12	1		4			19	7		6	1		1			16	1		13						
7:15	12	5		62			1			9			14	1		8			3			41	14		6			3			15			7						
7:30	13	7		45		1	5			6			22			11		2	4			40	7	2	7	1		1			26	1		17	1					
7:45	12	9		61	1	1	5			9			44	4		9			5			41	14		8	1		6			36			15						
8:00	15	6		66			9		1	27			45	2		23	1					51	14		9	2		4			34	1		17	4					
8:15	23	6		77		1	14			13			53	1		20	2	1				54	10	1	14	1		7			42		1	15	2					
8:30	19	9		61			11			24			67	1		21						57	11		17			9			58	1		19		1				
8:45	26	7		78	1		13			31			90	1	2	21	3					55	15		16		1	9	1		76			17						
11:00	25	1		72	5		9		1	26			42		2	31			26			61	12		14			15			44			27	1					
11:15	26			83	5		14	1		28	1		53	1		28	1		24	1	2	68	5		12	2		14	1	1	55	1		28	1					
11:30	26			62	7	2	16			24	1		53	1	2	23	1		13			70	9	2	20	2		16	1		55			18	1					
11:45	25			64	7	1	13			24	1	1	69	1	1	33	1		24		1	93	8		25			16			58		1	24						
12:00	28			73	9		12	2		23	1		61	1	1	41	1		26			73	13		17			11			61			20	1			All		1
12:15	10			49	2		6			25			55			17			27	1		61	10		11			7			46			20			AM	1538	2	3076
12:30	23			89	3		8			28	1		71	2	1	31			22	1	1	64	10		15	1		15			41			20	2		IP	1786	11.4	20360
12:45	25		1	70	7		10	1		37		1	68	1	1	33			21			82	8	1	5			9			63		2	24			PM	2179	2	4358
13:00	24			68	8		8			19	1		51	2	1	20	2		28			83	7		23	2		10			68			23				1786		27794
13:15	15			66	10	1	19			28			64	1		26			15			64	11	1	13	3		9	1		75			19	3				entering AADT	
13:30	20			72	8		10			23	1	1	54	1		29			22			68	13	2	20	1		10	1		62			16	2				0.940	
13:45	24			71	7		14		1	27			66	1		28	1		26			82	10	2	18	1		10			55	1		22	2				556	
16:00	26			74	9		11			33			80	4		35	3		21			105	5		13	1		11	1		56	4		28			493	29	522	5.6%
16:15	20			78	8		14			24			90	2		41			29	1		101	5		25			14			84	1		18			538	20	558	3.6%
16:30	31	2		81	13		14			29			68	1		32	1		26			100	10		12			6			63	1		20	1		482	31	513	6.0%
16:45	25	2		80	13		7			26	1		73			34			41	1		119	5		14	1		17			61	1		34			531	31	562	5.5%
17:00	29	2	1	82	5		14			30			88	2	1	29	2		23			127	5		24	1		16			88			21			571	21	592	3.5%
17:15	28	1		69	5		16			23			74	1		36			17			117	7		18			12			81	1		16	1		507	13	520	2.5%
17:30	21			64	7	1	13			22			39		1	37			21			79	4		23			14			56			17			406	18	424	4.2%
17:45	21			58	6		16			23			54	1		29			11			77	2		11			20			53			11			Intersection			

	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	%HV
7-9 am	125	54	179	494	5	499	63	1	64	127	0	127	344	12	356	125	10	135	16	0	16	358	95	453	83	7	90	40	1	41	303	5	308	120	8	128	2198	198	2396	8.3%
7:45-8:45	69	30	99	265	3	268	39	1	40	73	0	73	209	8	217	73	4	77	5	0	5	203	50	253	48	4	52	26	0	26	170	3	173	66	7	73	1246	110	1356	8.1%
8:00-9:00	83	28	111	282	2	284	47	1	48	95	0	95	255	7	262	85	7	92	0	0	0	217	51	268	56	4	60	29	1	30	210	3	213	68	7	75	1427	111	1538	7.2%
11-12	102	1	103	281	27	308	52	2	54	102	4	106	217	8	225	115	3	118	87	4	91	292	36	328	71	4	75	61	3	64	212	2	214	97	3	100	1689	97	1786	5.4%
12-1 pm	86	1	87	281	21	302	36	3	39	113	3	116	255	7	262	122	1	123	96	3	99	280	42	322	48	1	49	42	0	42	211	2	213	84	3	87	1654	87	1741	5.0%
1-2 pm	83	0	83	277	34	311	51	1	52	97	3	100	235	6	241	103	3	106	91	0	91	297	46	343	74	7	81	39	2	41	260	1	261	80	7	87	1687	110	1797	6.1%
4-6 pm	201	8	209	586	67	653	105	0	105	210	1	211	566	13	579	273	6	279	189	2	191	825	43	868	140	3	143	110	1	111	542	8	550	165	2	167	3912	154	4066	3.8%
4:15-5:15	105	7	112	321	39	360	49	0	49	109	1	110	319	6	325	136	3	139	119	2	121	447	25	472	75	2	77	53	0	53	296	3	299	93	1	94	2122	89	2211	4.0%
4:30-5:30	113	8	121	312	36	348	51	0	51	108	1	109	303	5	308	131	3	134	107	1	108	463	27	490	68	2	70	51	0	51	293	3	296	91	2	93	2091	88	2179	4.0%
5:00-5:15	443	2.0	0.875	465	11.4	1.034	520	2.0	0.875	449	2.0	0.917	449	11.4	0.893	551	2.0	1.121	328	2.0	1.315	494	11.4	0.894	668	2.0	0.770	318	2.0	0.828	378	11.4	0.849	440	2.0	1.119	0.979	0.944	0.931	0.892
appr PFF	390	2.0	7227	510	11.4	7944	675	2.0	15171	384	2.0	7119	392	11.4	6211	487	2.0	13329	454	2.0	7624	514	11.4	7868	550	2.0	15491	310	2.0	5825	370	11.4	5772	467	2.0	11597	15171	13329	15491	11597
2011 PM			119			412			2			69			384			141			0			496			87			0			338			0	908	1116	**2048**	T,app,all
2016 PM			124			402			0			91			406			162			0			503			84			25			520			4	905	1113	**2321**	SH1,1,all
2026 PM			123			436			0			86			403			161			0			534			83			6			505			0	970	1176	**2337**	
2041 PM			120			480			1			83			399			159			0			595			83			0			480			0	1075	1279	**2400**	

SH1 Oxford Street / Bath Street

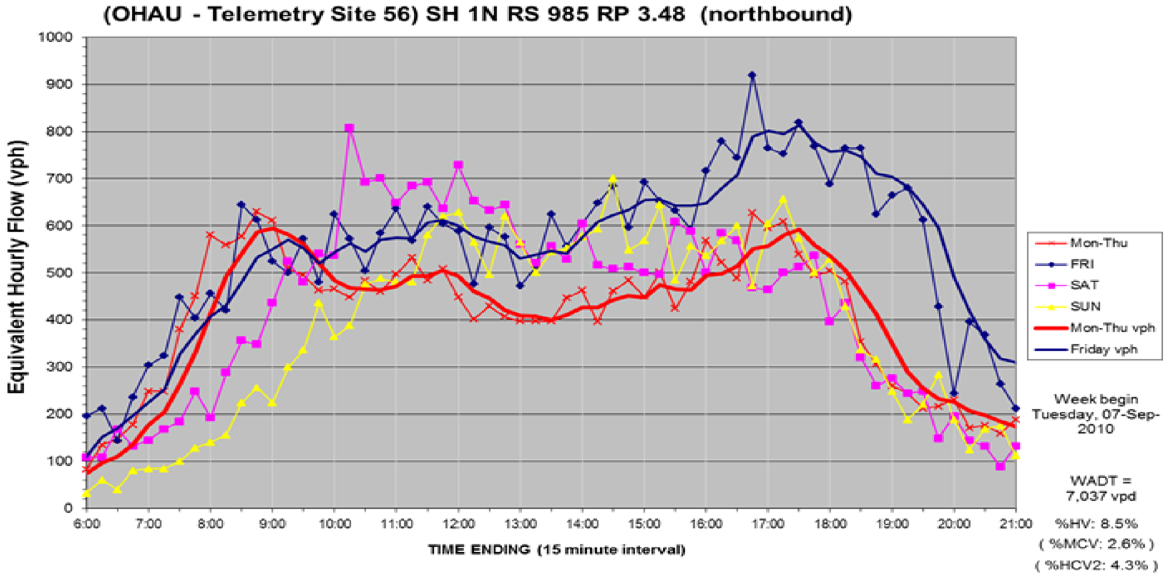
Bath St/ SH 1 Thurs 12/05/11 Weather rain on and off for most of the day

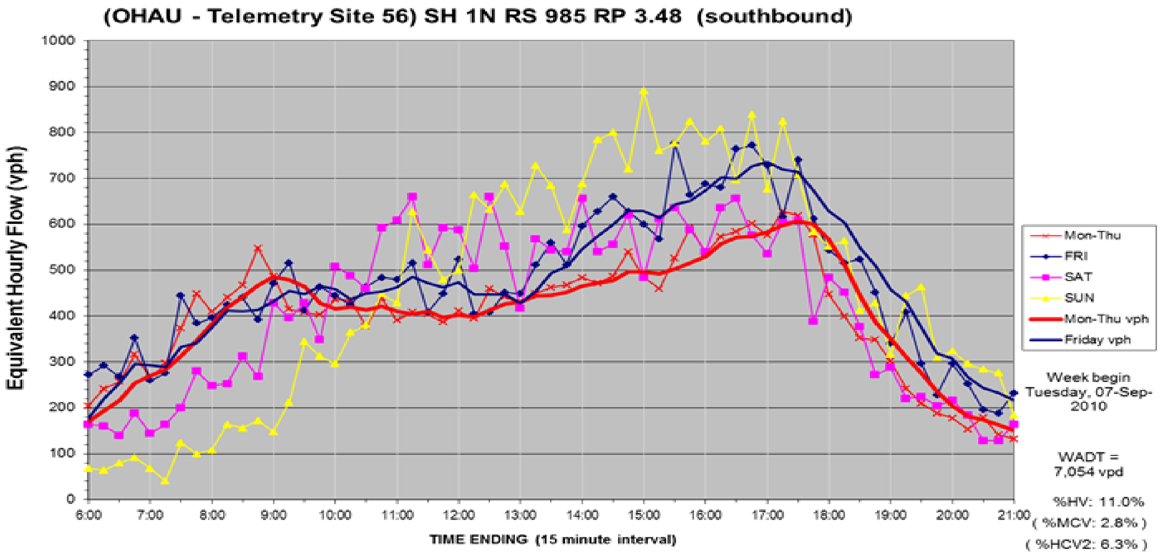
	SH 1 North			SH 1 North			SH 1 North			Bath St East			Bath St East			Bath St East			SH 1 South			SH 1 South			SH 1 South			Bath St West			Bath St West			Bath St West						
	Left into Bath St			Straight into SH 1 St			Right into Bath St			Left into SH 1			Straight into Bath S			Right into SH 1			Left into Bath St			Straight into SH 1 N			Right into Bath St			Left into SH 1			Straight into Bath S			Right into SH 1						
Time	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses	Cars	Trucks	Buses				
7:00	10			53	8		3			3			9			5			2			34	7		3	1		4			6	1		5						
7:15	5			69	1		3	1		7	1		10			3	1		1			36	17		5			6			5	1	1	2						
7:30	5			56	6		4	1		5			8	1		0			2			51	6		3			4			10			3						
7:45	13			65	10	1	7			13			26	1		7		1	11	1		47	17		7			7	1		15			10	1					
8:00	21	2		73	8		5			7			25			4	1		2			63	13	1	10			5			22		1	8	1					
8:15	14			73	6		10			22			43	1		7			5			79	10		12	1		11			35		1	9						
8:30	15			75	11		12			10			50		1	14			8			80	12	1	19			4			54	1	1	14	1					
8:45	17			83	8		16			20			51			12			7			80	16	1	15			12			30			6						
11:00	25			78	7		25	1		13	1		27		1	10			13	1		91	13		15			14	1		30	1		15	1					
11:15	17	2		86	6		22			14			30			3	1		9	1		83	8		12	1		10	1		46	1		18						
11:30	22		1	66	7	1	19			10			39			17	1		13			78	9		18			15			27	1		10						
11:45	23			74	10	1	14			13			45	1		16			8	2		99	9		26			18			54	1		20						
12:00	16	1		86	8		16		2	11			29			16			11			83	10		26			12			46			21	1	1		All		1
12:15	17			84	2		13			12	1		30			16			8			82	8	2	19			11			44			21	2		AM	1368	2	2736
12:30	23	1		88	7		13			14			36	1		13	2		8			71	12		13			13			38			17			IP	1542	11.4	17579
12:45	20			77	7		19			19	1		31			12			6			87	9	1	17			13			34			17	1	1	PM	1689	2	3378
13:00	16	3		74	10		10			12			36			18	1		16	1		93	9		22			12	1		25	3		12	1			1542		23693
13:15	20	2		81	11	1	12	1		12			24			10			9			70	14		11		1	10			24	3	1	16					entering AADT	
13:30	24		1	78	14	1	13			17			33	1		17		1	9			81	16		10	1		11			34			17	1				0.885	
13:45	22			82	7		15			13			26			15			6		1	89	13	1	14	1		12			30	1		13		1			420	
16:00	19			96	7		13			9			41			15			4			116	6		24			21			37			17			412	14	426	3.3%
16:15	15			82	6		17			14			31		1	17			6			97	8	1	6			16			29			12			342	14	356	3.9%
16:30	22	1		83	8		14	1		11			45	1		18			13			101	11	1	19			26			39	1		13	1		404	22	426	5.2%
16:45	29			94	11		20			9	1		34			13			10			117	7	1	17			12			32			12			399	25	424	5.9%
17:00	16			102	6		16			10			45			23	1		9			133	6		19	1		19	1		50			20		1	462	13	475	2.7%
17:15	22			71	6		10			8			43			8			5			100	5		6	1		22			40			16			351	12	363	3.3%
17:30	17			70	8		15			7	1		16			14			4			92	5	1	9			10			30			16		1	300	19	319	6.0%
17:45	10			64	6		10	1		7	1		20			6			7			81	3		10			11			33	1		9			Intersection			

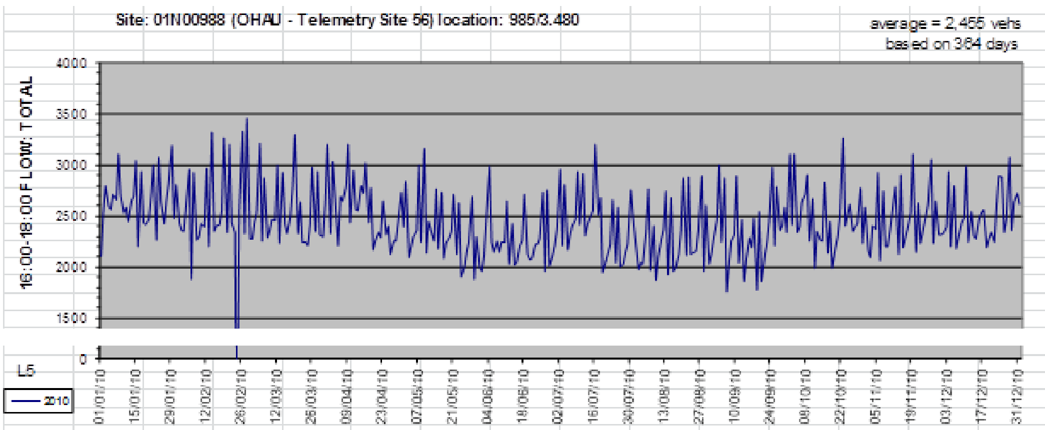
	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	LV	HV	All	%HV
7-9 am	100	2	102	547	59	606	60	2	62	87	1	88	222	4	226	52	3	55	38	1	39	470	101	571	74	2	76	53	1	54	177	7	184	57	3	60	1937	186	2123	8.8%
7:45-8:45	63	2	65	286	36	322	34	0	34	52	0	52	144	3	147	32	2	34	26	1	27	269	54	323	48	1	49	27	1	28	126	4	130	41	3	44	1148	107	1255	8.5%
8:00-9:00	67	2	69	304	33	337	43	0	43	59	0	59	169	2	171	37	1	38	22	0	22	302	54	356	56	1	57	32	0	32	141	4	145	37	2	39	1269	99	1368	7.2%
11-12	87	3	90	304	32	336	80	1	81	50	1	51	141	2	143	46	2	48	43	4	47	351	39	390	71	1	72	57	2	59	157	4	161	63	1	64	1450	92	1542	6.0%
12-1 pm	76	2	78	335	24	359	61	2	63	56	2	58	126	1	127	57	2	59	33	0	33	323	42	365	75	0	75	49	0	49	162	0	162	76	6	82	1429	81	1510	5.4%
1-2 pm	82	6	88	315	44	359	50	1	51	54	0	54	119	1	120	60	2	62	40	2	42	333	53	386	57	3	60	45	1	46	113	8	121	58	3	61	1326	124	1450	8.6%
4-6 pm	150	1	151	662	58	720	115	2	117	75	3	78	275	2	277	114	1	115	58	0	58	837	55	892	110	2	112	137	1	138	290	2	292	115	3	118	2938	130	3068	4.2%
4:15-5:15	82	1	83	361	31	392	67	1	68	44	1	45	155	2	157	71	1	72	38	0	38	448	35	483	61	1	62	73	1	74	150	1	151	57	2	59	1607	77	1684	4.6%
4:30-5:30	89	1	90	350	31	381	60	1	61	38	1	39	167	1	168	62	1	63	37	0	37	451	31	482	61	2	63	79	1	80	161	1	162	61	2	63	1616	73	1689	4.3%
5:00-5:15	449	2.0	1.297	507	11.4	0.907	532	2.0	1.063	268	2.0	1.125	242	11.4	0.872	270	2.0	0.750	435	2.0	1.056	509	11.4	0.869	582	2.0	0.775	216	2.0	0.925	284	11.4	0.755	305	2.0	0.702	0.970	0.867	0.868	0.780
appr PFF	426	2.0	7742	497	11.4	7768	625	2.0	15510	271	2.0	3835	323	11.4	4854	315	2.0	8689	435	2.0	7837	451	11.4	6977	483	2.0	14814	236	2.0	4280	271	11.4	4093	266	2.0	8373	15510	8689	14814	8373
2011 PM			41			351			54			44			138			18			48			464			134			0			214			63	815	1092	**1569**	T,app,all
2016 PM			34			369			56			31			151			7			48			483			23			0			114			59	852	1013	**1375**	SH1,1,all
2026 PM			24			393			56			30			151			7			48			518			32			0			127			64	911	1071	**1450**	
2041 PM			24			438			60			38			153			8			49			574			49			0			173			64	1012	1194	**1630**	

The red figures are the derived PFFs; blue figures the SATURN transport model base network PM peak turn flows.

3: TMS link surveys on SH1 and SH57: SH1 south of Ohau

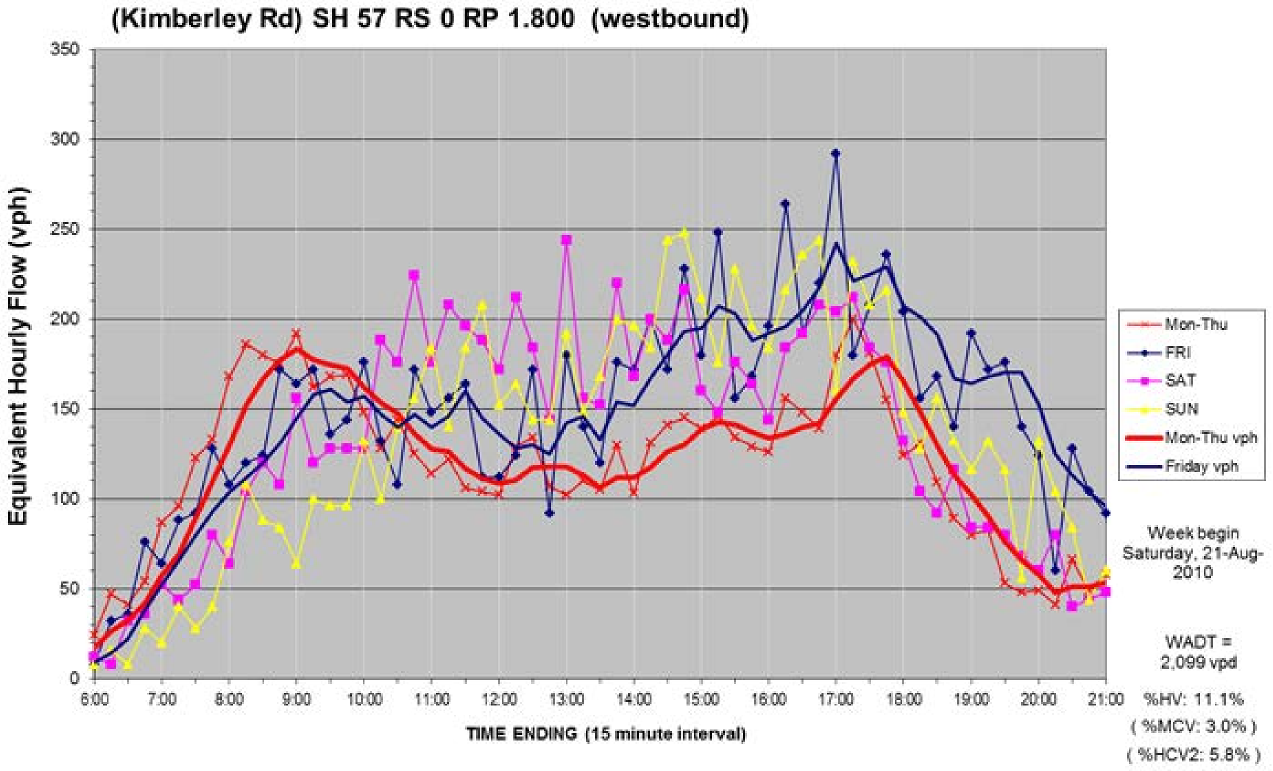


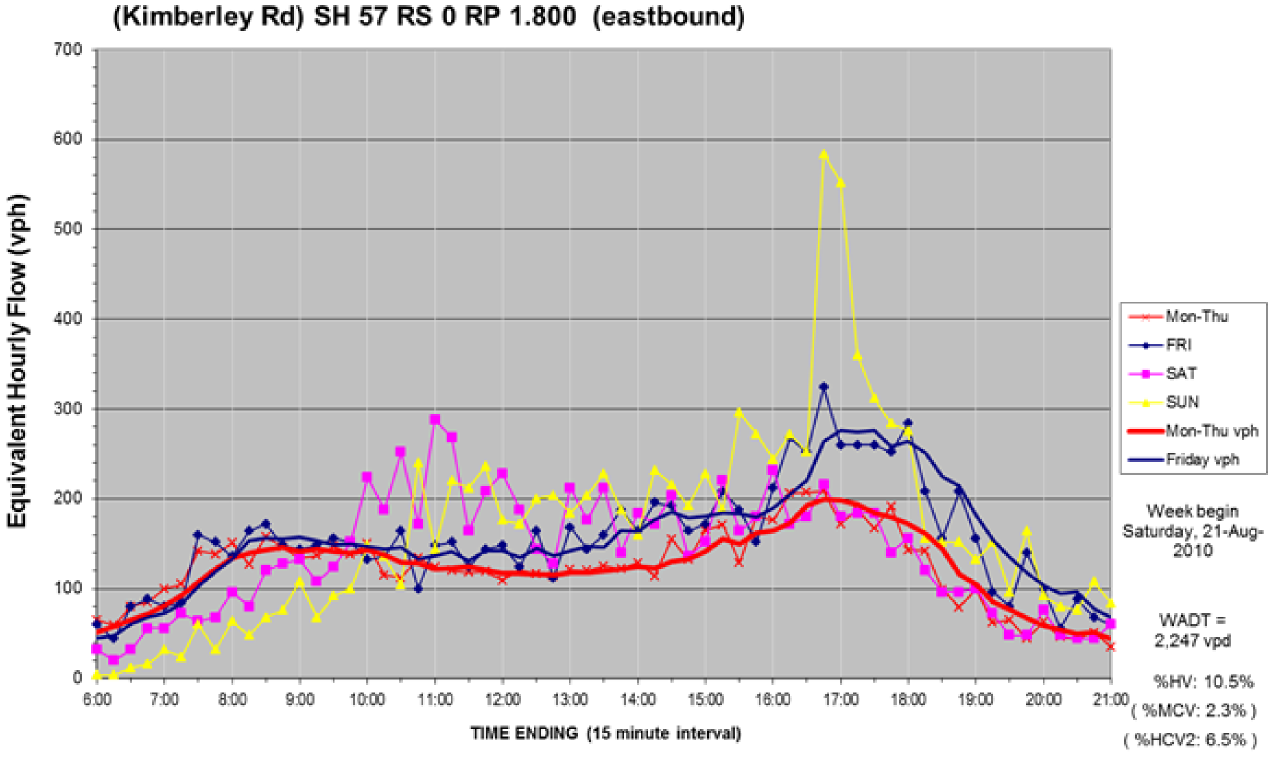




These reveal high Friday evening and weekend daytime flows. This pattern appears to relate both to the Wellington to Palmerston North route and to the Wellington to Levin route, given the preceding and the SH57 traffic profile overleaf.

SH57 Kimberley Road east of SH1

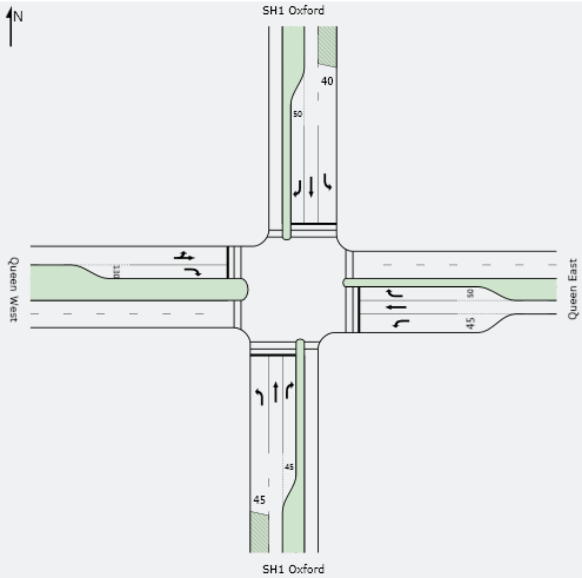


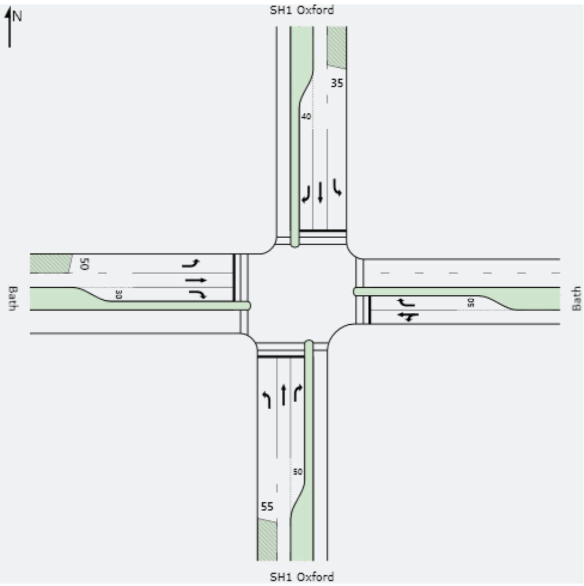


The reason for the Sunday late afternoon eastbound spike is unknown.

Appendix F SIDRA output

SIDRA Existing schematic layouts





Queen St User specified cycle time (70 s cycle)

Phase Timing Results

Phase	A	B
Green Time (sec)	32	26
Yellow Time (sec)	4	4
All-Red Time (sec)	2	2
Phase Time (sec)	38	32
Phase Split	54 %	46 %

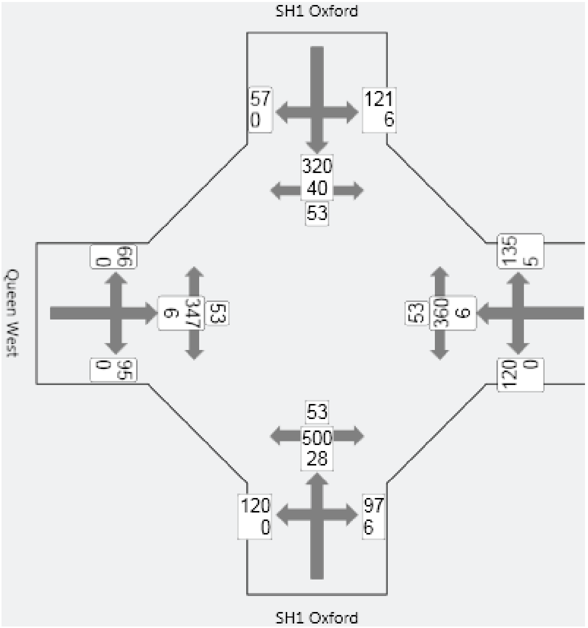
Bath St user specified phase times (70 s cycle)

Phase Timing Results

Phase	Oxford LT	Bath + ped	Oxford R +R
Green Time (sec)	37	11	6
Yellow Time (sec)	4	4	4
All-Red Time (sec)	2	1	1
Phase Time (sec)	43	16	11
Phase Split	61 %	23 %	16 %

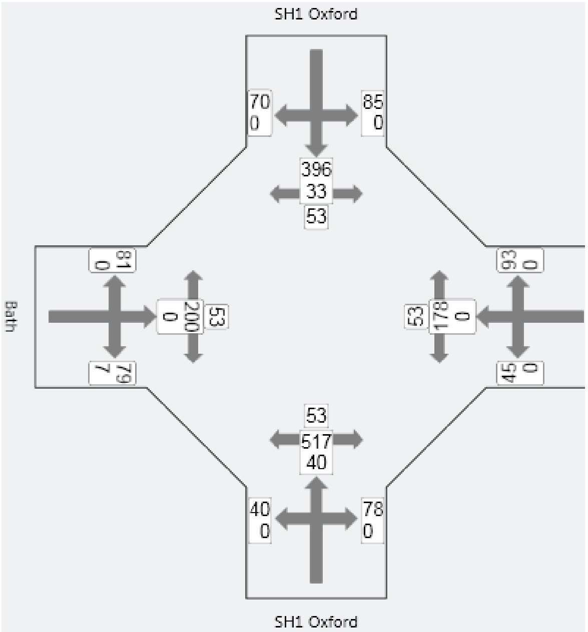
SIDRA LV & HV flows (peds default 50/hr / 0.95)

Thu 12 May 2011 (input nearest 5 vph, PFF 1%)



Mid Block Queen n/b; s/b: 717+34; 535+40

Mid-Block Bath n/b; s/b: 691+40; 551+33



Queen St: 2011 PM, user specified 70 s cycle [38 s Oxford, 32 s Bath]

Lane Use and Performance

	Demand Flows L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: SH1 Oxford																
Lane 1	120	0	0	120	0.0	501[1]	0.240	100	19.4	LOS B	2.0	14.0	45	Parking	0.0	0.0
Lane 2	0	528	0	528	5.3	862	0.613	100	12.9	LOS B	11.3	83.1	220	–	0.0	0.0
Lane 3	0	0	97	97	0.0	339	0.288	100	24.0	LOS C	2.2	15.6	45	Turn Bay	0.0	0.0
Approach	120	528	97	745	3.8		0.613		15.4	LOS B	11.3	83.1				
East: Queen East																
Lane 1	120	0	0	120	0.0	369[1]	0.324	100	22.9	LOS C	2.9	20.6	45	Turn Bay	0.0	0.0
Lane 2	0	365	0	365	1.5	717	0.509	100	18.6	LOS B	9.8	69.5	55	–	0.0	26.3
Lane 3	0	0	140	140	3.6	243	0.575	100	31.8	LOS C	4.6	33.2	50	Turn Bay	0.0	0.0
Approach	120	365	140	625	1.7		0.575		22.4	LOS C	9.8	69.5				
North: SH1 Oxford																
Lane 1	126	0	0	126	4.5	363[1]	0.348	100	20.5	LOS C	2.7	19.7	40	Parking	0.0	0.0
Lane 2	0	360	0	360	11.1	831	0.433	100	13.9	LOS B	8.4	64.3	500	–	0.0	0.0
Lane 3	0	0	57	57	0.0	233	0.244	100	28.3	LOS C	1.6	11.1	50	Turn Bay	0.0	0.0
Approach	126	360	57	543	8.4		0.433		17.0	LOS B	8.4	64.3				
West: Queen West																
Lane 1	66	353	0	419	1.4	739	0.568	100	23.1	LOS C	11.6	81.8	500	–	0.0	0.0
Lane 2	0	0	95	95	0.0	267	0.356	100	31.8	LOS C	2.9	20.1	130	Turn Bay	0.0	0.0
Approach	66	353	95	514	1.1		0.568		24.7	LOS C	11.6	81.8				
Intersection				2428	3.7		0.613		19.5	LOS B	11.6	83.1				

Bath St: 2011 PM user specified phase times, 70 s cycle [43, 16, 11]

Lane Use and Performance

	Demand Flows L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: SH1 Oxford																
Lane 1	40	0	0	40	0.0	549[1]	0.073	100	15.9	LOS B	0.7	4.8	55	Parking	0.0	0.0
Lane 2	0	557	0	557	7.2	985	0.566	100	12.0	LOS B	12.9	95.6	500	–	0.0	0.0
Lane 3	0	0	78	78	0.0	159	0.490	100	41.1	LOS D	2.8	19.3	50	Turn Bay	0.0	0.0
Approach	40	557	78	675	6.0		0.566		15.6	LOS B	12.9	95.6				
East: Bath																
Lane 1	45	178	0	223	0.0	292	0.763	100	35.5	LOS D	8.1	56.9	55	–	0.0	8.0
Lane 2	0	0	93	93	0.0	132	0.706	100	42.1	LOS D	3.5	24.6	50	Turn Bay	0.0	0.0
Approach	45	178	93	316	0.0		0.763		37.4	LOS D	8.1	56.9				
North: SH1 Oxford																
Lane 1	85	0	0	85	0.0	523[1]	0.162	100	14.1	LOS B	1.0	7.1	35	Parking	0.0	0.0
Lane 2	0	429	0	429	7.7	982	0.437	100	7.9	LOS A	6.3	46.7	220	–	0.0	0.0
Lane 3	0	0	70	70	0.0	159	0.440	100	41.4	LOS D	2.4	16.9	40	Turn Bay	0.0	0.0
Approach	85	429	70	584	5.6		0.440		12.8	LOS B	6.3	46.7				
West: Bath																
Lane 1	81	0	0	81	0.0	254	0.318	100	38.6	LOS D	2.6	18.4	50	Parking	0.0	0.0
Lane 2	0	200	0	200	0.0	306	0.653	100	35.3	LOS D	6.8	47.9	500	–	0.0	0.0
Lane 3	0	0	86	86	0.0	113	0.758	100	46.7	LOS D	3.3	22.9	30	Turn Bay	0.0	0.0
Approach	81	200	86	366	0.0		0.758		38.7	LOS D	6.8	47.9				
Intersection				1942	3.8		0.763		22.7	LOS C	12.9	95.6				

The 95th percentile queuing along SH1 Oxford Street between the intersections reaches 83 metres. The 95th percentile queuing along Queen Street east extends back beyond the NIMT railway line, and to or beyond the rail line for Bath Street (depending on whether queued vehicles keep clear of the South Lane intersection).

Queen St: 2041 PM / 30%, 15% traffic growth, user specified 80 s cycle [43, 37]

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: SH1 Oxford																
Lane 1	156	0	0	156	0.0	463[1]	0.337	100	20.6	LOS C	2.9	20.6	45	Parking	0.0	0.0
Lane 2	0	687	0	687	5.3	872	0.788	100	17.8	LOS B	21.1	154.7	220	–	0.0	0.0
Lane 3	0	0	127	127	0.0	257	0.493	100	31.9	LOS C	4.0	27.8	45	Turn Bay	0.0	0.0
Approach	156	687	127	969	3.8		0.788		20.1	LOS C	21.1	154.7				
East: Queen East																
Lane 1	138	0	0	138	0.0	341[1]	0.403	100	24.3	LOS C	3.8	26.3	45	Turn Bay	0.0	0.0
Lane 2	0	420	0	420	1.5	748	0.561	100	20.8	LOS C	12.9	91.7	55	–	0.0	52.0
Lane 3	0	0	161	161	3.6	214	0.752	100	41.6	LOS D	6.8	48.9	50	Turn Bay	0.0	3.0
Approach	138	420	161	718	1.7		0.752		26.1	LOS C	12.9	91.7				
North: SH1 Oxford																
Lane 1	164	0	0	164	4.5	331[1]	0.496	100	22.2	LOS C	4.0	29.3	40	Parking	0.0	0.0
Lane 2	0	468	0	468	11.1	841	0.556	100	16.8	LOS B	13.3	101.8	500	–	0.0	0.0
Lane 3	0	0	74	74	0.0	149	0.494	100	39.7	LOS D	2.8	19.5	50	Turn Bay	0.0	0.0
Approach	164	468	74	706	8.4		0.556		20.5	LOS C	13.3	101.8				
West: Queen West																
Lane 1	76	406	0	482	1.4	774	0.623	100	25.4	LOS C	15.3	108.4	500	–	0.0	0.0
Lane 2	0	0	109	109	0.0	238	0.459	100	36.5	LOS D	3.9	27.3	130	Turn Bay	0.0	0.0
Approach	76	406	109	591	1.1		0.623		27.5	LOS C	15.3	108.4				
Intersection				2985	3.9		0.788		23.1	LOS C	21.1	154.7				

Bath St: 2041 PM / 30%, 15% traffic growth, user specified phase times 80 s cycle [48, 21, 11]

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: SH1 Oxford																
Lane 1	52	0	0	52	0.0	499[1]	0.104	100	17.3	LOS B	1.0	7.2	55	Parking	0.0	0.0
Lane 2	0	725	0	725	7.2	978	0.741	100	15.9	LOS B	22.0	163.9	500	–	0.0	0.0
Lane 3	0	0	101	101	0.0	139	0.727	100	49.4	LOS D	4.3	30.2	50	Turn Bay	0.0	0.0
Approach	52	725	101	878	6.0		0.741		19.9	LOS B	22.0	163.9				
East: Bath																
Lane 1	52	205	0	257	0.0	376	0.682	100	34.7	LOS C	9.8	68.5	55	–	0.0	24.9
Lane 2	0	0	107	107	0.0	155	0.691	100	45.1	LOS D	4.5	31.4	50	Turn Bay	0.0	0.0
Approach	52	205	107	364	0.0		0.691		37.8	LOS D	9.8	68.5				
North: SH1 Oxford																
Lane 1	111	0	0	111	0.0	473[1]	0.234	100	15.2	LOS B	1.5	10.8	35	Parking	0.0	0.0
Lane 2	0	557	0	557	7.7	975	0.571	100	10.1	LOS B	10.9	81.2	220	–	0.0	0.0
Lane 3	0	0	91	91	0.0	139	0.653	100	48.6	LOS D	3.8	26.3	40	Turn Bay	0.0	0.0
Approach	111	557	91	759	5.6		0.653		15.5	LOS B	10.9	81.2				
West: Bath																
Lane 1	93	0	0	93	0.0	299[1]	0.310	100	38.9	LOS D	3.2	22.6	50	Parking	0.0	0.0
Lane 2	0	230	0	230	0.0	390	0.590	100	35.6	LOS D	8.4	58.8	500	–	0.0	0.0
Lane 3	0	0	99	99	0.0	138	0.715	100	49.7	LOS D	4.2	29.3	30	Turn Bay	0.0	2.9
Approach	93	230	99	421	0.0		0.715		39.6	LOS D	8.4	58.8				
Intersection				2422	3.9		0.741		24.6	LOS C	22.0	163.9				

For 80 s [43, 26, 11] cycle the maximum movement delay remains 49.4 sec/veh but the overall intersection increases to 27.0 seconds since delay increases to the SH1 left and through traffic. The 95^{th} percentile queue for Bath St decreases slightly to 61 metres (probably of vehicles having to queue on the eastern side of the NIMT railway tracks reducing to 14.5%).

Queen St: 2041 Friday PM / 44%, 22% traffic growth, user specified 70 s cycle [38, 32]

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: SH1 Oxford																
Lane 1	173	0	0	173	0.0	496[1]	0.348	100	19.8	LOS B	3.0	21.0	45	Parking	0.0	0.0
Lane 2	0	760	0	760	5.3	862	0.883	100	23.3	LOS C	26.6	194.4	220	–	0.0	0.0
Lane 3	0	0	140	140	0.0	232	0.605	100	32.8	LOS C	4.4	30.7	45	Turn Bay	0.0	0.0
Approach	173	760	140	1074	3.8		0.883		24.0	LOS C	26.6	194.4				
East: Queen East																
Lane 1	146	0	0	146	0.0	368[1]	0.396	100	23.2	LOS C	3.6	25.5	45	Turn Bay	0.0	0.0
Lane 2	0	446	0	446	1.5	717	0.621	100	19.6	LOS B	12.6	89.5	55	–	0.0	49.7
Lane 3	0	0	171	171	3.6	191	0.896	100	48.6	LOS D	7.4	53.3	50	Turn Bay	0.0	10.7
Approach	146	446	171	762	1.7		0.896		26.8	LOS C	12.6	89.5				
North: SH1 Oxford																
Lane 1	182	0	0	182	4.5	362[1]	0.503	100	21.0	LOS C	4.0	29.4	40	Parking	0.0	0.0
Lane 2	0	518	0	518	11.1	831	0.624	100	15.7	LOS B	13.6	104.2	500	–	0.0	0.0
Lane 3	0	0	82	82	0.0	133	0.617	100	41.6	LOS D	3.0	20.9	50	Turn Bay	0.0	0.0
Approach	182	518	82	782	8.4		0.624		19.6	LOS B	13.6	104.2				
West: Queen West																
Lane 1	81	431	0	511	1.4	739	0.692	100	24.5	LOS C	15.1	106.9	500	–	0.0	0.0
Lane 2	0	0	116	116	0.0	217	0.534	100	35.8	LOS D	3.8	26.9	130	Turn Bay	0.0	0.0
Approach	81	431	116	627	1.1		0.692		26.6	LOS C	15.1	106.9				
Intersection				3245	3.9		0.896		24.1	LOS C	26.6	194.4				

For 80 s [43, 37] cycle the overall delay increases to 25.6 seconds and queues lengthen.

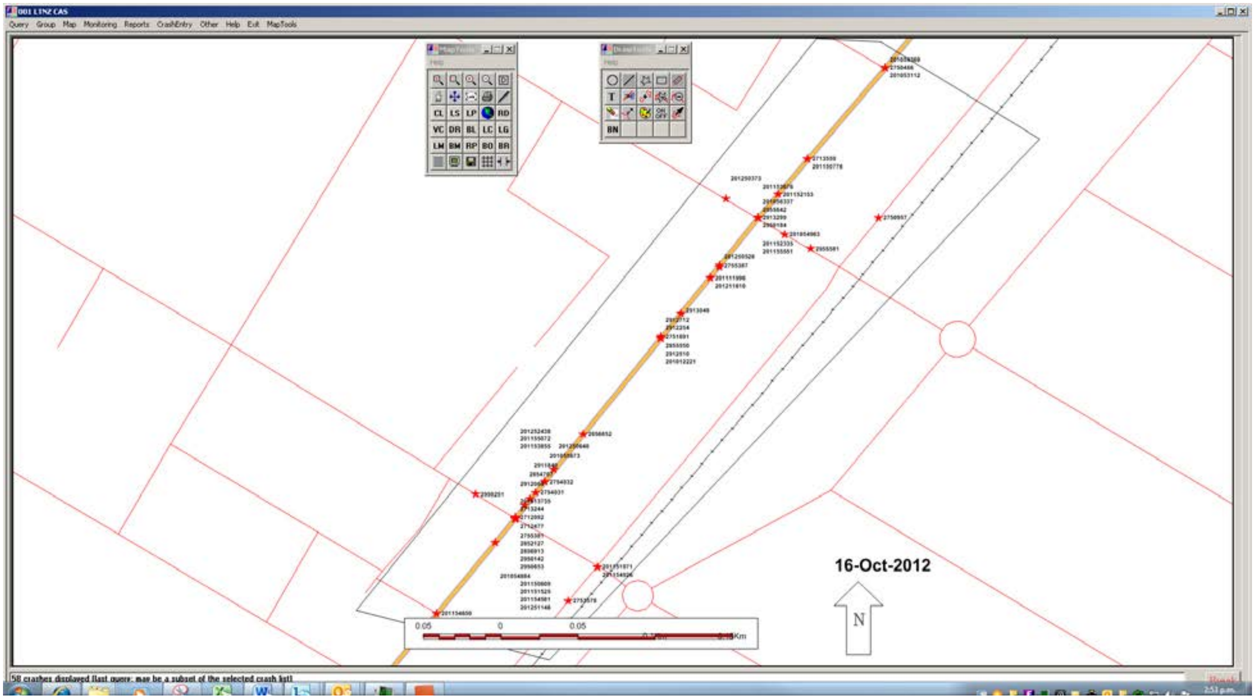
Bath St: 2041 Friday PM / 44%, 22% traffic growth, user specified 70 s cycle [40, 19, 11]

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: SH1 Oxford																
Lane 1	58	0	0	58	0.0	515[1]	0.112	100	17.8	LOS B	1.1	7.6	55	Parking	0.0	0.0
Lane 2	0	803	0	803	7.2	905	0.887	100	28.3	LOS C	31.2	232.2	500	–	0.0	0.0
Lane 3	0	0	112	112	0.0	159	0.705	100	43.2	LOS D	4.2	29.1	50	Turn Bay	0.0	0.0
Approach	58	803	112	973	6.0		0.887		29.4	LOS C	31.2	232.2				
East: Bath																
Lane 1	55	217	0	272	0.0	375	0.726	100	31.9	LOS C	9.4	66.1	55	–	0.0	21.6
Lane 2	0	0	114	114	0.0	156	0.732	100	41.5	LOS D	4.3	29.9	50	Turn Bay	0.0	0.0
Approach	55	217	114	386	0.0		0.732		34.8	LOS C	9.4	66.1				
North: SH1 Oxford																
Lane 1	122	0	0	122	0.0	460[1]	0.266	100	16.3	LOS B	1.8	12.4	35	Parking	0.0	0.0
Lane 2	0	617	0	617	7.7	902	0.684	100	11.9	LOS B	13.5	100.4	220	–	0.0	0.0
Lane 3	0	0	101	101	0.0	159	0.633	100	42.6	LOS D	3.6	25.3	40	Turn Bay	0.0	0.0
Approach	122	617	101	840	5.6		0.684		16.2	LOS B	13.5	100.4				
West: Bath																
Lane 1	98	0	0	98	0.0	338	0.291	100	35.5	LOS D	3.0	21.3	50	Parking	0.0	0.0
Lane 2	0	244	0	244	0.0	390	0.626	100	32.2	LOS C	8.0	55.7	500	–	0.0	0.0
Lane 3	0	0	105	105	0.0	136	0.771	100	45.9	LOS D	4.0	28.0	30	Turn Bay	0.0	0.0
Approach	98	244	105	447	0.0		0.771		36.1	LOS D	8.0	55.7				
Intersection				2646	4.0		0.887		27.1	LOS C	31.2	232.2				

For 80 s [48, 21, 11] cycle the maximum movement delay increase to 52.6 sec/veh (LoS D) but the overall intersection decreases slightly to 26.5 seconds since delay increases to the SH1 left and through traffic. The 95th percentile queue for Bath St increases to 75 metres (probably of vehicles having to queue on the eastern side of the NIMT railway tracks increasing to 32.6%).

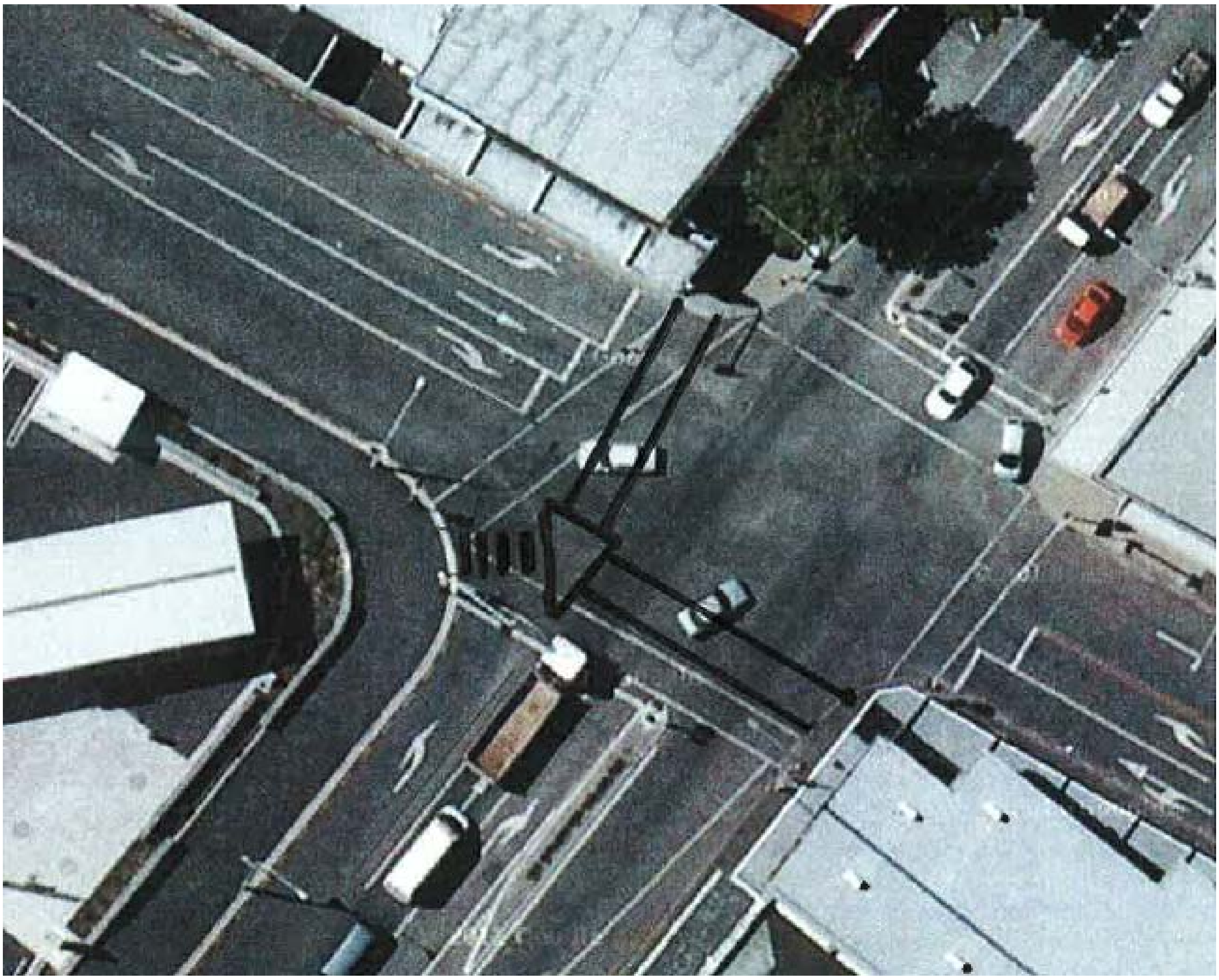
Appendix G Crash Data



Coded Crash listing (Red=Queen, Yellow=between, Blue=Bath; orange = serious injury, green = minor)

ROAD	DIST	FRO	INT	SIDE	IDNO	DATE	DYWK	TIME	MVMT	VEHS	CSCD	OBJS	CURV	SURF	LITE	WTH	JNTY	TRAF	MARK	SPDL	IFAT	NSER	NMIN	PEDA	CYC
BATH ST	30	W		SH 1N	2950251	07/01/09	Wed	1335	MA	CE1CC	370A 386B	M	R	D	B	F		N	C	50	0	0	0		
QUEEN ST EAST	20	E		SH 1N	201054963	26/09/10	Sun	2000	AA	CW1C	157A 372A		R	D	DO	F	X	T	C	50	0	0	0		
QUEEN ST WEST	25	W		SH 1N OXFORD	201250373	21/02/12	Tue	1346	MO	CS1C	330A 357A 371A 352B 440B		R	D	B	F		N	C	50	0	0	0		
1N/967/13.705	50	N		QUEEN ST EAST	2713559	13/11/07	Tue	1934	MC	CN1C	101A 372B 377B		R	W	O	L		N	P	50	0	0	1		
1N/967/13.707	50	N		QUEEN ST EAST	201150778	20/02/11	Sun	1207	FD	CS1C	331A 358A		R	D	B	F		N	P	50	0	0	0		
1N/967/13.737	20	N		QUEEN ST WEST	201152153	02/06/11	Thu	1715	FD	VS14	386A 402A		E	D	DO	F	X	T	R	50	0	0	0		
1N/967/13.755			I	QUEEN ST EAST	2955642	24/10/09	Sat	645	LB	CS1C	303B 375B		R	D	TF	F	X	T	R	50	0	0	0		
1N/967/13.755			I	QUEEN ST WEST	2950184	03/01/09	Sat	1930	FE	TN1C	181A 387A		R	D	B	F	X	T	C	50	0	0	0		
QUEEN ST EAST			I	OXFORD ST	201153676	30/08/11	Tue	1118	LB	CS1C	157A 330A 357A		R	D	B	F	X	T	R	50	0	0	0		
QUEEN ST EAST			I	1N/967/13.757	201155551	29/12/11	Thu	1650	KC	CS1C	305A 330A 402A		S	D	O	F	X	T	R	50	0	0	0		
1N/967/13.757			I	QUEEN ST EAST	201056337	18/12/10	Sat	1205	FE	TN14	181A		R	W	O	L	X	T	R	50	0	0	0		
1N/967/13.757			I	QUEEN ST WEST	201152335	29/06/11	Wed	1330	EC	CN14	374B	Q	R	D	B	F	X	T	R	50	0	0	0		
1N/967/13.757			I	QUEEN ST WEST	2913299	13/11/09	Fri	1100	NF	CE2E	307A 353A		R	D	O	F	X	T	R	50	0	0	1	84	
1N/967/13.795	40	S		QUEEN ST WEST	2755387	20/09/07	Thu	1709	MC	CN1C	372B		R	D	B	F		N	C	50	0	0	0		
1N/967/13.797	40	S		QUEEN ST EAST	201250528	05/03/12	Mon	1521	MO	CS1V	372B 671B		R	D	B	F		N	C	50	0	0	0		
1N/967/13.807	50	S		QUEEN ST EAST	201111996	03/06/11	Fri	1617	NB	MN1E	112A 376A		R	D	O	F		N	P	90	0	0	1	56	
1N/967/13.807	50	S		QUEEN ST WEST	201211610	21/04/12	Sat	1010	NG	CW1E	371A 427A		R	D	B	F		N	C	50	0	0	1	77	
1N/967/13.835	80	S		QUEEN ST EAST	2913048	29/09/09	Tue	1200	MF	CN1T	381A		R	D	B	F		N	P	50	0	0	1		
1N/967/13.855	100	S		QUEEN ST EAST	2912712	26/08/09	Wed	1655	FD	CS1CCC	331A		R	D	O	F		N	C	50	0	0	1		
1N/967/13.855	100	S		QUEEN ST WEST	2855550	16/10/08	Thu	1350	MO	VN14	386A	M	R	D	O	F		N	N	50	0	0	0		
1N/967/13.855	100	S		QUEEN ST WEST	2912510	26/07/09	Sun	1232	NA	CN1E	711B		R	D	B	F		N	C	50	0	0	1	23	
1N/967/13.855	100	S		QUEEN ST WEST	2912254	24/06/09	Wed	1255	NG	CS1E	730B		R	D	B	F		N	C	50	0	0	1	89	
1N/967/13.857	100	S		QUEEN ST WEST	201012221	22/06/10	Tue	1258	MO	CS1S	372A 671A		R	D	B	F		N	C	50	0	0	1		33
1N/967/13.934	70	N		BATH ST	2856652	31/08/08	Sun	2030	MF	CN14	371B		R	D	DO	F		N	C	50	0	0	0		
1N/967/13.966	40	N		BATH ST	201250640	09/03/12	Fri	1610	MC	CN1C	191A 330B 372B		R	D	B	F		N	C	50	0	0	0		
1N/967/13.974	30	N		BATH ST	2754032	20/07/07	Fri	1829	MA	CN1C	103B 374B		R	W	DO	F		N	C	50	0	0	0		
1N/967/13.976	30	N		BATH ST	201055673	12/11/10	Fri	1530	FD	4S1CCC	331A 402A		R	D	B	F		T	C	50	0	0	0		
1N/967/13.984	20	N		BATH ST	2754031	24/07/07	Tue	1209	FD	CS1C4	331A 351A		R	D	B	F	X	T	C	50	0	0	0		
1N/967/13.989	15	N		BATH ST	2911849	01/05/09	Fri	1025	NA	CS1E	711B 712B		R	D	B	F	X	T	R	50	0	0	1	41	
1N/967/13.994	10	N		BATH ST	2854707	05/08/08	Tue	1055	MO	TN1V	386A 440B 817		R	D	B	F	X	S	N	50	0	0	0		
1N/967/14.004			I	BATH ST	2950142	05/01/09	Mon	1012	FE	VS1VC	181A		R	D	O	F	X	T	C	50	0	0	0		
1N/967/14.004			I	BATH ST	2856913	28/11/08	Fri	1635	FD	CN1C	181A 352A 817		R	D	B	F	X	T	C	50	0	0	0		
1N/967/14.004			I	BATH ST	2950653	09/02/09	Mon	543	EC	CS1	377A 901	IP	R	W	DO	H	X	T	R	50	0	0	0		
1N/967/14.004			I	BATH ST	2755381	21/09/07	Fri	1105	FD	VN1CC	331A		R	D	B	F	X	T	C	50	0	0	0		
1N/967/14.004			I	BATH ST	2852127	06/05/08	Tue	1100	HA	CE2C	322A		R	D	B	F	X	T	C	50	0	0	0		
1N/967/14.004			I	BATH ST	2912060	21/05/09	Thu	1549	NA	VN1	322A		R	D	B	F	X	T	C	50	0	0	1	73	
BATH ST			I	OXFORD ST	201150609	28/02/11	Mon	1708	AC	VW14	159A 172A		R	D	B	F	X	T	L	50	0	0	0		
1N/967/14.006			I	BATH ST	201155072	09/12/11	Fri	930	DA	TN2C	130A 386A 818	M	R	D	B	F	X	T	C	50	0	0	0		
1N/967/14.006			I	BATH ST	201154581	17/10/11	Mon	1158	JB	CN14	129B 386B		R	D	O	F	X	T	R	50	0	0	0		
1N/967/14.006			I	BATH ST	201151525	25/04/11	Mon	1102	GO	TW1C	175A 179A 372A 333B		R	W	O	L	X	T	L	50	0	0	0		
1N/967/14.006			I	BATH ST	201013735	09/12/10	Thu	1242	NC	TW2E	378A 671A 718B		R	D	B	F	X	T	R	50	0	1	0	83	
1N/967/14.006			I	BATH ST	2713244	13/10/07	Sat	1951	HA	CW2T	322A		R	D	DO	F	X	T	C	50	0	1	0		
1N/967/14.006			I	BATH ST	2712477	20/07/07	Fri	1000	NF	XE2E	307A 376A		R	W	O	L	X	T	C	50	0	0	1	83	
1N/967/14.006			I	BATH ST	201153855	11/08/11	Thu	1635	FE	CN1C	181A 427A		R	D	B	F	X	T	R	50	0	0	0		
1N/967/14.006			I	BATH ST	201251148	07/04/12	Sat	1120	FA	VN14	181A 331A 402A		R	D	B	F	X	T	P	50	0	0	0		
1N/967/14.026	20	S		BATH ST	201054884	05/10/10	Tue	1240	JA	CN1C	205A 308B 314B 925		R	D	B	F	D	N	P	50	0	0	0		

Appendix H Bath Street pedestrian improvements



The suggested relocation and shortening of the pedestrian crossings is possibly back to where there were before the New World corer widening (it is unknown if the above option was considered or not).

In addition it is suggested that a cyclist holding bay area would be provided (in front of the truck) between the existing limit line and the relocated (and shortened) pedestrian crossing. The left/through lane line could also potentially be adjusted (or a short cycle lane introduced subject to being compatible tracking requirements for a supermarket articulated truck turning left).