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SH2 Melling
Intersection Improvements – Concept Design Review

July 2019

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Appendices

DISCLAIMER

The findings and recommendations in this report are based on an examination of available relevant plans, any addition information provided, and the opinions of the Design Review Team (DRT). However, it must be recognised that eliminating safety concerns cannot be guaranteed since no road can be regarded as absolutely safe and no warranty is implied that all safety issues have been identified in this report.

Readers are urged to seek specific technical advice on matters raised and not rely solely on the report.

While every effort has been made to ensure the accuracy of the report, it is made available on the basis that anyone relying on it does so at their own risk without any liability to the DRT or their organisations.

Any suggested solutions are intended to be indicative only, to assist the designer in focusing on the type of improvements that might be appropriate. They **are not** intended to be prescriptive or to be the most appropriate solution, and the designer/client should consider **all methods** of resolving the issues and determine which is the most appropriate to resolve the issue identified.

This Design Review is limited to the safety and operation of the identified intersection and does not constitute a formal Safety Audit (SA) in accordance 2013 NZTA Road Safety Audit Procedure. It is understood that this review may be incorporated in a formal SA of the total project which is to be completed by others.

1. Introductory Statement

1.1 Scope

This report has been prepared at the request of Mr Eddie Anand on behalf of NZTA Wellington Office.

The report presents the findings of a desktop only ñDesign Reviewò of the proposed improvements to the SH2 Melling interchange and four new signalised intersections within Hutt City.

As requested by the client the review has been limited to a ñDesk Top Studyò and therefore no site visits were undertaken.

Operational and safety issues have been considered against current standards supplemented by reference to other recognised design guidelines and the safety and operational experience of the member of the design review team (DRT). Also given the close proximity of the intersections their possible operation under a coordinated system such as SCATS has been considered.

1.2 Review Objectives

The objective of the review is to identify any potential safety and/or operational issues that may affect the efficiency or safety of the intersection and bring them to the notice of the designer and the client. The reviewers are independent of the design team. Any suggested solutions are intended to be indicative only, to assist the designer in focusing on the type of improvements that might be appropriate. They **are not** intended to be prescriptive or to be the most appropriate solution, and **other methods** of resolving the issues should be considered. It is the designer/clientôs responsibility that any modifications made from the outcomes of this review are the most appropriate solution.

1.3 Design Review Team (DRT)

The DRT team members were:

- Ross Thomson ï Principal Consultant, Urban Traffic Design Ltd.
- Peter Evans ï Traffic Systems and Safety Engineer.
- Ray Moriarty ï SCATS Consultant, RMHK2 Pty Ltd

2. The Project

2.1 Project Outline

The project being reviewed is the proposed upgrading of the SH2 Melling Interchange along with the installation of four new signalised intersections within Hutt City. The sites are

- SH2 Melling interchange ï
- Queens Drive / Rutherford Street
- Queens Drive / High Street
- Melling Link / Rutherford Street / Carpark Access
- Melling Link / High Street / Pretoria Street

2.2 Information Provided

The following information was supplied to the DRT:-

- Stantec Drawings Noôs 80509236-01-001-75 Rev A and 80509236-01-001-76 Rev A
- 4 Untitled sketch drawings. One for each of the four Hutt City intersections
- File Note FN190618_Melling interchange signals review authored by Oliver Brown dated 18 June 2019
- Sketch of proposed phasing for Melling Interchange (File Melling IC signal groups and phasing).

The information provided is included in Appendix A.

2.3 Form of Review

Given the incomplete design nature of the intersection drawings provided, the DRT considered that a õConcept Design Reviewò was the most appropriate form of review at this stage of the project. Therefore, this report concentrates on the broader detail against current standards and õgoodò practice rather than concentrating specific detailed design at each site.

Where issues have been identified the DRT considers that these need more consideration during the detailed design process.

2.4 Date of Audit

The review was undertaken in July of 2019.

3. Review Findings

3.1 Left Turn Movements and Conflict with Pedestrian/Cycle Crossings

The following notes are based on the experience of members of the DRT when cycle crossings were introduced into the Auckland Region and highlight some of the issues identified.

At all four Hutt City sites and at the Melling interchange the majority of the left turn movements will be in conflict with parallel pedestrian and cycle crossings.

During such conflict, significant delays to the overall intersectionôs operation can occur as it is considered unsafe to permit filter left turns when cyclists are crossing due to the possibility of a cyclist suddenly entering the crossing at speed. Therefore, it is considered necessary to provide full protection from left turning traffic. This means cyclists can only be provided with an absolute maximum green of six seconds to ensure there is still adequate time for vehicle left turn movements. Note that often side road phases are short and may only have enough time to allow the pedestrian/cyclist to cross leaving little time for the left turn movement.

If the pedestrian crossing is also called, cyclists tend to continue to cross throughout the pedestrian clearance period, regardless of the cycle signal. Hence for safety, the pedestrian crossing will also need to be fully protected. In particular, at the Melling Interchange the long crossing over Melling South will result in a significant delay before the left turn can run and hence a very long phase for the southbound off ramp to service pedestrians/cyclists and left turners with resulting significant impact on all other movements at the interchange.

Where possible it is considered that removing the left turn conflict by providing channelised left turns results in better intersection performance and pedestrian/cycle safety. If appropriate a separate short controlled crossing can be provided over the left turns. These new short crossings can run in most phases throughout the cycle, as left turn traffic will be held on red in most phases to service the conflicting through or right turn movement.

Provision of channelised left turns would also allow for the cycle crossings to run throughout phase green on demand or whenever possible (the same as a vehicle movement) without affecting overall cycle times.

3.2 SH2 Melling Interchange

The following comments are based on the experience of the DRT members from their involvement in the installation of several motorway interchanges within the Auckland Region.

It is noted that from the information provided to the DRT it appears the design considers that there are two distinct intersections associated with the interchange. In the Auckland Region it has been found that it is better that the two sites are configured as a single intersection controlled by one traffic signal controller and common phasing design. These are commonly called diamond interchanges.

The following comments highlight issues that the DRT considers need further attention when developing the detailed design.

3.2.1 Wrong Way Entry to Off Ramps

This is one of the most critical issues to be considered at full diamond motorway interchanges. There are normally four movements to consider, the right turns from the external approaches of the cross route and the left turns from the midblock sections of the cross route. The current Melling design introduces a fifth movement straight ahead from Pharazyn St.

These illegal movements need to be discouraged as much as possible by the use of:

- Geometric design to make the entry as difficult as possible
- Signal displays to emphasise the permitted movements
- Use of supplementary RG-7 and RG-8 (No left/right turn) signs, best mounted on the appropriate signal post, secondary for right turns – tertiary for left turns.
- Clear road marking and lane designation arrows

Two critical areas that have been identified by the DRT are:

- *Right Turn from Melling Northbound - External Approach* – It is possible that a driver approaching the interchange from the south could mistakenly turn right and head down the southbound SH2 off ramp

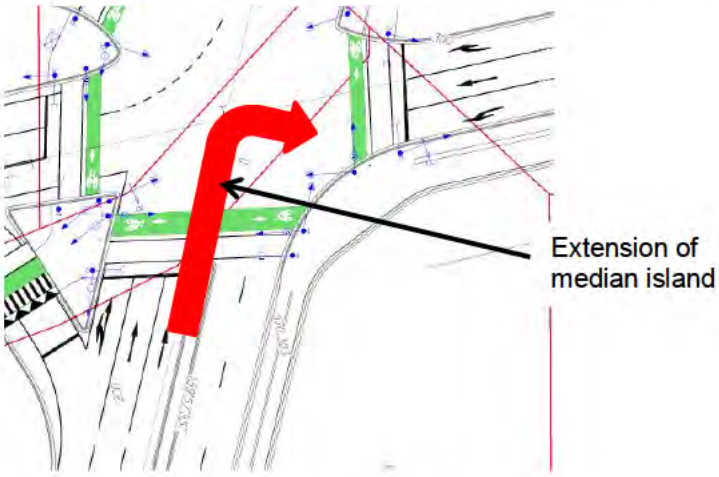


Figure 1 - Showing possible unsafe turn

This would normally be discouraged by extending the solid median island as far across the southbound off ramp as right turn tracking to and from the ramps permits. This may be difficult at this location due to the Pharazyn Street access requiring a right turn to Melling South and due to the through movement from the southbound off ramp.

The obtuse angle between Melling and the off ramp will further contribute to the risk of wrong way entry via the Melling right turn.

- *Through Movement from Pharazyn Street* - This is a high-risk approach facing directly towards the exit from the off ramp. A driver may think this is a typical crossroad type intersection which allows traffic to travel straight ahead.

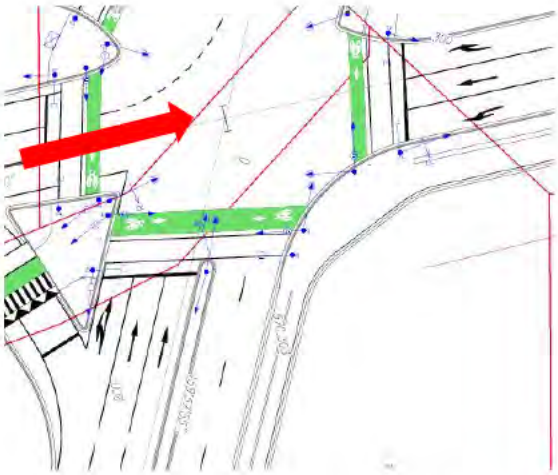


Figure 2 - showing possible through movement

3.2.2 Captured Lanes Northbound on Melling

The two outside lanes on the external approach (by Pharazyn Street) are required to be marked with straight ahead arrows but become right turn only lanes immediately on entry to the midblock area. Consideration needs to be given as to how best to mark the right hand lanes on the external approach to pre-warn motorists unfamiliar with the area of the changed lane designation ahead.

3.2.3 GIVE WAY Control Northbound on Melling - External Left Turn to Pharazyn St

A straight ahead movement from an off ramp at a diamond interchange is unusual. Drivers turning left from Melling onto Pharazyn Street, via the slip lane, may only look for a vehicle turning right and not be looking for a vehicle heading straight through from the southbound off ramp. This could be overcome if the left turn slip lane movement was signal controlled.

Also, there is no space for a vehicle stopped to give way to a pedestrian to wait clear of the through traffic. This could lead to nose to tail type accidents and reduce the efficiency of the through movement.

3.2.4 Dual Destination for Right Turn from Melling Southbound

The dual destinations when turning right from the midblock onto either Pharazyn Street or the southbound on ramp is uncommon. There will need to be some clear signposting to provide advance warning of the layout of the southbound on ramp and adjacent Pharazyn St to prevent last minute corrections from right turning drivers unfamiliar with the area.

3.2.5 Combined Right Turn and Through Lane Southbound on Melling

If there is congestion on the southbound on ramp or a blockage on Pharazyn St, right turns may be trapped on Melling thus reducing the dual through lanes to a single lane. This may result in traffic discharging onto the overbridge from the northbound off ramp or ahead from Melling north, making last minute lane changes.

A similar situation may occur if the controlled right turn movement leading onto the southbound on ramp or onto Pharazyn Street does not operate at the same time as the adjacent though movement

green display. For example, a vehicle in the outside right turn lane exiting the northbound off ramp may wish to ñUòturn back onto the motorway or turn onto Pharazyn Street. If the right turn movement is held on a red, then they will be required to stop thereby blocking the shared lane to following through vehicles.

Are the dual through lanes on Melling southbound crucial for the off ramp and Melling operation?

3.2.6 Staggered Pedestrian Crossing on Northern side of Melling

It is recognised that the split pedestrian crossing will provide some relief for the left turn from the northbound off ramp but will also result in some cyclists and pedestrians experiencing delays whilst being held on the median island.

Consider a channelised left turn from the off ramp which would enable a single crossing whilst minimising delays to the overall signal cycle time.

Alternatively, is there a suitable crossing site further north on Harbour View Rd which would cover crossing requirements north of the interchange?

3.2.7 Shared Left Turn/Through Lane Northbound on Melling

The left lane is the sole lane available for through traffic heading north on Melling, the other two lanes servicing the northbound motorway on ramp. The left turn will be held on a red arrow when the pedestrian/cycle facility across the southbound on ramp operates. This will result in delays to the straight ahead traffic and hence reduce overall intersection efficiency.

Have alternative lane designations enabling a dedicated left turn been considered on this approach?

3.2.8 Adjacent Crossings over Pharazyn St and the Southbound On Ramp

The two adjacent crossings will result in some pedestrians/cyclists being delayed on the nose area between Pharazyn Street and the southbound on ramp. Depending on the phasing design they may take two cycles to complete the crossing.

A single crossing would however be very long and cause additional delays to the left turn from Melling to the off ramp when the crossing operates.

Are there options to relocate Pharazyn St access away from the interchange?

3.2.9 Straight Ahead Visibility to Downstream Signals

At closely spaced intersections on a straight alignment there is the risk of upstream traffic reacting to the downstream display. It is recommended that whilst four displays are provided on the upstream approach to maximise visual impact, the downstream approach is minimalised to some extent by omitting the right hand supplementary primary display.

At the downstream site this can be achieved by providing a three aspect right turn display mounted alongside the primary three aspect signal. The right turn display in the six aspect secondary position can also be supplemented with an additional three aspect display to the far right of the carriageway backing the primary display for the reverse direction.

The risk of misreading a downstream signal can also be reduced in the phasing design by ensuring that a green downstream signal is never *introduced* whilst traffic is held on a red signal at the upstream intersection. Traffic is unlikely to suddenly proceed ahead when there is a *steady* green display downstream; it is the sudden introduction of green following red that may trigger a reaction at the upstream red signal.

3.2.10 Right Turn Visibility to Downstream Signals

Traffic right turning from the off ramps or left turning from Pharazyn St have limited ahead visibility to the downstream signals. It is strongly recommended that the signal phasing is sequenced to ensure that such traffic always encounters a green signal at the downstream intersection.

Where an individual phase is omitted, resulting in the following phase not providing progression through the downstream intersection, it is recommended that an ñEarly Cut Offò is provided at the upstream approach timed to allow discharge through the downstream intersection before introduction of the red signal at the downstream site.

3.2.11 Maintaining Consistent Phasing Sequences

The signal phasing proposed differs in sequence between the a.m. and p.m. peak periods. It is strongly recommended that the phasing sequence remains constant to minimise confusion for regular users.

3.2.12 Additional Notes on Signal Phasing

A signalised diamond interchange is a complex intersection both in terms of layout, signal phasing and operation. Generally serving as a strategic link between a motorway and the adjacent roading network, and carrying high traffic flows at times, optimum operation is essential. At practically all the Auckland diamond interchanges, 3 lanes both directions have been provided mid block regardless of traffic volumes. At the rare sites where this has not been the case, the reduction in efficiency has been noticeable.

The audit team has some concerns that a number of other issues at this site, that have been largely avoided at busy interchanges in the Auckland region, may also render optimum operation difficult. These include:

i. Shared lanes most of which at times will see stationary turning traffic blocking otherwise unobstructed through traffic

ii. Turning traffic in conflict with ped/cycle crossings creating overall interchange delays.

iii. The additional access for Pharazyn requiring an extra phase within the interchange.'

It is recognised that addressing all the safety and operational issues identified in this report can be a daunting task. The audit team have had extensive experience designing and developing signal phasing and logic for signalised diamond interchanges.

Experience has shown that treating the interchange as one intersection controlled by a single traffic signal controller is the most efficient.

3.2.12.1 Standard Interchange Phasing

At practically all the signalised diamond interchanges in the Auckland Region, a standard phasing design has been developed and is recognised as being the safest and most efficient under both heavy and very light traffic demands and is strongly recommended by the auditors. An example of the standard phasing is included in Appendix B. If this sequence was adopted, the Pharazyn Street phase would be best slotted in between the Melling northbound phase and the southbound off ramp phase.

The standard phasing sequence provides progression through the intersection either by using a constant phase sequence or, where due to no traffic demand a phase is skipped, by use of the Early Cut-off Green facility within the traffic signal controller programming.

The sequence also provides overlaps for practically all movements enabling them to run in two or more phases. On entry to most phases, all signals have either already experienced a green period of at least six seconds during the intergreen period of the previous phase, or are guaranteed a similar green period during the phase intergreen period whilst overlapping to the following phase. As a result of these overlap movements, the phase minimum greens can be set to one second for normal cyclic phase changes, resulting in very efficient off peak operation.

The overlaps also result in each phase being extended by only one major movement, thus further contributing to efficient operation and safe phase termination.

A further advantage is that every movement is serviced by a phase that guarantees discharge through both intersections thus providing easy operator controlled traffic management if a very heavy demand is experienced on any individual movement due to road work detours or other events resulting in unusually heavy flows on a particular approach.

It is also recommended that unless there is a particular need for progression along a route including the interchange that SCATS is used purely for monitoring isolated operation of the site thus providing maximum flexibility and efficiency at the interchange site.

3.2.12.2 Left Turn Movement Conflict with pedestrian / cycle crossings

All left turn movements to and from the motorway will be in conflict with parallel pedestrian and cycle crossings. Addressing such conflict safely will result in significant delays to the overall interchange operation. The experience in the Auckland region has found that separating this conflict, wherever possible, provides a safer and more efficient intersection.

3.2.13 Harbour View Road / Tirohanga Road Intersection

The DRT has concerns over the safety of this intersection due to its close proximity to the interchange signals, especially the right turn out of Tirohanga Road. At times queues will form on the southbound approach to the interchange as vehicles will be stopped by the signals. It will only take a queue of three or four vehicle before the sight distance for a driver turning right from Tirohanga Road will be severely restricted

3.3 Hutt City Intersections

3.4 Signal Displays

3.4.1 Vehicle Displays

In general, the placement, number and type of signal displays controlling vehicle movements are appropriate for the phasing designs shown for each intersection.

It should be noted however that when determining the number of vehicle ñSignal Groupsôthat will be required and the signal group numbering on the design drawings that each controlled vehicle movement requires a separate signal group output in the controller. For example, a óType 5Hôdisplay, which consists of a three aspect full roundel display with single aspect left turn and right turn red arrows, will require three separate signal group outputs.

The drawings do not use the standard drawing symbols; again, using the Type 5H as an example the attached figure shows the standard drawing symbol for a Type 5H display.

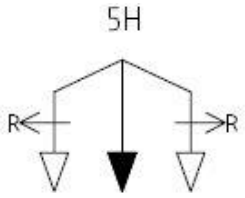


Figure 3 - Type 5H drawing symbol.

The DRT notes that there is limited use of overhead mastarm poles and displays. It is desirable that overhead displays are installed on approaches that have three or more lanes with the preferred position being in the primary location. The DRT notes that the westbound Rutherford Street approaches to Melling Link and Queens Drive and the southbound Queens Drive approach to Rutherford Street have three lanes but do not have primary overhead displays. Another approach where an overhead display may be required is on the Pretoria Street approach to High Street, due to the sharp horizontal curve on this approach immediately adjacent to the intersection.

3.4.2 Pedestrian and Cycle Displays and Pushbuttons

The cycle and pedestrian displays are generally appropriate for the layout of the intersections. It is noted that primary cycle displays are to be used as has become the standard in Christchurch.

The DRT noted that at some crossings it is assumed that cyclists will only be travelling in one direction and therefore cycle displays have only been provided facing one direction. During the detailed design process the possibility of cyclists travelling in the opposite direction needs to be considered. For example at the Queens Drive / Rutherford Street intersection a cyclist heading south on the eastern side of Queens Drive, from the interchange, may wish to cross across the slip lane, then across Queens Drive to the slip lane island on the north-western corner then cross to the south side of Rutherford Street to head west along Rutherford Street. When they use the cycle crossing across the west side of Rutherford Street there would be no cycle displays facing them. A similar situation could occur for a cyclist approaching from the south wishing to head east on Rutherford Street.

Another issue the DRT identified was the location of the primary signal poles where an on road cycle lane exits from the road onto the footpath. In all cases at both of the Queens Drive intersections the primary signal pole is placed directly in the path of a cyclist exiting onto the footpath. An example is shown in the figure below.

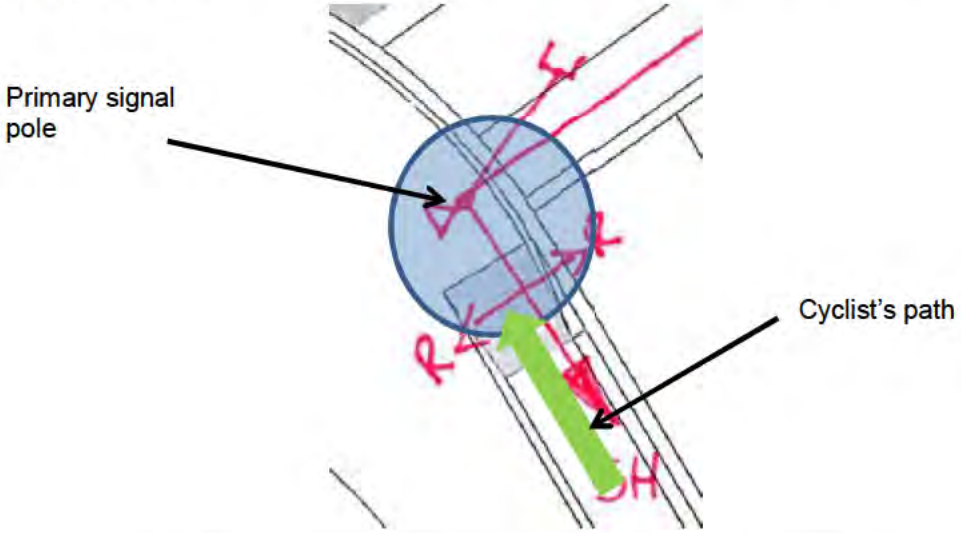


Figure 4 - showing primary pole in direct path of cyclists.

3.5 Phasing Design

3.5.1 Right Turn Filter Movements

All of the Hutt City sites propose to use a phasing design that allows right turning traffic to turn when the opposing through traffic may also proceed. - i.e. Filter Right Turns.

Whilst the provision of filter turns may improve efficiency, they can reduce the safety as conflicting movements may now occur. Studies have found that, at signalised intersections where filter turns are permitted, around 30% of all crashes are of the "Right Turn Against" type (NZTA Accident Database accident types LA and LB).

The phasing design needs to consider a balance between safety and efficiency. When considering allowing filtering it is the DRT's opinion that safety must be given a higher weighting in the decision process, especially where there is potential conflict with pedestrians or cyclists.

Filtering may be considered appropriate when: -

- The phase sequence is safe and does not introduce unsafe phasing transitions such as "The Right Turn Trap" (see Section 3.5.2).
- It will enhance the efficient operation of the signals without unduly compromising pedestrian, cyclist or driver safety.
- Turning volumes and opposing traffic flows are below a specific threshold. For example, Austroads suggests that filtering may be considered if:

  The right turn flow is less than 120 vehicles per hour and is opposed by less than: -

- 900 vehicles per hour when there is one opposing traffic lane or
- 700 vehicles per hour where there are two opposing traffic lanes

- There are no environmental factors that may potentially detract from the safety of making an uncontrolled manoeuvre e.g. inadequate sight distance, more than two opposing lanes etc.

Where opposing filter right turns using right turn only lanes are to be provided, in order to provide the greatest sight distance to an approaching through vehicle it is desirable that the right turn lanes are directly opposite each other (back to back) and not offset. At three of the sites the DRT noted that the opposing right turn bays are slightly offset. These are

- on the Rutherford Street approaches to Queens Drive
- on the Queens Drive approaches to High Street.
- on the Melling Link and carpark exit at Rutherford Street.

3.5.1.1 Right Turn Filtering Conflict with pedestrians and Cyclists.

Allowing filter right turn movements to occur when there is conflict with a pedestrian and/or cyclists is not considered desirable or safe. Where this situation occurs, full protection is provided to the pedestrian/cyclist (i.e. the right turn red arrow (RTRA) is held on red for the complete time the pedestrian/cyclist is crossing, generally the pedestrian walk and clearance intervals).

Depending on the length of the pedestrian crossing this time can be a significant proportion of the total green time allocated to the filter turn phase and may result in few vehicles being able to turn. Generally, in situations such as this the driverôs only opportunity to turn is during the phase intergreen period (amber and red intervals). Encouraging drivers to turn during the intergreen is not desirable or safe.

It is assumed that the phasing design has been developed using computerised traffic modelling. Often when developing the model, the effect of pedestrians/cyclists on turning traffic may be difficult to replicate and therefore the modelling results may not truly reflect how the intersection will actually operate.

3.5.2 Phase Sequence – "Right Turn Trap"

Some phase sequences can be unsafe, and should either be avoided or the traffic signal controller programmed so that the phase sequence cannot occur or if it does then it does so safely.

The most common unsafe phase sequence is known as ñThe Right Turn Trapò and occurs where a right turn lag phase is preceded by a phase in which the opposing conflicting right turn filter movement operates, as shown in the diagram on next page.

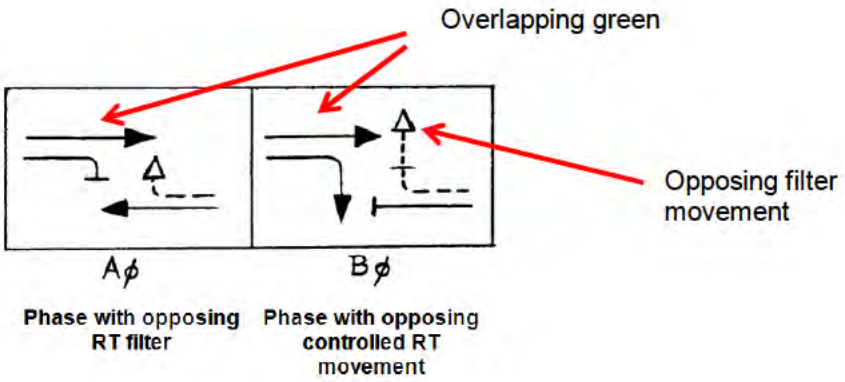


Figure 5 - Showing right turn trap sequence

It has been identified that drivers waiting on the opposing filter right turn movement often assume that when their yellow signal is displayed, the opposing driver is seeing a similar yellow display whilst in fact they may still be seeing a full green display which overlaps between phases. As the right turn filter often occurs during the yellow interval and sometimes into the all red, this erroneous assumption leads to drivers on the opposing right turn filter misreading the opposing driver's intention assuming that they are also going to stop.

The DRT noted that such a situation could occur at the Queens Drive / Rutherford Street intersection. The Figure below shows the proposed phasing at this intersection. If the Sequence A-B-C-D is run, as indicated, then lag right turn phases, and therefore the right turn trap issue, will occur when going from A phase to B phase and C phase to D phase.

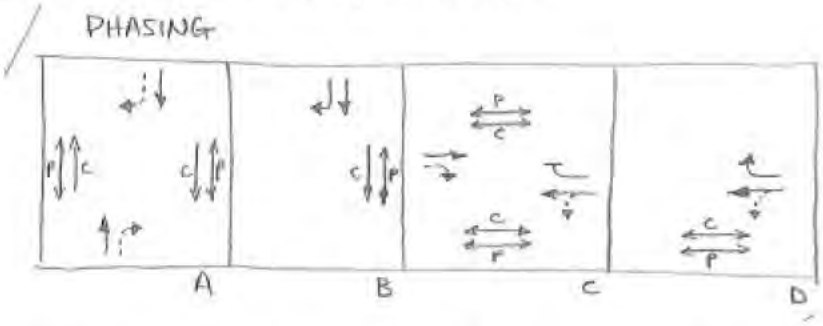


Figure 6 - showing lag right turn phases (B and D) at Queens Dr / Rutherford St

3.6 Captive Lanes and Safety

There are two 'Captive Lane' situations developed. These are:

- Westbound on Rutherford Street when exiting the Melling Link intersection as the outer through only lane changes to a right turn only lane at the downstream Queens Drive intersection.
- Southbound on Queens Drive when exiting the Queens Drive / Rutherford Street intersection as the kerbside lane changes from a through lane to a left turn only lane at the downstream Queens Drive / High Street intersection.

Captive turn lanes (left or right) can lead to:

- Erratic and undesirable driver behaviour, including sudden lane changes or through movements when only turning movements are allowed, potentially resulting in a higher crash rate.
- Drivers slowing down or stopping close to the intersection to move out of the captive lane, impacting on the intersection capacity.

Captive lanes may also impact on lane utilisation and coordination (See Section 3.8.2)

3.7 Vehicle Tracking

The DRT noted that many of the right turn movements are tight as the vehicle limit lines go straight across all lanes. Tight turns result in very slow movements which can reduce the capacity of the right turn movement.

Staggering the limit lines, as shown in the Figure below, has been shown to provide an easier vehicle turning path.

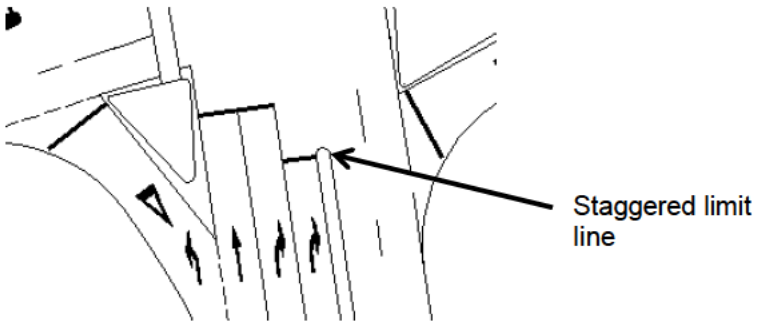


Figure 7 - showing staggered vehicle limit line to improve vehicle tracking.

The eastern approach of Rutherford Street to Queens Drive has two right turn lanes. The vehicle tracking needs to allow for the situation where a large vehicle (HV) and 90 percentile car are turning together.

Where there are double right turn lanes the convention is to check placing the largest design vehicle (i.e. Semi-trailer) in the outside (left hand) turning lane and the smallest vehicle (i.e. 90% car) on the inside lane. This is to ensure that the inside rear corner of the larger vehicle does not encroach into the inside lane.

3.8 Linking and SCATS Operation

The DRT assumes that full time coordination will most likely be desirable along each of the Rutherford and High Street routes, with the possibility of a cross link on Queens Drive in peak times.

It may also be necessary to link to the Melling Interchange in peaks to avoid queuing either to or from the Interchange.

Outlined below are some design aspects that may have an effect on the network performance and ability to provide good coordination

3.8.1 Shared Through and Left Turn lanes

For co-ordination to be effective, through traffic must be able to move freely. At each of the four intersections most of the through movements show a combined single lane providing for through and left turning traffic. For SCATS operation and co-ordination combined lanes can cause issues.

These include:

- The through traffic will be slowed by left turning traffic.
- There is a possibility that a left turn vehicle could block the lane as it is held on a Red Arrow to protect the parallel pedestrian movement.
- SCATS will record a high Degree of Saturation (DS) on the through lane as left turn vehicles are either held for pedestrian protection or move slowly because of the tight turn radius. A high DS will result in SCATS operating at high cycle lengths.
- High DS on the side roads will also increase the side road phase percentage to the detriment of main road traffic by reducing the green bandwidth required for coordination.
- Single lanes can create long queues that are slow to dissipate.

Coordination requires that all intersections involved use a common Cycle Length. Cycle Length will normally be driven by the busiest intersection. It might be necessary to remove some of the combined through and left turn lanes from SCATS control if they cause the Cycle Length to be pushed high as a result of the combined lane issues.

3.8.2 Captive Lanes and Coordination

As noted above there are two situations where a captive lane is created.

Captive lanes may cause merging issues if drivers are not fully aware that they have been placed into a specific direction turn lane that they may not have intended to be in. Merging traffic can reduce the efficient operation of the free flowing through lane, slowing traffic and affecting coordination.

Captive lanes can also create lane utilisation issues if traffic is not equally distributed between the two through lanes - for example, at the Rutherford Street intersection approach.

3.8.3 Phasing - Right Turn Filter

As noted above, all of the intersections propose to use filter turn movements. In respect to coordination, filtering is more of a safety issue rather than having any operational effect on SCATS. With filtering SCATS will run lower cycle lengths and give reasonable coordination, unless the capacity of the right turn bay is exceeded, resulting in the turning vehicles queuing back and blocking the through traffic lane

Under the proposed design, a non-filter phasing design would provide improved safety but would require SCATS to operate at higher cycle lengths and it will be harder to give good co-ordination. However, if, for safety reasons, during the detailed design process, filtering is felt not to be desirable, then other phasing designs, such as controlled lead / lag configurations, may need to be considered. Whilst these phasing designs may not be the most efficient for the operation of individual intersections they may provide better two way coordination and better overall network performance.

At those sites where lead right turn phasing is used, the operation can appear clumsy in low Off-Peak times to overcome the filter ôright turn trapô issue. As this will generally only occur at low Off-Peak times, it will probably not be a concern for coordination.

3.8.4 Network Efficiency

The efficiency of the network, as indicated by the modelling undertaken, suggests that it relies heavily on the ability of the right turn traffic to filter turn through the opposing traffic. Apart from the brief comments in the File Note the DRT has no other information on how the modelling outcomes were derived.

The DRT has some concerns on whether the modelling has accounted for some of the issues raised above, especially when considering the pedestrian and cycle facilities. This raises the following questions

- Does the model consider the effect of the safety requirements for pedestrian/cyclists where the right turn movement may not filter turn due to being held on a right turn red arrow?
- Does the model consider the effect of delay to through and left turning traffic due to the left turn not being able to turn as they are held by a left turn red arrow protecting pedestrians /cyclists?
- Did the model run at a cycle time that would accommodate all vehicle and pedestrian/cycle movements? - For example, the minimum cycle time to accommodate each phase and provide time for pedestrian/cycle movements at the Queens Drive / Rutherford Street intersection is estimated to be 90 seconds.

3.9 Specific Intersection Issues

3.9.1.1 Queens Drive / Rutherford Street

- Stagger limit lines to improve right turn vehicle tracking
- Rutherford Street right turn bays offset ï Filter turns
- Double right turn tracking paths ï check for large vehicle and car turning together
- Include primary overhead poles and displays on the eastern Rutherford Street and north Queens Drive approach as they have three approach lanes
- Relocate Rutherford Street westbound secondary overhead from secondary pole to eastbound primary. Include eastbound overhead primary display.
- Start of a captive lane shown for traffic southbound on Queens Drive leading to a left turn only lane at the High Street intersection
- Captive right turn lane shown for traffic coming from the northeast on Rutherford Street from Melling Link intersection
- Review phasing design

3.9.1.2 Queens Drive / High Street

- Stagger limit lines to improve right turn vehicle tracking
- The car parking on eastern side of High Street is too close to the intersection. May lead to vehicles reversing into the western bay conflicting with pedestrian/cycle crossings
- The primary signal pole is placed directly in the path of a cyclist exiting onto the footpath exiting from the southbound and eastbound on road cycle lanes
- The southbound Queens drive left turn only lane is a captive lane for traffic coming from the Rutherford Street intersection
- Review phasing design

3.9.1.3 Melling Link / Rutherford Street / Carpark Access

- Stagger limit lines to improve right turn vehicle tracking
- Melling Link and Car park exit right turn bays offset ï Filter turns
- Start of a captive right turn lane for traffic from the west heading towards the Queens/Rutherford intersection
- Include a primary overhead pole and displays on the eastern Rutherford Street approach as there are three approach lanes
- Review phasing design

3.9.1.4 Melling Link / High Street / Pretoria Street

- Stagger limit lines to improve right turn vehicle tracking
- Include primary overhead pole and displays for Pretoria Street due to curved approach.
- Review phasing design

4. Summary and Recommendation

Given the incomplete design nature of the intersection drawings provided, the DRT considered that a ñConcept Design Reviewò was the most appropriate form of review at this stage of the project. Therefore, this report has concentrated on looking at the broader detail against current standards and ñgoodò practice rather than concentrating on specific detailed design at each site, although some bullet points of specific issues have been noted for each intersection

The Design Review Team recommends that as part of the detailed design process the comments and issues raised in this report be considered and that the safety of pedestrians and cyclists be reviewed when developing the traffic signal phasing for each intersection.

5. Review Statement

We certify that in carrying out this review we have used the drawings listed in Section 2.2 . We have endeavoured to identify features that could be modified or removed in order to improve the efficiency and/or safety, although it must be recognised that safety cannot be guaranteed since no road can be regarded as absolutely safe.

The issues identified have been noted in this report together with recommendations that should be studied for implementation. Readers are urged to seek further specific technical advice on matters raised and not rely solely on the report.

Any suggested solutions are intended to be indicative only, to assist the designer in focusing on the type of improvements that might be appropriate. They **are not** intended to be prescriptive or to be the most appropriate solution, and **other methods** of resolving the issues should be considered.

9(2)(a) [redacted]

Signed: ..... Dated: 30th July 2019

9(2)(a) [redacted] Urban Traffic Design Ltd. Rodney

9(2)(a) [redacted]

Signed: ..... Dated: 30th July 2019

9(2)(a) [redacted], Traffic Systems and Safety Engineer

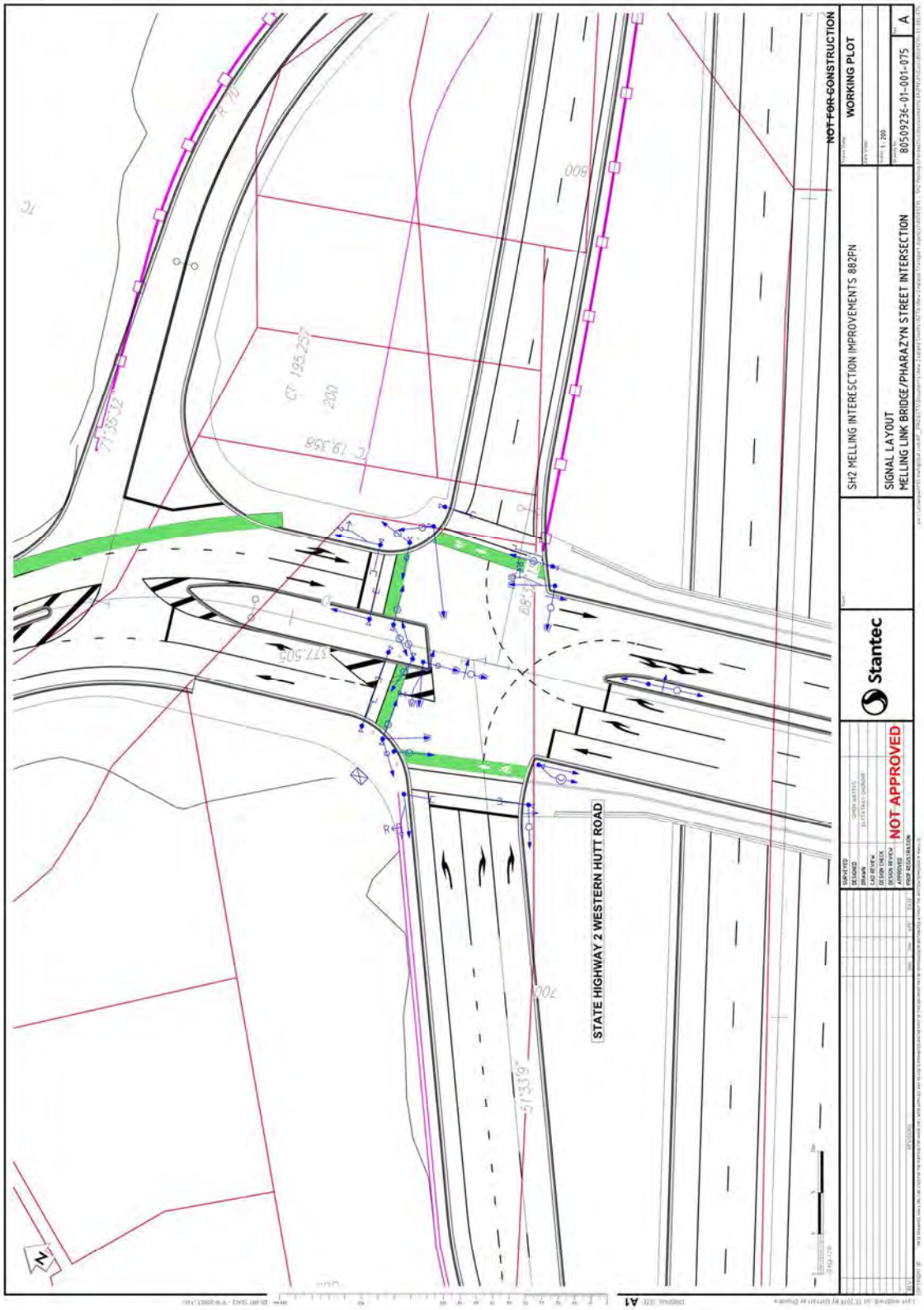
9(2)(a) [redacted]

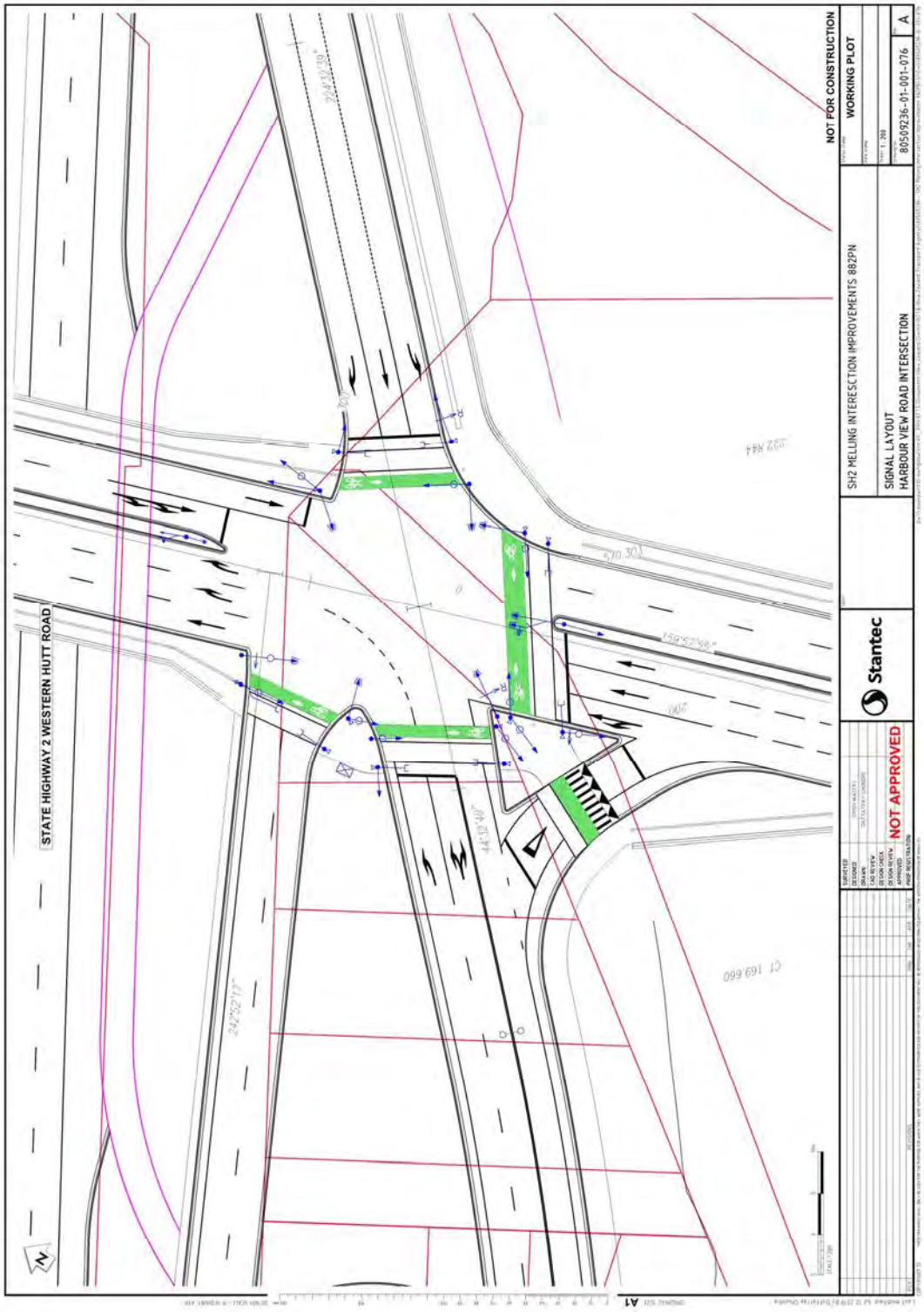
Signed: ..... Dated: 30th July 2019

9(2)(a) [redacted] SCATS Consultant RMHK2 Pty Ltd

Appendix A

Plans and information provide for Review


STATE HIGHWAY 2 WESTERN HUTT ROAD
NOT FOR CONSTRUCTION
WORKING PLOT
SH2 MELLING INTERSECTION IMPROVEMENTS 882PN
SIGNAL LAYOUT
MELLING LINK BRIDGE/PHARAZYN STREET INTERSECTION
Stantec
NOT APPROVED
80509236-01-001-075
A


STATE HIGHWAY 2 WESTERN HUTT ROAD
NOT FOR CONSTRUCTION
WORKING PLOT
SH2 MELLING INTERESCTION IMPROVEMENTS 882PN
SIGNAL LAYOUT
HARBOUR VIEW ROAD INTERSECTION
Stantec
NOT APPROVED
80509236-01-001-076
A

Melling DBC – Review of Traffic Signals

9(2)(a) – 18 June 2019

This file note records the high-level review of proposed traffic signals for the Melling Interchange. The review considers existing traffic modelling and road safety information then evaluates whether the proposed layouts are likely to be achieved onsite and operate safely and efficiently given the site constraints. The sites are presented in Figure 1 and 2 and are:

- Melling interchange SH2 overbridge – two intersections:
  - Cross road signals on north side
  - 5-arm cross road on south side
- Lower Hutt local – four intersections:
  - Queens / Rutherford cross road
  - Queens / High cross road
  - Melling Link / Rutherford Tee
  - Melling Link / High / Pretoria cross road

Figure 1: Proposed interchange layout (2018)

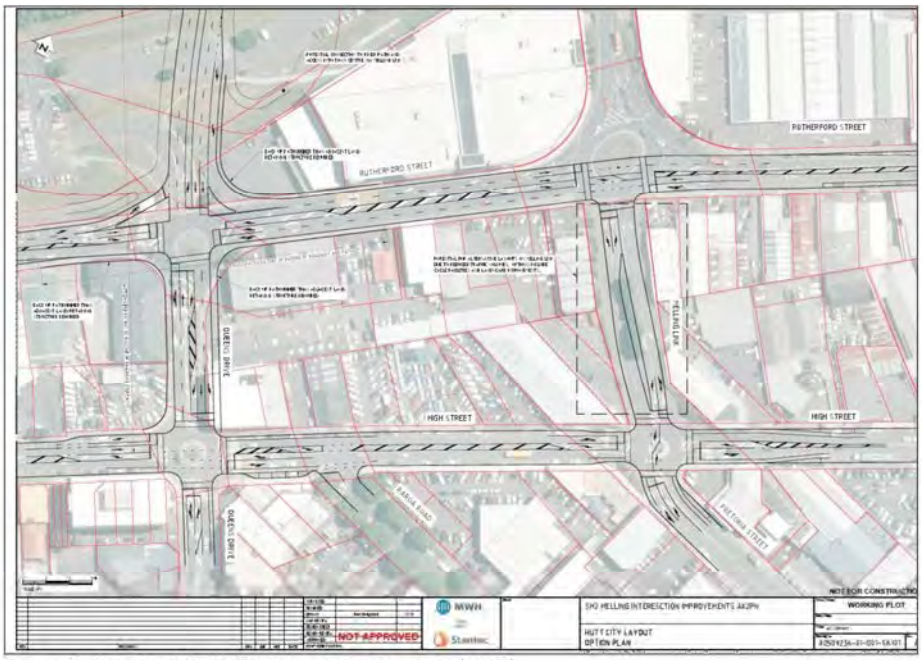


Figure 2: Proposed Hutt City Intersection Layouts (2018)

Documents Referenced

1. Stantec Meeting Notes dated 15 April 2019 (Traffic signals) and 16 May 2019 (Drainage)
2. Flow Transportation Specialists Modelling reports for SH2 Melling interchange:
    a. TA Options June 2018
    b. DBC paramics modelling technical note April 2018
    c. TA of Option 9 June 2018
3. Traffic Planning Consultants – Concept design RSA January 2018
4. Stantec Keith Weale File Note Revised 17 April 2018 and 2 May 2019

Modelling

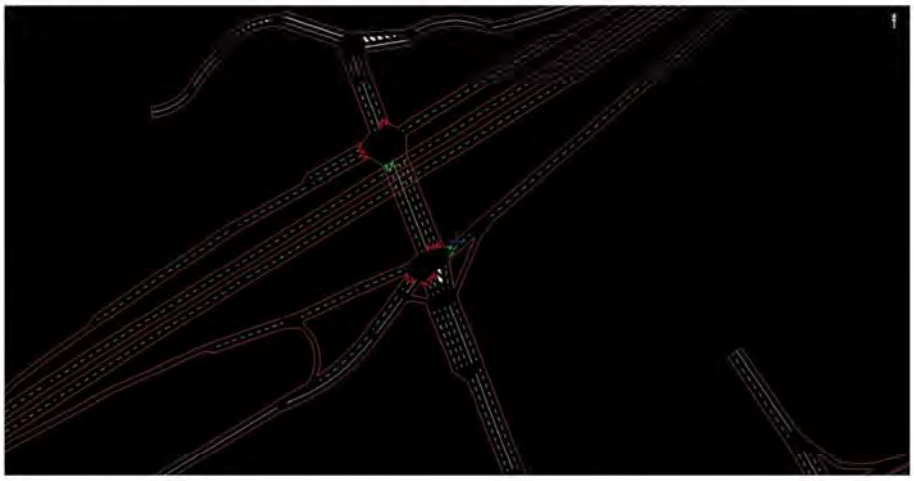
Saturn and Paramics modelling was undertaken by Flow Transportation Specialists and is detailed in the aforementioned reports. The reports evaluate three variations of Option 9, and ultimately recommend Option 9B from an overall transportation perspective to avoid the five leg signalised intersection in Options 9 and 9A. It also noted there was less the 5% difference in travel time of Options 9 and 9B compared to Option 9A. It is noted that Option 9 has been adopted by the wider project team partially based on safety benefits achieved from the 5-leg intersection compared to two closely spaced signalised intersections.

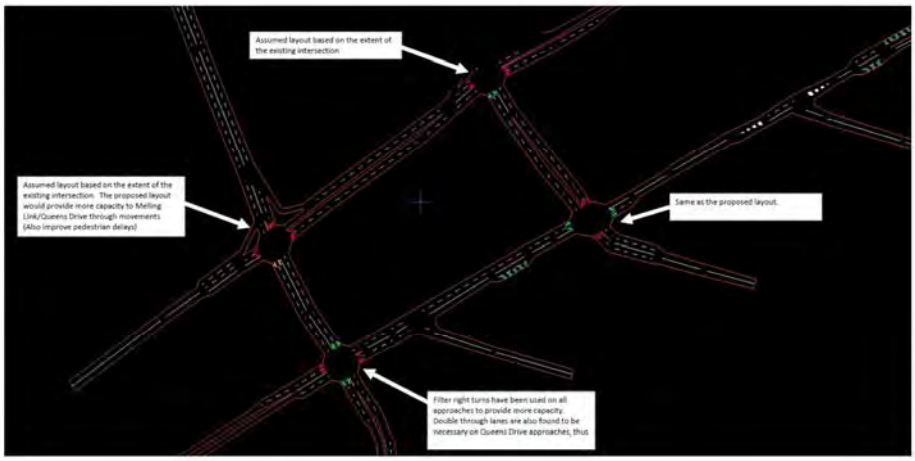
Modelling indicated that expected queue lengths would be accommodated within the proposed lane lengths and are unlikely to have effects on adjacent intersections and no queuing observed along off-ramps to the SH2 through movement.

Differences are noted between some of the modelled CBD signalised intersection layouts and the high level scheme layouts as a consequence of design improvements adopted post modelling. These include additional through lanes or provision of dedicated turn lanes. The modelled four lane section along Melling Link, from Rutherford to High Street, has been reduced to two lanes thereby decreasing capacity along this length. This is not anticipated to have any notable effect on the overbridge operation or congestion along the Queens Drive and High Street routes. This is based on the intersections, with number of turn lanes, governing the capacity and not the mid-blocks.

In general, it appears the modelled intersection layouts provide less capacity, therefore the outputs are considered conservative.

The paramics modelled network[1] is presented below.

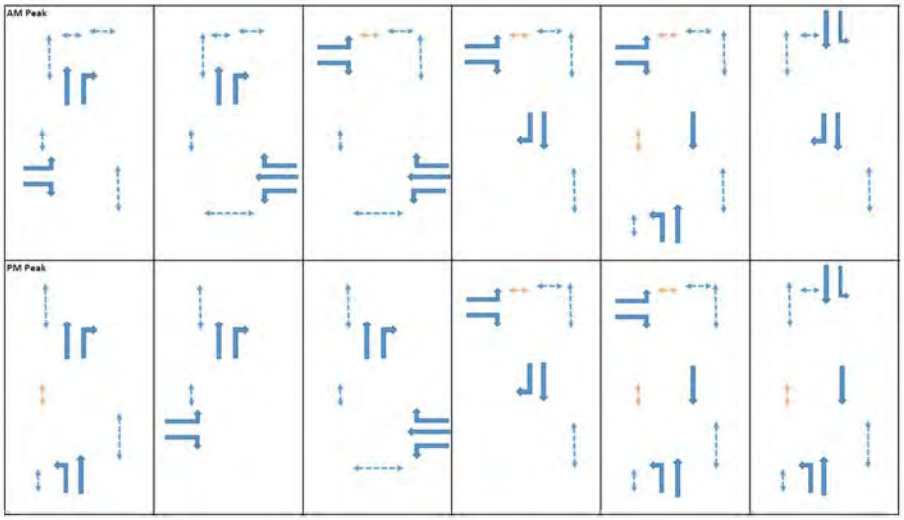




[1] Provided by Flow 2018

The modelled phasing of the two overbridge signalised intersections during the morning and evening peak periods are:

Interchange Phasing



Modelled phasing for the four Hutt City intersections was:

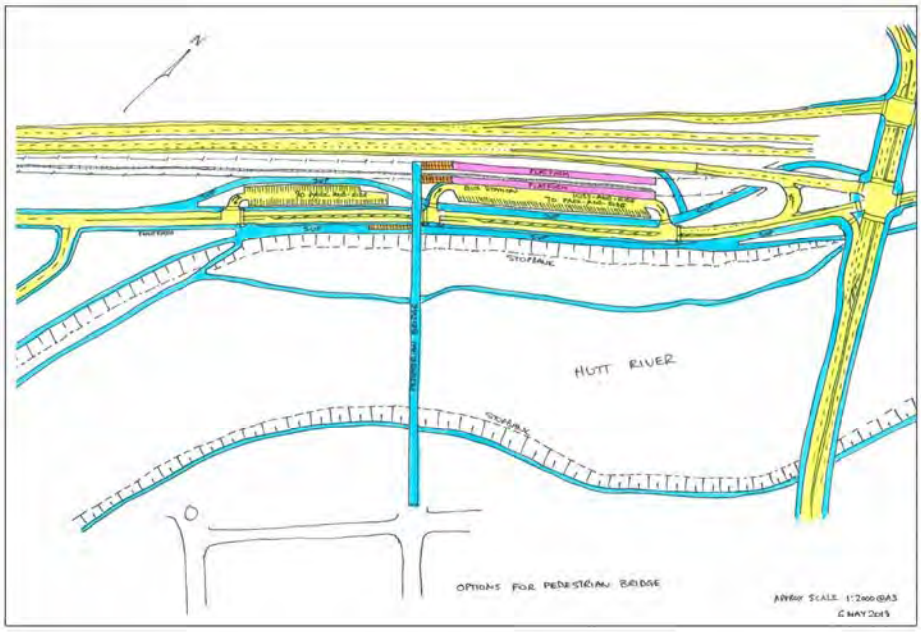
- Queens / Rutherford cross road – 4-phase split approaches (i.e. separate phase on each approach)
- Queens / High cross road - 2-phase operation (filtering allowed on all approaches)
- Melling Link / Rutherford Tee – 3-phase lead right turn from Rutherford Street west
- Melling Link / High / Pretoria cross road – 3-phase with split approach operation on Melling and Pretoria Street, and a single phase on Rutherford Street (allowing filtering)

The Hutt intersection phasing adopted for modelling was changed in the preliminary design to cater for the revised intersection layouts and improve intersection operation. This is detailed in subsequent sections, however in general increases capacity compared to the modelling.

Overall, the combination of Saturn and Paramics modelling is considered appropriate for capacity modelling of this project. Improvements to intersection layouts and modification of phasing is likely to have improved capacity of the intersections and hence network. These changes have not been modelled. Physical site constraints preclude the provision of additional lanes beyond that currently provided. Further refinement of intersection operation can be developed during detailed design using a combination of Paramics and Sidra.

Non-motorised user provisions

The following figure provides a high level plan of the potential pedestrian and cycle provisions, shown in blue. Separated paths are proposed onto and across the overbridge and a shared use path (SUP) on the Pharazyn Street leg. Separated pedestrian and cycle facilities (Toucan) are proposed at the traffic signal controlled intersections with crossings protected by red arrows. All cycle displays will be 3-aspect with demand called via cycle push button.

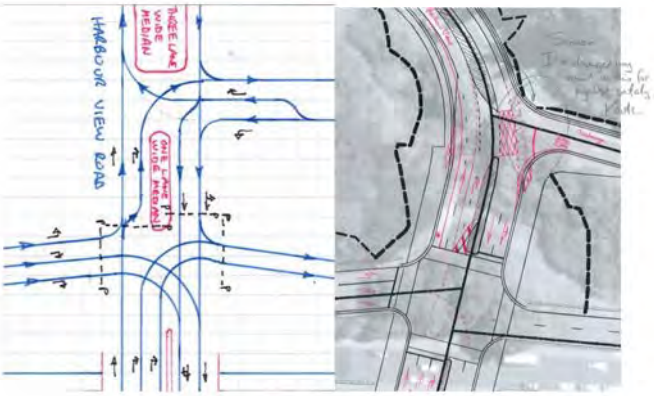


Constraints

No land purchase permitted for the Lower Hutt intersections except for that shown on the east side of Queens Drive between High and Rutherford Street.

1. SH2 Overbridge north side (Harbour View / Off-ramp / On-ramp)

Figure 3 presents the proposed layout, stick diagram of movements and revised Tirohanga intersection layout.



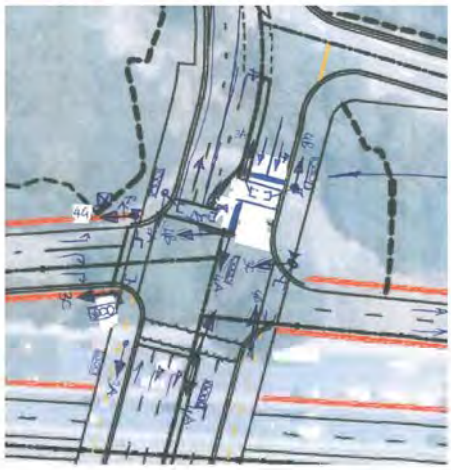
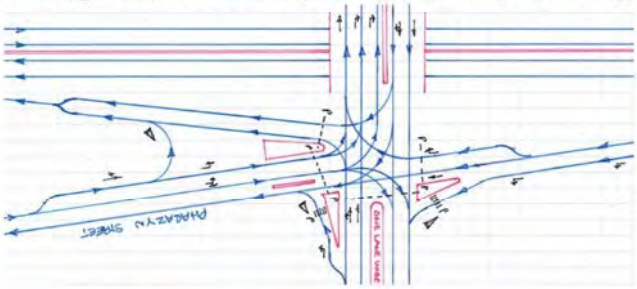


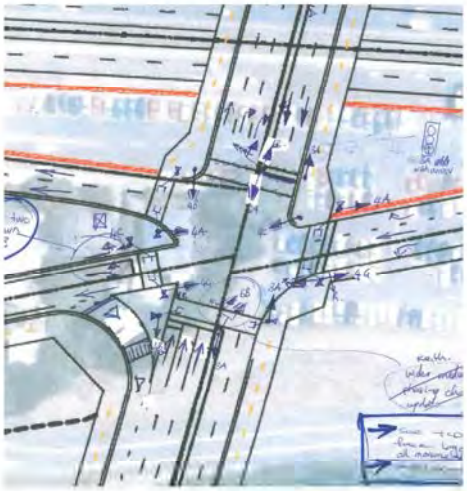
Figure 3: Proposed interchange layout (2018), Stick diagram of lane and traffic / pedestrian movements and amendment to Tirohanga intersection layout. Proposed lantern layout.

Key notes are summarised below:

- Modelling via paramics has indicated off-ramp queues will not extend back to the SH2 through movement. Phase times can be modified via SCATS if this did occur during an extraordinary event, or queue loops can be provided.
- Design now provides dedicated northbound through lane, improving capacity over modelled outcome that provided a shared through/right turn lane.
- Design shows pedestrian crossing on south approach. This can be removed, retaining the same LOS for shared path users and improving capacity for off-ramp right turn traffic.
- Support changes proposed in K Weale sketch (Tirohanga intersection). Unlikely to have capacity effect and will be simpler to use. Unclear where northbound cyclists re-enter road when shared path is provided around the curve however this can be addressed during detailed design.
- Unclear what phase intersection will rest in (i.e. when no vehicle/cycle/pedestrian demands). No phase is shown with two-way movements permitted between this intersection and the Five leg to the south. Discussions with K Weale indicate demand across overbridge is likely to be low and therefore unlikely to require this phase. Has been assumed controller will rest in phase providing green lights for the off-ramps.
- Further to above, central raised median on south approach is 1.6m wide (kerb face to kerb face), therefore will cater for 6-aspect two column lantern if required to permit the two-way green phase on overbridge as noted above.
- RSA queried how cyclists ride along SH2, further to this, how do they exit / enter SH2? SH2 provision is outside scope, exit / entry now provided with one-way off-road paths.
- Use of overhead mast arms is not proposed to reduce potential see though confusion.

2. SH2 Overbridge south side (Pharazyn Street / Off-ramp / On-ramp)



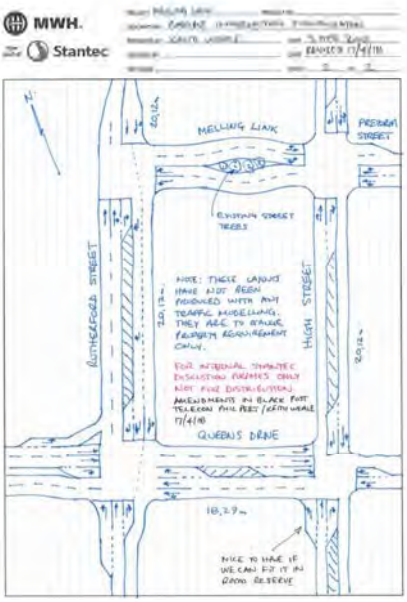


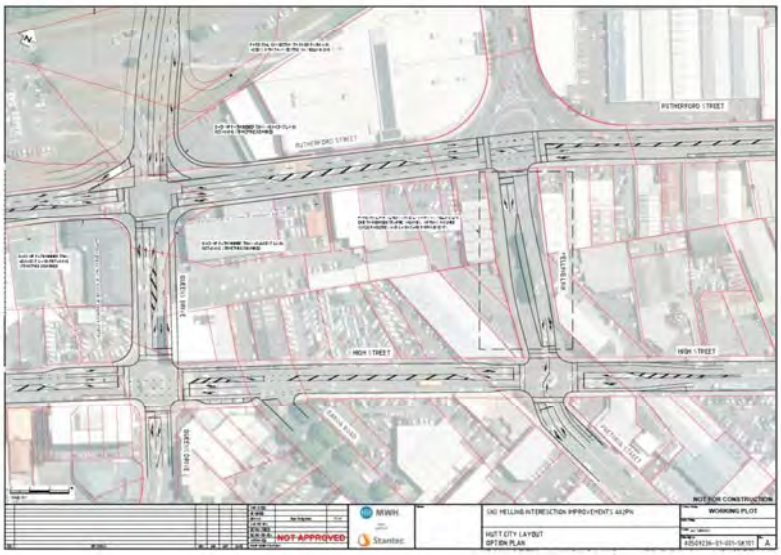
Key notes are summarised below:

- Modelling
  - High level of delay for left turn from Pharazyn Street. Two lanes are provided, therefore little scope to improve this. Better than other options
  - Westbound queues back up to Rutherford Street, however better than other options and not identified to create network gridlock.
  - Modelling via paramics has indicated off-ramp queues will not extend back to the SH2 through movement. Phase times can be modified via SCATS if this did occur during an extraordinary event, or queue loops can be provided.
- RSA suggested 5-arm intersection being evaluated. This is now the updated preferred design.
- Pedestrian and cyclists are catered for on dedicated separated facilities with Copenhagen style facility on the overbridge. Toucan crossings at signals.
- Design shows crossing on northern arm, this is not required and can be removed.
- As above. Controller has been assumed to rest in phase providing green lights on the off-ramp.
- Use of overhead mast arms is not proposed to reduce potential see though confusion.

Lower Hutt Intersections

Paramics modelling determined operation of Lower Hutt intersections to be improved with installation of traffic signals.[2] The proposed intersection layouts are presented and discussed in the following figures and sections.

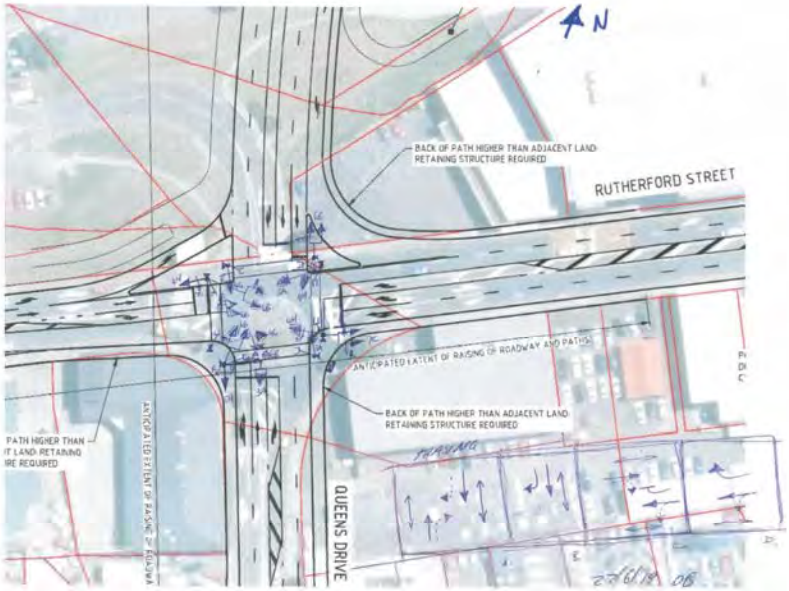




[2] TN2C180409 – Flow Paramics Modelling

3. Queens / Rutherford cross road

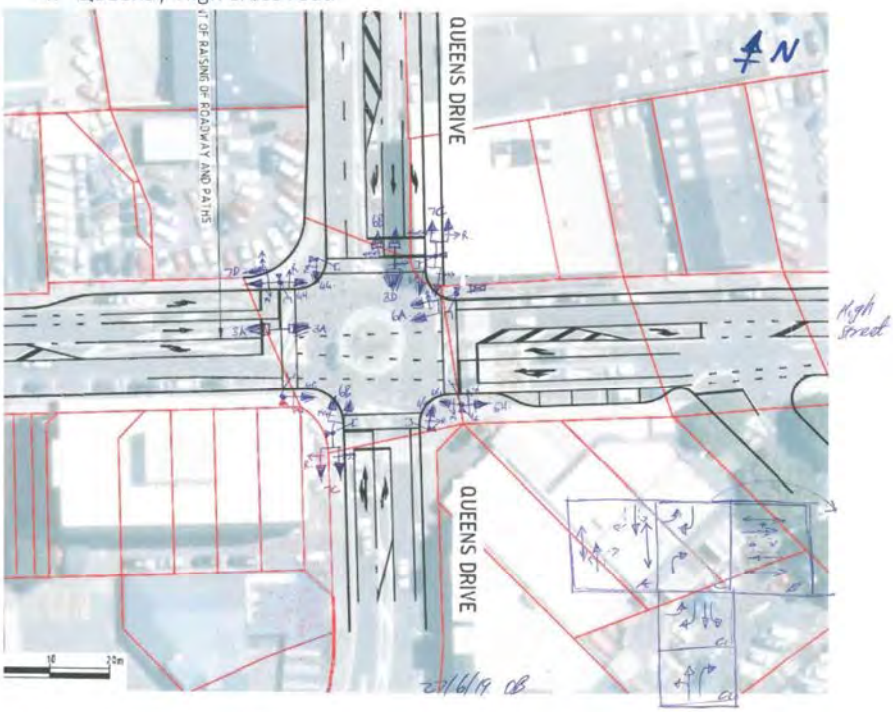
The proposed intersection layout is presented below.



Key notes are summarised below:

- The intersection will be raised above existing ground level.
- Key HCV link bridge along Queens Drive and overbridge onto Rutherford Street.
- Traffic modelling adopted 4-phase split approaches (i.e. separate phase on each approach). This has now changed to lead right turns from the overbridge and Rutherford east. Right turn from Rutherford east non-filter. Red arrow pedestrian / cycle protection.
- Proposed phasing has not been modelled, but likely to be more efficient than paramics modelling due to lane modifications providing additional right turn lane from Rutherford east, dedicated right turn from overbridge, and dedicated right turn from Queens south leg.
- Anticipated that separated cycle facility will continue both sides of Queens Drive to High Street. No opportunity to provide for cyclists along Rutherford Street.
- Mast arm proposed Queens south and Rutherford west to permit repeat of right turn displays.
- Left turn slip lane from overbridge to Rutherford east should be similar to slip lane from Rutherford west to overbridge. This allows the pedestrian zebra crossing movement to be separated from the left turn movement.

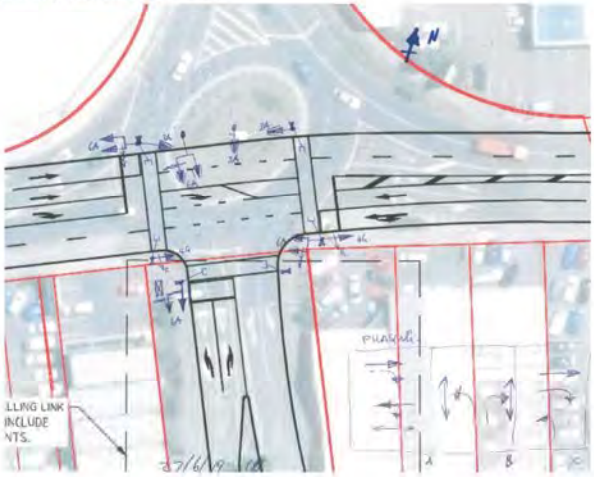
4. Queens / High cross road



Key notes are summarised below:

- High Street is priority cycle route – Hook turn boxes are recommended on all approaches.
- Queens Drive is key link from the bridge to the beltway cycle routes.
- Ministry of Social Development building kerb is currently being mounted and the awning being struck (northern corner). This building will be removed in association with road widening.
- Mast arm proposed Queens north and High west.
- Traffic modelling adopted a 2-phase operation (filtering allowed on all approaches). Proposed phasing provides diamond on Queens Drive to cater for the high right turn demands, with filter right turns permitted. Red arrow pedestrian protection.
- Lane modifications made post modelling include single through lanes on Queens Drive (reduction from two through lanes) to allow provision of dedicated right turn lanes on both approaches and a dedicated left turn on Queens north. A dedicated left turn lane has been added to High Street west.

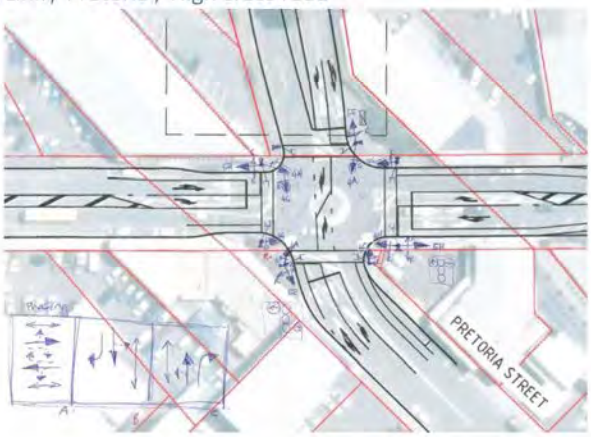
5. Melling Link / Rutherford Tee



Key notes are summarised below:

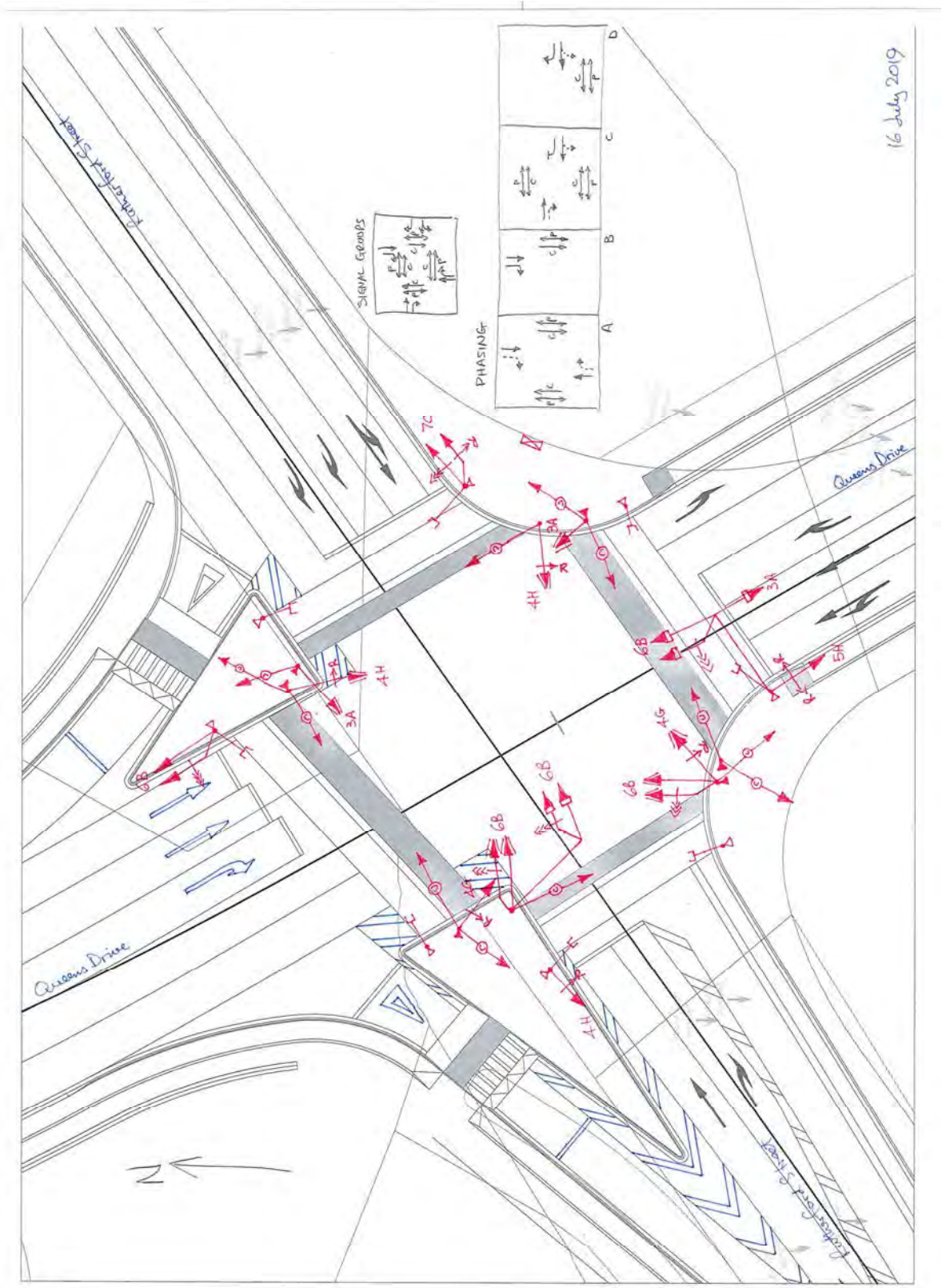
- Traffic modelling adopted 3-phase lead right turn from Rutherford Street west, which has been adopted for the design.
- Has been assumed there will be no vehicle access to the north.

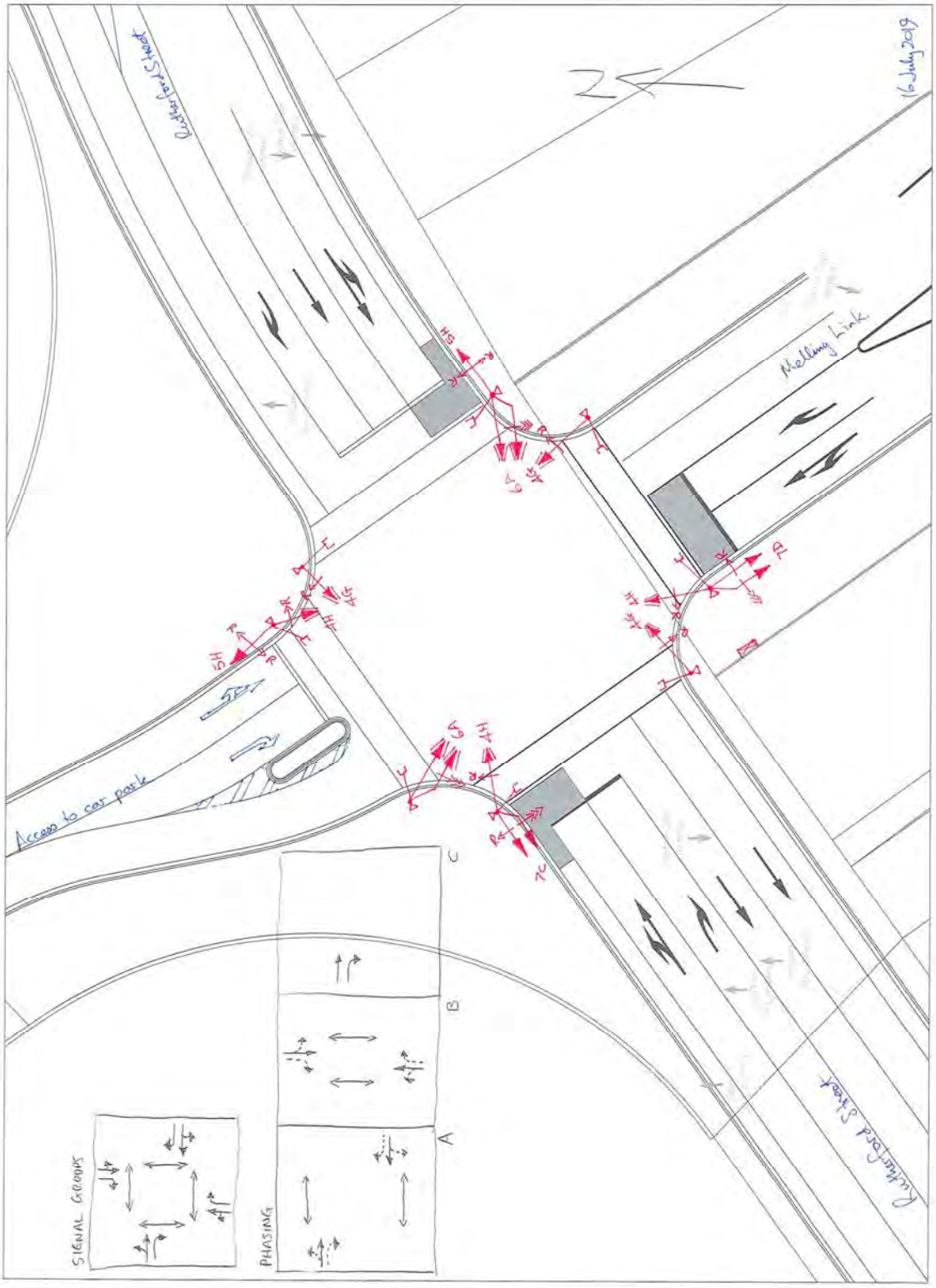
6. Melling Link / Pretoria / High cross road

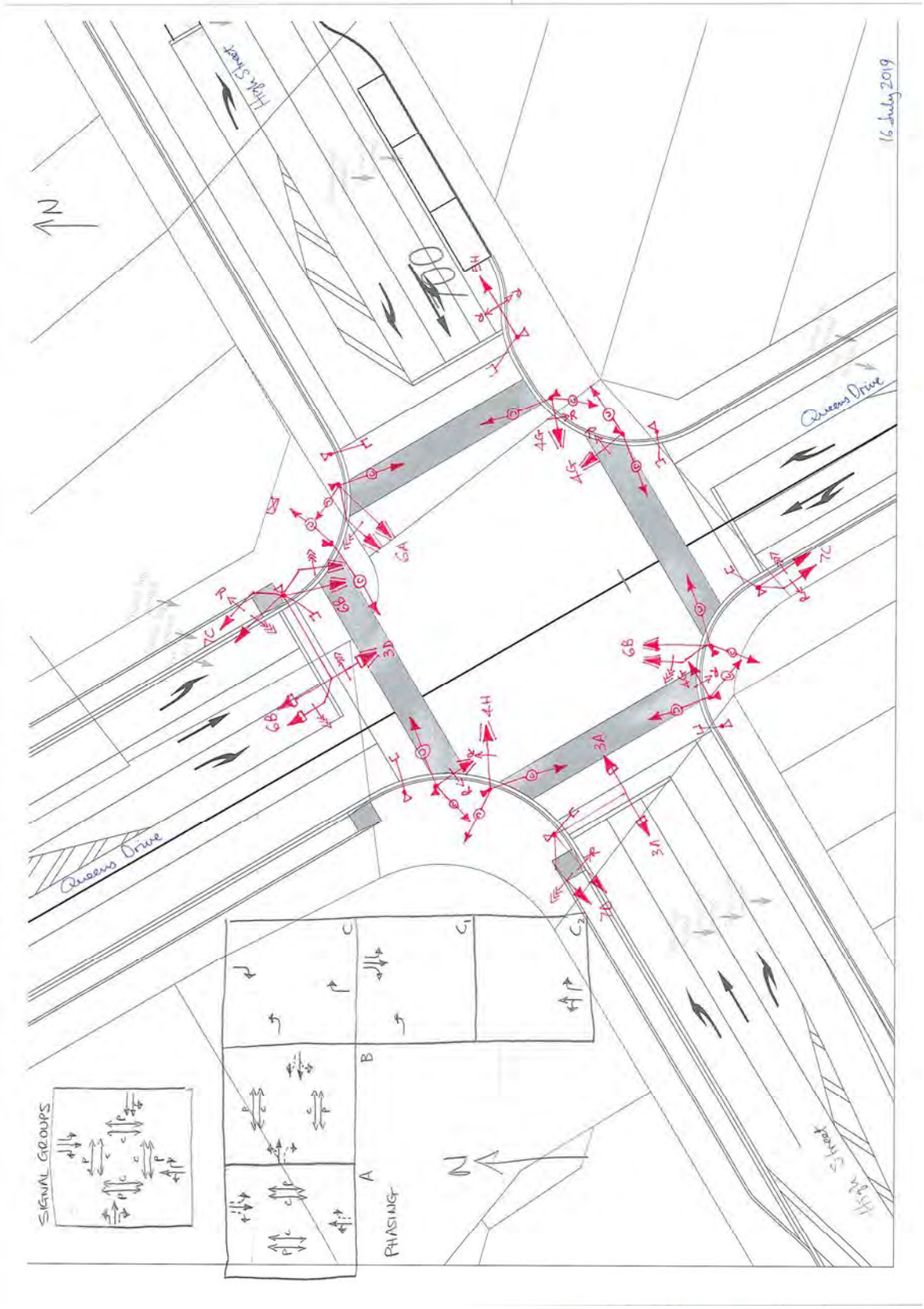


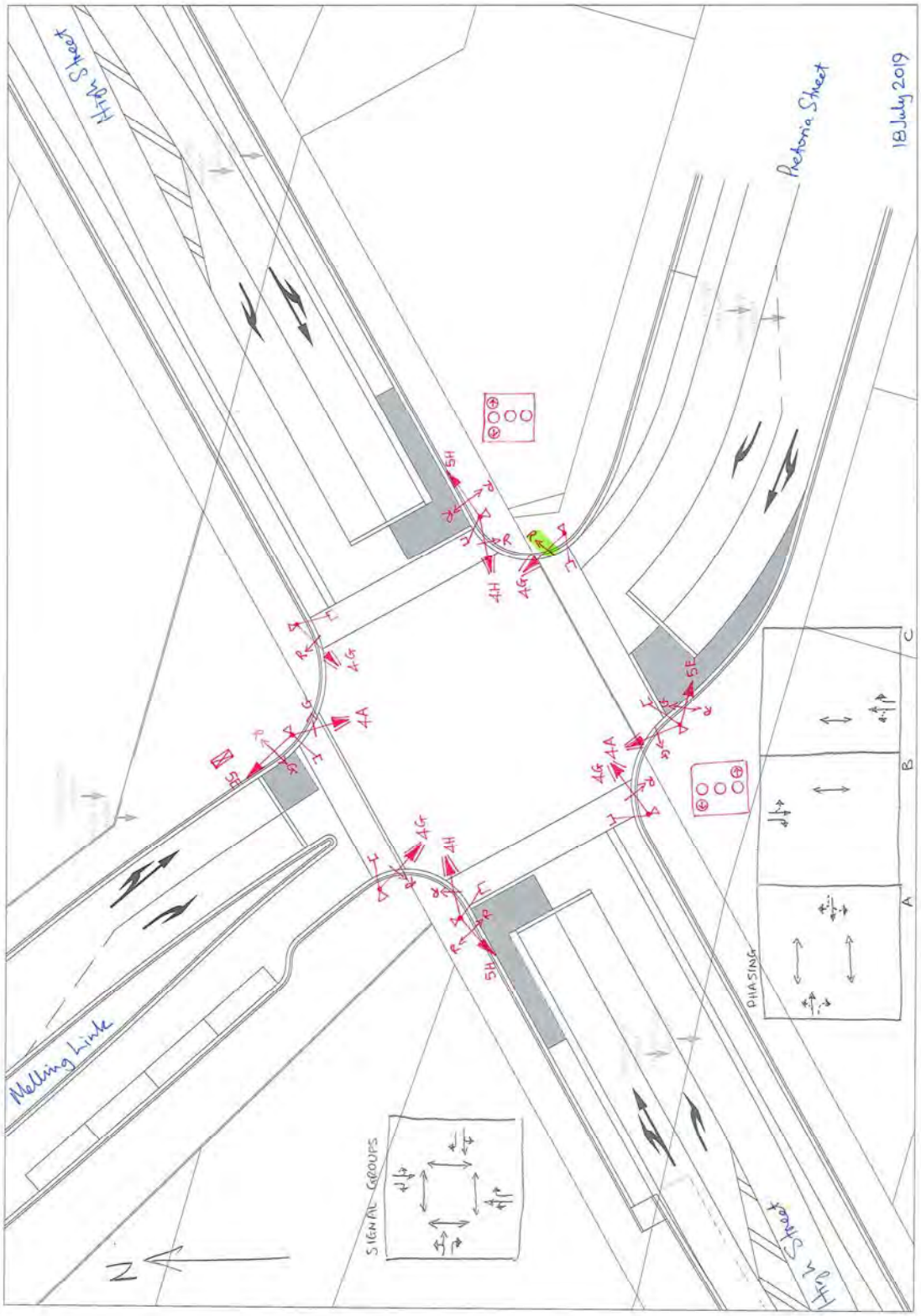
- High Street is priority cycle route – Hook turn boxes are recommended on all approaches.
- Traffic modelling adopted a 3-phase with split approach operation on Melling and Pretoria Street, and a single phase on Rutherford Street (allowing filtering), which has been adopted for the design.
- The right turn guide lines are not required on the Melling Link / Pretoria alignment due to split phasing.

- Lane modifications have been made post modelling to the Melling and Pretoria legs with replacement of shared through / right lanes with dedicated right turn lanes and associated reduction in the mid-blocks from four to two lanes.


Queens Drive
Queens Drive
Rutherford Street
Rutherford Street
SIGNAL GROUPS
PHASING
A
B
C
D
16 July 2019
N


Dunbar Road Street
16 July 2019
Melling Link
Access to car park
Hutt River Street
SIGNAL GROUPS
PHASING
A
B
C


High Street
Queens Drive
Queens Drive
High Street
N
16 July 2019
SIGNAL GROUPS
PHASING
A
B
C
C1
C2
1C
2C
3A
3B
3D
4H
5A
6B
7B


Hyde Street
Pretoria Street
18 July 2019
Melling Link
Hyde Street
PHASING
SIGNAL GROUPS
N
A
B
C
4A
4G
4H
5H
5E

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DESCRIPTION _____
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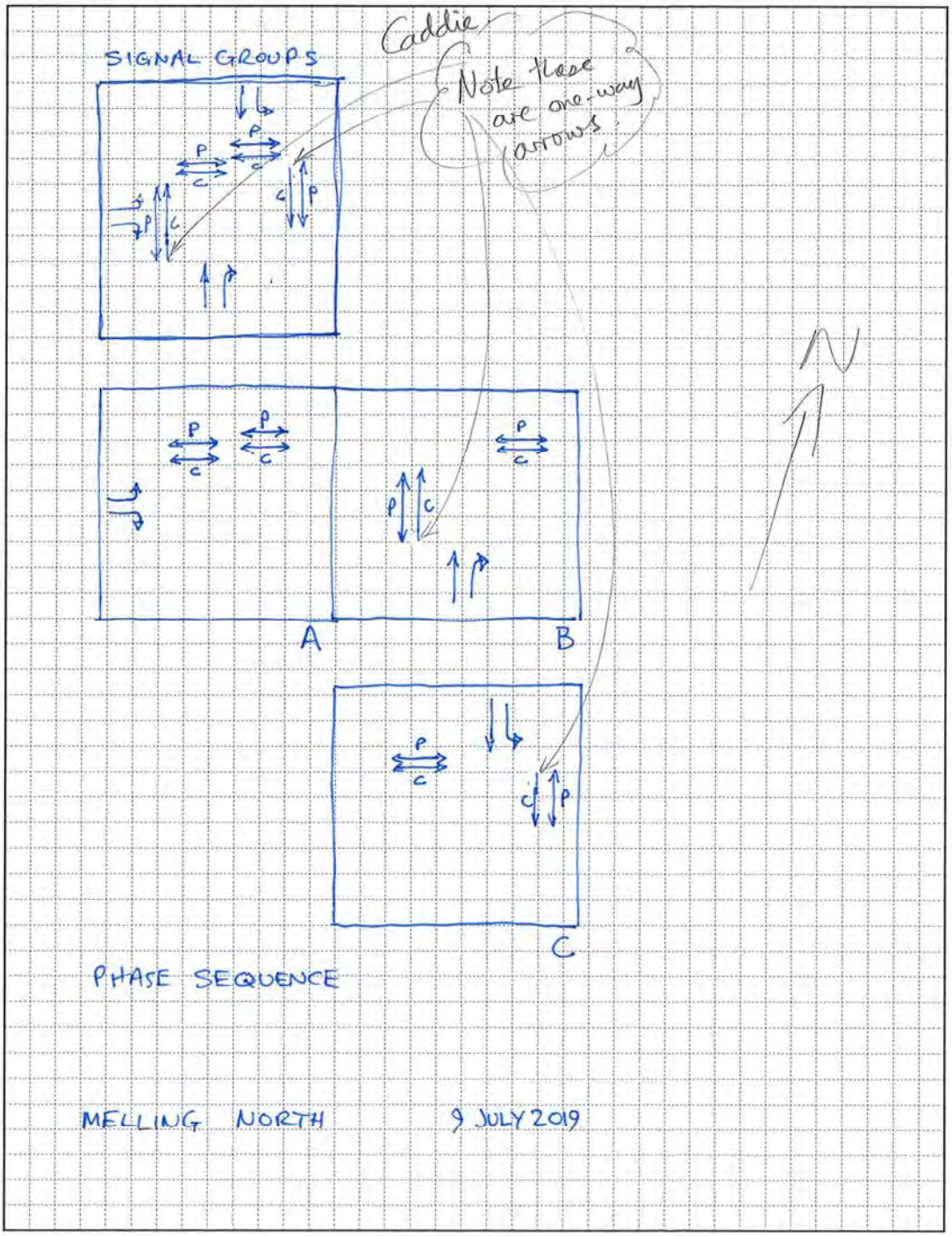

Design with community in mind

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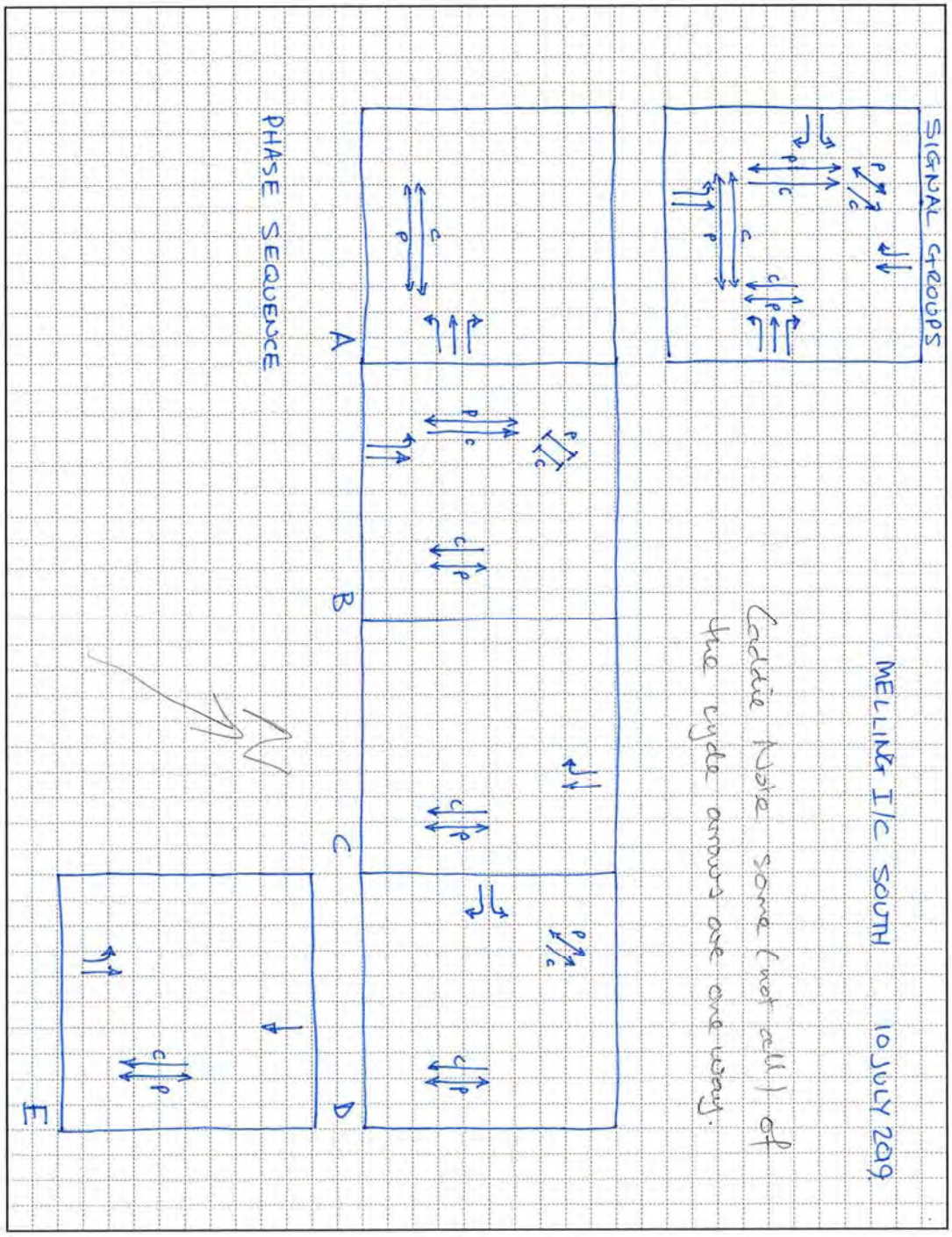
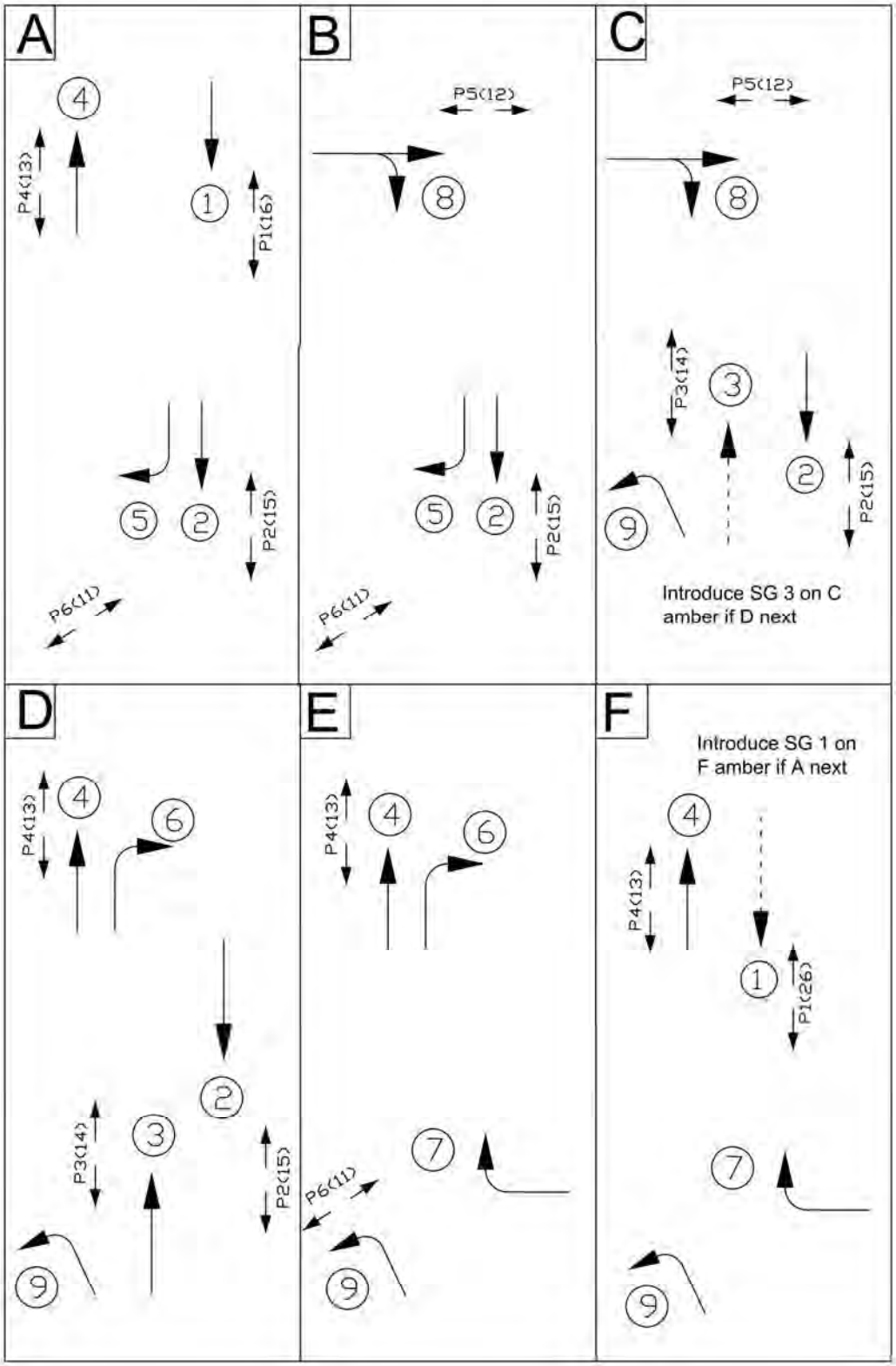


Design with community in mind

Appendix B

Example of Standard Interchange Phasing used in the Auckland Region


A
B
C
D
E
F
P4(13)
P1(16)
P5(12)
P3(14)
P2(15)
P6(11)
P1(26)
Introduce SG 3 on C
amber if D next
Introduce SG 1 on
F amber if A next