UNDERSTANDING THAT A MERGE IS LIKE AN OLD CAR, EVENTUALLY IT WILL BREAKDOWN

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ABSTRACT
Prior to the 4-laning there were delays to northbound traffic (our customers) on State Highway 1 outside Christchurch International Airport during the evening peak periods. These delays were of concern to us, in regards to keeping Christchurch moving. Observations were made on several occasions to understand and identify the issue; the northbound slip lane and merge from McLeans Island Road.

Knowledge of merge capacities is limited, however based on empirical data it is believed to be around 1200-1400 vehicles per hour before flow begins to breakdown. In addition, current theory does not align with observations therefore there is no robust method of assessing solutions to benefit our customers. An ingenious solution was trialled during a PM peak period (4-6pm) which involved closing McLeans Island Road and detouring traffic in order to close the merge.

The trial was an opportunity to learn how mergers operate, how mergers impact our customers during high traffic flow and to observe the effects of a proposed long-term closure of a merge during the 4-laning construction.

A simple, yet effective solution trialled resulted in some unforeseen and interesting problems, off the State Highway, leading us to advance our understanding of traffic behaviour and patterns. This exercise also enabled us to understand opportunities for making better use of existing infrastructure to benefit the State Highway users.
INTRODUCTION
An efficiency trial was conducted by the Transport Agency to identify the cause of the delays experienced by road users on the Western Corridor, State Highway One (SH1) outside Christchurch International Airport. The 2012 northbound traffic in the PM peak period (4-6pm) between the Harewood Road and Sawyers Arms Road roundabouts was of particular interest. Over this section of State Highway, two merges are located in close proximity to one another, either side of Mcleans Island Road, the Harewood Road roundabout merge and the Mcleans Island Road merge. Traffic here is regularly delayed and congestion occurs along the Western Corridor. A simple solution to improve the traffic flow along SH1 was trialled.

This paper discusses the problem in 2012, the background behind the trial and the results and lessons learned during the exercise.

Site Description
The Western Corridor (SH1) between the Memorial Avenue and Sawyers Arms Road roundabouts is 3.2km long and in 2012 was a single-lane carriageway with a posted speed limit of 80kph. This section incorporates four dual-lane roundabouts and a priority controlled T-intersection with Mcleans Island Road.

It is worth noting that the Western Corridor is part of the Christchurch Roads of National Significance project. The Western Corridor will be a 4-lane highway (two lanes in each direction) with a median; selected main road intersections will also be grade separated and/or improved. Several sections of the Western Corridor have been completed or are under construction.

The merge north of Mcleans Island Road is geometrically and functionally different to the merges following each of the roundabouts; the roundabout merges consist of two lanes of equal length and approximate equal volume departing each roundabout. The merges range from 70m (Harewood Road roundabout) to 100m (Memorial Avenue roundabout) long. The merge north of Mcleans Island Road is a 300m long free flow slip lane for left turning traffic exiting Mcleans Island Road. Figure 2 shows the characteristics of the Mcleans Island Road merge. These traffic volumes were manually collected prior to the trial in October 2012.
A proportion of the traffic that uses Mcleans Island Road (minor arterial) during the PM peak period (4-6pm) is made up of vehicles bypassing SH1 through Hornby and past Christchurch International Airport, as shown in Figure 1 (dotted line).

PROBLEM

A merge can be regarded as a source of conflict, congestion and bottlenecks which can create delays. These issues occurred frequently along SH1 between the Memorial Avenue and Sawyers Arms Road roundabouts during the PM peak period (4-6pm) when traffic volumes were at their greatest. Driving through the site on several occasions during the PM peak period (4-6pm) confirmed that something unusual was occurring at the intersection of Mcleans Island Road with SH1 where the northbound slip lane merges with the State Highway.

Traffic counts in September and October 2012 indicated that the volume of traffic exiting left out of Mcleans Island Road, $V_B$ and combined with the traffic heading north on SH1, $V_A$ are in excess of an empirically derived merge capacity of between 1200 and 1400vph. Figure 3 below shows speed and volume data collected from a traffic monitoring site managed by the Transport Agency between Harewood Road roundabout and Mcleans Island Road in September 2012. The data shows that as the volume increases past 1200 to 1300vph, the flow begins to breakdown and speeds begin to drop substantially. The flow does not begin to recover until traffic volumes have dropped below 1300vph at 5:30pm, even though the volume of traffic began to decrease 45 minutes earlier. This supports the empirically derived merge capacity figure of 1200 to 1400vph.

The high volume of traffic caused the merge at Mcleans Island Road to breakdown. This resulted in delays to northbound traffic, queuing of vehicles (which extended south through to the Harewood Road and Wairakei Road roundabouts) and caused reverse priority at the Mcleans Island Road intersection to occur. Reverse priority is where through traffic slows and stops to let right-turning traffic turn in and out of Mcleans Island Road, this results in a vicious and compounding cycle.
Speed Data Collection

Speed data was collected using two cars continuously driving during the PM peak period (4-6 pm) each with a GPS unit. Data were collected on three routes. These routes are described below and shown in Figure 1.

- **Route A.** Northbound, SH1 from the Memorial Avenue to Sawyers Arms Road roundabouts;
- **Route B.** Northbound via merge from Mcleans Island Road to Wilkinsons Road; and
- **Route C.** Northbound via Logistics Drive from Mcleans Island Road to Wilkinsons Road.

The average northbound speed from the Memorial Avenue roundabout to north of Sawyers Arms Road roundabout (Route A and beyond) was calculated. This is shown as the dark lines in Figure 4. It is clear from Figure 4 that the average speed during this time was significantly lower than the 80kph posted speed limit. The source of the problem is the Mcleans Island Road merge. From here speeds start to increase at a constant rate. The effects of this merge are far and wide as northbound traffic over 1km south were affected, such as queuing and reduced speeds at the Wairakei Road roundabout.

**THE TRIAL**

The Transport Agency conducted an efficiency trial at the Mcleans Island Road intersection a single PM peak period (4-6pm) in the first week of October 2012.

**Objectives**

The first objective of the trial was to confirm the source of the delays and understand the implications on road users. The second objective was to find a solution to minimise and/or eliminate the delays to road users. The efficiency trial was also an opportunity to assess the possible effects of closing the Mcleans Island Road intersection temporarily during the Western Corridor 4-laning construction of SH1 between the Harewood Road and Sawyers Arms Road roundabouts.

**Methodology**

A number of factors had to be considered to determine the most practicable solution. This included the knowledge that Mcleans Island Road, between SH1 and Logistics Drive would be temporarily closed during the Western Corridor 4-laning construction.

Mcleans Island Road was partially closed during a single PM peak period (4-6pm). Northbound road users on SH1 had to be oblivious to what was going on. This was achieved by minimising the amount of Temporary Traffic Management (TTM) on SH1, this included both signs and road cones. The left-turn into Mcleans Island Road from the south remained in use to minimise TTM. Traffic turning right into Mcleans Island Road from the north was discouraged via the use of TTM (though not prevented). Traffic departing Mcleans Island Road (350vph left and 60vph right) were detoured onto Logistics Drive (local access road) and accessed SH1 via the Sawyers Arms Road roundabout.

This solution was the safest, easiest and cheapest option to implement. This trial was old fashioned and very effective. The source of delays (the merge) was removed and northbound SH1 traffic was in no way influenced by TTM. Other options such as ramp metering and the banning of right turns were also considered. Ramp metering technology is not currently used in Christchurch, temporarily installing could create driver confusion and frustration. These options would not achieve the desired objectives. Road users would have likely become distracted and confused, causing them to slow.

Traffic count data were collected in the weeks prior, and during the week of the trial. This was to observe any variation in traffic volumes that might have been a cause of traffic delays and to see if any relationships existed to further our understanding of merge capacities.

**RESULTS**

Average northbound travel speeds were plotted against distance travelled from Memorial Avenue.
before and during the trial where Mcleans Island Road merge was open and closed respectively. This is shown in **Figure 4**. Route B is plotted from where it joins the State Highway at Mcleans Island Road and Route C is plotted from where it also joins the State Highway at the Sawyers Arms Road roundabout.

Prior to the trial, travel speeds on SH1 between the Wairakei Road and Sawyers Arms Road roundabouts were generally below 40kph. Not until after the merge, did average speeds begin to increase (dark lines in **Figure 4**). During the trial where the Mcleans Island Road merge was closed, speeds of over 60kph were recorded (light line in **Figure 4**).

![Figure 4: Comparison of northbound speeds on the State Highway](image)

Over 1600vph were recorded to be travelling northbound between the Harewood Road roundabout and Mcleans Island Road during the trial. This was 200vph higher than prior to the trial and well above the theoretical merge capacity of 1200 to 1400vph.

Travel times between the Memorial Avenue and Sawyers Arms Road roundabouts were also calculated. The average travel time prior to the trial when Mcleans Island Road was open was 325 seconds. This decreased to 201 seconds during the trial when the Mcleans Island Road merge was closed. On average, this equates to a decrease in travel time of 124 seconds for northbound traffic on SH1 between the Memorial Avenue and Sawyers Arms Road roundabouts.

Detoured local road users on Logistics Drive experienced on average, an additional 222 seconds travel time when using the detour (Route C) along Logistics Drive compared to previously using Route B. The average speed recorded along Logistics Drive (Route C) was 20kph.

**DISCUSSION**

A 124 second decrease in travel time for northbound SH1 road users equates to 55.1 hours of travel time saved during the PM peak hour. Similarly, a 222 second increase in travel time for local road users who were detoured via Logistics Drive due to Mcleans Island Road being closed created an additional 25.3 hours of travel time. The benefits to the State Highway significantly outweighed the dis-benefits to local road users. A total of 29.8 hours of travel time was saved during the PM peak hour.

The delays prior to the trial are partially redistributed to the local road network during the trial. Over
a prolonged trial period, it is likely that a proportion of traffic using Mcleans Island Road to bypass SH1 through Hornby and past Christchurch International Airport would revert back to using the State Highway, increasing the volume of traffic on SH1. This would reduce the delays on the local road network and detour route. Southbound traffic on SH1 was not affected on any occasion.

Interestingly, travel speeds immediately north of the Sawyers Arms Road roundabout were negatively affected by the trial. This may have been due to the change in traffic patterns at the Sawyers Arms Road roundabout. A traffic count was not conducted here during the trial and so no estimate of the negative effect can be made.

Data was recollected in August 2013 during the 4-laning construction whilst the Mcleans Island Road merge was closed and again once the merge had reopened. This was done to observe if the effect was less as road users became more familiar with the new road layout. The changes were minimal and only a slight increase in speed was noted. Traffic was still queuing along Logistics Drive when the Mcleans Island Road merge was closed. Traffic volumes using the detoured route along Logistics Drive however was however slightly less than the 410vph in October 2012.

Lessons Learned
The merge following the Harewood Road roundabout on the day of the trial carried over 1600 vph, this is greater than the empirically derived 1200-1400vph figure. This demonstrates that different merges (geometry, merge type, and volume of traffic per lane) have different capacities. The Highway Capacity Manual states that the capacity of a merge is controlled by the downstream lane capacity. By closing Mcleans Island Road, side-friction was removed which increased lane capacity downstream of the Harewood Road roundabout merge.

The trial was also an opportunity to assess the effects of the 4-laning of SH1 between the Harewood Road and Sawyers Arms Road roundabouts, which is now complete. This allowed the Transport Agency to prepare and plan construction and to inform the public of delays.

Logistics Drive was an oversight and as a result, the priority controlled intersections at either end caused significant delays. Care is required when traffic is detoured onto local access roads. The post earthquake environment in Christchurch however, has allowed TTM measures like this to occur. Each intersection was signposted more effectively during the 4-laning construction to help minimise the delays on Logistics Drive.

CONCLUSION
Conclusive evidence was collected and showed that a merge can easily breakdown- like an old car. This depends on the location, type of merge or high traffic volumes. Closing a merge (or in this case, restricting departing movements from Mcleans Island Road) significantly improved the average speed of northbound traffic on SH1 outside Christchurch International Airport.

A number of lessons were learned throughout the trial and subsequent data collection periods. These included greater knowledge of merge capacities, as the Harewood Road roundabout merge handled over 1600vph on the day of the trial and to look at the wider picture. Closing Mcleans Island Road had a significant negative effect on the detoured road users along Logistics Drive, as they encountered an additional 220 seconds of travel time. This suggests merges are influenced by a number of factors and can have a wide impact on the surrounding area.

REFERENCES

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