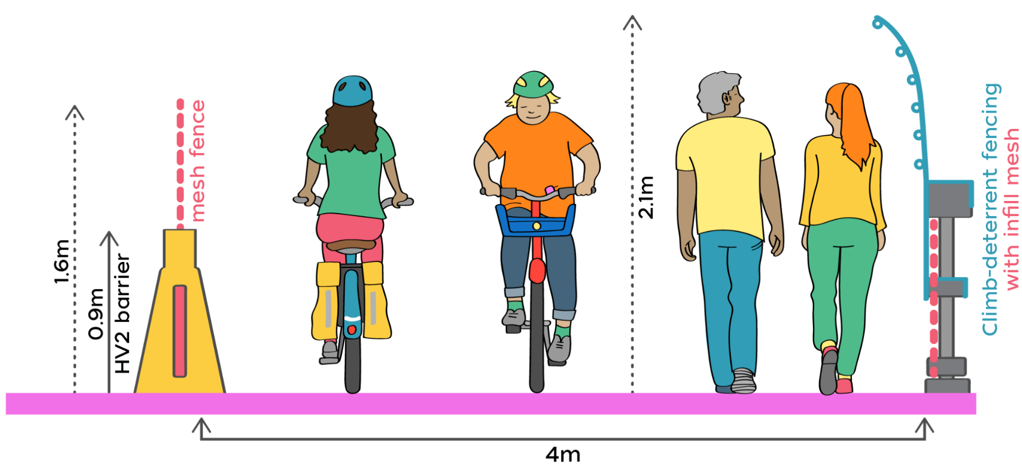
Liberating the Lane, an assessment

Overview

Bike Auckland commissioned SmartSense Ltd to investigate the feasibility of liberating a lane on the Auckland Harbour Bridge for active mobility - walking, cycling and other personal mobility options. The resulting report concludes that:

- There is **existing capacity on the Harbour Bridge** to support a lane permanently being used for active modes without significantly impacting on motor traffic
- A **safe design** would include:
    - A shared path for active modes located on the most easterly clip-on lane. The east side provides for better protection from wind (predominantly Westerlies), easy access on and off the bridge, and stunning views of the harbour and city
    - The use of free-standing HV2 Steel/Concrete composite barriers with mesh fence between the shared path and the motor traffic. This is a relatively lightweight barrier which Waka Kotahi has already approved the use of in Aotearoa NZ
    - An anti-climb barrier along the eastern edge of the bridge for suicide prevention, as has been effective on comparable bridges overseas
    - Potential for a 4metre shared path width which is within the Austroads guidance for gradient (5%) and width with the expected usage
    - Potential for dampers to be placed between the bridge and the clip-on (to prevent movement caused when a significant number of pedestrians march across at the same time)
    - Potential for a 60km/h speed limit for the motor-traffic in the lane adjacent to the shared path for additional safety if considered required



We consider that a cross-section similar to the image above would be a pragmatic, cost effective, and realistic design for an Auckland Harbour Bridge Shared Path.

- Based on data from Waka Kotahi, weather conditions on the bridge appear suitable for walking and cycling for 98% of the year. The shared path would be affected by adverse weather conditions approximately 3 - 7 days per year, similar to other road users.

Artist's impression of a shared path over the Auckland Harbour Bridge

SmartSense Ltd. estimates that access for walking and cycling across the Auckland Harbour Bridge could be delivered within 8 months for under 30 million dollars.

Bike Auckland notes that this is both affordable and can be rapidly delivered, and is a vital equitable solution for transport choice and emissions reduction in Tāmaki Makaurau, Auckland.

Not included in Waka Kotahi's assessment are the following benefits;

★ Empowers people to choose climate-friendly travel resulting in emissions reductions
★ More transport choice for people who don't drive
★ Saves people money
★ Creates a more resilient transport system
★ Delivers greater health and wellbeing from active travel
★ Greater independence, especially for children
★ Culturally significant crossing
★ Fun to cross and with great views for locals and visitors alike!
★ Potential to relieve congestion across the transport network as people switch to walking, cycling, and public transport

Note: Bike Auckland commissioned SmartSense Ltd. to create the following two reports, but for simplicity we are referring to them as one report. They are included in this PDF as follows:

1. Assessment of Waka Kotahi Safety Concerns Related to Active Mode Provision (on the Auckland Harbour Bridge)
2. Report on Traffic Flows on Auckland Harbour Bridge 2013-2023

Auckland Harbour Bridge

Assessment of Waka Kotahi Safety Concerns related to Active Mode provision

June 2023

Prepared for Bike Auckland

SmartSense
people driven intelligence

Contents

Auckland Harbour Bridge - Assessment of Waka Kotahi Safety Concerns related to Active Mode provision.

Executive Summary

The Auckland Harbour Bridge and approach viaducts (all referred to as the **AHB**) currently carries State Highway 1 across the Waitemata Harbour between Sulphur Beach (North Shore) and Westhaven (Downtown Auckland), an overall distance of 1.6km. To provide for marine clearance below, the AHB rises to 44m above High Water level at a maximum gradient of 5% (1:20) which extends approximately 500m on the northern side and 700m on the southern side.

Waka Kotahi has undertaken numerous assessments of many different active mode (**Active Mode**) options. Waka Kotahi appears currently reluctant to see any Active Mode trial on the AHB and it has stated that any one-off Active Mode events should not be seen to:

> *'..set an expectation that further consideration will be given to providing live lane access' or '..set unrealistic expectations around the likelihood of a dedicated lane becoming available in the short term.*[1]

Against this backdrop, Bike Auckland commissioned SmartSense Ltd to undertake two assessments.

The first report relates to the actual traffic flow volumes and the capacity of the AHB to carry known flows from 2013-2023. This assessment indicates that since 2016 peak traffic volumes have been reducing and that the conversion of a single traffic lane to Active Modes can be accommodated with very limited effects on recorded traffic levels.

Ongoing traffic flow trends both pre-COVID (prior to March 2020) and since then continue to support this conclusion. These findings were shared with Waka Kotahi which indicated that traffic flows were not the key reason why Waka Kotahi was not pursuing Active Mode provision on the AHB. Its stated concerns related to safety.[2]

The second commission from Bike Auckland is this report which undertakes an assessment of the safety concerns that Waka Kotahi has raised relating to motorised traffic sharing the bridge with Active Modes.[3]

It appears that Waka Kotahi has made particularly conservative assumptions (to the point of being unreasonable) about the likelihood and consequences of many of the safety risks associated with using a lane of the AHB for Active Modes. The inclusion of people walking and cycling on the bridge does present different risks to driving trucks, buses and cars. However, Waka Kotahi appear to have taken a pre-determined approach to raise risks that are not considered significant on other projects

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[1] Waka Kotahi Investment and Delivery Paper – Auckland Harbour Bridge Walking and Cycling Event 23/11/21released under OIA 9248

[2] Meeting between SmartSense's R Young and Waka Kotahi representatives D Hume. A Hooper, M Beamish, 27/5/22 2022.

[3] Active Modes taken as being people walking, running, in wheelchairs, on cycles, scooters and other micro-mobility devices etc).

with longer and steeper shared paths, potentially overstated the risk of wind and have ignored the human factors and human interventions that could significantly reduce those risks to very acceptable levels of likelihood and consequence. SmartSense assesses the residual risk to Active Modes on the bridge to be far lower than Waka Kotahi's apparently overly pessimistic and simplistic conclusions.

The dynamic behaviour of the bridge under mass pedestrian events was recently flagged by Waka Kotahi as a significant safety issue preventing a Shared Path trial. Whilst there is evidence (including video) that the clip-on does sway when large numbers of people walk on it, a relatively simple mitigation solution was designed thirteen years ago -but never progressed. The single lane Shared Path long term trial proposed is unlikely to be utilised by the volume of people attending a mass participation event, so is far less likely to generate the sway, and the only area where there may be a crushing risk (between original bridge and clip-on bridge) is remote from the Shared Path. There are several active mitigation options to manage pedestrian numbers and therefore this issue is not considered to be a fundamental reason to delay any Shared Path trial.

SmartSense concludes that there are practical, cost effective, and realistic mitigations to address Waka Kotahi's safety concerns. Rather than Waka Kotahi continue to resist all reasonable attempts to enable Active Modes on the AHB, we recommend that it proactively and collaboratively engages with Bike Auckland and others to rapidly deliver a twelve month monitored trial of a single lane Shared Path on the Auckland Harbour Bridge for Active Modes.

Active Mode Option to be Assessed

Based on our first commission from Bike Auckland[4], the only Active Mode option considered viable is the conversion of a single southbound traffic lane on the eastern clip-on to be a shared path (**Shared Path**).

This report focuses on assessing the stated safety concerns for that single lane option. This is generally referred to in Waka Kotahi documents as 'Option 3', the long term (permanent) reallocation of the most easterly clip-on lane from traffic to Active Modes. The other options that Waka Kotahi has identified are dismissed as unrealistic or overly disruptive.

Option 3 appears to be the most practical and attractive for the following reasons:

1. Single (4m) lane conversion from road traffic to Active Modes has a small and manageable impact on traffic flows. (Figure 1). The 4m path width has been retained for this analysis as this corresponds directly with Waka Kotahi Option 3. Whilst it may be possible to widen the path (to 4.5m) this would move the traffic lane further across the bridge deck and we are not able to assess if this is structurally feasible to achieve.
2. The 4m path could also serve as an emergency vehicle access lane (Figure 2)[5]
3. Waka Kotahi provided drawings show (Figure 3) the bridge gradient to be 5% and an original design report (1951 Figure 4) also references a 1 in 20 gradient on both sides.

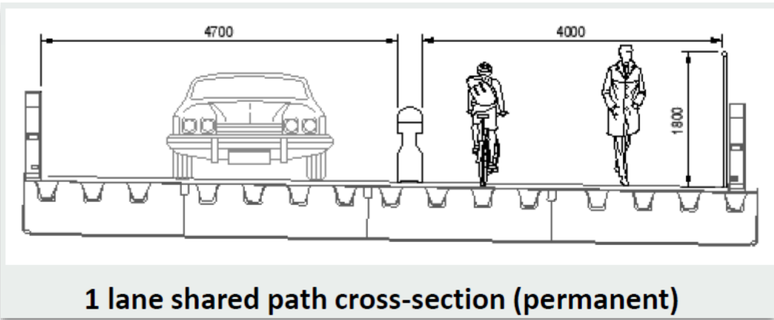


Figure 1 Waka Kotahi's 'Option 3' cross-section

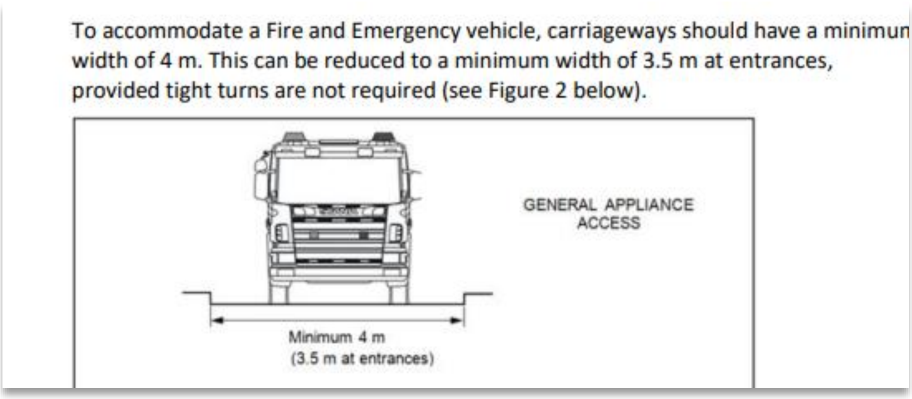


Figure 2 Emergency Access width for NZ Fire Service

[4] SmartSense Report on traffic volumes and capacity 2022.

[5] 4m is also the minimum recommended access width for a fire truck (F5-02-GD-FFO Emergency Vehicle-Access)

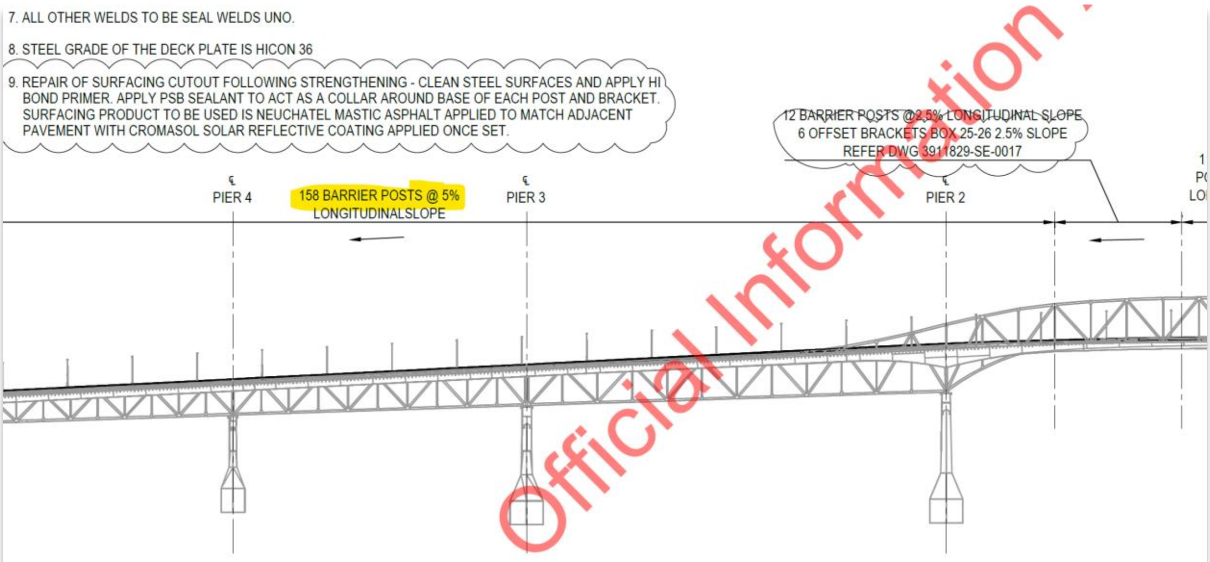


Figure 3 Waka Kotahi elevation of bridge showing 5% gradient (Northern end the same)

ALIGNMENT AND GRADIENTS

17. We have altered slightly the alignment recommended by the Royal Commission, so as to give better access to the south approach and to facilitate the possible future construction of a railway bridge, as explained in our letter to the Commissioner of Works dated 14.2.50, and approved by him in his letter to us of 14.3.50. The alignment proposed by the Royal Commission and the one recommended by us are shown on Drawing 1.

18. The road gradient of 1 in 20 on both sides of the navigation span and a vertical curve 800 ft. long over the main span are in conformity with modern standards for high speed motor traffic, and were approved by the Commissioner of Works in his letter of 3.2.50. A vertical transition curve of 4,000 ft. radius is proposed between chainages 1365 and 1565 on the South approach.

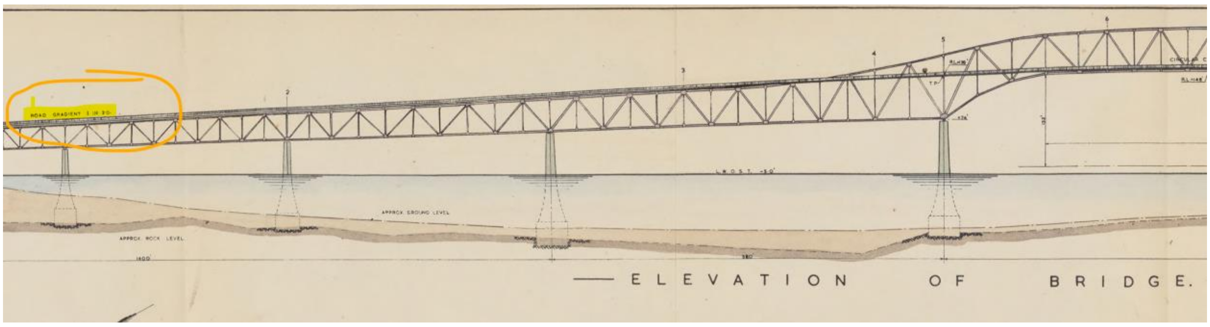


Figure 4 Extract from Auckland Harbour Bridge, Report by Freeman, Fox and Partners. March 1951 (ref b1865712 Auckland Libraries)

4. If required, it allows for five lanes of northbound traffic on the AHB.
5. The access / egress locations are relatively straightforward.
    a. Sulphur Beach (North Shore) has existing subway and road access under SH1 (Figure 5).
    b. Westhaven (Downtown Auckland) (Figure 6)

Figure 5 Sulphur Beach access to Active Mode path, under bridge (left) and through subway (right)

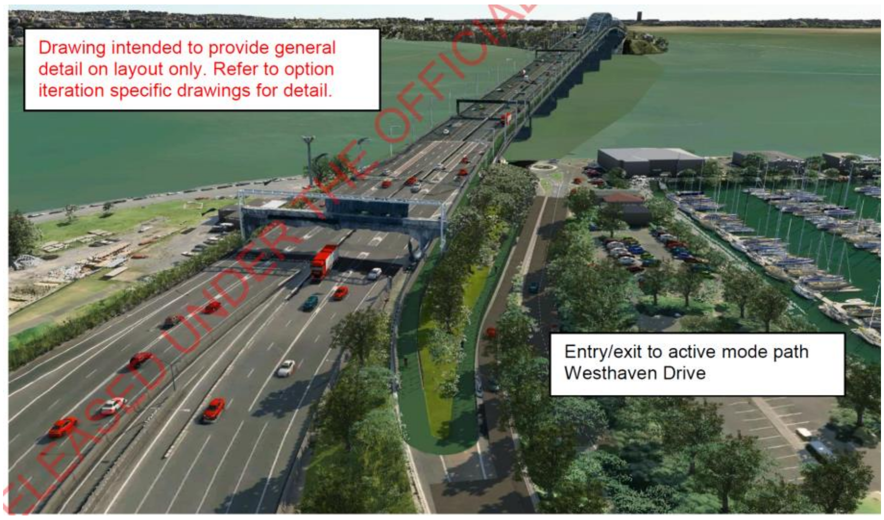


Figure 6 Westhaven Drive Access/ Egress. Local road realigned / repurposed Shelly Beach Rd off ramp may need to be closed.

6. Eastern location of Active Mode path provides a higher level of weather protection from prevailing westerly weather.
7. Eastern location of Active Mode path provides a clearer view of the wider Waitemata Harbour and Downtown Auckland than the west so is preferable from an aesthetic perspective.

On the basis of the above advantages Option 3 is the one that Smartsense considers is most practical and this report focuses solely on the safety concerns that Waka Kotahi have raised that relate to Option 3.

Suicide Prevention

Outer edge of Clip-On

Waka Kotahi has identified that the AHB is currently used by people for suicide attempts and any increase in access to the bridge is likely to increase these attempts.

Waka Kotahi has already designed[6] what it considers to be a highly effective suicide prevention barrier solution for the AHB; but to date it has chosen not to install it, and so that risk remains unmitigated. Their existing scheme draws heavily on large and high (3.2m, Figure 7) close spaced mesh to prevent people who exit a vehicle from climbing over the outer edges of the clip-ons.

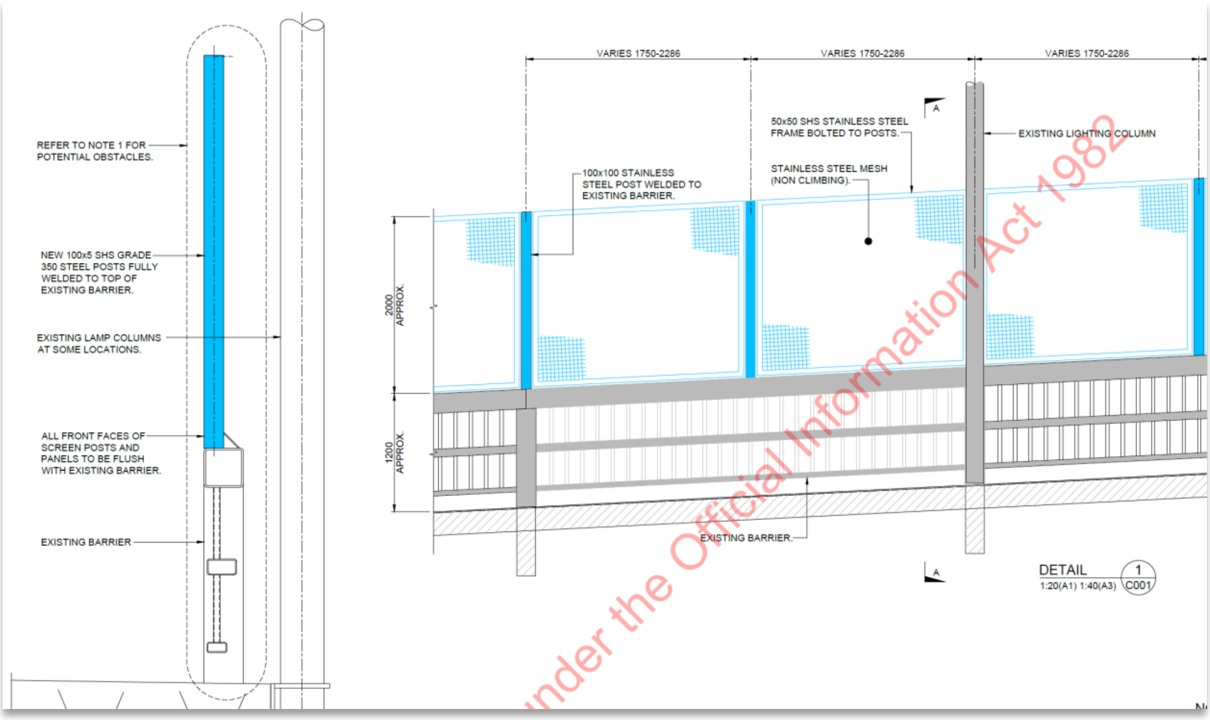


Figure 7 Schematic view of proposed Security Screen for Auckland Harbour Bridge

Subsequent structural assessments of the proposed scheme [7] range from this design being ‘insignificant in some locations’ to ‘..feasible, with possible local strengthening..’ in others. A budget of under $13M was (in 2019) identified as being sufficient for this barrier on one side of the bridge.

Whilst this may be an appropriate solution for a high-speed highway it is considered that the height and appearance would effectively block any meaningful view of the city and would therefore be far from satisfactory for a successful and enjoyable Active Mode solution. The anti-climb designs that Waka Kotahi have provided for an Active Mode solution are significantly lower (1.6-1.8m) and do appear more in keeping with the scale and potential risk.

It is recognised that there are numerous other highway and other structures around Auckland that can, and have, been utilised for suicide attempts; so whilst there is obvious merit in providing a level

[6] Suicide Prevention Barrier Feasibility Study Report 18_19 SH1N BSN 4232 Auckland Harbour Bridge 383545-18_19-BR-SH1-4232-RP-FS-001-REV_F1, May 2019 released under OIA 9593.

[7] AHB Protection Screen Structural Feasibility Study NZTA Memo 30/4/20 released under OIA 9593.

of anti-climb on the AHB Active Mode lane there is no absolute requirement to prevent determined and deliberate climb/ jump activities.

The case studies that Waka Kotahi drew on for assessing anti-climb systems were limited. There are numerous other less intrusive examples of anti-climb on high-profile bridges. Of note is the 412m long, 101m high Clifton Suspension Bridge in Bristol, UK (Figure 8). This 200+ year old structure has had a long history of suicides and has deployed a range of measures to minimise the likelihood and success of suicide attempts. In 1998, a 1.9m high anti-climb barrier was added (Figure 9).

Figure 8 Clifton Suspension Bridge - Bristol, UK, 101m above River Avon.

Figure 9 1998 anti-climb barriers on Clifton Suspension Bridge (1.9m height)

Research from the UK[8] indicated that this barrier halved the number of suicide deaths at the bridge from eight to four with little evidence to suggest that people used alternative suicide locations.

[8] Effect of barriers on the Clifton suspension bridge, England, on local patterns of suicide: implications for prevention, The British Journal of Psychiatry, Cambridge University Press, January 2018.

The Clifton Suspension Bridge (Figure 9) also includes some 'soft' approaches that the Clifton Suspension Bridge Trust has taken to deter and prevent potential suicide attempts. In addition to the fence in the image there are:

- Free helpline phones located at either end;
- Signs promoting counselling services;
- A minimum of two staff trained to deal with people contemplating suicide;
- Live CCTV monitoring with night time staff alarms; and
- A quiet room for people in distress to use whilst waiting for emergency services.

These soft measures are combined with the visually unobtrusive anti-climb barrier to a height of 1.9m [9] above the walkway. The use of horizontal wire stands reduces the visual impact from the shore, minimises degradation of view from the bridge and adds minimal wind loading, whilst providing an appropriate level of deterrence to anyone seeking to climb over.

Overall, we consider that the provision of an anti-climb barrier on the eastern edge of the AHB clip-on can be provided in a relatively unobtrusive manner so that it does not detract from the visual appearance of the AHB or views from the Shared Path. Waka Kotahi have already assessed the higher (3.2m) and more substantial barrier as being feasible (at $13M per side) therefore a lower less obtrusive 2.1m high barrier would appear to also be viable, provide a reasonable suicide deterrent and be a cost-effective solution. The provision of any higher barrier will be an improvement on the existing edge protection.

Shared Path to Road Traffic Barrier

There is an inherent risk anywhere on Waka Kotahi's road network of people climbing over a Shared Path/Traffic barrier (Figure 1) to enter a traffic lane. There should be some degree of anti-climb deterrent barrier between the Shared Path and Traffic lanes; but this should be consistent with the remainder of the motorway network.

For instance, the barrier preventing access onto the southbound approach to the AHB, at Sulphur Beach is a low ±1m fence and outside the ASM Annex / Police Station there are large, fully open grassed areas where anyone can walk directly onto the motorway (Figure 10).

Figure 10 Low fence and direct access onto SH1 at Sulphur Beach

[9] Letter from Clifton Suspension Bridge Trust to Bristol Coroner' Court 11/2/2019.

Loading of Active Lane

The assessment of the effect of a Shared Path on the structural capacity of the AHB is beyond the scope of this report as it would require highly specialist input and analysis. However, several Waka Kotahi documents have been made available that do provide a reasonable insight into the potential issues.

Additional Barriers

From the material provided by Waka Kotahi there is an underlying requirement that the barrier between the Active Mode lane (Lane 1 of the south bound clip-on) and the southbound clip-on traffic lane (Lane 2) would need to be freestanding. It is understood that this requirement is to prevent any barrier anchorages applying localised horizontal loads to the clip-on decks.

The assessment undertaken by Waka Kotahi[10] assumed a barrier deadweight of 715kg/m length (SRTS Barrier) with Option 3 flagged as being 'Overloaded*' (the * is not explained) and a proposed restriction on buses and heavy vehicles required to prevent the live load capacity being exceeded.

This Waka Kotahi assessment appears to be reliant on using the same movable concrete barrier used on the central span on the clip-ons. Other material also provided in the OIA indicates there is a lighter and equally suitable free-standing alternate. The HV2 (MASH TL-4) barrier has a linear mass of 360kg/m close to half the mass used in Waka Kotahi's assessment. This barrier was approved for use on New Zealand roads by Waka Kotahi in May 2019 [11].

There is no evidence that Waka Kotahi have performed a detailed loading assessment and analysis based on this lighter HV2 barrier. Additionally, Waka Kotahi do not provide any information on load factors applied to the extra barriers. These would be known fixed masses so could be considered as dead loads and have a significantly lower load factor applied than a more uncertain live load.

The removal of traffic live load from the outer lane on the clip-on would significantly reduce the eccentricity of the load and should have a beneficial impact on overall bridge loading and fatigue performance.

Waka Kotahi (OIA 9736) have separately advised that there is not expected to be any fatigue related issues related to increases in vehicle mass limits since 2009. It appears unlikely therefore that removing vehicles from the outer lane of the clip-on (longest cantilever) would be detrimental to the safety and longevity of the AHB. This is contrary to several statements made by Waka Kotahi about the structural capacity of the AHB being compromised and the bridge's life shortened should an outer clip-on be used for Active Modes.

Dynamic behaviour of bridge under pedestrian loading

During a media event to announce the advancement of options for a second harbour crossing (April 2023) Waka Kotahi's CEO publicly expressed concerns to Bike Auckland staff about the dynamic behaviour of the AHB under active mode loads that would limit its ability to safely cater for any active mode usage.[12]

This was obviously a matter of serious concern as until that time no meaningful information had been seen in any published Waka Kotahi material that related to the bridges' dynamic behaviour

[10] 04.AHB WC Options Structural Review Memo Draft Redacted .

[11] Product Acceptance – HV2 Steel & Concrete Hybrid Temporary Road Safety Barrier System, Letter from NZTA (J Hughes) 3/5/2019 to CSP Pacific Ltd.

[12] Discussions between Nicole Rosie (WK CEO) and Bike Auckland staff in the presence of media.

affecting its ability to be used by active modes. As a result of this statement an Official Information Request[13] was lodged on behalf of Bike Auckland and a response provided in late May 2023. Some clarifications on the material issued has been sought and this section will be updated if that material changes our understanding of the issue.

The OIA response indicated that lateral movements of up to 50mm had occurred during previous unplanned mass-pedestrian (protest) events on the clip-on spans. These movements were generated by large numbers of people subconsciously walking in step and inducing a degree of resonance in the bridge. This is a relatively well-documented effect on certain bridges (Synchronous Lateral Excitation) and in 2010 Waka Kotahi's advisors[14] calculated the likely movement and proposed some relatively straightforward measures to mitigate the effect.

Most significantly, the reports released under the OIA identify that the movement was only likely to occur at high pedestrian loads across both lanes of the clip-on and that the observed lateral movement (Figure 11, Figure 12) is between lane 2-3 or 6-7, the boundary of the clip-on to the original centre-spans (the bridges are not structurally connected). This was observed to occur on an (undated) video film when both clip-on lanes were used for an un-authorised pedestrian event and only on some of the viaduct spans.

Other information released in the OIA confirmed that whilst the dynamic movement posed a comfort risk to pedestrians on the bridge (lateral accelerations exceeding code) and a significant crushing risk should anything be placed into the opening and closing gap. However it was noted that the movement of the bridge did cause any structural damage nor was likely to affect the long-term life of the structure.

As Option 3 (Active lane in 'Lane 1[15]') does not permit pedestrians into the zone between the clip-on and the original structure (between Lanes 2-3), so there is no risk to Active Lane users coming close to the opening/closing gap. Also, this lateral movement was only associated with large numbers of people walking; there is no evidence that wheeled traffic generates such movements.

[13] OIA 12397 responded to by Waka Kotahi 29/5/23.
[14] OIA 12397 Attachment 1
[15] Counting southbound from the left

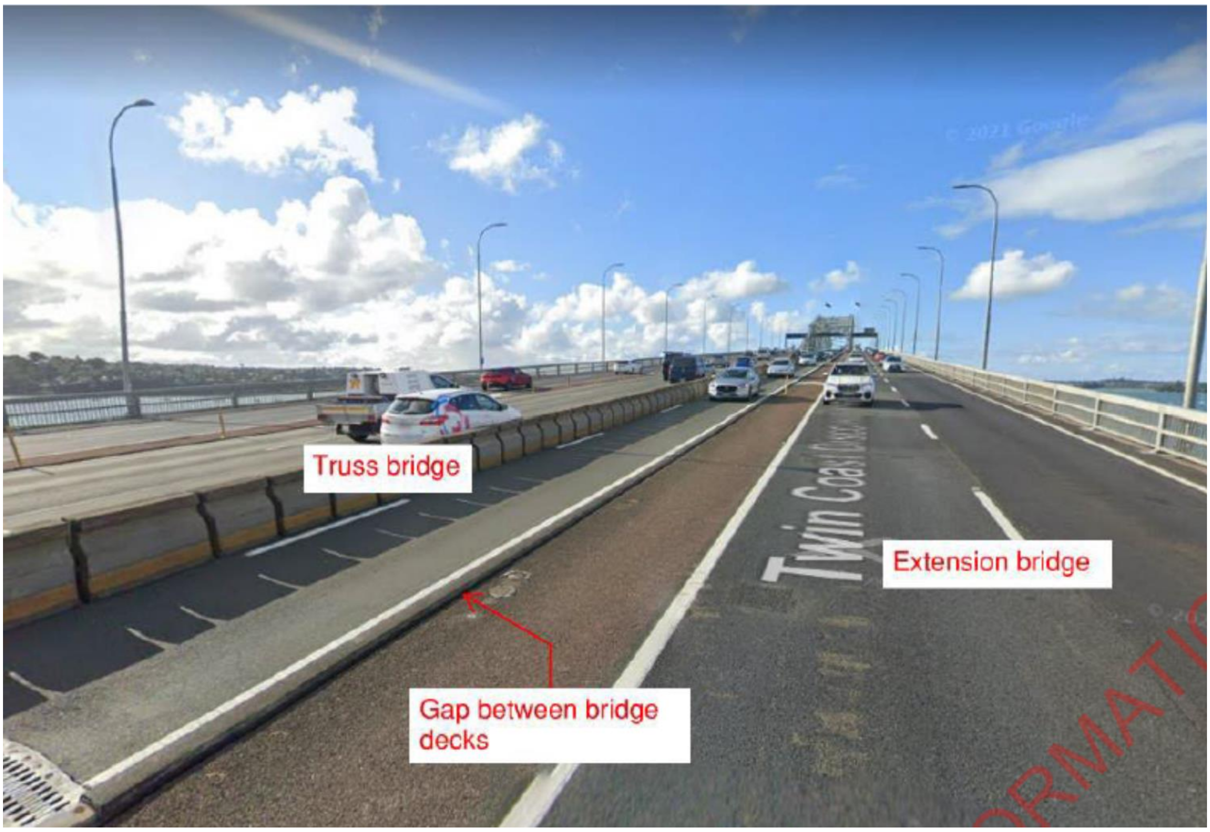


Figure 11 OIA 12397 Attachment 5 - location of joint observed to move under pedestrian loading

Figure 12 a ±50mm gap opening (left) and closing (right) on longitudinal joint between clip-on and main span. OIA 12397

In it's current (un-damped) condition the OIA attachments refer to limiting pedestrian loadings on the bridge to 250 people per span on three of the approach spans (Figure 13) but not the main centre span. The longest of these spans is 255m (Span 1) so this equates to 1 person every linear metre of the bridge.

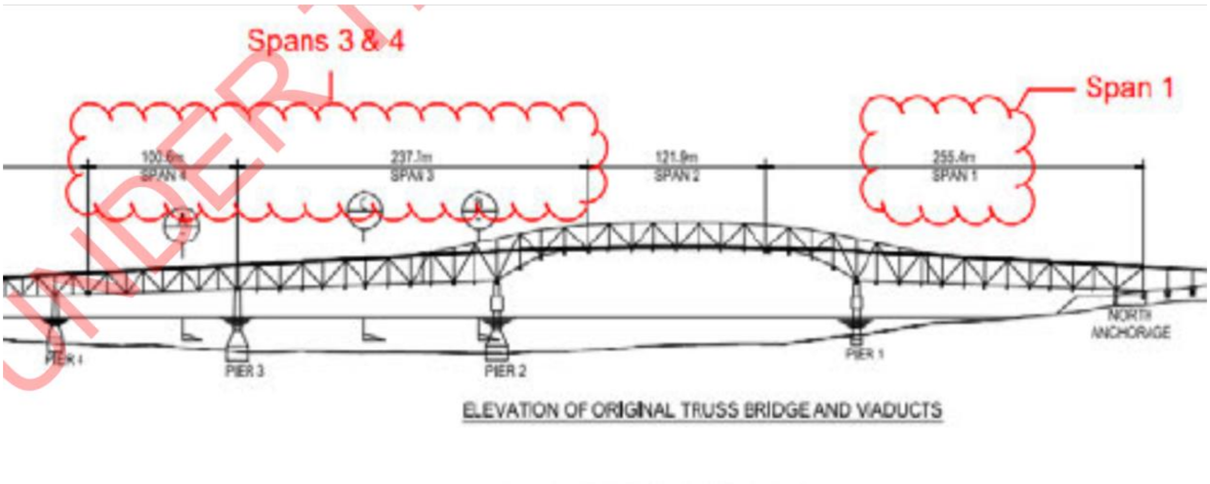


Figure 13 Spans 1, 3 & 4 identified for limiting pedestrian numbers

With a bridge length of 1,600m this would imply that if the pedestrian numbers were controlled that at least 1,600 people (evenly distributed) at any one time could walk across with no dynamic movements being triggered. Based on published estimates of daily usage this value of 1,600 exceeds the initial daily projection of pedestrian numbers. Therefore, the possibility that lateral movements could be generated on a routine day (commuting weekday) with a single walking and cycling lane are low.

To provide mitigation, real time people tracking and counting technology, combined with active (human) bridge wardens, a PA system on the active path (similar to that used in the Homer Tunnel on SH94) and remote control barriers to physically close the Shared Path path are all relatively simple measures that can monitor and if needed control pedestrian numbers on the bridge.

The dynamic swaying effect is far more likely to occur during managed events when both lanes of a clip-on are open for mass pedestrian crossings of the structure. This does call into question the plan to run one-off events rather than an extended trial.

It should be noted that the 2010 report in the OIA proposes permanent fixes to the issue that do not affect traffic and effectively removes the issue. Given that Waka Kotahi have been aware that the AHB does attract (unauthorised) mass pedestrian events there may be sound reasons to install the proposed dampers irrespective of any walking and cycling lane.

Deflection of barrier during impact.

Waka Kotahi refer to a single traffic lane running between barriers as a 'bull run'. We consider that this is inappropriate terminology as it portrays the notion of routinely 'out of control' vehicles bouncing between barriers. Instead, we have used the term 'constrained single lane running' where, under normal circumstances, a vehicle is freely driven on the road between barriers, but the barriers are able to provide side protection if required.

The potential ingress of the free-standing HV2 barrier into the Shared Lane during an impact is cited as a significant risk. Barriers are typically tested at impact angles of 5°, 10° and 15° and masses including 2.7T and 10T and speeds of up to 90km/h (Table 1, Table 2).

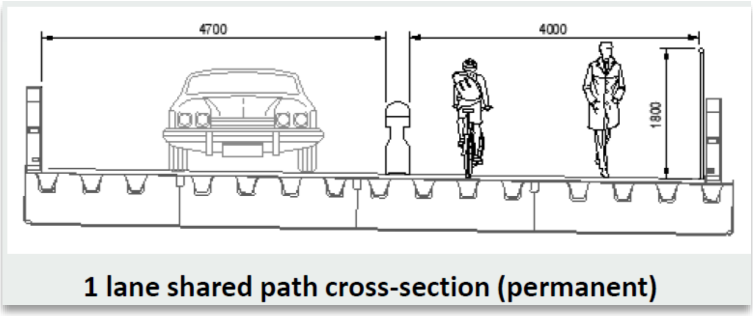


Figure 14 Schematic 'Option 3' cross section, 4.7m lane width maximum.

The impact angle of a long heavy vehicle running in constrained single lane to impact is governed by its speed (the higher speed the smaller the impact angle), the width of the lane and vehicle and the vehicle's dimensions. Figure 15 provides an approximate assessment of the maximum likely impact angle of the Auckland Transport bus running in a 4.7m wide constrained single lane. The impact angle is significantly less than the 5° impact angle in Table 2 which has a 0.71m deflection (0.24m for 2.4T vehicle, Table 1).

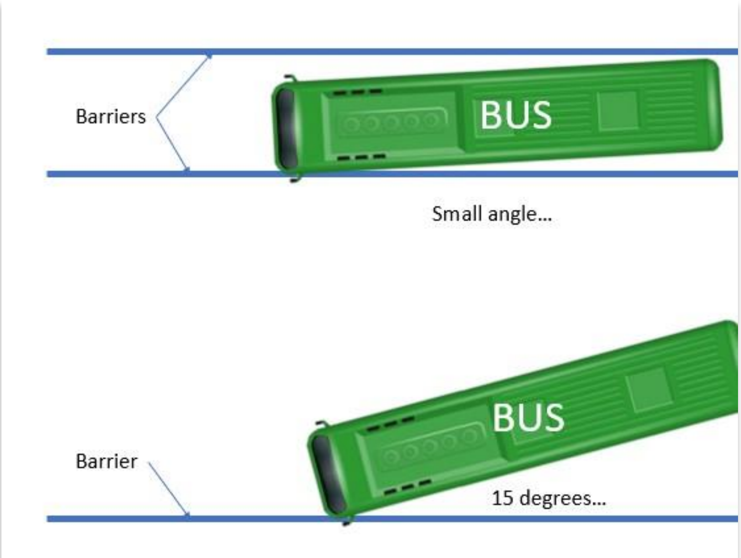


Figure 15 Restricted impact angle of vehicle in constrained single lane

Table 1 TL-3 deflections for 2.27T vehicle

TL-3 2,270kg VEHICLE					
Speed	**25°**	**20°**	**15°**	**10°**	**5°**
100km/h	1.47m	1.18m	0.88m	0.59m	0.30m
90km/h	1.33m	1.07m	0.80m	0.54m	0.27m
80km/h	1.18m	0.95m	0.71m	0.48m	0.24m
70km/h	1.03m	0.83m	0.62m	0.42m	0.21m
60km/h	0.89m	0.71m	0.53m	0.36m	0.18m
50km/h	0.74m	0.59m	0.44m	0.30m	0.15m
40km/h	0.59m	0.48m	0.36m	0.24m	0.12m

Table 2 TL-4 deflections for 10T vehicle

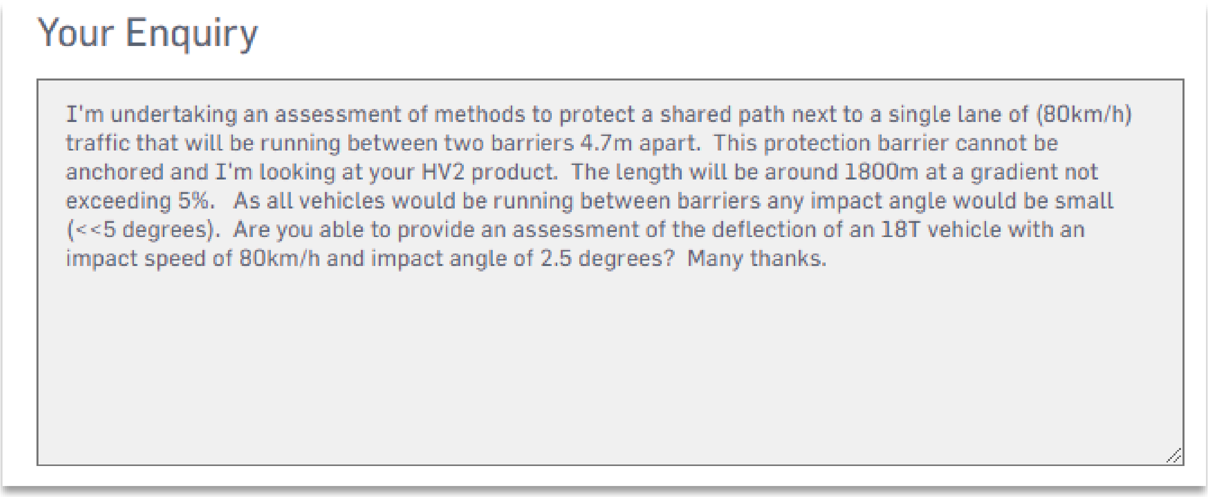
TL-4 10,000kg VEHICLE			
Speed	**15°**	**10°**	**5°**
90km/h	2.37m	1.58m	0.79m
80km/h	2.11m	1.41m	0.71m
70km/h	1.85m	1.23m	0.62m
60km/h	1.58m	1.06m	0.53m
50km/h	1.32m	0.88m	0.44m
40km/h	1.06m	0.71m	0.35m

Any deflection would be affected by vehicle mass with a bus weighing up to 18 tonnes (**T**) and this barrier does not appear to have been subjected to a comparable full-scale testing.

The New Zealand supplier of HV2 barriers (CSP) were contacted (Figure 16) to provide their assessment of a low angle impact of an 18T rigid vehicle at 80km/h[16].

Based on a 2.5° impact angle of this vehicle at 80km/h they advised that the energy in the impact would be 8.5kJ. This energy is less than 4% of the energy of a 10T vehicle impacting at a 15° angle (Table 2). Based on the energy of the impact, their assessment was that a deflection of 0.5m would be expected. They suggest adopting a more conservative nominal maximum displacement of 0.75m (equivalent to a 10T vehicle at 80km/h impacting at an angle of 5° - Table 2).

[16] Email from CSP to SmartSense 9/8/22 which included the response from Saferoads in Australia.


Your Enquiry

I'm undertaking an assessment of methods to protect a shared path next to a single lane of (80km/h) traffic that will be running between two barriers 4.7m apart. This protection barrier cannot be anchored and I'm looking at your HV2 product. The length will be around 1800m at a gradient not exceeding 5%. As all vehicles would be running between barriers any impact angle would be small (<<5 degrees). Are you able to provide an assessment of the deflection of an 18T vehicle with an impact speed of 80km/h and impact angle of 2.5 degrees? Many thanks.

Figure 16 Enquiry for technical assistance from HV2 provider

Their response appears to be supported by the trend data (Figure 17) from TL-3 (2.7T) and TL-4 (10T) where an 18T deflection line is postulated. Whilst this graph should be treated with caution and would require a more detailed analysis, it suggests that an 80km/h impact of an 18T bus at a more realistic 2° impact angle would result in a deflection of around 0.5m.

Whilst any deflection would encroach into the Shared Path (and therefore not be ideal), a deflection of 0.5-0.75m would be broadly comparable with a 0.5m minimum clearance between cyclists and the barrier (Figure 5.7 in Austroads AGRD06A). There is still a small probability that a cyclist or pedestrian would be within the 0.75m deflection zone of any impact. The presence of any anti-climb barrier above the 0.9m HV2 barrier may encroach further into the Shared Path and would have the ability to harm people.

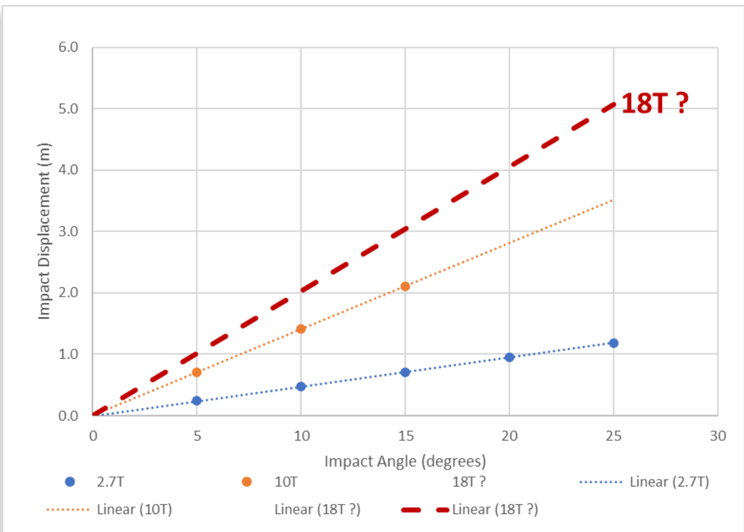


Figure 17 80km/h TL-3, TL-4 tests and potential extrapolated 18T test (based on factoring vehicle masses)

As a further mitigation against barrier deflection, there is no reason why a lower speed could not be posted on the constrained single lane on the southbound clip-on. A 60km/h limit appears to reduce barrier deflection by a further 25% for lower mass vehicles.

Whilst it is accepted there is a residual risk, this risk compared favourably to the risk on of many kilometres of other roads in Auckland with >60km/h traffic where pedestrians/cyclists are left totally unprotected.

By comparison the AHB HV2 barrier would appear to offer significantly higher protection than those other environments.

Bus Stability

Waka Kotahi [17]reference the risk of Northern Express busses suffering from 'yaw-steer' and cite this as posing an impact risk with the barrier or bridge superstructure (truss). Auckland Transport have been approached to provide a response to Waka Kotahi's stated concerns, but to date have not responded.

Shared Path Width / Edge barriers

The proposed AHB Shared Path would be 4m wide and cater for all active modes. It is a reasonable assumption that in a similar manner to road traffic that the flows will be tidal with more southbound movements in the morning peak, northbound in the afternoon peak. Figure 22 recommends a 3.5m wide path with a minimum clearance between the cyclists and barrier of 0.5m (Figure 5.7 of Austroads AGRD06A).

The proposed 4m path would appear (Figure 18) to be suitable to up to 600 cyclists and 200 pedestrians per <u>hour</u>. Whilst a detailed analysis of expected flows has not been performed this would appear to be within the expectations of usage for the AHB Shared Path. It is noted that these capacities significantly exceed the 850 cyclists / 100 peds a <u>day</u> in the Waka Kotahi Memo dated 18/2/22.

The Waka Kotahi Safe Systems Assessment (**SSA**)[18] noted that a 0.9m high barrier between the Shared Path and traffic lane would not prevent a cyclist who collided with the barrier or another person from over-topping the barrier, and this is accepted. Waka Kotahi then go on to say the due to 'extreme danger' to cyclists that a 1.6m high barrier should be placed between the Shared Path and the traffic lane. This 1.6m height is 0.2m higher than Austroads references and indicates that Waka Kotahi appear to be taking an overly conservative approach to their assessment.

[17] Auckland Harbour Bridge shared path safety assessment, Memo dated Feb 2022, released under OIA 10175.
[18] Auckland Harbour Bridge shared path safety assessment, 18/2/22 NZTA Memo from Safety and System Performance, System Design

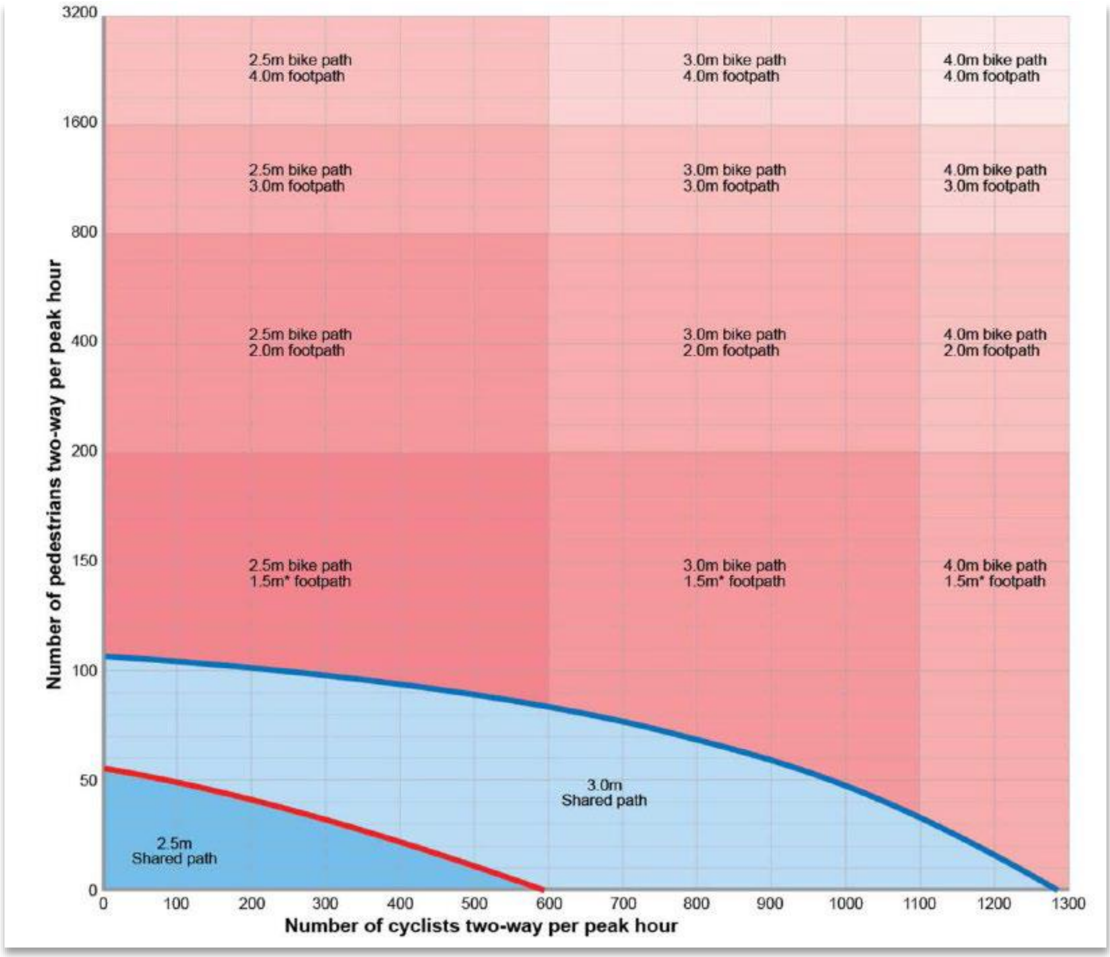


Figure 18 Austroads Figure 5.5 AGRD06A Path width for 75/25 directional split.

Gradient of Bridge

Waka Kotahi rank cyclist speed as a prime safety risk to the single Active Mode lane. It is recognised that there will be up to 700m of downhill 5% (not the 6% quoted by Waka Kotahi) and that there is the opportunity for cyclists to gather speed on these inclines. The 5% maximum gradient is not considered in the Austroads guide to be exceptionally steep and there are several other Waka Kotahi sanctioned / funded shared paths that are or comparable lengths and steeper. (Table 3)

Table 3 Schedule of shared paths with gradients

Location	Average Grade	Steepest Grade (over a min of 150m)	Length (m)	Height gain (m)	Comments	Direction	Reference
Auckland Harbour Bridge (northern approach)	4.5%	5%	990	45m			From Sulphur Beach path. Driven with barometric GPS
Auckland Harbour Bridge	4.3%	5%	930	40m			Assuming exit to Westhaven still 5m above ground level. Driven with barometric GPS
Grafton Gully	4.7%	8.3%	600	65 in 1400, 44 in 1000, 28 in 600	Shared path	2-way	Ridden with GPS
Wainuiomata, Wellington	9.1%		1,970	211 m	Shared path	2-way	https://www.strava.com/segments/1131930
Te Ara Ki Uta Ki Tai	5.2%	10%	810	43m	Shared path	2-way	
Franklin Rd, Auckland	5.8%	8%	920	48m	Cycle path	1-way	https://www.strava.com/segments/6829833
Apirana Ave. Climb	4.4%	12%	1,020	42m	Shared path	2-way	https://www.strava.com/segments/1115273
Mount Eden Summit Climb	3.4%	11%	1,310	88m	Shared path	2-way	https://www.strava.com/segments/3389538
Ngaio Gorge Rd, Wellington	4.8%	>20%	1,800	139 m	road		https://www.strava.com/segments/7282974
Te Ahu a Turanga	8.4%	10%	1,780	149 m	3.5m shared path	W>E	OIA 10639
Te Ahu a Turanga	8.0%	9%	2,780	222 m	3.5m shared path	E>W	OIA 10639

In the Grafton Gully example (Figure 19), a 600m section (from 0.4km to 1.0km) rises some 28m a slope of 4.7% with the steepest section rising 15m over 180m a slope of 8.3%.

The overall climb/ descent is comparable, and the maximum slope is significantly steeper than the AHB. We are not aware of any concerns raised about cyclist speed nor any proposals to close this shared path for safety reasons, nor are we aware of any major concerns raised by Waka Kotahi about cycling speeds or glancing/ head on collisions elsewhere on the cycling network.

Waka Kotahi cites just one example of a known collision (non-fatal) across the Auckland cycle path network. On this basis, we do not consider that Waka Kotahi is consistently applying the same assessment criteria to the AHB Shared Path as it has on other Waka Kotahi funded paths.

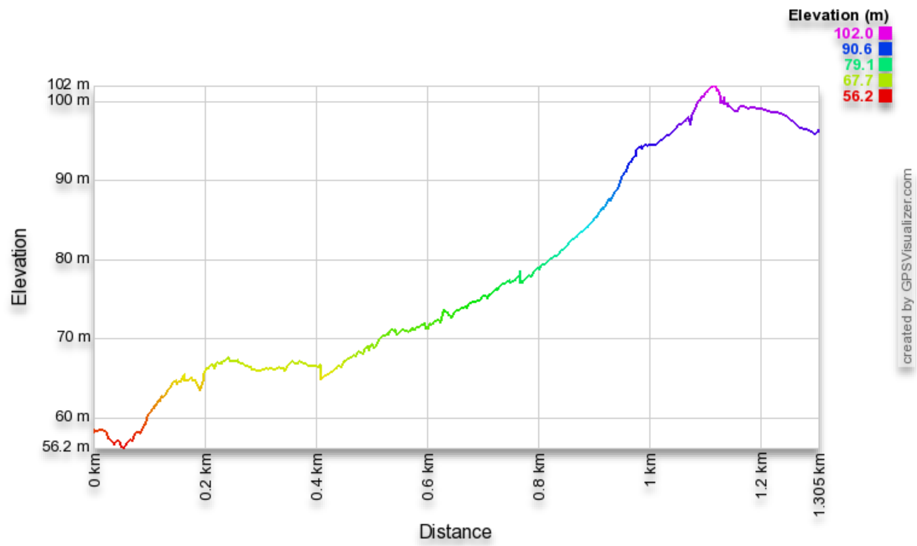


Figure 19 Grafton Gully Shared Path - Long Section, recorded with GPS and altimeter.

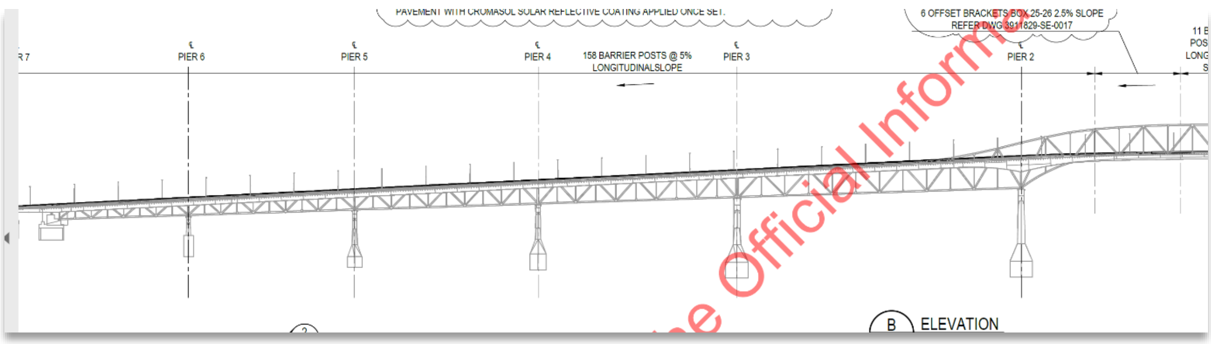


Figure 20 Southern Approach Spans on AHB - max gradient 5% released under OIA 9736

Based on Table 3 it appears that Waka Kotahi is applying a more onerous level of assessment on the AHB Active Mode path than they apply elsewhere.   As the AHB Active Mode lane is the only example where a State Highway traffic lane is proposed to be repurposed for Active Modes then the mode neutrality of Waka Kotahi’s approach must be questioned.

If the same approach in the Waka Kotahi SSA document was applied to other paths in Table 3 then it is unlikely that any of them would have been funded or constructed, yet they all were. To apply a different threshold assessment to repurposing a lane of the Auckland Harbour Bridge appears to be inconsistent and appears to show bias or a significant logic failure[19].

The most contemporaneous Shared Path that Waka Kotahi is currently constructing is Te Ahu a Turanga- Manawatū Tararua Highway[20]. This is a 3.5m wide chip sealed shared path that follows the new highway that is under construction. The area also contains a large wind farm, so is by definition -prone to wind, Waka Kotahi have advised that (**bold added**):

*"During the consenting process for Te Ahu a Turanga, Waka Kotahi NZ Transport Agency was instructed to provide a shared use path. As the shared path is a requirement **a risk assessment in relation to wind has not been undertaken**."*

Table 4 summarises the path's Chainage (distance from start) and Elevation and provides incremental and overall lengths and gradients.

Table 4 Gradient data for new Shared Path Te Ahu a Turanga - Manawatū Tararua Highway

Chainage (m)	Elevation (m)	Distance (m)	Height Change (m)	Gradient (%)
21880	93.783			
22180	121.228	300	27.445	9.1%
22260	123.264	80	2.036	2.5%
22940	183.273	680	60.009	8.8%
23240	203.63	300	20.357	6.8%
23540	232.344	300	28.714	9.6%
23660	242.574	120	10.23	8.5%
Total		1780	148.791	8.36%
28300	315.843			
28680	295.79	380	-20.053	-5.3%
29280	244.517	600	-51.273	-8.5%
29880	191.908	600	-52.609	-8.8%
30480	142.303	600	-49.605	-8.3%
30800	114.128	320	-28.175	-8.8%
31080	94.169	280	-19.959	-7.1%
Total		2780	-221.674	-7.97%

The shared path contains two long inclines with gradients in excess of 9% and *a sustained average gradient of 8.4% over 1.78km and 8.0% over 2.78km*. These two inclines are both significantly longer and steeper than either side of the Auckland Harbour Bridge which has a steepest incline of 5% over distance of under 1km.

There is a clear inconsistency in Waka Kotahi's assessment whereby they have assessed a high likelihood of cyclists causing deaths and serious injuries on the Auckland Harbour Bridge which is

[19] An OIA on the new Te Ahu a Turanga – Manawatū Tararua Highway linking the Manawatu to Hawkes Bay has been lodged to enquire about shared path protection, gradient and wind risk.

[20] Alignment and cross section information released under OIA 10639.

both significantly shorter and flatter, albeit busier, than the Te Ahu a Turanga Shared Path. The magnitude of this inconsistency indicates either that the Auckland Harbour Bridge assessment is overly pessimistic or that the Te Ahu a Turanga Shared Path has not been designed to meet Waka Kotahi's own high standards. We consider that Waka Kotahi's Auckland Harbour Bridge assessment is overly pessimistic.

Speed of Cyclists

Waka Kothai's Safe Systems Assessment concludes that the length and gradient of the AHB Shared Path will be:

- Highly likely to result in head-on cyclist collisions significantly in-excess of 60km/h with a high potential (ranked 3 out of 4) of death or serious injury.
- Highly likely to result in cyclist vs pedestrian collisions of up to 60km/h with the highest potential (ranked 4 out of 4) of death or serious injury.
- Likely to result in sideswipe collisions between cyclists and e-scooters/skateboarders.

These statements are however based on an incorrectly assumed 6% gradient (Figure 21) and flows of 450-850 cyclists and 100 pedestrians a <u>day.</u> These flows appear to exceptionally low and may account for Waka Kotahi assuming that the Shared Path is effectively empty for extended periods. The Austroads Guidance[21] seeks to limit gradients to 5% (which is the steepest gradient on the AHB) and provides an indicative commuting (tidal flow) cross section (Figure 21) that could be comfortably accommodated within the available 4m AHB Shared Path corridor.

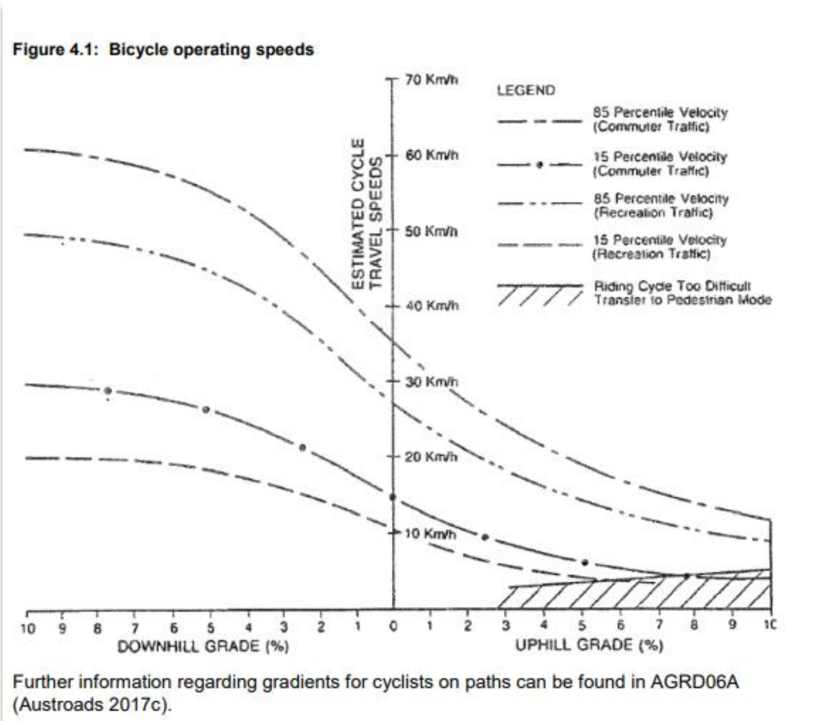


Figure 21 Austroads bicycling operating speeds

[21] Austroads AGRD06A-17 2021.

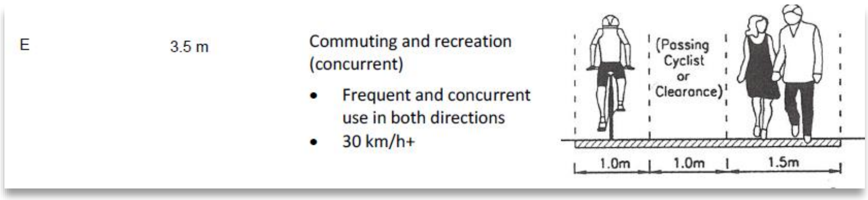


Figure 22 Austroads Guide AGRD06A-17 Shared path Figure A2 (commuting)

There appears to be a perception within Waka Kotahi that people on bicycles will ride at the maximum possible speed across the AHB, irrespective of the presence of other users. We consider that this approach is overly simplistic and may have resulted from them grossly under-estimating the path's expected usage.

To garner the views of cyclists on their actual cycling behaviour and likely speeds on a 700m shared path with a 5% downhill gradient, we posed some general questions to the NZ Cycle Action Network Facebook Page. Whilst not a scientific survey, it did result in over one hundred and sixty contributions. The consistent messages that the responses provided were:

1. ***Speeds in excess of 50kph are readily achievable on downhill gradients,***
2. ***These speeds were almost exclusively recorded on roads or occasionally empty shared paths,***
3. ***No-one reported reaching high speeds on shared paths with mixed users,***
4. ***People ride to the conditions (weather, other users),***
5. ***People ride within their abilities,***
6. ***People on cycles are generally conscious of the risks to themselves and others,***
7. ***Some support for speed limit with a degree of enforceability,***
8. ***Numerous steeper more challenging shared paths were cited,***
9. ***People on cycles tend to self-regulate themselves and their peers,***
10. ***Downhill speeds of 30kph on busy shared paths were generally referenced.***

The SSA[22] approach taken by Waka Kotahi appears to be based on a range of overly pessimistic assumptions that take little account of the shared path expected user volumes and users reacting responsibly to the environment. In particular, we consider that the use of the (incorrect) 6% gradient and Waka Kotahi's belief that 15% of cyclists will routinely travel faster than 60km/h simply does not reflect reality.

Waka Kotahi could equally apply the same SSA approach they have used to assess the risk to Active Mode users on the AHB to Active Mode users on other infrastructure. Whilst there are a few recorded collisions between cyclists and/or pedestrians, there are far more frequent deaths of cyclists hit by motor vehicles. If the same SSA approach used to assess the risks to Active Mode users on the AHB were applied in all other locations, then Waka Kotahi would only permit walkers and cyclists in fully segregated and protected corridors, separate from motor vehicles. This is neither achievable nor realistic.

By way of comparison, the speeds of over 5,700 bicycles were recorded in a recent survey in the Waikato[23] on a flat segregated cycle path (Figure 23). This showed median speeds (50th percentile) of 18km/h, and 85th percentile of 28km/h, with no recorded speeds in excess of 40km/hr greater.

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[22] Auckland Harbour Bridge shared path safety assessment, 18/2/22 NZTA Memo from Safety and System Performance, System Design released under OIA 10175.
[23] Cambridge separated cycleway 27 Hamilton Rd. Undertaken by SmartSense for Waipa DC. 2022.

Table 5 indicates that whilst the Austroads value appear consistent with the Cambridge survey for the slowest 15% of cyclists (mix of commuter and recreation) that the Austroads threshold speeds (27/36km/h) for the fastest 15% of riders are significantly faster (23km/h) than those recorded in Cambridge. This may suggest that the Austroads graphs (Figure 21) may be too high for the New Zealand environment.

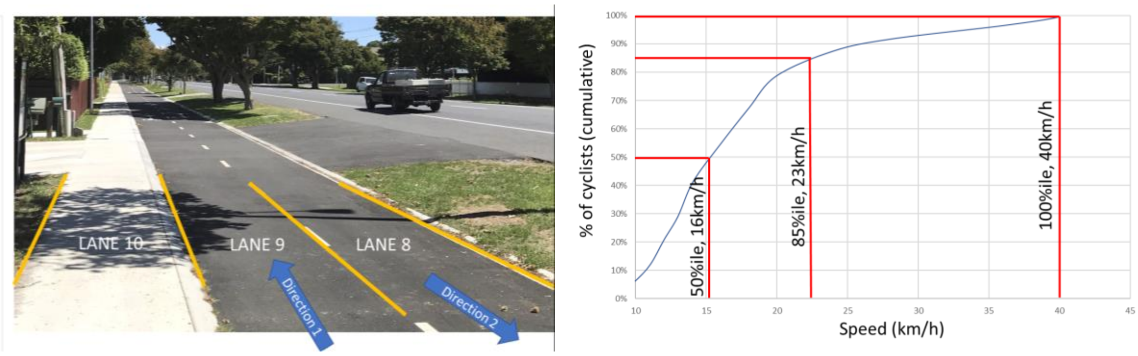


Figure 23 Distribution of cycle speeds - Hamilton Rd. Cambridge (Recorded in Lane 8 & 9)

Table 5 Comparison of Austroads and Actual cyclist speed recorded in Cambridge

% Sample (Cumulative)	AustRoads (Recreation/Commute)	Recorded in Cambridge
15%	10/14	12
50%	-	16
85%	27/36	23
100%	-	40

Weather Effects

There have been several well-publicised incidents where severe weather has closed or restricted the AHB. There are no options being proposed for providing Active Mode path users with wind or rain protection and due to the bridge loading constraints, we understand that this is not possible.

Waka Kotahi currently pro-actively advise motorists on the weather conditions ahead and the potential to restrict or close the AHB on occasions. This advance warning is important as traffic could be tens on kilometres away from the bridge and unaware of the local conditions around the AHB. This need for significant advanced warning is less important for Active Mode users, as unlike people in motor vehicles, pedestrians, cyclists and those using active modes are likely to be closer to the AHB and make self-informed decisions on whether to travel to the bridge.

It is accepted that there will be occasions (potentially at short notice) when due to high winds / exceptional rain that the Active Mode lane is closed by Waka Kotahi for safety reasons. We suggest that any decision on closure be based on the ability to safely walk (or push bicycles) across the AHB. Cyclists are generally able to make their sensible decisions whether to ride or push their bikes, especially if they have made a commitment reach the bridge.

Provision of wind related data from Waka Kotahi

Waka Kotahi have provided wind data[24] relevant to Auckland Harbour Bridge. The OIA request was for the last ten years of average and gust wind records (speed and direction) at fifteen-minute intervals. They were also requested to provide any risk assessment information over the last five years relating to people walking and cycling across the Auckland Harbour Bridge.

The only data that Waka Kotahi held was from the Met Service and was recorded at 67m above sea level, which is understood to be on the top of the bridge arch. This elevation is between 20-60m higher than the road deck.

The data provided only covers the wind records over 903 ten-minute periods across eleven years – this is around 0.15% of the requested period. The data provided relates only to occasions where wind gust speeds exceeded 75km/h and provides the gust speed and direction and the average speed/ direction over the preceding ten minutes.

Waka Kotahi has also advised that:

"***Waka Kotahi NZ Transport Agency has not undertaken an assessment of wind risk to people walking and cycling across the Auckland Harbour Bridge***."

Analysis of wind related data

It is accepted that a wind gust of 75km/h (strong gusts) would make cycling a challenge; in the absence of any other Waka Kotahi data, this analysis will use that value as the speed where any cycling would cease. Walking (or pushing a cycle) is likely to be possible in higher windspeeds.

A summary of the high windspeed occasions is shown in Table 1. If the incomplete 2022 and night-time data (20:00-06:00) are excluded there are 643 occasions of strong gusts over eleven years.

[24] OIA 10638 August 2022 available on FYI.org.nz

Table 6 Number of 10-minute periods where wind speeds at 67m above sea-level exceeded 75km/h (strong gusts)

Year	06:00-20:00	20:00-06:00	Total
2011	97	25	122
2012	59	17	76
2013	47	12	59
2014	103	59	162
2015	28	14	42
2016	55	46	101
2017	59	12	71
2018	42	15	57
2019	84	30	114
2020	38	5	43
2021	31	12	43
2022	12	1	13
Grand Total	**655**	**248**	**903**

The data provided includes both direction and speed and these can be resolved into head/tail wind and crosswind components. Cyclists are well aware that a head/tail wind affect speed but rarely stability, stability is most affected by the crosswind component. This is shown in Figure 24

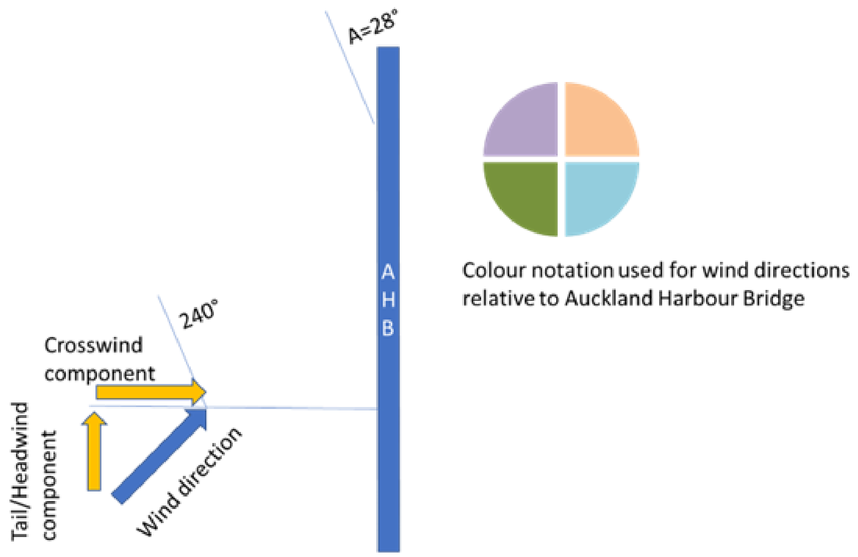


Figure 24 Schematic of wind analysis, Auckland Harbour Bridge alignment is 28° from North, Wind Direction resolved into Crosswind and Tail/Headwind elements.

As Waka Kotahi have already stated, the predominant wind direction is from the western side and the provided data (Figure 25) indicates that 83% of gusts were from the western side of the bridge, with only 17% of gusts were from the eastern side of the bridge.

Of this 83%, 40% are from directions that are more than 30° to the bridge and therefore more likely to affect cyclists. At smaller angles the crosswind component will be significantly reduced.

Any shared path is unlikely to have specific wind protection the fact that it would be on the eastern clip-on and the overwhelming direction of the gusts are from the west is significant. The bridge superstructure is likely to provide a degree of passive wind sheltering to a path on the eastern shared path. This will be affected by the bridge structure aerodynamics and without testing and monitoring at road level the actual effect of strong gusts is difficult to predict.

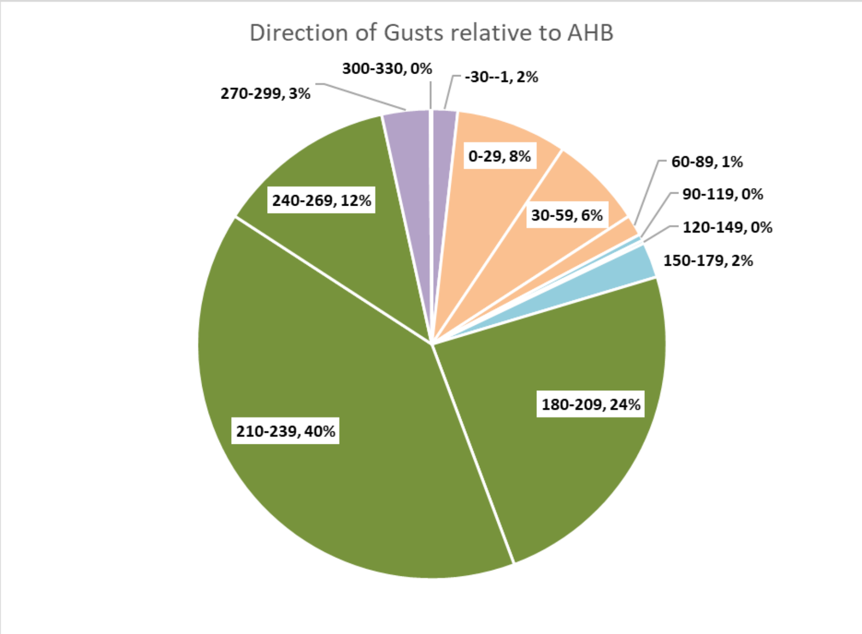


Figure 25 Frequency distribution of wind gusts 2011-2021

Cyclists naturally adapt to a steady crosswind or headwind and an annual headwind cycling event in the Netherlands[25] has recorded the wind conditions over a seven-year period. Whilst this is not being cited as a scientific survey it does indicate that windspeed alone is not the only factor to consider the ability to safely cycle and the direction relative to the cyclist is important.

Table 7 Wind Speeds during Dutch Headwind Cycling Championship

Wind Force (Beaufort number)	Description	Wind speed	Event Year
5	Fresh breeze	29–38 km/h	2013
6	Strong breeze	39–49 km/h	
7	High wind, moderate gale, near gale	50–61 km/h	2015, 2018, 2022
8	Gale, fresh gale	62–74 km/h	2014, 2020
9	Strong/severe gale	75–88 km/h	2016

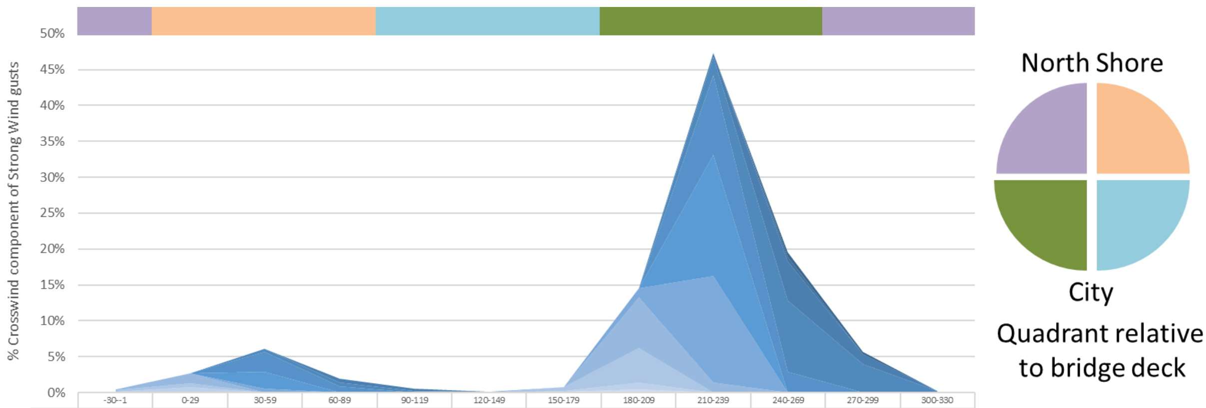
[25] https://en.wikipedia.org/wiki/Dutch_Headwind_Cycling_Championships

A strong wind gust is more likely to have a destabilising effect on a cyclist than when its direction is significantly different to the preceding wind. Table 8 shows that on 51% of occasions the strong gusts reported are within 5° of the preceding wind and in total on 88% of occasions the gust is within 15° of the preceding wind direction. The fact that 88% of strong gusts are within 15° if the preceding wind direction makes it likely that cyclists would already be compensating for a significant crosswind. Therefore the times when a gust in excess of 75km/h occurs from an unexpected direction is only around 12% of recorded gust.

Table 8 Difference between average direction (10mins preceding) to Strong Gust

Difference of Average to Strong Gust direction (°)	Percentage of wind gusts
0-4	51%
5-9	25%
10-14	12%
15-19	5%
20-24	3%
25-29	1%
30-34	1%
35-39	1%

Figure 26 shows the distribution of crosswind components for the provided wind data. As would be expected the most frequent and strongest crosswinds are with the prevailing winds from the green (SW) quadrant. The yellow box highlights the percentage of records where the crosswind component exceeds 50km/h – a speed that is likely to make cycling challenging. Of the 600+ strong gust recorded 65% generate a crosswind component in excess of 50km/h representing around 40 occasions a year. The lack of wind data for over 99.8% of the time does prevent a more detailed analysis to be undertaken of the time when wind speeds above the bridge did not exceed 75km/h.



	-30--1	0-29	30-59	60-89	90-119	120-149	150-179	180-209	210-239	240-269	270-299	300-330
100-110	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
90-100	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
80-90	0%	0%	0%	1%	0%	0%	0%	0%	1%	5%	1%	0%
70-80	0%	0%	0%	0%	0%	0%	0%	0%	3%	10%	4%	0%
60-70	0%	0%	3%	1%	0%	0%	0%	0%	11%	3%	0%	0%
50-60	0%	0%	2%	0%	0%	0%	0%	0%	17%	0%	0%	0%
40-50	0%	0%	1%	0%	0%	0%	0%	1%	15%	0%	0%	0%
30-40	0%	1%	0%	0%	0%	0%	0%	7%	1%	0%	0%	0%
20-30	0%	1%	0%	0%	0%	0%	1%	5%	0%	0%	0%	0%
10-20	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
0-10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Angle of wind gust to bridge deck

Figure 26 Crosswind component strength and direction distribution

Wind Profile

Waka Kotahi have advised that they have no wind speed data from bridge deck level, this lack of data makes any assessment of the actual wind profile of the bridge difficult to determine. The lack of data also makes it difficult for Waka Kotahi to make, or support, the statements that they have made around the risk of wind.

There are some theoretical relationships between winds speed and altitude with Figure 27 showing the gradient of wind across an open body of water. This can be considered likely to be an upper-bound solution and implies that at the bridge deck level (50m) the actual wind speed could be similar to that at 67m, reducing to around 60km/h as the road returns to ground level.

Applying a similar analysis, but assuming the bridge superstructure acts like a large town with high buildings, reduces the speed at 50m elevation to 70km/m and under 50km/h as the road returns to ground level.

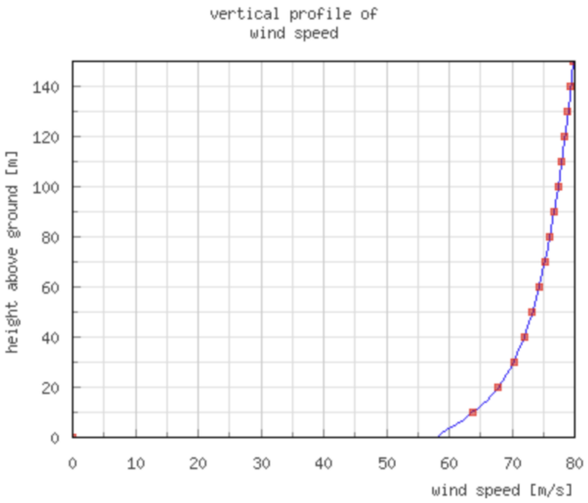
A reduction of wind speed at the bridge deck elevation is likely, but in the absence of any data being collected by Waka Kotahi we have not reduced the speeds to compensate for lower elevations. We consider this analysis to be a conservative approach.

Please specify parameters

height above ground	67 m	
wind speed	75 m/s	
roughness length z_0 (see table below)	0.0002 m	Refresh

Result

height above ground	wind speed
150 m	79.75 m/s
140 m	79.34 m/s
130 m	78.91 m/s
120 m	78.44 m/s
110 m	77.92 m/s
100 m	77.36 m/s
90 m	76.74 m/s
80 m	76.05 m/s
70 m	75.26 m/s
60 m	74.35 m/s
50 m	73.27 m/s
40 m	71.96 m/s
30 m	70.26 m/s
20 m	67.87 m/s
10 m	63.79 m/s



Roughness Classes and Lengths

Figure 27 Wind Gradient profile across open water (75km/h at 67m)

It is accepted that gusts can occur at any time of year, but 65% of gusts occurred in the months of July-October.

Table 9 Distribution of wind gusts 2011-2021

Month	% of Gusts
Jan	3%
Feb	1%
Mar	5%
Apr	5%
May	7%
Jun	7%
Jul	18%
Aug	13%
Sep	16%
Oct	18%
Nov	6%
Dec	3%

Assessment of wind risk

By simply combining the analysis of frequency of gusts of greater than 75km/h we have make an assessment of the likelihood of unexpected high gust occurrences. The first assessment are gusts from the east.

- 58 gusts/year during daytime,
- Percentage of gusts from the least protected eastern side of the bridge 17%,
- Percentage of gusts where the wind shift is more than 15° is 12%

A simple estimate of the frequency of a gust of >75km/h, that is more than 15° different than the preceding wind from the side of the bridge least exposed to wind (easterly) is to multiply these values together, these equate to around once a year.

This figure does not reflect wind gusts from the west, these would undoubtedly effect a shared path on the east,

- 58/year during daytime,
- Percentage of gusts from the least protected western side of the bridge with at more than 30° from the bridge 40%,
- Percentage of gusts where the wind shift is more than 15° is 12%

A simple estimate of the frequency of a gust of >75km/h, that is more than 15° different than the preceding wind from the side of the bridge most protected from wind (westerly) is to multiply these values together, these equate to around three times a year.

The wind speeds provided are likely to be higher than those experienced on the bridge deck.

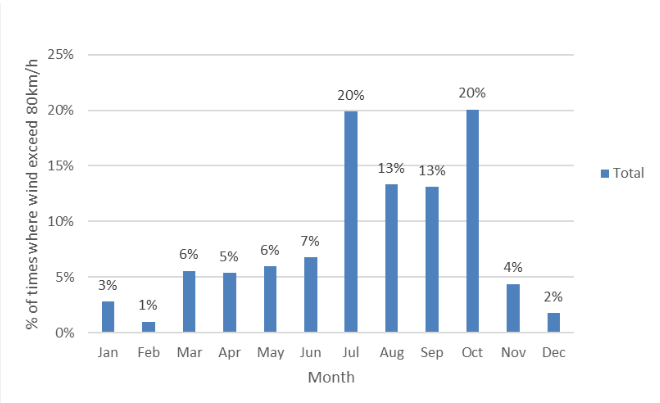
One the basis of the Waka Kotahi provided data there would appear to be a likelihood that unexpected winds gusts in excess of 75km/h may be experienced under five times in a year. On this basis it is not considered that unexpected or strong wind gusts would be a significant issue.

The wind data that Waka Kotahi have provided is incomplete and what has been provided is from an altitude significantly highest point of the bridge deck. On the data provided there could also be forty occasions a year when strong gusts could generate crosswinds in excess of 50km/h which may preclude cycling.

Waka Kotahi Safe Systems and Wind Assessments.

The SSA states that winds on the AHB reach 80km/h all year round, cycling in winds above 64km/h is 'impossible' and that a wind gust that occurred in September 2020 (resulting in a vehicle impacting the AHB and causing damage) occurred without any warning. However, the report also says that no assessment of weather risk has been made.

Table 10 Distribution of wind gusts > 80km/h



There appears to be a proven risk to the structural integrity on the bridge from trucks being blown over on the bridge. (per the structural damage of September 2020). If these winds are somewhat predictable then Waka Kotahi should be considering the banning of trucks from the AHB on days where high winds are likely and made to use the existing alternative harbour crossing, namely SH16 and SH18 to Albany.   If the winds are totally unpredictable, then allowing any truck to cross the AHB at any time appears to be unwise and potentially unsafe.

Other bridges where crosswinds are known issue have been equipped with windsocks to provide regular users with a simple but effective guide of wind strength and direction. The AHB does have prominent flags flying on the top of the structure, but these are 25m above the highest part of the bridge deck and designed to showcase the flags rather than specifically provide a visual queue of wind strength and direction. Figure 28 shows the windsock on the approach span of the Tacoma Narrows Bridge in Washington State, USA. It is recommended that similar windsocks be provided on the AHB approaches to assist Shared Path users (and drivers) assess the wind conditions on the AHB.

Figure 28 Windsock deployment to provide regular users with direction and strength information (Tacoma Narrow Bridge, Washington State, USA)

In addition to the provision of windsocks on each approach to the AHB it is considered sensible to provide full height automatic gates at either end of the Shared Path to facilitate occasional closures. At 1,600m long, most people could leave the bridge in under ten minutes on foot. On occasions, where conditions deteriorate rapidly there may need to provide some assistance by staff. The behaviour of users and Waka Kotahi to weather conditions on the AHB would be a key part of a twelve-month trial.

Maintenance / Emergency Access and Assistance

The AHB Active Mode path will be unique in New Zealand and as such Waka Kotahi could provide trained staff (Wardens) to assist users and ensure the safety of users on the Shared Path. Fortunately, there is already a specialist staff base at the northern access point to the path which is co-located with the NZ Police.

The path will be 4m wide, so suitable for small maintenance vehicles (e.g. Polaris type vehicles) or purpose built double ended utilities (Figure 29), e-bikes, walking or e-scooter equipped Wardens and maintenance teams. Wardens can also be trained in first aid, suicide risk assessment and counselling. The AHB can have local by-laws enacted to place provisions on active mode users to limit their speed and empower Wardens with specific authority. We recognise that the provision of trained staff (Wardens) to interact with users of the Shared Path is not a task that Waka Kotahi provide elsewhere in Aotearoa, but given the unique characteristics of the AHB Shared Path we suggest they are warranted here.

Any vehicle incidents on the constrained single lane running lanes on the AHB will need to be managed effectively. Waka Kotahi and their contractors have existing experience with constrained single lane running on the AHB, so no significant new issues are anticipated.

The provision of a single southbound lane on the clip-on between two barriers makes a major impact (high angle / high speed) between a vehicle and the AHB barrier / superstructure less likely. The conversion of the outer clip-on traffic lane to be a shared path and the addition of an extra barrier would also provide additional protection to the outer barrier of the clip-on. We are aware that there is already barrier strengthening work underway on this barrier so further protection should be beneficial.

On the occasions where emergency services need to be attended incidents there are numerous transport options for first responders (Figure 30) with storage at the NZ Police station near Sulphur Bay. For more significant incidents, there is the capacity to utilise the adjacent traffic lane, or the 4m wide evacuated Shared Path.

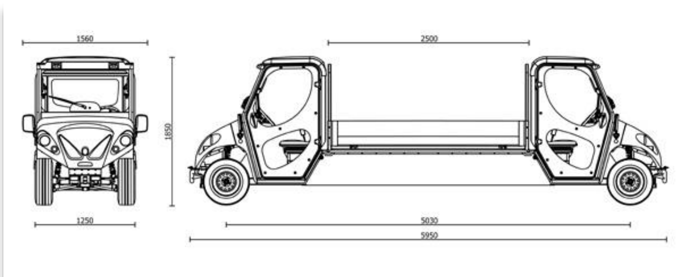


Figure 29 Specialised double ended maintenance vehicle

Figure 30 Restricted access maintenance and emergency vehicles

Summary - Potential mitigations to safety items raised by Waka Kotahi

Waka Kotahi appears to have predetermined that converting the outer southbound clip-on on the AHB to be a Shared Path is not something that it wishes to provide. It has cited safety concerns as the prime reason. We consider that, rather than seek practical reductions to some of the risks, Waka Kotahi's SSA approach considers several unrealistic worst-case scenarios and applies a level of conservatism that does not appear to be used on other projects. As such there is a significant likelihood that Waka Kotahi is applying unconscious institutional bias against enabling active mode travel on the Auckland Harbour Bridge.

Effective controls exist to reduce inherent risks to an acceptable residual level (most notably with the imposition of a 30 km/h speed limit in the Active Mode lane through by-laws and wardens). Waka Kotahi has overlooked such controls.

Converting one traffic lane on the Auckland Harbour Bridge to Active Modes introduces both risks and opportunities, and by focusing only on the inherent risks (before controls) of Active Modes, Waka Kotahi ignores the significant opportunities for social inclusion, improved health, financial betterment, commuter time savings and more for the many people that would use the Active Mode lane. A more balanced approach than is clearly more appropriate and useful.

There are safety related matters that remain to be addressed and below we have listed some pragmatic and reasonable mitigations.

Barriers

- There is no clear evidence that Waka Kotahi has made a detailed assessment of the lighter free-standing HV2 interlocking barriers that are available and approved[26] by them. This assessment must be undertaken. The assessment would need to specifically consider their use on a constrained single lane running environment with greatly reduced impact angles.
- Outer-edge anti-climb barriers have been shown to be structurally viable and whilst not eliminating the risk, a 2.1m high wire strand barrier has been empirically shown to reduce the likelihood of suicides in situ by 50%.
- A 1.6m high mesh barrier between traffic and the Shared Path appears to 0.2m higher than referenced on Austroads and would provide a reasonable anti-climb and screening barrier.

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[26] NZ Transport Agency, Austroads Safety Barrier Assessment Panel (ASBAP) and specified in M23 – Appendix C, the HV2 BARRIER.

- Auckland Transport has been asked to respond to Waka Kotahi's stated concerns about the ability of their double decker busses to cause damage to the bridge or barriers.

Gradient and Width

- The AHB Shared Path is no steeper or longer than numerous other shared paths that Waka Kotahi have provided, some delivered as recently as 2022. Another shared path in construction by Waka Kotahi is nearly twice as steep and twice as long.
- The 4m width Shared Path has the capacity for at least 800 people/hour in a commuter environment, including 600 on bicycles.

Dynamic behaviour

- Waka Kotahi have identified a potential safety and comfort issue when two clip on lanes are used for mass pedestrian events.
- The safety issue related to a 50mm gap that rapidly opened and closed between the clip-on and original bridge that could severely crush anything inserted into it.
- The comfort issue was the lateral (sideways) sway generated by people subconsciously walking in step.
- In 2010 a relatively simple mitigation measure was identified (dampers) that could be installed with no impact on the bridge use.
- The one lane Shared Path proposed is remote from the gap and not an issue.
- The swaying is generated by pedestrians walking, not cyclists/scooters and using Waka Kotahi's undamped bridge data the structure could accommodate the total daily predicted pedestrian numbers at any one time. (1,600)

Shared Path Cycling Speeds

It is accepted that there is the potential for cyclist impacts on other Active Mode users. The SSA appears to make no allowance for users moderating their riding based on environmental and human factors - these factors include other users, rider experience and the weather. Waka Kotahi's assumptions on excessive speed were not supported when regular cyclists were consulted.

The risk of excessive speed and impacts cannot be fully ruled out so several options to reduce the risk are considered:

- Use of speed monitoring and enforcement. This may provide both official and peer enforcement of a proposed 30kmh speed limit that can be added as a Bylaw on the AHB. We consider that this approach is practical and likely to provide a safe and controlled environment for all users of the AHB Shared Path.
- Staged launch with cycles first and pedestrians and micro-mobility added later. This approach would provide for a staged launch of shared path so allow cyclists to familiarise themselves with the new path. This is also unlikely to meet the predicted demand of micro-mobility and pedestrians and could lull people on cycles into not expecting other modes – it is not a preferred option.
- Cycles only, this can be catered for without any legislative change (cycles can be permitted on motorways). The downside of this approach would be to encourage fast cycling in the knowledge that they were only cyclists present – albeit in both directions. This is also unlikely to meet the predicted demand of micro-mobility and pedestrians – it is therefore not a preferred option.
- Cycles only – tidal flow. It is reasonable to assume that there will be a predominant southbound flow in the morning and northbound in the evening. A tidal flow would remove

the risk of head-on and side-swipe collisions would encourage higher speeds. This is also unlikely to meet the predicted demand of micro-mobility and pedestrians and people cycling 'against the flow' – it is not a preferred option.

Staffing, Maintenance and Emergency Access

There are numerous operational access requirements that need to be addressed to provide access for emergency services:

- Pre-positioning customised maintenance and emergency vehicles at the NZ Police station by the northern access point to the shared path.
- Modify existing Waka Kotahi processes for managing vehicle incidents in constrained single lane running environments.
- The provision of trained staff (Wardens) to assist users, attend incidents and identify and intervene with any potential suicide attempt would be a prudent investment. These staff (minimum of 2 on duty when the Shared Path is open) would also have powers to control speed and other anti-social actions and summon assistance as required.

Severe Weather

It is accepted that on occasions the Shared Path will need to be closed due to severe weather.

- Some data on frequency and predictability of severe weather events has been provided by Waka Kotahi.
- The data provided indicates that on around 40 occasions a year cross winds would exceed 50km/h.
- The data also indicates that unexpected string gusts (>75km/h) that are likely to affect cyclists may be experienced up to five times a year.
- A need to enable users to make informed decisions about the likelihood of the path closing.
- Facility to prevent access to and then manage the exit of people crossing the bridge.
- The addition of windsocks to provide visual cues of weather conditions to regular users.

The data provided by Waka Kotahi indicates that, as expected there will be some occasions when cycling is not possible, but the level of unpredictability and frequency appears to be far lower than Waka Kotahi state. Waka Kotahi have stated that no risk assessment has been undertaken on the effect of wind on pedestrians and cyclists on the bridge.

Overall, we consider that a cross-section similar to that shown in Figure 31 would be a pragmatic, cost effective and realistic initial design for the Auckland Harbour Bridge Shared Path.

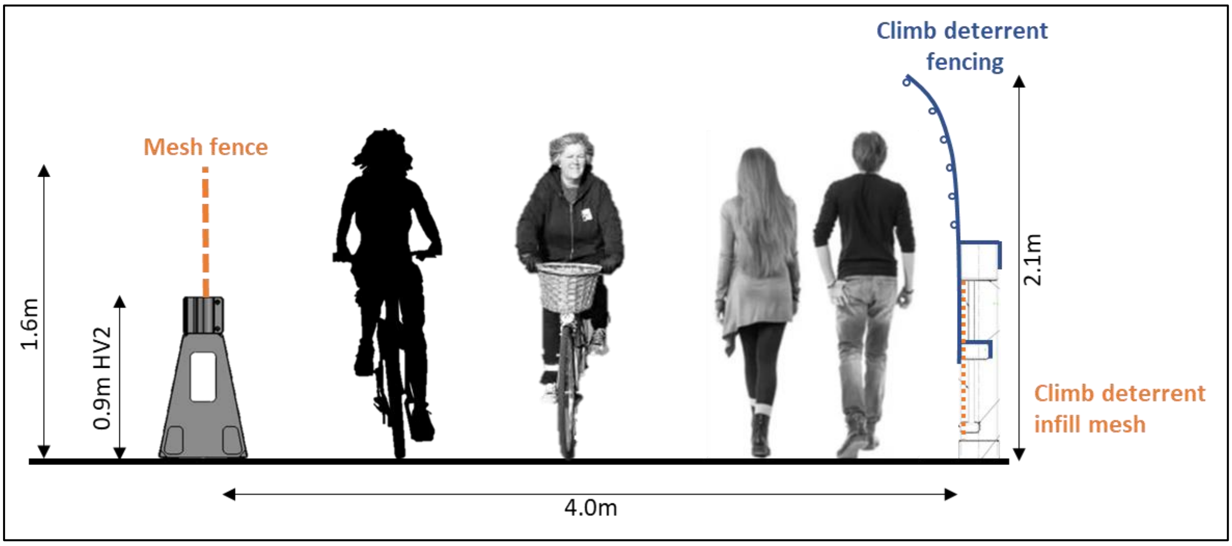

Figure 31 Proposed cross-section of Auckland Harbour Bridge Shared Path to address Waka Kotahi safety concerns (1.8m high people used for reference)

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SmartSense Ltd
June 2023

Assessment of traffic flows on Auckland Harbour Bridge 2013-2023

June 2023

Prepared for

Bike Auckland

SmartSense

people driven intelligence

Executive Summary

Bike Auckland (Client) commissioned SmartSense Ltd to undertake an analysis of the available traffic count data for the Auckland Harbour Bridge (AHB) to assess the what the impact of re-purposing one lane from vehicular traffic to active modes (walking / cycling / personal mobility) (Active Lane) would be on historic traffic volumes.

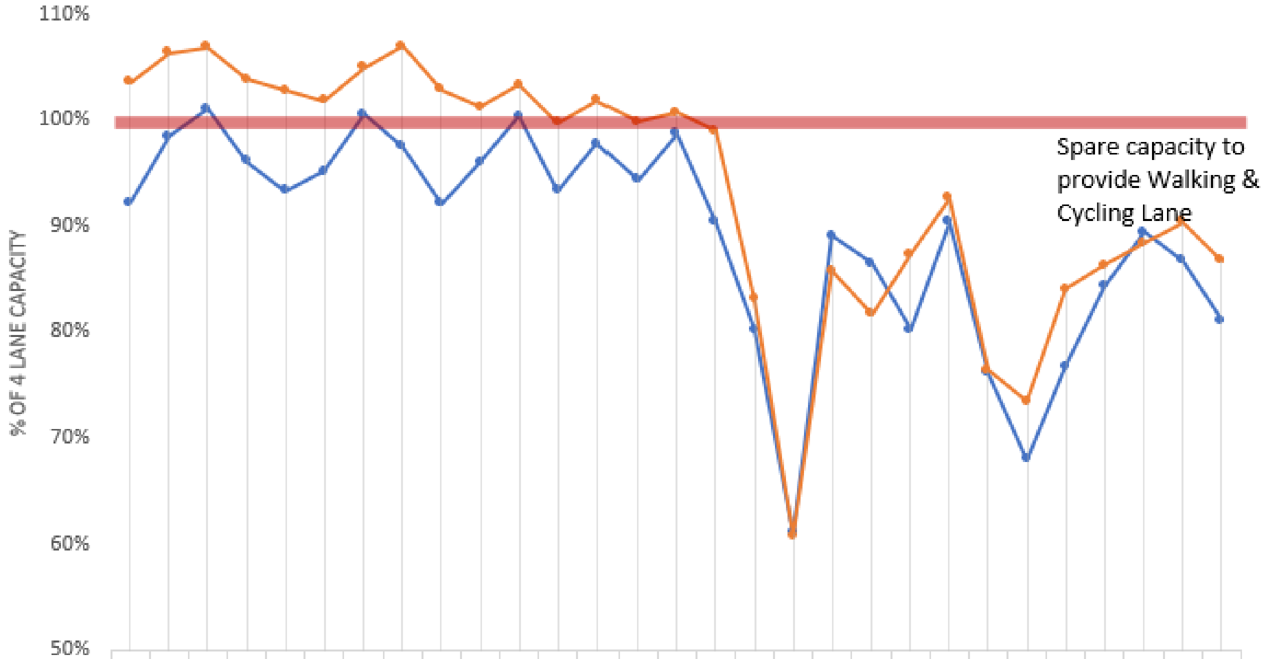
The AHB generally operates with a 5+3 Lane arrangement at peak times with the extra capacity southbound in the morning and northbound in the evening. The reassignment of a traffic lane to active modes would therefore reduce the capacity from 5 lanes to 4 lanes.

An Active Lane is understood to be a 4m wide shared path protected from traffic for people who choose to walk or run and safely ride bicycles or scooters up to 30km/h. The analysis used the available data to determine how a 4+3+1Active Lane bridge configuration would have coped with the actual traffic flows recorded from 2013 to date. As such, this was an analysis of historical data to assess the hours, days, months, and year that the AHB could (or could not) have carried an Active Lane.

The 3, 4, and 5 Lane hourly traffic capacities used by Waka Kotahi to assess traffic flow have been demonstrated to be conservative and flows of up to an additional 200 vehicles per hour for 4 Lane arrangements have been achieved. 2022 (Jan – July) data provided by Waka Kotahi demonstrates that 4 Lanes have been adequate for carrying all peak traffic flows during that period. 2023 summary

The average quarterly peak period traffic flows (Figure 1) from 2013 to 2020 (pre-lockdowns) show steadily reducing traffic volumes towards a flow that could be accommodated in 4 lanes, rather than the 5 provided. The (3 month rolling) average southbound morning flows could have been accommodated in 4 Lanes (rather than 5) from 2018 onwards and northbound the same trend achieved close to a 4 lane capacity in late 2019.

Post lockdown there has been a slow recovery in 2021 to levels well within the capacity of a bridge that has a lane dedicated to people choosing to walk or ride cycles and scooters. 2023 data



	2016				2017				2018				2019				2020				2021				2022				2023
	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1
Southbound	92%	98%	101%	96%	93%	95%	101%	98%	92%	96%	100%	93%	98%	94%	99%	90%	80%	61%	89%	86%	80%	90%	76%	68%	77%	84%	89%	87%	81%
Northbound	104%	106%	107%	104%	103%	102%	105%	107%	103%	101%	103%	100%	102%	100%	101%	99%	83%	61%	86%	82%	87%	93%	76%	73%	84%	86%	88%	90%	87%

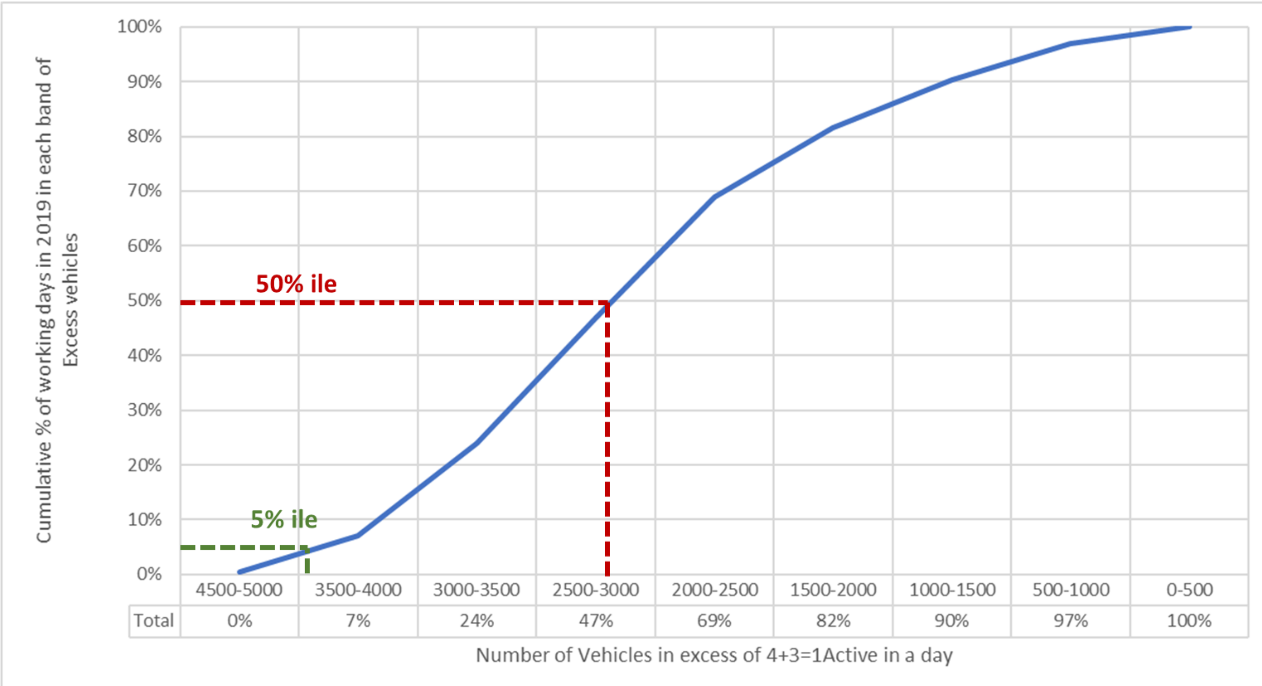
Figure 1 Percentage of 4 Lane capacity used - (M-F Southbound 06:00-9:00, Northbound (15:00-19:00) since 2013 by quarters. (Updated April 2023)

Although the average flows used above are a useful indicator of trends, there are significant day-to-day and seasonal variations in flow and detailed analysis of the data trends show that between 2016 - 2019 (pre-pandemic) traffic volumes were reducing, with a southbound peak period reduction of 1.4% between 2018-19. Trend data from 2016-2019 indicates that (even without the impact of the pandemic) the busiest three-hour peak period southbound traffic flows on the AHB would be fully accommodated with a 4-lane capacity by 2021. Northbound data indicates that (even without the impact of the pandemic) the busiest three-hour evening peak period northbound traffic flows on the AHB would be less than the 4- lane capacity by 2022.

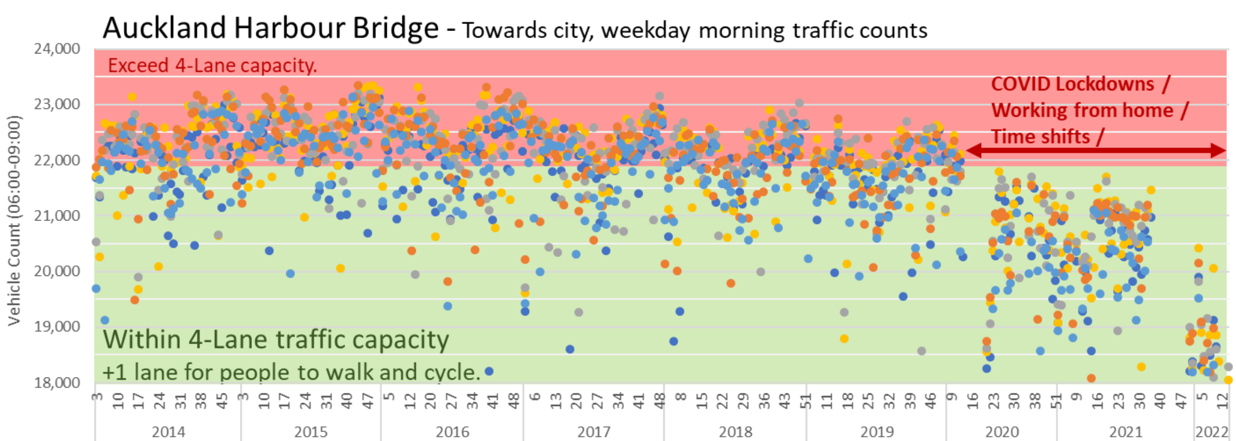
As the data shows that just 1 Lane for people (not in vehicles) is capable of being deployed with minimal overall impact of traffic flows we found no evidence to support Waka Kotahi's statement[1] that a traffic reduction on the AHB of 17,000 vehicles per day (vpd) would be required to avoid wider traffic disruption in Auckland.

[1] Waka Kotahi I&D Paper 23/11/21 P2 Para 6

Using 2019 data a daily traffic reduction of 3,000 vpd (for 50% of days) or 5,000 vpd (for 100% of days) would have been sufficient to provide sufficient capacity on a 4-lane configuration. In early 2022 these flow reductions were achieved.



To indicate the changes to weekday traffic on the AHB since 2014 Figure 2 has been included here that shows the realistic capacity of providing 4-Lanes of traffic in the morning peak rather than the 5 lanes provided with key points listed below.



	2014	2015	2016	2017	2018	2019	2020	2021	2022
% of days within 4-Lane capacity	30%	13%	25%	29%	36%	53%	93%	100%	100%
Year on Year change			12%	3%	7%	17%	40%	7%	0%

● Mon ● Tue ● Wed ● Thu ● Fri

Figure 2 Traffic volumes and capacity Auckland Harbour Bridge 2014-22

- From 2016 to 2019 the morning traffic volumes into the city on the Auckland Harbour Bridge have reduced by around 1% each year.

- The 2020 COVID pandemic accelerated this reduction, with 2020 traffic volumes[2] being lower than 2019, 2021 volumes being lower than 2020, and 2022 (to date) lower than 2021.

- Morning city bound traffic volumes on the Auckland Harbour Bridge in January-March 2022 were 19% lower than the same period in 2016.

- By 2019 over half the working mornings (53%) could have accommodated a walking and cycling lane without restricting city-bound traffic on the Auckland Harbour Bridge.

- If those trends continued, then by 2022 (even without COVID) a walking and cycling lane on the Auckland Harbour Bridge could have been accommodated without restricting city-bound traffic.

- On every weekday morning since March 2020 the city-bound traffic on the Auckland Harbour Bridge could have been fully accommodated in 4 Lanes, rather than the 5 lanes that were provided.

- 2022 data indicates that peak period traffic flows on the Auckland Harbour Bridge are up to 14% lower than their 2016 peak.

- Even prior to 2020 the off-peak traffic flows rarely exceeded the Proven Capacity of the bridge (6% of the time southbound, 10% northbound) and these occurred between 12:00-14:00 so would be likely to have cleared before the afternoon peak period..

- Since March 2020 a walking and cycling lane could have been installed with without significantly restricting the morning traffic heading to the city.

- These figures are conservative as they take no account of people who would choose to leave their cars at home and take a bus, walk, run, scoot or cycle across the Auckland Harbour Bridge.

A range of other factors have been identified that indicate traffic flows on the AHB are likely to remain significantly below the 2016 peak values. Whilst several of the factors are pandemic related there is evidence that any return to 2016 traffic levels may not occur in the near future, if ever.

[2] Median values 06:00-09:00 M-F

This report has focused on assessing data that has been made available by Waka Kotahi, and SmartSense wishes to thank Waka Kotahi for their high level of co-operation.

There is strong evidence to demonstrate that whilst converting one lane of the AHB to Active modes would have had some impact on historic traffic flows, in the current environment it's impact would be easily manageable. With some degree of time and mode shift by current low occupancy vehicle occupants the effects could be mitigated.

If March 2022 – April 2023 traffic levels are maintained, then reassigning one lane to Active modes would be no significantly impact on motor vehicle travel times or traffic flows using the AHB. With the June – August period showing the lowest traffic volumes and evidence to date showing 2022 traffic volumes being less than 2018/19 then there is a strong incentive to operate the bridge in a solely 4+4 lane mode. This would save money (no need to move the barriers twice a day) and most usefully provide a wealth of real-world data on the actual impact of running 4 lanes for in the peak flow direction. This should be accompanied by accurate lane specific traffic counts and point-to-point journey time monitoring on the approaches to and across the bridge.

Richard Young,

June 2023.

Rev	Prepared by	Date Issued	Reviewed	Status
Draft	R Young	10/4/22	Bike Auckland	Initial comments
REV0	R Young, CEng, MICE, DIC, MBA, MSc, BSc.	28/4/22	Viastrada (Dr Glen Koorey PhD, ME(Civil), BE(Hons), BSc, CMEngNZ	Peer review and Bike Auckland Board review
REV1	R Young, CEng, MICE, DIC, MBA, MSc, BSc.	16/5/22		Updated with peer review and Bike Auckland comments
REV2	R Young, CEng, MICE, DIC, MBA, MSc, BSc.	4/7/22		2019 Northbound data added and off-peak capacity assessed.
REV3	R Young, CEng, MICE, DIC, MBA, MSc, BSc.	15/9/22		2022 April – July data added.
REV4	R Young, CEng, MICE, DIC, MBA, MSc, BSc.	27/6/23		August 2022 – March 2023 data added and report updated.
REV4.1	R Young, CEng, MICE, DIC, MBA, MSc, BSc.	29/6/23		Excess vehicle graphs added and modified.

Contents

1. Introduction

The Auckland Harbour Bridge (AHB) carries State Highway 1 (SH1) across the Waitematā Harbour between Stokes Point and Westhaven. The main bridge is around 1,040m between anchorages[3] with the elevated highway extending to around 1,800m between Sulphur Beach Reserve and Shelly Beach Road off ramp.

The main bridge comprises of two two-lane structures (clips-ons) that were added onto the original central 4-lane bridge providing a total of eight lanes. There is a movable concrete barrier on the central bridge which enables a tidal flow of traffic with up to five lanes available for traffic in one direction and three in the opposite direction.

Waka Kotahi (New Zealand Transport Agency) is the Road Controlling Authority and responsible for the bridge.

Through a series of Official Information Act requests[4] and data pro-actively released [5] [6] by Waka Kotahi the 15 minute and 1 hour traffic volumes crossing the AHB have been obtained along with the normal positions and times of the moveable barrier and information on abnormal events including a bridge strike in late 2020.

This report contains the results of analysis of the available data to assess the potential effect of a re-assignment of one traffic lane to active modes on the AHB's ability to carry the traffic flows recorded.

[3] Waka Kotahi Suicide Prevention Barrier Feasibility Study Report 18_19 SH1N BSN 4232 Auckland Harbour Bridge 383545-18_19-BR-SH1-4232-RP-FS-001-REV_F1 May 2019
[4] OIA 10208, 9262, 9593 and 9816
[5] https://opendata-nzta.opendata.arcgis.com/datasets/tms-traffic-quarter-hourly
[6] https://www.nzta.govt.nz/resources/state-highway-traffic-volumes/

2. Scope of Report

The report contains an assessment of the actual flow data (vehicles per hour (**vph**) and vehicles per day (**vpd**)) from 2013 onwards on the AHB. The bridge has a movable barrier so that although it has eight lanes the number of lanes in either direction can be flexed from three to five.

The assessment includes an analysis of the likely impact that a bridge with seven traffic lanes (4+3 or 3+4) and one dedicated to active modes (+1Active) would have on those flows.

The report's scope is limited, and the following items are out of scope:

- Traffic impacts and assessment of any delays off the bridge, including the wider Auckland motorway and road network.
- Assessment of re-routing onto SH16/18/20 associated with the bridge strike in late 2020.
- Detailed design assessment of the converted lane (barriers, on/off ramp provisions).

3. Methodology

Waka Kotahi have made significant volumes of data available. Some data was obtained through Official Information Act requests and other data was downloadable from the Waka Kotahi website. Some questions on the reliability of Waka Kotahi count data was expressed by their consultants at a meeting held between the author and Waka Kotahi[7], whilst it is accepted that loop-counters may not be perfect they are generally relied on provide reliable and consistent data and for the purposes of this report it is assumed that all data provided by Waka Kotahi is accurate.

Limitations on Data

Whilst Waka Kotahi have provided a large volume of 15-minute interval data there are some gaps which have limited the analysis:

- There is no 2019 Northbound count data available on the AHB counter due to 'equipment and loop failure'.[8]
- This data has been replaced by data that Waka Kotahi have provided since May 2022 based on nearby loops and is considered to be reliable.[9]
- Between January and November 2020 15-minute interval count data was not available and 1-hour data has been used instead.
- No count data is available for the period of a major bridge strike.[10]
- Some counts were classified by Light and Heavy, and some were only classified as Light but the volumes appeared to include both Light and Heavy. It is understood that Heavy would include trucks and buses. As only totals of all vehicles have been used this has not been given detailed consideration.
- For peak periods the percentage of Heavy vehicles appears to be around 5%.
- Count data back to 2013 was made available and this has been included in the analysis.

[7] Meeting Young, Deb Hume (DH) - National Manager Multimodal & Innovation (WK), Andy Hooper (AH) – Technical Advisory Service to Auckland System Management (ASM, WK), Mike Beamish (MB) – Harbour Bridge Structural Engineer (BECA)
[8] OIA 9262 Reply 8/2/22
[9] OIA 10208
[10] OIA 9593 incident between 18/9/20-6/10/20

4. Capacity Analysis

To undertake this analysis an assessment of the capacity of the AHB to carry the measured traffic volumes with the introduction of a 'virtual' Active Lane was undertaken. This assessment used data provided by Waka Kotahi to quantify the potential impact that a 7-lane 4+3+1Active Lane arrangement would have had on the existing 8 lane (5+3 at peak times) structure.

Stated Capacity -

Waka Kotahi provided the following capacities and standard operating hours for different lane configurations in Table 1[11]. These have been taken as the 'Stated Capacities', we have not sought for Waka Kotahi to justify these capacities.

With the exception of the 3 Lane capacity the Stated Capacities are lane multiples of 1,800 vph. This value is generally accepted as a reasonable value for a typical highway. In the case of the AHB there are some specific environmental factors that could make the adoption of these values conservative: -

- High degree of lane separation and lack of merging/ lane changing. Due to the bridge geometry there are never more than 3 lanes available for traffic to change lanes (even when 5 are open). This limits the ability of traffic to encounter flow break-down.
- Steady speeds. The AHB has an 80kph speed limit and it is observed that traffic using the crossing travels at a steady speed (slightly below 80kph).
- High level of driver familiarity. The bridge is regularly used by many drivers who are familiar with how traffic flows and are less likely to behave in a way to cause flow-breakdown.
- Alignment, gradient and lack of on/off ramps. The AHB is a long straight route with two steady gradients (<5%) and little side friction or other factors that could disrupt flow.

Table 1 Movable barrier and AHB capacity

Times (M-F)	Southbound		Northbound	
	Lanes Available	Stated Capacity (vph)	Lanes Available	Stated Capacity (vph)
5 am to 10 am	5	9,000	3	5,200
10 am to 3 pm	4	7,200	4	7,200
3 pm to 10 pm	3	5,200	5	9,000
10 pm to 5 am	4	7,200	4	7,200

[11] OIA 9262

Proven Capacity
Based on Lane Available data provided in Table 1 an analysis of the actual traffic flows recorded for each configuration was determined.

Figure 3 shows the recorded southbound flows did not exceed the Stated Capacity in the 4 and 5 lane configurations but in the 3-lane arrangement the Stated Capacity of 5,200 was exceeded 13% of the time.

The fact that actual traffic flows of the 3-lane arrangement exceeded the 5,200 vph Stated Capacity for a significant proportion of time implies that the Stated Capacity provided by Waka Kotahi is overly conservative. As a result, we have proposed a Proven Capacity of 5,400 vph as the capacity that the actual data from Waka Kotahi supports.

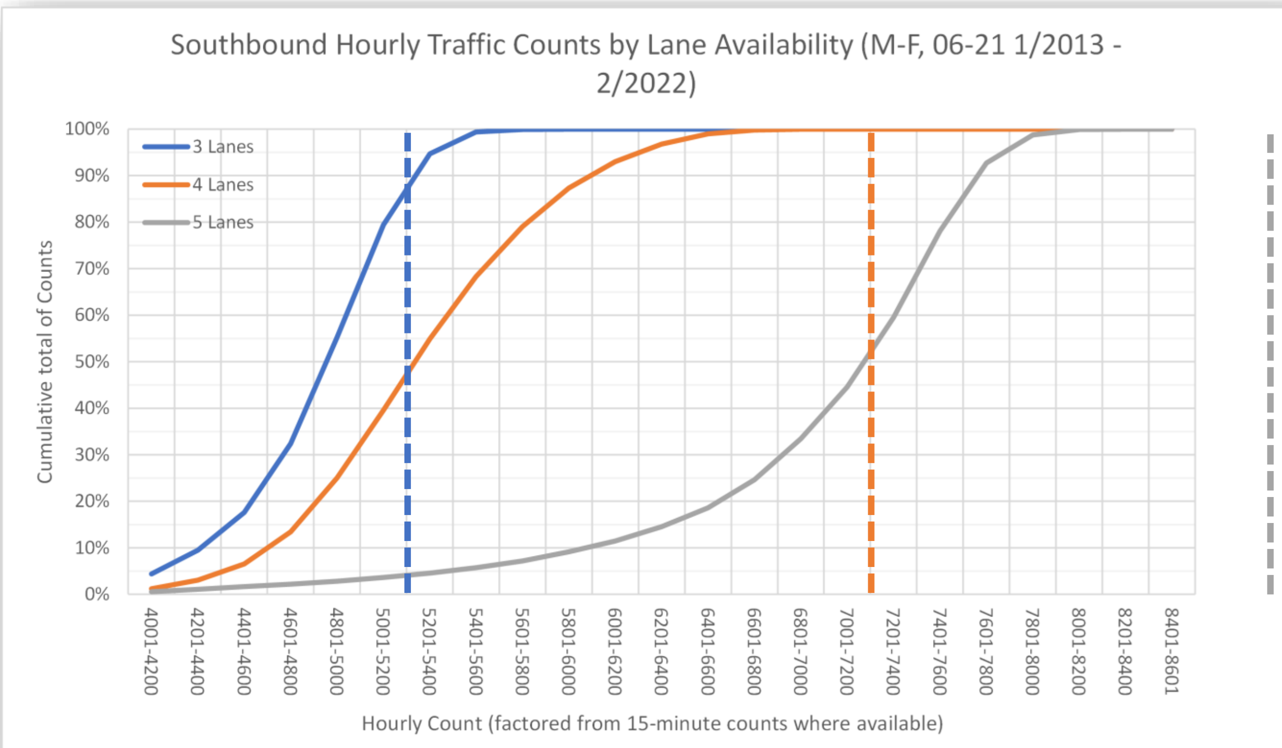


Figure 3 Traffic Counts by Lane Availability (Southbound)

Figure 4 shows the maximum northbound flows did not exceed the Stated Capacity in the 4-lane configuration but marginally did exceed the Stated Capacity in both the 3 and 5 Lane configurations. This demonstrates that when the bridge has 3 or 5 lanes flowing in one direction the Proven Capacity is higher than the Stated Capacity of 5,200 / 9,000vph.

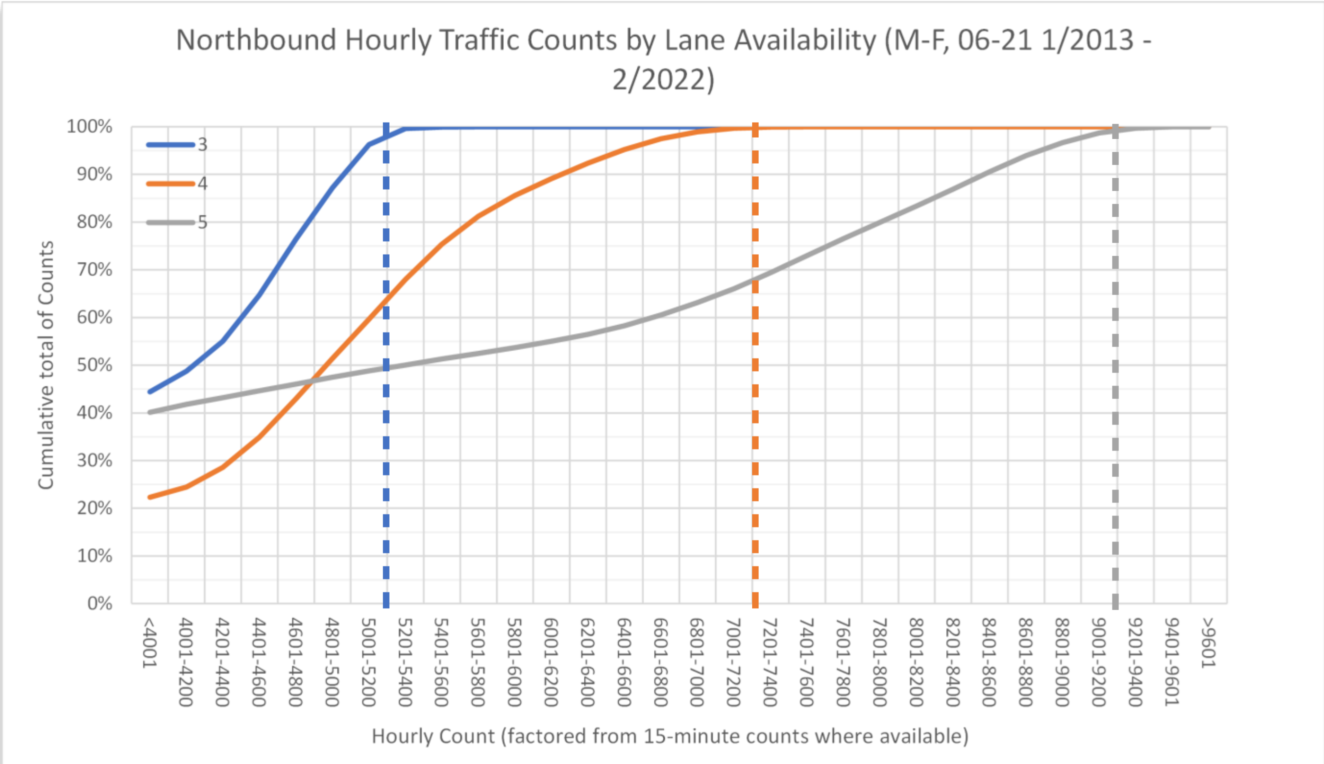


Figure 4 Traffic Counts by Lane Availability (Northbound)

On the basis of the actual hourly flows provided by Waka Kotahi, the 3 and 5 lane configuration capacities can reasonably be increased by 200 and 400 vph respectively.

The 4-lane configuration is generally used at off-peak times when traffic flows may not approach capacity. So, although the Stated Capacity of 7,200 was only rarely exceeded, this does not mean that the Proven Capacity is not higher. The 2013-2020 data supports a 4-lane arrangement having a Proven Capacity of 7,270 (around 1% higher than Stated Capacity), whilst a Proven Capacity increase of 300vph would appear to be a reasonable assumption based on the increases of 200 and 400 for 3 and 5 lane alignments.

In February / March 2022, due to COVID affecting staff availability, the 4-lane arrangement was left in place for several weeks across all periods and this provides more recent information on the Proven Capacity of a 4-lane arrangement. This is described in below.

Any increase in Proven Capacity of a 4-lane arrangement above the Stated Capacity would have a material effect on the potential of the AHB to operate in a 4+3+1Active arrangement. Even a modest increase in the 4-lane Proven Capacity has a significant impact on the analysis.

Using the actual count data from 2013 to 2/2022 it is apparent that even these higher Proven Capacities (Table 2) were exceeded on many hundreds of occasions. This means that Proven Capacities potentially higher than we have used for the analysis may be reasonable. Any higher Proven Capacity, especially above 7,270vph for 4 Available Lanes will materially reduce any negative impact of an Active Lane on AHB peak period traffic flows.

Table 2 Comparison of Stated Capacity and Proven Capacity

Available Lanes	Stated Capacity (vph)	Proven Capacity (vph)	Uplift in Capacity (% above Stated)	Number of 1-hour periods where Proven Capacity exceeded	Comments	Maximum recorded hourly count
3	5,200	5,400	3.84%	1,252 since 1/1/2013	All between 15:00-20:00	5,767 SB15:00-16:00 17/12/21
4	7,200	7,270	0.97%	10	All in November / December 2020	7,417 NB 20/12/2013 14:00-15:00
5	9,000	9,400	4.44%	223, since 1/1/2013	All between 16:00-18:00	9,428 30/9/2013 17:00-18:00

These Proven Capacities (Table 2) were used for analysing the ability of the AHB to operate with 3+4 Traffic and 1 Active Lane. This is reasonable because the data provided by Waka Kotahi demonstrates that their Stated Capacities are overly conservative, unrealistic and represent an understatement of the AHB's proven performance.

5. Available Traffic Count Data

Waka Kotahi have provided a significant volume of data from 1/2013 to 7/2022.

As described elsewhere, data was generally provided at 15-minute intervals but where that was unavailable 1-hour data has been used and the totals are understood to include both Light and Heavy vehicles. In total over 930,000 individual count records and over 514 million classified vehicle counts were provided.

The data (Figure 5) shows that until 2019 that typical daily traffic counts would be around 90,000 in each direction (Wednesday) with some day-to-day fluctuation.

In 2019, the Waka Kotahi northbound counter failed to provide any data, but this was replaced with comparable data from nearby. In June 2022 Waka Kotahi provided alternate data for this location and this has now been included in the report. The Northbound data is significant issue because the evening northbound peak period traffic flows were heavier than the morning southbound volumes and from early 2020 the Covid pandemic significantly affected traffic.

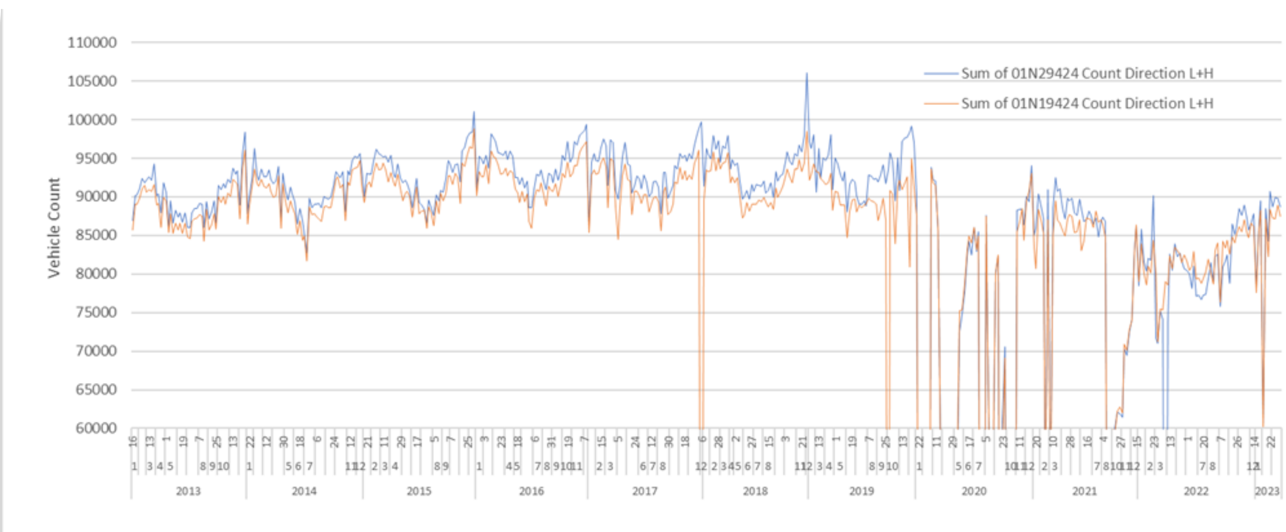


Figure 5 Vertical scale is Daily Traffic Counts Northbound (Blue) and Southbound (Orange) on the AHB. Data for Wednesday, excluding first and last 2 weeks of each year, 0 counts are where no data is available.

Variation between years

From 2016 until 2019 (pre-pandemic) there has been a net reduction in southbound traffic using the AHB. In 2018 this was 2.3% lower than the 2016 peak(Figure 6). [12] This trend of reducing traffic accelerated significantly in 2020 (25% reduction) and 2021(16%) but these two reductions were affected by pandemic lockdowns.

Between 2018 and 2019 the southbound reduction was 1.4%, equivalent to over 2,600vpd on the AHB. Ignoring the pandemic effects, the data demonstrates a measurable and accelerating trend of reducing traffic volumes on the AHB. There is no reason to believe that this trend will cease, especially as work practices have changed, with a likely permanent increase in working from home practices. The 2022 data (weeks 9-31) provided BY Waka Kotahi confirms this trend with Southbound traffic volumes in this period around 14% lower than 2016.

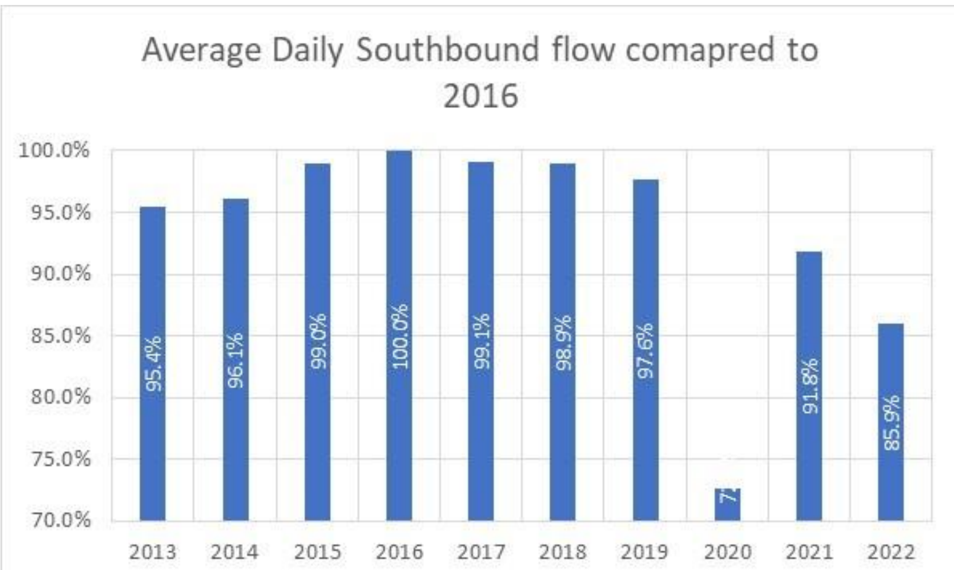


Figure 6 Changes in Southbound weekday volumes 2013-2022 Weeks 9-31, where complete data available

The Northbound daily count (Figure 7) also shows a peak in 2016 with a reduction each year since then and a 1.2% reduction by 2019.

2022 data shows an 16% reduction in traffic volumes since the peak in 2016.

[12] Data based on the 133 days where same Week / Weekday (Mon-Fri) was data available from 2013-2020.

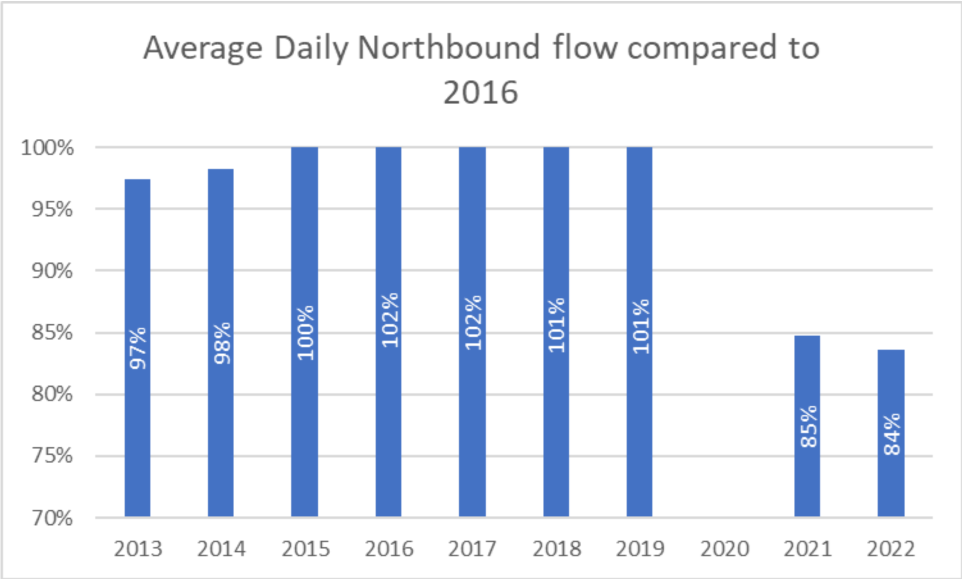


Figure 7 Changes in Northbound weekday volumes 2013-2022

Seasonal variation in traffic flow across the Year

Across the calendar year there is a week-to-week variability in traffic counts. Figure 8 shows the Southbound daily counts.[13] There is a clear trend of lower counts between weeks 19-35 of the calendar year with peak volumes in February and November/December. This trend is highlighted for **2019** but the graph shows a common trend for 2016-2019.

This analysis demonstrates that the week-to-week fluctuation in traffic flows is likely to affect the impact of any Active Lane has on 4+3 traffic lane arrangements on the AHB. Therefore, any analysis of the impact of an Active Lane would need to take account of the seasonal fluctuation in traffic flows. For example, higher February flows may increase the impact of an Active Lane on traffic compared to June.

[13] Taken on every Thursday where reliable count data was provided.

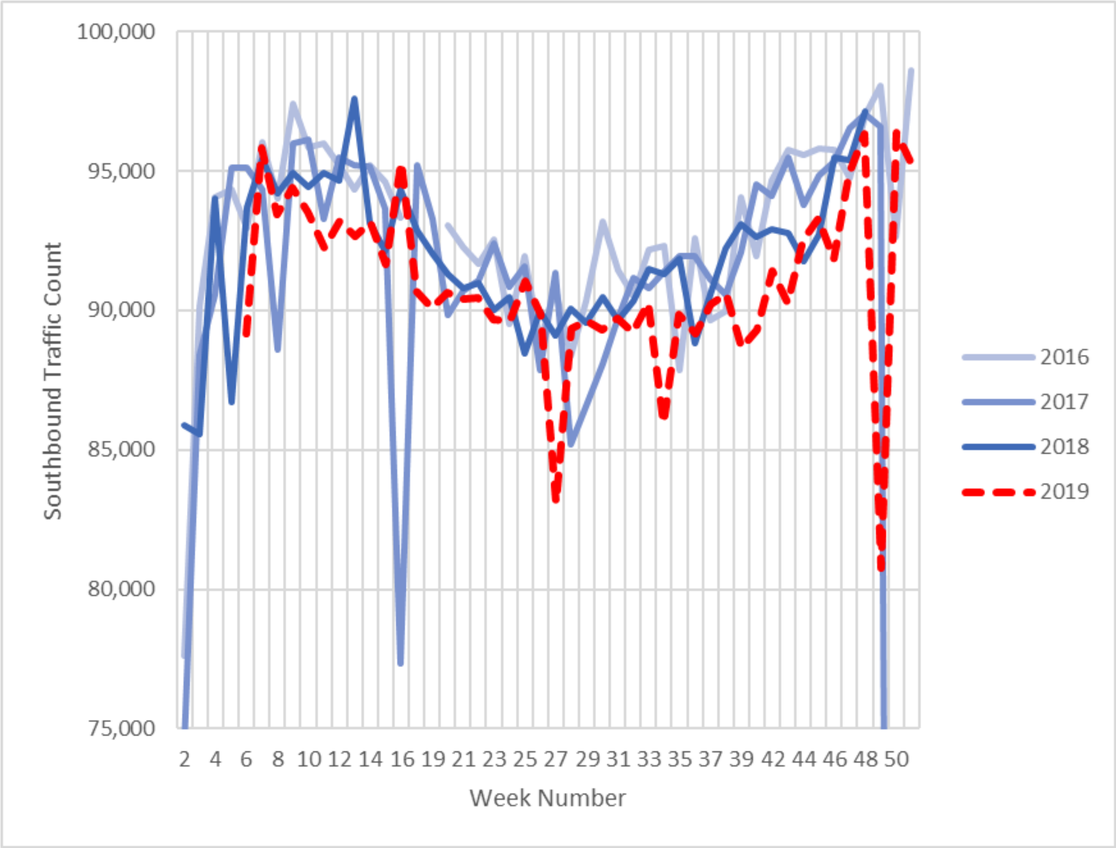
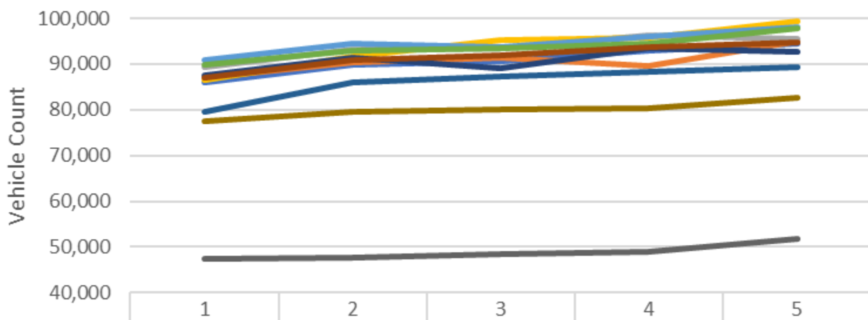


Figure 8 Weekly variability of Northbound (Thursday) volumes on the AHB

Weekday fluctuations in traffic flows

As well as seasonal and year-on-year trends the data also showed a variability in daily flows across the working week. Figure 9 shows the clear upwards count from Monday (Day 1) to Friday (Day 5) for this southbound count data. Across the week the counts would typically vary from the weekly mean by ±5%. This day-to-day variability is significant when analysing the impact of an +1Active Lane on 3+4 Traffic Lanes.



	1	2	3	4	5
2013	85950	89812	90543	92914	94574
2014	87144	90292	91329	89527	94889
2015	89239	93097	93562	96255	95588
2016	86481	91746	95216	95831	99377
2017	90899	94432	93819	96128	98123
2018	89841	93019	93576	94416	97857
2019	87432	91423	89106	93555	92596
2020	86990	90972	91850	93638	94666
2021	47501	47695	48390	49076	51669
2022	77580	79645	80130	80215	82692
2023	79654	86064	87235	88349	89253

Weekday (M=1, for Week 10)

Figure 9 Daily variation in traffic counts across M-F, week 10 2013-2022

As with other variations across time, this day-to-day variation may affect the impact of an Active Lane on traffic, so it is important that any analysis considers a range of flows and undertakes a sensitivity (probabilistic) analysis rather than using a single flow.

Additionally the marked reduction in traffic volumes in 2021 (lockdown affected) and 2022 (not affected by lockdown) are evident. In 2023 the Week 10 counts are still around 5,000 vpd below those of 2020 (pre-pandemic).

6. Peak Periods – impact of a one lane reduction.

To be able to provide an Active Lane, one of the eight existing traffic lanes will need to be repurposed. It is understood that Waka Kotahi's preference is that the outside lane of the eastern clip-on would be most suitable as the Active Lane, this arrangement (Figure 10) provides for 4 lanes in the dominant flow direction and 3 in the opposite direction. Should it be required it can also be configured to enable 5 lanes northbound (away from the CBD).

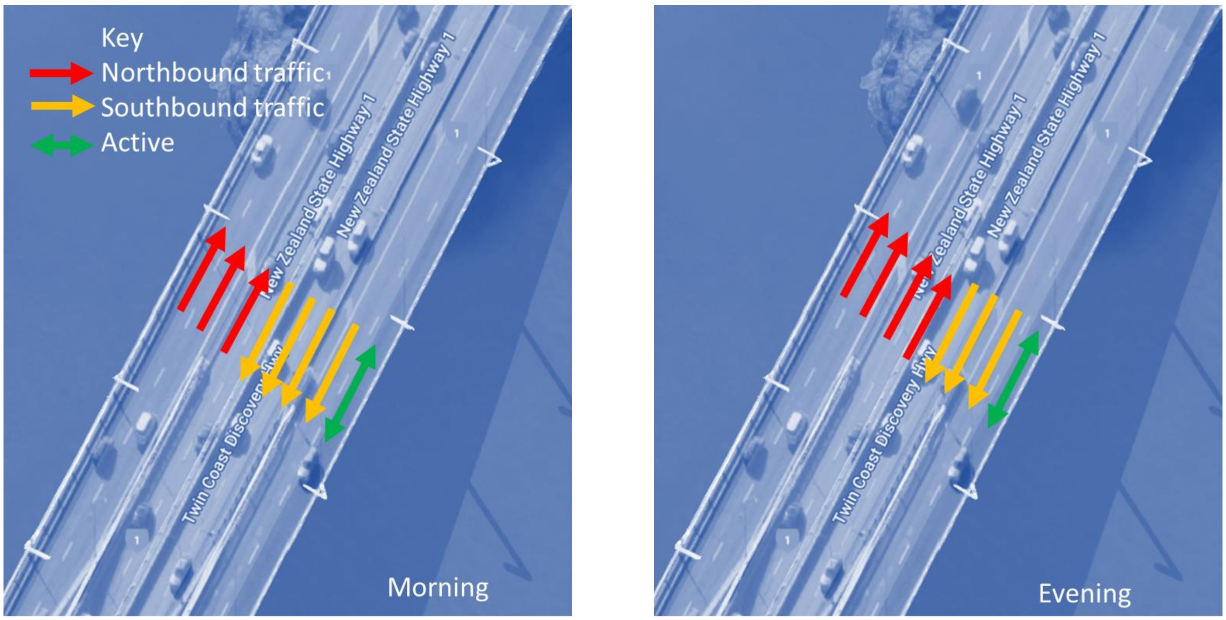


Figure 10 Schematic of Traffic Lane arrangement AHB with Active Lane

As the AHB has a movable barrier this would have the effect of reducing the dominant flow from 5 to 4 lanes at peak times. The alternate option is to maintain 5 lanes in the dominant flow direction and reduce the opposite direction from 3 to 2 lanes.

Our analysis of the theoretical impact on historic traffic flows for these two options shows that the 4+3 option rather than the 5+2 option (combined with optimised barrier movement times) provides the least impact to traffic. This 4+3 Traffic + 1 Active has therefore been used for the analysis.

As described above, the traffic flow on the AHB is not uniform across the day, week or season and year; it varies. It is unclear how Waka Kotahi have undertaken their analysis of the ability of the AHB to cope with an Active Lane. For our analysis we have used the data provided by Waka Kotahi to assess the AHB's capacity to manage an Active Lane on each hour of each day[14] since 2013. This has allowed a sensitivity assessment to be undertaken of the potential impact of an Active Lane to be performed.

[14] Where data was available

7. Analysis of Peak Period flows since 2013

To investigate the historic ability of the AHB to cater for an Active Lane, an analysis has been undertaken that assesses the percentage of peak periods each year since 2013 in which the AHB historic traffic flows could have been affected by repurposing one lane to active modes.

The analysis in this paper is based on historic data and takes no account of trip reduction / reassignment / time shifting / migration to active transport and public transport that may have occurred over the time period. This is deliberate, in order to be clear that the analysis of this report does not rely on behavioural assumptions or policy levers. Recipients of this report may apply their own assumptions on changes in transport behaviour (i.e. use of the Active Lane by numbers of people), including policy levers such as congestion charging.

However, by assessing the impact of an Active Lane on actual data over many years it has been possible to identify trends showing how often a 3+4 Traffic +1Active configuration would have been inadequate to meet unfettered traffic demand.

The analysis utilises the Proven Capacity (Table 2) to determine the percentage of peak periods since 2013 that the AHB could have accommodated an Active Lane.

Table 3 summarises the existing movable barrier timings and those used for the analysis.

Table 3 Existing and analysed Southbound and Northbound traffic lane configuration

Period (24 hour clock)	Existing Southbound (Weekday)	Existing Northbound (Weekday)	Analysis Southbound with 4+3+1 Active	Analysis Northbound with 4+3+1 Active
00-05	4	4	3	4
05-10	5	3	4	3
10-13	4	4	4	3
13-14	4	4	3	4
14-15	4	4	3	4
15-16	3	5	3	4
16-22	3	5	3	4
22-00	4	4	3	4

Southbound Morning Peak
The busiest southbound period occurs between 06:00-09:00 Monday-Friday. Traffic count data from this period has been analysed to assess the theoretical impact that an Active Lane could have had on the AHB's traffic carrying capacity from 2013-2022 (week 31).

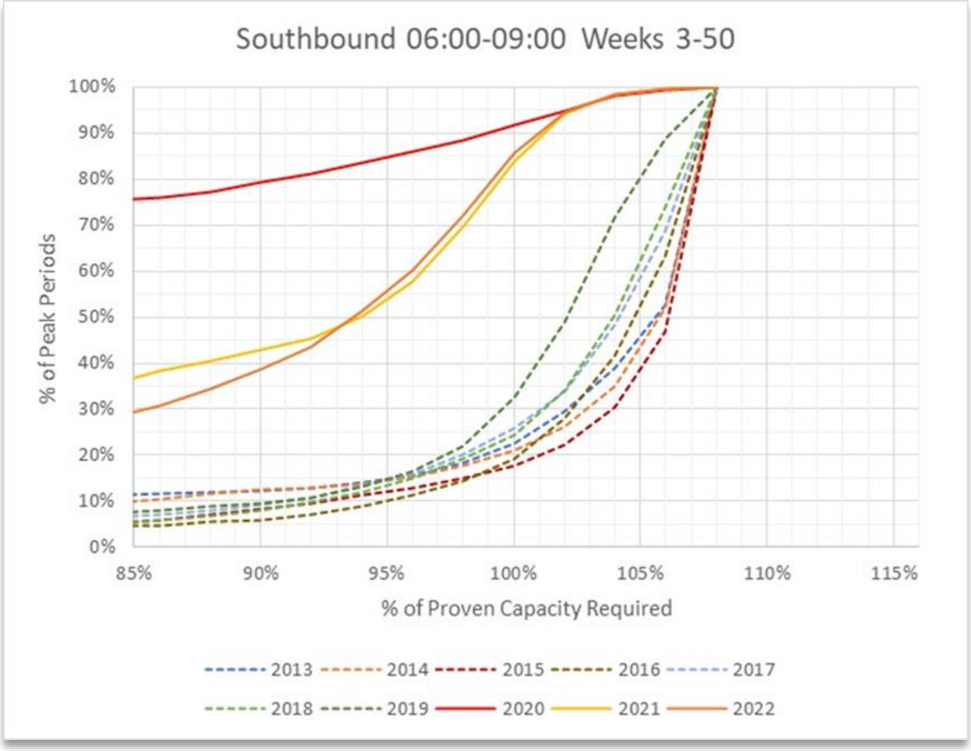


Figure 11 Morning Peak Southbound % of Proven Capacity required with an Active Lane 2013-2022 Weeks 3-50 (2022 to 31)

Figure 11 shows the percentage morning peak Proven Capacity required (for a 4-traffic lane arrangement) for southbound weekday (06:00-09:00) traffic flows. Where the lines cross to the right of the 100% Proven Capacity vertex then that percentage of peak periods in that year can be accommodated with a 4+3+1Active arrangement with no capacity constraints.

For example, in **2015** only 20% of peak periods could be accommodated with no capacity constraints. Each year after 2015 the number of morning peaks that could accommodate an Active Lane with no capacity issues rises: **2016** - 27%, **2017** - 31%, **2018** - 32%, **2019** - 46%.

This indicates that in 2019 on over 100 of the 240 working days (48 weeks) a 4+3+1Active Lane arrangement would have provided sufficient morning peak southbound traffic capacity.

If the annual reduction in southbound morning peak traffic recorded between 2018 and 2019 continued at the same rate, then by 2023 a 4+3 Traffic Active arrangement would not impact flows for around 200 weekdays a year (out of a possible 260 weekdays per year). This analysis takes no account of people migrating from vehicles to use the Active Lane, so can be considered conservative.

The dashed data for **2020** (79%), **2021**(93%) and the first part of **2022** (95%) are affected by traffic reductions associated with the COVID-19 pandemic so should not be relied on as being representative. However, from 2015-2019 there is a clear trend that shows that morning peak traffic volumes have been reducing such that a 4-lane southbound arrangement would have provided sufficient capacity for at least half the time.

The latest data for 2022 (weeks 3-31) shows that 85% of weekday mornings would have had no capacity issues.

The **2019** data additionally shows that 95% of morning peak periods could accommodate an Active Lane with just a 5% traffic volume reduction.

Based on 2019 flows just a 5% reduction in southbound morning peak traffic would enable 95% of all weekdays to support an Active Lane with negligible impact on traffic flows.

Based on 2022 flows just a 2% reduction in southbound morning peak traffic would enable 95% of all weekdays to support an Active Lane with negligible impact on traffic flows.

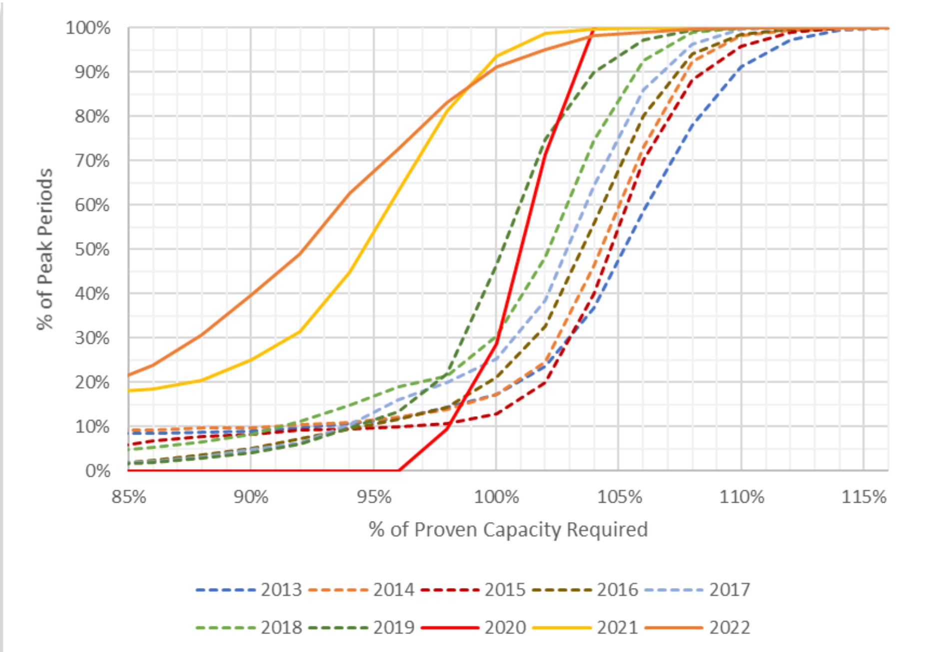
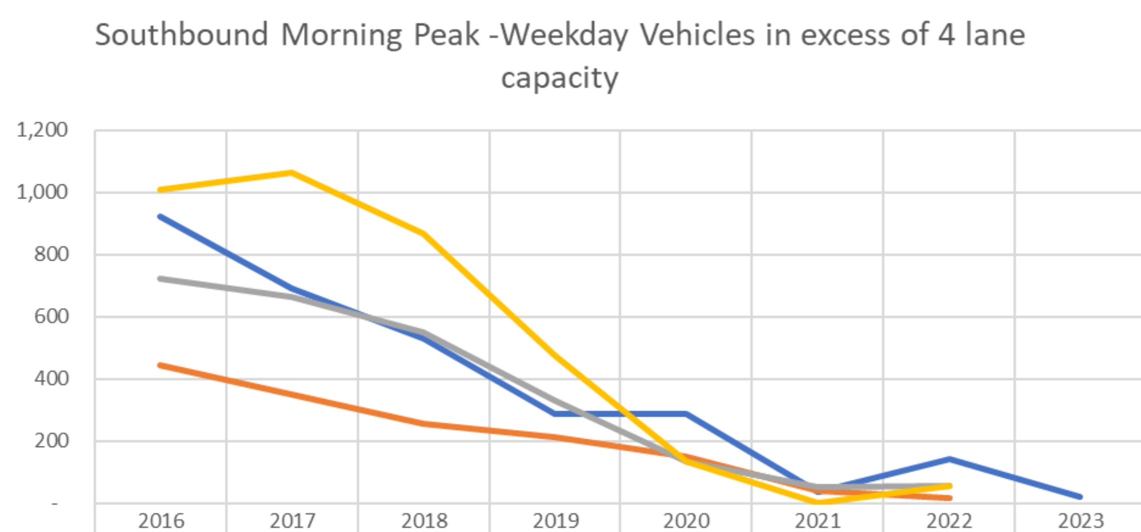


Figure 12 Morning Peak Southbound % of Proven Capacity required with an Active Lane 2013-2022 Weeks 5-11 only

Figure 12 has limited the same analysis to February and the first three weeks of March – this enables the pre-pandemic data from 2020 to be compared to the trend. This indicates that, in the early part of 2020, 95% of southbound morning peak periods could have been accommodated with 4 traffic lanes +3% capacity (or 4 lanes with 3% less traffic).

Based on early (pre-pandemic) 2020 flows just a 3% reduction in southbound morning peak traffic would enable 95% of all weekdays to support an Active Lane with negligible impact on traffic flows.

If an Active Lane was in place then the reduction in vehicle numbers to enable the AHB to effectively operate with an for each morning between 2016-2022 is shown (Figure 13). By June 2022 the average excess traffic (above a 4-Lane capacity) was under 20 vehicles over four hours. The February 2023 data is the lowest average excess traffic volume of only 22 vehicles a day.



	2016	2017	2018	2019	2020	2021	2022	2023
Feb	921	692	530	289	286	37	141	22
Jun	445	352	255	215	152	40	16	
Aug	722	663	549	329	135	53	58	
Nov	1,007	1,061	868	475	135	-	57	

Figure 13 Southbound Morning Peak (06:00-09:00) number of vehicles in excess of 4 lane Proven Capacity

The February data (up to 2020) is considered unaffected by the pandemic and shows from 2016 to 2020 that the number of excess vehicles reduced from **921** (2016) to **286** (2020). This **286** represents only 1.3% of the AHB's Proven Capacity during that period.

If the traffic reduction trend from 2016-2019 continued, then even without the pandemic, the southbound morning peak period flows on the AHB would have enabled an Active Lane to be installed in 2021 with negligible impact on traffic flows.

Northbound Evening Peak

A similar analysis has been undertaken for the northbound evening peak flows. Figure 14 shows the percentage of northbound evening peak periods that would exceed the 4 traffic Lane Proven Capacity since 2013. The 2019 data indicates that on 29% of weekdays that the three-hour evening peak flow could have been accommodated with a 4 Lane arrangement. With just a 5% reduction in 2019 traffic volumes this would have increased to 44% of weekdays.

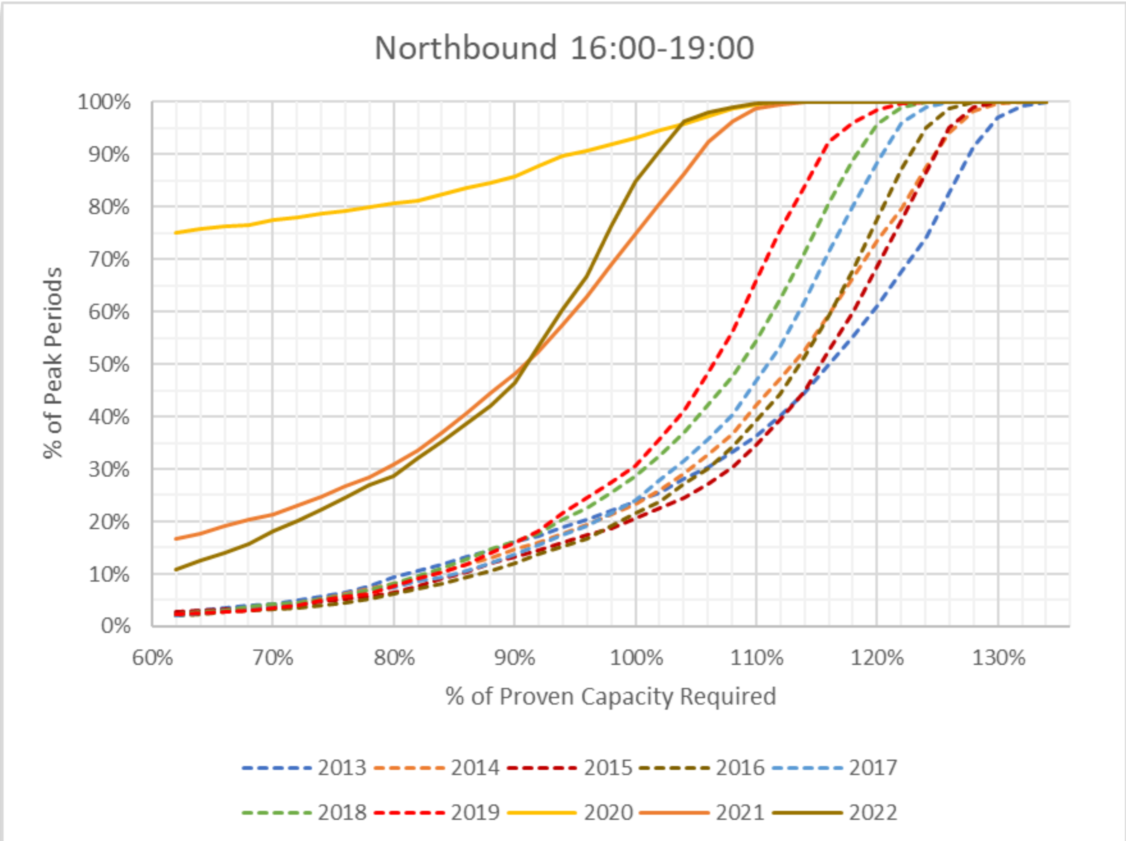
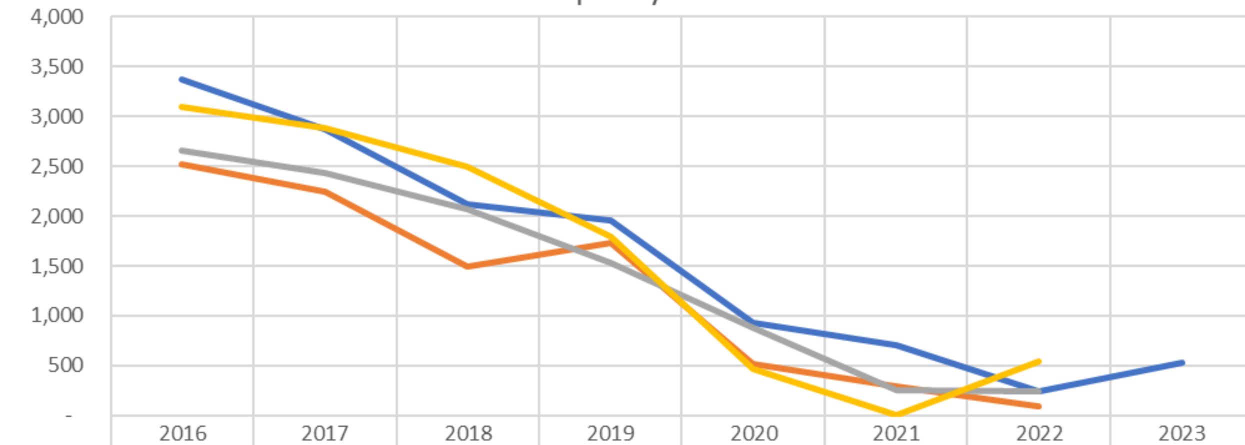


Figure 14 Evening Peak Northbound % of Proven Capacity required with an Active Lane 2013-2022 Weeks 3-50 only (to wk 31 in 2022)

To provide a clear indication on the volume of traffic reduction necessary to facilitate a 4+3+1Active lane to operate the number of vehicles in-excess of the 4 traffic Lane Northbound capacity across the three-hour evening peak has been calculated of four months for each year 2016-2023 (Figure 15). The February data prior to 2021 is considered unaffected by the pandemic and shows from 2016 to 2020 that the number of excess vehicles reduced from **3,366** (2016) to **934** (2020). This **934** represents 4.1% of the Proven Capacity of a 4 traffic Lane arrangement. The 2022 data (Feb and June) clearly shows that the excess traffic volumes had reduced with June 2022 showing under 100 vehicles more than a four lane capacity. The February 2023 calculation of excess traffic volume has risen to 529 but is still lower than the 934 in pre-pandemic 2020.

The trend from 2016-2018 indicates that even without the impact of the pandemic that three-hour evening peak period northbound traffic flows on the AHB would be less than the 4 traffic Lane capacity by 2022.

The 2022 data (weeks 3-31) shows that on 85% of weekdays that a 4-lane evening peak bridge capacity was not exceeded and 2% reduction in traffic would raise that 85% to 96% of the time.



	2016	2017	2018	2019	2020	2021	2022	2023
Feb	3,366	2,875	2,124	1,961	934	703	238	529
Jun	2,514	2,239	1,499	1,730	518	290	86	
Aug	2,653	2,427	2,071	1,533	884	260	246	
Nov	3,097	2,882	2,499	1,796	469	2	544	

Figure 15 Northbound Evening Peak (15:00-19:00) number of vehicles in excess of 4 lane Proven Capacity

Assessment of Quarterly Trends

For each quarter since 2013 the average weekday peak period flows have been expressed as a percentage of a 4-Lane AHB Proven Capacity (7270 vph) southbound Figure 15, northbound Figure 16.

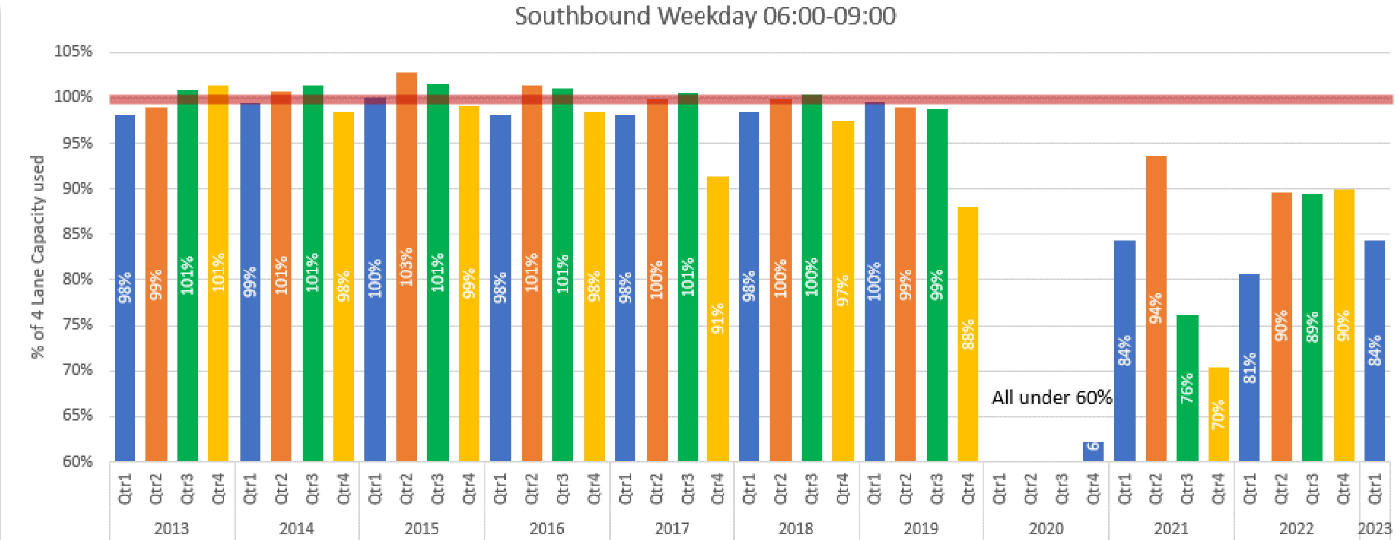


Figure 16 Average quarterly southbound peak (06:00-09:00) flow as a percentage of proven 4-Lane capacity

Since 2016 the weekday morning peak southbound quarterly average traffic flows have reduced. (Figure 16**)**

In each quarter of 2018 and 2019, the weekday southbound morning traffic flows were within the capacity of a 4-Lane arrangement, enabling one lane to be converted for people who choose to walk, cycle, scoot etc. with limited impact on traffic flows.

The 2022 data shows a traffic peak southbound morning volumes are 10-12% lower than a 4-lane bridge's capacity.

The latest 2023 data shows a traffic peak southbound morning volumes are 16% lower than a 4-lane bridge's capacity

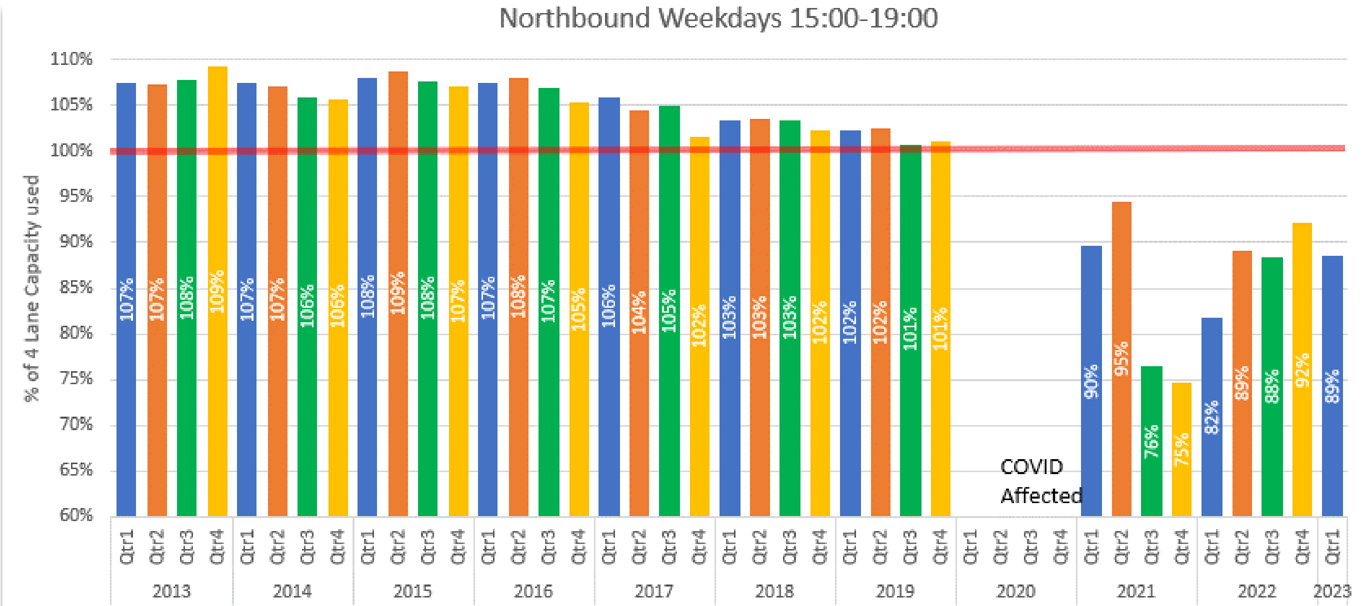


Figure 17 Average quarterly northbound peak (15:00-19:00) flow as a percentage of proven 4-Lane capacity

Since 2016 the weekday morning peak northbound quarterly average traffic flows have reduced. (Figure 17**). By 2020, the weekday northbound evening traffic flows were approaching the capacity of a 4-Lane arrangement.**

The 2022 data shows a traffic peak northbound evening volumes are 11-14% lower than a 4-lane bridge's capacity.

The latest 2023 data shows a traffic peak southbound morning volumes are 11% lower than a 4-lane bridge's capacity

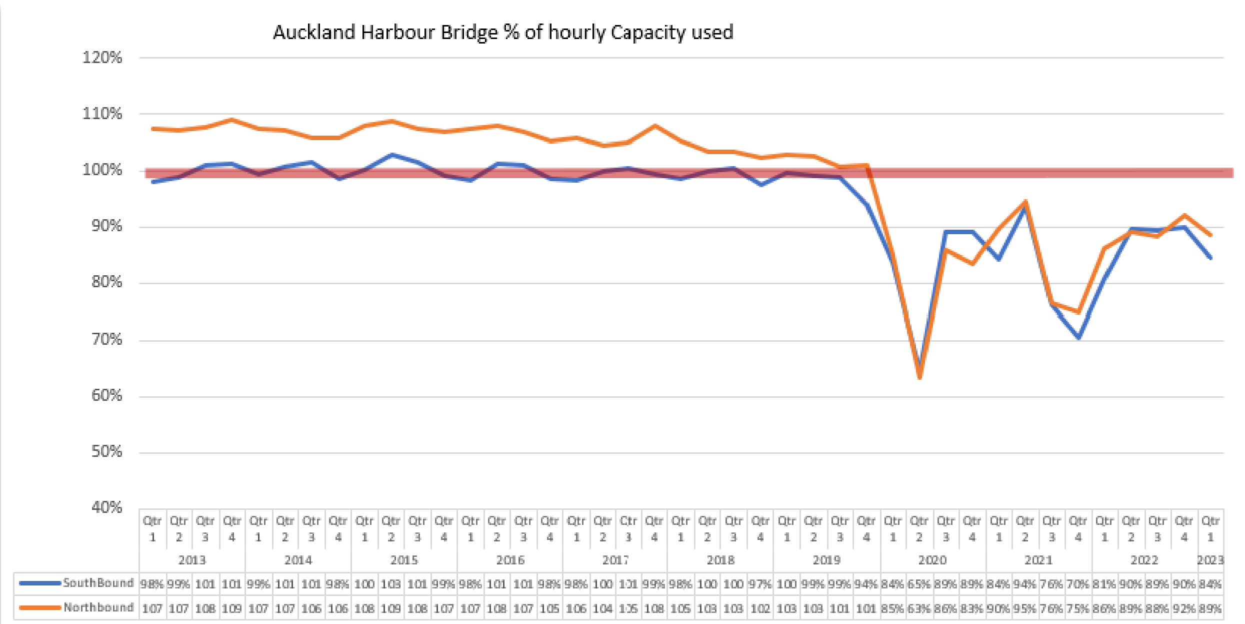


Figure 18 Percentage of 4-Lane Capacity used 2013-2023 Southbound (06:00-09:00), Northbound (15:00-19:00)

When these graphs are combined (Figure 18) the trend of reducing traffic flows prior to the 2020 lockdowns is clearly evident. The late 2021 and all the data for 2022 and the first three months of 2023 is also showing that the peak period traffic can be accommodated on a 4-lane carriageway.

8. Off-Peak flows

Waka Kotahi have expressed[15] concerns that there would be significant risks of the AHB not operating effectively in off-peak weekday periods if one lane was converted for active modes.

To assess the validity of this concern an analysis was undertaken to determine:-

- Frequency of capacity being exceeded each off-peak hour with an active lane installed
- Severity of capacity shortfall each off-peak hour with an active lane installed

Between 2013 and 2022 for each one hour between 09:00-15:00 the number of 15 minute periods when the Proven Capacity was exceeded was calculated. For each quarter year there are 1,560 15-minute weekday off-peak periods.

Figure 19 shows that 2015 Q4 southbound had the largest number of periods (297) when the off-peak liberated capacity was exceeded, this equated to 19.1% of the off-peak period. Over time the frequency and timing of these over-capacity events reduces with capacity exceeded for 104 hours (6.6% of off peak period) in 2019. By 2021 only 54 hours (217 15-minute periods) across the year would have occurred (3% of the time) and predominantly between 13:00-14:00

[15] Meeting between author and Waka Kotahi 27/5/22

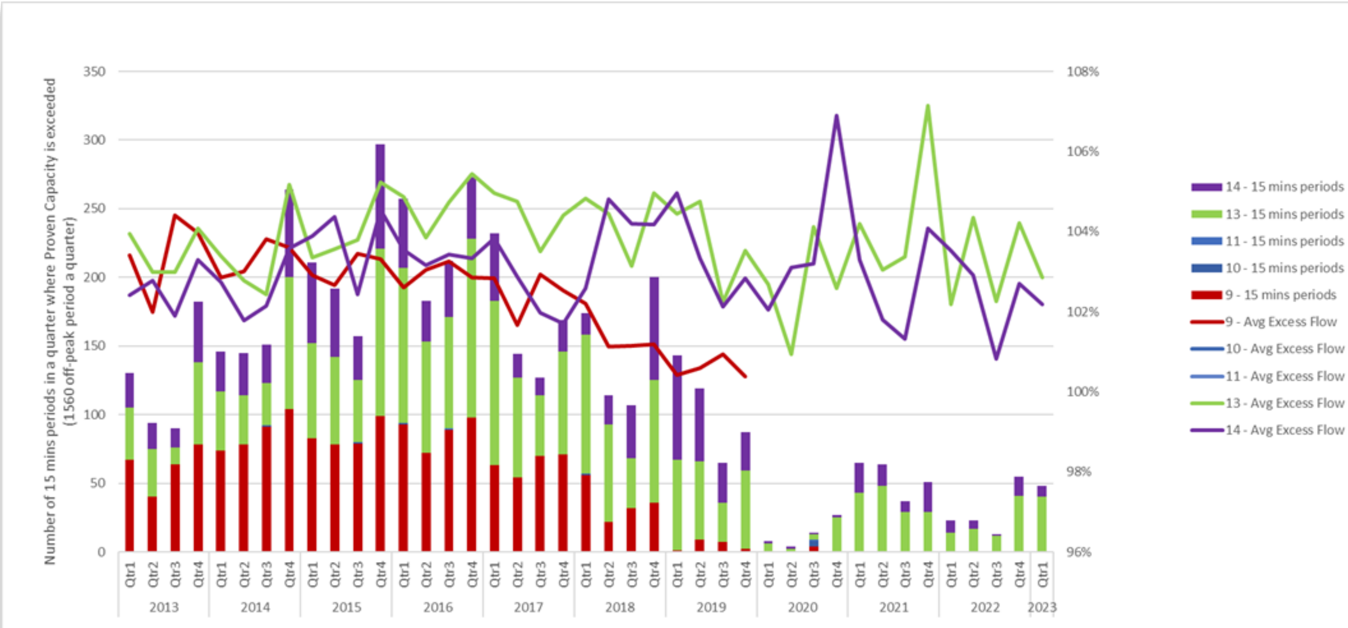


Figure 19 Southbound Off-Peak, frequency and severity of periods where flow exceeds Proven Capacity

Figure 20 shows that 2016 Q4 northbound had a large number of periods (247) when the off-peak Proven Capacity was exceeded, this equated to 15.9% of the off-peak period. With the exception of Q4 2019 and 2020[16], over time the frequency and timing of these over-capacity events reduced with capacity exceeded for 160 hours (10.3% of off- peak periods) in 2020. By 2021 only 107 hours (430 15-minute periods) across the year would have occurred (6.8% of the time) and predominantly between 12:00-13:00.

[16] Unclear why these have such high values, further investigation required.

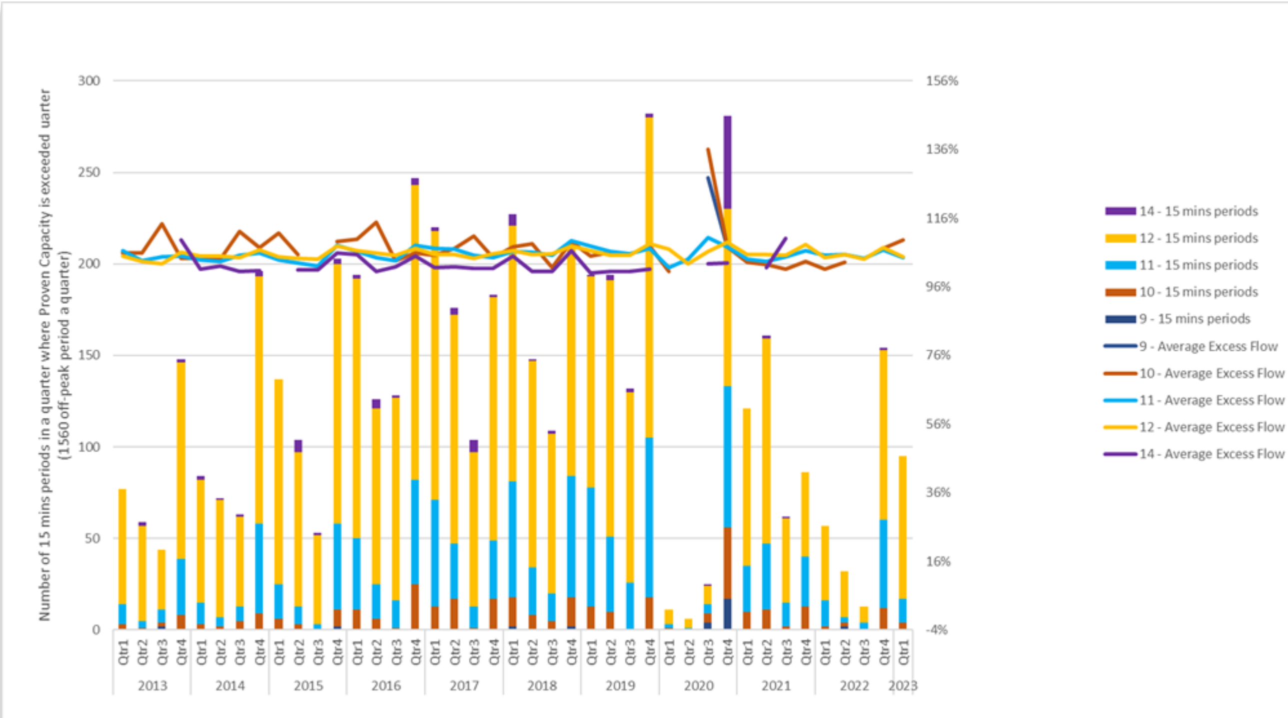


Figure 20 Northbound Off-Peak, frequency and severity of periods where flow exceeds Proven Capacity. (High values in Q4 2019 and 2020 need further investigation.)

The trend of graphs Figure 19 Figure 20 clearly shows that frequency of off-peak capacity exceeding the Proven Capacity is reducing (3-6% of the time) and focused between 12:00-14:00. This indicates a low probability that any off-peak delay would not clear before the evening peak period taken as starting at 15:00.

9. Sensitivity Analysis of 4-Lane Capacity

The 4-Lane capacity of the AHB is the most relevant as in any 4+3+1Active Lane arrangement the 4 Lane direction will take the peak traffic flow.

The AHB does not have any on/off ramps, traffic speed is limited to 80km/h, morning peak period Heavies are 5%[17] and the bridge has a maximum gradient of 5%. It is therefore a relatively controlled environment.

As described above, during peak periods (prior to Feb 2022) the AHB operated in a 3+5 Lane arrangement with the 4+4 Lane arrangement being limited to 10am-3pm (Table 1). During these daytime periods the recorded traffic volumes were lower and therefore are unlikely to represent the maximum flow that the AHB can carry with 4 Lanes.

Additionally, any morning peak 3+4+1Active arrangement will comprise of one lane on the clip-on and three on the main span, this is a different lane format than would occur in a conventional 4+4 lane arrangement.

The NSW Motorway design guide (Capacity and flow analysis)[18] provides some Australian, UK and German examples of ranges flows for differing lanes arrangements.

The 'real world' data from the AHB on 4-Lane capacity is limited and it is therefore reasonable to assess the sensitivity of varying the 4-Lane capacity.

A range of 4 Lane capacities have been assessed (Table 4) for the 2019 southbound morning peak period (06:00-09:00) data to investigate the sensitivity of a 4+3+1Active arrangement. This analysis shows that should a 4 Lane capacity of 7,500 be achievable (300vph higher that Waka Kotahi provided) then for close to 200 out of 240 weekdays[19] in 2019 the morning peak flows could have been accommodated on a 4+3+1Active Lane arrangement. If those 2019 flows in the morning peak reduced by only 2% this would increase the days from 200 to 230, leaving only 12 days where capacity would have been exceeded in 2019.

[17] From 22,694 15-minute interval records from 2013-2021.
[18] Motorway design guide: Capacity and flow analysis – April 2017 Version: 1.0 Table 3
[19] Last two weeks of December and first two weeks of January excluded.

Table 4 Sensitivity analysis for varying capacities of a 4 Lane arrangement (Southbound 2019 mornings)

Capacity	Comment	% of days where Capacity is sufficient to meet demand	Traffic flow reduction % (and approx. count) required to not exceed Capacity on 95% of weekdays
7,200	Provided by Waka Kotahi	39%	6.5% (1,430)
7,270	Proven capacity based on data	42%	6.5% (1,430)
7,300		51%	5.5% (1,200)
7,400		67%	3.5% (770)
7,500		81%	2.0% (440)
7,600	NB with 3 Lanes 5,800, 1 lane 1,800	90%	1% (220)

February - March 2022 4-Lane Operation

Waka Kotahi have provided[20] data on the dates and counts when the AHB operated in a 4+4-Lane arrangement. It is understood that this arrangement was necessitated due to staff shortages associated with COVID-19 isolation requirements preventing the movable barrier being relocated. From Monday February 28th to Monday 28th March (20 working days) the AHB operated in this 4+4-Lane Arrangement (Figure 21).

[20] OIA 9816

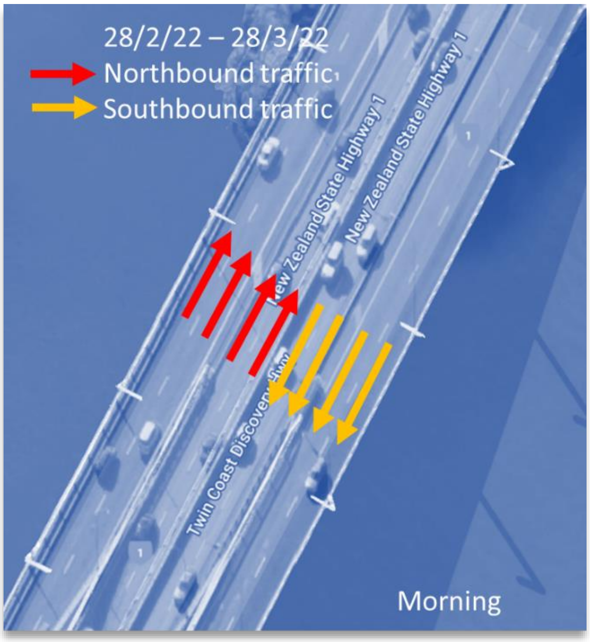


Figure 21 Feb-March 2022 4-Lane Arrangement

Figure 22 shows the 3-hour southbound morning peak period counts on the AHB for March from 2017-2022 with Figure 23 the comparable evening peak period northbound count. These graphs indicate that 2022 volumes were noticeably lower than 2017-2020 (Pre COVID) and also 2021 (COVID affected).

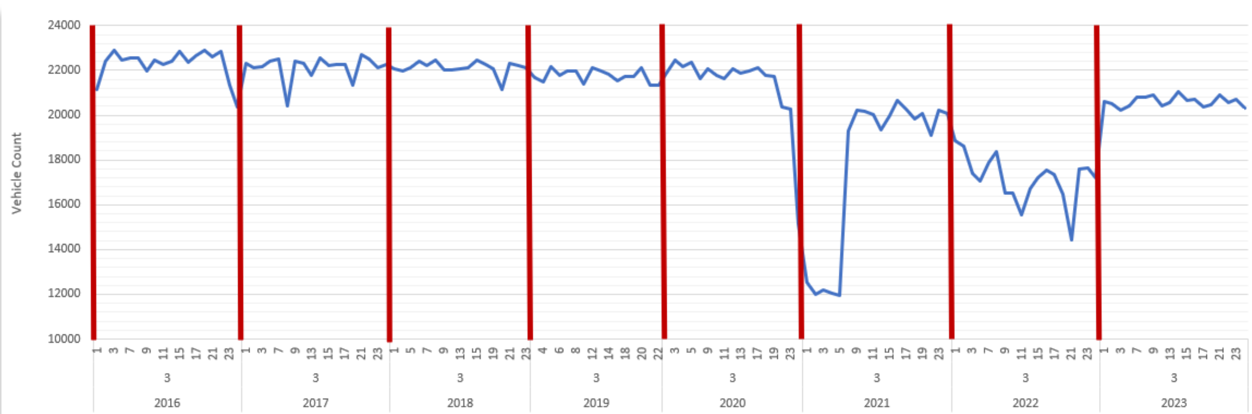


*Figure 22 3 Hour weekday count **(06:00-09:00 Southbound)** March 2017 -2023*

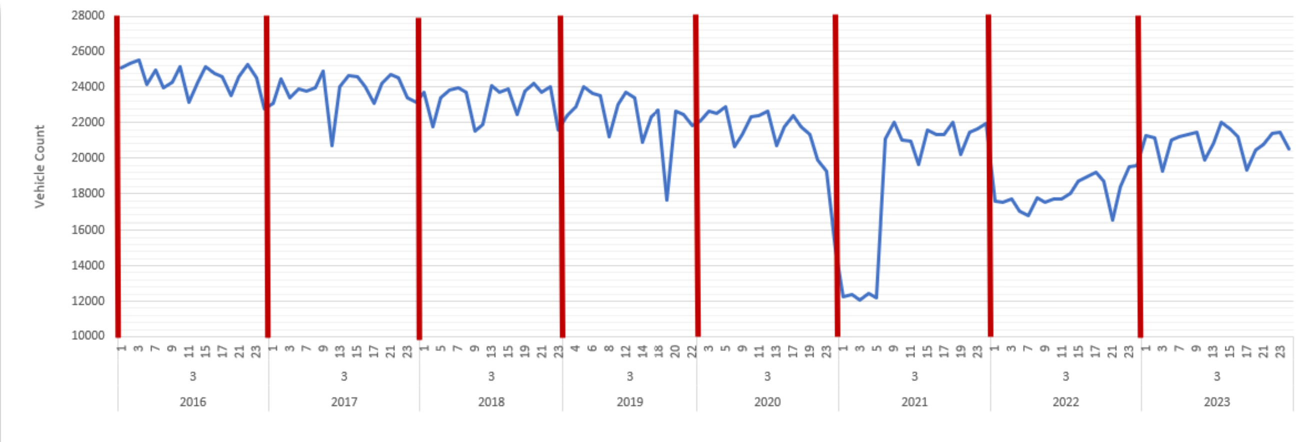


Figure 23 3 Hour weekday count ***(16:00-19:00 Northbound****) March 2017 -2023*

It is considered likely that the March 2022 volumes have been affected by COVID related factors but in both directions the traffic volumes recorded were significantly below Waka Kotahi's Stated Capacity for a 4-Lane arrangement (21,600 for 3 hours).

Waka Kotahi data from March 2022 demonstrates that having 4-Lanes available in the predominant flow direction was more than adequate to cater for peak flows during that period.

Whilst the volumes recorded in March 2022 were below comparable periods prior to the COVID pandemic they did provide some evidence to support hourly flow rates in excess of the Waka Kotahi Stated Capacity of 7,200vph (Table 2) for a 4-Lane road. Based on 15-minute counts over the two busiest peak hours in each direction around 1% of hourly flows exceeded 7,300 vph with an absolute peak of 7,452vph[21]. Figure 24 and Figure 25.

The 2023 data for both directions shows an increase on 2022 but still below the 2020 pre pandemic levels.

[21] 28/2/22 17:30 1,863 vehicles in 15 minutes northbound, equivalent to 7,452vph.

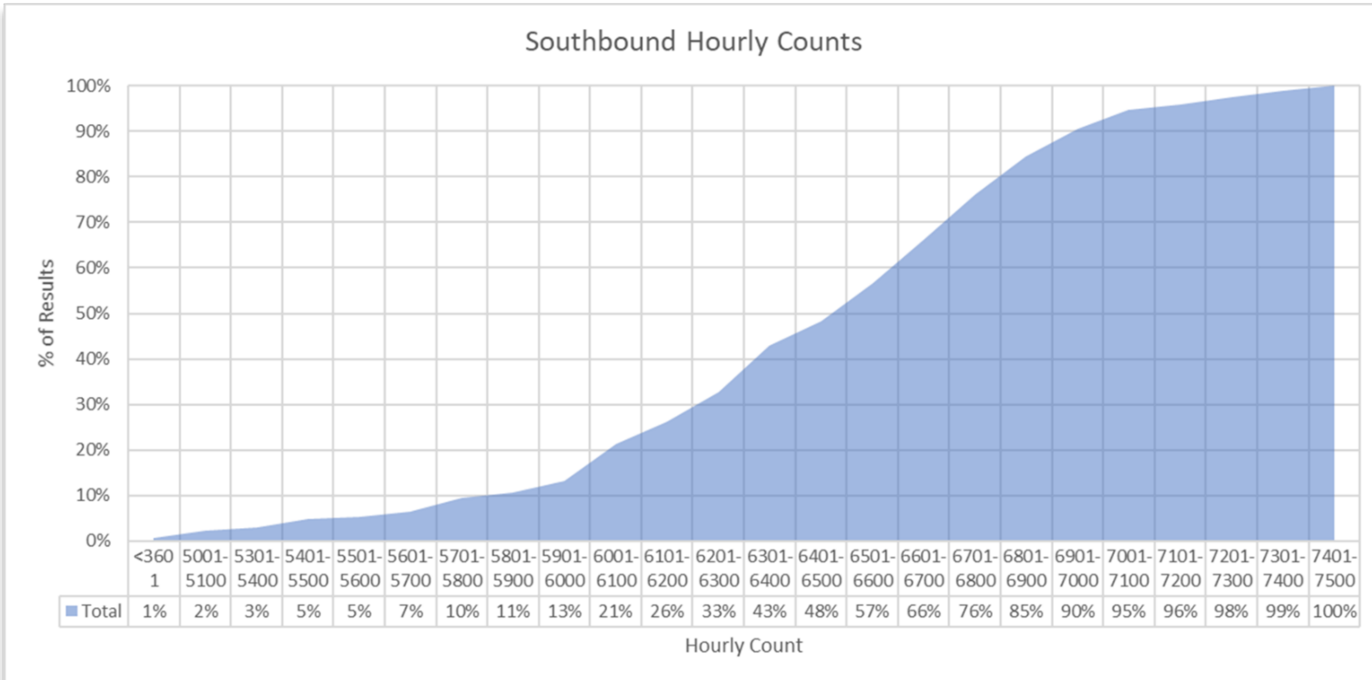


Figure 24 Distribution of Southbound Flow Rates (M-F 07:00-09:00) every 15 minutes March 2022. Maximum 7,444vph, 95%ile 7,240vph

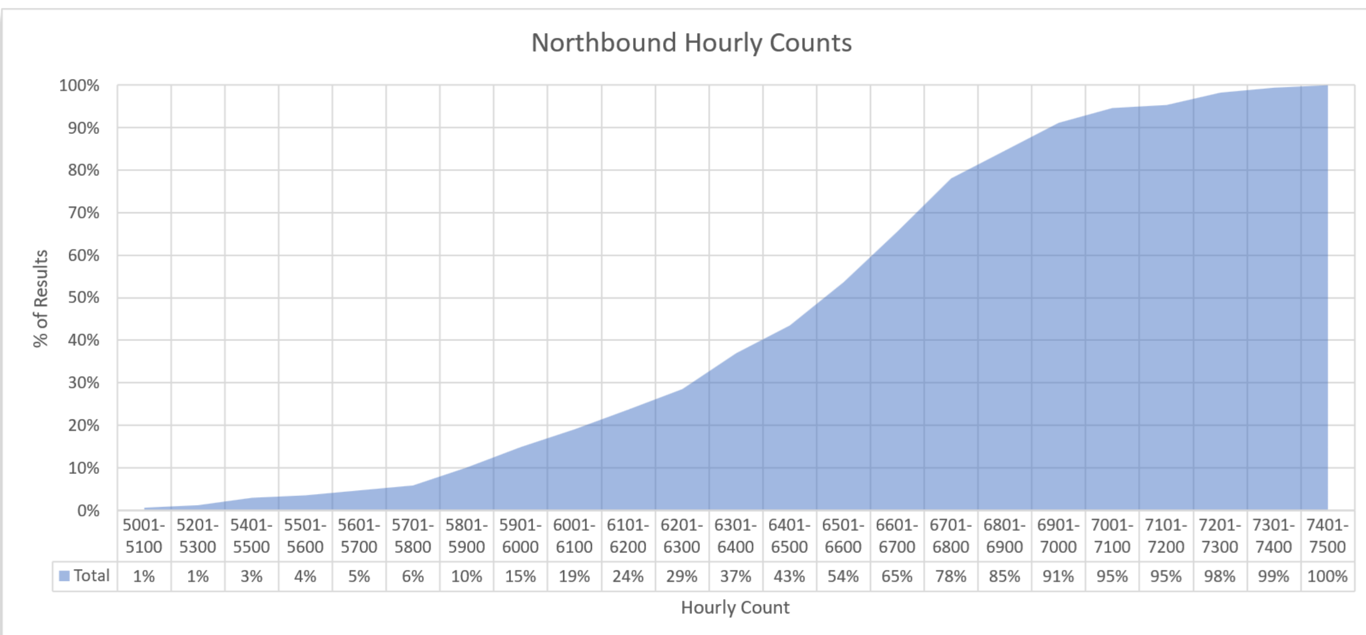


Figure 25 Cumulative Distribution of Northbound Flow Rates (M-F 16:00-18:00) every 15 minutes March 2022. Maximum 7,452vph, 95%ile 7,216vph

These figures support the view that the Waka Kotahi Stated Capacity of a 4-Lane AHB of 7,200vph is conservative and although the Proven Capacity used in the analysis of 7,270vph Table 2 is realistic it to may also be conservative as a capacity of up to 7,400vph has been achieved.

The sensitivity analysis shown in Table 4 shows that at 7,400vph the 2019 morning peak volume would only need to reduce by 3.5% to be within a 4-Lane capacity on 95% of weekdays. This would equate to approximately 770 vehicles across three hours, or one bus full of commuters every 25 minutes[22].

[22] Based on a notional bus capacity of 100 people replacing single occupancy vehicles.

10. Wider State Highway Network

This analysis has focused on the carrying capacity of the Auckland Harbour Bridge. Waka Kotahi have stated that their modelling '*suggests*' that[23] '*to have a neutral effect on the wider Auckland transport System (greater than 17,000 vehicles per day or a 10% reduction)*' on the AHB is required.

We have identified a steady reduction in traffic volumes across years (and months of the year) so the 17,000 vpd number would require Waka Kotahi to provide an explanation of its source. It would be a reasonable assumption that this 17,000vpd reduction was split evenly between northbound and southbound flows – resulting in an 8,500vpd reduction in each direction.

Southbound Flows

The volume of morning southbound traffic (Excess Traffic) above the 4 Lane Proven Capacity are shown in Figure 26(2016 Week 9) and Figure 27 (2019 Week 29) with additional graphs provided in Appendix A. There was negligible southbound Excess Traffic outside of this period.

These southbound figures show that in early 2016 the typical Excess Traffic volume was around 1,000 vehicles over 4 hours, which reduced to under 100 vehicles by mid-2019. Even in a busy month in 2016 the Excess Traffic (1,000) was far below the Waka Kotahi value of 8,500. By mid-2019 the Excess Traffic was less than 1% of the Waka Kotahi stated value.

The mid-2022 data (Figure 28) shows that in week 29 there was no Excess Traffic and all the current morning flow could have been accommodated within 4 lanes.

[23] Waka Kotahi Investment & Delivery Committee Paper 22/11/21' Auckland Harbour Bridge Walking and Cycling Event' P2

2016 Week 9 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity

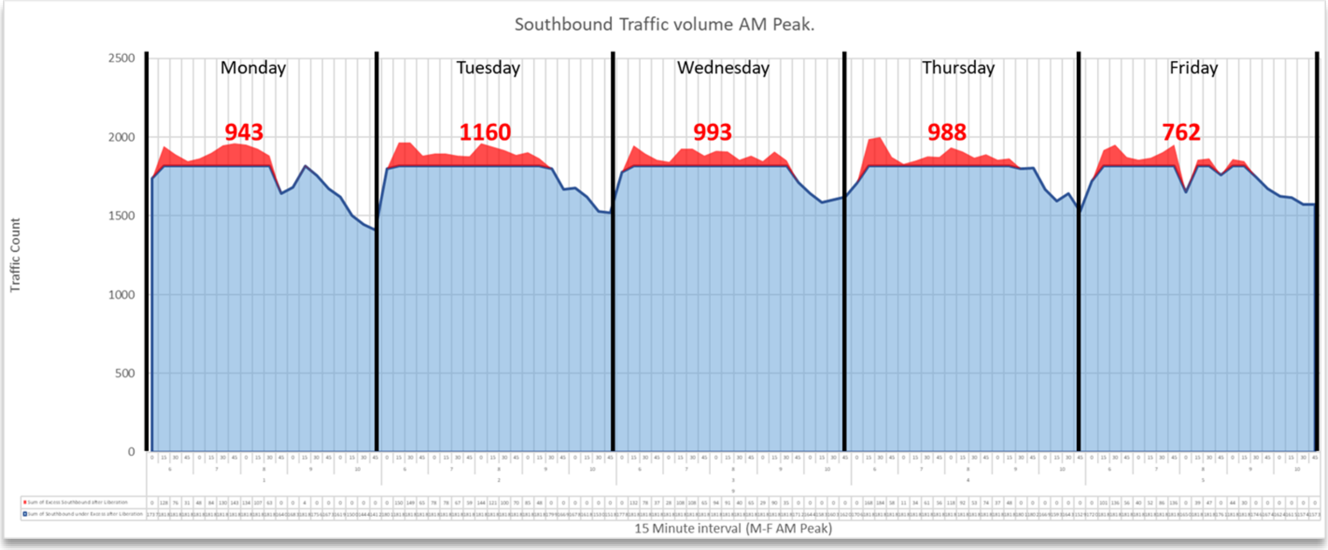


Figure 26 Southbound Excess Traffic 2016 Week 9 Morning Peak

2019 Week 29 06:00-10:00

203 Vehicles above 4-Lane Capacity

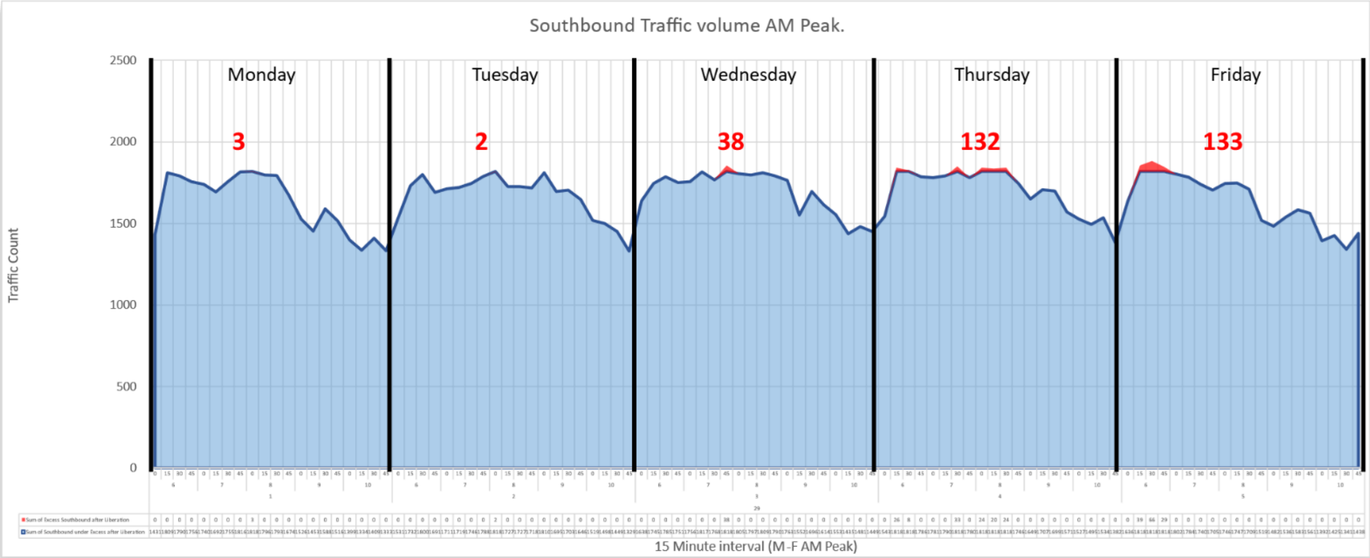


Figure 27 Southbound Excess Traffic - 2019 Week 29 Morning Peak

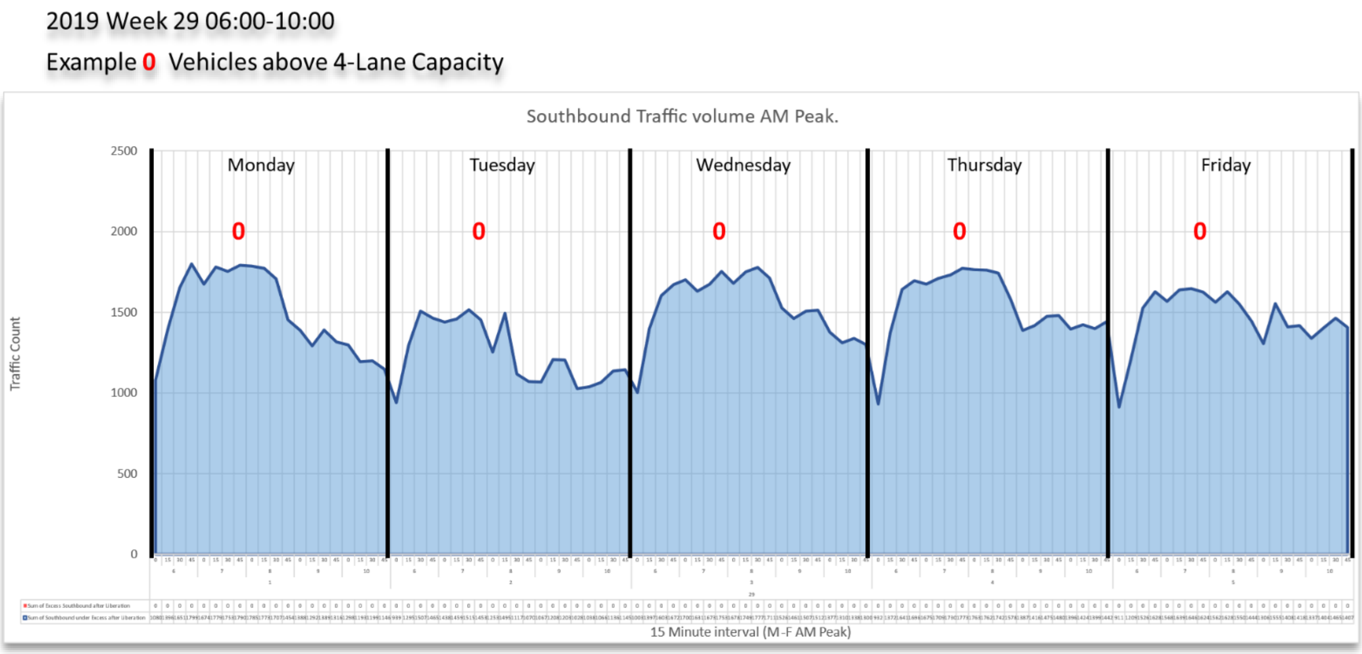


Figure 28 Southbound Excess Traffic - 2022 Week 29 Morning Peak

Northbound Flows

The volume of evening northbound traffic (Excess Traffic) above the 4 Lane Proven Capacity are shown in Figure 29 (2016 Week 9) and Figure 30 (2019 Week 29) with additional graphs provided in Appendix A. There was negligible northbound Excess Traffic outside of this period.

These northbound figures show that in early 2016 the typical Excess Traffic volume was around 3,000 vehicles over 4 hours, which reduced to around 775 vehicles by mid- 2019. In a busy month in 2016 the Excess Traffic (3,000) was only 35% of the Waka Kotahi value of 8,500. By mid-2019 the Excess Traffic was only 9% of the Waka Kotahi stated value.

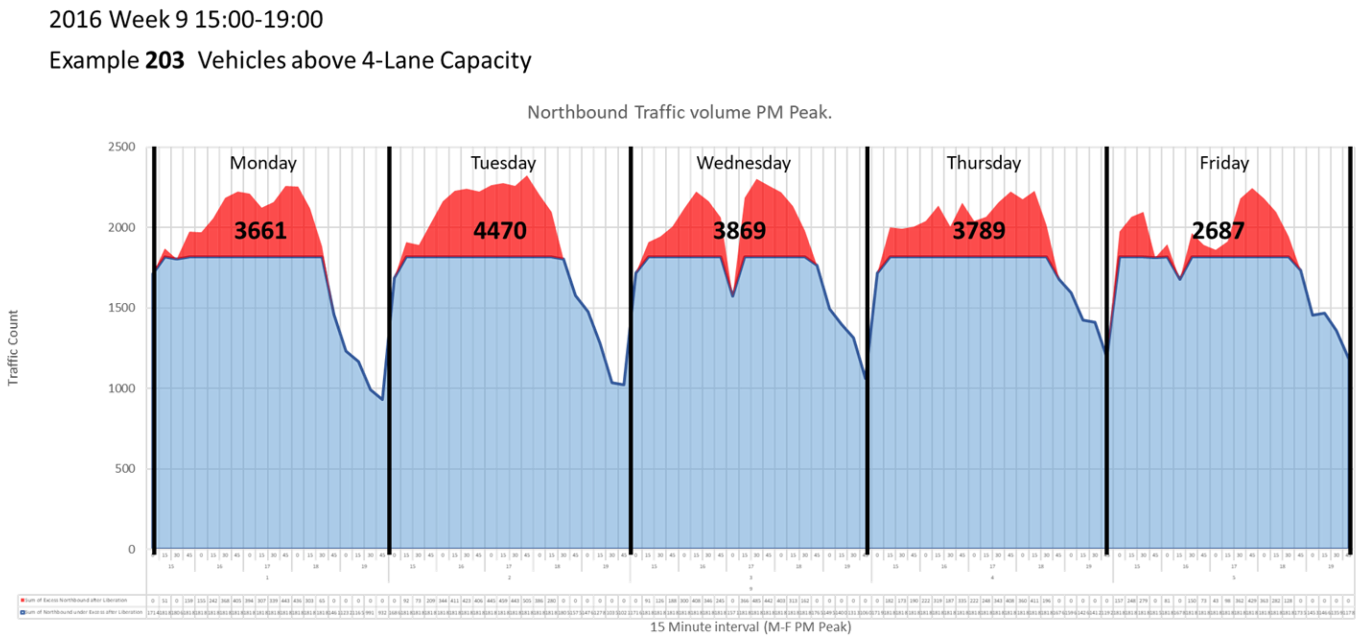


Figure 29 Northbound Excess Traffic 2016 Week 9 Evening Peak

2019 Week 29 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity

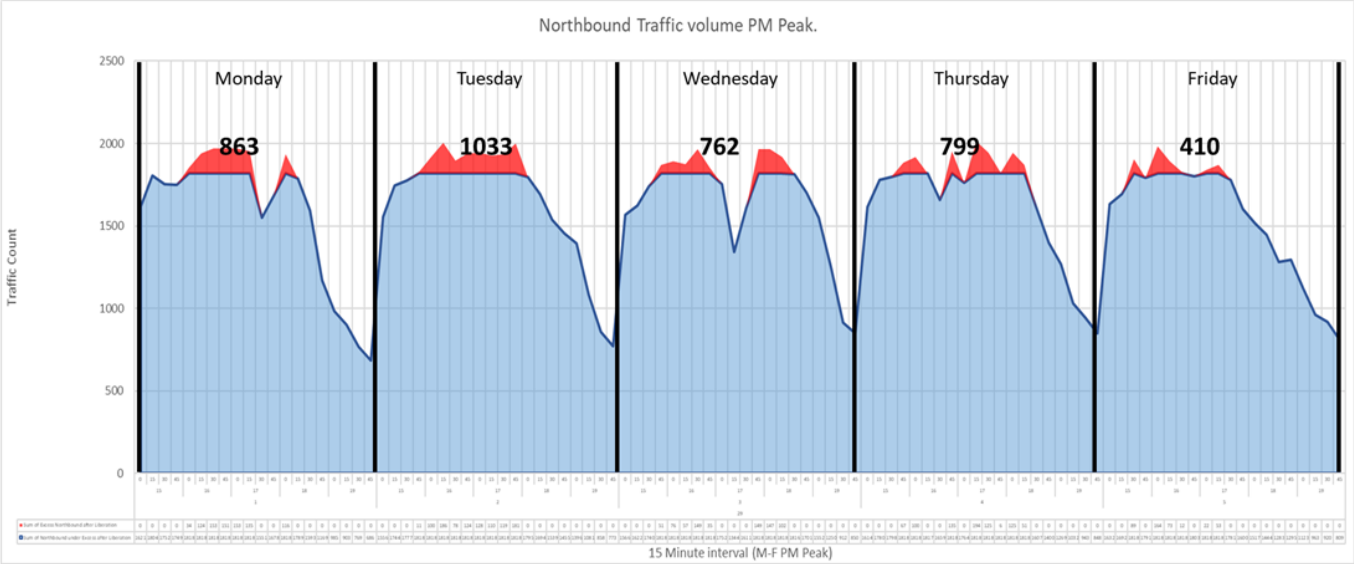


Figure 30 Northbound Excess Traffic - 2019 Week 29 Evening Peak

2022 Week 29 15:00-19:00

Example **0** Vehicles above 4-Lane Capacity

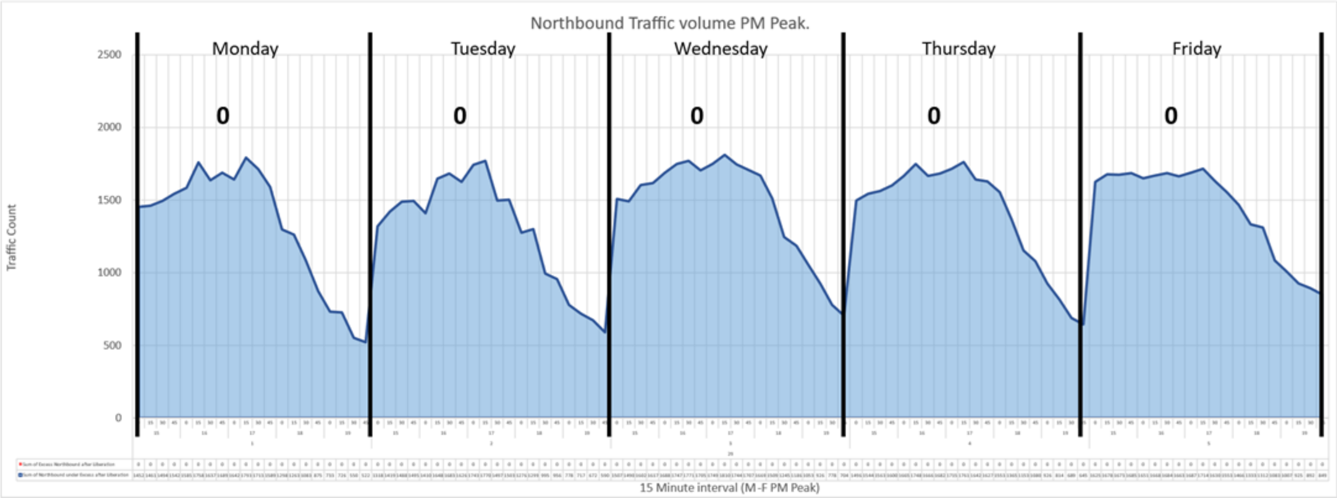


Figure 31 Northbound Excess Traffic - 2022 Week 30 Evening Peak

2022 Week 9 15:00-19:00

Example **624** Vehicles above 4-Lane Capacity

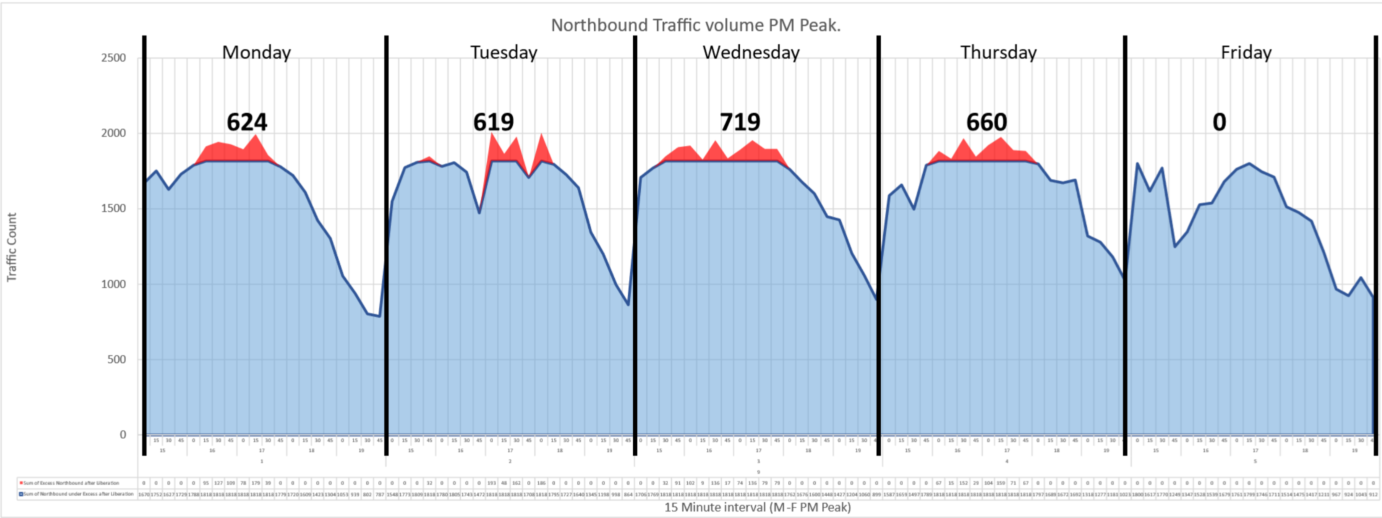


Figure 32 Northbound Excess Traffic - 2023 Week 9 Evening Peak

The mid-2022 data (Figure 31) shows that in week 29 there was no Excess Traffic and all the current morning flow could have been accommodated within 4 lanes.

Both Directions

Based on the analysis above and additional analysis we have undertaken that analysed every working day since 2013 (Figure 33 shows all of 2018), we have not identified a single day since 2013 where a 17,000 vpd reduction would have been required to enable the AHB to operate in a 4+3+1Active arrangement.

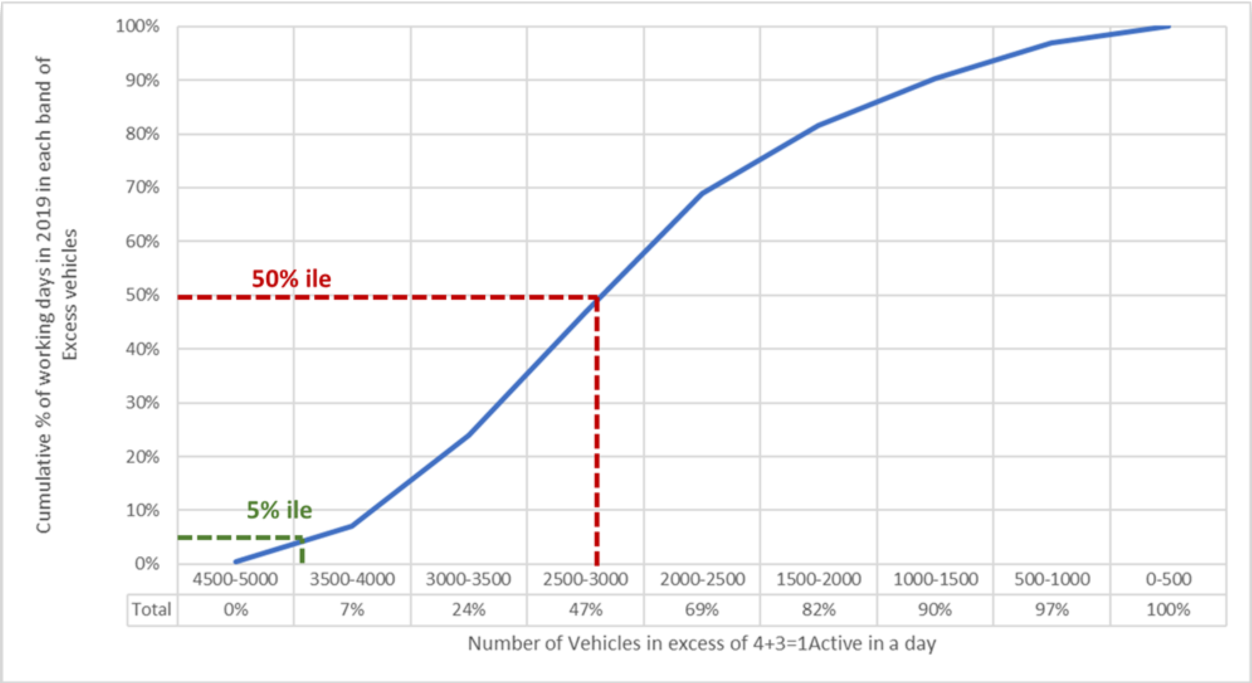


Figure 33 Percentage of Weekdays in 2019 where the number of vehicles (Excess) was above the capacity of a 4+3+1Active arrangement.

Figure 33 identifies that on only **5%** of weekdays in 2019 did the AHB carry up to 4,000 more vehicles than could have been accommodated by a 4+3+1Active arrangement.

In 2019 an average reduction of under 3,000vpd was required to enable a 4+3+1Active arrangement to operate with no impact for at least **50%** of the time, much of this reduction was already occurring prior to the pandemic.

We therefore cannot find any evidence to support Waka Kotahi's statements that repurposing a lane of the AHB for active modes would require a 17,000vpd reduction to neutralize any adverse effects of the wider Auckland network.

11. Other Factors

The analysis undertaken is limited to assessing known data and identifying how effectively a 4+3+1Active lane arrangement on the AHB could have worked since 2013. There are numerous other factors that are likely to further reduce any potential impacts of the Active Lane on current traffic flows.

Reduced 2022 Traffic Volumes due to changes in behaviour due to pandemic
The data clearly shows that traffic volumes have dropped significantly since March 2020. Some of this reduction has been due to enforced lockdowns, but there is evidence emerging that there are longer term changes to traffic volumes and timings occurring.

Increases in the number of people working from home and split shifts / time shifting will have direct beneficial effects on reducing demand on the AHB. Even small reductions (1-2%) of volumes during peak periods would make significant changes to the expected number of peak periods where a 4+3+1Active arrangement would operate with little impact. For example, using 2019 flows just a 2% reduction in peak period southbound traffic increases the number weekdays a year by 50 days when a 4+3+1Active lane would have operated effectively. Based on the downward trend of traffic volumes since 2016 this 2% reduction would have been significantly exceeded by 2022.

Impact of fuel price rises, car tax changes and PT uptake and subsidy
The recent significant fuel price rise and extra tax on many new vehicles, combined with the 50% subsidy to incentivise use of PT are both factors that are likely to reduce vehicles usage of the AHB. Whilst the PT subsidy is currently only announced to last three months the ending of the subsidy is likely to coincide with the reintroduction of an extra 25c/litre in fuel tax. These factors may all result in further and accelerating reductions in vehicle trips over the AHB.

As a bus carries between 80-100 people, only a few extra full buses replacing single or low occupancy vehicles would have significant beneficial impact on the AHB's capacity to add an Active Lane with minimal impact on traffic flows.

The option of using the southbound clip-on as a bus priority lane (along with Ponsonby bound traffic) could further speed up bus travel into the CBD making mode shift more likely. The soon to be opened Northern Busway extension could then become even more attractive. The analysis of how this would affect the morning traffic flows was outside the scope of this report.

Uptake of Active modes

This report does not set out to examine the predictions around predicted patronage usage of an Active Lane. Projected usage figures of 3-5,000 trips a day have been quoted by Waka Kotahi, of which some will be leaving their cars at home. Figure 15 shows that in 2020 and 2021 it only required a few hundred fewer northbound vehicle movements across the four hour peak period to reach a flow where the 4+3+1Active arrangement can cater for demand.

With no current active modes options available to cross the Waitemata Harbour the comparison of changes to other crossings around the world is difficult to benchmark. Figure 34 shows the recently converted traffic lane on New York's Brooklyn Bridge which has removed cyclists from the wooden shared path above the traffic lanes. This cycle path would not meet NZ Standards but has nonetheless resulted in a 90% increase in cycle usage[24].

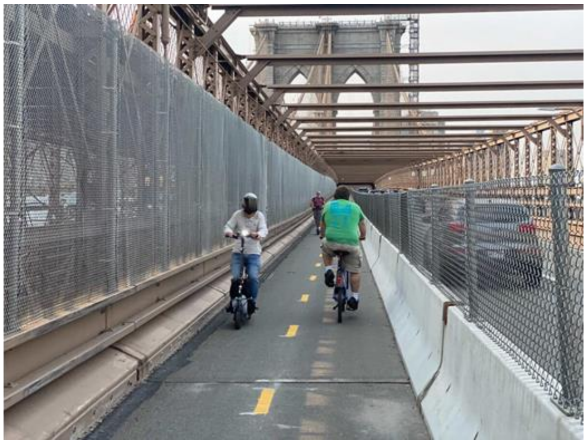


Figure 34 Brooklyn Bridge (left) shared path and (right) new dedicated protected cycle path

One commonly quoted disincentive to cycle on the AHB is the gradient and the proposed 4m width. The bridge has a 5% (1 in 20) maximum gradient and there are many well-used urban cycle paths in New Zealand that are steeper and narrower.

Additionally, the sales of e-bikes (Figure 35) shows that the trend of sales has outpaced even the most extreme predictions, so these combined with e-scooters are

[24] 88% increase in cycle usage from Oct 2020 to Oct 2021, https://www1.nyc.gov/html/dot/html/pr2021/brooklyn-bridge-bike-ridership-skyrockets.shtml#:~:text=Brooklyn%20Bridge%20Bike%20Lane%20Ridership%20Skyrockets,-Report%20shows%20continued&text=NEW%20YORK%E2%80%94NYC%20DOT%20today,lane%20opened%20in%20September%202021.

likely to increase the number and distance that people will be willing to commute. These factors all are likely to reduce traffic usage on the AHB.

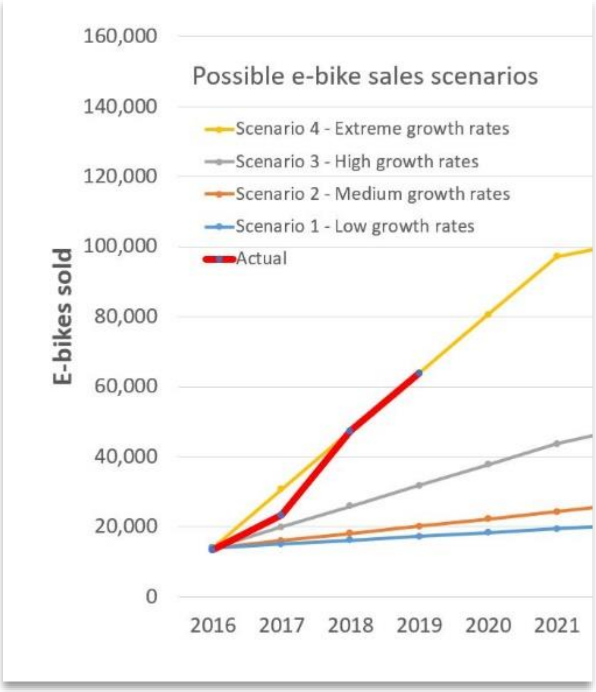


Figure 35 E-bike sales NZ (Via Strada data)

12. Conclusions

From analysing the Waka Kotahi traffic count data on the Auckland Harbour Bridge (AHB) we can conclude.

1. The trend from 2016-2019 indicates that (even without the impact of the COVID-19 pandemic) the morning peak period southbound traffic flows on the AHB would be within the 4 Lane capacity by 2022.

2. The latest 2023 data clearly shows significant traffic flow reductions since 2016 to a point where in July 2022 all existing traffic flows could have been accommodated with 4+4+Active lane arrangement.

3. The trend from 2016-2019 indicates that (even without the impact of the pandemic) the evening peak period northbound traffic flows on the AHB would be less than the 4 traffic Lane capacity by 2023.

4. There is strong evidence to show that prior to March 2020 (the start of the COVID-19 pandemic) peak traffic volumes on the AHB were reducing, with a traffic reduction of 1.4% recorded between 2018 and 2019.

5. Traffic volumes have declined materially during the pandemic and although there has been some recovery towards the end of 2022 there is little evidence or trend data to suggest that these will soon exceed pre-pandemic values.

6. The conversion of one traffic lane to an Active Lane (4+3+1Active) would have impacted the ability of the AHB to carry traffic volumes at peak times in previous years, however this may not occur in the future. The latest 2023 data suggests that traffic volumes are significantly lower than the peak in 2016.

7. The Lane Capacities (vph) provided by Waka Kotahi have been demonstrated to be conservative. Increases of 200-400vph have been shown to be realistic for the 3 and 5 lane arrangements and even a conservative 70vph increase for 4 lanes (from 7,200 to 7,270) has a material beneficial effect on the AHB to operate in a 4+3+1Active configuration. This 4-lane capacity may be even higher, recent data suggested that flows up to 7,400vph are achievable.

8. There are significant traffic flow variations across the week, season and year. Any predictions on traffic should take into consideration the weekday and month and not treat every day and week the same. By applying this

approach to historic data we have been able to assess the percentage of days that a 4+3+1Active Lane arrangement would have provided sufficient capacity.

9. From 2019 data it appears that on over 100 of 240 working days a 4+3+1Active arrangement would have provided sufficient morning peak southbound traffic capacity.

10. A sensitivity analysis shows that if 7,400vph can be accommodated then the 2019 weekday morning peak traffic flow would only need to reduce by 3.5% to be within a 4 Lane capacity 95% of the time. This is equivalent to replacing single occupancy vehicles with one full double decker bus every 25 minutes.

11. In 2019 a net reduction of 3,000 vpd (at the right time of day) would have been required so that a 4+3+1Active arrangement on the AHB would have provided sufficient capacity for half of the working days that year.

12. 2022 data indicates that further modest reductions of traffic volumes of 2-3% would reduce the number of days when peak period capacity was exceeded to under 12 a year.

13. If a reduction of 5000vpd (at the right time of day) in 2019 occurred then the 4+3+1Active arrangement would have provided sufficient capacity on all working days. By 2022 the reduction the reduction required would be around 3,000vpd.

14. No evidence was found to support Waka Kotahi's statement that a 17,000 vpd traffic reduction on the AHB would be required to neutralise effects on Auckland's transport system.

15. Recent fuel price increases, a 50% PT subsidy and reintroduction of 25c/litre fuel tax are unlikely to generate higher traffic volumes on the AHB.

16. The uptake of more active mode travel options, especially e-bikes and scooters has reached extreme growth rate and would likely surprise on the upside.

17. Recent US experience has demonstrated that using a lead infrastructure approach (*build it and they will come*) for an active mode lane on New York's

Brooklyn Bridge has generated unexpectedly and unpredicted higher active mode patronage.

18. With the June – August period showing the lowest traffic volumes and evidence to date showing 2022 traffic volumes in that period being less than 2018/19 then there is a strong incentive to operate the bridge in a solely 4+4 lane mode. This would save money (no need to move the barriers twice a day) and most usefully provide a wealth of real world data on the actual impact of running 4 lanes for in the peak flow direction. This should be accompanied by accurate lane specific traffic counts and point-to-point journey time monitoring on the approaches to and across the bridge.

13. Completion of Deliverables

This report completes the deliverables for the scope of work that the Client has instructed, our Richard Young is available to answer any questions, make a presentation on this material or undertake any further analysis as you may instruct.

Richard Young

Managing Director, SmartSense Ltd

June 2023.

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14. Appendix A

This Appendix contains graphs showing the Waka Kotahi provided peak period15-minute counts on the Auckland Harbour Bridge for weeks (9 and 29) in each direction from 2016 – 2023. The weeks were chosen to show the seasonal range of traffic flows (9 high, 29 low) and the trend across 4 pre-pandemic years (southbound) and 3 northbound (no data provided for 2019).

On each graph the Proven Capacity of a 4-Lane AHB (7,270 vph) is shown and the excess traffic count above this line calculated. Recent 4+4 Lane data (March 2022 data) suggests that this 7,270vph may be conservative as flows up to 7,400vph have been recorded.

These counts are the excess traffic that a 4 Lane arrangement recorded in that 15 minute period. The counts take no account of Time Shifting (filling in gaps when there was unused capacity), mode shift (to PT, Active, Working From Home etc.). These graphs show the day today, season to season and year to year trend, a summary is provided in Table 5.

Table 5 Summary of Excess traffic Graphs 2016-2023 Southbound

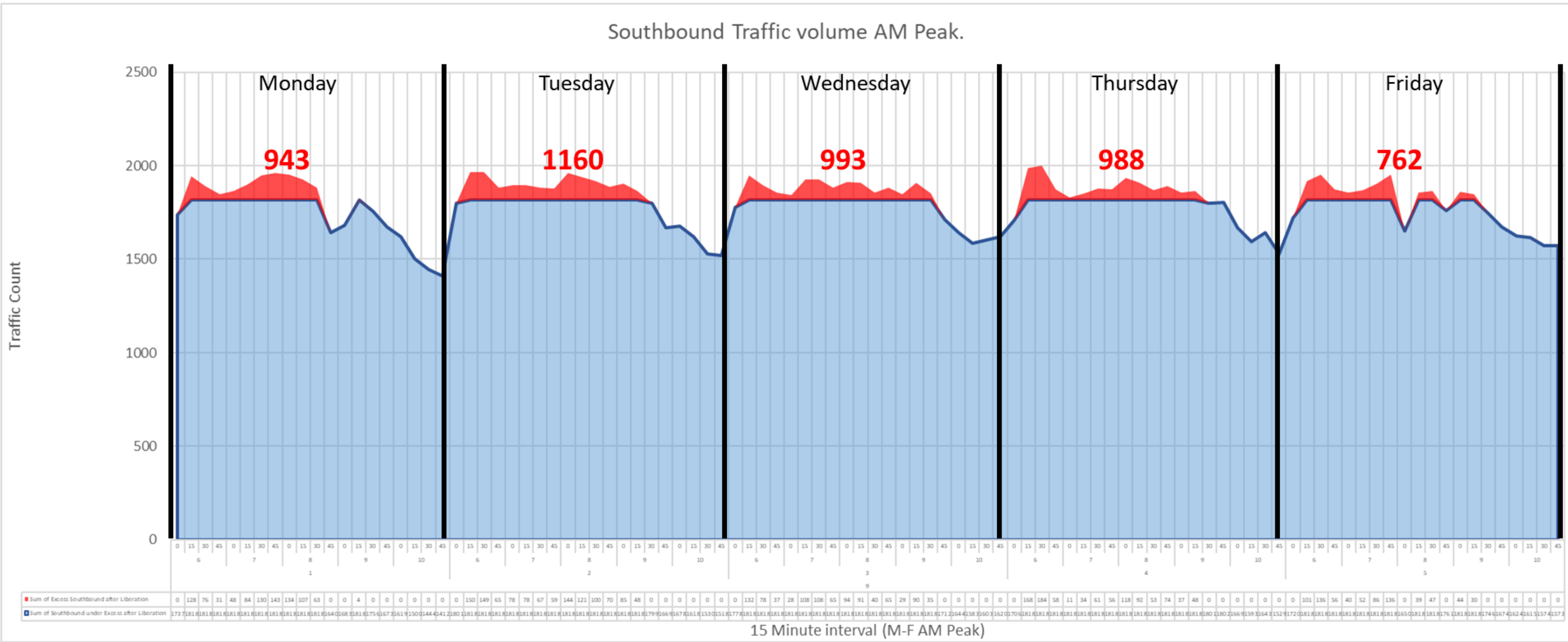
Year	Week	Direction	Peak	Monday	Tuesday	Wednesday	Thursday	Friday	Weekday Total	Weekday Average
2016	9	Southbound	Morning	943	1160	993	988	762	4,846	969
2017	9	Southbound	Morning	457	955	931	949	649	3,941	788
2018	9	Southbound	Morning	527	937	1023	636	640	3,763	753
2019	9	Southbound	Morning	203	346	379	414	114	1,456	291
2020	9	Southbound	Morning							No Data
2021	9	Southbound	Morning							No Data
2022	9	Southbound	Morning	105	497	319	175	0	1096	219
2023	9	Southbound	Morning	19	17	54	5	0	95	19
2016	29	Southbound	Morning	370	603	346	72	54	1,445	289
2017	29	Southbound	Morning	242	301	235	441	130	1,349	270
2018	29	Southbound	Morning	117	225	432	140	19	933	187
2019	29	Southbound	Morning	3	2	38	132	133	308	62
2020	29	Southbound	Morning	0	0	0	0	0	0	0 – No graph
2021	29	Southbound	Morning	0	59	0	99	2	0	32
2022	29	Southbound	Morning	0	0	0	0	0	0	0

Table 6 Summary of Excess traffic Graphs 2016-2023 Northbound

Year	Week	Direction	Peak	Monday	Tuesday	Wednesday	Thursday	Friday	Weekday Total	Weekday Average
2016	9	Northbound	Evening	3661	4470	3869	3789	2687	18,476	3,695
2017	9	Northbound	Evening	2909	3649	3246	3180	2158	15,142	3,028
2018	9	Northbound	Evening	2772	2906	2358	2789	1533	12,358	2,472
2019	9	Northbound	Evening	2143	2359	2240	2322	1166	10,230	2,046
2020	9	Northbound	Evening							No Data
2021	9	Northbound	Evening	793	1634	1000	1271	362	5,060	1,012
2022	9	Northbound	Evening	59	394	1450	254	116	2,273	454
2023	9	Northbound	Evening	624	619	719	660	0	2,653	530
2016	29	Northbound	Evening	3090	1733	2923	2665	1175	11,586	2,317
2017	29	Northbound	Evening	2031	2589	2051	875	1581	9,127	1,825
2018	29	Northbound	Evening	1903	1889	2636	1146	1516	9,090	1,818
2019	29	Northbound	Evening	863	1033	762	799	410	3,867	773
2020	29	Northbound	Evening	238	754	306	273	51	1,376	276 – No graph
2021	29	Northbound	Evening	507	603	432	183	0	1,725	345
2022	29	Northbound	Evening	0	0	0	0	0	0	0

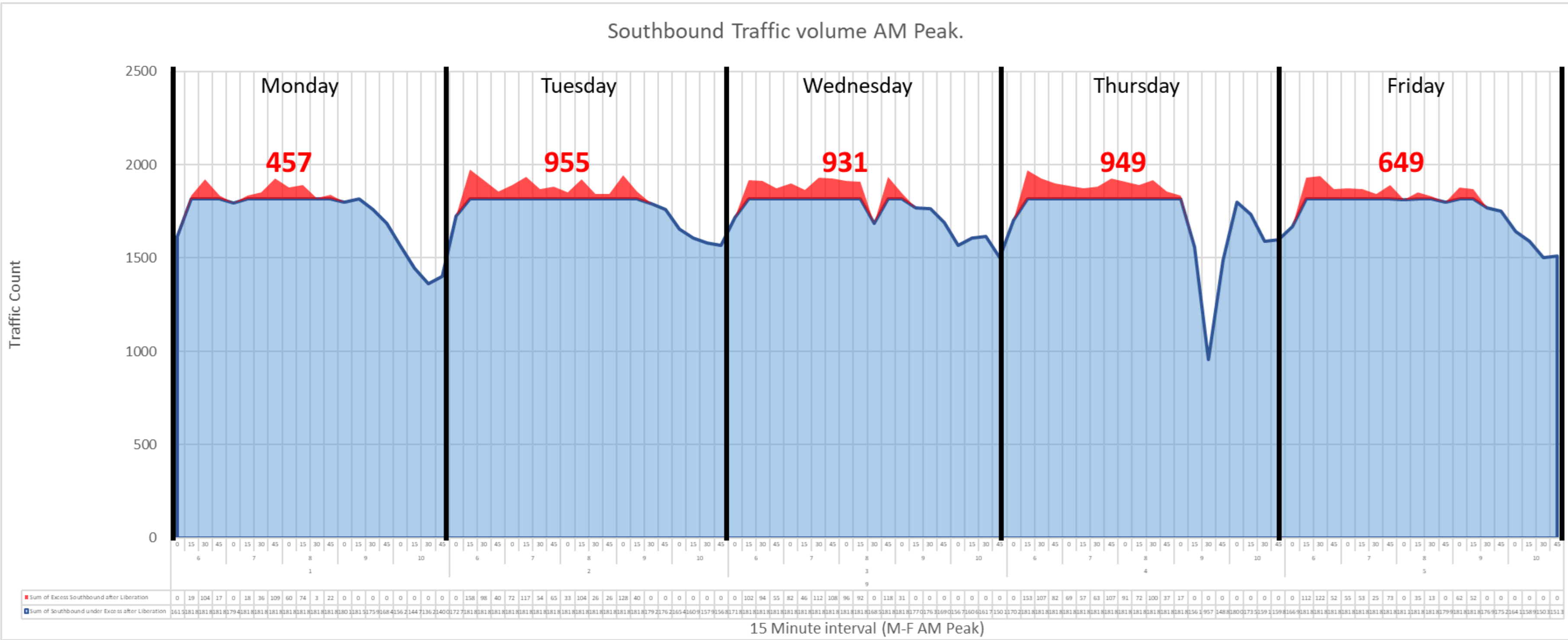
2016 Week 9 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



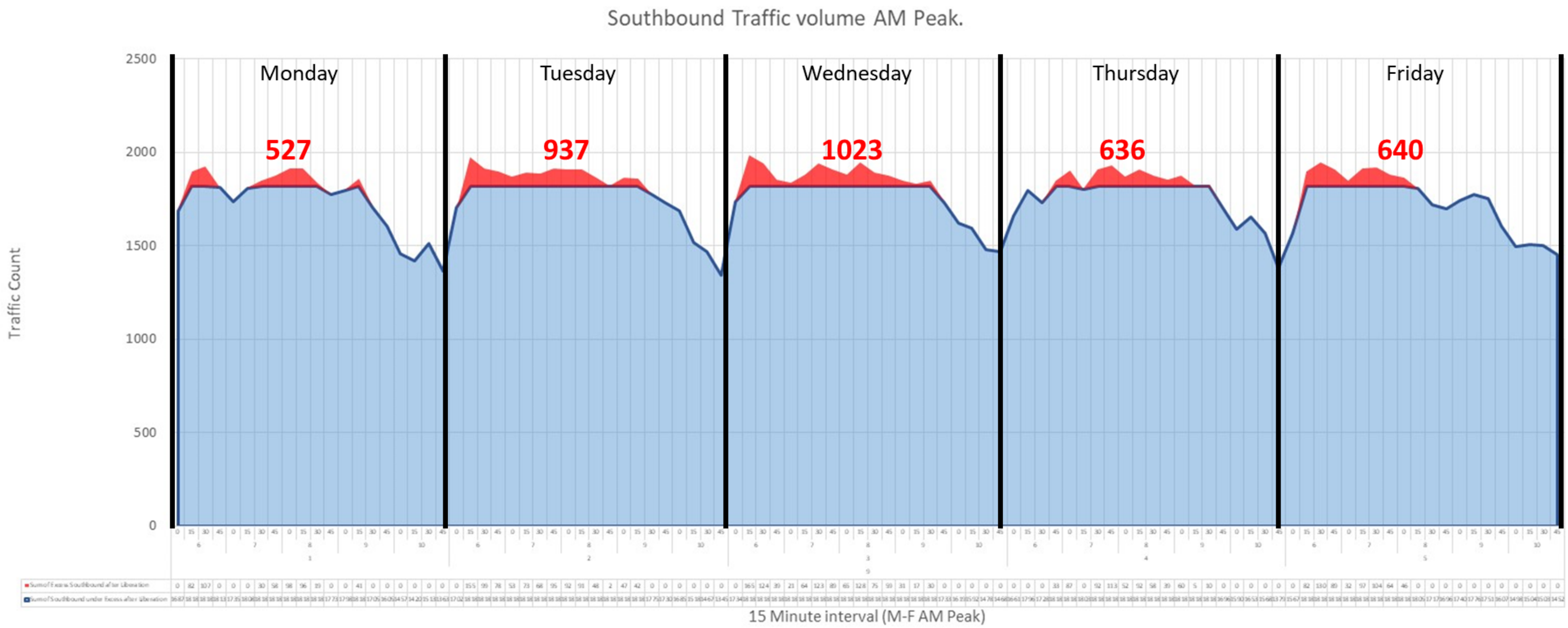
2017 Week 9 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



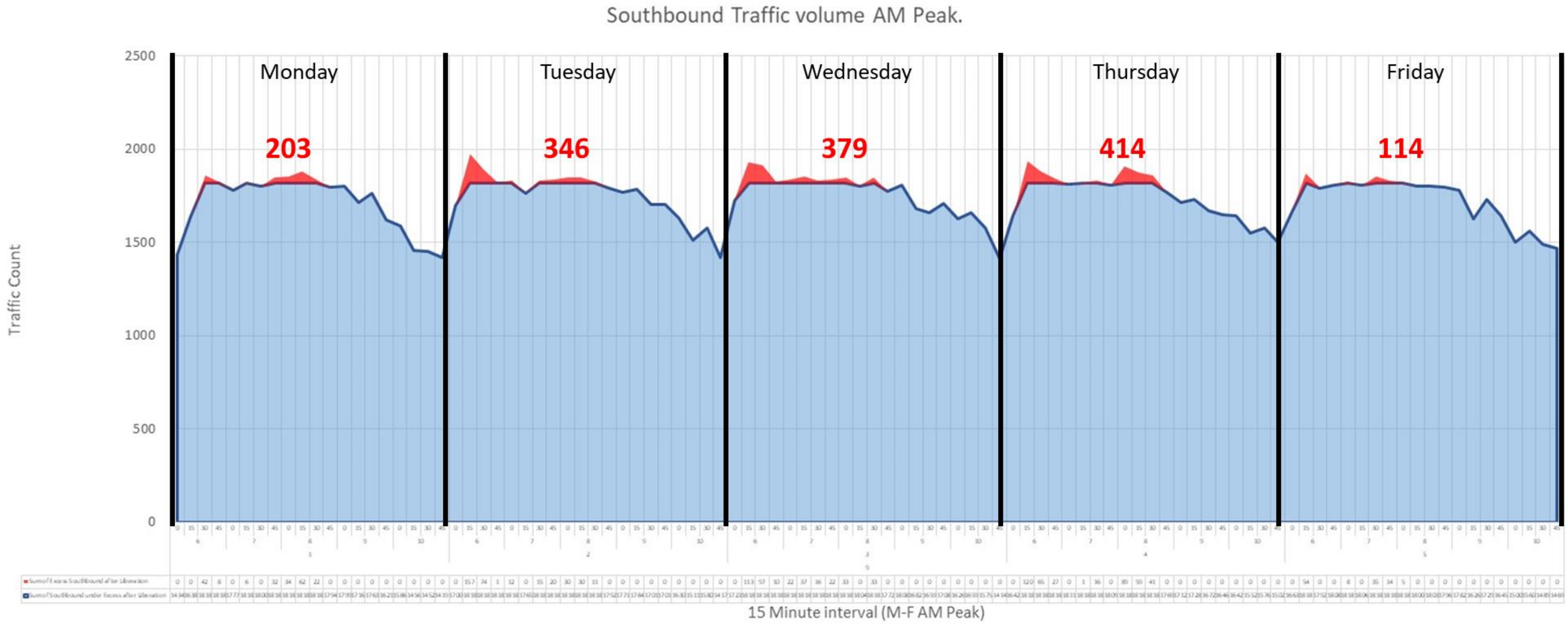
2018 Week 9 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



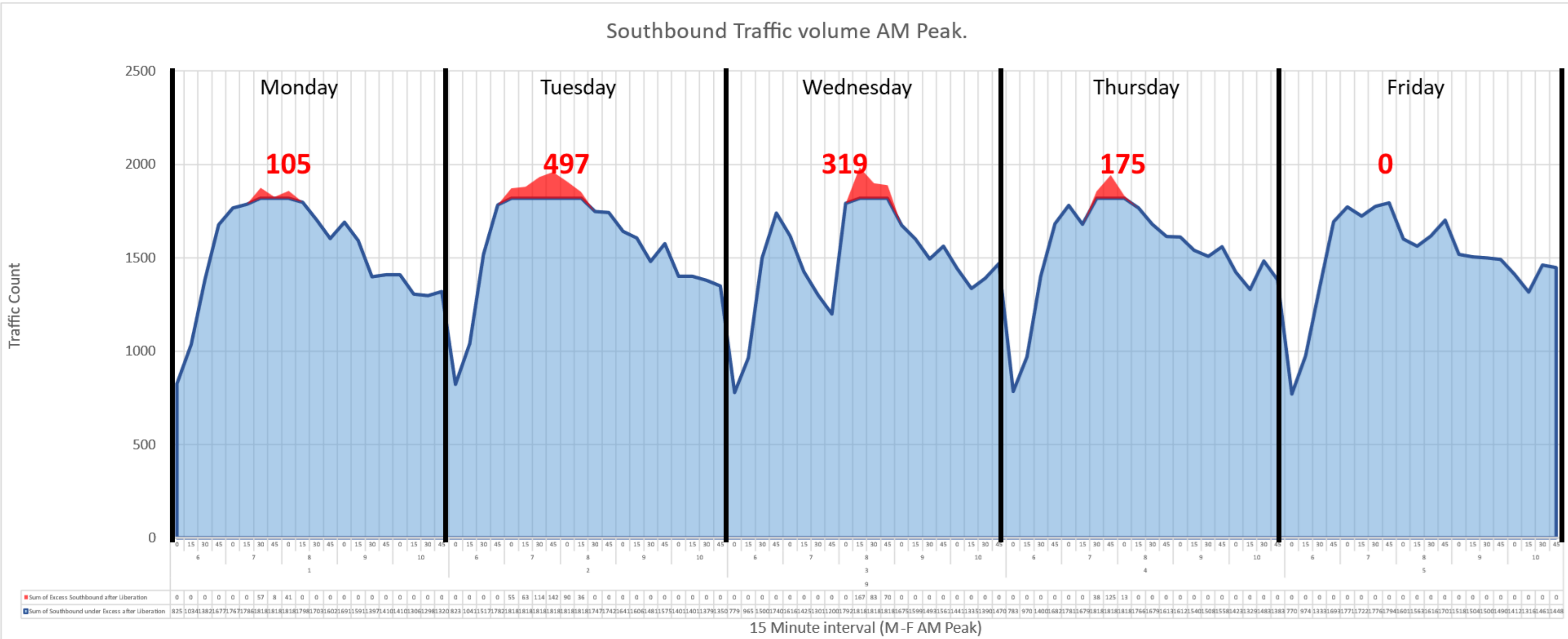
2019 Week 9 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



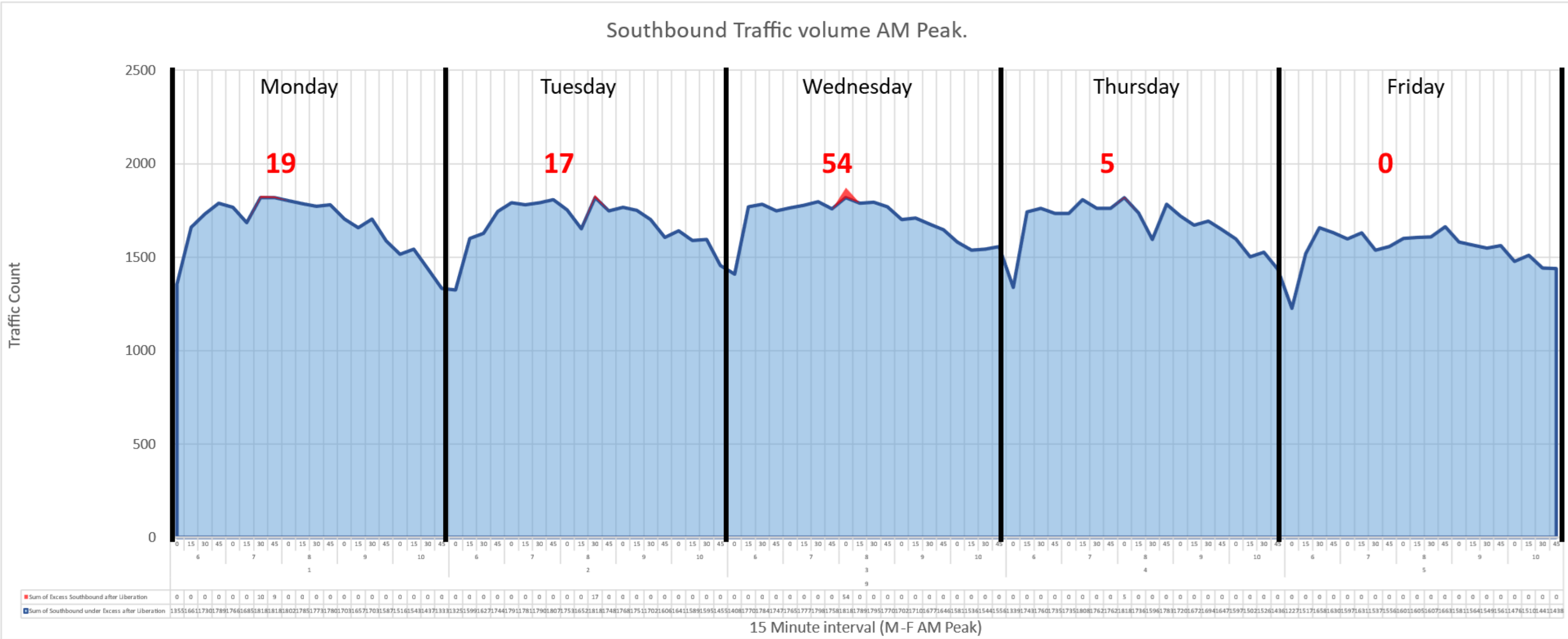
2022 Week 9 06:00-10:00

Example **105** Vehicles above 4-Lane Capacity



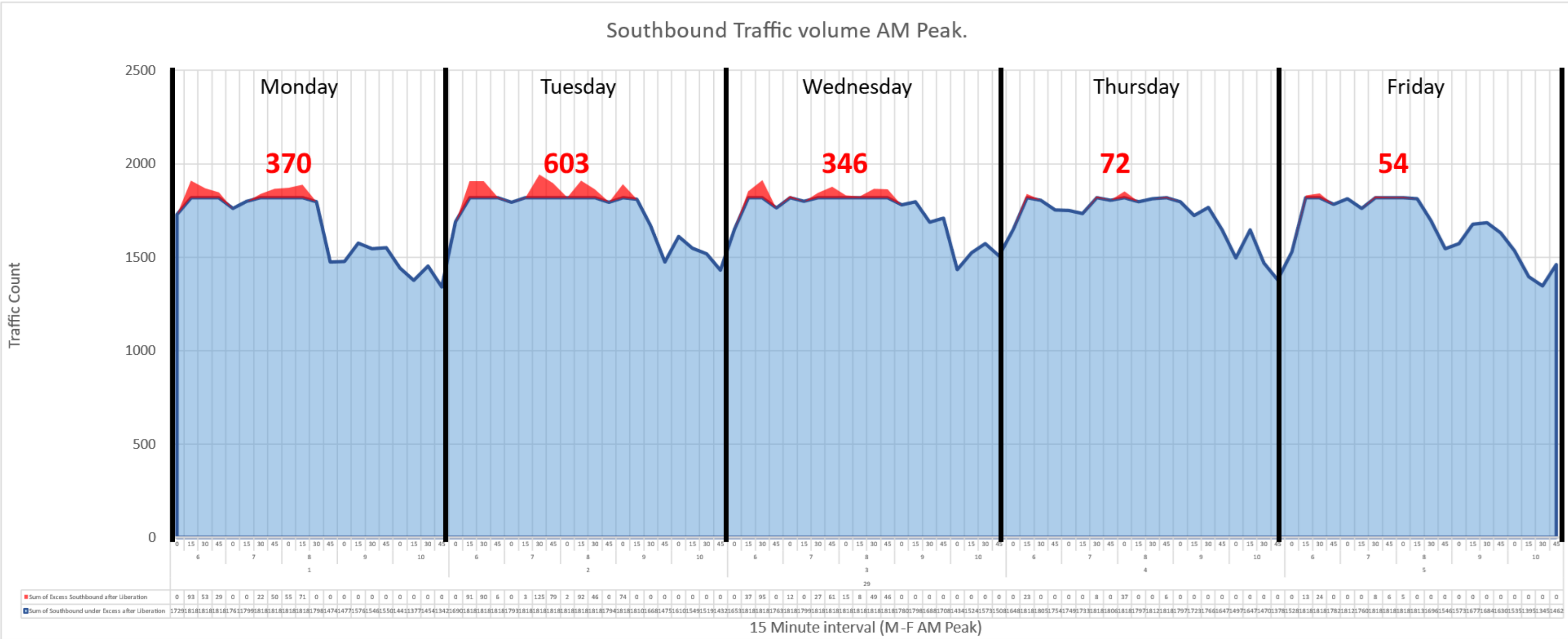
2023 Week 9 06:00-10:00

Example **0** Vehicles above 4-Lane Capacity



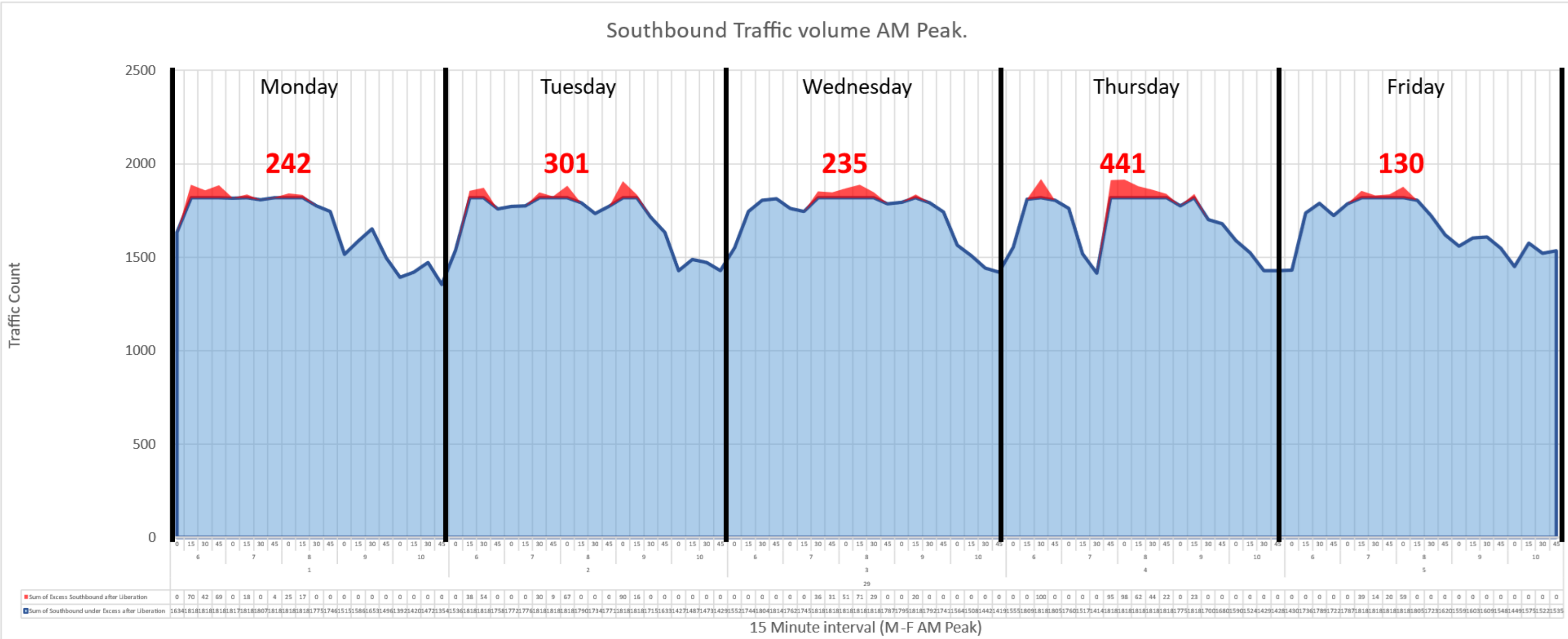
2016 Week 29 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



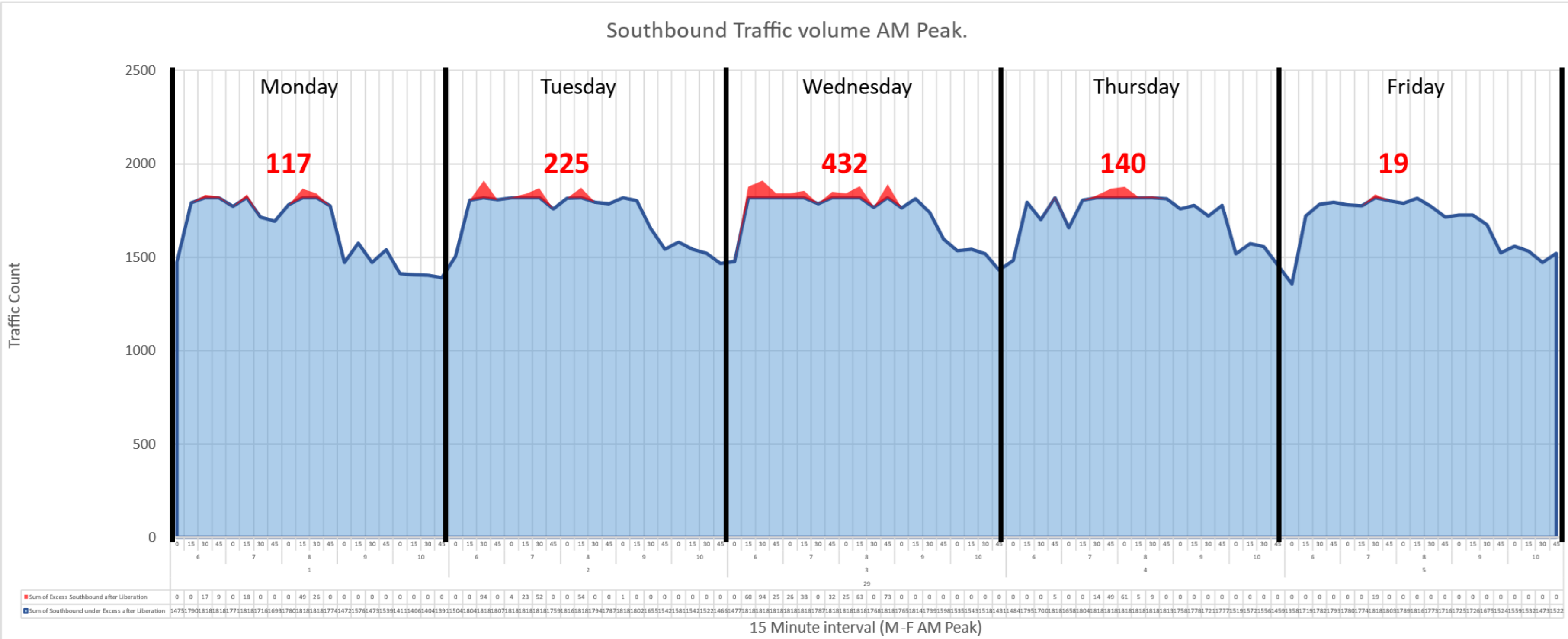
2017 Week 29 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



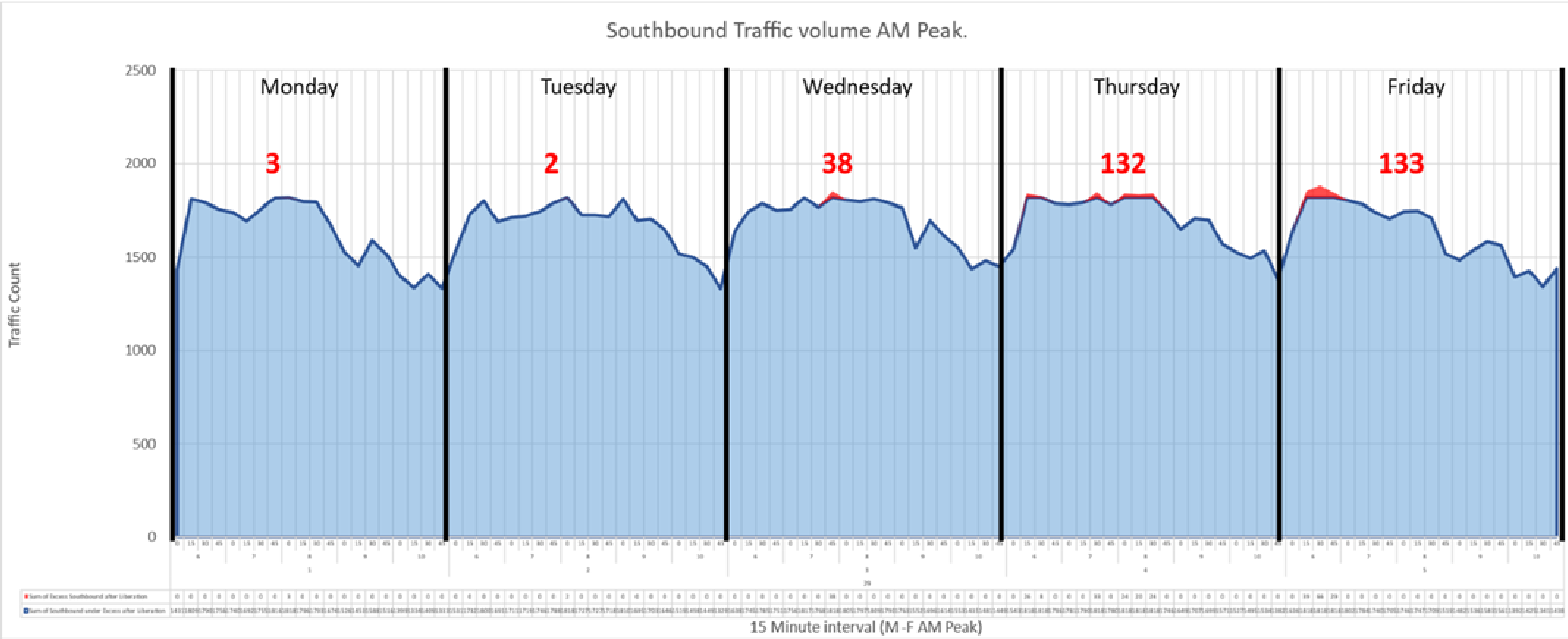
2018 Week 29 06:00-10:00

Example **203** Vehicles above 4-Lane Capacity



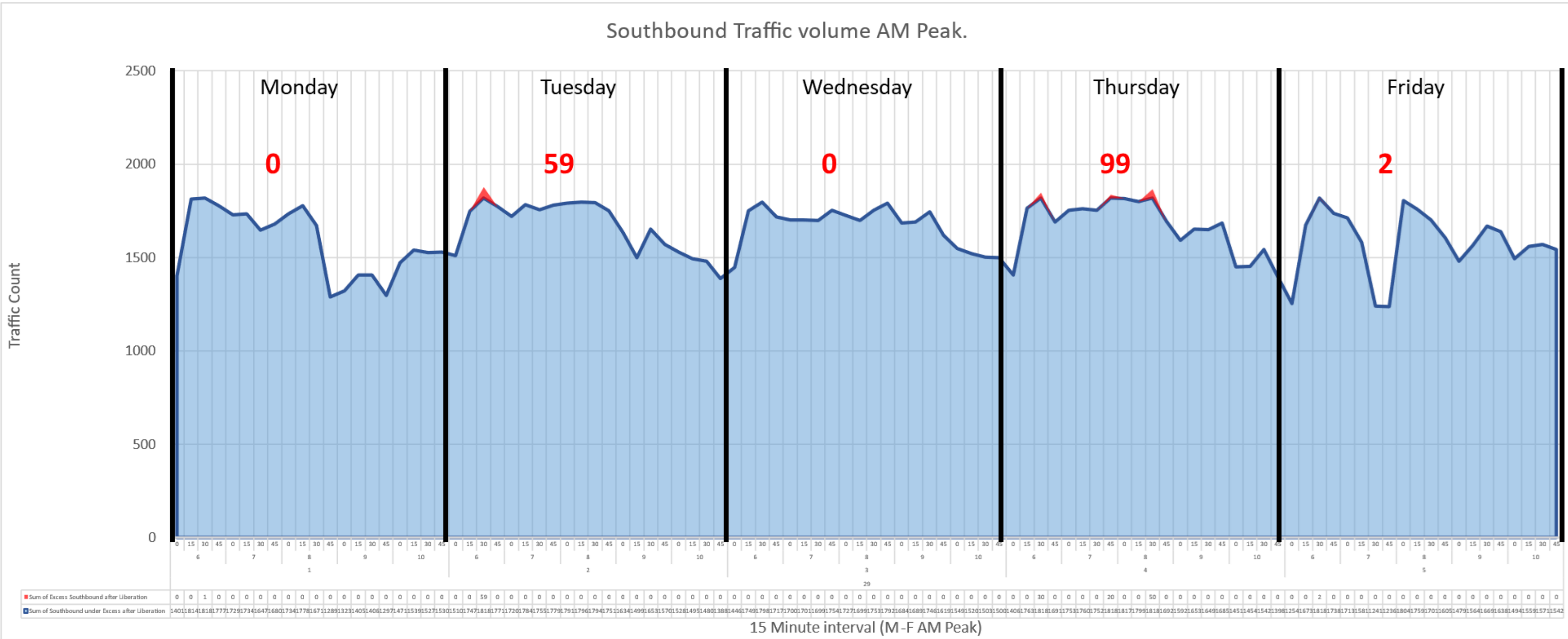
2019 Week 29 06:00-10:00

203 Vehicles above 4-Lane Capacity



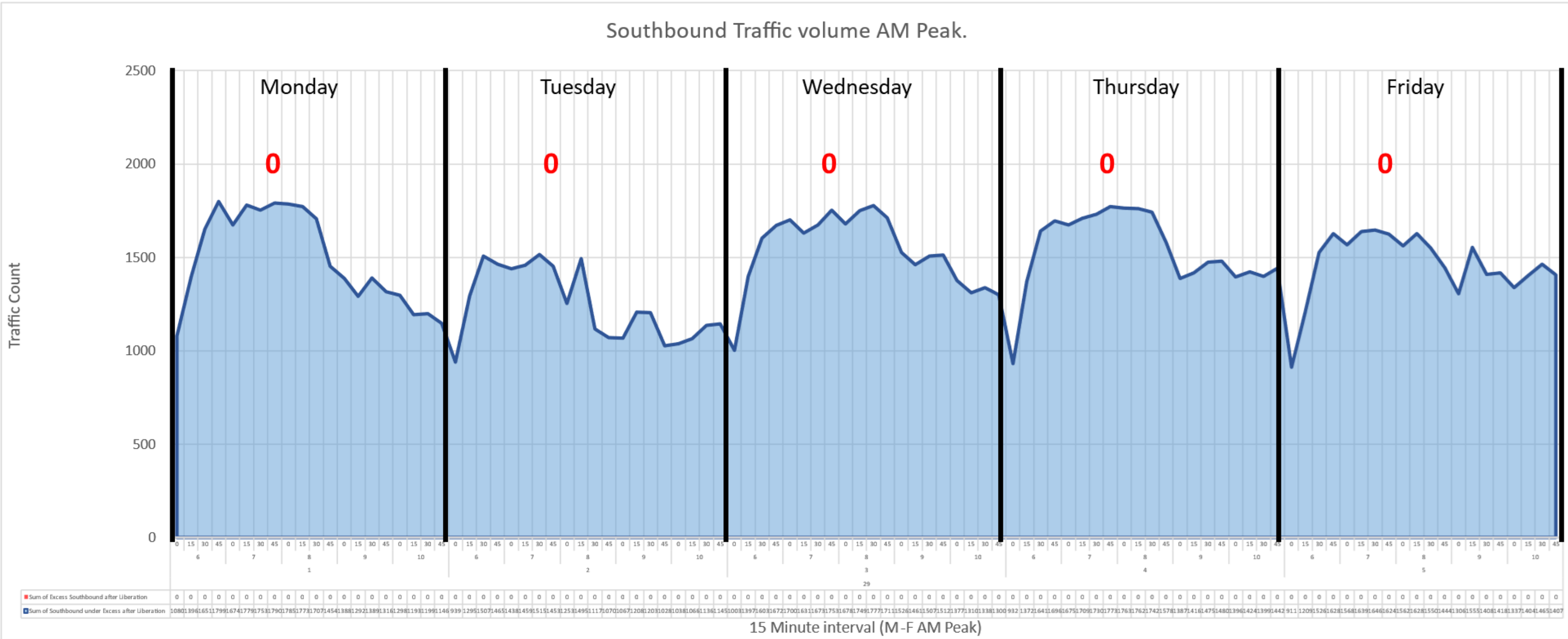
2021 Week 29 06:00-10:00

Example **59** Vehicles above 4-Lane Capacity



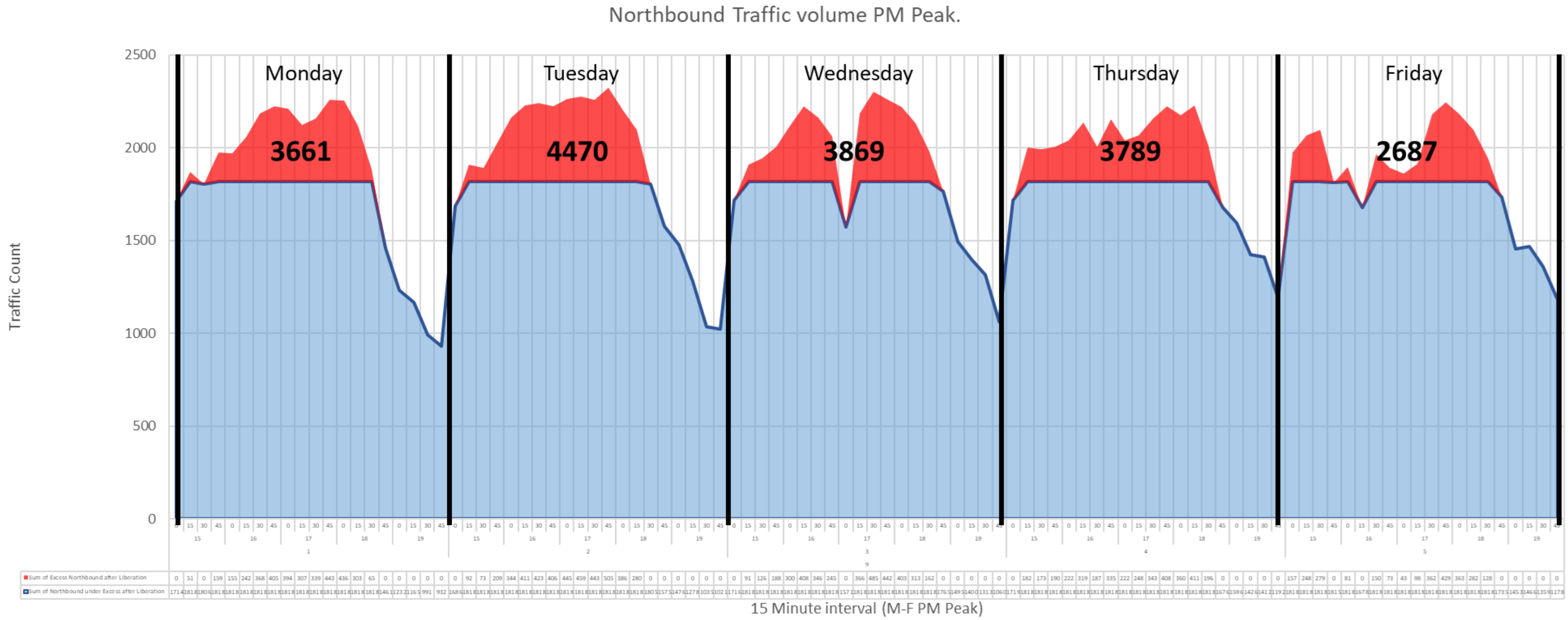
2022 Week 29 06:00-10:00

Example **0** Vehicles above 4-Lane Capacity



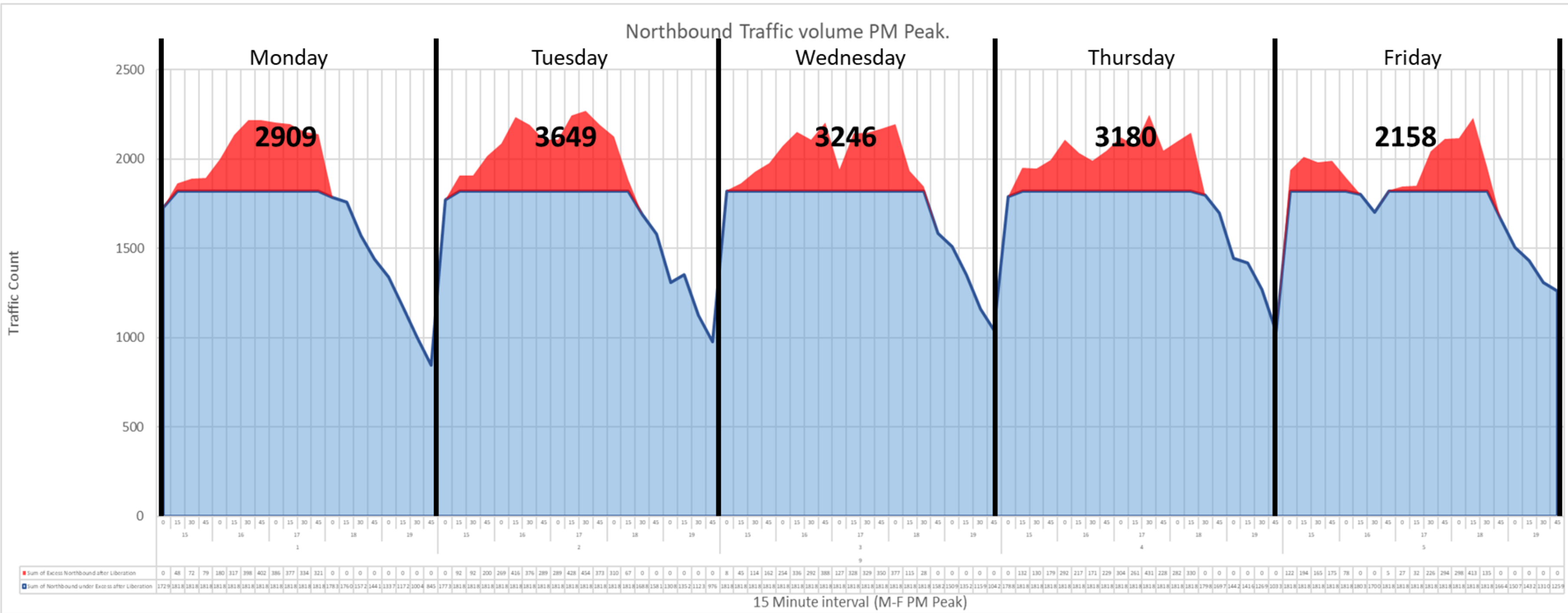
2016 Week 9 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



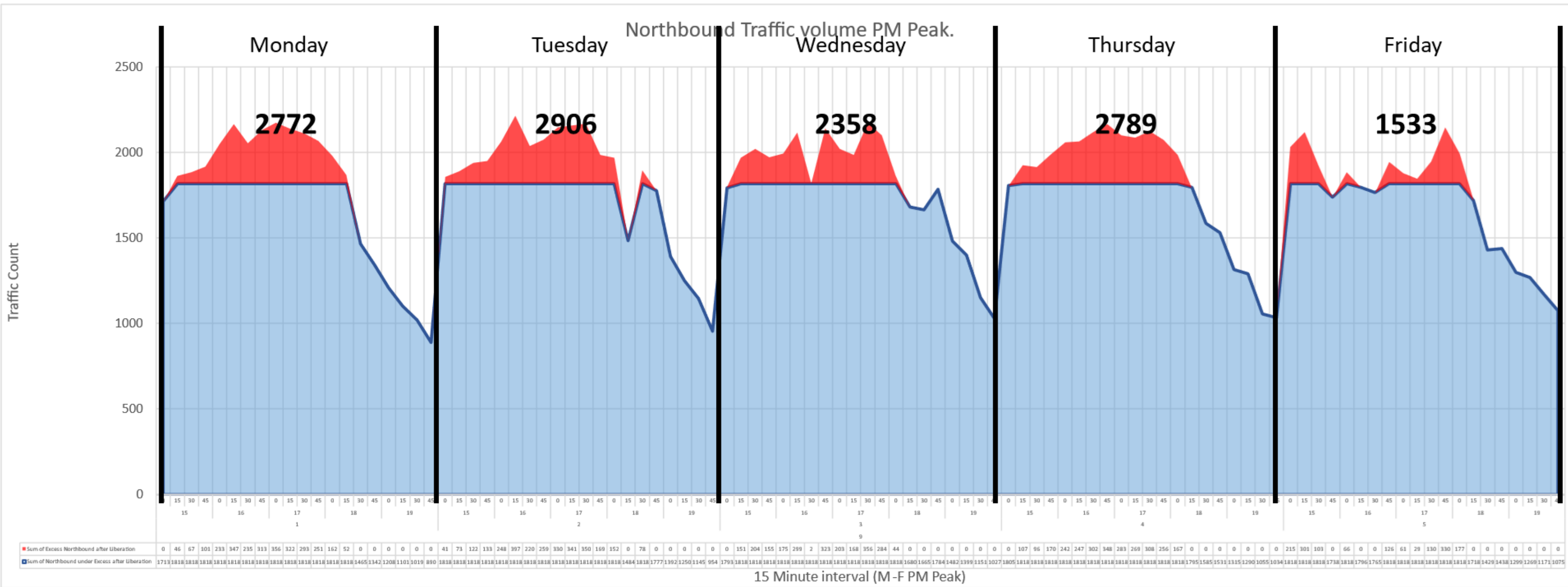
2017 Week 9 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



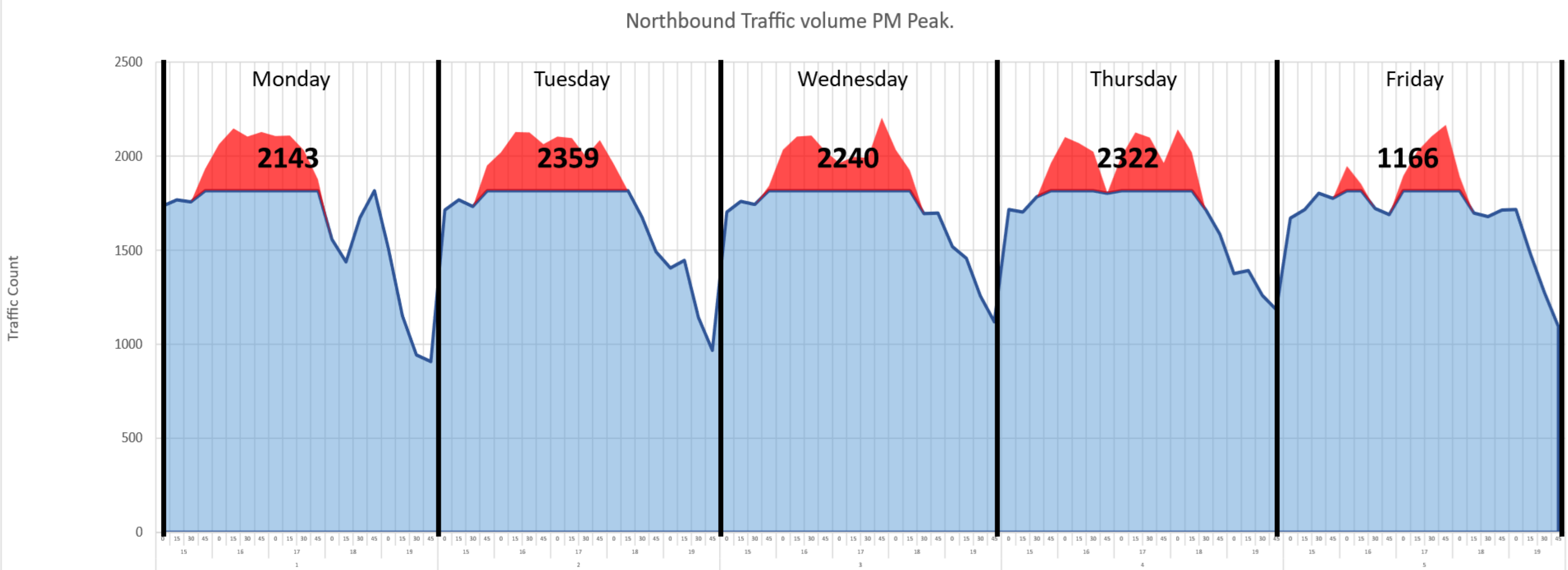
2018 Week 9 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



2019 Week 9 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



9

1	15				16				17				18				19			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
Sum of Excess Northbound after Liberation	0	0	0	113	246	331	288	313	290	292	214	60	0	0	0	0	0	0	0	0
Sum of Northbound under Excess after Liberation	1734	1769	1757	1818	1818	1818	1818	1818	1818	1818	1818	1818	1558	1438	1673	1816	1509	1151	943	909

2	15				16				17				18				19			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
Sum of Excess Northbound after Liberation	0	0	0	132	204	312	308	248	288	280	181	269	140	2	0	0	0	0	0	0
Sum of Northbound under Excess after Liberation	1714	1769	1733	1818	1818	1818	1818	1818	1818	1818	1818	1818	1818	1818	1675	1493	1406	1446	1142	968

3	15				16				17				18				19			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
Sum of Excess Northbound after Liberation	0	0	0	24	218	287	294	209	148	180	173	387	217	108	0	0	0	0	0	0
Sum of Northbound under Excess after Liberation	1704	1760	1743	1818	1818	1818	1818	1818	1818	1818	1818	1818	1818	1818	1694	1698	1518	1456	1257	1119

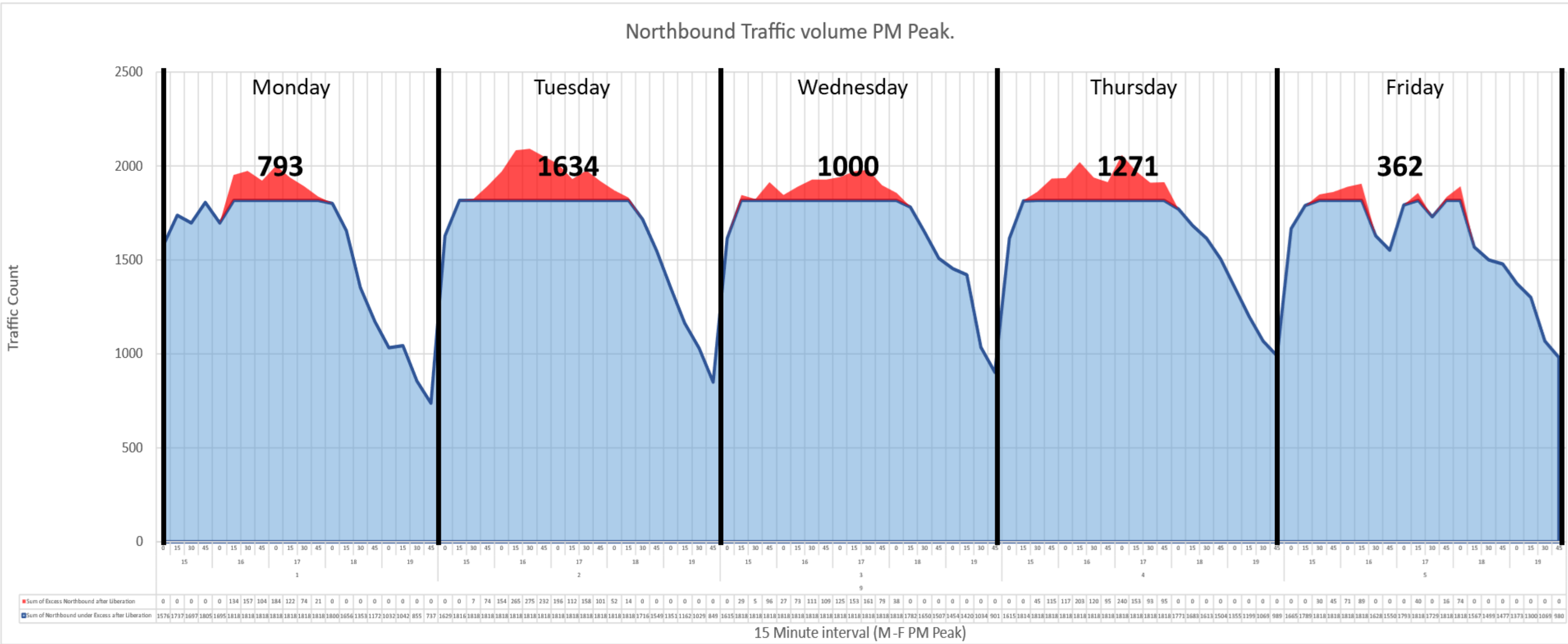
4	15				16				17				18				19			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
Sum of Excess Northbound after Liberation	0	0	0	146	285	252	207	0	183	308	281	146	326	203	0	0	0	0	0	0
Sum of Northbound under Excess after Liberation	1716	1702	1783	1818	1818	1818	1818	1804	1818	1818	1818	1818	1818	1818	1713	1585	1376	1392	1259	1184

5	15				16				17				18				19			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
Sum of Excess Northbound after Liberation	0	0	0	0	131	37	0	0	80	209	287	350	75	0	0	0	0	0	0	0
Sum of Northbound under Excess after Liberation	1671	1716	1802	1776	1818	1818	1723	1690	1818	1818	1818	1818	1818	1697	1679	1713	1715	1480	1275	1095

15 Minute interval (M-F PM Peak)

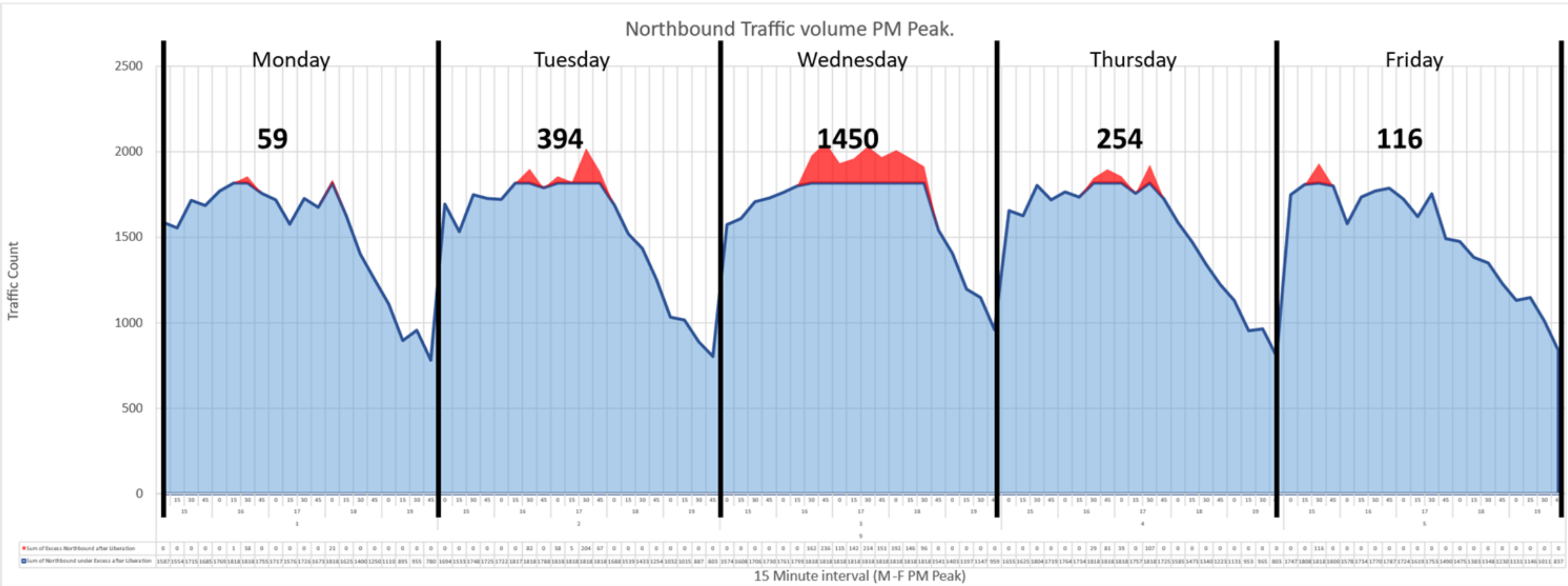
2021 Week 9 15:00-19:00

Example **793** Vehicles above 4-Lane Capacity



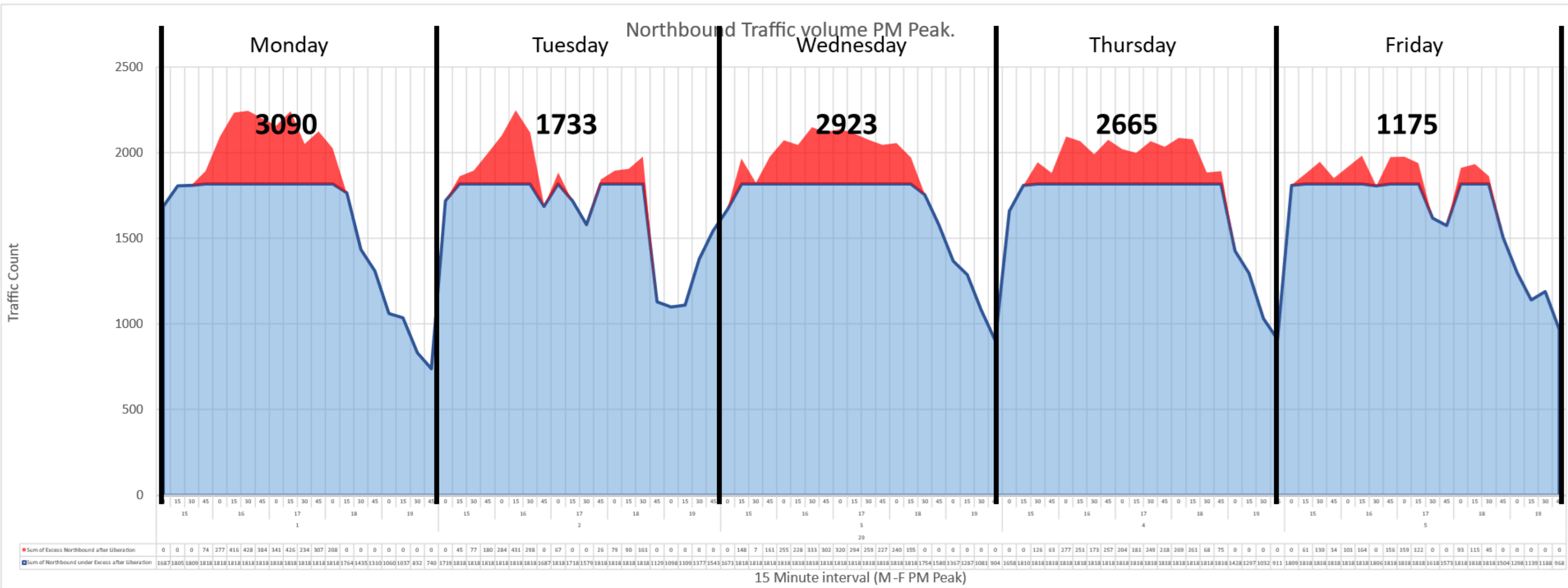
2022 Week 9 15:00-19:00

Example **59** Vehicles above 4-Lane Capacity



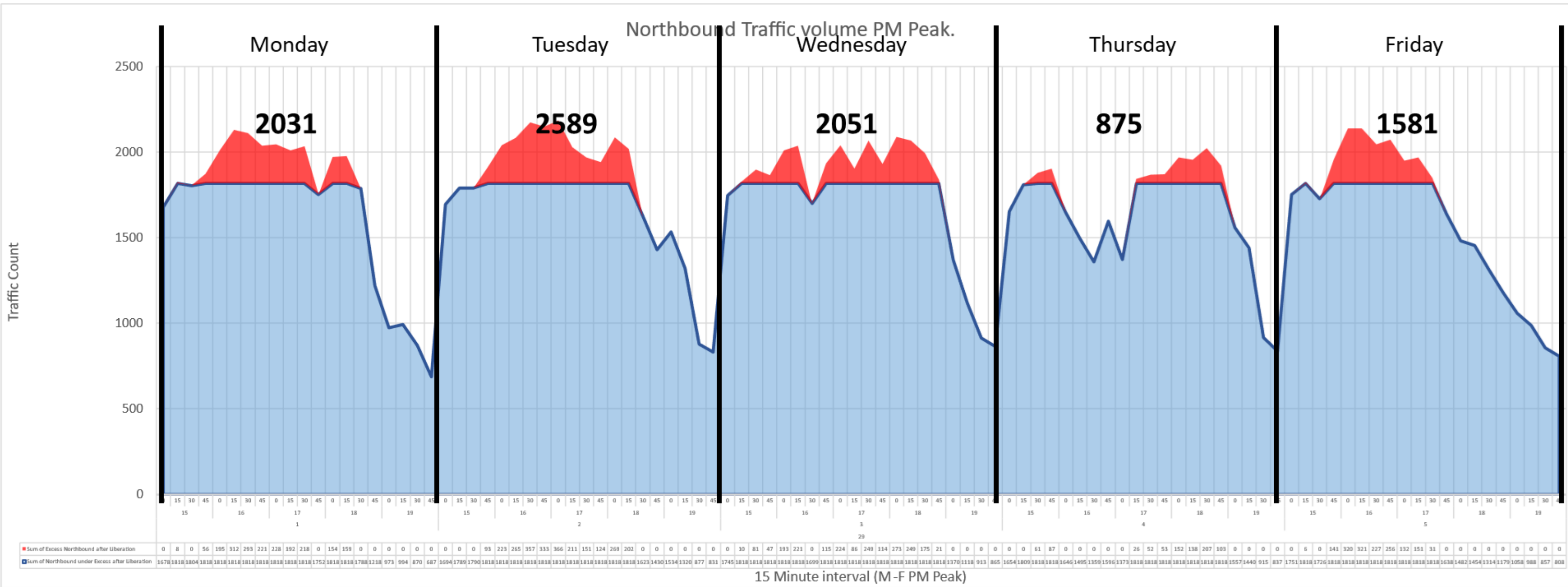
2016 Week 29 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



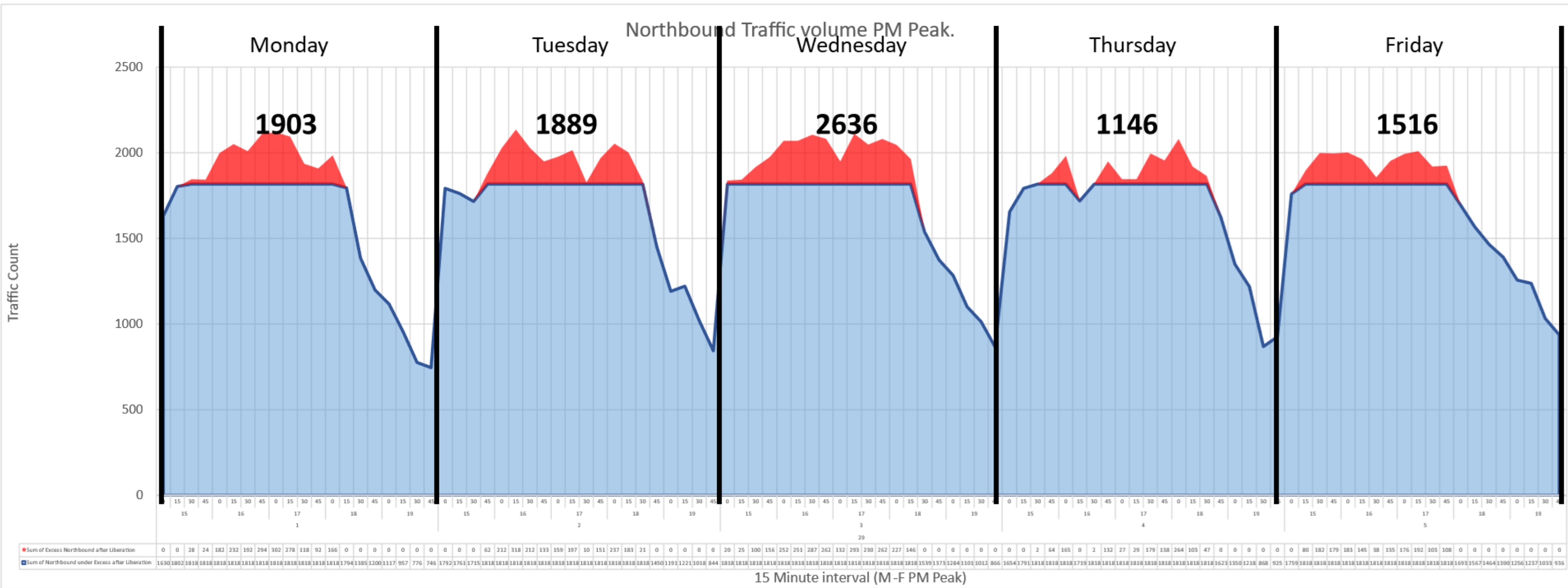
2017 Week 29 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



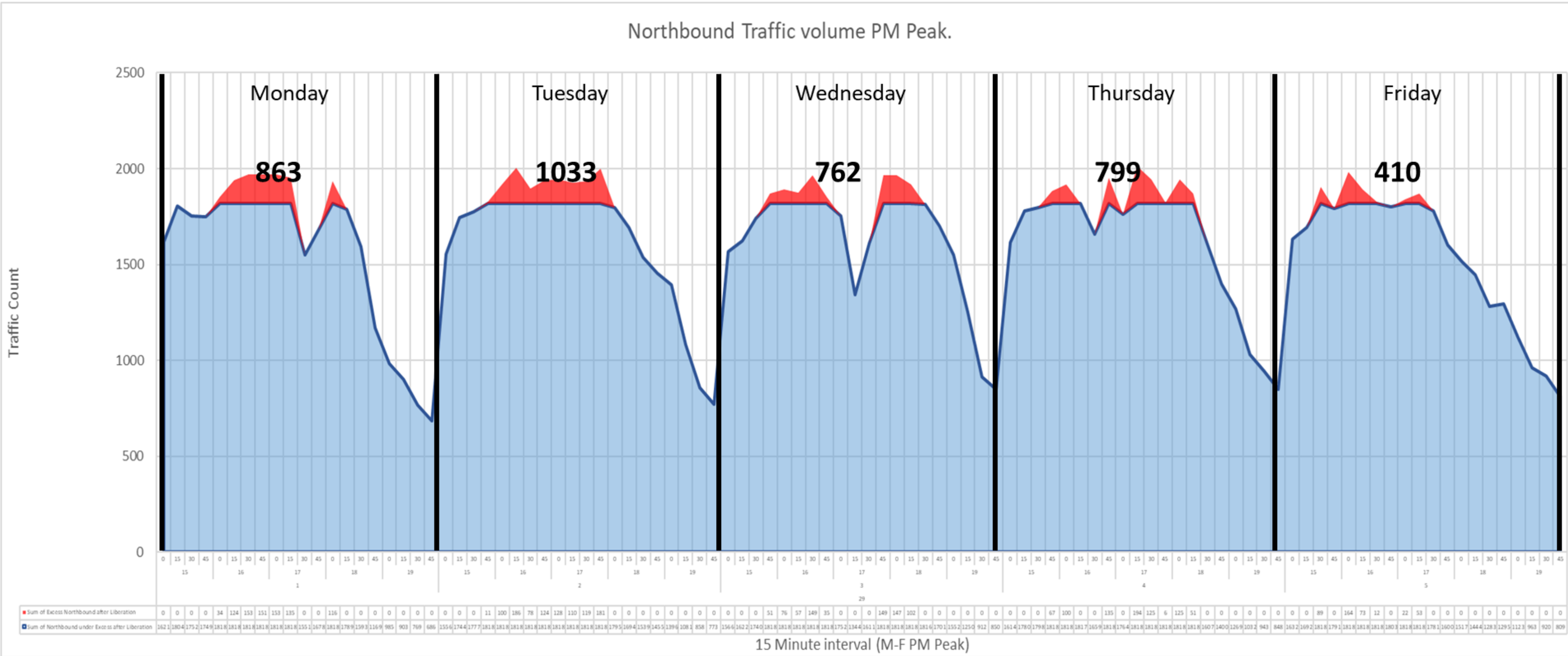
2018 Week 29 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



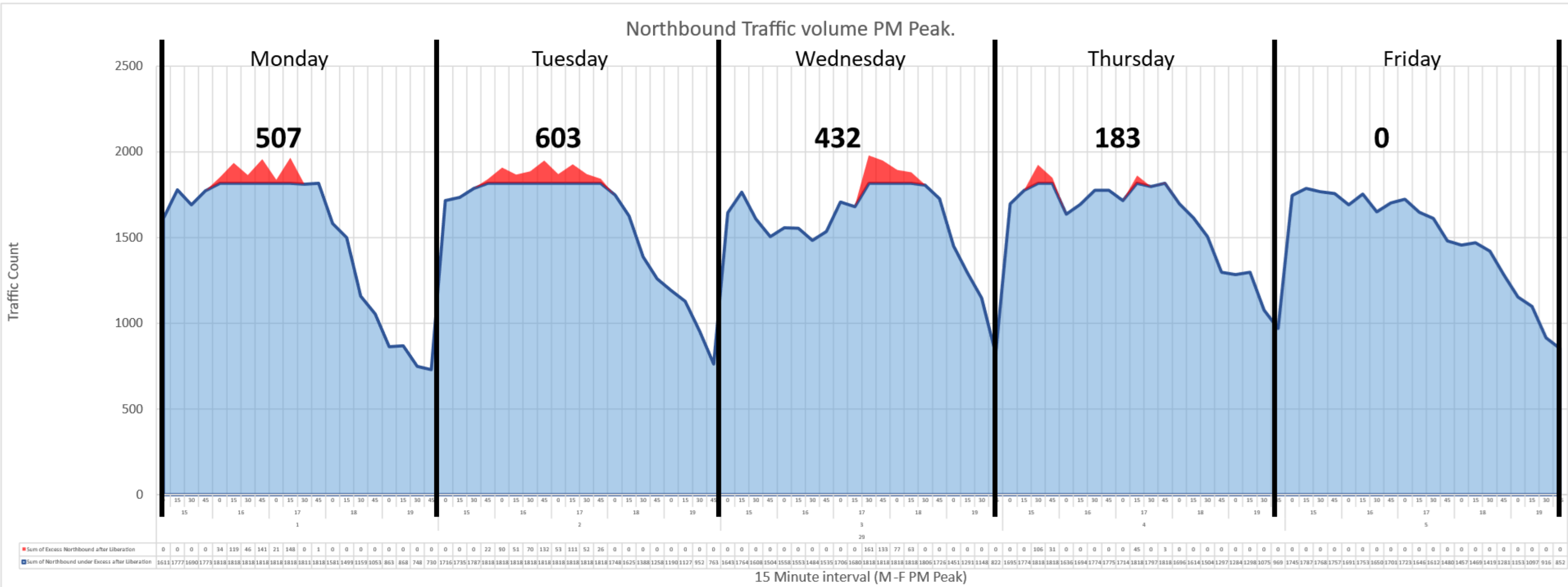
2019 Week 29 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



2021 Week 29 15:00-19:00

Example **203** Vehicles above 4-Lane Capacity



2022 Week 29 15:00-19:00

Example **0** Vehicles above 4-Lane Capacity