NZUP BROUGHAM STREET IMPROVEMENTS PROJECT

TECHNICAL MEMORANDUM 7: PROJECT IMPACTS ON CLIMATE CHANGE AND AIR QUALITY

Context

SH76 Brougham Street corridor improvements form part of the Government's $6.8 billion New Zealand Upgrade Programme that aims to get New Zealand cities moving, save lives and boost productivity. The improvements have been developed as part of a business case process for the wider Brougham-Moorhouse area developed by Waka Kotahi and Christchurch City Council.

A multimodal transport plan is recommended for Brougham Street to enhance the operation and performance of the corridor, making it more efficient, reliable, and safe for all users. This includes a traffic management strategy to make optimal use of the available road space, together with a range of other interventions to improve safety, enhance access and prioritise more efficient travel modes and freight.

In the process of seeking endorsements and approvals of the recommended plan, the project team has prepared a series of briefing notes on specific areas of concern to inform the process and decision makers. They are intended to complement the Business Case Report and deliverables as well as provide input into communications materials that Waka Kotahi may develop to inform stakeholders.

Purpose of this briefing note

This briefing note outlines how the proposed NZUP Brougham Street improvements would help reduce greenhouse gas (GHG) emissions, honouring/ in line with the Government's commitment to lowering greenhouse gas emissions, as specified in the Climate Change Response (Zero Carbon) Amendment Act 2019.

It recognises that Climate Change should be addressed in terms of both; mitigation of project impacts on the climate and adaptation of the transport system to possible climate change impacts.

The primary focus of this note is on Climate Change mitigation measures. The concern of adaptation has been considered in greater detail in earlier business case work.

Strategic Context

Transport is a leading contributor to GHG emissions as well as one of the fastest growing sources. It accounts for about 20% of all GHG emissions in New Zealand, with 90% of these from land transport. Most land transport GHG emissions come from light vehicles in our fastest growing urban areas such as Christchurch.

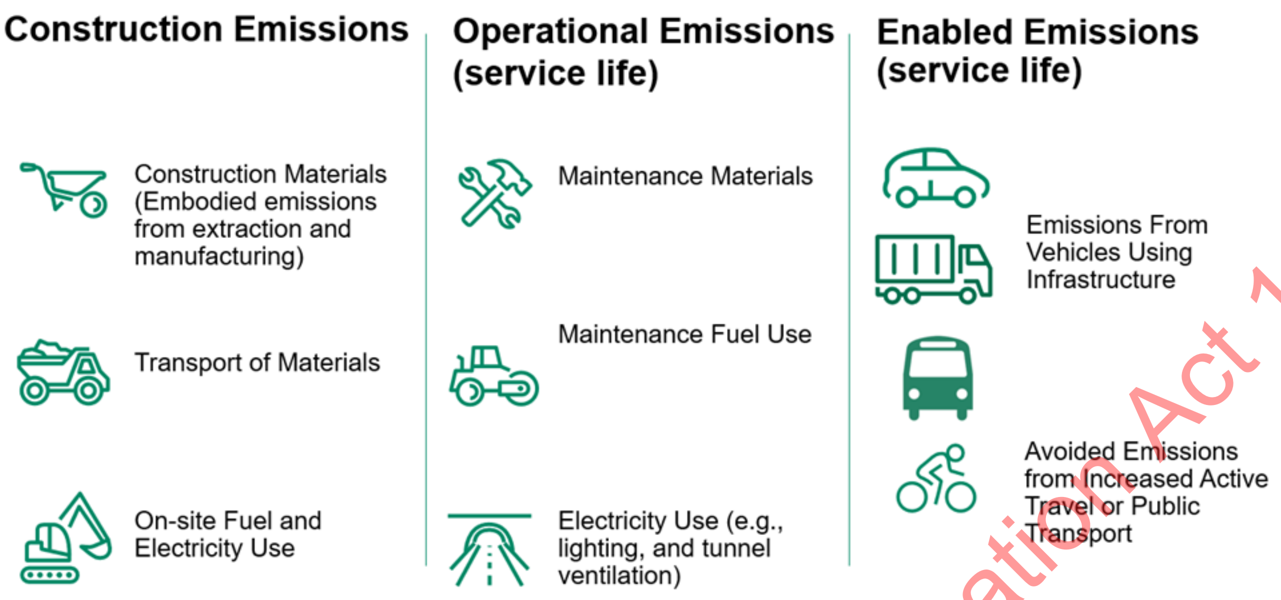
The Government Policy Statement on Land Transport 2021 (GPS) has climate change as one of four strategic priorities. The GPS is clear that investment decisions need to:

- support the rapid transition to a low carbon transport system
- contribute to a resilient transport sector that reduces harmful emissions
- give effect to the emissions reduction target the Climate Change Commission recommended to Cabinet

Projects managed or funded by Waka Kotahi must "give effect to" or be "consistent with" the GPS 21.

Toitu Te Taiao - Waka Kotahi's Sustainability Action Plan sets out Waka Kotahi's vision for a low carbon, safe and healthy land transport system. The implementation of this action plan is part of how Waka Kotahi will deliver on the outcomes of the GPS. Other substantive change is ahead, including the Climate Adaptation Act.

The following figure shows the different sources of emissions from transport projects.



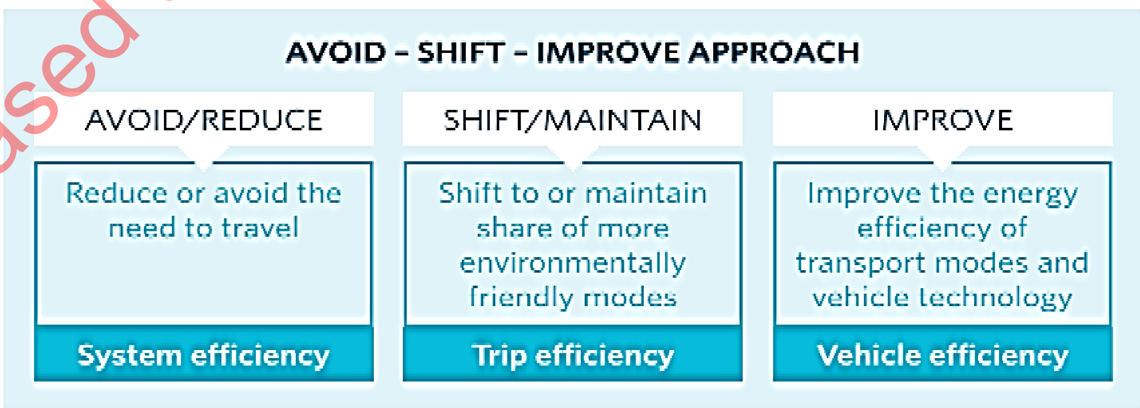
Project Context

Although the NZUP Brougham Street project has not been developed with the primary purpose of reducing GHG emissions, it is expected to contribute to Climate Change mitigation through measures aimed at:

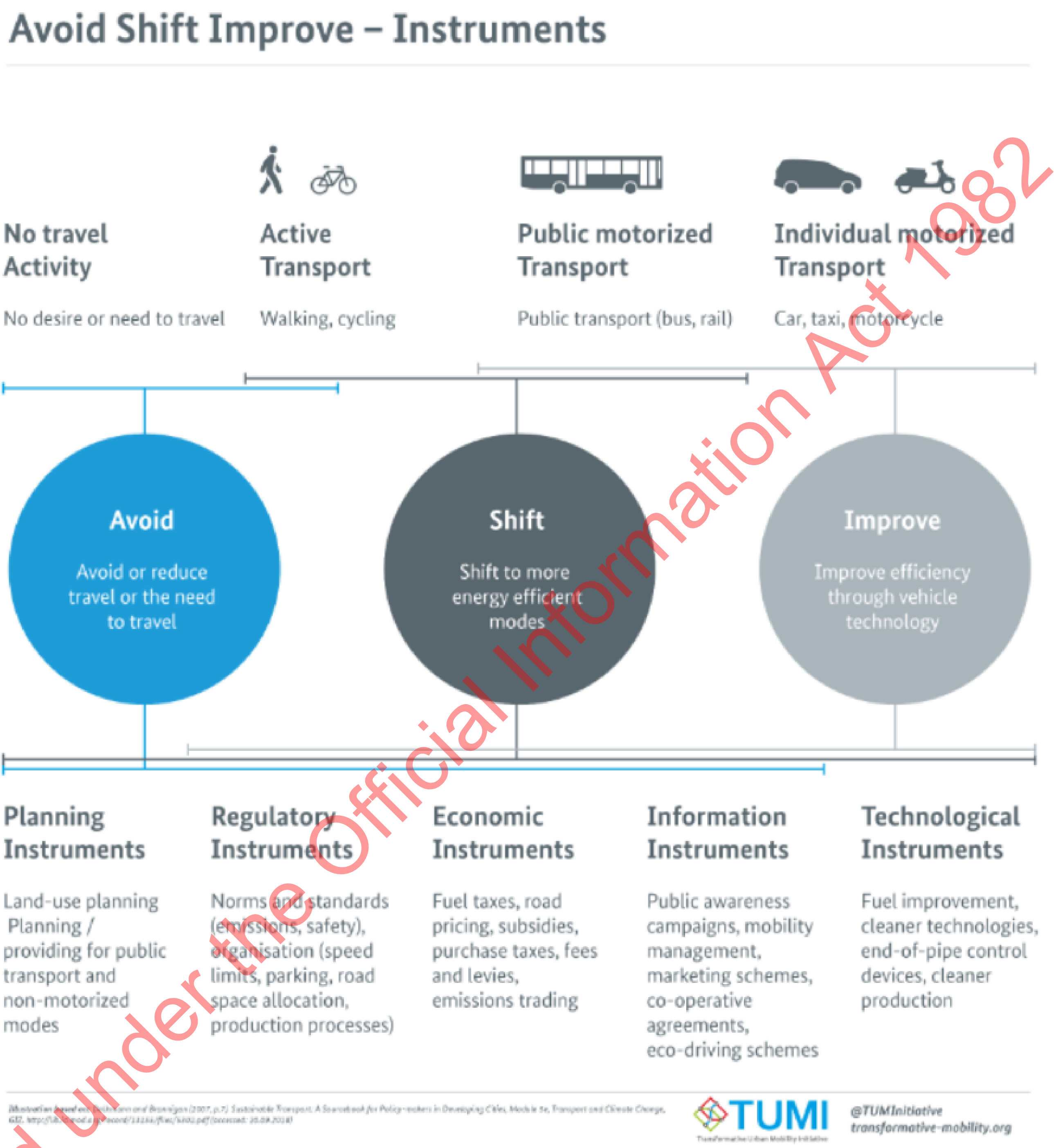
- using existing infrastructure rather than constructing new infrastructure
- increasing transport choices and encouraging the use of alternative modes including new pedestrian and cyclist crossing, bus infrastructure improvements, and priority lanes for buses and high occupancy vehicles
- improving traffic management and reducing congestion including bus priority measures, managed lanes, carpooling, traffic signal optimisation and parking management
- improving freight travel efficiency
- measures to improve the safety for pedestrians, cyclists and other modes.

Avoid – Shift – Improve framework

A high-level review of the recommended plan has been undertaken using the internationally recognised Avoid – Shift – Improve framework[1]. This is included in Waka Kotahi's Sustainability Action Plan, Toitū Te Taiao as an approach for supporting emissions reduction. The review indicates that the plan performs better than other scenarios with no NZUP investments.



[1] The A-S-I approach was initially developed in the early 1990s in Germany and first officially mentioned 1994 in the report of the German parliament´s Enquete Commission. The approach serves as a way to structure policy measures to reduce the environmental impact of transport and thereby improve the quality of life in cities



Avoid measures aim to avoid or reduce the need to travel, or the time or distance travelled by car, The main interventions in this approach are of a regulatory and planning nature, to integrate land use and transport planning.

Shift measures focus on shifting the mode of travel from the most energy consuming and polluting urban transport mode (i.e., cars) towards more environmentally friendly modes such as walking and cycling and public transport. A shift to higher occupancy vehicles (HOV) will also reduce the number of Single Occupant Vehicles (SOVs).

And finally, the **Improve** measures which focus on vehicle and fuel efficiency as well as on the optimisation of the transport system operations.

The A-S-I approach follows a hierarchy where “avoid” measures should be prioritised, followed by “shift” and finally the “improve” measures.

It is clear that a broad response is necessary both in terms of the type and size of interventions.

The proposal for Brougham Street along with the wider business case is aligned with the ASI framework.

- A shift to more sustainable modes through the provision of improved infrastructure for walking, cycling, and priority lanes
- Improvements to the efficiency of public transport, freight and cars by encouraging higher occupancy vehicles.

Effect of the Project on Enabled Emissions

Traffic modelling

Traffic modelling has been used to predict the effects of this NZUP project on greenhouse gas and other emissions for the future year of 2028. The citywide CAST model considers how traffic patterns will change with the project, with a Paramics microsimulation model looking at the detailed operation of Brougham Street. The traffic volumes and trip patterns used by the Paramics model come directly from the CAST model. This allows for the wider network effects to be captured by the CAST model whilst the detailed operation of the Brougham Street corridor is covered by the Paramics model.

The following scenarios were modelled for the 2028 forecast year:

- Existing Situation – the current layout of Brougham Street, with two general traffic lanes in each direction;
- Converted Lane – with one managed lane and one general traffic lane in each direction;
- Added Lane – with one managed lane and two general traffic lanes in each direction

The CAST modelling of the Added Lane scenario considered how the network would operate with the existing split between SOV and HOV use i.e. operation of the network on opening of the project, as well as a scenario with a shift from SOV to HOV. This shift would come about as the improvements for HOV's on Brougham Street will encourage ridesharing, with a shift from single occupant vehicles. Additional complementary measures to encourage HOV's and discourage SOV's will be required to achieve a significant shift away from SOV's.

The Added Lane scenario includes a number of safety improvements along the corridor, including right turn arrows, protected pedestrian movements at intersections, grade separation of the existing Collins/Simeon signalised crossing (with removal of these signals) and a new signalised pedestrian east of Waltham Road. The provision of right turn arrows and providing right turn arrows reduce the amount of green time available for through movements on Brougham Street. However, the extra capacity provided by the added lane means that the green time along Brougham Street can be reduced without impacting on Brougham Street capacity. As a result, the existing level of service can be maintained for vehicles in the general traffic lanes whilst improving it for HOVs.

Traffic emissions modelling

Both SATURN (the transportation modelling suite used by CAST) and Paramics have built-in pollution modules, which calculate emissions. These calculations are relatively sophisticated, taking account of travel speeds, acceleration and deceleration rates, idling time, primary and secondary stops, vehicle weight, etc. The resulting emissions have been calibrated against Waka Kotahi's and Auckland Council's Vehicle Emissions Prediction Model[2] (VEPM) to adjust them to the New Zealand vehicle fleet composition expected in 2028.

The following polluting emissions are reported from the modelling:

- Carbon Dioxide CO_2
- Carbon Monoxide CO
- Oxides of Nitrogen (NOx)
- Particulate matter (PM10)

Summary Modelling Outcomes

The CAST model predicted that the Converted Lane scenario would result in faster travel times along Brougham Street for HOV's, due to a lessening of congestion in the managed lane. This attracts more HOV's to the corridor to benefit from the faster travel times. For vehicles not able to use the managed lane, higher levels of congestion are expected in the single general traffic lane, resulting in slower travel times. With the reduced capacity and slower travel times, SOV's reroute to alternative parallel routes. Overall, there is a decrease in the number of vehicles on Brougham Street, with the displaced vehicles taking alternative routes.

[2] VEPM 6.1

The CAST model predicts that the Added Lane scenario will draw vehicles to the Southern Motorway and Brougham Street to take advantage of the faster travel times along this corridor. This applies particularly to HOV's, which are expected to see time savings on the corridor with the managed lane. Total travel times for all vehicles decrease (i.e. there is a drop in VHT), though total travel distance increases slightly as some vehicles travel further to access the improved travel times on the corridor (i.e. VKT goes up). The net result is more vehicles travelling on Brougham Street with fewer vehicles on the routes parallel to Brougham Street.

With a shift away from SOV's, there is a general reduction in traffic volumes across the entire Christchurch road network. The higher speed limit on Brougham Street relative to the surrounding local roads means that there is less of a reduction on Brougham Street, as vehicles reroute to Brougham Street.

Unlike the CAST model, which has the same total number of vehicles travelling through the network, the number of vehicles in the Paramics model changes between scenarios as it only includes the Brougham Street corridor (and not the parallel routes that vehicles can reroute from or to). This means that in the Added Lane scenarios, which see an increase in the traffic volume along the corridor (as well as entering or leaving the corridor at side roads), the emission results are for more vehicles than in the Do Nothing and Converted Lane scenarios.

The Converted Lane scenario operates very poorly, with very high levels of congestion and delay on the single general traffic lane and side roads (with vehicles are blocked by queuing vehicles on Brougham Street).

The Converted Lane scenarios both see reductions in congestion. Retaining the existing 60 kph speed limit does produce faster travel times, but this is at the expense of safety for all road users and poor co-ordination of the traffic signals (resulting in an inefficient "green wave" progression along Brougham Street).

Reducing the speed limit to 50 kph loses some of the travel time savings, but it does allow for better co-ordination of the traffic signals and improved safety for all road users (especially for vulnerable uses walking or cycling along/across the corridor).

Emissions Modelling Results

Carbon Dioxide (CO_2)

The predicted CO_2 emissions across the Greater Christchurch area calculated by the CAST model are reported in Table 1, whilst those generated along the Brougham Street corridor from the Paramics model are in Table 2. Both of these tables report the hourly emissions during each modelled period, which have also been combined to generate daily emissions.

Table 1: Hourly and daily CO_2 emissions in tonnes across Greater Christchurch (CAST model 2028)

Scenario	AM	IP	PM	Daily	Daily Change
Do Nothing	236.6	186.9	278.7	2,879.1	
Converted Lane	237.2	186.9	279.6	2,882.2	+0.1%
Added Lane – No Shift from SOV	236.9	187.1	279.6	2,883.3	+0.1%
Added Lane – Shift from SOV	205.8	164.9	240.0	2,517.8	-12.5%

The Converted Lane scenario shows a slight increase in CO_2 emissions in both peak periods compared to the existing situation due to increased congestion in the general traffic lane on Brougham Street and drivers travelling further to avoid that congestion. There is no difference in the IP period, when the reduction to a single general traffic lane has less effect due to lower traffic volumes. On a daily basis, there is a 0.1% increase in CO_2 emissions for the Converted Lane scenario.

For the Added Lane scenario, without any shift from SOV to HOV there is a slight increase in CO_2 emissions in each of the modelled time periods as drivers travel further to take advantage of the faster travel times and lower congestion on Brougham Street. This results in 0.1% more CO_2 emissions across the Greater Christchurch area.

Given the small extent of the project relative to the entire road network in Greater Christchurch, it is not surprising that the difference in CO_2 emissions is very small without a wider programme of measures to encourage people out of SOV's (and private vehicles).

With an increase in HOV use across Christchurch, CO_2 emissions are predicted to decrease, generally in line with the decrease in the number of private vehicles travelling on the network. The decrease in CO_2 will be slightly less than the decrease in private vehicles, as the remaining vehicles (including trucks) will reroute to faster routes with the general lowering in congestion across the network.

Table 2: Hourly and daily CO_2 emissions in tonnes along Brougham Street corridor (Paramics model 2028)

Scenario	AM	IP	PM
Do Nothing	6.2	5.2	6.7
Converted Lane	7.6	5.1	8.2
Added Lane – 60 kph	5.0	4.9	7.4
Added Lane – 50 kph	6.2	6.1	6.7

The Paramics modelling of the Converted Lane scenario shows an increase in CO_2 emissions in both peak periods, due to the increased congestion in the single general traffic lane. In the IP period, these emissions are slightly less than for the existing situation, although across the day there is a 9% increase in CO_2 emissions.

Modelling of the Added Lane (60 kph) scenario shows significant reductions in CO_2 emissions in the AM period, a smaller reduction in the IP period and a small increase in the PM period. On a daily basis, the Added Lane (60 kph) scenario shows a 4% reduction in CO_2 emissions along the corridor.

Despite the slower speeds in the Added Lane (50 kph) scenario, peak period (AM and PM periods) CO_2 emissions are practically identical to those for the existing situation (Do Nothing scenario). CO_2 emissions increase in the IP period, resulting in a 10% daily increase.

Note that both of the Added Lane Scenarios have many more vehicles travelling along or across the corridor (a 20% increase on the Do Nothing and Converted Lane scenarios). So although total CO_2 emissions increase in the 50 kph scenario, the emissions per vehicle decrease compared to the existing situation.

Other Harmful Emissions

Daily emission totals for the other reported pollutants are summarised in Table 3 for the wider Christchurch area and Table 4 along the Brougham Street corridor.

Table 3: Daily CO, NOx and PM10 emissions in kg across Greater Christchurch (CAST model 2028)

Scenario	CO	NOx	PM10
Do Nothing	10,281	5,983	323
Converted Lane	10,322	5,999	324
Added Lane – No Shift from SOV	10,299	5,990	324
Added Lane – Shift from SOV	8,803	5,211	279

Similarly to the outcomes reported for the CO_2 emissions, Table 3 shows that without a shift away from SOV's, there will be a very small increase CO, NOx and PM10 emissions across Christchurch as a result of the slight increase in VKT under the Added Lane scenario. Reducing the number of SOV's will have the effect of proportionally reducing CO, NOx and PM10 emissions.

Table 4: Daily CO, NOx and PM10 emissions in kg along Brougham Street corridor (Paramics model 2028)

Scenario	CO	NOx	PM10
Do Nothing	155	91	5.0
Converted Lane	149	88	4.5
Added Lane – 60 kph	149	85	4.0
Added Lane – 50 kph	161	98	4.9

The Paramics model predicts a similar pattern of outcomes for the Added Lane (60 kph) scenario, with decreases in all harmful pollutants. With the lower speed limit, emissions of CO and NOx are predicted to be higher than in the existing situation, but the better co-ordination of the traffic signals at 50 kph results in less stop/start activity, producing a reduction in PM10 emissions with the reduced braking requirements.

Effect of the Project on Construction Emissions

The project mostly involves use of/re-purposing of existing infrastructure, rather than constructing new infrastructure. Therefore, construction emissions are not a significant component of the project, with the exception of the grade separated pedestrian/cycle crossing at Collin St Simeon St. A GHG emissions estimate carried out for the NZUP programme assessed the construction emissions of a proposed grade separated pedestrian cyclist overpass crossing at Collins/Simeon. The assessment estimated embodied emissions associated with the consumption of materials in the construction, such as steel and cement.

The result of the CIPA assessment for embodied emissions is summarised in table below

Brougham Street Multimodal Improvements — **CONSTRUCTION**

Pedestrian/cycle bridge — Expected construction 2023-2025; Range of traffic management options including pedestrian/cycle overpass

		Units	Emissions Factor	Unit	Sources and notes
Do Intervention					
Material Quantities Estimate					
Construction Fuel Use					
Diesel	0	L	0.0027	tCO2e/L	MfE 2020
Construction Materials					
Concrete	2,339	tonnes	0.11	tCO2e/tonne	AECOM derived factor (See assumptions below)
Steel	788	tonnes	2.85	tCO2e/tonne	MfE 2020
Road Surface					
Crushed rock or recycled material		tonnes	0.0032	tCO2e/tonne	IS Calculator NZ v2.0
Gravel	1,150	tonnes	0.0182	tCO2e/tonne	IS Calculator NZ v2.0
Bitumen		tonnes	0.3966	tCO2e/tonne	IS Calculator NZ v2.0
Asphalt	68	tonnes	0.0542	tCO2e/tonne	IS Calculator NZ v2.0
Project Breakdown Total	2,528	tonnes of CO2e			
Calculated Emissions					
Best estimate of calculated emissions	2,528	tonnes of CO2e			

Assumptions

Emissions for construction have been calculated from data provided by Waka Kotahi for this project. When possible assumptions have been made in a consistent manner to ensure
Refer to construction schedule worksheet for indicative schedule of quantities of concrete, steel, aggregates, gravels and fuels used during construction.
Based on previous research for Waka Kotahi, only emissions from the largest emission sources from construction of infrastructure projects have been estimated (concrete, steel, aggregates, asphalt, and on-site fuel use).
Materials and works related to bridge abutments have been included where relevant.
Fuel used in the construction is assumed to be 2 litres of diesel for every m3 of earth works (AECOM derived fuel-use ratio).
The following were not included in the estimate: fuel used in quarrying activity; emissions from the transportation of construction materials to/from site.

Emission factors are sourced from MfE's 2020 Guide (see link below) where appropriate, or from the ISCA-IS Calculator v2.0.
https://environment.govt.nz/publications/measuring-emissions-detailed-guide-2020/
The ISCA-IS Calculator v2.0 is available for ISCA members at https://www.isca.org.au/Tools-and-Resources
The emission factor for concrete is based on MfE 2020 guidance and is based on a standard concrete mix.

Conclusions

The primary focus of this note is on assessing how the NZUP Brougham Street proposed improvements are likely to impact on greenhouse gas (GHG) emissions and local air quality.

The recommended option (with Added Lane scenario - with one HOV Lane and two General Traffic Lanes with 50 km/h speed limit) shows the effectiveness of the managed lane in achieving less traffic congestion, carbon reduction and other related benefits, such as reduced travel delay, greater use of carpool, buses and alternative modes, improved safety, and enhanced economic activity.

For the recommended option, there are reduced adverse environmental effects across the peak periods due to more HOVs using Brougham Street and the more efficient operation of the corridor. This will assist in meeting carbon emissions reduction targets and aid climate change mitigation efforts.

This is because of the reduced number of vehicles and passengers in the general traffic lanes and because the proportion of passengers using the HOV modes (which are both better environmentally and travel faster than the SOVs) is greater.

If the improvements for higher occupancy vehicles, buses and active modes on Brougham Street are supported by complementary measures from regional and local partners, much greater reductions in CO_2 emissions are possible than could be achieved by this project in isolation, furthering local, regional and national climate change goals.