VULNERABLE ROAD USER INCLUSION IN SPOIL REMOVAL ROUTE PLANNING

Matthew Bennett

School of Engineering, RMIT University, Melbourne, Victoria 3000, Australia

email:mfcxb@hotmail.com

Submitted for the David Sudgen Award, 2018

ABSTRACT

Tunnelling is an activity that creates tonnes of spoil that need to be disposed of in a safe and efficient manner. This is usually done with trucks and dog trailers removing the spoil from the site and taking it to a suitable place for disposal. As it is nearly impossible to provide these trucks with dedicated infrastructure, they must share the road space with other road users. By sharing the road space, these trucks must interact with other road traffic, including Vulnerable Road Users (VRUs), defined as cyclists and pedestrians. With the increase of interaction between trucks and VRUs, there is an increase in the risk of collision between the two types of road users. Due to the sheer difference of momentum between the two, collisions often result in serious injury or fatality for the VRU. When planning routes for spoil removal from a Tunnel Boring Machine (TBM) site, route planners often overlook the interaction trucks may have with VRUs. This results in avoidable, unnecessary risk to VRUs that can be mitigated with planning and consideration during the route selection process. This paper investigates current practice of route selection, and how it can be improved to include VRUs in the route selection process.

I. INTRODUCTION

Tunnelling and other underground works are inherently dangerous activities. Therefore, engineers ensure that safety is one of the first and foremost considerations when constructing tunnels. As a result, safety is structurally integrated as part of the decision-making process for site-based activities. This inclusion extends to the immediate vicinity of the site, with standards and guidelines for Traffic Management Plans (TMPs) covering traffic safety considerations for the site, and the approach to the site. Unsurprisingly, this is then reflected in the TMPs focusing on the safety impacts near the site.

Vulnerable Road Users (VRUs), primarily cyclists and pedestrians, often interact with Tunnel Boring Machine (TBM) sites in urban environments. TMPs cover the management of VRU diversions and safety in the immediate vicinity of TBM sites. However, trucks removing spoil must interact with VRUs along the entire length of the haulage routes, not just at the TBM site. Although not always entirely ignored, the interaction between trucks and VRUs along haulage routes is often not considered with the same level of detail as VRU-site interactions. This paper looks at gaps in the traditional haulage route selection process, and how VRUs can be included as part of this process.

II. TRUCK AND VRU INTERACTIONS

For most of the haulage routes, trucks can use major traffic corridors such as freeways, on which there is little to no interaction with VRUs. However, TBM sites are not always located close to these major traffic corridors, so haulage trucks have to use a series of smaller roads to reach the site. It is on these roads where trucks must interact with VRUs. Due to the sheer difference in momentum, collisions between VRUs and other road users can result in fatalities even at low speeds (1). Moreover, of all collisions involving heavy vehicles (trucks and buses), 12% also involved pedestrians (2). Collisions between heavy vehicles and VRUs are much more likely to result in a fatality than lighter vehicles such as cars and vans (1). Despite high traffic volumes of trucks do increase the risk to VRUs, and large scale urban construction projects are not a recent phenomenon there is little literature covering heavy freight vehicle safety (3).

III. CURRENT ROUTE SELECTION

Haulage route planners need to obtain permission from road authorities and local government when defining routes for trucks to and from site. In Victoria, VicRoads provide a couple of online tools that help route planners select routes which are likely to be approved.

The first of these tools is the Heavy Vehicle Network Maps. This is a series of maps that show roads that have been assessed and gazetted by VicRoads for certain truck types. The gazetted roads come under three categories: approved; conditionally approved; and restricted. Clicking on a conditionally approved or restricted road on the map, a dialogue box shows information on conditions and reasons for the restrictions. Restrictions are usually placed on roads if they are not geometrically suitable for the truck type, to avoid restricted structures or to address amenity concerns (4). Other states have similar maps for their networks, and the National Heavy Vehicle Regulator provides an Australia wide map that combines all data sets from the state road authorities' maps (5).

The second tool available to route planners in Victoria is the SmartRoads framework.[1] Like the Heavy Vehicle Network Maps, this is an online tool provided on the VicRoads website. SmartRoads is an alternative method of defining the road hierarchy. Rather than the traditional, fixed role hierarchy model, SmartRoads prioritises different modes of transport at different times of the day to make the most of the road network. SmartRoads also factors activity centres into the road prioritisation, diverting traffic routes around, rather than through, activity centres (6).

IV. Gaps in Current Methodology

Current codes and standards focus on safety in the immediate vicinity of, and on the work site, not along the entire haulage route. There is little structured or collaborative decision-making framework installed for route planners to use in designating haulage routes. Although using the Heavy Vehicle Network Maps can expedite the route approval process, not every road has been gazetted for the Heavy Vehicle Network maps, leaving large gaps in the road network. Of the roads that have been gazetted, the maps do not necessarily reflect the suitability of roads with regard to VRU safety. In Melbourne, St Kilda Road, Elizabeth Street and Royal Parade are examples around the CBD of roads that have high VRU traffic and are approved for large heavy vehicles.

SmartRoads does cover Melbourne's entire road network. If route planners select roads that are designated as 'preferred traffic routes', then the route is likely to be approved by the road authorities and local government agencies. However, particularly in urban environments, it can be hard to identify 'preferred traffic routes' among all the other competing priorities such as public transport, pedestrians and cyclists.

Figure 1: Truck in cycle lane

Without structured inclusion in the route selection process, VRUs are often overlooked in route selection. Figure 1 shows an example where truck and dogs, often used for spoil removal, were staged on a road with a high volume of cyclist traffic. As the trucks could not fit in the parking space, they took up part of the cyclist lane as well, this forced cyclists into the active traffic lane, placing them at risk of being struck by another road user.

V. CLOCS

The lack of inclusion of VRUs in haulage route selection is not an issue unique to Melbourne, or even Australia. When confronted with high truck

[1] The SmartRoads framework is currently being updated to Movement and Place which will perform a similar task to the current SmartRoads framework

traffic volumes resulting from the Crossrail project in London, Transport for London (TfL) commissioned a report from the Transport Research Laboratory (TRL). The report, titled Construction Logistics and Cyclist Safety, reviewed transport activities, particularly that of the construction sector, to identify and understand the causes of collisions between heavy vehicles and cyclists. The report found that of the 16 cyclist fatalities in 2011, nine involved a heavy vehicle, seven of which were from the construction sector (7). Two of the general findings from the report were (7):

1. *Road risk is viewed as less important than general health and safety risk;*
2. *Although road casualty statistics make it difficult to identify industry sectors associated with collisions, construction traffic appears likely to be over-represented in collisions with cyclists.*

Based on these findings, TRL produced 12 recommendations for TfL. Recommendation nine states that Construction Logistics Plans (CLPs) must include the delineation of safer routes to construction sites. TRL states "as part of the mandatory CLPs, principal contractors should define safer routes to their sites (within a set local radius, for example five miles), where possible avoiding risky areas such as schools, cyclist 'hotspots', narrow roads and difficult junctions. In all cases, consideration should be given to minimising exposure to vulnerable road users". Although the TRL CLOCS report covered the entire construction sector, not just trucks from tunnelling activities, Crossrail was the major project at the time of the report. Therefore, tunnelling related truck traffic would have been one of the primary catalysts for TfL commissioning the report.

From the report, TfL founded the CLOCS[2] program, which published the CLOCS standard in 2013. There are two requirements within the standard that address routing traffic, one for the client and one for the fleet operator (8):

- Requirement 3.1.5: *Clients shall ensure that a suitable, risk assessed vehicle route to the site is specified and that the route is communicated to all principal contractors and drivers. Clients shall make principal contractors, fleet operators and other service suppliers aware that they are to use these routes at all times unless unavoidable diversions occur.*
- Requirement 4.1.3: *Fleet operators shall ensure that any vehicle routes to sites or premises specified by clients are adhered to unless directed otherwise.*

Unlike Australian practice, CLOCS includes VRUs in the route selection process. However, even CLOCS only provides the standards, not the tools that can be used to achieve those standards.

VI. VRU SAFETY TASKFORCE

The Melbourne Metro Rail Authority[3] (MMRA), like TfL, recognised that the high volumes of truck traffic produced by tunnelling projects places VRUs at a higher risk of collision. Therefore, in December 2016, MMRA hosted a VRU and Truck Safety Forum at which stakeholders were invited to discuss the impacts the Metro Tunnel Project (MTP) will have on VRUs in Melbourne. This resulted in the creation of a VRU Safety Taskforce. The taskforce includes four working groups and a steering committee. The four working groups covered different areas of VRU safety, one of which is heavy vehicle route selection. This working group decided that a tool should be created that facilitates the collaborative and structured inclusion of VRUs in haulage route selection through a risk assessment. The resulting tool has been named the Human Impact Route Assessment tool, or HIRA.

[2] Since the publication of the 2012 TRL report, TfL has rebranded CLOCS as Construction Logistics and Community Safety to include other VRUs.

[3] MMRA has since been renamed Rail Projects Victoria as the scope of the authority has expanded

VII. Introduction to HIRA

HIRA has been developed to encourage collaboration between different stakeholders in the haulage route selection process. HIRA is used in a workshop where stakeholders meet to assess routes using the tool. The tool is still in development and is not in its final form but has proved successful in pilot studies (9). HIRA has not been designed to be the only step in the route selection process, but as a decision aiding tool, allowing for the structured inclusion of VRUs in the route selection process. Even if the route HIRA proposed was not selected due to other considerations such as noise or road pavement quality, HIRA provides a structured risk assessment, identifying risks to VRUs along the selected route.

HIRA is structured as a rubric. It has 15 elements that are categorised into four attributes. Each route is assessed against four performance standards using a numerical scoring system between one and ten:

- Preferred (nine to ten);
- Good (six to eight);
- Average (three to five);
- Less Than Average (one to two).

Each element has a descriptor for each performance standard. This helps participants identify what a 'Preferred', 'Good', 'Average' and 'Less Than Average' route looks like for each element. In its current form, HIRA is an Excel Spreadsheet (see appendix) which can be printed onto an A3 piece of paper and distributed to participants in the workshop.

The first of the four attributes is 'Activity Hubs'. This attribute has six elements that cover risks to VRUs based on roadside activities. The elements are:

- Hospital and Emergency Services Access;
- Childcare, Schools and Education Institutions;
- Retail Precincts;
- Entertainment Precincts;
- Sporting and Recreational Precincts/Facilities;
- Service Access and Trader Deliveries.

The second attribute is 'Route Dynamics'. This attribute focuses more on the on-road risks and operation of the route. This performs a similar role to the Heavy Vehicle Network Maps. However, the 'Route Dynamics' attribute functions as a current assessment of the route, less dependant on previous assessments of the roads, and with a stronger focus on VRU safety. 'Route Dynamics' also contains six elements:

- Flexibility (access to alternate routes);
- Distance and Directness;
- Conflict with other Construction Projects;
- Road Type and Function;
- Active Transport;
- En Route Holding Area.

The third attribute is 'Public Transport'. This attribute contains only two elements, one focusing on interaction with the modes of public transport, and the other, with the stops and stations on public transport routes.

The final attribute is called 'Road Closures/Events'. This attribute has only one element, covering the reliability of the route.

Each element was assigned a weighting by the working group. The weighting was intentionally skewed so that it prioritised VRUs in the assessment. More specifically, the weighting favoured:

- Cyclists;
- People who are sick or infirmed and those who are visiting them;
- Students from childcare through to tertiary level;
- People who are visiting entertainment precincts who may be affected by drugs and/or alcohol.

Although participants use a numerical system to score individual elements. The final score is displayed as the performance standards, rather than the numerical equivalent.

VIII. HIRA IN THE DECISION-MAKING PROCESS

HIRA was never intended to be used as the only step in the route selection process. Nor was it intended to be the only consideration for route planners when selecting a route. HIRA forms only part of the larger route selection process.

Before using HIRA, the client or contractor should identify a set of potential routes using conventional route selection methodologies, such as the Heavy Vehicle Network Maps.

Collaboration is one of the main intentions and benefits from using HIRA as part of the route selection process. Therefore, HIRA performs best when done as part of a collaborative workshop. The agency hosting the HIRA workshop (usually the client) should gather a group of stakeholders together to conduct the workshop. This includes, but is not limited to:

- Local government representatives (ideally a traffic engineer/planner);
- Main road authority representatives, preferably with local knowledge of the area;
- The client, who usually hosts the workshop;
- The contractor delivering the project.

Workshops should be facilitated by an external individual who is familiar with HIRA and the HIRA process. The facilitator ensures that all participants stay focused on the element being discussed and are allowed to express their view on VRU safety. The facilitator is also responsible for entering the scores and comments into the HIRA tool.

Participants must unanimously agree on a score before moving onto the next element. If comparing multiple routes, each route must be assessed against an element before moving onto the next element. Each route must be scored against the descriptors rather than against each other. Although HIRA does allow for route comparison, it primarily should be used for risk assessment, determining actual risk rather than relative risk.

The facilitator should note why a route received a certain score for an element. This is particularly important for the low scoring elements. By providing comments, suitable mitigation measures can be discussed in a separate workshop. HIRA does not aim to address who is responsible for the implementation of mitigation, or for the determination of the mitigation, but rather aims only to identify risks to VRUs.

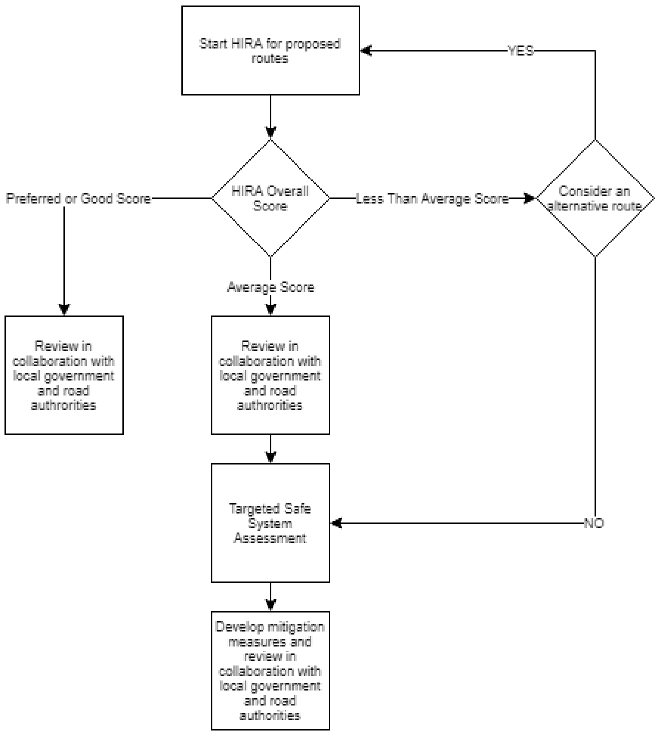

Figure 2: HIRA Decision Support Flowchart (courtesy of the HIRA working group)

Figure 2 shows the decision flow chart for HIRA. This flowchart advises participants on what steps should be taken after the completion of a HIRA workshop. It should be noted, that reviewing the effect of implemented mitigation measures could include reconducting the HIRA workshop assuming the mitigation measures are in place.

IX. HIRA PILOT STUDY

As part of a thesis for a master's degree, HIRA was piloted with industry to determine how HIRA can be improved before wider release. The pilot study looked a how HIRA can be used in a real-world context. As HIRA was developed for the MTP, the pilot study primarily focused on using HIRA on spoil haulage routes. However, the City of

Moreland Council also participated in the pilot study, using HIRA to assess routes to a major urban development site. As the City of Moreland project was significantly smaller than the MTP, the two studies tested how HIRA can be used for projects of different sizes.

To determine whether the pilot study was a success, three Key Evaluation Questions were determined:

1. Did HIRA support and affect collaborative decision-making on route selection?
2. Can HIRA be of value to participants?
3. How can HIRA be further developed.

Data was collected through pre and post-workshop questionnaires, as well as through observations during the workshops. As the MTP had more than one workshop, the questionnaires were only undertaken on the first workshop.

Results from the pilot studies were overwhelmingly positive. Many participants commented on the benefits they recognised from conducting a HIRA workshop. Of the benefits cited, risk identification through inter-agency collaboration was very much prevalent. This aligns well with the intent of HIRA. Some participants suggested that the collaboration can be expanded further, inviting additional stakeholders to the ones recommended earlier, including local residents. However, involving the general public in the decision-making process can sometimes prove unreliable and counterproductive (10). Ultimately, it is up to the host agency to determine who will be invited to the HIRA workshop.

Observations over sequential workshops showed that participants were changing the way they perceived the road space. Participants were considering HIRA's elements when reviewing routes before the workshop. This significantly reduced the time it took to complete a HIRA workshop, from around two hours to a little over one hour.

The time it took to complete a HIRA workshop was concerning for some of the participants. Some participants stated that they felt rushed to complete the workshop in the two hours that is usually allocated to a HIRA workshop. However, as mentioned above, as participants became more familiar with HIRA, the time it took to complete a workshop dramatically decreased.

Wording and relevance of some elements were also raised as concerns with HIRA. Participants found that some of the descriptors were too vague, making it hard to score against them. Some elements were also raised as being potentially irrelevant to VRU safety. However, it may partially be due to the wording of the descriptors rather than the elements themselves.

There were three main recommendations from the pilot study:

1. The order of the attributes should be rearranged so that first-time users of HIRA can become used to the process with relatively familiar assessments, such as the 'Distance and Directness' element, before scoring the less intuitive elements;
2. The elements and their descriptors should be revisited to ensure they align with HIRA's intent;
3. An introduction that is clear and concise should be written for HIRA.

As HIRA enters the next stage of development, these recommendations will be reviewed and implemented by the working group.

X. CONCLUSIONS

When working in tunnelling and other underground works, safety is paramount. Therefore, there is strong safety culture, ensuring that the site is as safe as possible. This safety culture also extends to the immediate surrounds of the site, ensuring that traffic, including VRUs are moved around the site with minimal disruption and maximum safety. However, particularly with tunnel construction, the interaction with other road users does not end there, as high volumes of trucks removing spoil travel between major traffic routes such as freeways, and the site. These trucks interact with other road users along these haulage routes, placing them at risk of collision. This is particularly relevant for VRUs, who are considerably smaller than trucks and already over-represented in road fatality statistics.

This safety risk is often overlooked as part of the route selection process. Current route selection methodologies in Victoria focus more on the suitability of the road for the truck, rather than the impact the truck will have on VRUs. Going against this trend, a report published in the UK, TfL started CLOCS, a program focusing on VRU safety around the construction industry, to improve the safety of VRUs around construction trucks.

Inspired by CLOCS, a VRU Safety Taskforce was formed in Melbourne to increase the safety of VRUs not just around the site, but in all interactions with construction vehicles. One of the working groups of this taskforce has developed a tool called HIRA to provide a systematic inclusion of VRU safety in the route selection process. HIRA was not developed to replace the current route selection process, but to supplement it, including a structured, and collaborative approach to the route selection process.

HIRA was used in a pilot study on the MTP as well as a smaller local council project. Results from the pilot study showed that there was a place in the route selection process for a tool like HIRA. HIRA was shown to help change users' perception of the road space from a link between two places, to a place itself, with important interactions with other road users including VRUs. Including HIRA in the route selection process allows for a more holistic approach to project safety, expanding from just the site, to include related interactions that may be further afield.

Acknowledgements

I wish to thank the members of the HIRA working group (Lora Colussi, Ben Phillips, Jen Thompson and Victor Trumper), with whom I have worked with on HIRA over the past 10 months. I would also like to thank all those who helped develop HIRA and participated in the pilot study. Finally, I would like to thank Dr. Arun Kumar from RMIT University for his supervision over my thesis, covering the pilot study of HIRA.

References

1. Elvik, R., *Why some road safety problems are more difficult to solve than others.* 2010, Accident Analysis & Prevention, Vol. 43 (4), pp. 1089-1096.

2. Bureau of Infrastructure, Transport and Regional Economics (BITRE), *Road Trauma involving heavy vehicles 2016 crash statistical summary.* Canberra : BITRE, 2017.

3. Richardson, B. C., *Sustainable transport: analysis frameworks.* 2005, Journal of Transport Geography, Vol. 13 (1), pp. 29-39.

4. VicRoads, Heavy Vehicle Network Maps. *VicRoads.* [Online] 10 April 2018. [Cited: 27 June 2018.] https://www.vicroads.vic.gov.au/business-and-industry/heavy-vehicle-industry/heavy-vehicle-map-networks-in-victoria.

5. National Heavy Vehicle Regulator (NHVR), NHVR Journey Planner. *National Heavy Vehicle Regulator.* [Online] [Cited: 27 June 2018.] http://gis.nhvr.gov.au/journeyplanner/.

6. VicRoads, Movement and Place. *VicRoads.* [Online] 2 December 2016. [Cited: 27 June 2018.] https://www.vicroads.vic.gov.au/traffic-and-road-use/traffic-management/smartroads.

7. Transport Research Laboratory (TRL), *Construction Logistics and Cyclist Safety Technical Report PPR639.* London : TLR, 2012.

8. Construction Logistics and Community Safety (CLOCS), *CLOCS Standard for Construction Logistics Managing Work Related Road Risk.* London : CLOCS, 2017.

9. Bennett, M., *Development and Pilot Study of the Human Impact Route Assessment Tool for Heavy Vehicle Route Selection.*, Thesis (MEng), Melbourne : RMIT University, 2018.

10. Irvin, R. A. & Stansbury, J., *Citizen participation in decision making: Is it worth the effort?* 2004, Public administration review, Vol. 64 (1), pp. 55-65.

APPENDIX

Route Description:							The description of the first route including direction (inbound/outbound) and roads travelled on	The description of the Second route including direction (inbound/outbound) and roads travelled on
Attributes		Weighting	Standards				Score	
Attributes		Importance	**Preferred (9-10)**	**Good (6-8)**	**Average (3-5)**	**Less than Average (1-2)**	**To be entered**	**To be entered**
Activity hubs	Hospital and emergency services access	8%	No hospital or medical facilities on route	Speed limit control and pedestrian separation (e.g. barriers, traffic islands, signalised crossings).	Pedestrian related activity near road site accompanied by appropriate speed limit control.	Pedestrian related activity near road side.	10	5
	Childcare, schools,education institutions	7%	No schools or education facilities	Schools on route with pedestrian separation, speed controls and signalised / assisted intersections.	Schools enroute with speed control only (no signalised crossings).	Route passes pedestrian entrances with limited pedestrian protections.	10	5
	Retail precinct	6%	No retail	Retail featuring separate dedicated off road parking and pedestrian access.	Retail environment with limited pedestrian separation and limited safe crossing facilities.	Neighbourhood strip shopping centre or local store.	10	5
	Entertainment precinct (night time venue operation)	7%	No licensed venues / LGA designated dry area	Limited licensed venues with pedestrian protections such as speed restrictions and traffic calming.	Licensed venues and late night trading with limited pedestrian protections.	High level of entertainment and late night licensed venues.	10	5
	Sporting and recreational precinct / facility	6%	No sporting or recreational facilities on route	Facility with ample off street parking and signalised pedestrian access.	Facility with limited off-street parking and limited pedestrian protections.	Facility with on-street parking and limited pedestrian protections.	10	5
	Service access and trader deliveries	5%	No traders requiring deliveries	Limited businesses with dedicated off-road or separated delivery areas (.e.g dedicated loading docks).	On-street loading / off-loading for mixed businesses.	Narrow street with on-street loading / off loading.	10	5
Route dynamics	Flexibility - ease of access to alternatives	5%	≥ 3 alternative routes available in the event of route disruption	1-2 alternative routes available in the event of route disruption	Alternative routes go through areas of high -pedestrian / active transport activity (see activity hubs)	No alternative routes available in the event of route disruption.	10	5
	Distance and directness (inc. number of turns required of trucks)	5%	No left hand turns required where traffic control to and from site is not provided. Last km access to site is arterial road/s.	Limited left hand turns required where traffic control to and from site is not provided. Last km access to site is mostly arterial roads.	> 3 left hand turns required where traffic control to and from site is not provided. Last km access to site is a combination of arterial and local roads.	> 5 left hand turns required where traffic control to and from site is not provided. Last km access to site is mostly local roads.	10	5
	Conflict with other construction projects	5%	No route overlapping exists with other construction / high truck traffic projects.	Limited route overlapping exists with other construction / high traffic projects.	Route overlapping exists at intersections and en route with other construction / high traffic projects.	Route overlapping exists with multiple construction / high truck traffic projects.	10	5
	Road type and function	7%	Route is an existing B-Double gazetted road.	Route predeominatly compromises existing B-Double gazetted roads.	Route predominantly comprises High Mass Limit and Performance Based Standards vehicle approved roads.	Route predominantly comprises local roads that are only approved for general access heavy vehicles (< 19m).	10	5
	Active Transport (cycling / skateboards etc)	9%	Limited bicycle (and other AT) traffic.	Bicycle route with mode separation.	Bicycle route with disconnected dedicated lanes.	High bicycle use, popular cycle route with or without on road infrastructure.	10	5
	En route holding / staging areas	6%	En route holding / staging areas exists to coordinate truck shuttles with up to 20 truck bay parking	En route holding /staging areas exists to coordinate truck shuttles with up to 10 truck bay parking capacity.	Holding/staging area at constrution site with limited capacity.	No en route holding / staging area exists.	10	5
Public Transport (bus and train)	En route public transport	7%	No public transport en route	Limited interaction with en route public transport. No level xing.	Public transport en route is separated from other vehicle traffic. Level crossings are present.	Public transport on shared road way.	10	5
	En route Stops / Stations	7%	No stops	Limited number of stops that all provide pedestrian separation and signalised pedestrian access.	unprotected stops with limited pedestrian protections.	Unprotected stops with people alighting into traffic / no controlled access route.	10	5
Road closures / event	intermittent road closures (LGA, VicRoads) - for events, protests, festival or works	5%	No events or no intermittent road closures (LGA confirmed)	One or two scheduled events which can be avoided using good or preferred alternative routes.	Several scheduled events which require route change through alternative routes which rate as average or unsatisfactory according to this tool.	Route incorporates regular road closures.	10	5
			HIRA overall score				**Preferred**	**Average**