City of Toronto Union Station - Queens Quay Transit Link Study

Final Report

April 2019



ARUP

ARUP

Executive Summary

The Union Station – Queens Quay Transit Link Study considered two technologies for enhancing the connection between Union Station and Queens Quay: an expanded streetcar loop at Union Station; or, an Automated People Mover (APM) using the existing tunnel replacing the existing streetcar.

As the central node of the Waterfront Transit Network, the Union Station – Queens Quay Transit Link provides the means of connecting Canada's busiest rail station and Toronto's waterfront, with its many residences, employers, and cultural and event amenities. Ensuring the Link meets the needs of a growing population will allow the successful development of the waterfront to continue, serving millions of annual commuter, leisure, and tourist trips.

Overall, streetcar was found to be preferable to APM as a means of connecting Union Station and the waterfront due to its advantages for the overall waterfront LRT network and user experience benefits. The conclusion of a preferred technology and development of a preliminary design is an important step in the next phases of developing the Waterfront Transit Network in Toronto.

Background

Since the opening of the Union Station streetcar loop in 1990 first established a higher order transit connection along the waterfront, ridership has grown steadily as development along the waterfront has increased. Today, growth in the East Bayfront has resulted in the need to continue expanding transit along the eastern waterfront. The existing Union Station streetcar loop cannot accommodate the demand from new riders, particularly when transit is added to the east. In 2010, an Environmental Assessment (EA) was completed on an expansion of the streetcar loop at Union Station as a means of providing the infrastructure to serve growing demand.

In 2016, City of Toronto Council approved the Waterfront Transit Reset; a comprehensive study of the needs and options for implementing improved transit along Toronto's waterfront including the connection of the waterfront LRT to Union Station. In early 2018, Council directed staff to find an appropriate and implementable solution for the Union Station – Queens Quay Transit Link, carefully considering suitable options given the importance of the Link and the costs associated with its renewal and expansion.

Due to the extended length of study of this project, transit in the East Bayfront has been significantly delayed. Development in the East Bayfront has therefore preceded the necessary transit to adequately support it. Currently, Port Lands flood protection works are underway to facilitate further development of the east waterfront.



Options Development

The direction by Council began the focused comparative study of the EA-approved expanded streetcar loop and an alternative option to repurpose the tunnel with an Automated People Mover (APM) through the Union Station – Queens Quay Link Transit Study, which was proposed as a potentially cost-effective alternative.

Various technical studies since the completion of the EA determined that these were the two preferred technologies to carry forward to preliminary design. The Study has been led by the City of Toronto with a technical advisory team from the City, TTC, and Waterfront Toronto, and contribution from Metrolinx.

Designs & Costs

Following an options screening process and preliminary user experience and transportation assessment, the two preferred options identified to carry through design development were (1) a modification of the existing streetcar loop at Union Station to accommodate additional streetcars, per the EA-approved option, or (2) the repurposing of the streetcar tunnel and the introduction of a new APM connecting Union Station to streetcar along Queens Quay.

Stations were designed to the latest standards and integrated with the Union Station retail concourse, with the opportunity for integration with existing and future developments at the north and south ends of the Link. Both designs had very similar capital and operating costs. Notably, the streetcar better serves the East Bayfront and wider waterfront while the APM serves a smaller geographic area with more concentrated ridership.

Following a comparative evaluation of the two options, streetcar was identified as the preferred option for the following reasons:

- Increased accessibility from a user experience perspective due to a lack of transfer to the East Bayfront and Central Waterfront;
- Strongest amount of flexibility for the future Waterfront Transit Network implementation and TTC service planning; and,
- No substantial cost disadvantages.

Public Consultation

Public consultation also showed that the consulted public overwhelmingly supported the streetcar option. The APM presented advantages from a constructability perspective with shorter construction timelines due to minimal impacts below the rail viaduct at Union Station, but both options are feasible and construction risks are well-understood because of current construction efforts at Union Station.

Next Steps

To proceed with the detailed design and construction of a preferred option, the City of Toronto and partner agencies will require:

- Approval to proceed from City Council and funds for the next phases of work;
- A potential EA Addendum given the refinements to the station configuration and possible relocation of the streetcar portal east of Bay Street;
- Advancing the design to at least the 30% stage and updating the cost estimate to the AACE-3 or CIQS-C level, fully assessing risks with construction;
- A review of delivery options with funding partners; and,
- An assessment of the impacts to pedestrian circulation and access during construction.



Table of Contents

Overview and Background

- 1.1 Study Purpose
- 1.2 Importance and Implications
- 1.3 Primary Study Area
- 1.4 Projected Ridership

Options Development

- 2.1 Technologies
- 2.2 Options Considered
- 2.3 Preliminary Evaluation Framework
- 2.4 Options Screening
- 2.5 Preferred Options for Design Development

Concept Design & Evaluation

- 3.1 Concept Designs
- 3.2 Evaluation Process
- 3.3 Evaluation Outcomes
- 3.4 Risks

Public Consultation

- 4.1 Stakeholder Advisory Committee Input
- 4.2 Public Information Centre Input
- 4.3 Overall Outcomes

Conclusions & Next Steps

Appendices

10

6

16

36

33

Overview & Background

tom:

2 4m

Activity along Queens Quav

Waterfront Toronto

Overview & Background

1.1 Study Purpose

The purpose of the Union Station – Queens Quay Link Study (the Study) is to confirm an appropriate and implementable solution for the connection of Union Station to Queens Quay and the East Bayfront. The output of the Study is intended to inform decisions about next steps in advancing higher order transit to the East Bayfront and other communities that are currently underserved by transit, by recommending a preferred technology for the link.

1.2 Importance and Implications

The Union Station – Queens Quay Transit Link (USQQL) is a unique transit project in Toronto for a variety of reasons:

- Though it represents a short distance (approximately 550m), the link serves a very high volume of riders in a high traffic area of the city.
- It is a vital connection to enable the development of the waterfront east and west. The growth and success of the wider Waterfront Transit Network relies on the strength and capacity of the link between the waterfront and Union Station.
- The link connects Canada's busiest multimodal rail hub with local transit and other transportation services including Billy Bishop Airport.
- The link is of importance to travellers of all types, including commuters and all-day riders such as tourists and special event riders. Tourists and special event riders are a unique consideration given the high number of venues in the area including Scotiabank Arena, Harbourfront Centre, and the Toronto Islands/Jack Layton Ferry Terminal.

For these reasons, this transit link does and will serve not only a high volume of riders, but those who may be occasional or first-time visitors to the city. To continue supporting population and employment as well as a growing tourism sector, the Study carefully evaluated these unique considerations.

1.3 Primary Study Area

The primary study area for this segment of the Waterfront Transit Network is the Bay Street corridor between Union Station and Queens Quay, and the Queens Quay corridor between York Street and Freeland Street. This is shown in Figure 1.

Beyond the study area, consideration was had over the course of the study for the Jack Layton Ferry Terminal south of Queens Quay and the wider Waterfront Transit Network, owing to the operational impacts in the broader network of the USQQL. The Initial Business Case considers the full Waterfront Transit Network.



Figure 1: Primary study area

1.4 Projected Ridership

Ridership in the Bay Street corridor and along Queens Quay is anticipated to grow substantially by 2041. Already, growth has resulted in challenges comfortably accommodating passengers at the existing Union Station loop. The figures to the right show existing versus future transit demand in the Bay Street corridor based on City of Toronto models.

Currently, approximately 1,000 riders use the existing southbound streetcar service, and approximately 1,500 riders use the northbound service, between Union Station and Queens Quay in the AM Peak Hour. Additionally, thousands of walk trips are made along Bay Street and in the PATH network between Union Station and destinations at Queens Quay and Bay Street.

By 2041, transit demand in the corridor is projected to be 4,000 to 8,000 passengers southbound in the AM peak hour based on estimates from the City of Toronto GTAv4 EMME model (Appendix A1). Demand varies based on the technology of the USQQL. Streetcar was shown by the model to have lower overall demand (approximately 4,000) but increased ridership continuing to the East Bayfront and Central Waterfront due to the convenience of the connection for medium- and longer-distance trips. APM has higher demand (approximately 8,000) but this demand is highly concentrated on Bay Street, capturing a number of otherwise short-distance walking trips from transit, with fewer riders continuing east or west on the waterfront by streetcar due to the additional transfer introduced between APM and streetcar.

Demand projections assume all funded transit projects including the Relief Line South, and fare integration assumptions. Of note, the GTAv4 EMME model is limited in its ability to assess with a high degree of accuracy the ridership of a small link in a GTA-wide model. As noted by the City of Toronto: *Highly nuanced differences in operational characteristics and passenger environments are often difficult to capture in regional models such as GTAModel v4.* Overall, however, the trend is clear that significant growth is expected.



By 2041, transit demand in the corridor is projected to be 4,000 to 8,000 passengers southbound in the AM peak hour



QUEENS QUAY

1.5 Policies and Previous Studies

There are several policies and plans which call for improved public transit in Toronto, the East Bayfront, and the Central Waterfront. In addition, many previous studies and technical reports have been developed for the USQQL. These are:

- City of Toronto Official Plan The Official Plan contains several policy objectives geared towards reducing auto dependency by shifting travel modes towards transit and active transportation.
- Central Waterfront Secondary Plan The Secondary Plan called for a 'transit first' approach. This approach was a call to have transit precede development such that new developments would be planned and built with transit already available. This approach would ensure that people new to the area would be accustomed to using transit from day one.
- East Bayfront Transit EA In 2010, City Council approved the East Bayfront Transit EA. This EA proposed building transit from Union Station to Parliament Street where a temporary loop would be built for turning back streetcars. Ultimately, when Queens Quay would be extended to Cherry Street and beyond, the loop could be decommissioned. Studies subsequent to the EA assessed a number of alternative options including the retrofit of the existing streetcar tunnel with a moving walkway.
- Waterfront Transit Reset In 2018, City Council approved the Waterfront Transit Network Plan. This included a complete streetcar network on the waterfront from Park Lawn in the west to Leslie Barns in the east. New connections would be made to Dufferin and Broadview with a central terminal and loop at Union Station. Direction from Council was, in part, to identify potential cost-saving solutions for the USQQL which is the subject of the current studies underway by the City and their partners.
- **Previous cost estimates –** Generally, previous high-level cost estimates for the

previous options date from 2014 to 2017. Technical studies date from 2011 to 2017. The previous iteration of the streetcar loop design, produced in 2011, represents a refinement of the EA-approved option upon which the latest design is based.

Previous studies and background files – As a first stage of the project, Arup conducted a comprehensive review of previous studies and background files received from the City of Toronto including: subsurface utility information (DMOG drawings), 2010 East Bayfront Transit Environmental Assessment, previous preliminary design drawings for Union Station streetcar loop expansion, condition survey reports for the existing streetcar tunnel, and miscellaneous drawings for proposed and in-construction developments in the study area. Subsequent work was based on the results of this comprehensive review.

As a whole, the review of background files does not appear to reveal any constraints in the corridor that would preclude the construction of either option; however, further detailed analysis is necessary given the complexity of the Bay Street corridor in general. Due to the level of development that has occurred in the Bay Street corridor since the issuance of previous studies and cost estimates, the next phases of this project will require considerable attention to constraints that may not have been identified in previous phases of work and prior study. These include but are not limited to:

- Constraints imposed by planned and under construction developments (e.g. 45/141 Bay Street) and opportunities for integration;
- Utilities in the Bay Street right of way and adjacent the Union Station loop, particularly Toronto Hydro utilities which supply power to the existing streetcar loop;
- The rail viaduct below which the Union Station streetcar loop would require expansion; and,
- Various planned Metrolinx projects such as rail viaduct rehabilitation and teamway upgrades.

Northbound streetcar at Queens Quay Station ©James Bow Photographe

PADINA INTON STN

03

DO NOT PASS OPEN DOORS

......

Options Development

1000 10 1 0 0 TO

Options Development

2.1 Technologies

Two technologies were considered to serve the USQQL: streetcar, as is the case today, and APM. APM technology is used in multiple short- to medium-distance applications around the world in similar environments and can operate in a wide range of weather conditions. An example of APM technology is the Terminal Link Train at Toronto's Pearson Airport (see Figure 2).

2.2 Options Considered

Eight options were initially considered during the beginning stages of the Study. These options were based on the results of the numerous previous studies which identified an expanded streetcar loop or APM retrofit of the streetcar tunnel as the two technologies to consider during this Study. The eight options (described in Appendix A2) were:

- Streetcar to Union Station with expanded streetcar loop (two options considered).
- Below-grade streetcar at Queens Quay and Bay with APM to Union Station (two options considered).
- Surface streetcar along Queens Quay with APM to Union Station (four options considered).



Figure 2: Pearson Terminal Link Train

Options were carefully evaluated, and design refinement exercises were conducted on many of the options to ensure a fair and comprehensive assessment of the merits of each option was well understood.

2.3 **Preliminary Evaluation Framework**

In order to screen preliminary options and arrive at two preferred alternatives for design development, and as a precursor to the final evaluation, an evaluation framework was developed to assess each option. Criteria were based on key elements of the City of Toronto's Rapid Transit Evaluation Framework and were refined given the level of detail of the Study and uniqueness of this short but critical connection in Toronto.

TTC Low-Floor Streetcar		Automated People Mover (APM) Vehicle	
Length Capacity (standard load)	30m	Length Capacity (standard load)	36m 200 (mostly standing)
Propulsion	Traction power	Propulsion	Cable-pulled
Boarding/Alighting	Single side	Boarding/Alighting	Both sides

Figure 3: Technology comparison

Overall, the evaluation framework, shown in Table 1, led to the refinement of the designs and allowed the team to respond to the primary purpose of the Study which was to find an appropriate and implementable solution for the USQQL. • There is insufficient space in the Queens Quay right of way to accommodate adequately sized and optimally located stairs and elevators to access the platforms. Barrier-free access (elevators between

Criterion	Method of evaluation
User experience	 Travel time based on trip type (short-, medium-, or long-distance)
	 Service reliability due to technology or on-street factors such as traffic and weather
	 Passenger comfort, convenience, and accessibility
Transportation operations	 Impacts to surface transit operations in the study area, e.g. GO buses and TTC buses
	 Impact to local (Queens Quay and Bay area) transit ridership volumes
	 Impact to network-wide (GTA) transit ridership volumes
	 Resiliency of the waterfront streetcar network
Construction impacts	 Risk profile of the overall project (e.g. likelihood of encountering unforeseen risks which could delay construction)
	 Impacts to pedestrian teamways
	 Property impacts on Bay Street and Queens Quay
	Duration of construction
Capital and	 Capital expenditures (CapEx)
operating costs	 Operating expenditures (OpEx)

Table 1: Preliminary evaluation framework

Initial evaluation also considered urban design and aesthetic components of the eight preliminary options such as the possibility of maintaining a suitable width along the Martin Goodman Trail and opportunities for landscaping and urban design treatments suitable for the project's high profile, high traffic waterfront location.

2.4 Options Screening

Much consideration was given to surface streetcar during the initial phases of the Study given the potential it may have offered in terms of cost savings and aesthetics.

Following preliminary user experience and transportation operations assessments which included pedestrian simulation modelling, surface streetcar options were screened out for the following reasons: APM terminus and street) could not be accommodated in the right of way.

- A major volume of riders would transfer between APM and streetcar at grade, presenting risks from a safety perspective given the likelihood of pedestrians crossing against traffic and impacting the Martin Goodman Trail.
- The transfer would be non weather protected, which would introduce a worse condition than currently exists for riders from Queens Quay Station, which is currently underground and weather protected.

A detailed options screening assessment describing the challenges associated with surface streetcar options is included as Appendix A3.

2.5 Preferred Options for Design Development

Following the removal of surface streetcar options, two options were selected for design development. These were:

- (1) Streetcar to Union Station with expanded streetcar loop, with portal east of Yonge Street (per the East Bayfront Transit EA)
 - The option carried forward was the EA-approved portal location east of Yonge Street (see Figure 4), due to the existing approval of this portal location and reduced impacts to properties in the study area.
 - The two streetcar options with expanded streetcar loop were the same with respect to station design but varied with respect to the location of the new streetcar portal east of Bay Street.
- (2) Below grade streetcar at Queens Quay and Bay with APM to Union Station, with portal east of Yonge Street

- The option carried forward was the EA-approved portal location east of Yonge Street (see Figure 5), due to the existing approval of this portal location and reduced impacts to properties in the study area.
- The two APM options with below grade streetcar at Queens Quay and Bay were the same with respect to station design but varied with respect to the location of the new streetcar portal east of Bay Street.

In addition, it was also confirmed that:

- For the APM option, a double track bypass midway between Union Station and Queens Quay would not be required to support the projected demand forecast, with two larger APM trains (one in each tunnel) replacing four smaller APM trains (two in each tunnel).
- For the streetcar option, two platforms at Union Station cannot support the projected demand forecast and desired operational reliability for the project.



STREETCAR BELOW GRADE WITH PORTAL EAST OF YONGE



Figure 4: Preferred streetcar option

2.5.1 Future Portal Considerations

A new streetcar portal east of Bay Street is required for both options. The portal can be located either east of Yonge Street near Freeland Street (as approved in the 2010 East Bayfront Transit EA) or west of Yonge Street. Locating the portal east of Yonge Street would require significant works to the existing Combined Sewer Overflow (CSO) at the foot of Yonge Street. Locating the portal west of Yonge Street would not require works to the CSO but would require changes to the Yonge Street slip and would create a new access area for the Westin Harbour Castle property.

The location of the portal, whether east or west of Yonge Street, was deemed not decision relevant given that its location did not impact the selection of a preferred technology to serve the USQQL. Given this, options with the EA-approved portal location were carried forward. Future phases of the project will evaluate the portal location and evaluate potential cost savings. Detailed preliminary plans and renders of the alternate portal location are included as Appendix B8.

STREETCAR BELOW GRADE WITH PORTAL EAST OF YONGE TRANSFER TO/FROM APM VIA UNDERGROUND CONNECTION YONGE MAY BAY NOTE HORIZONTAL PLATFORM CURVATURE REQUIRED BELOW GRADE EXISTING Í Ŕ QUEEN'S QUAY ------EXISTING CRIB WA NEW PEDESTRIAN TRACK CROSSING BELOW <u>GRADE</u> EXISTING PORTAL **BELOW GRADE** NEW PORTAL APM STREETCAR PLATFORM (30 M) PORTAL PORTAL APPROACH 10 20 50 m

Figure 5: Preferred APM option



o Streetcars, Waterfront

and Ferry Terminal



onge-University tina Lin

430

Concept Design & Evaluation

The concept design of the two preliminary options, one streetcar and one APM, was informed by user group meetings and preceding tasks.

The following are key overall assumptions that guided the development of the concept designs:

- Station designs will adhere to the following design guidelines:
 - TTC station design guidelines
 - Ontario Building Code (OBC)
 - Accessibility for Ontarians with Disabilities Act (AODA)
 - City of Toronto PATH guidelines
 - National Fire Protection Association (NFPA) 130
- Level pedestrian track crossings in stations are eliminated in favour of pedestrian underpasses below streetcar tracks, providing access between platforms and to the south side of Queens Quay/Ferry Docks.
- Embedded tracks are used in the portion of the streetcar tunnel below Queens Quay for both technology options, allowing a passenger vehicle that has entered the streetcar tunnel in error to exit the tunnel by driving straight through, thereby causing minimal disruption to streetcar service.
- Connections between new stations and existing/proposed developments in the Bay Street corridor are desirable. Where new connections are proposed to existing buildings, it is assumed that building owners will be amenable to these new connections and/or the City may require the connections through site plan approval.
- Existing station infrastructure (e.g. walls, columns, access stairs, and elevators) will be maintained where possible to reduce

the amount of demolition, excavation, and infrastructure replacement.

The primary differentiator of the two technology options is that:

- The streetcar option requires a significant expansion at Union Station with a less significant expansion at Queens Quay Station; while,
- The APM option requires a **significant expansion of the existing Queens Quay Station** with a less significant expansion at Union Station.

Common features of the two preferred options include the following:

- The new portal can be located either east or west of Yonge Street, however is assumed to be located east of Yonge Street near Freeland Street.
- The existing streetcar tunnel connection from Union Station to Queens Quay Station/ Ferry Docks would require rehabilitation to address conditions.
- Direct pedestrian connections with adjacent development in the Bay Street corridor is recommended as a means of strengthening the overall connectivity of the built environment and support a weather protected travel experience.

Detailed station plans are included as Appendices B1 and B2.

Plan showing overall extents of the streetcar option.



Figure 4: Plan of streetcar optior

3.1 Streetcar Concept

The streetcar option sees a significant expansion of the streetcar loop at Union Station to allow maximum operational flexibility with four independent stops. Any vehicle stopped for unloading or loading can be bypassed by other vehicles entering or exiting the loop. For efficient one-way passenger flow, the east side of the loop may be designated for unloading while the west side of the loop could serve loading functions, given its proximity to Union Station. These and other operational refinements will be considered in subsequent phases of work.

At Queens Quay Station, the existing station is somewhat expanded to increase platform length to allow for vehicle double berthing. This supports operational flexibility and reduces the likelihood of streetcars queueing on the track junction at Queens Quay and Bay Street, which would create delays.

Relative to previous design iterations done by others, the streetcar option has been updated as follows:

Union

- The overall extents of construction at the southeast end of Union Station have been modified so as not to impact the development currently under construction at 45 Bay Street.
- Due to NFPA 130 fire and life safety requirements, the level of the Union Station streetcar loop has dropped by at minimum 1.4m to accommodate additional ventilation.
- The integration with Union Station has been updated to include escalators and better integrate with existing infrastructure.
- The Bremner connection continues to be protected for.

Queens Quay

- Platforms are extended north to allow for vehicle double berthing.
- Though track is provided at Queens Quay for operational flexibility, allowing streetcars to bypass the Union Station loop.

Artist's depiction of expanded streetcar terminal at Union Station ©DTA





3.2 APM Concept

The APM option requires a considerable expansion of Queens Quay Station to permit the interchange between APM and streetcar. At Union Station, the APM repurposes the existing streetcar loop and provides additional connections to the Union Station retail concourse and Line 1 subway. Key considerations of the APM option include the following:

- The APM system in this location would likely be cable-drawn as opposed to selfpropelled. Cable-pulled APM systems are cheaper to install and maintain, and are ideal for short distance, medium demand, high frequency applications such as the USQQL.
- A mid-point bypass is not required to meet forecasted demand and is excluded from the design to reduce costs. Should demand increase, a mid-point bypass could be added at a later date to double the capacity of the link by increasing the number of vehicles from two to four.
- The APM drive wheel would be located at the Union loop, below track level. A control room could be co-located with the drive wheel area, at or below track level. Alternatively, the control room could be located in Queens Quay Station, in combination with maintenance facilities.
- An APM maintenance facility is integrated with Queens Quay Station, north of the station, within the right of way. This doubleheight facility provides access to the underside of vehicles. Above the facility, maintenance hatches in the roadway would allow for vehicle delivery, as well as for vehicle extraction at the end of vehicle service life or for significant maintenance or refurbishment.

 It is not possible for the future Bremner connection to use the former loop due to the amount of space occupied by the APM in the former loop area. The future Bremner connection would likely require doubleended streetcars and a new terminal station beneath the Scotiabank Arena. This was not fully designed in concept as part of this study nor was it costed. It would not be an insignificant addition and further reinforces the streetcar as the preferred technology. Plan showing overall extents of the APM option.



Figure 5: Plan of APM option





3.3 Evaluation Process

The two preliminary concept designs were evaluated to determine a single preferred option. This final evaluation was done using the criteria in the preliminary evaluation framework, focusing on key differentiating criteria. The evaluation focused on:

- User experience;
- Transportation;
- Construction management and constructability; and,
- Costs.

A detailed final evaluation matrix is included as Appendix B7.

3.3.1 User Experience

At a high level, both options performed well and would generally provide a better user experience than existing service due to expanded station areas and increased accessibility at Union Station and to the Ferry Docks south of Queens Quay. Specific criteria included:

- Travel time
- Passenger level of service
- Reliability
- Comfort/convenience
- Accessibility

Travel time assessment

A travel time assessment was conducted based on trip type: short-, medium-, or long-distance.

- **APM:** for short-distance trips, the APM option provided faster service. This was primarily due to a shorter walking distance between Union Station GO platforms or Line 1 subway and the Union APM terminal, and faster vehicle travel time in the Bay Street tunnel.
- **Streetcar:** for medium- to long-distance trips to the East Bayfront, Central Waterfront, and other waterfront areas, the

streetcar option provided faster service. This was due to the lack of transfer required at Queens Quay Station.

Figure 6 illustrates the average travel times for one-stop trips in the Bay Street corridor relative to longer-distance trips to Sherbourne or Spadina.

Passenger level of service assessment

Pedestrian simulation modelling using MassMotion software was conducted on station areas to assess overall station levels of service. The assessment evaluated passenger density and flow in station areas to ensure stations were properly designed for anticipated passenger demand. Level of service requirements are defined in the TTC levels of service for station planning.

Results of the assessment showed that station areas are appropriately sized to meet demand with minimal congestion, based on City of Toronto ridership projections for both options. All TTC level of service requirements are met. As expected, some congestion is experienced at vehicle doorways during boarding or at station exits during alighting, as anticipated.

A detailed passenger level of service assessment including MassMotion pedestrian analysis details is included as Appendix B3.

Qualitative user experience assessment

The qualitative user experience assessment evaluated passenger comfort, convenience, and accessibility with both options. Ensuring that the same level of service is maintained, or service improves relative to the existing condition, was an important consideration in the preliminary design exercises. The following criteria were included in this assessment:

- Reliability: headways, maintenance delays
 - Streetcar: headway reliability would be subject to on-street operations, with the potential for delays due to factors such as traffic and weather. The likelihood of maintenance delays would be no different than today.



Figure 6: Average travel times for each technology

- APM: headway reliability on the APM system would be unaffected by external conditions for trips between Union Station and Queens Quay Station; however, longer trips which transfer to streetcar would still be subject to any reliability issues causes by on-street delays. Maintenance delays would be rare, plus the system includes two independent lines which would allow one line to always remain operational.
- **Comfort/convenience:** ride quality, transfers, weather protection, wayfinding, and walking distances
 - **Streetcar:** ride quality would be no different than today, and no transfer would be required for medium- and long-distance trips. Wayfinding would be straightforward, though walking distances at Union Station would increase relative to today.
 - **APM:** ride quality on the APM system would be good, but a transfer would be required at Queens Quay Station for medium- and long-distance trips. Additional wayfinding would be required given the need to transfer. Walking distances would be similar to today at Union Station but walking to transfer would be required at Queens Quay Station.

- Accessibility: track crossings, vertical transfers, and connection to Jack Layton Ferry Terminal
 - **Streetcar:** no level crossings of track would be permitted at Queens Quay Station, and a new underground crossing would be provided between platforms and to the Ferry Terminal.
 - **APM:** no level crossings of track would be permitted at Queens Quay Station, and a new underground crossing would be provided between the station and the Ferry Terminal. Vertical transfer would be required for passengers transferring between APM and eastbound streetcars.

The main differentiator in user experience is in the need to transfer between APM and streetcar at Queens Quay Station with the APM option and the additional wayfinding requirements. This transfer, though AODA compliant, introduces an inconvenient transfer for people with limited mobility and/or using mobility devices, or for large groups. For this reason, the APM option scores poorer from a user experience perspective overall.

User experience evaluation outcomes

User experience is one of the primary considerations when assessing any transit project as it has a high impact on ridership, neighbourhood accessibility, and overall equity. Based on the user experience assessment, streetcar is the preliminary preferred option. Table 2 shows the user experience evaluation summary.

- **APM** serves a higher volume of riders overall, but these trips are concentrated in the Bay Street corridor. Under the APM scenario, there are fewer streetcar riders east and west on Queens Quay.
- Overall network impacts are insignificant under both options.

Criterion	Streetcar	APM
Travel time assessment	Medium/longer trips to East Bayfront and Central Waterfront are faster	Short, one-stop trips on Bay Street are faster
Passenger level of service assessment	Stations function adequately	Stations function adequately
Service reliability	Subject to on-street delays	Higher headway reliability in Bay Street corridor; longer trips also subject to on- street delays
Comfort/ convenience/ accessibility	Single ride to/from Union Station	Additional transfer to/from Union Station
Overall	Preliminary preferred	

Table 2: User experience evaluation summary

3.3.2 Transportation

The transportation assessment evaluates overall impacts to local and network ridership, surface operation conditions, network flexibility, service plans, and resultant vehicle headway times under each option. Overall, both options have the same surface condition with minimal post-construction impact to surface operations. Specific criteria included:

- Ridership, both within the study area and network-wide
- Network impacts for the Waterfront Transit
 Network
- Operational flexibility

Ridership

As concluded in the City of Toronto's travel demand modelling (Appendix A1):

• **Streetcar** serves more riders east and west on Queens Quay, including to the East Bayfront.

Network flexibility

- **Streetcar** provides an expanded loop at Union Station, allowing for strong flexibility from a TTC service planning perspective. Most trips along the waterfront are to/from Union Station.
- **APM** does not provide additional network flexibility and would require looping at Spadina or Parliament (at present, Parliament is proposed as a temporary loop only).

Service plans

• The operational assessment shows that the same number of streetcars would be required to serve overall demand on the network under both options, despite lower ridership along the waterfront streetcar under the APM option. This is due to the operational efficiencies of the Union Station streetcar terminal which allows streetcars to serve the east and west legs of the study area on a shorter circuit, thereby reducing the travel time to complete the circuit and the number of vehicles required to meet demand.

 Under the streetcar option, the primary capacity constraint is the track junction at Queens Quay and Bay Street. An analysis of the TTC's Vissim model of the streetcar loop expansion shows that between 45-55 vehicles per hour can be accommodated at this junction with minimal delay. This is more than the number of vehicles that is required to meet projected demand which is estimated to be 29 vehicles.

Overall, the streetcar option is preferred due to:

- Its provision of a central terminal for the east and west waterfront LRT network.
- The service planning assessment which shows that the same number of streetcars can serve higher demand if routes are split east-west, which the loop facilitates.

Though both options are viable and provide the necessary improvements to transit service in the study area, the streetcar option presents distinct benefits when assessing overall network impacts. From an operational standpoint, the streetcar option with the continuous link to Union Station provides a central node that provides greater flexibility in route planning and operational efficiency compared to the APM option.

The complete transportation operations assessment, included as Appendix B4, provides additional detail on the above findings.

Transportation evaluation outcomes

The transportation assessment provides an important understanding of the overall impacts to the broader transportation system of both options. Based on the transportation assessment, streetcar is the preliminary preferred option. Table 3 shows the transportation evaluation summary.

3.3.3 Constructability

The constructability assessment evaluates challenges and risks associated with the construction of each option which could impact project timelines. Specific criteria included:

- Risk profile
- Pedestrian teamway impacts
- Property impacts
- Construction duration estimation

Risk profile

- **Streetcar** poses additional risks due to construction below the rail viaduct. Constructing the expanded streetcar loop will require underpinning the existing rail viaduct piers. A similar construction has recently been done as part of the Union Station Revitalization; however, it does come with cost and schedule risks. Noise and vibration mitigation will be an important consideration, particularly at Union Station, given Metrolinx construction tolerances.
- **APM** poses minimal risks due to limited impacts below the rail viaduct.

Criterion	Streetcar	APM
Ridership	Higher ridership along Queens Quay east and west	Higher ridership on Bay Street
Network flexibility	Higher flexibility due to new terminal at Union which supports planned waterfront LRT improvements	Reduced flexibility due to need to loop at Spadina or Parliament
Service plans	29 streetcars needed to serve demand	29 streetcars needed to serve lower demand, plus APM required on Bay Street corridor
Overall	Preliminary preferred	

Table 3: Transportation evaluation summary

Pedestrian teamway impacts

- **Streetcar:** construction of the expanded streetcar loop may require temporary closure of one or both of the Bay Street teamways which would result in either: significant additional pedestrian demand within the Bay Street concourse; or, temporary bridge structures to keep the teamways open during construction.
- **APM** would not require closures of the teamways.

Property impacts

- **Streetcar:** property risks associated with the need to acquire portions of 1 Front Street and 141 Bay Street basements to allow for the Union loop streetcar option expansion.
- **APM** would not require the acquisition of portions of properties adjacent Union Stations.

Construction duration estimation

- **Streetcar** would require a longer construction period due to the increased risks below the rail viaduct. Construction is estimated to take 4-5 years.
- **APM** would have a shorter construction period due to minimal impacts below the rail viaduct. Construction is estimated to take 3-4 years.



Figure 7: Developments underway in the Bay Street corridor include 141 Bay Street/CIBC Square (©Metrolinx/GO Transit)

Construction management and constructability evaluation outcomes

From a construction management and constructability perspective, both options are constructible and therefore feasible. The APM provides many advantages due to reduced impacts below the rail viaduct that results in a reduced construction timeframe, making it the preliminary preferred option from a construction perspective. Table 4 shows the constructability evaluation summary.

Criterion	Streetcar	АРМ
Risk profile	Risks associated with construction below rail viaduct	No rail viaduct risks
Pedestrian teamway impacts	Closed due to construction and pedestrian rerouted	Not impacted by construction
Property impacts	1 Front St and 141 Bay St basement impacts	No significant impacts
Duration estimation	4-5 years	3-4 years
Overall		Preliminary preferred

Table 4: Construction impacts evaluation summary

Overall, neither option permits the operation of streetcar between Queens Quay and Union Station during construction. In both cases, replacement bus service would be required between Queens Quay and Union Station for the duration of the project.

Ideally, sequencing would result in Queens Quay reopening before Union Station works are completed, with through-track at Queens Quay Station permitting service along the waterfront as early as possible. It is recommended that the retrofit of Queens Quav Station be accelerated to the extent possible and that the through-track for streetcar be installed along with surface works to an interim loop at Parliament Street. This construction sequencing will allow service to continue along Queens Quay without the requirement to terminate at the Spadina loop, allowing east-west trips along the waterfront to continue to be served by LRT, and allowing a shorter replacement bus service to be operated.

3.3.4 Cost Estimates

Cost was an important consideration given that the USQQL has been studied over many years in an effort to determine whether a more cost-effective solution to streetcar loop expansion is possible. The Study evaluated capital costs and operating costs as a means of determining whether there were significant cost savings that could be realized with the alternate APM technology.

Capital costs

Previous cost estimates have been prepared for various design iterations of the USQQL. These estimates have ranged from between \$440-\$620M (various year dollars) based on Class 5 capital cost estimates. As the design has been refined over the course of this study, so too has the cost estimate. The current estimates are based on the concept designs which have been refined to incorporate the latest NFPA 130 Fire & Life Safety requirements which has resulted in the need for significant additional works at Union Station with the streetcar option to accommodate over track ventilation systems. For this and other reasons, the latest capital cost estimates for both options are at the

higher range of previous estimates but still within the range previously reported.

The AACE Class 4 capital cost estimate is intended to be accurate to within +/- 25%. The estimate is based on the following assumptions, which apply to both options:

- Remediation work will be required on the existing TTC streetcar tunnel.
- At least one traffic lane must remain open per direction on all roads during construction. If full road closure is permitted, a cost savings would be achieved.
- Premium finishes in stations are assumed given that these stations are the gateway to the waterfront.
- Given the proximity to Lake Ontario, wet soils, waterproofing, and significant dewatering will be required during construction. A new pump station is assumed to be required beneath Queens Quay Station for both options.
- Business compensation during construction and escalation have not been included.
- Significant utility relocation and protection, both temporary and permanent, will be required.

Table 5 shows the AACE Class 4 capital cost estimates. Note that the APM option does not include an incremental increase related to the need to build a new terminal north of Scotiabank Arena at the terminus of the potential future Bremner line. This terminus is required because without the use of the loop, the Bremner line must terminate near Union Station independently. This could be a simple single platform with connections to the street and/or Union Station. This would require double-ended streetcars which could result in small incremental costs. The costs of the Bremner terminus are not captured in these cost estimates.

Table 5: AACE Class 4 capital cost estimates

Option	Base construction cost	General requirements, labour & materials, fees, contingencies, and engineering costs	Total (2019\$) rounded to nearest \$1M
Streetcar	\$291,159,000	\$320,392,000	\$612M
APM	\$285,434,000	\$314,093,000	\$600M

Overall, capital cost estimates show that there is approximately a \$12M difference between options, or less than 2%. The difference is not substantial, and the result is that neither option is preferred from a capital cost perspective.

The complete capital cost estimate is included as Appendix B6.

Operating costs

Operating costs are based on service assumptions developed during the transportation operations assessment and assume a 5.5% discount rate. The operating and maintenance ("O&M") costs generally include the following components:

- Vehicle revenue kilometres ("VRK"): the total distance travelled by all the streetcar vehicles, expressed in vehicle-kilometres;
- Vehicle revenue hours ("VRH"): the total hours travelled by all the streetcar vehicles, expressed in vehicle-hours;

- Non-vehicle maintenance: the blended cost of non-vehicular components such as track, stop/station, and other infrastructure maintenance costs; and
- General admin ("GA"): the blended cost for system operations and maintenance, separate from vehicle-specific figures above.

The vehicle-dependent components – the VRK and VRH – are generally the operating costs associated with labour costs and vehicular maintenance, and as implied by its definition, scale with usage of the vehicles.

Estimates of the above components are based on the operational assessment completed for the Study. In the assessment, the streetcar operating plans (for both streetcar and APM options) were developed based on the peak point ridership as provided by the City's demand model. Fleet requirement and service levels were calculated, and then processed into VRK and VRH. Table 6 summarizes the O&M costs between the two options which are less than 1% apart.

Item	Streetcar	APM
Daily streetcar costs (vehicle)	\$53,000	\$49,000
Daily streetcar costs (non-vehicle)	\$36,000	\$36,000
Annual cost (306 days)	\$27,309,000	\$26,019,000
APM annual O&M Cost		\$2,000,000
Total annual cost	\$27,309,000	\$28,019,000
Present value (60 year)	\$390,000,000	\$400,000,000

Table	6:	O&M	costs	summarv

Over the 60-year lifecycle of the project, the APM is somewhat more expensive because both options require the same number of streetcars to serve projected demand, and the APM option also requires the operation of the APM system (approximately \$2M per year).

Of note, the operating costs include costs of the nine streetcars which already operate on the portion of track between Spadina and Union Station. To appropriately compare current versus projected operating costs, the cost of operating these streetcars may be subtracted from the operating cost calculations as an understanding of the net increase over current operating costs.

While not costed, additional operational costs may be incurred on the potential future Bremner line under the APM option because of the potential need to operate double-ended streetcars to serve the Bremner terminus. These costs could be related to vehicle maintenance (more doors and an additional cab) plus reconfiguring existing maintenance facilities to accommodate double-ended cars.

Cost evaluation outcomes

Cost is an important criterion of the overall evaluation as one of the main purposes of the evaluation of alternatives to streetcar loop expansion has been to review more cost-effective options. However, there are no significant cost savings associated with the APM relative to the streetcar option. Slightly lower capital costs for APM are offset by slightly higher annual operating costs. Overall, there is no preliminary preferred option from a cost perspective, given the similarities in both capital and operating costs.

Next steps

- Cost estimates must be updated with refinements to the design at each stage of the project:
 - 30% schematic design AACE Class 3 estimate
 - 60% schematic design
 AACE Class 2 estimate
 - 90% schematic design AACE Class 1/tender estimate
- An additional important consideration which may impact construction duration and cost will be the evaluation of teamway closure impacts during construction. Teamways must be closed during construction of the streetcar loop expansion, but there may be the opportunity to incorporate a temporary bridge structure to replace the teamway for the duration of construction. The feasibility of this element has not been evaluated.



Figure 8: Looking north on the Bay Street corridor showing active GO viaduct and temporary pedestrian infrastructure (@2019 Google)

Table	7:	Cost	evaluation	summarv

Criterion	Streetcar	APM
Capital costs	\$612M	\$600M
Annual operating costs (PV)	\$27M	\$28M
Overall	No preliminary preferred	
	(less than 2% difference)	

3.4 Summary Evaluation

The purpose of the final evaluation was to determine a preliminary preferred option to bring forward for recommendation and future design development. The final evaluation focused on key differentiators and decisionrelevant criteria. Many factors for future consideration, such as the location of the portal east of Bay Street, do not impact the selection of a preferred technology and were not evaluated with respect to determining a preferred technology.

Both options presented are viable and would provide an increased level of service and quality relative to the existing condition. However, due to the benefits from a user experience and transportation perspective streetcar is the preliminary preferred option to serve the USQQL.

3.5 Risks

Though streetcar is the preliminary preferred option, it carries additional risk, primarily associated with construction below the rail viaduct east of Union Station. As noted previously, these are known and accepted risks that do not preclude the streetcar option from being considered the preliminary preferred option overall. The following are some key risks associated with the deliverability of the USQQL preferred option:

- Constructing the expanded streetcar loop will require underpinning the existing rail viaduct piers. A similar construction has recently been done as part of the Union Station Revitalization; however, it does come with cost and schedule risks.
- Construction of the expanded streetcar loop may require temporary closure of one or both of the Bay Street teamways which would result in either: significant additional pedestrian demand within the Bay Street concourse; or, temporary bridge structures to keep the teamways open during construction.
- Property risks associated with the need to acquire portions of 1 Front Street and 141 Bay Street basements to allow for the Union loop streetcar option expansion.
- There are risks associated with utilities; subsequent phases should include SUE level B at minimum to accurately cost utility relocations.
- Risk in ability to secure capital and ongoing funding from provincial and/or federal government sources.
- Escalation of costs in subsequent phases of design due to known and unknown risks including those associated with construction of the streetcar loop expansion below the GO rail viaduct south of Union Station.



Figure 9: Construction at Union Station has involved lowering floors which would be required for the USQQL project (©2011 Rick McGinnis/Medium)

Artist's depiction of potential future Queens Quay streetscape east of Bay Street ©DTAH

07

Public Consultation

Public Consultation

Public consultation is an important consideration in any large project; particularly one that will directly impact residents' ability to travel between key destinations in the City. Over the course of the Union Station – Queens Quay Transit Link Study, two Stakeholder Advisory Committee (SAC) input sessions were held to garner feedback from key members of the community including local landowners, members of the Waterfront BIA, transit enthusiasts, and other interest groups. Input from the SAC helped inform the development of options and the dissemination of details at the Public Information Meeting that followed the SAC meetings.

The consultation program also included an online component through updates to the project website (www.toronto.ca/ waterfronttransit) and emails to the project mailing list (waterfronttransit@toronto.ca).

Through these methods of consultation, over 100 in-person participants were engaged and over 50 detailed comment forms and online responses were received.

4.1 Stakeholder Advisory Committee Input

The first SAC meeting was held on 22 January 2019 and constituted a workshop format. Approximately half a dozen members of the SAC attended. At this meeting, SAC members were presented with the preliminary findings of the study. At this time, no preferred option had been determined. SAC members provided feedback on their considerations for determining a preferred option and helped inform the final refinements of the evaluation process.

The second SAC meeting was held on 28 February 2019 and involved a presentation followed by a workshop and discussion period. Approximately 15 members of the SAC attended. At this meeting, SAC members were presented with the preferred streetcar alternative and provided feedback to inform final design refinements for the following Public Information Meeting. The key themes of this session were:

- Those who provided written and/or verbal feedback were **unanimously supportive of the streetcar option.**
- There were no questions or issues raised about the evaluation criteria and the metrics used to determine the preferred option.
- Most of the questions and comments centered around construction staging: how it would be done, what impacts to service would be, and recommendations from the group on how to best manage this process.

4.2 Public Information Centre Input

The Public Information Centre was held on 4 March 2019 and began with an open house session where members of the public were able to ask questions of the study team, followed by a formal presentation and question & answer session. Afterwards, members of the public were once again able to attend the open house where members of the study team remained to respond to any final questions. 84 members of the public attended. The key themes of this session were:

- The public comments received showed overwhelming support for the streetcar option, particularly because of efficiency/ ease of use, no transfer at Queens Quay Station, and resulting benefits to accessibility.
- Many of the public's comments were related to construction staging; particularly, how the route would be serviced and what alternatives would be used during the construction period. Reducing construction impacts will be an important consideration moving forward.

- Another common theme was timelines and funding, particularly when the project is expected to start/finish, how a lack of funding would affect the project, and how much of a priority this project is for Council given the number of transit projects planned and underway in the city.
- The public felt that the evaluation criteria used to assess the options was logical and clear.
- Some design recommendations were put forth by the public including extra accessibility features, art and design elements that reflect the waterfront, and platform screen doors. These may be considerations during the next design phases of the project.

Details of the meeting were advertised in the local newspaper, on Twitter (@CityPlanTO and @CityofToronto), on the project website (www. toronto.ca/waterfronttransit), and emailed to all project list subscribers and stakeholders. However, members of the public noted that outreach could have been stronger, as many were not aware of the meeting until shortly before it was held.

4.3 Overall Outcomes

Feedback from the SAC meetings and Public Information Centre provided valuable insight on means of refining the preliminary designs. The selection of streetcar as the preferred alternative to serve the USQQL was overwhelmingly supported by all respondents of the three above noted meetings held over the course of the Study.

Summaries of the noted public consultations are included as Appendices C1 and C2.

rtist's depiction of potential future Yonge Street slip infill public realm ©DTAH

St. The

Conclusions & Next Steps

Conclusions

The construction of the USQQL is a critical next step in supporting the continued growth of Toronto's waterfront. Already, development in the East Bayfront is proceeding without the higher-order transit needed to provide improved accessibility to major assets and regional destinations; most significantly, to Union Station.

Based on each phase of the project, the following was concluded:

- The review of previous studies and background materials concluded that the Bay Street corridor is intensely constrained due to a narrow right of way and numerous developments planned and under construction on either side of the corridor. The existing rail viaduct directly south of the existing streetcar loop poses the most significant challenge to the construction of the expanded streetcar loop due to its large piers and strict construction tolerances.
- The options development phase of the project defined the preliminary evaluation criteria which were used to determine a shortlist of two preferred options. The criteria were based on a modified version of the City of Toronto's Rapid Transit Evaluation Framework which is designed to compare transit options at a high level. This phase concluded that of eight initial options, the two technology options to serve the USQQL were (1) a modification of the existing streetcar loop at Union Station to accommodate additional streetcars, similar to the EA-approved option, or (2) the repurposing of the streetcar tunnel and the introduction of a new APM connecting Union Station to streetcar along Queens Quay. Surface streetcar at Queens Quay and Bay was removed from consideration for various passenger safety and transportation operations reasons.
- The concept design and evaluation **phase** of the project involved the design of the two technology options to a level suitable for the development of the AACE Class 4 cost estimate. Both options would be designed to the latest standards, have a high-quality fit and finish, and provide a connection below the streetcar tracks at Queens Quay Station to the Jack Layton Ferry Terminal. The streetcar option would require more significant works at Union Station while the APM option would require more significant works at Queens Quay Station. Both options had very similar capital and operating costs. A user experience assessment on the concept designs concluded that both options would improve the overall user experience in the corridor. The APM was preferred for one-stop trips in the Bay Street corridor due to faster travel to Queens Quay and would serve a higher volume of riders in this corridor but would introduce a transfer for those going east or west along the waterfront. The streetcar was preferred for medium- and long-distance trips and would be more accessible for riders due to no transfer required at Queens Quay Station for those continuing east or west along the waterfront. A transportation assessment concluded that both options would require a similar number of streetcars to serve future demand, despite less streetcar track under the APM option. In addition, the streetcar loop expansion would provide superior service planning opportunities for the TTC and allow for a more seamless Waterfront Transit Network. As a result of these assessments on the concept design, it was determined that streetcar was the preliminary preferred option to serve the Union Station – Queens Quay Transit Link.

 Public consultation over the course of the study indicated overwhelming public support for the streetcar option during both Stakeholder Advisory Council sessions and the Public Information Centre.

Overall, the streetcar option was found to better serve the city by supporting the buildout of the Waterfront Transit Network with a flexible terminal at Union Station. From a user experience and transportation operations perspective, the streetcar option is the most effective technology for providing transit to the East Bayfront, Central Waterfront, and beyond.

Given the scope of the Study, it was not possible to address all comments and thoughts raised during the Study. As such, a list of potential next steps has been prepared to help inform subsequent phases of work.

Next Steps

The expansion of the Waterfront Transit Network in Toronto relies on the successful implementation of the USQQL. In the next phases of this important project, the following considerations should be had:

- Approval to proceed from City Council and funds must be secured before proceeding to the next phases of work.
- Comments from the Design Review Panel should be incorporated into the design. Additional architectural studies should be undertaken to create a design suitable for the gateway to the waterfront.
- A review of the project's Initial Business Case and consideration for the next Business Case requirements to support the delivery of the project are required.
- A potential EA Addendum may be required given the refinements to the station configurations at the north and south ends of the link, and possible relocation of the new streetcar portal to west of Yonge Street. As part of the discussion on relocating the portal west of Yonge Street, discussions should be advanced with the Westin Harbour Castle and adjacent stakeholders, e.g. Pier 27 condominiums.
- The design should be advanced to at least the 30% stage and updated cost estimates prepared to the AACE-3 or CIQS-C level, fully assessing risks with construction.
- Consider splitting work packages per the Initial Business Case Deliverability & Operations Case to advance the project appropriately.
- A review of delivery options with funding partners should be undertaken.
- An assessment of the impacts to pedestrian circulation and access during construction should be undertaken using pedestrian simulation software. This includes an evaluation of potential temporary works

that may be installed to accommodate pedestrian flow.

- The closure and reinstating of the teamways will require significant consideration, with attention paid to appropriate connections between station areas and the teamways, and allowances for reinstating the teamways to a high level of fit and finish, including retail areas.
- The service plan should be further refined.

ARUP