RELIEF LINE SOUTH

Environmental Project Report

Section 3 - Preferred Transit Project Design

TORONTO

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3 Preferred Transit Project Design

The following section describes the permanent features associated with the Transit Project as well as the operational assumptions that inform the impacts and mitigation section**.** This section also outlines the recommended construction plan which informs the construction impacts. More details on the conceptual design can be found in the Conceptual Design Report under separate cover. **Appendix 3-1**, **Appendix 3-2**, and **Appendix 3-3** contain the Transit Project alignment plan and profile, station plates, and construction plan, respectively.

3.1 Alignment

3.1.1 Horizontal Alignment

The horizontal alignment of Relief Line South was developed following the existing TTC Design Manual standards for subway infrastructure. The alignment includes 12 horizontal curves as depicted in **Table 3-1** and **Table 3-2** and labelled on the Transit Project alignment plan and profile plates in **Appendix 3-1**.

The Relief Line South will have a total length of 7.4 km from the end of the new tail track at Osgoode Station to the north end of the tail track to be located north of Pape Station. The entire alignment will be underground.

Vehicle Dimension Assumptions

For the purpose of the Relief Line South Conceptual Design, the vehicle dimensions and track gauge are assumed to be similar to the existing T-1 vehicles operating on Line 2. The track gauge is 4’-10 7/8”, the vehicle width is 10’-3 3/8” and the height is 12’ (top of car to bottom of wheel). The TTC has not yet committed to a particular configuration for the T-1 replacement fleet (i.e. married pair vs. 6-car or 7-car trainset), with the exception that all cars will be capable of operating under ATC/ATO. The T-1 cars on Line 2 were purchased between 1995 and 2001 and are scheduled for replacement in 2026. All replacement vehicles are expected to be received and operational by 2031.

The Relief Line South alignment is based on the TTC Design Manual criteria for subway infrastructure and the running structure cross-sections are based on the T-1 series subway vehicle dimensions and dynamic clearances. All alignments are assumed to be underground.

Alignment Stationing / Chainage

Stationing/chainage is the distance along the alignment and is measured in metres. The stationing on the Relief Line South increases in an easterly direction along Queen Street, and then a northerly direction on Carlaw Avenue and Pape Avenue. The Relief Line South starts at chainage -0+030.006 at the west end of Osgoode Station tail track and ends at chainage 7+410.360 at the north end of Pape Station tail tracks.

Subway Running Structure: Queen Street (West to East)

The Relief Line South subway running structure and station platforms are primarily located within the Queen Street right-of-way. There is a station at University Avenue (Osgoode Station) along Queen Street West. Crossovers which allow trains to switch between the westbound and eastbound tracks are provided west of Osgoode Station, where the underground tail tracks extend to John Street.

The alignment continues underground along Queen Street, where it turns into Queen Street East at the Queen Station interchange. Another station is at Queen Street East and Sherbourne Street. At Berkeley Street, the horizontal alignment at Curve #3 turns southeast to Adelaide Street East, where there is a station at Sumach Street.

The alignment continues crossing the Don River and the Don Valley Parkway underground at Eastern Avenue, where there is a station at Broadview and Eastern Avenues. The alignment crosses the Stouffville / Lakeshore East GO rail corridor and continues along Eastern Avenue to Curve #6, where it turns in a northeasterly direction and then continues north along Carlaw Avenue.

Subway Running Structure: Carlaw / Pape Alignment (South to North)

There is a station at Queen Street East and Carlaw Avenue. At Curve #7, the alignment turns northeasterly again while crossing the GO rail corridor underground at Gerrard Street East, where there is a proposed station. At Curve #8, the alignment then continues north along Pape Avenue to Danforth Avenue, where there is an interchange station at Pape Station. Crossovers which allow trains to switch between the northbound and southbound tracks are provided north of Pape Station, where the tail tracks extend to Westwood Avenue.

There are wye tracks connecting the Relief Line South and tail tracks to the Bloor-Danforth Subway (Line 2) northwest and northeast of the interchange station to move the subway vehicles throughout the system, especially if the primary maintenance and storage facility for the Relief Line South is located on another line.

Horizontal Curve Data

The horizontal alignment of Relief Line South was developed following the existing TTC Design Manual standards for subway infrastructure. The horizontal curves along the alignment from east of John Street along Queen Street West to Browning Avenue on Pape Avenue (north of Pape Station at Danforth Avenue) are summarized in **Table 3-1** and **Table 3-2.**

Table 3-1: List of Horizontal Curves and Sags (Relief Line South – Mainline)

Station	Station		Dc	Radius (m)	Length (m)	V (kph)	Ea (mm)
0+957.757	0+977.757	S1			20.000	80	
0+977.757	1+005.788	C1	0°42’	2500.000	28.031	80	20
1+005.788	1+025.788	S2			20.000	80	
1+179.090	1+199.090	S3			20.000	80	
1+199.090	1+222.377	C2	0°40’	2600.000	23.287	80	20
1+222.377	1+242.377	S4			20.000	80	
1+944.089	2+014.089	S5			70.000	80	
2+014.089	2+129.716	C3	3°49’	457.000	115.627	80	100
2+129.716	2+199.716	S6			70.000	80	
2+750.061	2+820.061	S7			70.000	80	
2+820.061	2+951.855	C4	3°49’	457.000	131.794	80	100
2+951.855	3+021.855	S8			70.000	80	
3+719.177	3+739.177	S9			20.000	80	
3+739.177	3+766.120	C5	0°58’	1800.000	26.942	80	20
3+766.120	3+786.120	S10			20.000	80	
3+984.567	4+040.946	S11			56.379	65	
4+040.946	4+463.784	C6	5°42’	306.800	422.838	65	100
4+463.784	4+520.163	S12			56.379	65	
5+019.523	5+089.523	S13			70.000	80	
5+089.523	5+197.580	C7	3°49’	457.000	108.057	80	100
5+197.580	5+267.580	S14			70.000	80	
5+532.087	5+602.087	S15			70.000	80	
5+602.087	5+711.515	C8	3°49’	457.000	109.428	80	100
5+711.515	5+781.515	S16			70.000	80	
6+437.161	6+457.184	S17			20.023	80	
6+457.184	6+526.304	C9	0°35’	3006.800	69.120	80	20
6+526.304	6+546.327	S18			20.023	80	
6+878.294	6+897.294	S19			19.000	80	
6+897.294	6+919.438	C10	0°16’	6500.000	22.144	80	10
6+919.438	6+938.438	S20			19.000	80	

Table 3-2: List of Horizontal Curves and Sags (Wye track)

Station	Station		Dc	Radius (m)	Length (m)	V (kph)	Ea (mm)
0+162.574	0+181.574	S21			19.000	30	
0+181.574	0+560.357	C12	5°49’	300.000	378.783	30	0
0+560.357	0+579.357	S22			19.000	30	
0+079.398	0+098.398	S23			19.000	30	
0+098.398	0+480.068	C11	5°49’	300.000	381.670	30	0
0+480.068	0+499.068	S24			19.000	30	

3.1.2 Vertical Alignment

The vertical alignment of Relief Line South was developed following the existing TTC Design Manual standards for subway infrastructure.

The minimum and maximum design parameters used on the vertical alignment are:

1. Minimum gradient at stations and special track structures = 0.3%
2. Maximum gradient along rest of running structure = 3.5%
3. Minimum length of vertical curve: LVC = 60 m

Sight line for signalling will be confirmed during Detailed Design phase of the project.

The vertical curves along the alignment from Osgoode Station to Pape Station are summarized in **Table 3-3** and **Table 3-4.**

Table 3-3: List of Vertical Curves and Sags (Relief Line South – Mainline)

BVCS	EVCS	BVCE	EVCE	G1	G2	K	L (m)
0+903.88	0+963.88	57.93	58.23	0.30%	0.68%	156.131	60.00
1+299.14	1+359.14	60.52	60.82	0.68%	0.30%	154.547	60.00
2+205.31	2+265.31	63.32	63.32	0.30%	-0.30%	100.682	60.00
2+699.14	2+729.14	62.10	61.31	-0.30%	-2.37%	29.057	60.00
3+028.34	3+128.34	54.23	53.86	-2.37%	1.62%	25.073	100.00
3+266.84	3+326.84	56.11	56.68	1.62%	0.30%	45.311	60.00
3+854.42	3+914.42	53.15	52.22	-2.82%	-0.30%	23.763	60.00
4+836.15	4+896.15	49.50	49.50	-0.30%	0.30%	101.173	60.00
5+473.82	5+533.82	51.22	52.31	0.30%	3.36%	19.573	60.00
6+543.49	6+603.49	86.27	87.37	3.36%	0.30%	19.579	60.00

Table 3-4: List of Vertical Curves and Sags (Wye Track)

	BVCS	EVCS	BVCE	EVCE	G1	G2	K	L (m)
northwest	0+042.98	0+102.98	107.19	105.95	-0.70%	-3.45%	21.859	60.00
northwest	0+584.32	0+644.32	89.37	88.43	-3.45%	0.30%	16.004	60.00
northeast	0+026.97	0+086.97	88.47	89.42	-0.30%	3.47%	15.926	60.00
northeast	0+502.78	0+562.78	103.83	104.94	3.47%	0.21%	18.451	60.00

The subway alignment is a twin bore tunnel that is generally within the bedrock in the downtown core, with the exception of the Don River crossing. At Dingwall Avenue along Pape alignment segment (approximately Stat. 5+950), the alignment rises above the bedrock to transition up to the interchange at Pape Station.

The subway alignment is within a -0.30% - 0.68% grade until the Don River crossing where the grade drops to -2.37%. North of Gerrard Street E, the original ground elevation increases, and the alignment rises at an approximate 3.36% grade as it continues northerly to Pape Station, with the top-of-rail remaining at an elevation approximately 29m below surface grade. The crossover track north of Pape Station allows trains entering or exiting revenue service to transfer between the tail tracks for storage and the mainline.

Crossovers also enable trains to transfer between mainline tracks in order to change direction, for failure management purposes (for disabled trains), and for line storage purposes. The northeast and northwest wye tracks connect the Relief Line South to the Line 2 mainline to move subway vehicles and work cars from one line to another for maintenance.

Future Alignment Refinements

The alignment illustrated is preliminary in nature. Additional refinements will continue in the Detailed Design phase and may be undertaken to:

- Improve operating characteristics;
- Simplify construction methods or mitigate construction impacts;
- Minimize impacts to properties and utility relocations;
- Improve future maintenance; and
- Reduce capital costs.

3.2 Stations

Station concepts were defined for all eight Relief Line South stations including preliminary layouts for platforms, station entrances, emergency vent shafts, interchange connections, and other station facilities located within the general station locations. Elements that are common to all stations are detailed below. The project objectives outlined in the Terms of Reference were used as a foundation for developing the station concepts and alignments. The sections below describe the specific features of each station.

All stations will generally have a street entrance, a concourse level, and a platform level. Interchange stations (Osgoode, Queen, and Pape) will have a street entrance, upper concourse level, Line 1 or Line 2 platform levels, lower concourse level(s) and Relief Line South platform level.

Stations will be designed in accordance with the TTC Design Manual and the Accessibility for Ontarians with Disabilities Act (AODA), and will be fully accessible to persons of all abilities.

Station-to-station distances for the Relief Line South are summarized in **Table 3-5.**

Table 3-5: Station to Station Distances

From (Centre of Platform)	To (Centre of Platform)	Approximate Distance (m)
Osgoode Station	Queen Station	420 m
Queen Station	Sherbourne Station	1010 m
Sherbourne Station	Sumach Station	750 m
Sumach Station	Broadview Station	1000 m
Broadview Station	Carlaw Station	1040 m
Carlaw Station	Gerrard Station	770 m
Gerrard Station	Pape Station	1290 m

3.2.1 Subway Platforms

Stations typically have a “centre platform” configuration in which passengers can board and exit trains via a single platform between the two tracks. The use of centre platforms enables more efficient vertical circulation and cross-platform transfers. It also provides a greater capacity to accommodate surges in traffic flow, especially during service interruptions.

The revenue train vehicle configuration and technology selected for the Relief Line South will determine the minimum platform length for the stations.

Platform widths will typically be 10.3 m based on the tunnel track centrelines. Some rooms, (such as ancillary rooms and service rooms) are provided at the platform level.

3.2.2 Concourse Levels

The concourse level is located directly above the platform and is connected to the platform through stairs, escalators and an elevator. The interchange stations (Osgoode, Queen and Pape) have multiple concourse levels. The collector’s booth and turnstiles will be located at the concourse level where Proof of Payment is required beyond that point. Other rooms, such as service rooms, staff rooms and electrical rooms may be located at the concourse level. Exact configurations will be determined during the detailed design phase.

3.2.3 Station Entrances

Station entrances provide access / egress to each station associated with walk-in traffic. The station entrances will be located at street level and will be equipped with stairs, escalators and an elevator to direct pedestrian traffic to the concourse level where the fare collection is located. Secondary entrances typically comprise a set of stairs from ground level that connect down to the concourse level. Secondary entrances may include escalators that are dependent on the depth of the station and the proximity to the main entrance.

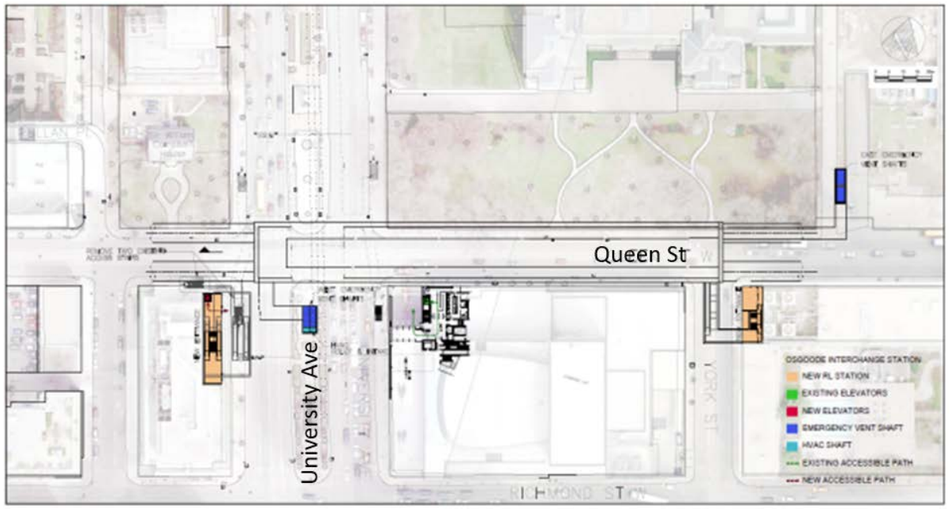
3.2.4 Ventilation Shafts

Ventilation shafts are located throughout the Relief Line South alignment, including at station entrances. Ventilation is incorporated into the stations to balance air pressure within the tunnels and stations and to provide for emergency exhaust and fresh air supply in case of an underground fire.

3.2.5 Osgoode Station (Interchange)

Osgoode Station's Relief Line South station box (**Figure 3-1**) is located at the furthest west point of the alignment and under the station box of the existing Osgoode Station. Although these station boxes do cross, the interchange configuration will be a functional "T" configuration. The Relief Line South station box is located under the Queen Street West right-of-way starting at the western edge of the University Avenue right-of-way and going east to the intersection of York Street and Queen Street West.

Figure 3-1: Osgoode Station (Interchange)



The Relief Line South deep station box is organized into three levels; platform, concourse and a limited upper concourse level at either ends of the station box that provide direct connections to the existing Osgoode Station and to its entrances. The west upper concourse allows for a direct connection to the existing Osgoode Station's platform level from below. The existing Osgoode station box will be modified to accommodate the additional stairs and escalators from below. Modifications will include the relocation of the northern stairs and escalator further north to provide sufficient space on the platform level to accommodate the new escalators connection from below, and the extension and relocation of the accessible elevator further south to allow it to travel to the Relief Line South upper concourse.

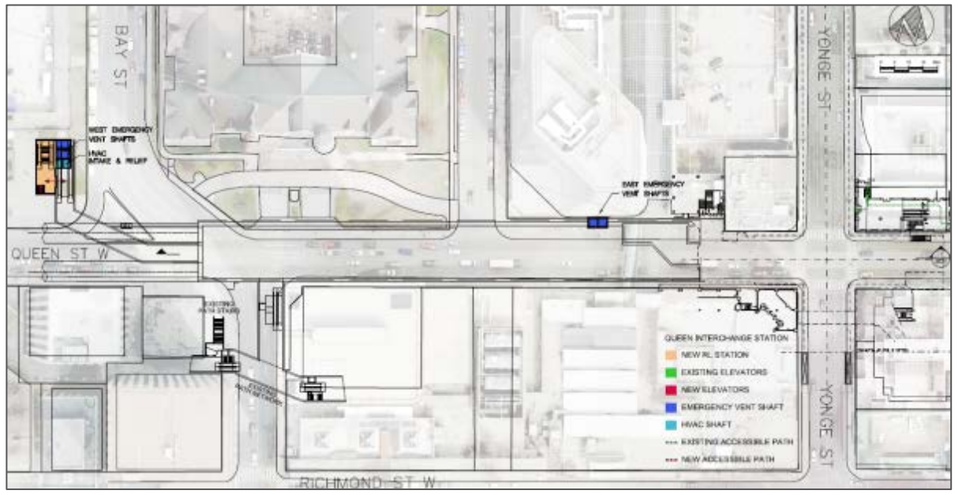
The Relief Line South station will have a primary entrance at the southwest corner of the University Avenue and Queen Street West intersection and it will be part of an existing building. There will be a secondary entrance at the southeast corner of York Street and Queen Street West. The Relief Line South primary entrance will replace the existing Osgoode Station street entrances at the corners with combined access to both stations. The other entrances into Osgoode Station will be maintained. The Relief Line South primary entrance will connect to the existing Osgoode Station passageway to provide an additional accessible route to the existing station's concourse level. It will connect to the Relief Line South upper concourse level for access to the Relief Line South station. The secondary entrance will occupy a portion of the Sheraton Centre Hotel's concourse level and will tie into the PATH network.

This configuration provides for transfers between the two stations and single transfer accessible routes between the new Relief Line South primary accessible entrances and both stations' platforms, as well as a single transfer accessible route between the two stations' platforms.

3.2.6 Queen Station (Interchange)

Queen Station's Relief Line South station box (**Figure 3-2**) is located west of Yonge Street, past the existing Queen Lower station box and under the wider portion of the Queen Street West right-of-way. The west end of the Queen Station box extends to the intersection of Bay Street and Queen Street West. Its station box forms a "T" interchange with the existing Queen station. This configuration provides for direct transfers between the two stations using the existing Queen station's platform and Queen Lower levels, as well as the connections between the existing Queen station entrances at all four corners of the Yonge and Queen intersection, and the new Relief Line South primary entrance.

Figure 3-2: Queen Station (Interchange)



The Relief Line South station will have a primary entrance at the northwest corner of the Bay Street and Queen Street East intersection within Nathan Phillips Square, and a Relief Line South secondary entrance that ties into the PATH network at the southwest corner of the same intersection. At the east end of the station box, the Relief Line South station ties into the existing Queen station entrances, as well as the existing surrounding development and the PATH network.

The Relief Line South station box is organized into four levels; platform, concourse, an expanded Queen Lower level and a limited expansion of the existing Queen Station concourse. The limited expansion of the TTC Queen concourse allows for direct unpaid access to the Relief Line South station from the existing retail developments on either side of Queen Street. The expanded Queen Lower level is divided into paid and unpaid zones, allowing for paid and unpaid connections between the 2 stations and all entrances. The unpaid zones could potentially be used as part of the PATH network. The Relief Line South concourse level is an intermediate connecting level from the expanded Queen Lower level to the platform level.

The configuration provides a single transfer accessible route between the new Relief Line South entrance and the two station platforms as well as a single transfer accessible route between the two stations.

3.2.7 Sherbourne Station

Sherbourne Station (**Figure 3-3**) is a two-level inline station with its station box within the Queen Street East right-of-way, straddling Sherbourne Avenue.

Figure 3-3: Sherbourne Station

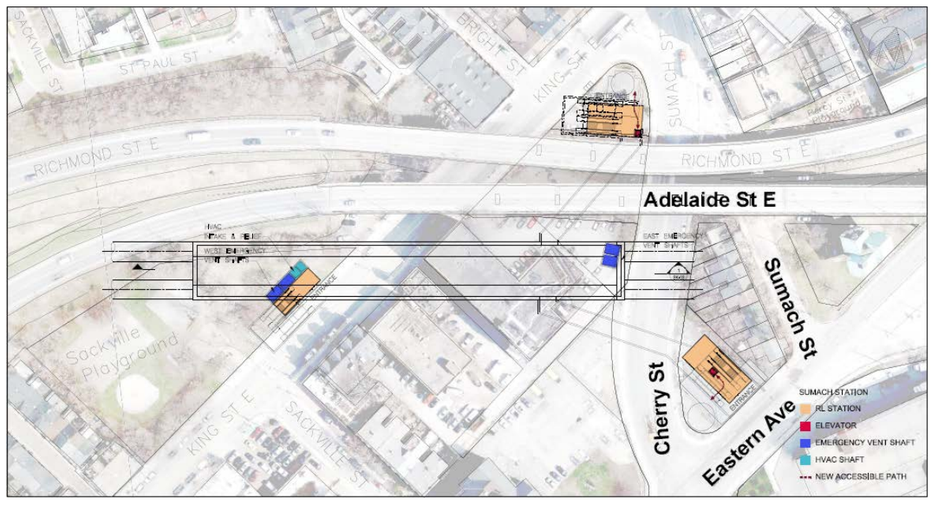
The station box starts just west of Sherbourne Avenue and ends just west of Seaton Street. It will have a primary entrance at the northwest corner of the intersection of Sherbourne Street and Queen Street East. The secondary entrance will be located on the east side of Seaton Street and the north side of Queen Street East.

The primary entrance will have a direct connection to the southbound TTC 75 Sherbourne bus and connections to the TTC 501 Queen, 502 Downtowner, 503 Kingston Road, and 301 Queen streetcars, and the northbound TTC Sherbourne 75 bus at the various corners of the intersection. It will also connect to the City of Toronto Cycling Network through the grade separated bike lanes on Sherbourne Street. In addition, the station's primary accessible entrance will anchor the southeast corner of the Moss Park redevelopment. The station's secondary entrance on Seaton Street serves a high density neighbourhood to the east.

3.2.8 Sumach Station

Sumach Station (**Figure 3-4**) is a two-level, inline station with its station box located south of the Adelaide Street East and Richmond Street East flyovers and parallel to the Adelaide Street flyover.

Figure 3-4: Sumach Station



Its station box starts within the Sackville playground, crosses King Street East and ends just east of Sumach Street. It will have a primary accessible entrance at the southwest corner of King and Sumach Streets. There will be two secondary entrances located on the north side of King Street East, adjacent to the Adelaide Street East flyover and at the northeast corner of the intersection of Sumach/Cherry Street and Eastern Avenue.

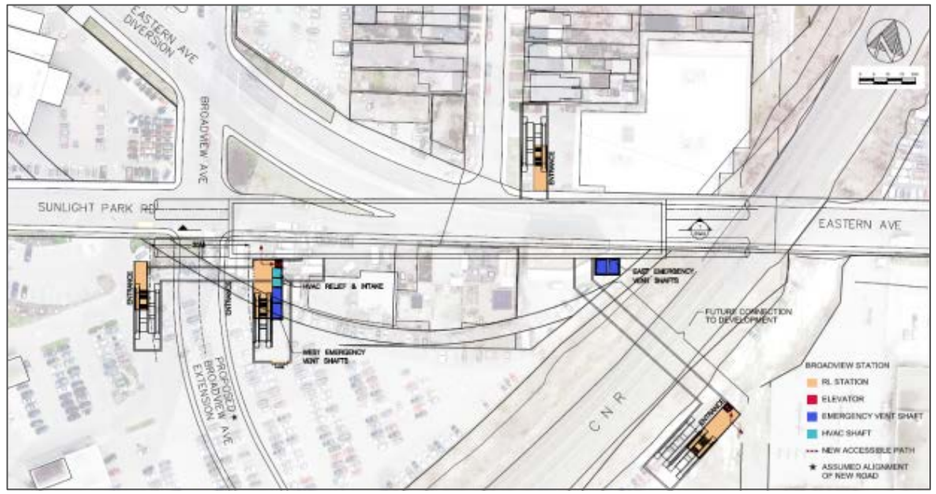
The two entrances on King Street East will connect to the TTC 304 King, 503 Kingston Road, 504 King, and 514 Cherry streetcars. The primary accessible entrance will serve the pedestrian traffic from the neighbourhoods to the north of the Adelaide and Richmond flyovers. The Sumach/Cherry/Eastern entrance will serve the developing neighbourhood of the West Don Lands.

3.2.9 Broadview Station

A station is at Eastern Avenue and Broadview Avenue as part of an emerging transit hub. Broadview Station (**Figure 3-5**) is a two-level, inline station with its station box located just east of the future Broadview Avenue Extension and under the Sunlight Park Road and Eastern Avenue right-of-ways. It will have a primary accessible entrance at the southeast corner of Sunlight Park Road and the Broadview extension. Additional entrances are located at: the southwest corner of Sunlight Park Road and the future Broadview Avenue extension; at the northeast corner of Eastern Avenue and Lewis Street; and on the east side of the GO rail corridor right-of-way at the edge of the proposed East Harbour development.

The entrances on either side of the Broadview extension will provide good connections to the Broadview streetcar route running along the Broadview Avenue Extension, as well as the future East Harbour SmartTrack Station. A secondary entrance at Lewis Street will service the neighbourhood immediately north of Eastern Avenue.

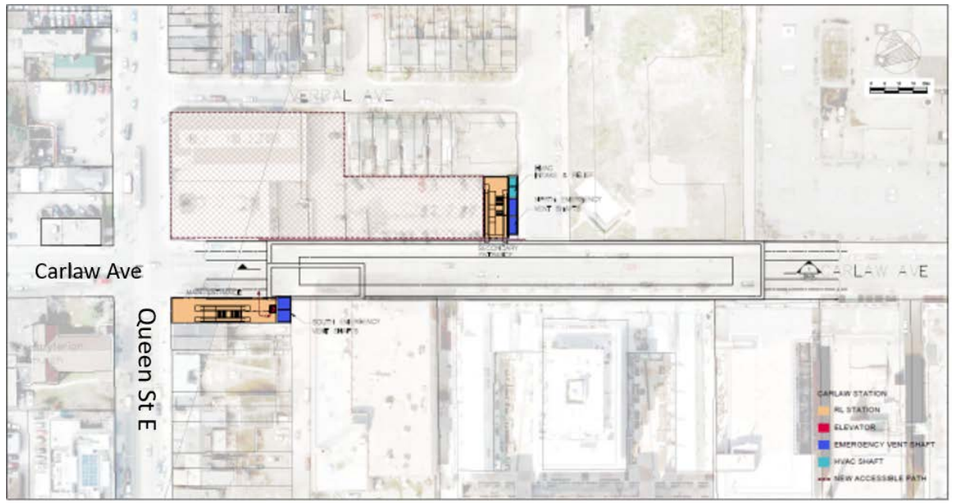
Figure 3-5: Broadview Station



3.2.10 Carlaw Station

Carlaw Station (Figure **3-6**) is a two-level, inline station with its station box located just north of Queen Street East within the Carlaw Avenue right-of-way. Its primary entrance will be located at the northeast corner of Carlaw Avenue and Queen Street East. A secondary entrance will be located on the west side of Carlaw Avenue south of Colgate Avenue. The primary entrance will have direct connection to the westbound TTC 301 Queen, 501 Queen, 502 Downtowner, and 503 Kingston Road streetcars running along Queen Street East, as well as access to the eastbound streetcars across the intersection. In addition, it will provide connections to the TTC 72 Pape and 325 Don Mills buses running along Carlaw Avenue.

Figure 3-6: Carlaw Station

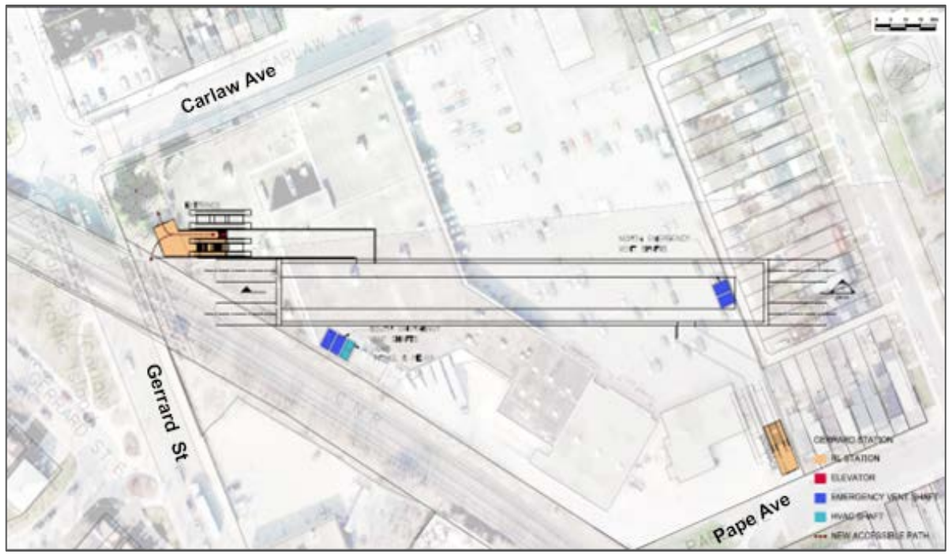


3.2.11 Gerrard Station

Gerrard Station (**Figure 3-7**) is part of an emerging transit hub. It is a two-level, inline station with its station box located on a diagonal spanning between Carlaw and Pape Avenues, and beneath the existing Riverdale Shopping Centre. Its primary entrance will be located at the northeast corner of Carlaw Avenue and Gerrard Street East; and the secondary entrance will be located on Pape Avenue, north of the GO rail corridor. The primary accessible entrance will have direct connection to the westbound TTC 306 Carlton and 506 Carlton streetcars on Gerrard Street, access to the eastbound streetcars, and the TTC 72 Pape and 325 Don Mills buses across the intersection.

The new Gerrard-Carlaw SmartTrack Station is also proposed for this location. That station is being designed to include an entrance at the north-east corner of Carlaw Avenue and Gerrard Street East which will be shared with the Relief Line South.

Figure 3-7: Gerrard Station

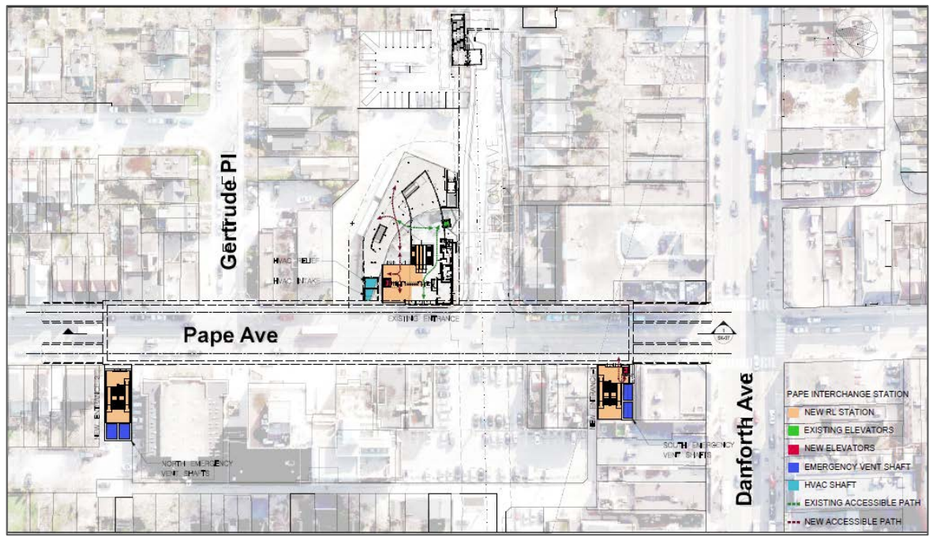


3.2.12 Pape Station (Interchange)

Pape Station's station box (**Figure 3-8**) is located as far south as the alignment will allow to form an "X" interchange (centre points of two platforms align) as it crosses beneath the TTC's Line 2 - Pape station box. The "X" configuration provides for direct transfers between the two stations and the bus terminal. This Relief Line South station will have two entrances on the west side of Pape Avenue and the primary accessible entrance located south of Pape station and just north of Danforth Avenue. The secondary entrance is located mid-block north of Pape station. The Relief Line South station box is organized into three levels- platform, concourse and an expanded Pape Station platform level. The expanded Pape platform level allows for direction connections between all three entrances and the two stations, as well as access to both stations from both sides of Pape Avenue.

The configuration provides accessible routes between the new Relief Line South entrances and the expanded Pape entrance/bus terminal, a direct accessible route from the station's primary entrance to the Line 2 eastbound platform, and an additional direct accessible route from Pape Station entrance to the Line 2 westbound platform.

Figure 3-8: Pape Station (Interchange)



3.3 Station Design Considerations

3.3.1 Approach

The general approach to the station design presented is functional in nature and follows the general requirements of the TTC Design Manual, including integration of an

accessible route within the station general circulation. The designs presented are proof of concept for fit within the overall corridor alignment and fit within the individual urban and infrastructural context of each station.

The station design is based on a typical TTC centre platform station functional layout with a 152m long platform and a concourse level above that acts as an intermediary between the platform and station entrances at street level. This arrangement allows for a greater flexibility of appropriately siting station entrances within the urban context and locating the station box within the constraints of the alignment.

For interchange stations at the existing Queen, Osgoode and Pape stations, the approach is to integrate the new facilities with the existing station and the unique urban context of each station.

The recommended Relief Line South alignment will run with the underlying bedrock along its route and the stations will be deep. The additional depth allows for opportunities to arrange operational spaces stacked above the platform level and greater flexibility in providing the required connectivity between the subway platform and the surface entrances.

3.3.2 Primary Design Considerations

Stations will be designed to provide an inviting environment through appropriate station architecture, urban design, and landscape architecture. Considerations include:

- Enhanced accessibility for all users;
- Sensitive integration into the existing urban fabric;
- Enhanced potential for Transit Oriented Development (TOD), by designing entrances for potential incorporation into future development;
- Sustainable design in keeping with the Toronto Green Standard;
- Enhanced connectivity to surface routes with convenient transfers; and
- Uncomplicated circulation with intuitive way-finding and signage.

3.3.3 Station Design Guidelines

The Relief Line South alignment goes through a series of Toronto neighbourhoods with very different characteristics, including the dense Downtown, emerging post-industrial or rejuvenating neighbourhoods, and established neighbourhoods with a strong identity. In some neighbourhoods, the challenge will be integration into the established fabric. In others, the station will be the catalyst for rejuvenation of the neighbourhood. Although the general station entrance layout will be very similar for all stations, their individual design will either reflect the established urban fabric or support the emerging urban fabric.

Following is a set of design guidelines that will govern station design. Note that at this stage of the project the stations are only being developed to a concept level.

3.3.4 Station Planning

Urban Context

Stations will reflect their urban context, be it an established urban core, an established neighbourhood or a neighbourhood undergoing rejuvenation. Station design must also consider flexibility for future connections and potential incorporation into future development.

Considerations include:

- Station Entrance Siting – sensitive siting fitting within the urban fabric of an established neighbourhood or to preserve developable land to encourage future TOD;
- Functional and adaptive layout that minimizes disruption to station operations during adoption of new technology and potential integration into new development;
- Crime Prevention Through Environmental Design (CPTED) requirements to provide a safer environment for all; and
- Well integrated infrastructure including substations, ventilation structures and emergency exit buildings (EEBs) that fit within their context and reduce potential impacts on future development.

Property Impacts

The Relief Line South alignment follows existing public rights-of-way wherever possible. It travels through a series of Toronto neighbourhoods, crossing the city grid underground as it transitions from one right-of-way to another, with minimal impacts to the surface structures. Stations and required infrastructure will require property takings, including a big box mall for Carlaw Station, be designed to minimize land requirements, and be in keeping with the urban fabric, existing or proposed. For more information on Property Impacts, please see **Section 6**.

Network Connectivity

All stations will have connectivity to a variety of other transportation modes including bicycles, cars, buses, streetcars, regional commuter rail and subways. The Relief Line South will have two interchange stations connecting to Line 1 at Osgoode and Queen Stations, and one interchange station connecting to Line 2 at Pape Station. There will be two intermodal stations connecting to the regional commuter rail lines at Eastern Station and Gerrard Station. In addition, these stations will have connections to surface routes including buses and streetcars.

Station locations and layouts will provide intuitive and efficient connections between modes, including transfers to surface modes.

Accessibility

All stations will be designed to be accessible. Following the TTC Design Manual, all stations will be provided with at least one accessible path connecting to all modes. Wherever feasible, a single elevator transfer accessible path has been provided between all major transfers.

Sustainability

The City of Toronto has established sustainability requirements embodied in the Toronto Green Standard (2018). For City Agency, Corporation, and Division-Owned Facilities (non-residential uses), the Toronto Green Standard outlines one tier of mandatory standards that will serve as a minimum requirement in the design of the station facilities. The overall goal remains to have designs that minimize the ecological footprint while providing an inviting space for its end users.

3.3.5 Station Elemental Components

Typical urban underground transit stations can be broken down into four major components. These consist of the Platform Level, the Concourse Level and the Street Level with the fourth major component, vertical and horizontal circulation, connecting them. Individual stations may include additional components. These could include a streetcar or bus facility, connectivity to regional commuter rail, or possibly a traction power substation. The detailed station plates for all eight Relief Line South stations are provided in **Appendix 3-2**.

Street Level – Entrance Facility

The primary expression of an urban underground station upon its surrounding urban fabric is the entrance facility. While other elements of a station (like vent structures) will present themselves onto the surface, they are typically designed to blend into the urban fabric. The entrance facility in a dense urban environment should be easily identifiable, while fitting in and contributing to urban context. The siting of the entrance should be at a prominent node, and allow for easy connections to other transit modes and facilities such as streetcars, buses, bicycle lanes and pedestrian networks (PATH).

The physical entrance may take a number of forms. Depending on the context, the facility may be the primary or secondary entrance; it may be part of an existing building, part of a new building, a pavilion of its own or a pavilion design for incorporation into future development. Despite its many forms, the basic formal organization of the entrance remains, with a plaza or urban scape that signifies a transit node, an entrance hall that welcomes patrons into the subway environment and stairs, escalators and elevators that connects to the station below. All of this is supported and reinforced with the appropriate signage and wayfinding.

Concourse Level

The concourse is the intermediate connecting level that joins the street level and the platform level. The concourse provides horizontal circulation space allowing entrance facilities to be appropriately located within its urban fabric and connect to a platform level below whose placement is dictated by alignment and other constraints. The concourse also provides opportunities for connections to adjacent facilities and amenities, including integration into the PATH network. Vertical Circulation Elements (VCEs) including stairs, escalators and elevators connect the street level to the concourse and in turn to the platform. This arrangement allows for an easy transfer from the platform level to the concourse, then straightforward navigation and transfer to multiple entrance facilities.

The arrangement described also ensures a fast evacuation of the platform level to the concourse level through multiple VCEs and the provision of two or more means of egress onto the surface, thus meeting Ontario Building Code requirements, as well as National Fire Protection Association (NFPA) requirements.

In addition to its connectivity and life safety functions, the concourse level houses a number of operational spaces, including emergency fire ventilation equipment, and it also serves as the demarcation point between the paid and unpaid zones at most of the urban stations in TTC's current operational model.

All of this is supported and reinforced with the appropriate signage and wayfinding.

Platform Level

The platform level is the connection to the trains where people wait for, get off and get on the trains; making it a very busy place during peak periods. The platform will be designed with effective and intuitive movement of people in mind, a form common to all stations and with variation to meet the specific requirements of each station. The form for the Relief Line South is the centre platform with clear platforms for both sides and a central spine of VCEs and amenities. The centre platform allows for greater effective use of the station infrastructure, including its VCEs by allowing the same VCEs to serve both the morning and the evening rush hours. The distribution of the VCEs along its spine also serves to influence the distribution of people along the length of the platforms allowing for a more effective use of the platform and in turn, the train and the next station down the line.

All of this is supported and reinforced with appropriate signage and wayfinding.

The Relief Line South platforms will be designed with Platform Edge Doors (PEDs). This along with ATC/ATO, will provide a more uniform and safer experience for the patrons. The form of the PEDs will influence the passenger experience. Partially segregated PEDs allows for the trains' movement to provide piston effect ventilation of the station, similar to

existing TTC stations. Fully segregated PEDs allow for a station's environment to be tempered; heated during the winter and cooled during the summer, and will reduce the amount of brake dust within the station. A full analysis of alternative forms of PEDs will need to be carried out during the next phase of the project.

The Circulation Level

The vertical and horizontal circulation elements inform the users experience and must be efficient and appear seamless and natural. Circulation needs to be sized to accommodate demand in all situations and the directional grain of the circulation needs to be reinforced. The use of intuitive wayfinding and signage will reinforce the movement from platform to street, platform to platform, and to other point to point transfers.

Barrier-free circulation needs to be effective and efficient with minimal transfers between levels and modes. As a general design rule, a barrier-free path should not have more than one elevator transfer from origin to destination. For a street to platform transfer, this means a single elevator ride from the street to the concourse and another single elevator ride from concourse to platform.

Additional Elements

Depending on the station, additional elements could be a connection to:

- The existing TTC bus terminal for Pape Station;
- A streetcar stop along Queen Street;
- In the case of the new Gerrard Station, connections to streetcar stops along Gerrard Street;
- A new bus terminal; and
- A Commuter rail station.

The numbers and types of these elements are specific to each station and will be accounted for in the overall design to ensure proper integration into the overall station design and to provide smooth and efficient transfers between modes.

Other Facilities

In addition to the station-related elements, a number of support facilities are required along the alignment; including four stand-alone Traction Power Substations, plus the one at Gerrard Station, seven EEBs, and tunnel ventilation structures at the end of each tail track. These facilities will be designed to integrate into their immediate urban environment.

3.4 Ancillary Features

3.4.1 Running Structure

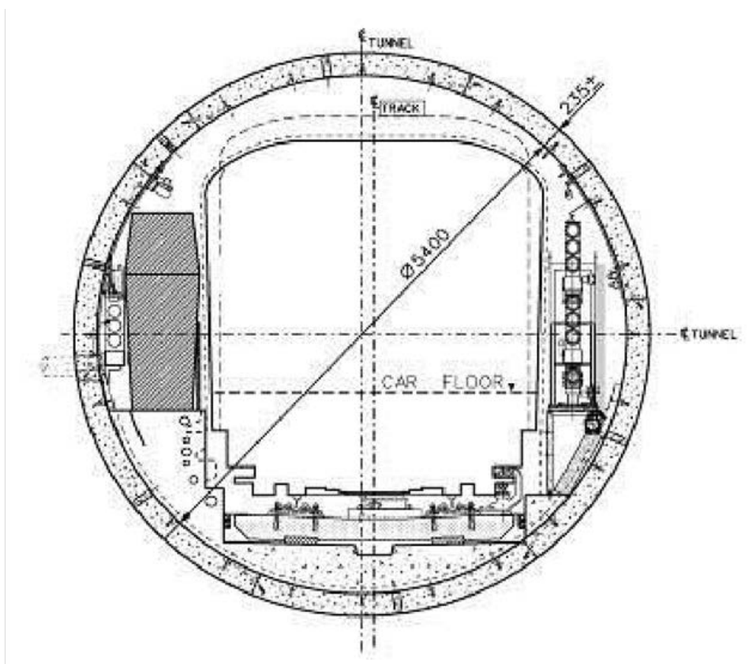
This section summarizes the Relief Line South running structure and access provisions including emergency access points and walkways. It includes descriptions of typical cross-sections for bored tunnel and box section running structure. For complete details on these requirements, refer to the TTC Design Manual.

Tunnels

The Relief Line South will be constructed with an internal tunnel diameter of 5.4 m. A typical cross-section for a tunnel is shown in **Figure 3-9**. The tunnels will be constructed using the twin boring construction method that is effective for difficult ground conditions (sands and clays under high groundwater pressure).

Modern Tunnel Boring Machines (TBMs) use a pressurized face at the front of the machine to maintain stability in the ground while allowing workers to operate in safe conditions within the tunnel.

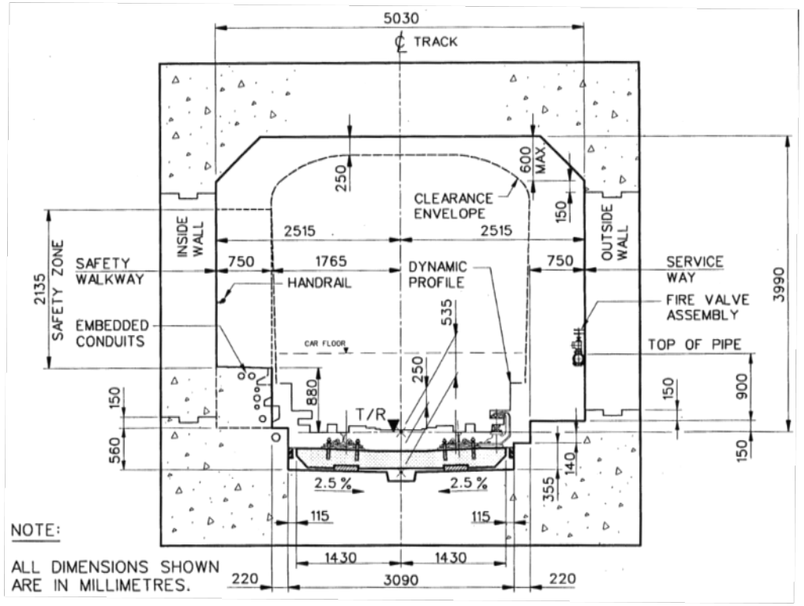
Figure 3-9: Typical Cross-Section of a Bored Tunnel



Box Structure

A typical cross-section for a box structure is illustrated on **Figure 3-10**.

Figure 3-10: Typical Single Box Section – Double Tie, Tangent Track (TTC, Design Manual- 0205-01)



Open Cut Sections

The Relief Line South will be constructed following TTC standard practice of construction, involving twin bore with box structure (open cut) at tail tracks, special track works, and stations.

Walkways

Safety walkways will be provided in all new tunnels for the Relief Line South. A walkway system will consist of a safety walkway and a service-way between stations. The safety walkway will be located on the left of the track-ways for operations in the normal direction of travel, and will provide direct connections to the centre platform stations. The walkways will be elevated and the service-way will be near track level.

The Emergency Exit Buildings (EEBs) track-way access will be centred between the northbound and southbound tunnels.

The safety walkway will support the emergency evacuation of a train in a tunnel and provide an access path to track-way installed equipment for maintenance personnel.

During subsequent design phases, the design should be optimized so that zero-clearance areas for workers at track level are not created.

Drainage

The entirety of the Relief Line South will exhibit a longitudinal gradient of at least 0.3% to ensure adequate run-off, via the standard drainage provisions described in the TTC Design Manual.

Track Support Structure

The track will be laid upon noise and vibration isolated double ties, with the exception of the special trackwork areas. Floating slab support structures with noise and vibration isolation will be constructed in the special trackwork areas with direct rail fixation to the slabs.

Embedded Conduit

Power supplies and communications caballing will be embedded in the walkways and invert of the tunnel structures during construction of the subway. Cables to be embedded include:

- Emergency trip;
- Emergency alert system telephones or other telephones;
- UPS to wayside mini-substations/load centres for tunnel lighting and utility outlets;
- Fibre optic cables;
- Power supply cables to select stations;
- Supervisory Control and Data Acquisition (SCADA) cables; and
- Power for tunnel pump stations.

3.4.2 Emergency Exits and Cross Passages

Emergency Exits

In accordance with NFPA-130 (2010), emergency egress from the tunnel will be provided throughout the underground system so that the distance to an exit will not be greater than 381 metres. Therefore the maximum distance from emergency exit to emergency exit or emergency exit to station will be 762 metres. Emergency Exit Buildings (EEBs) will be provided in the tunnel sections at the following locations:

- EEB #1 at approximately Sta.-0+050, near the John Street substation;
- EEB #2 is located within sub-station #2 at approximately Sta.1+420, on Queen Street E between Mutual Street and Jarvis Street;

- EEB #3 is located within sub-station #3 at approximately Sta.2+800, north of Eastern Avenue, between Richmond Street E and Adelaide Street E;
- EEB #4 at approximately Sta.4+300, between Carlaw Avenue and Morse Street;
- EEB #5 at approximately Sta. 6+260, south of Cavell Avenue on Pape Avenue;
- EEB #6 at approximately Sta.7+040, north of Browning Avenue on Pape Avenue; and
- EEB #7 is located within sub-station #5 at approximately St.7+400, on Pape Avenue, south of Westwood Avenue.

All ancillary features are shown in **Appendix 3-1**. These structures extend from the underground tunnels to above grade and are designed to provide an emergency exit for passengers and an emergency access for firefighting crews. They can also provide emergency ventilation and secondary power sources.

Cross Passages

NFPA-130 (2017) allows the use of cross passages in lieu of emergency exit stairways provided they are fire separated from the trainways with 1 ½ hour fire-rated doors and they are located at a maximum distance of 244 m between cross passages, and between cross passages and stations or portals. As EEBs are included are sited at the required intervals along the alignment as per NFPA-130 (2017) standards, cross-passages are not included in the conceptual design.

3.5 System Operation & Configuration

3.5.1 Service Requirements

Run and Dwell Times

On opening day the Relief Line South will operate service frequency ranging between 2 minute 45 second and 4 minute in the AM peak depending on the number of cars per train which will be determined through future work. By 2041, demand is forecasted to increase and the service will operate a frequency ranging between 2 minute and 3 minute in the AM peak depending on the number of cars per train. The Relief Line South project will be designed to accommodate an ultimate service of a 1 minute 30 second frequency with 6-car trains. This service frequency is estimated to be required when the Relief Line is extended north towards Sheppard Avenue.

Fleet Size and Train Configuration

The Relief Line South project will be designed to accommodate an ultimate service frequency of 1 minute 30 seconds with 6-car trains. This will require approximately between 48 to 54 cars in-service or between 56 and 63 total cars with a 15% operating spare ratio.

3.5.2 Track Plan

Figure 3-11 and **Figure 3-12** presents a schematic diagram of the Relief Line South mainline track from the Osgoode Station to Pape Station, as well as the tail tracks and Wye connection. The track plan complies with the requirements for "subway" alignment as defined in the TTC Design Manual. Specific features of the track plan are discussed in the following sections.

Figure 3-11: Relief Line South track and station schematic

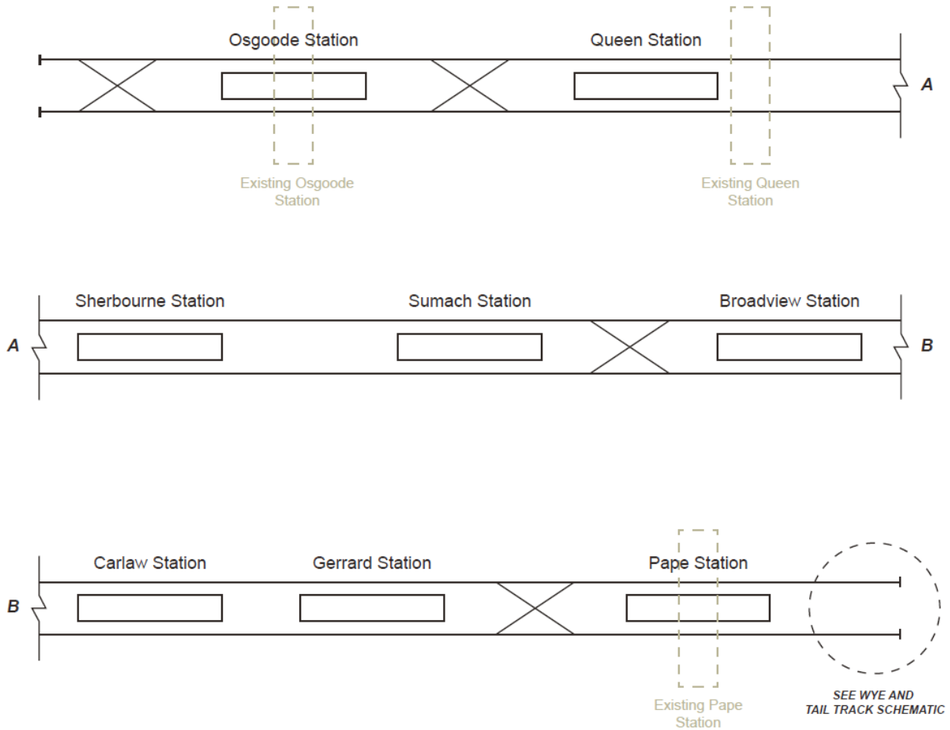
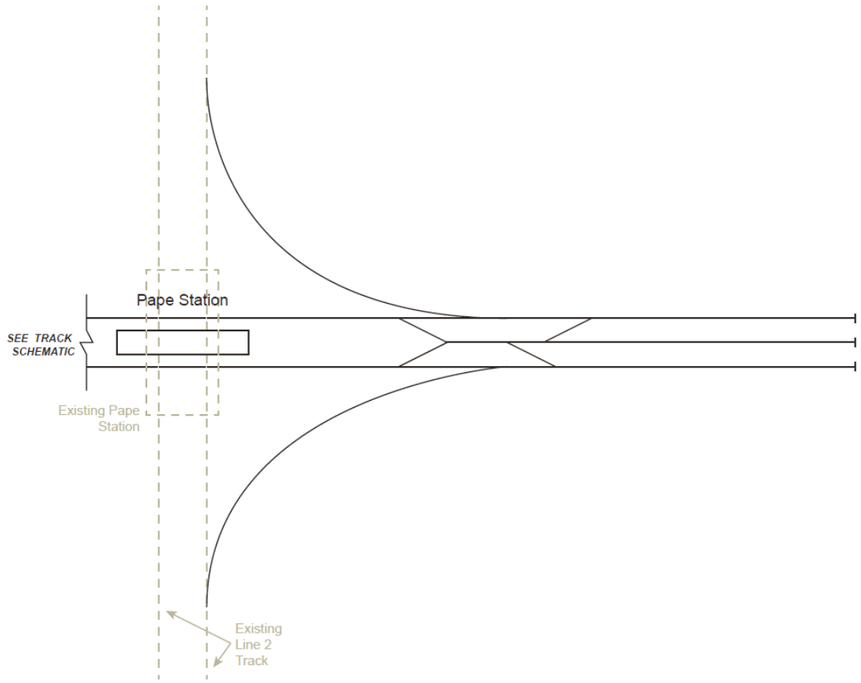


Figure 3-12: Relief Line South Pape tail track and Wye connection schematic



Train Maintenance and Storage

Greenwood Yard will be the primary facility for maintenance and storage of the Relief Line South revenue fleet. Greenwood Yard is located at 400 Greenwood Avenue, south of Line 2 between Donlands and Greenwood Stations. It is currently home to Greenwood Carhouse, the principal inspection and running maintenance facility for Line 2; and Greenwood Shops which is the principal heavy repair and overhaul facility for the entire subway fleet. Connection from the Line 2 mainline is made by a wye connection track to the portal at the north end of the site.

The connection from the Relief Line South mainline to Greenwood Yard will be made by a wye connection to the Line 2 mainline. From the mainline, the trainsets can enter the yard through the existing wye connection and portal. Wye connection details can be found on plates 12 and 13 in **Appendix 3-1**.

In addition to Greenwood Yard, overnight storage will occur on the tail tracks connected to the mainline (west of Osgoode Station) and on the east (north) portion of the pocket track that is north of Pape Station and north of the Line 2 mainline. Only light duty maintenance and interior cleaning of the trains may occur at the end of line storage locations (tail and pocket tracks) and all major maintenance will continue to occur at the Greenwood Yard.

Wye Connection

Wye connections will be located north of Pape Station and will consist of:

- Northwest wye track – from Line 2 to west tail track; and
- Northeast wye track – from Line 2 to east tail track.

The transition between Relief Line South northbound and southbound tracks and wye tracks will be through the tail tracks. The northwest and northeast wye tracks will connect to the existing westbound track on Line 2.

Crossovers

Crossover tracks serve several purposes with respect to smooth station operations. Crossovers allow disabled trains to be bypassed which promotes inline and at station failure management. Crossovers also provide terminal station operation flexibility, required redundancy, and minimize single points of failure. Generally speaking, crossovers facilitate access to and from tail and storage tracks and reversing of trains at terminal stations, including those described below.

Osgoode Station

Double crossovers are proposed west of Osgoode Station for redundancy and a front double crossover east of Osgoode Station for standard terminal station operations.

Broadview Station

There are double crossovers located west of Broadview Station for short turns.

Pape Station

There is an optional double crossover proposed west (south) of the existing Pape Station which would be used for the future Relief Line extension north to Sheppard Avenue and for redundancy. The crossover would also allow for short turns to support the current direction that every other train will short turn at Pape Station and will be used for failure management and maintenance operations.

Two single crossovers are east (north) of Pape Station. The tail and pocket track connections are used for standard terminal station operations.

Tail Tracks

Tail tracks are located just beyond the double crossovers at both ends of the proposed mainline. The tail tracks are located west from Osgoode Station for standard terminal station operations.

At the east (north) of Pape Station, the tail tracks will be used for standard terminal station operations and for wye track connections.

Pocket/ Storage Tracks

A pocket track is proposed east (north) from Pape Station. The west part of the pocket track is for standard terminal operations and wye track connections to the Line 2 mainline. The eastern segment is for overnight train storage and disabled train storage.

Other Special Trackwork Requirements

An equilateral turnout will be required east (north) from Pape Station for the pocket track connection.

3.5.3 Vehicles

Revenue Trains

Revenue service will ultimately run with 6-car train sets. The track and platform dimensions on the Relief Line South will accommodate the standard 6-car train and allow for a future 7-car train. Platform lengths will be built to the TTC standard of 152.4 m.

The revenue train configuration will be 6-car trains for purposes of overall track planning, service and operations planning. These trains will be stored overnight at the underground train storage facility to be located north of Pape Station (6 train sets) and west of Osgoode Station (2 train sets) with in line total storage capacity of 8 train sets.

Work Trains

Existing electric and diesel powered work trains will operate on the line during non-revenue service periods. These vehicles will originate from Greenwood Yard.

3.5.4 Power Source

Traction Power Substations

Traction power will be supplied at 600V DC (nominal voltage level) from traction power substations located at passenger stations and at standalone facilities along the line. The substations are sized assuming two 1500 kW rectifiers with a provision for a third rectifier branch. The power is distributed to the trains by way of the third rail power distribution system. The substations will supply each station with 600VAC power supply through a set of pad mounted step-down power transformers. The supply scheme will be redundant and will have spare capacity such that it would be possible to replace major electrical components without curtailing station operation and without major shutdown periods. Power redundancy will be provided to all of the major downstream power equipment to meet latest TTC design standards and regulations. Substations are sited at a spacing of approximately 2.0 km, not exceeding 2.5 km apart (per TTC Design Manual DM-0804-01).

There are a total of five substations required for the Relief Line South, one at either end of the Queen and Pape tail tracks, and three inline:

- Substation #1 – -0+030 (end of Queen tail tracks);
- Substation #2 – 1+420;
- Substation #3 – 2+760;
- Substation #4 – 5+420 (Gerrard Station); and
- Substation #5 – 7+400 (end of Pape tail tracks).

Substation spacing will be confirmed during later design phases via a verifiable computer simulation based load flow analysis.

AC Power

Medium voltage power supply will be provided to each of the substations from local hydro overhead or underground network. The exact power supply arrangement and requirements will be finalized with hydro providers during the design stage and will consider power authority access guidelines and incoming service isolation details.

Essential Power

Emergency Power and Uninterruptible Power Supply (UPS) requirements are outlined in TTC Design Manual DM-0701-04. In summary, UPS will be provided at each station. The UPS system will provide a minimum of 90 minutes of battery power at full load for life safety and essential services within the station, substation, and underground running structure. The UPS supply scheme will be fully redundant and will include level of redundancy for batteries and UPS system itself.

3.5.5 Tunnel Ventilation

As per the requirements of NFPA-130 (2017), an Emergency Ventilation System will be provided. The system will be designed to provide a tenable environment along the path of egress from a fire incident in enclosed stations and enclosed trainways and to provide continuous ventilation during maintenance operations when fumes are being generated. In addition, the system helps to moderate the piston effect at stations even when not actively engaged.

The ventilation system is comprised of ventilation structures and fan rooms at ends of stations and at the ends of tail tracks. Fans are designed to work in concert with each other to push or pull the air as required. In a fire event at a station or between stations in either of the twin tunnel, the fans on either side of the event will work in conjunction with

the other to control the migration of smoke and maintain a tenable egress path away from the event.

The ventilation system is centrally controlled from the Transit Control Centre using a SCADA system. In addition, local control is also provided from the Central Alarm and Control Facility located near the attended entrance at each station for that specific station, as well the ventilation equipment at the adjacent stations to provide the ventilation system required set up for the station and the adjacent tunnels.

3.5.6 Drainage and Pumping Stations

The entirety of the Relief Line South will exhibit a longitudinal gradient of at least 0.3% to ensure adequate run-off, via the standard drainage provisions described in the TTC Design Manual.

Pumping stations will be provided at the low points on the alignment as follows:

- Sta. 0+000 at the tail tracks west of Osgoode Station;
- Sta. 3+080 near the Don Valley Parkway / Don River crossing; and
- Sta. 4+860 near Carlaw Station (lowest elevation of the alignment).

During construction, resulting pump discharge would be directed to a sanitary sewer. For the ultimate condition, beyond construction, there will be a need to permanently pump water from the subway tunnels. This pump discharge would also be directed to sanitary sewers.

A detailed analysis of the drainage and pumping systems should be reviewed during the detail design stage.

3.5.7 Don River Crossing

The Don River crossing (alignment between chainages 3+050 to 3+350) is especially challenging for constructability purposes due to the changes in the sub-surface soil and bedrock profiles, proximity to the river and possible flow of construction process effluent into Lake Ontario, and the built environment that includes the Don Valley Parkway and multiple railway tracks.

The area directly under the Don River may require ground conditioning treatment due to the confluence of conditions that transition in quick succession between shale bedrock to soft ground and back. The purpose of the ground conditioning would be to provide conditions at this location that would then be suitable for a hybrid TBM with the capability for tunneling in both soft soils and in the shale bedrock. This hybrid TBM would be capable of open faced drilling in the bed-rock, as well as earth-pressure-balanced drilling in the soft soil conditions. Hydrostatic pressures under the Don River would have to be considered to arrive at the most suitable tunnel design and type of TBM chosen for this project.

Additional geotechnical and hydro-geological studies of the soft soil under the Don River need to be conducted to understand the soil characteristics, including the adhesion limits. In addition to the use of bentonite based soil conditioners, additional ground-improvements such as jet-grouting may be necessary at this location.

Jet grouting has been successfully employed for construction of underground jet-grout blocks that may be suitable to reduce the risk of face collapse and infiltration for the hybrid TBMs which may be operating in open-face mode. The challenge with jet grouting however, is that there is a potential risk of communicating jet-grout spoils into the Don River. This risk is in addition to the risk of accidentally discharging spills of process fluids (wash effluents, fuel or hydraulic oils, etc.) into the watercourse.

Significant environmental review is recommended, along with implementation of properly engineered solutions to mitigate these environmental concerns. A regime of environmental monitoring should also be adopted as due-diligence for ground conditioning techniques selected.

Another alternative would be to construct this portion of the alignment by Sequential Excavation Methods (SEM), if during preliminary design and investigational studies find that the section under the Don River as high risk due to ground conditions and high water pressure. There is a high possibility that this too may require ground conditioning and improvement efforts. SEM construction may also result in additional environmental impacts due to the need for additional laydown areas on the west side of the Don River crossing.

If the preliminary design studies indicate that the section under the Don River is best suited for SEM style construction, a launch/extraction shaft in the West Don Lands would be needed as an access shaft for the SEM construction going East under the Don River. According to the existing profiles and the geotechnical report (**Appendix 3-4**), the elevation of the top of the bedrock abruptly changes and lowers suddenly near the Don River and this occurs around Bayview Avenue (to be further refined with investigation). The SEM launch shaft would be located in the sand and silty sand layers (wet area).

Although the type of the SOE system for the SEM launch shaft will be recommended by the design phase geotechnical engineer, through experience the use of a caisson wall (contiguous secant pile system) would be a typical construction method as it forms a cut off wall that minimizes any ground water seepage into the bottom of the shaft. Before the drilling of the caissons, a headwall would be formed by jet grouting at the exterior edge of the launching shaft. A vertical braced frame would be formed on the inner face of the headwall. The other three sides of the launch shaft (Caisson wall will be supported with whalers and horizontal struts spanning between the face of the caisson walls).

3.5.8 Conceptual Major Utility Projection/ Relocation Requirements

General Overview

The major utilities located in the vicinity of the Relief Line South alignment have been identified through direct contact with the respective companies or providers and through a review of the Toronto Digital Map Owners Group (DMOG). These utilities examined include:

- Municipal (City of Toronto) storm sewers, watermains, steam mains and sanitary sewers;
- Bell Canada;
- Rogers Communications;
- TELUS;
- Cogeco Data Services;
- Group Telecom;
- Toronto Hydro
- Hydro One
- Enwave Energy Corporation
- Beanfield Metroconnect
- Enbridge Gas Distribution Inc.;
- Zayo;
- Sun Oil Co Pipe;
- Imperial Oil Co Pipe;
- Trans Northern Pipe;
- Ammonia Pipe Gas Co.;
- Metronet Water Main;
- AT&T Canada Conduit; and
- TeraSpan

Utilities were examined in the vicinity of the Relief Line South alignment and at station locations. The underground utilities with diameters greater than 600 mm have been noted and any major utilities conflict have indicated on the plan and profile drawings.

A thorough review of existing and future utilities plans, as well as all necessary relocations or modifications will be undertaken during detailed design phase of the Relief Line South project to determine any permanent relocation requirements.

All other utilities can be relocated either prior to or during construction depending on the relocation strategy. Utility impacts and relocation strategies will be confirmed during the detailed design phase of the project.

Utilities shown on the DMOG in 2D (for example, streets north of Selkirk Street on Pape Avenue do not show vertical elevations) will be re-visited during the detailed design phase. The tail track profile may be revised to avoid any possible conflicts with the existing large diameter sewer systems north of Selkirk Street on Pape Avenue.

Utilities (up to 6 metre depth)

In locations where open cuts and station boxes are required for construction of the alignment or stations, utilities in conflict will need to be suspended in-place or relocated.

Services to residential homes and local businesses in the vicinity of the Relief Line South alignment will be maintained to the extent possible during construction and notice of planned service interruptions will be provided to service users prior to interruptions. All potential conflicts and the relocation strategy will be confirmed with service providers during detailed design.

Utilities (6 metres or greater)

Utilities along the Relief Line South alignment in the right-of-way have been identified and strategies have been proposed at this stage of the project for mitigation measures. Refer to **Appendix 3-1** for further details. The limits of Pape Corridor are Eastern Avenue (to the south) and Canning Avenue (to the north). From south to north along Pape Avenue, the existing utilities more than 6 meters below ground, that may cause conflict are:

1. 1650mm concrete Storm Sewer that runs along Queen Street E and crosses Pape Avenue at a depth of 5.40m (top of sewer) to 7.91m (bottom of sewer).
2. 2700mm circular Brick Circular Sanitary Sewer that runs along Dundas Street E and cross Pape Avenue at a depth of 3.50m (top of sewer) to 7.23m (bottom of sewer).
3. 3000mm Mid Toronto Interceptor Sanitary Sewer that runs along Gerrard Street E and crosses Pape Avenue. The depth is unknown. Further investigation is required to confirm the depth.
4. A concrete Storm Sewer (size varies from 1350mm to 1500mm) that runs along Langley Avenue, turns onto Pape Avenue and runs along Pape Avenue to Strathcona Avenue. At Strathcona Avenue, the concrete Storm Sewer turns and continues along Strathcona Avenue. The depth of this sewer is 5.60m (top of sewer) to 10.50m (bottom of sewer).
5. 1050mm x 1050mm Horseshoe Storm Sewer that runs along Danforth Avenue and crosses Pape Avenue at a depth of 7.40m (top of sewer) to 8.81m (bottom of sewer).
6. Pape Station Subway Tunnel is located at Lipton Avenue and Pape Avenue at a depth of 4.10m (top of tunnel) to 13.38m (bottom of tunnel).

7. 1200mm reinforced concrete pipe (RCP) Storm Sewer that runs along Pape Avenue from Danforth Avenue to Gertrude Place at a depth of 4.40m (top of sewer) to 7.14m (bottom of sewer).

The limits of the Queen Street Corridor are John Street (to the west) and Jones Avenue (to the east). From west to east along Queen Street, the existing utilities, more than 6 meters below ground, that may cause conflict are:

1. 1575mm circular brick Combined Sewer that runs along Simcoe Street and crosses Queen Street at a depth of 4.07m (top of sewer) to 6.10m (bottom of sewer).
2. 2100mm Enwave Steam Main that runs along Simcoe Street and cross Queen Street at a depth of 7.20m (top of steam main) to 9.83m (bottom of steam main).
3. Osgoode Station Subway Tunnel is located at University Avenue and Queen Street at a depth of 7.10m (top of tunnel) to12.95m (bottom of tunnel).
4. 3550mm Steam Tunnel that runs along York Street, Queen Street, and ends at James Street, at a depth of 10.00m (top of tunnel) to 30.35m (bottom of tunnel).
5. 3550mm Steam Tunnel that runs along Bay Street and crosses Queen Street at a depth of 26.0m (top of tunnel) to 34.65m (bottom of tunnel).
6. Combined Sewer that runs along Bay Street (south of Queen St) at a depth of 7.00m (top of sewer) to 9.00m (bottom of sewer).
7. Pedestrian Tunnel is located at Bay Street (south of Queen St) at a depth of 2.80m (top of tunnel) to 7.60m (bottom of tunnel).
8. Queen Station Subway Tunnel is located at Yonge Street and Queen Street at a depth of 3.70m (top of tunnel) to 10.81m (bottom of tunnel).
9. 1500mm x 1350mm concrete Combined Culvert over 600mm Vitrified Pipe (VP) Combined Sewer that runs along Victoria Street and crosses Queen Street at a depth of 4.10m (top of sewer) to 6.83m (bottom of sewer).
10. 1500mm Egg Shaped (ES) Concrete Sanitary Sewer that runs along Victoria Street and crosses Queen Street at a depth of 14.00m (top of sewer) to 17.60m (bottom of sewer).
11. 1500mm to 1650mm concrete pipe (CP) Storm Sewer that runs along Queen Street (from Victoria Street to Don Valley Parkway overpass) at a depth of 4.40m(top of sewer) to 9.50m (bottom of sewer).
12. 750mm RCP Storm Sewer that runs along Berti Street (south of Queen St) at a depth of 5.47m (top of sewer) to 6.41m (bottom of sewer).
13. 800mm x 1200mm ES Brick Combined Sewer that runs along Church Street and cross Queen Street at a depth of 5.00m (top of sewer) to 6.50m (bottom of sewer).
14. 2325mm circular brick Combined Sewer that runs along Ontario Street and crosses Queen Street at a depth of 4.00m (top of sewer) to 7.00m (bottom of sewer).
15. 1200mm circular brick Combined Sewer Overflow that runs along Queen Street (from Don Valley Parkway overpass to Munro St) at a depth of 4.37m (top of sewer) to 8.00m (bottom of sewer).
16. 1650mm concrete Storm Sewer that runs along Queen Street (from Booth Avenue to Jones Avenue) at a depth of 4.90m (top of sewer) to 8.47m (bottom of sewer).
17. 1800mm circular concrete Sanitary Sewer that runs along Carlaw Avenue and crosses Queen Street at a depth of 14.02m (top of sewer) to 19.20m (bottom of sewer).
18. 2700mm concrete Storm Sewer that runs along Larchmount Avenue (south of Queen St) at a depth 20.12m (top of sewer) to 23.50m (bottom of sewer).
19. 1800mm concrete Storm Sewer that runs along Larchmount Avenue (south of Queen St) and crosses Queen Street at a depth 6.20m (top of sewer) to 8.50m (bottom of sewer).
20. 1350mm concrete Storm Sewer that runs along Coady Avenue at a depth of 5.80m (top of sewer) to 7.92m (bottom of sewer).

Major Conflicts

The existing utilities which could be considered major constraints located below ground on Pape Avenue and Carlaw Avenue, between Withrow Avenue to the north and Eastern Avenue to the south, as well as the utilities on Queen Street from John Street to Jones Avenue were examined.

Enwave Steam and Cooling Tunnels

Many of the buildings in Toronto's downtown core utilize Enwave's Deep Lake Water Cooling system which is an alternative to conventional air conditioning. This system uses water from Lake Ontario to drive a heat exchange system to cool large buildings such as office towers and hospitals. Enwave, in coordination with the City of Toronto, has a network of steam systems and a separate district cooling tunnels that are in the vicinity of the Relief Line South alignment and its stations.

In the downtown core near Queen Street, there is a 2100mm Enwave pipes that runs along Simcoe Street and crosses Queen Street at a depth of 7.20m (top of steam main) to 9.83m (bottom of steam main). There is a 3550mm Enwave Tunnel that runs along York Street, Queen Street, and ends at James Street, at a depth of 10.00m (top of tunnel) to 30.35m (bottom of tunnel), and a 3550mm Enwave Tunnel that runs along Bay Street and crosses Queen Street at a depth of 26.0m (top of tunnel) to 34.65m (bottom of tunnel).

Due to the depth and size of the Enwave tunnel, especially for the district cooling system, it would be challenging to relocate. In the Detail Design phase when the alignment and station design is refined, the designer should meet with Enwave to determine the most

functional, cost efficient resolution. The designer should also continue to work with the utility owner through the design and construction process.

Queen Street Municipal Sewer Conflicts

Utilities that are shallow, small in diameter, and/or are located to the edge of the right-of-way will have fewer challenges associated with relocation or suspending in-place. On Queen Street East, there is a 1500mm ES concrete Sanitary Sewer that runs along Victoria Street and crosses Queen Street at a depth of 14.00m (top of sewer) to 17.60m (bottom of sewer), a 1800mm circular concrete Sanitary Sewer that runs along Carlaw Avenue and crosses Queen Street at a depth of 14.02m (top of sewer) to 19.20m (bottom of sewer), and a 2700mm concrete Storm Sewer that runs along Larchmount Avenue (south of Queen Street) at a depth 20.12m (top of sewer) to 23.50m (bottom of sewer). These municipal sewers will be challenging to suspend in place due to their size and locations underground. These utilities may require temporary by-passes or permanent relocations prior to construction. All other utilities can be relocated either prior to or during construction depending on the proposed relocation strategy. Utility impacts and relocation strategies will be confirmed during the detailed design phase of the project.

Carlaw/ Pape Avenue Conflicts

The tables below outline the utility conflicts, location and proposed solution for the major conflicts.

Table 3-6: Utility Conflicts, Locations, and Proposed Solutions (1/3)

	Utility Conflict	Depth	Location	Proposed Solution
A	1350mm ø Concrete Storm Sewer	3.93m (cover) 5.18m (to invert)	South on Pape Ave and west along Langley Ave	Relocate
B	3000mm Mid Toronto Interceptor Sanitary Sewer	Unknown on DMOG – Approx. 12m deep.	On Gerrard St East, crossing Pape Ave.	Remain in place – protect during construction
C	2700mm Circular Brick Sanitary Sewer	3.50m (cover) 7.23m (to invert)	On Dundas St East, crossing Pape Ave	Remain in place – protect during construction
D	Two 115kV cables Hydro-Electric Power Commission of Ontario (OH)	Approx 1.5m (cover)	On Carlaw Ave, north of Dundas Street East	Remain in place – protect during construction

Table 3-7: Utility Conflicts, Locations, and Proposed Solutions (2/3)

	Utility Conflict	Depth	Location	Proposed Solution
E	1325 x 1275mm Concrete Culvert Storm Sewer	1.24m (cover) 3.2m (to invert)	Carlaw Ave south of Colgate Ave (proposed Queen Station)	Relocate
	1050 x 1200mm Concrete Culvert Storm Sewer	1.07m (cover) 2.65m (to invert)	Carlaw Ave, north of Colgate Ave	Relocate
	900 x 1175mm Concrete Culvert Storm Sewer	1.3m (cover) 2.86m (to invert)	Carlaw Ave, near the GO Rail Bridge at Dundas St East	Relocate
	1050 x 1475mm Concrete Culvert Storm Sewer	1.32m (cover) 3.24m (to invert)	Carlaw Ave, north of the GO Rail Bridge (north of Dundas St East)	Relocate
F	600 x 900mm Egg-shaped brick Combined Sewer	0.73m (cover) 2.07m (to invert)	Carlaw Ave south of Colgate Ave (proposed Queen Station)	By-pass and Relocate
	600 x 900mm Egg-shaped brick Combined Sewer	1.74m (cover) 3.15m (to invert)	Carlaw Ave near the GO Rail Bridge at Dundas St East	By-pass and Relocate
	600 x 900mm Egg-shaped brick Combined Sewer	2.82m (cover) 4.25m (to invert)	Carlaw Ave north of Dundas St East	By-pass and Relocate
	600 x 900mm Egg-shaped brick Combined Sewer	7.3m (cover) 8.78m (to invert)	Carlaw Ave, south of the GO Rail Bridge at Gerrard Street East	By-pass and Relocate

Table 3-8: Utility Conflicts, Locations, and Proposed Solutions (3/3)

	Utility Conflict	Depth	Location	Proposed Solution
G	1800mm ø Circular Concrete Sanitary Sewer	16.9m (cover) 19.2m (to invert)	Carlaw Ave south of Colgate Ave (Proposed Queen Station)	Reconstruct 1800mm sewer and realign. Temporary bypass system is required.
	1800mm ø Circular Concrete Sanitary Sewer	16.15m (cover) 18.45m (to invert)	Carlaw Ave south of the GO Rail Bridge at Dundas St East	
	1800mm ø Circular Concrete Sanitary Sewer	17.98m (cover) 20.28m (to invert)	Carlaw Ave north of Dundas St East	
	1800mm ø Circular Concrete Sanitary Sewer	21.3m (cover) 23.9m (to invert)	Carlaw Ave south of the GO Rail Bridge at Gerrard St East	
H	1050mm ø Storm Sewer	4.8m (cover) 5.9m (to invert)	King St East, west of Sumach St and south of Adelaide St	Relocate

3.6 Construction Plan

The construction plan included in this study is considered preliminary and conceptual in nature, and may need significant revisions based on input from stakeholders, including members of the public, business and property owners affected by the project, various departments within the City of Toronto, various government agencies, and other transit system operators in the region.

During the subsequent design phases for the project, the construction plan is also expected to be revised in order to better reflect information that will be gathered through geotechnical, hydro-geological and geo-environmental investigations.

Similarly, revisions to the construction plan may result from information obtained from utility surveys. This information is expected to lead to identification of utility conflicts, both underground and overhead, and strategies for mitigation of these conflicts will need to be implemented with participation of the third party utility owners.

Finally, an effort for gathering information related to abandoned underground structures, including temporary shoring structures and soil anchors is expected to be undertaken, along with sub-surface investigations at locations where such confirmation would be considered critical due to construction risk.

The construction plan presented here is therefore intended to serve as a conceptual plan articulating one possible construction strategy, which is generally premised on means and methods of construction which have successfully been implemented for transit and underground infrastructure projects in the Greater Toronto Area over the past two decades. As such, it is assumed that availability of both design and construction expertise required to successfully undertake this construction plan will be available in the region.

Appendix 3-3 illustrates the conceptual construction plan for the Relief Line South.

3.6.1 Construction Staging/ Methodology

It is assumed that where possible, stations and ancillary underground structures such as pocket tracks, crossover tracks and tail track sections, for the Relief Line South would be constructed with open-cut construction techniques. The station envelope would be situated within the existing municipal right-of-way wherever possible, and depending on the alignment depth, the structures could be located in the bedrock, as well as in soft ground.

Due to the fact that the existing width of the municipal right-of-way is only approximately 20 m wide in most locations, the station width of 21 m dictates that permanent as well as temporary property takings would be necessary on either side of the station box structures. In some instances it is recommended that the option to acquire existing buildings which may be in conflict with the excavation footprint be considered for the express purpose of demolishing these buildings to facilitate construction. These instances must be considered on a case by case basis, taking into account the potential heritage or cultural value of these buildings, as well as the input received from the owners and tenants.

It must be recognized that the suggested locations for launching and extracting Tunnel Boring Machines (TBMs) as well as the locations and sizes of the construction laydown yards presented in this study are based on the assumed type of tunnel construction, i.e. hybrid or multi-mode TBM capable of open face as well as Earth Pressure Balanced (EPB) operation, and the use of pre-cast concrete segmental tunnel liners. The overall alignment can be represented in four distinct sections as follows:

a. The western rock section from the western limit of the project (chainage 0+000) to just west of Bayview Avenue (approx. chainage 3+150). This section is approx. 3.35 km long, and the alignment in this section is within the shale bedrock. Tunnelling in this rock layer is well suited to open face TBM excavation, although tunnelling would have to compensate for the “squeezing” or relaxing effect of the shale bedrock. A possible solution may be to select a TBM with a larger diameter tunnel bore, so that the finished and lined tunnel may have the required dimension.

b. The Don River crossing (between chainages 3+150 to 3+350), only 300 m long, is quite arguably the most complex from a constructability standpoint. This is because the section not only includes crossing of the Don River itself, but also due to the

transition between shale bedrock to soft soil, likely clay to very stiff till, and back to shale bedrock. The hybrid TBM would operate in earth-pressure balanced mode in the soft soil, and as discussed in Section 2, there may be need for improvements of the existing soil conditions including possible jet-grouting, based on additional geotechnical investigations to be undertaken during preliminary and detailed design stages.

c. The eastern rock section that may be considered to extend from east of the Don River crossing (chainage 3+350) to west of Dingwall Avenue (approx. chainage 5+900). This section is approx. 2.25 km long, and the alignment in this section is also situated within the shale bedrock. Considerations for constructability for this section will be very similar to the western rock section discussed above.

d. The eastern soft-soil section, from Dingwall Avenue (approx. chainage 5+900) to the northeastern limit of the project at chainage 7+411. This 1.5 km (approx.) section may itself be considered to be comprised of the following two sub-sections:

   i. An approx. 700 m long sub-section (between chainages 5+900 to 6+600) where the alignment transitions from the bedrock to soft soil. Construction of this portion of the alignment could be undertaken by utilization of the open-face rock operating mode of the hybrid TBM. However, soil improvement treatments, such as jet grouting may be required for the transition from hard to soft ground. Based on further geotechnical investigations and detailed design considerations, it is feasible that this sub-section could be considered to be suitable for construction by cut-and-cover methods, including the use of temporary shoring.

   ii. A second northern 811 m long sub-section (between chainages 6+600 to 7+411) where the alignment crosses under existing Pape Station on the existing TTC Line 2, and then runs north to the project limit at chainage 7+411. It is important to note that this second sub-section also includes the two wye-connection tracks connecting the Relief Line South with the existing TTC line 2. The fact that these wye-tunnels are largely situated underneath existing homes essentially dictates that both the wye-connections be constructed by use of TBMs. The connection of these TBM-constructed wye-tunnels with the existing Line 2 subway tunnels will require open-cut construction and the use of temporary shoring and underpinning. A single EPB TBM could be considered adequate to complete both the wye-sections. The TBM could be launched from approx. 7+050, and would be extracted after the construction of one of the 2 wye sections close to the existing Line 2. Then the TBM would be moved back to the launch shaft at 7+050 so that the other wye section could be built. The wye TBM drives would have to be staged ahead of the cut and cover since it will require approx. 100 m drive to ensure the TBM enters the radius without compromising the alignment. The launch shaft for wye sections will require less space than, say, the launch shaft and laydown complex at Eastern Avenue, due to the fact there would only be one TBM, which would be required to tunnel only short (approx. 700 to 800 m long) drives. The first 100 m approx. of the wye single bore tunnel segments would be “sacrificed” used only for assisting with tunnel boring launch into the radius curve.

The locations of the extraction and launch shafts, as well as the locations of the laydown yards are contingent upon permission from TTC to allow the TBM’s to pass under existing TTC infrastructure at multiple locations. Based on this premise, the locations of the launch and extraction shafts have been suggested based on the possibility of incorporating these structures into station boxes along the Relief Line South alignment.

Launch Shafts

Launch shafts for the Relief Line South are suggested to be located at the location immediately east of the Don River crossing. This location is considered ideal for this purpose due to its proximity to the Don Valley Parkway and Lake Shore Boulevard, and is large enough to accommodate laydown areas for stock-piling tunnel segment liners, as well as areas for excavated spoils prior to being hauled off site. The property at 1 Sunlight Park Road currently used as an automobile dealership will be acquired for the launch shaft and associated construction laydown area.

The typical dimensions for a launch shaft are 160 metres long and 27 metres wide. Prior to construction, the Toronto and Region Conservation Authority (TRCA) should complete flood protection to mitigate impacts. Water levels at the launch shafts will be managed through lowering these to 1m below bottom of shafts during construction. The depth of water varies along the line from 1.3 m to 15m below grade. The launch sites would also require a large enough footprint to support the following:

- Crane pad with swing radius;
- Grout plant;
- Excavated material spoils containment area;
- Office trailers, mechanics shop;
- Substations for power supply to TBM along with backup generators;
- Flat area to stock pile segmental liner plates;
- Area for ventilation fans; and
- Water treatment facility.

Chainage 0+300 to 0+500 Launch Shafts 1 & 2

Launch Shafts 1 and 2 would be located on Eastern Avenue and Sunlight Park Road just east of the Don River, at the current location of Downtown Mini and BMW dealership (see **Figure 3-13**). This site is large enough to support two sets of TBMs, which would be launched in opposite directions, one set of twin drives going west across the Don River and towards University Avenue, while the other set of twin drives would head east and then north towards Pape Station. This location is capable of accommodating laydown areas for stock-piling tunnel segment liners, as well as muck bins for handling excavated spoils prior to being hauled away from site. This location is also ideal due to its proximity to the Don Valley Parkway and Lake Shore Boulevard, which would be the main supply lines for needed for delivery of tunnel segment liners, and for removal of tunnel construction spoils.

Figure 3-13: Illustration of Launch Shafts 1 and 2 on Eastern Avenue at Broadview Station

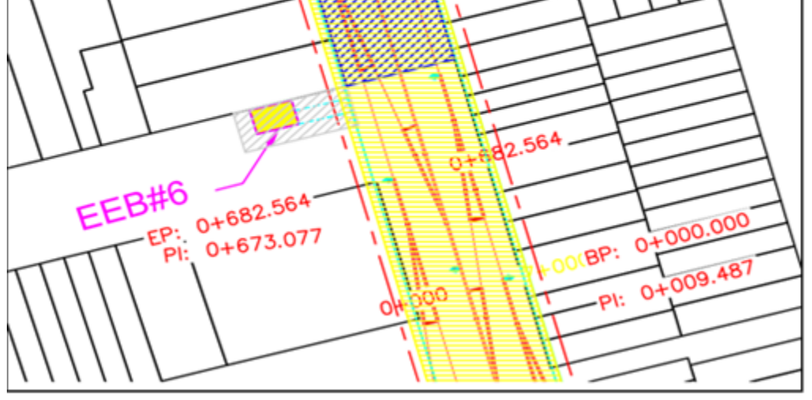
Chainage 3+100 to 3+200 (Potential Launch Shaft, depending on Don River crossing)

A site somewhere in the West Don Lands could potentially be utilized as a launch shaft for TBMs heading west towards downtown, but only if crossing of the Don River with a hybrid TBM were considered too risky after further geotechnical studies. If this location were to be used as a launch shaft, then the surrounding area would lend itself reasonably well to construction due to the relatively large amount of open space for storing materials and tunnel construction supporting equipment. This location is close to the Don Valley Parkway which would improve delivery of materials and removal of excavated materials. The excavation area would need to be well clear of the recently completed flood protection landform.

Chainage 7+050 to 7+090 Launch Shaft 3

Another launch shaft would be required along Pape Avenue, approximately near the intersections with Browning and Aldwych Avenues. The TBM would be launched from this shaft and would be extracted after the construction of one of the two wye sections, extracted close to the existing Line 2, moved back to the launch shaft at 7+050 and then the other wye section could be built. The launch shaft for wye sections will require less space than the launch shaft and laydown complex at Eastern Avenue, due to the fact there would only be one TBM, which would be required to tunnel only short (approx. 700 to 800 m long) drives. The first 100 m approximately of the wye single bore tunnel segments would be “sacrificed” used only for assisting with the tunnel boring launch into the radius curve. Please see **Figure 3-14** below for an illustration of the Launch Shaft 3.

Figure 3-14: Illustration of Launch Shaft 3 on Pape Avenue at Aldwych Avenue



Tunnel Boring Machines

As described above, the design of Relief Line South consists of twin tunnel construction with an inside finished diameter of 5400 mm. The majority of the twin tunnel construction will be in bedrock shale, along with areas of soft ground that the TBM will have to enter along the tunnel alignment. The Relief Line South will differ from TTC Sheppard Line and

Toronto-York Spadina Subway Extension due to the significantly greater depth of twin tunnels, as well as due to the fact that most of it will be located in the shale bedrock.

Further geotechnical investigations and studies of the bedrock shale would be required in order to understand the extents of the fractured layers, as well as to confirm the properties. In any case, these investigations and studies will have to be undertaken prior to detailed design, and in order to ensure the size of TBM in bedrock, accounting for the possibility of encountering “squeezing” shale during excavation.

TBMs for the Relief Line South will require both hard rock and EPB soft ground capabilities. The majority of the alignment will be located in shale bedrock with sections that require EPB Machines to maintain sufficient pressure on ground to avoid ground lose during twin tunnel constructions. EPB Machines are fully shielded and can be equipped with either ripper tools or disc cutters depending on soil conditions. TBMs will require a design to allow for a 5400mm inside diameter reinforced concrete tunnel liner to be installed during tunnel construction. The choice of type and design of TBMs will greatly impact the project costs and schedule; it would be highly recommended that a hybrid style TBM that is capable of mining through hard rock and also can change to closed face EPB machine would reduce the need for extraction shafts at areas where the alignment changes from hard rock to soft ground. The sections of the alignment where it changes from hard rock to soft ground will still require additional ground conditioning to improve soil and lower the risk of settlement when transitioning.

This recommendation of the TBM is itself based on the background geotechnical information available as input for this report. Additional geotechnical information to be gathered during the subsequent detailed design phases may result in revision of the construction strategy.

Tunnel Drives

Drives 1 & 2

Drives 1 & 2 starting at Launch Shaft 1 and heading towards the west would extend from 3+320 to 0+820, i.e. near the intersection of Queen and James Streets. The drives 1 & 2 have a distance of approx. 2,500 m with TBMs being extracted at Queen Station. TBMs could be left at Queen Station until station construction commences and be removed once construction of shaft is completed for station.

Remaining alignment from 0+820 to 0+000 could best be constructed either as cut and cover or by Sequential Excavation Method (SEM) due to tail track train storage area.

Drives 3 & 4

Drives 3 & 4 starting at Launch Shaft 2 and heading east along Eastern Avenue, before it turns northwards near Carlaw and Eastern Avenues. The drives would extend from 3+660 to 6+580. The drives 3 & 4 would have a distance of approx. 2,920 m with TBMs being extracted at Pape Station. Drives 3 & 4 would be in both hard rock and soft ground, transition between hard rock and soft ground would be located between 5+950 and 6+250. With the use of a hybrid TBM, the transition from hard rock to soft ground would not be a problem.

The remaining alignment from 6+650 to 7+410.36 would best be constructed using cut and cover method due to cross over and tail track three track design required to use a storage for subway cars on the Relief Line South.

Tunnel Segmental Lining

Tunnel segmental lining for the Relief Line South is to be assumed as concrete reinforced with internal diameter of 5400 mm. Thickness of segmental liner plates would require further geotechnical studies for areas where twin tunnel alignment will be in bedrock shale, and data from previous tunnels constructed in the downtown Toronto area will be useful for designing the compensating to allow for “squeezing” of the shale. For soft ground sections it would be assumed that a 235 mm thick segment with internal diameter of 5400 mm would be used as previously on the Toronto-York Spadina Subway Extension with annulus grouting to fill void between extrados of liners and overcut left by the TBM.

It is proposed that the design of the segmental linings would be constant for both the soft ground and hard rock sections. This would be beneficial for efficiency and practicality of manufacturing, and for installation by a TBM. Segmental liners could have additional steel fibre added to concrete mixture to increase strength and durability if areas where the alignment does encounter the “squeezing” of the shale.

Extraction Shafts

It is assumed that extraction shafts would be incorporated within the subway station boxes where possible, for cost and schedule savings. If locating an extraction shaft within the subway station boxes is not possible, then the extraction shafts could be incorporated within the footprints of ancillary structures such as Emergency Exit Buildings (EEBs).

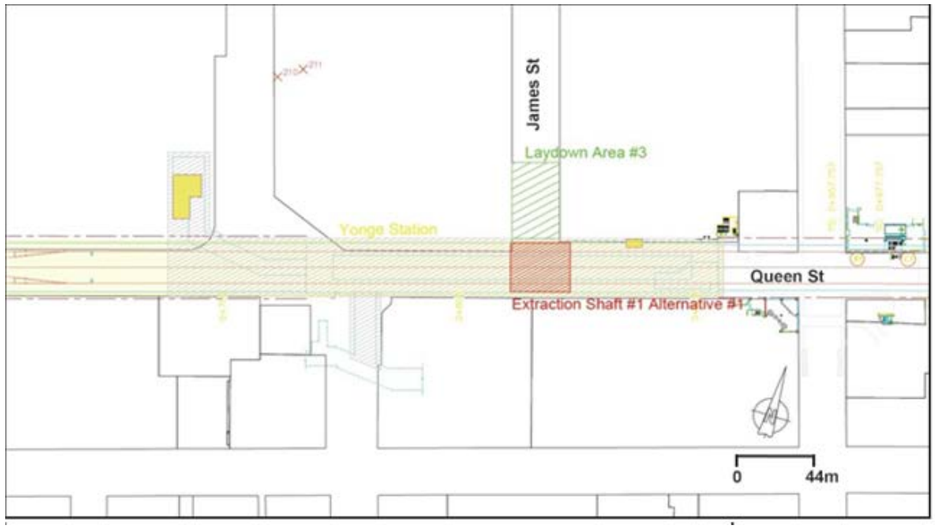
Extraction shafts would require full width of the station box for twin tunnels and TBMs to enter and ensuring full coverage between twin tunnels.

It is recommended that finalization of the location for extraction shafts be done in conjunction with the development of an appropriate strategy for procurement of the construction contracts for the Relief Line South. For example, construction of the extraction shafts for either set of drives could be included in scope of station contract scope, and the tunnelling contract could contemplate leaving the TBMs buried within the limits of station boxes. This may also be an appropriate means to mitigate impacts to neighborhoods due to the sensitivity of construction and space along the alignment.

Extraction Shaft 1 – Alternative 1, Chainage 0+300 to 0+500 (approx.)

If the TTC permits tunnel construction to pass under the existing subway line at Yonge Street, an extraction shaft location can be incorporated into Queen Station (see **Figure 3-15**). The TBM can stay idle at this location until station construction commences, and then removed during station construction.

Figure 3-15: Illustration of Extraction Shaft 1 on James Street adjacent to Queen Station



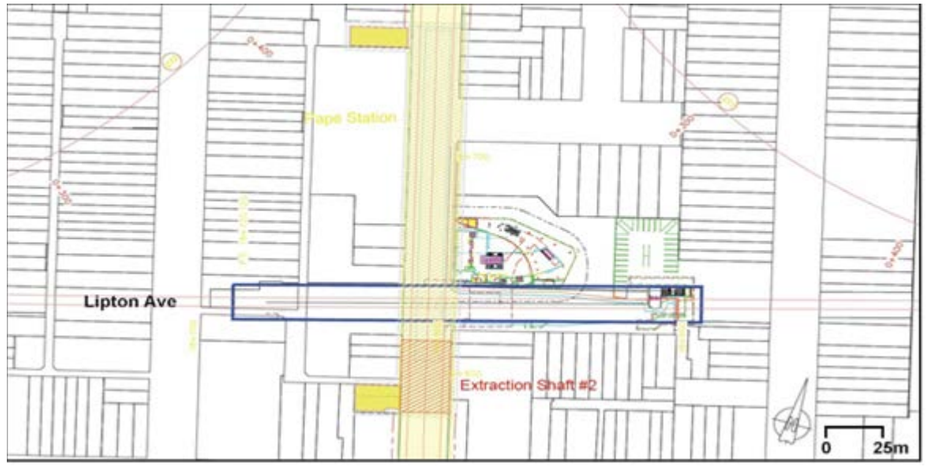
Alternately, if the TTC does not allow the TBM to pass under Yonge Street Subway tunnel then an extraction shaft would be required at the intersection of Bond and Queen Streets (approximate chainage 0+820 to 0+860). This will enable use of adjacent parking lots as potential laydown yards.

In this case, the remaining tunnel section from 1+300 to 0+000 would have to be completed using either open cut excavation using temporary shoring construction, or alternatively by SEM methods.

Extraction Shaft 2, Chainage 6+580 to 6+620 (approx.)

Extraction shaft for Drives 3 and 4 would be located on Pape Avenue, just north of the intersection of Pape and Danforth Avenues. This location would be part of the structure required for underpinning of the existing Pape Station, required for the construction of the interchange station between the Relief Line South and Line 2. Please see **Figure 3-16** below for an illustration of Extraction Shaft 2.

Figure 3-16: Illustration of Extraction Shaft 2 on Pape Avenue at Danforth Avenue



Wye Extraction Shaft 1, Chainage 0+100 to 0+120 (approx.) - Northwest Wye

The extraction shaft for the wye on the northwest quadrant of the intersection of TTC Line 2 and Relief Line South is half in park, half on private home at 925 Logan Avenue and impedes somewhat onto 927 Logan Avenue. These homes will need to be demolished. The area to be excavated using the cut and cover method will impede on the property at 922 Logan Avenue, which will be demolished.

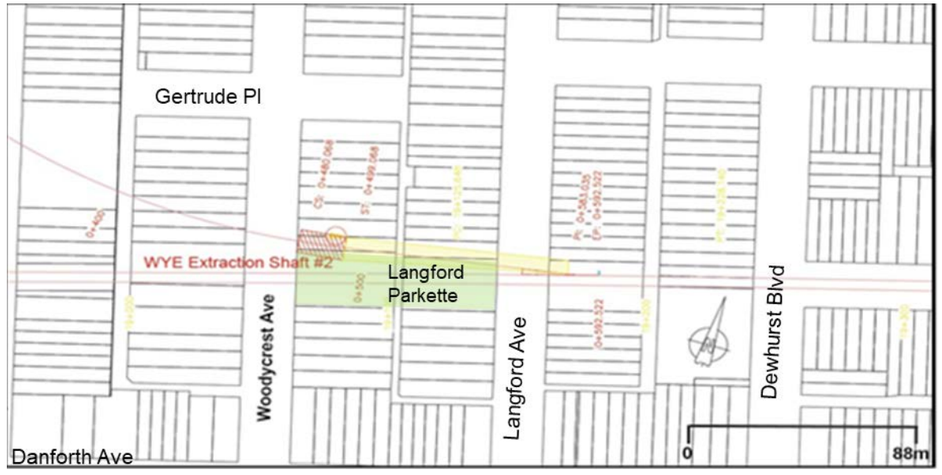
The park area east and west of Logan Avenue will be partially occupied by construction. This park may provide additional space for site storage. Please see **Figure 3-17** below for an illustration of the Wye Extraction Shaft 1.

Figure 3-17: Illustration of Wye Extraction Shaft 1 - Northwest

Wye Extraction Shaft 2, Chainage 0+470 to 0+490 (approx.) - Northeast Wye

The extraction shaft for the wye on the northeast quadrant of the intersection of Line 2 and the Relief Line South occupies a portion of Langford Parkette and two residential properties at 17 and 19 Woodycrest Avenue. The area to be excavated further impinges on the park as well as a residential property at 32 Langford Avenue and a parking lot. These structures will need to be purchased for demolition. Please see **Figure 3-18** below for an illustration of Wye Extraction Shaft 2.

Figure 3-18: Illustration of Wye Extraction Shaft 2 - Northeast



Cut and Cover Construction

Cut and cover construction portions of the Relief Line South would cause a major impact on the surrounding area due to road closures and footprint required for this method of construction. Timber decking incorporated into the cut and cover design to allow for temporary traffic would assist with reducing impacts to the surrounding neighbourhood during the construction and with traffic flow. Cut and cover would require piling and major excavation works with limited space. It is assumed all station boxes would be cut and cover for the support-of-excavation system to be installed. The tail track area at the north end of Pape Station to the end of the storage track would require cut and cover method of construction for the tunnel box structure. This type of construction method would also require all utilities to be moved or supported during excavation and installation of the support-of-excavation system.

Cut and cover construction will require dewatering which is to be developed during the detailed design phase. Sub-surface utility engineering investigations and identification of potentially abandoned piles and soil anchors should also be undertaken before construction.

3.6.2 Construction Sites

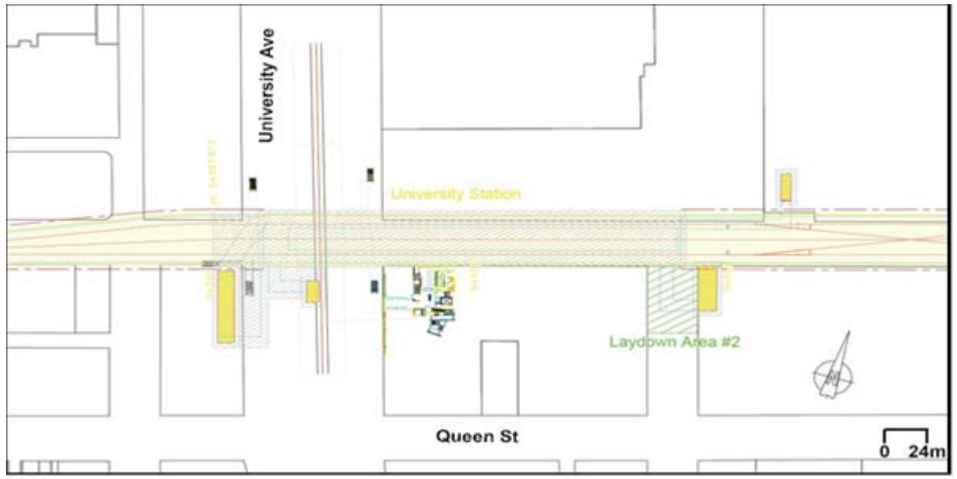
Construction sites for Relief Line South tunnel construction would include the launch shaft sites, which would require an area large enough to support two TBMs at the tunnel launching locations. The location immediately east of the Don River crossing is considered ideal for this purpose and is capable of accommodating laydown areas for stock-piling tunnel segment liners, as well as areas for excavated spoils to be contained prior to being hauled away from site. This location is also ideal due to its proximity to the Don Valley Parkway and Lake Shore Boulevard, which would be the main supply lines for needed for delivery of tunnel segment liners, and for removal of tunnel construction spoils, with minimal additional impacts to surrounding roads.

The following is a high-level discussion of the remaining sites that will be part of the project. These locations are based on the Relief Line South alignment as well as the available geotechnical information at the time of this report. Subsequent design development, geotechnical and sub-surface utility investigations, and input from various stakeholders may result in a revision to some of the following sites.

Osgoode Station

The Osgoode Station is located on the right-of-way of Queen Street West between intersections of University Avenue and Osgoode Lane (see **Figure 3-19**). It is abutted by Osgoode Hall to the north and the Four Seasons Centre for the Performing Arts to the south.

Figure 3-19: Illustration of Osgoode Station site on Queen Street (Depth: 33m from Top of Rail to Ground)



Multiple exits are tied into foundations of existing structures and will need to be incorporated within the structures. These exits are currently at: the southwest corner of University Avenue and Queen Street West, incorporated with a mid-rise building at 250 University Avenue; within the median on University Avenue south of Queen Street West; in the existing motor court of the Sheraton Centre high-rise building (99-123 Queen Street West). Ventilation shafts are also located between Osgoode Lane and an underground parking driveway to the east of the station box in the southwest corner of Nathan Philips Square.

Installation of support-of-excavation (SOE) system for the station box at the southwest quadrant of the intersection of Queen and University will be required in very close proximity to a low-rise building with a glass façade. Protection of this building will be needed to be put in place to shield from damage during construction. Additional underpinning and supports may also be required in order to support loads from the existing Four Seasons Centre for the Performing Arts. Osgoode Hall is located to the north of the station box, and will require an environmental and building protection assessment before the construction phase of Osgoode Station.

This area will also present challenges for space and laydown area. Crane swing radius will have to be considered since to the north and south of the station box have existing

structures that will require protection. This area will also require utility relocations which may have an impact on surrounding buildings.

The relocation of existing Enwave tunnels will have to be a priority when staging the construction at this location, and permanent relocation of these tunnels will need to be incorporated into the station design.

Right-of-way and surface traffic at this location will be severely impacted during the construction phase of the station. The TTC streetcar currently operating on Queen Street will have to be re-routed to avoid construction on Osgoode Station. Surface traffic impact in the area will require many levels of traffic management to avoid congestion in the surrounding side streets, and consultation and incorporation of emergency services planning will be required to ensure emergency vehicles and services can be provided to surrounding area during the construction phase.

Osgoode Station for the Relief Line South will be constructed beneath the existing Osgoode Station. SOE of the proposed Osgoode Station will expose a section of Osgoode Station which will also require underpinning and extensive monitoring of the existing station. It is also anticipated that TTC subway service interruptions will be required at Osgoode Station, which will be identified and, if possible, mitigated during the scheduling phase.

Queen Station

Queen Station is located in the right-of-way of Queen Street West between intersections of Bay and Yonge Streets (see **Figure 3-20)**. It is abutted by Old City Hall and a commercial high-rise at 26 Queen Street West to the north, and the Simpson Tower high-rise and historical Hudson's Bay Company building to the south. The excavation creates a risk of settlement and damage of these structures, necessitating protection and monitoring during excavation. A monitoring plan will need to be developed and implemented.

Figure 3-20: Illustration of Queen Station site on Queen Street (Depth: 31m from Top of Rail to Ground)

The foundation of this building will need to be assessed to determine any presence of structural tiebacks on the north side of the structure as well as the west, where excavation will be required to construct a passageway to station entrances. Further, the vertical and lateral loads of this building need to be determined in order to select appropriate structural protection and SOE. Assessments of the high-rise at 26 Queen Street West will also be needed.

An above-ground pedestrian passage crossing Queen Street West east of James Street connects two adjacent structures. This will also need to be monitored for damage due to any settlement due to excavation or dewatering, and may also impede site mobility by creating a height restriction in this area.

Restrictions of possible crane swing radii will be another challenge at this site, due to the proximity with adjacent high rise buildings. The exit on the northwest side of the station is in an open space in Nathan Phillips Square, and the laydown area is in the right-of-way on James Street, which will effectively be a dead-end street during construction.

Queen Station will be constructed adjacent to the existing Queen Station. SOE of Queen Station will expose a section of the existing Queen Station which will also require underpinning and extensive monitoring of the existing station. It is also anticipated that TTC subway service interruptions will be required at Queen Station, which will be identified and, if possible, mitigated during the scheduling phase.

Sherbourne Station

Sherbourne Station is located in the right-of-way of Queen Street East near the intersections of Sherbourne and Seaton Streets (see **Figure 3-21**).

Figure 3-21: Illustration of Sherbourne Station site on Queen Street (Depth: 23m from Top of Rail to Ground)

The west access is within the park area of Moss Park Arena, while the east access point will require a partial taking of the Toronto Community Housing Corporation parking lot (southwest corner of the property at 275 Shuter Street). A laydown area is within the right-of-way of Seaton Street.

The station box footprint impedes on a row of shops in this area, many of which are designated or listed heritage properties. Structural protection will be required to ensure no damage occurs during excavation. Impact of station box construction on businesses in this area will also need to be considered.

Sumach Station

Sumach Station is located between chainage 2+510 and 2+670, parallel to the Adelaide Street East overpass (**Figure 3-22**).

Figure 3-22: Illustration of Sumach Station site at Sumach Street and Adelaide Street (Depth: 19m from Top of Rail to Ground)

The footprint of this station box passes beneath three structures, addressed 497 King Street East, 501 King Street East, and 507 King Street East / 11 Virgin Place / 18 Virgin Place. To avoid the need for demolition of these properties during construction, the station box will be constructed by SEM under these properties. Construction of the station exits will also require the acquisition and demolition of properties at 90 Eastern Avenue and 525 King Street East. At 507 King Street East, an underground passageway and leading to the exit at 525 King Street East crosses the parking lot and a vent shaft will be permanently located in the eastern corner of the property. Additionally, the passageway to the exit at the north of Richmond Street East crosses underneath the road overpasses for Richmond and Adelaide Streets. The limited clearance from the underside of these overpasses will limit the use of traditional drill rigs.

The existing green space located on the west side of the station site is proposed as the site for an additional entrance as well as a temporary laydown area and SEM shaft.

The station bisects the King streetcar line, and discontinuation of this service will be necessary during the construction at this location. This is likely to cause a significant effect, not only on the immediate neighborhood, but to the overall transit options available within a larger area.

Broadview Station

Construction of Broadview Station, located to the east of the Don River (see **Figure 3-23**), will impact multiple properties, including a BMW dealership (1 Sunlight Park Road), which will need to be acquired and demolished. It will then be used as a laydown site for storage of tunnel liners, waste material, equipment, etc. The other properties to be demolished, consisting of commercial structures, are located between 341 and 361 Eastern Avenue.

Figure 3-23: Illustration of Broadview Station site on Eastern Avenue at Broadview Avenue (Depth: 20m from Top of Rail to Ground)

Additionally, a property easement will be required to construct the exit at the north of the station in the parking lot of 356 Eastern Avenue.

An entrance south of the GO rail corridor is proposed which will require an underground connection and passageway. The construction method for the passageway includes open-cut methods with the use of temporary shoring. Construction of this line across the existing railway Lakeshore East corridor to the southeast of the lay-down yard will require crossing underneath the rail lines. Conceptually, precast concrete sections for the underground connection could be installed using weekend work-blocks on the railway corridor, as long as the temporary shoring to support this excavation is installed ahead of time. This methodology is commonly employed for construction of underground pedestrian crossings across GO corridors at stations.

Carlaw Station

Carlaw Station, located on Carlaw Avenue north of Queen Street (see **Figure 3-24**), is to be constructed adjacent to several low to mid-rise structures that will require protection and monitoring during construction, including 970 Queen Street East, a row of structures at 181-233 Carlaw Avenue, and a residential midrise on the northwest corner of the Carlaw and Colgate Avenue intersection.

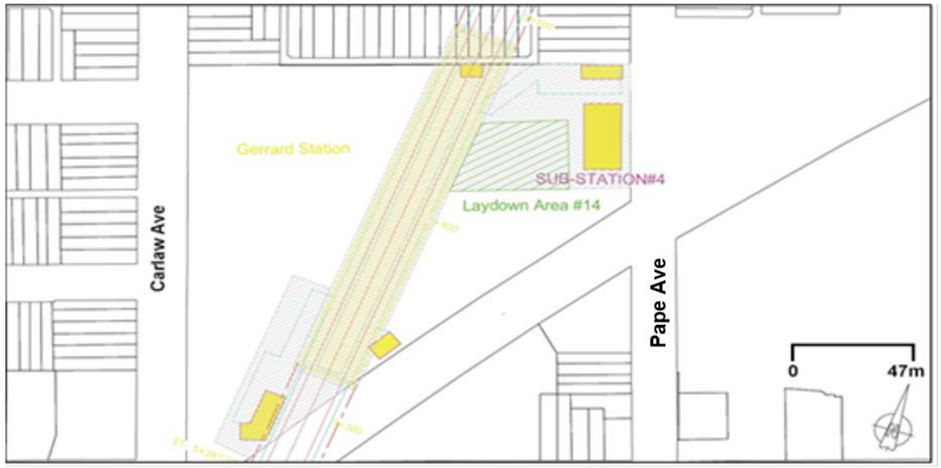
The exit at the north of the station is located in a parking lot, which can be used for the construction staging and laydown area. However, construction of the south exit will require demolition of buildings at 972 and 974 Queen Street East. These properties would have to be acquired and demolished for the construction of this project.

Figure 3-24: Illustration of Carlaw Station site on Carlaw Avenue at Colgate Avenue (Depth: 29m from Top of Rail to Ground)

Gerrard Station and Substation #4

This station is to be located in the area of existing Riverdale Shopping Centre, which will need to be purchased and demolished (see **Figure 3-25**). In addition to this, the station construction footprint extends north beyond the shopping centre property into alleyway and back yards of eight residential properties (229-243 Langley Avenue). The structures themselves can remain with appropriate monitoring; however, a partial easement will be required.

Figure 3-25: Illustration of Gerrard Station and Substation #4 site on Gerrard Avenue and Pape Avenue (Depth: 38m from Top of Rail to Ground)



The shopping centre property will also be the site of Substation #4 and several pedestrian access points. The size of this property will provide sufficient space to modify site logistics as construction proceeds.

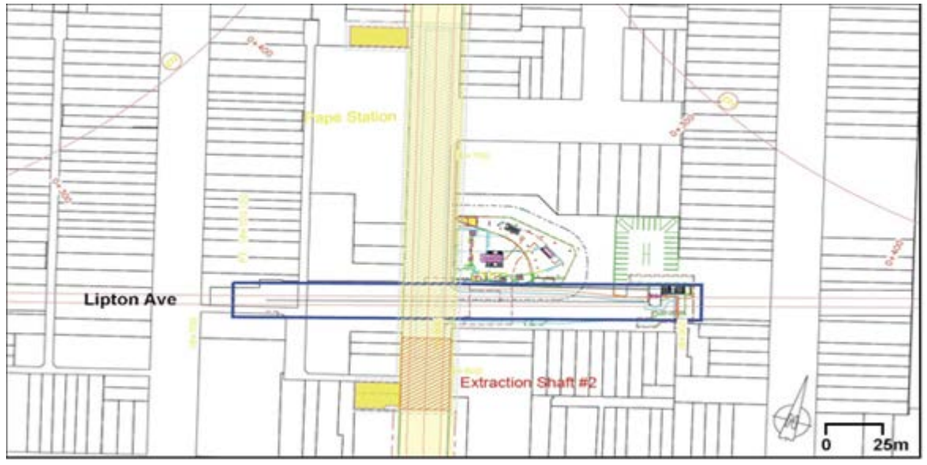
Pape Station

Pape Station (see **Figure 3-26**) crosses existing Pape Station at Lipton and Pape Avenues. This station intersects with the existing Pape Station on Line 2, and will be an interchange station when the Relief Line South is completed.

The south entrance to the station will be constructed within the properties of 698 and 700 Pape Avenue (part of a single parcel addressed 640 Danforth Avenue), which will need to be demolished. The adjacent property at 696 Pape Avenue may also need to be included if additional space is required.

The northern access point is located in a parking lot, flanked by Calvary Church to the south and a residential property to the north. This site will temporarily cut off access to the parking lot behind the residential buildings, and this will require mitigation during construction.

Figure 3-26: Illustration of Pape Station site on Pape Avenue and Danforth Avenue (Depth: 29m from Top of Rail to Ground)



Pape Station will be constructed beneath the existing Pape Station on Line 2. SOE of Pape Station will expose a section of existing Pape Station which will also require underpinning and extensive monitoring of the existing station. It is also anticipated that TTC subway service interruptions will be required at existing Pape Station, which will be identified and, if possible, mitigated during the scheduling phase.

Substations and Emergency Exit Buildings

Emergency Exit Buildings (EEBs) throughout the Relief Line South will require property easements and acquisitions, and demolition of existing structures in various areas. These sites will be excavated for the construction of the EEBs, then can be covered as the work progresses to the excavation and construction of the pedestrian passageways, which generally enter into the public right-of-way. Traffic will, therefore, be impacted during this stage of the process. Timber decking can be used in stages in order to minimize this impact and maintain traffic flow.

Where possible, laydown areas will be located outside of the right-of-way to avoid additional influence on traffic flow. In areas where this is not an option, sites will be chosen that minimally impact traffic flow and pedestrian access.

Substation #1 and Emergency Exit Building #1

Substation #1, EEB #1 and an emergency ventilation shaft are located on the northeast corner of Queen Street West and John Street. Prior to construction, a series of mixed commercial and residential structures will need to be demolished at 248-250 Queen Street West and 155-183 John Street. Note that the structure at 248-250 Queen Street West is a protected heritage property designated under Part V of the ***Ontario Heritage Act*** and will require City Council approval to proceed with demolition.

A laydown area to the west of this site, occupying a portion of John Street. Also, excavation will be required in the right-of-way of Queen Street West east of John Street for the construction of the pedestrian passageway.

Substation #2 and Emergency Exit Building #2

Substation #2 and EEB #2 are located at the southwest of Queen Street East and Jarvis Street. This construction will require the acquisition and demolition of 141 Queen Street East. The laydown area is in the parking lot of this property. The passageway to EEB #2 is in the right-of-way of Queen Street. Impact on businesses in this area will need to be considered.

Substation #3 and Emergency Exit Building #3

Substation #3 and EEB #3 is located between the Adelaide Street East and Richmond Street East overpasses, between chainages 2+760 and 2+820. This area has sufficient room for a laydown area.

Emergency Exit Building #4

The excavation and construction areas for EEB #4 and the pedestrian passageway are all within a park area of Morse Street Jr. Public School, with sufficient room for a laydown area. This property is under ownership of the Toronto District School Board and consultations will be required to proceed with work in this area.

Emergency Exit Building #5

Located at the southeast of Cavell and Pape Avenues, the construction zone impedes on two properties (625 and 627 Pape Avenue) that will need to be acquired and demolished. This EEB will be in close proximity to open cut excavation for cross-over tracks, and therefore, it is anticipated that the construction staging for this open-cut excavation will incorporate the construction and laydown areas for this EEB.

Emergency Exit Building #6

EEB #6 is located within the right-of-way of Browning Avenue, west of Pape Avenue. Its construction does not impede on adjacent properties.

Substation #5 and Emergency Exit Building #7

Substation #5 and EEB #7 are located at the southeast corner of Pape and Westwood Avenues. This construction will require 945 and 943 Pape Avenue to be demolished. Excavation of the passageways will extend the site footprint onto Pape Avenue's right-of-way.

3.6.3 Traffic Management

A Traffic Management Plan will detail arrangements to accommodate pedestrian, cyclist, transit, and vehicular displacement during the construction phase of the project. The Traffic Management Plan will be developed during the detailed design phase in partnership with the City of Toronto, TTC, and other relevant stakeholders. All elements of a future traffic management concept must be approved by the affected road authorities in consultation with Police, Fire, and Emergency Medical Service, prior to the award of a construction contract.

A construction and staging plan will be developed at the site level, outlining temporary and permanent effects (if applicable). Prior to the start of construction, the Proponents will organize information sessions, as required, with local community and business groups to explain the construction activities and restrictions, as well as to establish communication protocols.

The general guidelines and principles that will be followed in developing the Traffic Management Plan for the Relief Line South project include but are not limited to the following.

Traffic Lanes

Wherever possible, the existing number of lanes will be preserved. Where maintaining the existing lane capacity is not feasible, reasonable effort should be made to accommodate all road users. Specifically, **Table 3-9** outlines the minimum number of lanes to be maintained. Note that maintaining TTC service (for all transit modes) is considered the top priority.

Table 3-9: Minimum number of lanes to be maintained

Existing Lanes	Minimum Number of Lanes to be Maintained
1 lane in each direction	1 lane with appropriate controls
2 lanes in each direction	1 lane in each direction
2 lanes in each direction 1 centre left turn (continuous)	1 lane in each direction 1 left turn at signalized intersections
3 lanes in each direction	2 lanes in peak direction 1 lane in off-peak direction
3 lanes in each direction 1 centre left turn lane (continuous)	2 lanes in peak direction 1 lane in off peak direction 1 left turn signalized intersection

Alternative Traffic Options

Segments where lane closures are anticipated, baseline traffic operations will be assessed in the construction areas, including upstream and downstream intersections, to assess queue lengths, delays and general level of auto and transit service.

Road Closures

Full road closures require a suitable detour. Temporary full closures of arterial roads may be considered during designated time periods and with approval from Transportation Services.

Turn Lanes

Left turn lanes, where one is already provided, should be maintained during construction. Where this is not possible, approval from Transportation Service will need to be obtained and a suitable mitigation options should be outline – e.g. a detour to the left turn movement.

Right turning lanes may be closed and need not be accommodated; however, where the baseline traffic analysis dictates their permanent need, a mitigation plan will need to be developed – approved or dictated by Transportation Services.

Signage

Suitable advance signage will be provided for all construction areas. Areas where the period of planned road closure is anticipated to be long, advanced signage will be provided to encourage motorists to avoid the construction area.

Traffic Signal Adjustments/Timing

Adjustments to signal timing may be considered at part of the Traffic Management Plan.

Transit Operations

The maintenance of transit operations are deemed to be the highest priority during any lane restrictions imposed by construction activities. The Proponents will coordinate the development of a transit operations plan for construction. Should disruption to streetcar service be determined as necessary, replacement buses with equivalent capacity should be provide along the length of the closure.

Pedestrians and Cyclists

Temporary sidewalk widths will depend on observed pedestrian volumes during the AM and PM peak periods. At the very minimum a 1.5 m pedestrian sidewalk will be provided on both sides of the street. A sidewalk may be closed temporarily on one side of the roadway with approval from the City. In these cases, a safe and reasonable alternative pedestrian route with appropriate signage must be provided. All pedestrian facilities must meet or exceed the Province's and City's accessibility standards as outlined in the Accessibility for Ontarians with Disabilities Act (AODA).

Where possible, separated cycling facilities should be provided. Where there is insufficient space, lane widths should be wide enough to allow for safe passage of cyclists. Where lanes widths would be too narrow to accommodate safe passing by vehicles, clear "share-the-road" signage should be provided at regular intervals encouraging cyclists to take up the whole lane when passing through the construction area.

Private Access

Access to all driveways and doors to buildings must be maintained throughout the construction period, unless suitable arrangements have been made with the property owner to provide an alternative access or temporary closure.

3.6.4 Construction Schedule

The conceptual plan is premised on the concept of two separate sets of twin tunnelling drives, launched from the Launch Shafts 1 and 2 located immediately east of the Don River crossing. Drives 1 and 2 will be launched from launch Shaft 1, and will head west to cross underneath the Don River, and then along Queen Street. Meanwhile, Drives 3 and 4 will be launched from Launch Shaft 2, and will head east before turning north along Carlaw Avenue, and further on would shift eastwards slightly, in order to continue along Pape Avenue.

This scenario would have the centralized location at the construction site and laydown yard near the Launch Shafts 1 and 2 as the main location for receiving all tunnel segments, and from where all tunnel muck will be removed.

Depending on the capital outlay for the project, it may be feasible to have two sets of twin hybrid TBM's tunnelling simultaneously for the two sets of tunnelling drives, i.e. Drives 1

and 2 to the west and Drives 3 and 4 to the east and north. These TBMs would be with hybrid or dual-mode TBMs capable of mining in rock with an open shield, as well as in soft soil with earth-pressure-balanced mode.

The location of the extraction shaft for Drives 1 and 2 would depend on whether or not the TBMs would be allowed to pass underneath the existing Queen Station on Line 1. Additional geotechnical investigations of the shale bedrock, as well as structural design will be required to arrive at the conclusion as to whether tunnelling beneath the existing Line 1 may be acceptable. As a result, there are two possible alternative locations for the extraction shaft for these drives, as discussed in **Section 3.6.1**. The remaining portions to the west including Osgoode Station and tail tracks are to be open cut or SEM.

Drives 3 & 4 would head east and then turn north along Carlaw Avenue and then Pape Avenue to just south of existing TTC Pape Station. The remaining portion of the main tracks to the north would be by open cut, and would include underpinning of the Line 2 Pape Station.

Tunnel construction for the wye connections between the Relief Line South and Line 2 is also assumed to be undertaken by TBMs, although these are likely to be earth-pressure-balanced TBMs, due to the fact that these wye tracks are located in soft soil. These relatively short tunnelling drives (< 800 m each) would require the construction of one launch shaft and two separate extraction shafts.

Construction of the headwalls is assumed to be undertaken ahead of tunnel construction only at those station locations where the station is to be constructed in soft soil. Constructing the headwalls ahead of tunneling is preferred for these stations to ensure a proper seal of the tunnel with the headwall. However, in the case of stations and tunnels completely situated in sound bedrock, installation of the temporary shoring for the future stations can happen either before or after the TBMs have passed. This does provide additional flexibility to construction scheduling for the project.

It is noted that if the detailed design of the temporary shoring relies on embedding the piles into bedrock, or on end-support of the piles, then the validation of the bedrock profile and physical characteristics of shale bedrock layers is necessary before assuming the methodology for station construction mentioned above.

Figure 3-27 illustrates the overall concept for the construction of the Relief Line South.

The construction plans are detailed in **Appendix 3-3**.

Figure 3-27: Construction Plan Overview