Winnipeg's First Rapid Transit Corridor – Southwest Transitway

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Paper Abstract

On April 8 2012, Winnipeg's first rapid transit facility opened for service. Constructed during 2009-2011, this initial stage of the Southwest Transitway includes a 3.6 km grade-separated busway, three highly-developed stations, a tunnel beneath the CN main line, a bridge over a major arterial roadway, and active transportation facilities.

The newest buses in the fleet operate a network of 13 rapid transit routes over the transitway, offering one-seat trips for most passengers travelling between downtown and the growing southwest quadrant of the city. The rapid transit routes use the transitway in combination with other transit priority measures and real-time passenger information systems to provide service that is fast, reliable, comfortable, and convenient.

Project funding approval in 2008 included a commitment to complete construction of this $138 million project by the end of 2011. With preliminary design only partially completed at the time of funding approval, a condensed schedule for final design and construction was developed. To achieve the construction target, the following major elements of the project were tendered separately:

- 3.6 km of transitway runningway.
- 2.5 km of land drainage sewer.
- A 350 m transitway tunnel underpass of seven CN tracks.
- A land drainage pump station for the tunnel underpass.
- A100 m overpass of a major arterial road.
- Three new transitway stations.
- Overall project signage, streetscaping, aesthetics and landscaping.

The technical paper discusses how the challenging features of site, location, and construction conditions influenced implementation strategy, and how a unique mix of design ingenuity, technology, and equipment were used to successfully complete the project faster, and safer.

1 PROJECT BACKGROUND

With an area population of 750,000 people, Winnipeg is growing at a pace that has not been seen in several decades. While this growth presents challenges, it provides opportunities for innovative and proactive transportation solutions to support Winnipeg's prosperity in an economically, socially, and environmentally sustainable manner. The development of a rapid transit system is a key component of the City's Transportation Master Plan to provide citizens with a viable alternative to the automobile, to reduce road congestion, and to build a transportation system that serves future generations.

Winnipeg began a multi-year comprehensive transit improvement program in 2007 that involved an accelerated program of bus replacements, the implementation of upgrades to major stops and terminals, transit priority measures, a leading-edge implementation of Intelligent Transportation System (ITS) technology for transit, and new park & ride facilities. Physical improvements are concentrated in the city's "Transit Quality Corridors" where high levels of transit service operate. These measures, in combination with real-time passenger information made possible by the ITS deployment, are designed to enhance the speed, reliability, comfort, accessibility, and convenience of the city's transit service.

While the transit priority component of the improvement program includes such on-street measures as new diamond lands, queue jumps, and priority signals for buses, its most significant element is the development of a rapid transit network for the city. Operating in exclusive transit-only corridors, rapid transit in Winnipeg will shift a higher proportion of urban travel to the transit system by offering a higher order service characterized by high speed, high reliability, high frequency, real-time passenger information, modern ITS-equipped vehicles, a flexible route network, beautiful stations, a high quality runningway, and a distinct image.

The consultant design team was assigned responsibility for the design and construction management of the initial phase of the rapid transit network, Stage 1 of the Southwest Rapid Transit Corridor. Following the announcement of a funding agreement for the project by the three levels of government in 2008, the consultant design team was tasked with fast-tracking this complex $138 million project to achieve a targeted completion by the end of 2011. The project was delivered "on time and on budget", and following Winnipeg Transit's commissioning, testing, and training period, rapid transit service began operation on April 8, 2012.

Figure 1 – Rapid Transit Opening Day

2 THE SOUTHWEST TRANSITWAY

The Southwest Transitway is a high-speed roadway for buses, physically separated from the regular street system. Buses operate at speeds up to 80 kph, free of any other traffic, providing very fast, reliable service. Stage 1 of the transitway extends from Queen Elizabeth Way & Stradbrook to Pembina & Jubilee. Stage 2, planned for construction completion by 2018, will extend the transitway further south from Pembina & Jubilee to Bison Drive/University of Manitoba.

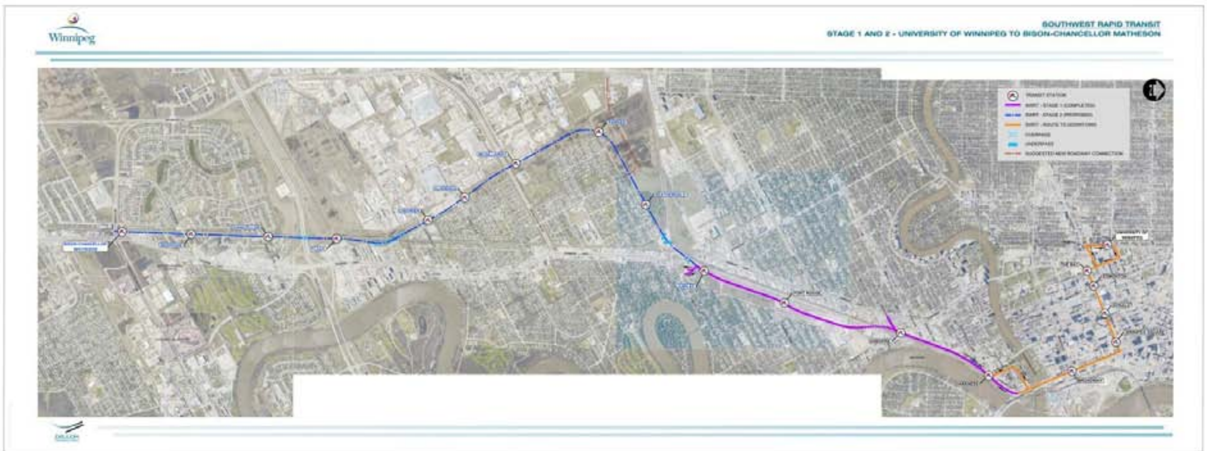

Figure 2 – Southwest Transitway Alignment – Overall Project

For the completed Stage 1 section of the transitway, there are two major structures: Osborne Station built atop a new bridge that overpasses Osborne Street and a tunnel beneath the CN rail line. Bus-only access roads between the transitway and the street system let rapid transit buses operate both on the street and on the transitway. This routing flexibility provides one-seat travel without transfer for most passengers. Buses transition between the street system and the transitway at Queen Elizabeth & Stradbrook, at Harkness Station near Stradbrook & Harkness, at the east end of Warsaw Avenue, and at the Jubilee Overpass. Transit priority signals are used at several of these locations to provide efficient bus access/egress to/from the transitway. There is also a bus-only access road to the transitway at the Fort Rouge Transit Base. This provides a fast, efficient way for buses to travel between the garage and route terminals at the start and end of service.

There are 13 routes that operate on the Southwest Transitway. Most of the rapid transit routes operate between the new Balmoral Station (former Greyhound Inter-City Bus Station – upgrade design/construction performed as a separate project) at the University of Winnipeg in the downtown and various destinations in southwest Winnipeg. These routes use the Graham Transit Mall and diamond lanes on Main Street to access the transitway at Queen Elizabeth Way & Stradbrook. The rapid transit routes then operate at high speed on the transitway (serving Harkness, Osborne, Fort Rouge Stations, and a stop at the Jubilee Overpass), then exit the transitway at the Jubilee Overpass to proceed south on Pembina Highway, then branch off Pembina Highway at several points to the routes' ultimate destinations.

Routes that operate on Grant Avenue also use the Graham Mall, the Main Street diamond lanes, and the north portion of the Transitway between Queen Elizabeth Way and Warsaw

Avenue (stopping at Harkness and Osborne Stations). At the east end of Warsaw Avenue, they use a bus-only link to exit the Transitway onto Warsaw and, from there, travel via Pembina to Grant Avenue.

3 PROJECT SCOPE

Based on the consultant's functional and preliminary design work, funding for the detailed design and construction of Stage 1 of the Southwest Transitway was approved in 2008, with an aggressive construction completion target set by the client for the end of 2011. To achieve that target, a fast-track schedule for final design and construction was developed by separating the project into the following tendered contracts:

Contract	Description
1	Land Drainage Sewer (2.5 km)
2	Land Drainage Pumping Station for the Transitway Tunnel
3	Transitway Roadway – Queen Elizabeth Way to Osborne Station (3.6 km)
4	Transit Tunnel beneath 7 tracks of CN mainline (350 metres)
5	Bridge (100 metres) over Osborne Street, including Osborne Station atop the Bridge
6	Transitway Roadway – Tunnel to Jubilee; Landscaping
7	Station Construction, Warsaw Reconstruction

A dedicated contract administration team was formed to provide a cohesive approach to the management of construction activities to encourage the forward momentum of this project. Coordination of the separate contracts and communication amongst the contract administration team, the contractors, City staff, utilities, and other stakeholders was vital to meeting the fast-track schedule. The contract administration team met weekly to discuss coordination of overlapping construction activities, safety concerns, and various other site issues facilitating an organic evolution of the design, thus leading to innovations in the field. This collaborative process helped to accelerate the project schedule and maintain a clear path for the work to proceed.

4 CONTRACTS 1 & 2 – LAND DRAINAGE SEWER & PUMP STATION

The City of Winnipeg's urban land drainage system has two main types: combined sewer and separate land drainage sewer systems. Stage 1 of the Southwest Transitway straddles a number of Combined Sewer Districts including the River Sewer District adjacent to the northern portion of the right-of-way, the Baltimore/Jessie Sewer District in the central part, and the Cockburn Sewer District at the southern end of the transitway. As some of these Districts are already beyond capacity, a land drainage study was undertaken to determine possible drainage options for both the transitway and its immediately adjoining lands.

Based on site characteristics, two distinct drainage areas were established. Drainage Area 1 included lands adjacent to the southern part of the transitway between Jubilee Avenue and Osborne Street. It is a brownfield site with no existing development, sewers, or streets in close proximity to the transitway. Drainage Area 2 included the urbanized lands around the northern part of the transitway between Osborne Street and Queen Elizabeth Way.

Drainage Area 1 required a new land drainage sewer with a separate discharge to the Red River via an existing outfall at Glasgow Avenue. Connections to the existing combined sewer system were not feasible as the existing system is at capacity. This new separate sewer drains the transitway tunnel, the transitway roadway south of the tunnel, the CN-owned lands located between the mainline and the transitway, and the privately-owned lands in the Fort Rouge Yards immediately east of the transitway. After extensive input from the consultant design team, the City approved this sewer design as it provides sufficient capacity to accommodate the future development of the Fort Rouge Yards lands. The development agreement for the Fort Rouge Yards includes a provision for the City to recover from the developer the portion of the land drainage sewer installation costs attributable to the developer's lands.

Drainage Area 2, located in the urbanized area of Donald Street, includes both a combined and a separated sewer system. The overall study concluded that any existing catchbasin inlets tied into the combined sewer be diverted to the land drainage sewer, and that any new transitway inlets be connected to the existing land drainage system.

Contract 1, with a value of over $5 million in underground works, involved the installation of the land drainage sewer. It included installation of new manholes, abandonment of sewers and manholes, restoration of gravel access roads/pavements/boulevards, and sewer video inspection. A major component was the installation of 350 metres of large diameter (1350 mm) pipe immediately adjacent to the bus storage garage at the Fort Rouge Transit Base. The Tunnel Boring Method (TBM) was used for the installation of the sewer in this area as it provided minimal disruption to the high volume of bus access/egress movements each day and it was less costly than other construction methods.

Contract 2 involved the construction of an operating pumping station for the tunnel underpass. It included site development, demolitions and removals, installation of gravity sewers, excavations and rough grading, shoring, dewatering, and substructure/superstructure/ mechanical works. The design for these new land drainage facilities was based on a 5-year design storm for the transitway roadway lands and a 25-year design storm for the underpass. It is important to note that the operation of the pumping station is protected for a 700-year Red River elevation, which is the design event that governs the operation of the Red River Floodway around Winnipeg.

Figure 3 – Large Diameter Pipe Installation Using TBM

Figure 4 – Pumping Station

5 CONTRACT 3 – TRANSITWAY CONSTRUCTION (QUEEN ELIZABETH WAY TO OSBORNE STATION), DONALD/STRADBROOK/HARKNESS RECONSTRUCTION AND ASSOCIATED WORKS

Contract 3 was carried out over 2009-10. During the first year, portions of Donald Street and Stradbrook Avenue and the Stradbrook & Harkness intersection were realigned to create space for the northern portion of the transitway adjacent to the western side of the CN mainline. The northern portion of the transitway was then constructed in 2010. Challenges related to property constraints, construction staging, and access to existing businesses were met through collaboration with City staff and area stakeholders. As an example, concrete retaining walls were used to protect area businesses from the construction required for the new vertical and horizontal alignments of Donald Street.

A complex staging plan was used during the construction to minimize traffic disruptions and keep traffic safely moving through the project area. This occasionally required "lane at a time" pavement installation, with traffic operating on existing or temporary lanes adjacent to contractor activity. Each lane's sequential construction approach included removal and relocation of existing infrastructure and utilities, excavation, limestone rock placement, and concrete paving. Pavement design was undertaken according to the "AASHTO Guide for Design of Pavement Structures" incorporating local knowledge of sub-grade material, weather data, and past pavement performance. The pavement design is a 230 mm concrete pavement slab with a 675 mm limestone rock structure.

Further to the roadworks taking place on Donald and Stradbrook, it was determined during the course of design that the use of an urban roadway cross necessitated additional land drainage sewer at various locations within the proposed project area. Where possible, existing lines were lengthened and expanded to accommodate additional flow. Where an existing land drainage sewer did not exist or the existing line could not be altered to account for the additional flows, a completely new line was installed. A constraint encountered during design of the land drainage system was the requirement that no additional flows be diverted to the City of Winnipeg's existing combined sewer system. This strengthened the need for additional land drainage sewer.

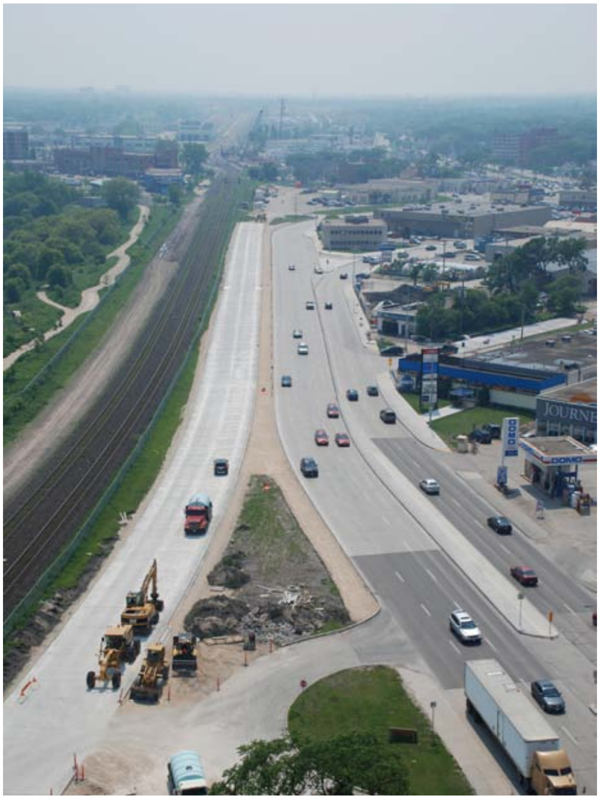

Figure 5 – View of Corridor Parallel to Donald Street Looking South

In 2010, the northern portion of the transitway was constructed between Queen Elizabeth Way and Osborne Station. While most removals and relocations were completed as part of the 2009 construction, a relocation of an existing CN security fence and a realignment of Lagopoulos Way were required to preserve access to the parking garage of two apartment

Figure 6 – Rapid Transit Bus on Transitway Beside Donald Street

buildings. A major issue identified from discussions with CN during the design period was the need for reinforcement of the CN rail embankment adjacent to the proposed Harkness Station site. To address this, a sheet pile wall was installed between the embankment and the station to a depth of approximately 15 metres. The original tender did not include the construction of the sheet pile wall, but did include a clause stating that the successful contractor would have an opportunity to submit a cost to perform the installation at a later time. This provided an opportunity to optimize the design and obtain a favorable construction price if the initial submitted cost was above budget.

With necessary removals and relocations performed and the sheet pile wall at Harkness Station complete, construction of the transitway could begin. Work began prior to frost formation in the early winter of 2009 with excavation and limestone sub-base placement, allowing for construction of the concrete pavement slab and traffic barrier on each side of the transitway to take place immediately in spring of 2010. Survey staff used the latest in GPS and robotic total station technology allowing for more efficient and accurate layout and onsite verification of contractor work. To allow for a better overall pavement product and a faster construction timeline, a two-lane paver was used to place the 9.55 m concrete roadway.

A major constraint encountered during the excavation of the transitway related to the existing Manitoba Hydro infrastructure located within the transitway right-of-way. For approximately 300 m of the transitway adjacent to Donald Street, two 69 kilovolt power lines ran parallel and immediately under the centerline of the proposed roadway. The depths of the lines varied but were on average 0.5 m below the bottom of excavation. Manitoba Hydro imposed several safety constraints to protect the lines: at least 0.45 metres of in-situ cover be maintained on the lines, no vibratory compaction take place immediately above the lines, and a Manitoba Hydro inspector was required to be on site during all excavation activities above and adjacent to the lines.

Ancillary works of Contract 3 included the reconstruction of Scott Street and Gertrude Avenue to tie-in with the relocated sections of Donald Street, and the construction of new active transportation paths along the east side of Donald and the south side of Stradbrook as new links in the City's growing active transportation network.

To integrate transitway operations with the street network, new traffic signals were installed at Stradbrook & Harkness to accommodate bus egress from Harkness Station and traffic signal timing plans at the intersection and those upstream and downstream of it were reconfigured.

6 CONTRACT 4 - TUNNEL

Built in two phases, the transitway tunnel is a 200-metre cast-in-place concrete structure with an additional 150 metres of retaining/wing walls. It was structurally shored during construction, required three phases of CN track relocation, features a 67° skew at the construction joint, and can accommodate a future conversion of the transitway to a light rail transit (LRT) alignment.

Clearly the most important issue at the tunnel site was the potential for interference with the CN tracks in the area. A total of seven railway tracks crossed the path of the transitway, intersecting at the aforementioned skew angle. This skew made avoiding interference with the tracks during construction much more difficult than if the crossing was aligned perpendicular to the tracks, which was not possible due to property constraints.

During design, extensive consultation was undertaken with several stakeholders to reach a workable and cost-effective tunnel solution to underpass the CN mainline. These stakeholders included CN, City departments, utilities, adjacent property owners, and the City's Active Transportation Advisory Committee.

Several structural design options were initially considered, including overpass and tunnel coring alternatives, but were eliminated due to property constraints, unsuitable site conditions, and cost. Although an open cut excavation required closure of one or more tracks at various times throughout construction, a structurally shored open cut alternative with cast-in-place construction was recommended on the basis of simplicity and more robust resistance to water penetration. A brief description of the design follows.

Originally, the foundation was to consist of driven precast piles supporting each side of the tunnel independently, with a simple slab-on-grade forming the roadway surface. However, the geotechnical analysis of this arrangement showed the potential for uplift below the roadway slab caused by the heavy train loads applied behind the tunnel walls on each side. As a result, the structure was revised to be a closed box structure, with the roadway slab becoming structural and forming the bottom of the section.

Figure 7 – Tunnel Construction

The tunnel has an inside width of 10.9 metres, providing two lanes of traffic and generous shoulders on each side. A tunnel of this width would often have a line of supports running down the center but for operational and safety reasons the client requested that the tunnel be kept free of interior supports, requiring an innovative structural design. As a result, the roof slab is up to 1500 mm thick, reducing to 900 mm at the portal areas. The roof slab was normally reinforced, with up to three closely-spaced layers of 35M bars required in critical areas of the tunnel. The critical areas are not the deepest parts of the tunnel but the areas to each side; although the deeper sections of the tunnel carry more soil, this extra depth of soil also serves to better distribute the weight of the trains overhead. As a result, the transition areas – where the soil depth is reduced but the train loads remain constant – are the critical locations. To simplify reinforcement detailing, the roof slab was designed as a simple span, with hinges located at the top of each wall.

The floor slab experiences similar loads to the roof slab, as all the vertical loads transferred down through the walls must be distributed into the soil below. As a result, the floor slab is also very massive, running to 1300 mm thick in some areas. The floor slab is not quite as thick as the roof slab because it has been designed to be continuous with the side walls. This was required due to the difficulty of designing a hinge at the bottom of the walls; a simple span design would have been preferred in order to simplify the reinforcement detailing.

The walls range from 900 mm to 1000 mm in thickness. Because of the fixity with the bottom slab, most of the reinforcement was required at the bottom of the outside face in order to carry moments transferred around the corner from the bottom slab. The walls were designed with temporary openings to allow the open excavation to be braced during construction. After the bracing was removed, these openings were sealed.

Although the water table is some distance below the underside of the tunnel, a perched water table exists in the area just below the ground surface. As a result, waterproofing of the tunnel was an important consideration. The main waterproofing system was a bituminous waterproofing membrane installed over the top of the roof slab, down both walls, and extending to the outside edge of the bottom slab. The bottom slab inside the tunnel is protected from roadway runoff by a similar membrane. In addition to the membrane, construction joints were protected by two levels of waterstop protection – a continuous polyvinyl strip located at the outside face of the tunnel and a hydrophilic waterstop (bentonite) located within the concrete itself – along the route that water would have to follow from the exterior surface to the interior of the tunnel.

The tunnel is built on a sag curve, so the low point in the tunnel clearly requires positive drainage measures. A double catch basin was provided at this point to accept water into the newly constructed land drainage system. As the base of the tunnel is below the elevation of the surrounding land drainage system, a dedicated lift station was required to take storm water from the tunnel and pump it high enough to join into the existing system under gravity flow. This land drainage lift station was constructed prior to the tunnel project under Contract 2.

To minimize future corrosion potential, all reinforcement in the tunnel was hot-dip galvanized after fabrication.

Figure 8 – Tunnel Sheet Piling Installation

Figure 9 – Installation of Shoring System

A Value Engineering exercise led by specialists within the engineering and construction community was undertaken to review the selected design and identify improvements

Given transitway alignment requirements to accommodate high speeds (grades, curve radii) and existing property constraints, the tunnel was required to underpass the seven tracks at a significant skew. This created a significant challenge to meet CN's requirement that tunnel construction not interfere with rail operations. As complete closure of all seven tracks for the duration of the construction was unacceptable to CN, construction was staged in a manner to maintain rail operations. Some tracks were closed and new switches were installed to transfer trains to the four mainline tracks required to be maintained during the two stages of tunnel construction. To meet the requirements of both CN and the City, the tunnel construction was phased as follows:

Phase	Description
1	**First CN Track Detour:** Non-essential tracks removed and remaining tracks shifted eastward of CN's permanent alignment to accommodate the construction of the west half or the tunnel.
2	**Construction of West Half of Tunnel**
3	**Second CN Track Detour:** Tracks shifted westward of CN's permanent alignment to accommodate the construction of the east half of the tunnel
4	**Construction of the East Half of Tunnel**
5	**Re-installation and Re-location** of all seven tracks to CN's original permanent alignment above the completed tunnel

One of the most complex components of the tunnel construction was the installation and removal of the shoring system, along with the excavation works. Due to the depth of excavation required, close proximity of the CN rail tracks and the narrow constraints on site, it was necessary to design and implement a specialized shoring system prior to the installation of the tunnel structure. The contractor, together with the engineering design team, devised a shoring system that included sheet piling located on three sides of the tunnel structure and struts that spanned between the sheet piles. Sheet piling installations commenced first, with excavation and strut installation staggering at equal intervals throughout the shoring structure to ensure maximum support and containment. The benefits of this design are the lack of vertical obstacles allowing for more continuous unobstructed work and increased safety.

Shoring removal was synchronized with construction of the tunnel's structural works. As the construction reached certain elevation points, backfill was placed and the associated struts were removed. Following completion of the structure and all backfill, the sheet piling was removed.

The Contractor was required to perform open and supported excavations throughout the construction of the tunnel structure. This excavation was time consuming and difficult due to the complicated shoring that was required because of the close proximity of CN tracks, as well as adjacent Pembina Dodge and Quintex properties. Excavation needed to be carried out in stages and with smaller equipment so that critical shoring struts could remain in place to support the shoring. It was critical that the Contractor maintained conditions and protection of the CN railway tracks and ensure that work activities did not at any time jeopardize the stability or impact the performance of the tracks.

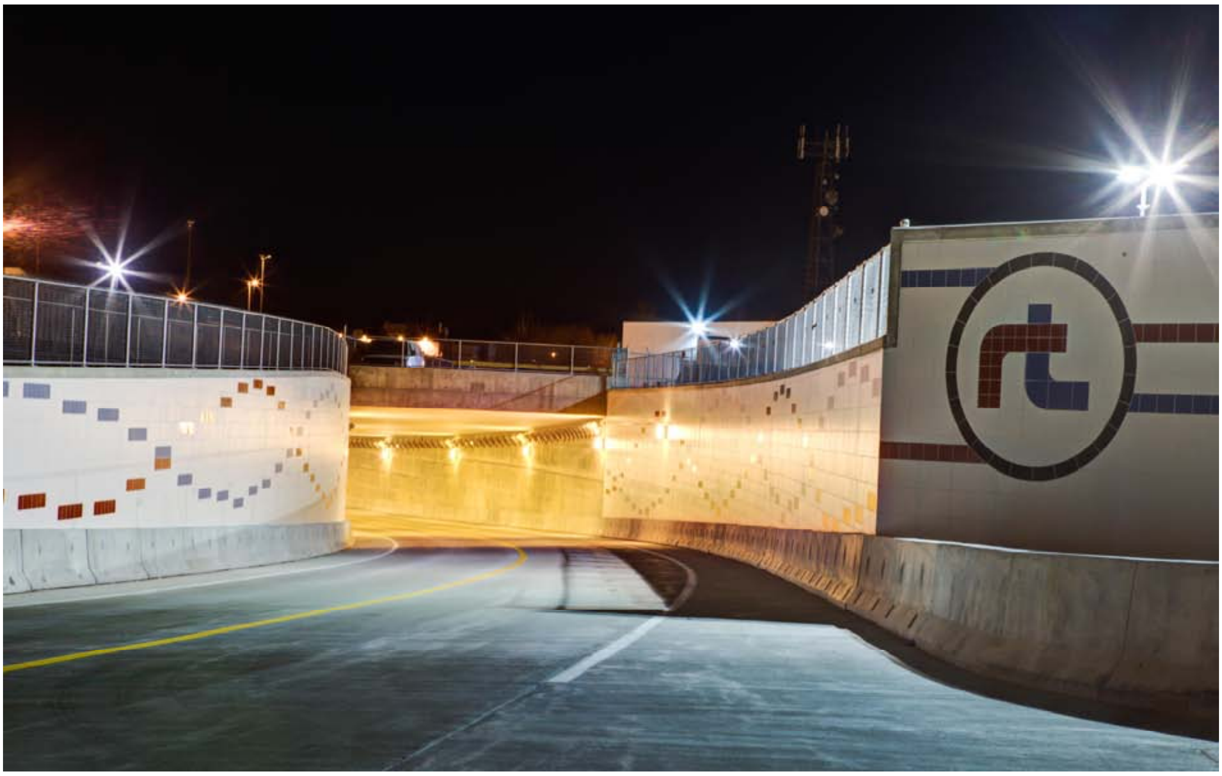

Figure 10 – View of Tunnel Entrance

7 CONTRACT 5 – OSBORNE STATION

The transitway's showpiece is Osborne Station. Located atop a new bridge, it spans a busy arterial roadway, Osborne Street, and is bounded by the Masonic Temple and Manitoba Hydro Substation on one side and by the CN mainline on the other.

Osborne Station consists of a fully enclosed steel structure over a steel "I" girder bridge with a reinforced concrete bridge deck. The bridge has a total length of 70.5 metres with two abutments and two piers. The curved steel structure (12.8 metre height) over the bridge has a total length of 99.7 metres complete with smaller wind baffles (4.8 metre height) on either side to limit the exposure to the elements inside the station. The structure forms the backbone of a complex building that includes electronic passenger information displays, information kiosks, benches, illuminated signage, heaters, fire protection, bus exhaust management, lighting, and a bus detection and warning system.

Passenger access to the station is gained from either side of Osborne Street. On the west side, there is an accessible ramp with an overhead canopy. On the east side, a large plaza provides a gathering and resting area as well as ramp access to the station. Both access points are fully landscaped with trees, shrubs, and native plants. All aspects of the station (plazas, ramps, sidewalks, station interior) incorporate Universal Design, with visual and tactile cues in all locations.

Figure 11 – Construction of Foundations for Bridge Substructure

Figure 12 – Erecting Bridge Girders for Superstructure

There were many design challenges for this project:

- A skew angle of 51º for the bridge and building had to be maintained within a small footprint.
- The site constraints required that the bridge's width be narrowed to 9.4 metres from an originally contemplated 15.5 metres. This required the termination of exterior girders at the west pier. To mimic the profile of continuous girders, innovative methods of analysis were used to generate a design that cast the terminated girders into the pier. This arrangement avoids damage to the concrete caused by differential movement of the girders.
- To provide sufficient roadway clearance beneath the bridge and the necessary vertical curvature of the transitway on the bridge, a very shallow bridge girder was necessary. Because the bridge design must sustain LRT loadings, thick member sizes and tight girder spacings were used. Site conditions dictated various span lengths, with a long center span and shorter end spans. This variability created uplift forces at the abutments under live load. To resolve this, a large dead load of non-compositely acting concrete was placed in the area between the end span girders.
- Expansion/contraction effects due to temperature variations were required to be considered in the design for both the bridge and the station superstructure, as the station is not completely enclosed and heated. As the fixed points of the bridge and building superstructure are different, the superstructure could not be braced to the bridge. This required significantly larger member sizes for the side truss supports.

These design challenges had major implications for construction. The space available for stockpiling materials and construction was very limited. A rigorous staging schedule was required to ensure that construction activities occurred without conflicts. Construction was conducted over a busy arterial roadway and only limited closures were permitted during the project's year and a half duration. Extensive hoardings and platforms were required to provide protection to traffic and pedestrians below the bridge.

The proximity to the CN main line also required careful staging for the excavation works. Some excavations were within 5 metres of active tracks and shoring had to be provided in a very specific manner to avoid any horizontal or vertical deflection of the tracks. Any equipment that could potentially foul the tracks was required to be locked down during the passage of trains, which often slowed construction on an already tight schedule.

The subsurface conditions on the site were highly variable and required highly specialized excavation techniques for the construction of rock-socketed concrete caissons. As examples, complications that arose included a high water table, uneven bedrock, a large fractured rock layer above the bedrock, a deep till layer with both large and small boulders and fine sands. To maintain positive hydrostatic pressure and the integrity of the caisson shaft and to prevent deterioration of the rock strata, upwards of 10,000 litres of water were required to be injected into the shafts following excavation.

There was an extensive network of underground utilities on site including pressurized oil-filled electrical ducts, a large combined sewer, and communication ducts. It was uncommon for any excavation to occur on site without encountering a utility line. Extreme caution was required whenever any excavation was required, regardless of depth of cut. Due to the extensive works above the high voltage lines, a concrete and void-form system was designed to limit the pressures from heavy equipment to less than the equivalent weight of a normal passenger car. For example, when staging the 300 ton crane for superstructure erection, over 1.2 m of granular fill topped with 0.3 x0.3 m heavy timber mats were required to bring the pressures to within allowable limits.

Figure 13 – View from Inside Osborne Station

The proximity of the structure to the Manitoba Hydro substation presented a significant safety hazard. Although the existing substation fencing was grounded, you could be electrocuted during a fault occurrence if you touched the substation fencing and the Station structure. As a result, a non-conductive fencing was installed. This non-conductive fencing was also isolated from the bridge and building structures using a canopy structure on the access ramp on the west side of Osborne Street, portions of the building structure itself, and permanent fencing to limit access. While it was determined that a non-conductive fencing was required, there were also requirements that the fence meet smoke and fire spread requirements as imposed by the utility. The material used to provide the necessary requirements was fibre-reinforced polymer

(FRP) formed into structural sections, the polymer of which was comprised of a specialized phenolic resin.

Another design challenge was to ensure the Station and spaces surrounding maintained an open feeling, while reducing the impact of inclement weather on the users. Additionally this had to be married with the safety design guidelines for sightlines, safe egress and overall user safety within the Station. Through the use of a blue tinted glass curtain wall, clear glass for the railings and canopies, appropriate coverage and sightlines were maintained, which provides an open and safe ambience while being protected from the elements.

The design and construction challenges yielded many opportunities for collaborative success. One of the greatest triumphs of the Station was the development of the bus detection and warning systems. As the wind baffles can partially impede sightlines of buses entering the Station, and the pedestrian crossings are just inside the wind baffles, a system was required to detect and monitor bus traffic and provide an alert to the users, through both audible and visual cues. In the original design, a concept was formed and specified based on that initial concept. Throughout construction, the design of the system was enhanced by communication and research efforts by the contractor, sub-contractors, sub-consultants, Dillon, and the Transit Department. The final design of the system provides a robust and reliable system of chimes and flashing lights to alert users when a bus will enter the Station and come near the pedestrian crossings. The buses are monitored in real time and due to the extreme flexibility of the detection and warning system, can provide warning for 1 bus or 100 busses in a row without any adjustments or complications.

Figure 14 – Osborne Street Station

8 CONTRACT 6 – TRANSITWAY CONSTRUCTION, LANDSCAPING & ASSOCIATED WORKS

Contract 6 was carried out over 2010-11. The first year's activities included site clearance, construction of the transitway between the south end of the tunnel and Jubilee Avenue, construction of a new bus access/egress between the Fort Rouge Transit Base and the transitway, and installation of connections to the land drainage sewer.

The transitway pavement design used for the northern portion under Contract 3 was also used for this contract and involved excavation, limestone sub-base placement, and concrete paving. Similar to Contract 3, survey staff used the latest in GPS and robotic total station technology allowing for more efficient and accurate layout and onsite verification of contractor work. To allow for faster construction and better overall quality, the concrete roadway was placed using an 8.2 m wide paver with integral mountable curb on either side. At the intersection of the transitway and the Jubilee Overpass, coordination was required with those responsible for the Jubilee Overpass rehabilitation project to ensure proper grades were installed at the bus egress and access locations at the overpass. Construction works immediately at the Jubilee tie-in were limited to importing fill material to build the area up to design grade. Coordination was required with the Jubilee overpass rehabilitation project to ensure proper grading was used at all tie-in locations. Concrete was intended to take place during the 2011 construction season as the area required considerable fill material, and settlement was expected. Road works taking place within the Transit base grounds were conducted to provide access to the transitway. Due to site requirements and activities taking place as part of the tunnel project, this access was only partially complete. The remainder would be completed during the 2011 construction season.

Several drainage connections were made throughout the length of the transitway to the land drainage sewer installed under Contract 1. In addition, several pipe segments were installed from the mainline sewer to the property line to accommodate the Fort Rouge Yards development.

Activities in 2011 included construction of the transitway from Osborne Station through the tunnel to the transit base access/egress approach, the construction of an extension of Morley Avenue and loop roads/parking at Fort Rouge Station, reconstruction of VIA Rail's employee parking lot (including paving, fence relocation, electrical works), and construction of a parking area at the tunnel's pumping station.

Figure 15 – Slip Form Paving of Transit Corridor

Figure 16 – Transit-only Access

The construction required detailed coordination with other contracts and other projects. Between Osborne Station and the north end of the tunnel, the area was quite confined and, at times, 3 general contractors and 10 subcontractors were working concurrently. Ventilation in the tunnel during granular placement and paving operations was a priority as roadworks took place corresponding to the tunnel construction staging, meaning only one exit/entrance was available while construction took place.

9 CONTRACT 7 – STATION CONSTRUCTION, WARSAW RECONSTRUCTION & ASSOCIATED WORKS

This wrap-up contract included fabrication and installation of all station elements for Harkness Station and Fort Rouge Station, the reconstruction of Warsaw Avenue between Osborne Station and Pembina Highway, and landscaping/aesthetic treatments for the complete project.

The station elements included large heated shelters, overhead canopies over the platform, pedestrian lighting, illuminated signage, information kiosks, electronic BUSwatch signs to display real-time bus departure information, bike racks and lockers, benches, recycling receptacles, universal design features, a centre median fence to prevent jay-walking across the transitway, and fencing to guide pedestrians to designated crosswalks. To meet power needs, a significant amount of electrical cable was installed throughout each station. The design and installation of the canopy over the northbound platform at Harkness Station was complex as it had to be attached to the sheet pile wall installed under Contract 3.

Figure 17 – Completed Fort Rouge Station

In addition to the station works, a substantial amount of roadwork was also included. The roadway works included the construction of links between the transitway and the street system; these were left unfinished until the end of the project to discourage motorists from inadvertently accessing the transitway during construction. Being the final of seven, this contract was seen as the completion contract. The two major areas of roadwork included within this project are at the northern most extent of the transitway at Queen Elizabeth Way and at the Warsaw Street access at the convergence of Contracts 4, 5, and 6. As mentioned in the description of Contract 6 works, this small physical area had up to ten separate contractors working at any given time. Coordination of separate contracts and communication amongst contractors was vital for success in this area.

The Warsaw work also involved the reconfiguration and reconstruction of the Pembina & Warsaw intersection, including new traffic signals to accommodate bus turning movements to/from Pembina Highway. Physical work involved pavement reconstruction from Pembina Highway to the Manitoba Hydro substation immediately adjacent to the Osborne Station. This entailed removal of existing pavements, excavation, minimal land drainage sewer works, limestone sub-base placement, and concrete paving. Similar to Contracts 3 and 6, a concrete depth of 230 mm was utilized. The intersection at Pembina Highway and Warsaw Avenue also witnessed significant upgrades, including a left turn lane addition for southbound transit buses wishing to access the transitway via Warsaw, and signalization of the intersection to facilitate transit movements to and from the transitway.

At the northern end of the transitway at Queen Elizabeth Way, traffic islands and roadway lanes were realigned to provide proper channelization for southbound buses to enter the transitway and traffic signal upgrades were implemented to accommodate the new patterns of bus, traffic, cycling, and pedestrian movements.

10 ACTIVE TRANSPORTATION

Although the main focus of the Southwest Transitway was to provide improved transit infrastructure, equally important was the opportunity to improve active transportation facilities, thus designing a system that supports active, accessible and healthy lifestyle options. To support the City's development of its AT network, several Active Transportation Paths (ATP) were constructed:

- A major upgrade of the South Winnipeg Parkway ATP (along the west bank of the Red River between The Forks/Queen Elizabeth Way and Osborne & Glasgow)
- ATP through the Fort Rouge Yards between Osborne & Glasgow and Jubilee Avenue
- ATP linking the Assiniboine Avenue Cycle Track, Queen Elizabeth Way, Harkness Station, and Osborne Station via Stradbrook Avenue and Donald Street
- Canopy-protected bike racks and bike lockers at Harkness, Osborne, Fort Rouge Stations

Planning considerations (connectivity, accessibility, safety, public/private property implications, flood protection impacts, etc.) and engineering considerations (i.e. City of Winnipeg and ATP design standards, implications for existing infrastructure, structural requirements, CN clearance requirements. transit and vehicular traffic impacts, etc.) were taken into account during the active transportation analysis. The active transportation component includes bicycle storage at rapid transit stations and new paths that connect with existing Active Transportation Pathways (ATPs).

The criteria used to identify and lay out routing options for the connection between the Fort Rouge ATP (Osborne Street shared sidewalk) and the Donald - Stradbrook ATP was based on a minimum 3.5 m wide multi-use paved path. Where that path width was not feasible, a minimum 3.0 m wide shared sidewalk was considered.

All identified options were laid out to meet the universally accessible standards of the City of Winnipeg (City of Winnipeg 2006). Ramp layouts used a 5% slope where feasible, with landings provided when ramps exceeded recommended distances. All options were developed so that they could be used by both commuting and recreational ATP users.

Safety considerations were twofold: general public safety; and Crime Prevention Through Environmental Design (CPTED) principles. General safety of the public and users of the ATP included such considerations as the potential conflict with vehicular traffic along roadways, transit vehicles on the transitway, and rail traffic on the CN mainline. It also included considerations of inappropriate access to public or private spaces (i.e. ability to throw objects from structures onto the transitway or CN mainline or otherwise access and vandalize property).

The second aspect of safety considered CPTED principles. Options were developed and evaluated on whether they created opportunities for 'natural surveillance' (i.e. clear sight lines from busy streets or public spaces) and provided 'natural access control' (i.e. clear exits and entrances).

Figure 18 – Bike Lockers outside Fort Rouge Station

11 PROJECT SUMMARY

Winnipeg's rapid transit network will have very positive socioeconomic impacts in terms of increased ridership, reduced traffic congestion, greenhouse gas reductions, improved access to downtown, and new transit oriented development opportunities in lands adjacent to stations. Although faced with extraordinary challenges of location, site conditions, construction complexity, and an aggressive schedule, the unique mix of design ingenuity, technology, and equipment facilitated the efficient and safe completion of this first phase of the rapid transit network. Stage 1 of the Southwest Transitway sets a high standard for further system expansion, provides an important new transportation option for Winnipeggers, is good for the environment, and will support Winnipeg's future growth.

Figure 19 – Harkness Station