

**2013 CANADIAN CONSULTING ENGINEERING AWARDS
FULL PROJECT DESCRIPTION**

NAME: WINNIPEG'S FIRST RAPID TRANSIT CORRIDOR – SOUTHWEST TRANSITWAY
CLIENT: CITY OF WINNIPEG – TRANSIT DEPARTMENT
FIRM: DILLON CONSULTING LIMITED

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.**

Dillon Consulting Limited 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, Dillon 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.

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 by 2018, will extend the transitway further south from Pembina & Jubilee to Bison Drive/University of Manitoba.

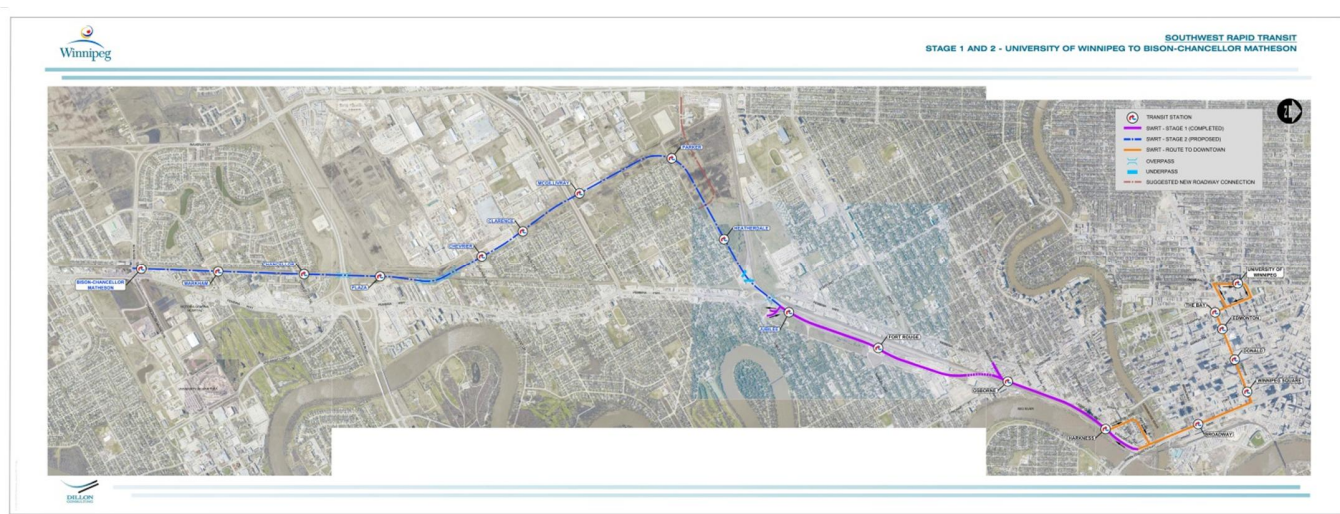


Figure 1: Southwest Transitway Alignment – Overall Project

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 by Dillon 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 Dillon'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

3.1 Contracts 1 and 2: Land Drainage Sewer and Pumping 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 Dillon, 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.

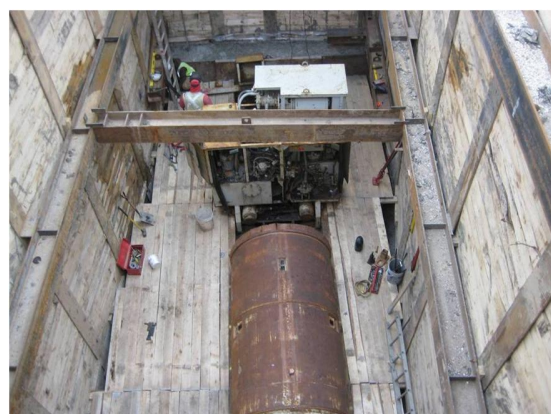


Figure 2 – Large Diameter Pipe Installation Using TBM

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 – Pumping Station

3.2 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. 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.

During design, it was determined that the urban roadway cross-section used for Donald and Stradbrook would require additional land drainage sewer capacity within the 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, a new line was installed. A design constraint was that no additional flows could be diverted to the combined sewer system.

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 buildings. A major issue identified by CN was the need to reinforce the rail embankment adjacent to the

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.



Figure 4 – View of Corridor Parallel to Donald Street Looking South

This work was followed by the construction of the transitway: excavation, placement of sub-base limestone, and pouring of concrete pavement with a traffic barrier on either side. During construction, special attention was paid to two 69 kilovolt power lines beneath the centreline of a 300-metre length of the transitway adjacent to Donald Street. The depths of the lines averaged 0.5 metres below the bottom of excavation. Manitoba Hydro required that at least 0.45 metres of in-situ cover be maintained on the lines, that no vibratory compaction take place immediately above the lines, and that a Manitoba Hydro inspector be on site during all excavation activities above and adjacent to the lines.

Ancillary works of Contract 1 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.

3.3 Contract 4: Transitway 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.

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. A structurally-shored open-cut approach with cast-in-place construction was selected due to simplicity and a robust resistance to water penetration. A Value Engineering exercise led by



Figure 5 – Tunnel Construction

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 of 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

The tunnel's scope of work included installation of gravity sewers, demolition and removals, groundwater depressurization, dewatering, and structural/architectural/electrical works.

Shoring methods were complex due to the required depth of excavation, the proximity of the CN tracks, and the narrow site constraints. The contractor and engineering team designed a system of sheet piling 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 staggered at equal intervals throughout the shoring structure to ensure maximum support and containment. This design eliminated vertical obstacles, allowed continuous unobstructed work, and increased safety. Excavation was carried out in stages with small equipment so that critical struts could remain in place to support the shoring. 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.

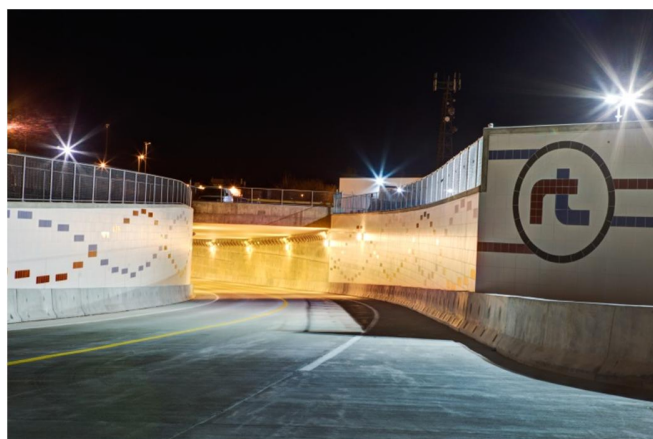


Figure 6 – View from Outside Completed Tunnel

3.4 Contract 5: Osborne Bridge, 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.

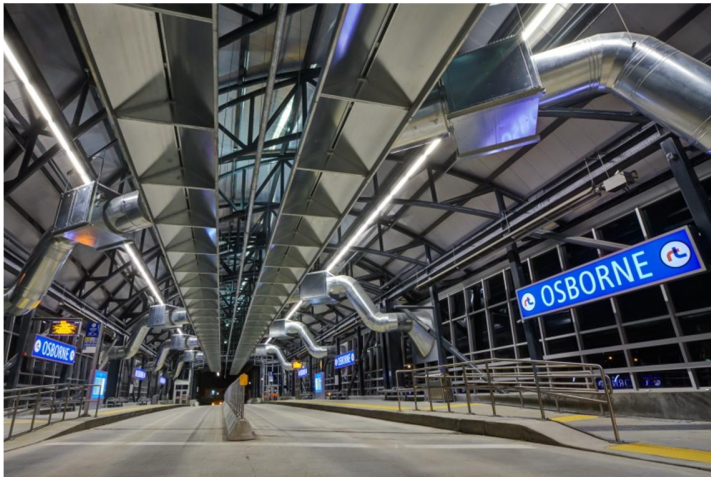


Figure 7 – View from Inside Osborne Station during Construction

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.

There were many design challenges for this element of the project:

- A skew angle of 51° 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.



Figure 8 – Osborne Street Station

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.

3.5 Contract 6: Transitway Construction (Osborne Station to Jubilee); 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. 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 9 – Slipform Paving of Transitway

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. Concrete was placed using a paver, 8.2 metres in width, with an integral mountable curb on either side.

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. 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. 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.

3.6 Contract 7: Station Construction (Tunnel to Jubilee); Warsaw Reconstruction

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.



Figure 10 – Completed Fort Rouge Station

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.

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) and the reconstruction of Warsaw Avenue to provide a bus link between Pembina Highway and the transitway for Grant Avenue routes. 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. 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.

4 ACTIVE TRANSPORTATION

A significant component of the project was Active Transportation. 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

Dillon and client staff worked closely with the City's Active Transportation Advisory Committee and Universal Design Coordinator to incorporate universal design, planning, and engineering considerations in these facilities.

5 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 successful 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 11 – Completed Osborne Station