5 IMPLEMENTATION

The previous sections of this report describe the development of alignments and the assessment of associated effects on the environment. This section provides an overview of alternative construction methodologies and recommendations for construction of the double track 2.8 km subway extension from Steeles West station to the VCC Station.

This implementation section is intended to provide technical insight into activities that will occur during the design and construction phases. Additional research and analysis during design will confirm the ultimate construction methodology, which will be finalized in consultation with the Region, TTC, and other major stakeholders.

The section discusses the following:

- **Implementation Plan**: issues and recommendations pertaining to the VNSL Subway extension implementation process;
- **Tunnelling Construction;**
- **Cut and Cover Construction;**
- **Dewatering**;
- **Additional Implementation Activities Required** (geotechnical investigations, pre-construction surveys, and instrumentation and monitoring); and
- **Construction Staging**.

5.1 IMPLEMENTATION PLAN

The implementation of the subway will consist of design, construction, system installation and testing and commissioning phases.

In support of the original Environmental Assessment Study, and this supplementary Conditions of Approval Report, the preferred subway alignment design has been developed to a functional planning level of detail including both horizontal and vertical geometry of the preferred subway alignment. Also, preferred locations for the 407 and VCC (Highway 7) Stations have been identified and conceptual layouts of the facilities have been developed. The infrastructure planning undertaken during the study is considered adequate to identify the effects of implementation and operation of the undertaking and establish whether any mitigation is needed and what form it should take. .

5.1.1 The Design Phase

Following approval of the EA by both provincial and federal agencies, further preliminary design and subsequently, detailed design will constitute the first stage of the implementation plan.

The expectation is that the subway design and construction will take place in stages. The timing and extent of each stage of construction will depend on the availability of funding and the period required.

Once these factors have been determined, a work plan to carry out the detailed design will be developed. Multiple design components for the subway infrastructure will be completed simultaneously. Each design phase will allow sufficient time for post-EA approvals prior to the scheduled start of construction. Besides the MOE and CEAA approvals of the EA itself, examples of these approvals are:

- Municipal Building Permits, for the stations and associated Facilities;
- TRCA permits;
- Federal DFO authorization;
- Permits under the Lakes and Rivers Improvement Act for alternations to the watercourses and/or stream crossings; and
- Any Ontario MNR approvals.

Design efforts are anticipated to continue for up to 4 years, with construction beginning less than two years after the commencement of the design activities.

5.1.2 The Construction Phase

The timing of construction of the subway extension is influenced primarily by the requirements of the "Move Ontario Trust". The terms of the trust dated March 24, 2006 require that construction begin no later than April 1, 2008 (or 365 days from the receipt of Final Provincial Environmental Assessment Approval – whichever is earlier). The term of the trust is ten (10) years terminating on March 24, 2016. Construction should be completed by this date.

Because of the aggressive schedule requirements, it is expected that the design, tender award and construction of various elements will occur in parallel. The construction efforts will include all subway extension components between Sheppard West Station and the VCC Station. As such, significant coordination between TTC/Toronto and the Region of York is expected. The exact schedule will be developed and formalized by the selected contractor.

5.1.3 System Installation, Testing and Commissioning

System Installation (trackwork, power, communications) is expected to require approximately 42 months (3.5 years). These activities can be performed in parallel with facilities construction activities. Initial system installation activities will commence once portions of the subway (tunnel or stations) are built and accessible. System installation could reasonably begin as early as 2011.

The installation of station and tunnel finishings will commence upon completion of each the construction phases. The installation of finishings is typically completed within 6 months. System testing and commissioning follows installation of each component and concludes with trial running on the completed facilities and systems.

5.2 TUNNELLING CONSTRUCTION

5.2.1 Construction Methods

The ground conditions along the proposed alignment are considered to be favourable for machine-bored tunnelling, provided that groundwater is adequately controlled. Therefore the construction of the VNSL subway between stations is anticipated to consist of twin bored tunnels, for independent northbound and southbound tracks, of approximately 6m diameter and at 12m Centerline (C/L) spacing. Tunnel crown to surface distances vary from 10m to 20m.

All tunnelling operations will be advanced from one station site to the next with the stations constructed using the cut-and-cover method. Construction will be initiated from a working site, at an access shaft, (typically near a cut and cover station location), for tunnelling equipment installation and removal (typically 1000m to 2000m minimum). Little, if any, access to the tunnels from the surface is required at any other locations along the tunnel drives.

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Based on the geotechnical investigation conducted for this study (see Appendix A for the complete Geotechnical/Hydrogeological Assessment Report), the anticipated ground conditions along the proposed alignment should be favourable to tunnel construction.

The Geotechnical Report describes feasible tunnelling techniques. For relatively long lengths of tunnel, generally greater than about 600 m as anticipated for this proposed alignment, it is considered feasible and likely economically suitable to use a tunnel boring machine (TBM). Tunnel boring machines are generally not suited to construction of underground transit stations. The recently-built Sheppard Subway was constructed using TBMs specifically designed for and purchased by the TTC. These TBMs were designed as earth-pressure-balance (EPB) machines so as to assist in controlling ground displacements in potentially difficult ground conditions below groundwater levels.

A permanent tunnel lining is installed directly behind the TBM in a one pass tunnelling operation. The fully bolted, waterproof, pre-cast concrete liner is

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continuously grouted in place as the TBM advances to minimize the opportunity for any ground movement or subsidence, and prevent ground water from infiltrating into the finished tunnel.

Removal of excavated earth material, and input of materials such as liner segments and grout components, is all conducted from the single operating shaft location for the duration of the complete tunnel drives.

Where the tunnels pass directly beneath existing structures (e.g. Jane Street, CN Halton Subdivision, Highway 407, Hydro towers), additional ground control measures may be necessary as discussed in Section 4 (Assessment of Effects).

Appendix A discusses in detail possible methods to be used for groundwater control and lining.

5.2.2 Preferred Tunnelling Method

It is proposed that tunnelling would be undertaken by Tunnel Boring Machine(s) (TBM), using the Earth Pressure Balance (EPB) technique. This technique maintains a positive pressure at the excavation face at all times to minimize or eliminate the release of in situ earth pressures and subsequent surface subsidence during the tunnelling process. The EPB TBM technique also controls underground water pressures, eliminating ground water inflows without the requirement for external dewatering procedures.

5.3 CUT AND COVER CONSTRUCTION

Construction of the 407 and VCC Stations will be performed using cut and cover construction methods. Special track structures such as cross-overs and tail tracks are also expected to be built and installed using cut and cover construction methods. Although initial hydrological investigations were carried out as part of this study, it is expected that additional, more detailed groundwater investigations will be conducted prior to the detailed design. The initial investigations resulted in the following findings:

- Though the Highway 407 Station is located in close proximity to Black Creek and two of its tributaries, distinct sand and silt deposits were not encountered at the investigation locations.
- On the basis of the subsurface conditions encountered to date at the Highway 407 Station, water-bearing deposits that would require extensive dewatering systems are not anticipated to be present.
- In the vicinity of the VCC Station, several significant granular layers are present over the depth of the station excavation (Upper Sand/Silt).
- The recent sinkhole incident at the intersection of Highway 7 and Jane Street indicates that a significant thickness of sand and silt exists at the location. This may constrain the proposed VCC Station excavation and require that groundwater control be provided.

5.3.1 Cut-and-cover Excavation Construction Methods

It is expected that in most instances, vertical excavation will be required, particularly in the Highway 7/VCC Station area. These excavations will require temporary shoring. Shoring could consist of soldier-piles and wood lagging, drilled secant pile (caisson) walls, or soil-nail ground supports, depending on the requirements for groundwater control and the need to limit ground movement adjacent to the shoring system.

Based on previous construction for Toronto subway projects, station excavations or dewatering may be accomplished using deep wells, eductor well systems or well-points installed from within the excavation. The influence of dewatering on settlement of the surrounding ground should be relatively minimal. Based on the subsurface information gathered during the recent investigations, groundwater will have to be controlled for the Highway 7 Station. The recent investigations suggest that the Upper Sand/Silt is not present in significant thicknesses in the vicinity of the Highway 407 Station, indicating that extensive dewatering may not be necessary in this area.

Based on the prevailing ground conditions, temporary cuts for open-cut construction may be made with side slopes in the range of 1H:1V to 1.5H :1V. It is expected, however, that in most instances, vertical excavation sides will be required and that these excavations will require some form of temporary shoring. Horizontal support may be provided by internal braces or drilled anchors that extend into the ground behind the supporting walls.

Where temporary or permanent easements can be obtained from neighbouring property owners, it may be assumed that ground anchors or soil nails will extend horizontally (or at some shallow angle) into the ground a distance of up to twice the depth of the excavation. For soil nail supported excavations, this distance may be less (approximately equal to the excavation depth) but for planning purposes, the greater extent should be used since the actual or likely support systems are unknown at this time.

Cut and cover construction effects on existing structures and facilities are addressed in Section 4.

5.3.2 Temporary Ground Support Systems Construction Methods

For temporary ground support during deep excavations, soldier pile and lagging walls are typically used where groundwater conditions are favourable or where dewatering is carried out and wall and ground displacement are permitted to some degree. Where ground displacement must be minimized and the ground support system must be closely controlled, contiguous bored and cast-in- place concrete pile (secant pile) walls are often used. In some instances, depending on cost and ground/groundwater condition considerations, soil nail walls or concrete diaphragm walls may also be appropriate.

5.4 DEWATERING

Dewatering of the interstadial granular soils (Upper Sand/Silt) will be necessary for cut-and-cover stations, tail track, or crossover track structures. In addition, it is anticipated that dewatering may be required for the start and end shafts for tunnels constructed with tunnel boring machines, and for ventilation/emergency exits. Based on previous construction for Toronto subway projects, such dewatering may be accomplished using deep wells, eductor well systems or well points installed within excavations. It is anticipated that active dewatering for lengths of tunnel constructed using closed-face tunnel boring machines would not be required. It is expected that significant groundwater dewatering will be required for the proposed VCC station as the mezzanine and the upper portion of the platform occurs within a water-bearing interval. Also some groundwater dewatering will likely be required for the proposed Highway 407 station. More detailed sites specific geotechnical and hydrogeological studies will be required during detailed design to confirm both groundwater control requirements, estimated dewatering quantities, the zone of influence (ZOI), and potential impacts to any watercourses (i.e. Black Creek and its tributaries). Additionally, the need for any permits (Permit to Take Water) for VCC or Highway 407 stations will be identified.

For the purpose of this study, an outline assessment of potential dewatering conditions was conducted. This dewatering assessment, considered the following:

- Station construction was assumed to be completed using conventional cut-and-cover methods without implementation of any groundwater control measures except for dewatering using wells or well-points.

- The permeability (hydraulic conductivity) of the granular deposits around Highway 7 station was assumed to be between 5x10-3 and 5x10-5 cm/s.

Based on these assumptions, it is anticipated that nominal dewatering is expected at the site of the Highway 407 Station to control the stormwater and residual flows during construction. The lateral extent of the groundwater drawdown at the site of Highway 7 Station could be on the order of 500 m to 1,500 m from the dewatering system to where the drawdown is on the order of about 1 m.

Where groundwater taking is carried out near potentially contaminated sites or at the Highway 407 site where there had been ongoing agricultural activities, the groundwater extracted during dewatering may require treatment prior to disposal.

Further discussion of dewatering is included in Appendix A.

5.5 ADDITIONAL IMPLEMENTATION ACTIVITIES

5.5.1 Geotechnical Investigations

Prior to tunnel design and construction, an extensive Geotechnical Investigation will be undertaken to determine to the best extent possible the expected ground conditions to be encountered, and assist in the design of tunnelling equipment and final lining design components. It will be necessary to complete more boreholes in the areas where variation may be important for determining aquifer continuity characteristics for dewatering or groundwater cut-off. The investigations and analyses will better define estimated dewatering quantities and drawdown radius values for final design and final permitting. The investigation and supporting documents would be undertaken by a geotechnical specialist experienced in this type of work.

In general, the investigation program would be phased to encompass preliminary data, followed by subsequently more detailed work phases to refine the information, until the most likely interpretation of existing conditions along the entire alignment can be made.

Work would consist of exploratory bore-holes at regular intervals, followed by more extensive drilling and sampling at specific locations mandated by the type of construction anticipated, or to clarify any apparent anomalies from the initial investigations. Extensive laboratory testing and analysis, core samples, and written reports would be available to designers and constructors for determining the final tunnel methodology and design parameters. A typical arrangement for this phased investigation is summarized in the table below:

Investigation Phase	Maximum Borehole Spacing
Phase 1	450 m
Phase 2	150 m
Phase 3	50 m Stations 75 m Tunnels

5.5.2 Pre-Construction Surveys

Typically, an initial survey is undertaken of all existing structures, above and below the ground surface, within the envelope of influence from the anticipated tunnel construction. This report can be used to confirm any changes occurring as a result of construction activity.

5.5.3 Monitoring Program

A monitoring program will be established to provide a continuous record of any movement during all phases of construction activity.

Special instruments will be installed on sensitive structures, such as hydro towers or railway tracks, to provide “continuous” and “immediate alert“ monitoring of these structures for potential movement.

Additional monitoring devices will be installed on the surface, extending below the frost line at relatively close spacing along the centre-lines of both tunnel alignments. (For example, the ground monitoring program for the Sheppard Subway project consisted of settlements points installed about 2 m below the ground surface at 10 m intervals along the centrelines of each tunnel). Each settlement point will consist of a sleeved steel rod with the bottom 0.3 m grouted into a borehole. Other instruments including deep settlement points (installed every 100 m) and probe extensometers will be installed at other locations along the alignments as secondary measures for judging overall patterns of ground response and construction workmanship.

Perpendicular arrays will be provided at larger intervals (e.g. 200 m) to extend beyond the expected envelope of influence from the anticipated tunnel construction and monuments are installed on structure or building foundations.

Utilities will be monitored by strain gauges or settlement points at critical locations. All buildings within the zone of influence will also be regularly monitored for settlement.

Vibrating wire and open standpipe piezometers will be installed at critical points around braced excavations or tunnelled cross-passages to observe the effectiveness of dewatering systems within the multiple aquifers present. Vibrating wire strain gauges will be installed on selected struts within braced excavations to monitor strut load.

5.6 CONSTRUCTION STAGING

As described in Section 5.3, only the stations and special track structures will be built using cut-and-cover methods, the rest of the subway will be tunnelled. The twin tunnels will have no surface effect; consequently their construction will not require a specific staging sequence.

To minimize the impact on traffic circulation, decking is anticipated in the cut-and-cover sections under existing roadways, complemented by a traffic management plan, which will be developed during the detail design phase.

Areas where traffic circulation will be impacted, are Millway Avenue including the intersection with Highway 7 affected by the VCC Station, and Jane Street (south of Highway 407) affected by the access to the 407 Station.