

Region of Waterloo  
Stage 1 Light Rail Transit Project

Performance Output Specifications  
Article 2  
Civil

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**ARTICLE 2 CIVIL**

**2.1 General**

- (a) The purpose of this Article is to provide design specifications for the Surface Civil Works. Project Co's solution to Civil Works shall meet or exceed these requirements. Project Co shall prepare a Basis of Design Report – Civil with specifications and concept drawings, which explain Project Co's approach to Civil design work in greater detail and in a site specific manner. The presentation of specific Civil design requirements within this Article must not be construed to limit or modify in any way Project Co's responsibility to provide a holistic, comprehensive, and fully functional solutions to all Civil conditions. The Basis of Design Report – Civil shall address every aspect of the Civil design requirements cited in this Article. The rationale for all deviations or variances from any requirement cited in this Article must be fully described in the Basis of Design Report – Civil, which is referred to within this Article as the Basis of Design Report.
- (b) This Section describes the design requirements for the LRT and associated infrastructure improvements:
  - (i) Survey
  - (ii) Alignment Control
  - (iii) Geotechnical Design Criteria and Parameters
  - (iv) Approvals and Permitting
  - (v) Public Infrastructure Works
  - (vi) Road Construction
  - (vii) Traffic Signal Infrastructure
  - (viii) Roadway Illumination
  - (ix) Traffic Control Devices
  - (x) Maintenance and Protection of Traffic
  - (xi) Landscaping
  - (xii) Miscellaneous Civil
  - (xiii) Environmental Investigations
  - (xiv) Noise Mitigation
  - (xx) Salvage

**2.2 Cited References**

- (a) The following is not intended to capture and/or cover all cited references of all applicable Codes, Standards and Regulations of design, construction, inspection, legal, quality and safety requirements and/or enforcement policies. Project Co shall comply with all during the Project Agreement.
- (b) Project Co shall in all cases of conflicting Code, Standard, and Regulation utilize the most Stringent Code, Standard and Regulation. Project Co shall utilize the latest edition and amendments in all cases.

- (i) Canada Standards Association (CSA)
- (ii) Canadian Environmental Protection Act
- (iii) Environmental Protection Act, R.S.O. 1990, c. E.19
- (iv) Ontario Water Resources Act, R.S.O. 1990, c. O.40
- (v) Occupational Health and Safety Act (OHSA)
- (vi) Department of Fisheries and Oceans Fisheries Act
- (vii) Grand River Conservation Authority (GRCA) Policies for the Administration of the Development, Interference with wetland and alterations to shorelines and watercourse regulation (O. Reg. 150/06)
- (viii) Region of Waterloo Regional Transportation Corridor Design Guidelines
- (ix) Region of Waterloo and Area Municipalities Design Guidelines and Supplemental Specifications for Municipal Services (DGSSMS)
- (x) Region of Waterloo Standard Specifications (RWSS), 2013 and as revised
- (xi) Region of Waterloo Standard Special Provisions (RWSSP), 2013 and as revised
- (xii) City of Kitchener Urban Design Manual
- (xiii) City of Waterloo Urban Design Manual
- (xiv) Canadian National Railway Design and Construction Standards (CN)
- (xv) Canadian Rail Operating Rules (CROR)
- (xvi) Transport Canada Rules and Regulations
- (xvii) Genesee & Wyoming (Goderich-Exeter Railway) (GEXR) Railroad Design and Construction Standards
- (xviii) Grand River Conservation Authority Erosion and Sediment Control Guidelines
- (xix) Ontario Ministry of the Environment Stormwater Management Planning and Design Manual 2003
- (xx) American Railway Engineering and Maintenance of Way Association (AREMA)
- (xxi) VIA Rail Design and Construction Standards
- (xxii) Metrolinx Design and Engineering Standards
- (xxiii) Illuminating Engineering Society of North America (IESNA) Standards
- (xxiv) Region of Waterloo Illumination Policy
- (xxv) Transportation Association of Canada Manual of Uniform Traffic Control Devices for Canada (1998)
- (xxvi) Transportation Association of Canada Geometric Design Guide for Canadian Roads
- (xxvii) Transportation Association of Canada Guide for the Design of Roadway Lighting
- (xxviii) Low Impact Development Stormwater Management Planning and Design Guide Version 1, 2010 – Credit Valley Conservation Authority

- (xxix) Canadian Portland Cement Association “Thickness Design for Concrete Highways and Street Pavements”
  - (xxx) Environmental Guide for Fish and Fish Habitat, MTO
  - (xxxi) Environmental Guide for Noise, MTO
  - (xxxii) Region of Waterloo Construction Activity Vibration Specifications
  - (xxxiii) Mix Design Method for Recycled Hot Mix, MTO
  - (xxxiv) Ontario Provincial Standards and Specifications (OPS) User's Guide
  - (xxxv) OPS Specifications for Roads and Municipal Services, Vol. 1, General Conditions of Project Agreement and Specifications for Construction (Div. 1 to 9), as revised
  - (xxxvi) OPS Specifications for Roads and Municipal Services, Vol. 2, Specifications for Material, as revised
  - (xxxvii) OPS Specifications for Roads and Municipal Services, Vol. 3, Drawings for roads, barriers, drainage, sanitary sewers, watermains and structures, as revised
  - (xxxiii) OPS Specifications for Roads and Municipal Services, Vol. 4, Drawings for Electrical Work, as revised
  - (xxxix) Ontario Structure Inspection Manual, MTO
  - (xl) Ontario Traffic Manual (OTM) Series
  - (xli) Ontario Traffic Signal Control Equipment Specifications
  - (xlii) Retained Soil System (RSS) Guidelines (2007)
  - (xliii) Seeding and Cover Quality Assurance Visual Inspection Field Guide
  - (xliv) Transportation of Dangerous Goods, Transport Canada
  - (xlv) 1993 AASHTO Guide for the Design of Pavement Structures for Rigid and Flexible Pavements
  - (xlvi) City of Kitchener Development Manual
  - (xlvii) City of Kitchener Standard Specifications for Construction
  - (xlviii) City of Kitchener Cycling Master Plan
  - (xlix) City of Kitchener Constructed Asset Data Submission Manual November 29, 2012 or as revised.
  - (l) Manual of Uniform Traffic Control Devices for Canada (MUTCD)
- c) Reference Drawings
- (i) AutoCAD Standard Drawing Layout and Linetypes
  - (ii) Plan and Profile Drawings – Appendix I
  - (iii) Public Infrastructure Works Scope Drawings – Appendix N
  - (iv) Areas of Region with Existing Concrete Road Base – Appendix P

**2.3 Survey**

- (a) A base reference survey shall be provided by the Region. These drawings are provided in AutoCAD Civil 3D for reference purposes only. It is intended that these documents are complete and accurate; however, it is the responsibility of Project Co to field confirm site conditions prior to design and construction.
- (b) Road Alignment
  - (i) The alignment shall be per existing plans (Drawing Set C-PP, Appendix I), provided the alignment fits the pavement C/L within 0.3 metres, and shall be integrated with the primary horizontal control information provided.
  - (ii) The Functional Design for the Project starts at station 0+026 as shown on Drawing C-PP-01 and the chainage shall be continuous running from north to south. A separate chainage has been developed for each of the northbound and southbound tracks. Project Co shall use the same chainage approach for the design.
- (c) Vertical Project Control
  - (i) Vertical Project Control shall be set at a maximum of 250 metre intervals, and shall be of a permanent nature. Vertical Project Control Points in rock/concrete shall be at least 10 metres from centreline and nail and washers set in tree roots shall be at least 10 metres from centreline. In areas of potential conflict the distance from centreline the vertical control points are set, shall increase accordingly.
  - (ii) Maintain all existing control points installed by the Region as detailed in Exhibit 2.3-1. Any control points removed or disturbed shall be replaced by an Ontario Land Surveyor (O.L.S.) at Project Co’s expense.

Exhibit 2.3-1  
List of Control Points

Monument No.	Description	Location	Easting	Northing	Elevation
029-11-001	Brass cap in concrete cylinder – flush with ground	Northwest corner of King Street and Northfield Drive Intersection	537689.879	4816646.602	345.858

Exhibit 2.3-1  
List of Control Points

Monument No.	Description	Location	Easting	Northing	Elevation
029-11-002	Brass cap in concrete cylinder – flush with ground	Easterly limit of Railway lands, in City of Waterloo, West of ramps to Conestoga Parkway, Approximately 160 metres South of Northfield Drive, Waterloo	536976.670	4816063.567	337.337
029-11-003	Brass cap in concrete cylinder – flush with ground	South side of Weber Street North, West of Dutton Drive, East of Parkside Drive and 5.6 metres West of West End of a Concrete and Metal Bridge Railing in the City of Waterloo	537047.528	4815600.657	348.638
029-11-004	Brass cap in concrete cylinder – flush with ground	North side of Bearinger Road between Parkside Drive and Albert Street, City of Waterloo, 20 metres West of Rail Line	536811.546	4814849.952	341.889
029-11-005	Brass cap in concrete cylinder – flush with ground	North side of Columbia Street West, West of Phillip Street, City of Waterloo, opposite the University of Waterloo School of Optometry Building, 14 metres west of Rail Line	536946.489	4813779.513	336.354

Exhibit 2.3-1  
List of Control Points

Monument No.	Description	Location	Easting	Northing	Elevation
029-11-006	Brass cap in concrete cylinder – flush with ground	North side of University Avenue West, Southwest of Phillip Street, City of Waterloo, opposite “East Side Mario’s” and 19.4 metres East of Rail Line	537371.860	4813241.702	334.851
029-11-007	Brass cap in concrete cylinder – flush with ground	Northeasterly side of Father David Bauer Drive in the City of Waterloo, Approximately 300 metres Northwest of Erb Street and approximately 25 metres West of Rail Line, Waterloo	538016.150	4812585.876	326.112
029-11-008	Brass cap in concrete cylinder – flush with ground	Easterly side of Caroline Street South in City of Waterloo, North of Willis Way, South of Erb Street and Approximately 6 metres South of Rail Line, Waterloo	538442.824	4812462.188	323.274
029-11-009	Brass cap in concrete cylinder – flush with ground	North side of Allen Street in the City of Waterloo, Approximately 63 metres East of King Street and 18 Metres West of Mary Street, Waterloo	538942.773	4812107.808	326.540



Exhibit 2.3-1  
List of Control Points

Monument No.	Description	Location	Easting	Northing	Elevation
029-11-010	Brass cap in concrete cylinder – flush with ground	Easterly side of Mount Hope Street in City of Kitchener, North of Park Street and 15 metres South of King Street, Kitchener	539372.251	4811732.410	336.140
029-11-011	Brass cap in concrete cylinder – flush with ground	North side of Louisa Street, West of Moor Avenue, and approximately 62 metres East of King Street, Kitchener	540146.616	4811482.683	343.326
029-11-012	Brass cap in concrete cylinder – flush with ground	Westerly side of Francis Street, North of Charles Street and Approximately 22 metres south of King Street, Kitchener	540717.928	4811131.355	330.800
029-11-013	Brass cap in concrete cylinder – flush with ground	South side of Charles Street between Benton and Eby Streets in the City of Kitchener, approximately 57 metres East of Benton Street in front of House No. 19	541456.521	4810691.886	338.826

Exhibit 2.3-1  
List of Control Points

Monument No.	Description	Location	Easting	Northing	Elevation
029-11-014	Brass cap in concrete cylinder – flush with ground	Northwesterly side of Pandora Avenue South between King Street and Charles Street in the City of Kitchener, 25.5 metres northeast of Charles Street	542118.733	4810325.638	323.632
029-11-015	Brass cap in concrete cylinder – flush with ground	Northwesterly side of Borden Avenue, South of King Street and approximately 17 metres north of Charles Street, City of Kitchener	542543.014	4810078.803	321.989
029-11-016	Brass cap in concrete cylinder – flush with ground	Northeast side of Alley, Northeast of the Railway, Northwest of Ottawa Street and approximately 24 metres Southwest of Grenville Avenue, City of Kitchener	512103.236	4809291.212	324.951
029-11-017	Brass cap in concrete cylinder – flush with ground	North side of Overland Drive, South side of Conestoga Parkway, East of Ardelt Place and 18.2 metres East of the Easterly rail of the Canadian National Railway, City of Kitchener	542651.030	4808675.776	317.868

Exhibit 2.3-1  
List of Control Points

Monument No.	Description	Location	Easting	Northing	Elevation
029-11-018	Brass cap in concrete cylinder – flush with ground	Westerly side of Courtland Avenue, South of Walton Avenue and approximately 20 metres North of Hayward Avenue, City of Kitchener	543190.934	4808344.550	320.674
029-11-019	Brass cap in concrete cylinder – flush with ground	South side of Siebert Avenue, West of Vanier Drive and approximately 20 metres East of Courtland Avenue, City of Kitchener	543921.217	4807710.983	314.548
029-11-020	Brass cap in concrete cylinder – flush with ground	Easterly side of Wilson Avenue, North of the Railway Lands, approximately 74 metres South of Fairway Road, City of Kitchener	545140.806	4807640.430	326.738

- (iii) Fly levels shall be run between Primary Vertical Control Points and adjusted through all Project Horizontal & Vertical Control Points, (Bench Marks and Total Station Points).
  - (iv) The adjusted fly level elevations for the benchmark, total station control, and Horizontal Control Points shall be inserted as the elevation attribute.
  - (v) All Primary and Project Horizontal and Vertical Control Points require a Centreline of rail chainage and an offset distance.
- (d) Horizontal Project Control
- (i) The Project shall be co-ordinated in UTM Zone 17N using the primary horizontal NAD 83 CSRS control values provided.
  - (ii) Project Co shall add intermediate project control points as necessary to allow for the data capture of any Right-of-Way monumentation or topographic features as per the coverage requirements.

- (iii) Each new monument shall be intervisible with at least two other Horizontal Project Control and/or Primary Horizontal Control Network points. The monuments shall be set within the LRT Right-of-Way corridor and out of the grading area such that they shall likely not be destroyed during construction and also set at a maximum spacing of 250 metre intervals.
- (iv) Orange wooden marker stakes (1.2 metres in length and 5 centimetres square) shall be placed beside all Project Control Points with the exception of stakes that may interfere with traffic. Project Co shall supply and install all stakes.
- (e) Detail
  - (i) The Region will supply a common coding list with proper identifiers for AutoCAD Civil 3D.
  - (ii) All manmade and topographical features shall be detailed to 10 metres past the existing Right-of-Way limit or to building face where buildings are located.
- (f) Digital Terrain Model
  - (i) Break lines along edges of features shall be followed and used as fault lines in the Digital Terrain Model (DTM).
  - (ii) All topographic features shall be shown whether natural or manmade.
  - (iii) Field notes and sketches shall be kept to ensure that any natural break lines are used as fault lines.
  - (iv) One model is required for the entire alignment.
  - (v) The TIN shall respect all fault lines as noted in the standards. It shall be cleaned up with extraneous vectors removed and vectors flipped if necessary to prevent aberrations in the contours. Points with elevations, which do not properly reflect the ground elevation, shall not be used for the TIN, (examples: top of Right-of-Way monuments, bars, top of openings of culverts, etc.)
  - (vi) Coverage Limits:
    - A. Minimum coverage right and left of centreline shall be
      - 1. a minimum 5 metres past the existing LRT Right-of-Way limits along property frontages
      - 2. a minimum of 15 metres on to existing entrances to confirm tie in slopes and drainage;
      - 3. extending a minimum of 100 m along intersecting streets
- (g) Cross Sections
  - (i) The ground model shall be of sufficient coverage and density to generate cross-sections from the applicable centreline to 5 metres beyond the existing or proposed Right-of-Way limits or to the drainage breakpoint at the following intervals:
    - A. 25 metres plus breaks in number of lanes, changes in cross-section, intersections, mid-block between intersections and at platform locations.

- (h) Commercial Entrances
  - (i) Entrance alignments shall be generated to a minimum of 15 metres, from the centreline of proposed alignment or 5 metres past the existing Right-of-Way limit (which ever is greater). The ground model shall be of sufficient coverage and density to generate cross-sections every 10 metres with an additional section at the Right-of-Way to 15 metres right and left.
- (i) Sideroads
  - (i) Side roads shall have alignments and profiles generated to 100 metres from the applicable centreline. The ground model shall be of sufficient coverage and density to generate cross-sections at 10.0, 25.0, 50.0, 75.0 and 100.0 metres from the centreline.
- (j) Plan and Profile
  - (i) Plans and Profiles shall be produced.
  - (ii) The plan portion shall show all main road and side road alignments with the stationing and curve data and all detail features as per Region of Waterloo CAD Standards.
  - (iii) Each plan shall illustrate a maximum of approximately 250 metres of LRT alignment.
  - (iv) All features shall be correctly labelled.
  - (v) All existing Right-of-Way monumentation shall be located and limits shown as per the property plans supplied.
  - (vi) Reference Plan mark-ups of found, missing and disturbed monumentation shall accompany each relevant survey submission.
  - (vii) The profile portion shall show the datum grid with the alignment stations and the centreline profile plotted. Culverts shall be plotted with the correct description and with the chainages, offsets and elevations shown for each end.
- (k) Field Inspection
  - (i) A set of roll plans demonstrating that a complete and thorough survey field check has been completed is to be submitted. All data shall be crosschecked with existing and new plans and any disagreement shall be noted in red and corrected.
- (l) Plans – General
  - (i) Drawings shall be in AutoCAD Civil 3D 2013, \*.dwg format. Scale shall be 1:250 horizontal and 1:50 vertical.
  - (ii) All plans, profiles, ground model and alignment shall be co-ordinated (NAD 83, CSRS values in MTM 3° Zone 17 co-ordinates).
  - (iii) The plan title block shall conform to the Region of Waterloo Standards.
  - (iv) Each plan is associated to an AutoCAD Project. The Project shall contain all of the required digital data. The Project shall be named after the plan number. The Project shall include the raw field data in the survey folder. The Horizontal and Vertical control files shall be named according to the plan number with “hv” added to the beginning of the plan number.

- (v) As-Constructed Plans – Drawings shall be prepared to allow for the submission of as-constructed plans to each governing authority (Region, City of Kitchener, City of Waterloo, CN, and GEXR). All drawings and data submissions shall comply with the most stringent standard which is the City of Kitchener Constructed Asset Submission Manual. The number of hardcopies to be submitted shall be three (3) hard copies to the governing authority and two (2) copies to the Region Rapid Transit for review. Final documents shall be submitted in digital format and hardcopy on Mylar (2 copies per governing authority).
- (m) Right-of-Way
  - (i) Project Co shall locate field survey and coordinate all of the existing Right-of-Way monumentation in order to illustrate the Region lands as indicated below.
  - (ii) An identification plaque and 25 mm (1”) sq galvanized tube delineator post shall be placed beside all monumentation.
  - (iii) Coordinated field observations, in conjunction with plan and document information from LRT/Region of Waterloo and Land Registry Offices, are to be used to illustrate the current limits of the LRT/Region of Waterloo Right-of-Way and adjacent lot fabric.
  - (iv) LRT/Region of Waterloo limits are to be depicted as per the Existing Conditions Drawings with the defining reference plan number labelled outside the limits and using the arrow leader feature to illustrate inside the LRT/Region of Waterloo limit.
- (n) Legal Survey Monument Protection Program
  - (i) LRT/Region of Waterloo has experienced significant damage to Right-of-Way monumentation due to construction. In an effort to minimize this damage, the service provider shall supply and erect marker posts at all iron bars or standard iron bars planted on the roadway Right-of-Way limits unless conditions (such as parking lots, residential areas) make it impractical or unsafe.
  - (ii) A marker post may also be excluded if it shall be within 3m of another marker and a marker stake may be used instead.
- (o) Legal Survey Monument Marker Post
  - (i) Provide and place legal survey monuments in accordance with Ontario Land Survey Standard practice.
- (p) Staking
  - (i) White enamel paint shall be used on existing paved surfaces. Markings on pavement shall be in this format: 10+1, +, +5, +, 10+2. (Full station is required every 100 metres.)
  - (ii) Alignment is to be painted on the edge of the northbound lane at a consistent offset.
  - (iii) Stationing shall reflect the start and end chainages outlined above and the best-fit approved alignment generated during processing.
  - (iv) Alignment curve points (TS, SC, CS, ST, BC, and EC) shall be painted as well.
- (q) Pavement Markings

- (i) Pavement Marking Detail Notes shall be recorded after the approved alignment has been staked.
- (iii) The preparation of plans, profiles and the Digital Terrain Model shall be in AutoCAD Civil 3D 2013.
- (r) Permission to Enter
  - (i) Every effort shall be made by Project Co to obtain permission from the property owner, prior to entering onto privately owned property for the purposes of obtaining pre-engineering survey data. Project Co shall clearly inform the property owner the purpose of the survey and to update engineering plans information with no immediate effect on the existing Right-of-Way limits.

**2.4 Alignment Control and Right-of-Way (ROW)**

- (a) Control Survey
  - (i) A control survey of the proposed corridor shall be performed by Project Co. using an Ontario Land Surveyor (O.L.S.).
  - (ii) This line shall serve as the baseline for construction. Primary control points shall be set approximately every 1000 metres. These control points shall be tied to all Region, local, utility, railway, provincial or federal monuments within the corridor. A coordinate (x, y, z) value shall be established for each control point and other monuments in each of the various coordinate systems within the area.
  - (iii) The points shall be numbered with consecutive numbers in the direction of the survey. Primary control points shall start with alpha characters GPS-xxx. Secondary points shall start with the alpha character S-xxx. Photo control points shall start with the alpha character T-xxx.
  - (iv) Horizontal Control
    - A. Primary control points shall be located using a Global Positioning System (GPS) to meet or exceed horizontal accuracy of Order “C” 1:100,000 closure, as defined by the Federal Geodetic Control Committee. The secondary control points shall be located by traverse. The traverses shall begin and end at a primary control point with a horizontal closing accuracy of 1:50,000 and triangular closure average not to exceed 100 mm. Closure results and adjustments shall be provided to the Region for all traverse lines.
  - (v) Vertical Control
    - A. Project Co shall provide elevations for all of the monuments to the nearest 0.001 meter, following the requirements of Federal Geodetic Control Committee Classification for Second Order Class II. All points shall be turned through using differential levels on NGVD 1929. Levels shall begin from a basic control benchmark, go to the point, and then carry the levels back to the original benchmark or to a second benchmark. The point itself shall be included as a turning point in the level line, and the rod reading itself shall not be observed as a side shot.

- (vi) Monumentation
  - A. Primary control points for all locations described in this Article shall be marked with a 16 mm (5/8") diameter iron rod with a 63 mm (2.5") brass cap, set flush. Monuments shall be located in a place where local disturbance is at a minimum and out of the way of future construction. In locations where iron rods may not be driven, a substitute material may be used, provided that it shall last.
  - B. The monuments shall be witnessed by a minimum of three local swing ties. The location of these ties shall be carefully noted in the certified field notes. The field notes shall include a sketch with a description, distance, and bearing from the monument. Project Co shall take a vertical photograph in the field showing the monument and the witness points. The back of the photo shall contain the date, monument number, and the swing tie direction from the monument; e.g., ESE of Monument GPS-015.
  - C. Elevations for monuments shall conform to the requirements of this Article and to the requirements of the Region. Datum's shall conform to Region standards.
- (vii) Note Keeping
  - A. Field Books - When field notes are kept in field books, they shall be neat and orderly and generally in accordance with The Handbook of Survey Note Keeping (F. Wm. Pifford, Wiley & Sons, Inc.). Original field notes shall be submitted to the Region.
  - B. Each session shall be preceded by the following information: date; time; party member's function, first initial and last name only (no nickname); general weather conditions; instrument(s), including serial number(s); and north arrow on sketches. All lettering shall be at least 6.35 mm (1/4") in height, neatly written, and legible. Adequate space shall be left for reduction of all notes.
  - C. Electronic Field Notes - Data gathered electronically shall be transmitted via CD/DVD or transferred electronically AutoCAD Civil 3D 2013 compatible with Digital Terrain Models (DTMs) in Design Web Format (DWF) format. The disks shall also contain data in an ASCII file, which shall list point number, x value, y value and z value, along with an identification label.
  - D. Hard copies shall also be transmitted. The hard copies shall be paper plots of data on 558.8 mm x 863.6 mm (22" x 34") drawing size, and 215.9 mm x 279.4 mm (8.5" x 11") printouts of the ASCII file. Each printed copy shall have the logo/name of the surveyor, Project name, date of survey, time, party member's function (first initial, last name only - no nicknames), general weather conditions, instrument including serial number, location and type of survey. The layering, symbols and format shall be furnished by the Region.
  - E. Every sheet shall have a certification for a "true and correct copy" of data, attested to by an Ontario Licensed Surveyor (OLS). Any digital format shall also contain the same certification.
  - F. Samples of the above shall be submitted to the Region for review.



- G. Supplementary sketches and field notes, during electronic field data acquisition, particularly in areas of complexity, shall be provided.
- (viii) Miscellaneous Surveys
  - A. Pre-construction utility, structure and pavement condition surveys shall be prepared by the Project Co. These surveys shall identify existing utilities, structures, and pavement conditions, on and adjacent to the construction site, which have the potential to be damaged by Project Co's construction operations.
  - B. Clearance field surveys shall be performed to check areas of tight clearance in the horizontal and vertical plane. The surveys shall be on an "as-needed basis" per particular site.
  - C. Cadastral field surveys shall be performed in areas where Right-of-Way purchases or long-term easements require precise delineation for the preparation of land descriptions when transferring property title.
  - D. Surveys shall be performed to field locate and verify utilities along the LRT alignment.
  - E. Topographic and planimetric field surveys shall supplement aerial mapping in areas needing further definition. Areas requiring supplemental data may include the undersides of bridges along the alignment, intersections of roadways (for definition of grading requirements), and other areas where required.
  - F. For construction survey requirements see Schedule 15-2 Article 18.
- (ix) Permits and Access Rights
  - A. Project Co shall prepare all necessary applications including any necessary attachments to secure all necessary and required permits, access rights, and other jurisdictional approvals, for these efforts on this Project. Copies of all applications and associated attachments shall be forwarded to the Region. Permits and access rights on private property shall be coordinated with the Region requirements.
- (b) Right-of-Way
  - (i) The Region of Waterloo has or is in the process of obtaining the permanent land and easements required for the construction of the LRT. The existing and proposed permanent Right-of-Way limits are shown on the RFP drawings

Project Co shall design the System to stay within the proposed permanent Right-of-Way limits shown on the RFP drawings.

After Commercial Close, if Project Co. wishes consideration of acquisition of additional permanent land or easement(s) that may improve Project Co's design, then Project Co shall propose a Variation in accordance with Schedule 22 Variation Procedure. This process would have Project Co send the Region a Project Co. Variation Notice including sufficient detail to enable the Region to evaluate the land acquisition proposal in full, including cost savings to the Region and any other implications. If the Region, in its sole discretion, elects to consider the Variation, the Region would issue a Variation Enquiry and go through the Estimate process and Variation Confirmation process if approved by the Region.

Moreover, Project Co has been previously advised of the land expropriation process and its estimated time lines which shall be reflected in an updated Project Co. Schedule as part of the Variation procedure. Project Co. will not be compensated for any delay resulting from the land expropriation process whether within or in excess of any estimated timelines for land acquisition by expropriation or otherwise.

Temporary Right-of-Way rights also require a justification prepared by Project Co and submitted to the Region for approval and the above-noted provisions apply similarly to such proposed acquisition.

(ii) Types of ROW and Definitions

A. Consent to Enter - Verbal or written permission given by a property owner to a third party to enter lands owned by the property owner for a limited purpose and duration. Consents to Enter are typically not registered on title to the land owner's property and are typically appropriate where very minor encroachments may be necessary. As part of its negotiations with property owners expropriated for the Project, the Region has solicited written and/or contractual Consents to Enter to:

1. Reconstruct/widen the adjacent Regional Road whose cross section shall include LRT and associated works, as well as, to relocate and replace utility infrastructure as deemed necessary by design (collectively, the "Work");
2. Remedy or repair any physical impact to the property owner's retained lands resulting from the Work; and
3. Assess the condition of the property owner's retained lands and/or any buildings thereon, as deemed necessary.

It is generally a requirement that entry be as minimally intrusive as reasonably possible. Any damage caused to property owners' lands must be rectified. The term of the Consent to Enter generally expires upon the "completion of the Work and associated remedial activity". Most expropriated property owners that the Region has negotiated a settlement with have agreed to the above wording or a modified version thereof. Negotiations with expropriated property owners are ongoing. Some property owners that have provided Consent to Enter have sought indemnity from the Region in the event that they suffer losses or damages as a result of the Consent to Enter. The Region solicited similar Consents to Enter from property owners along the Project alignment that are not being expropriated with minimal response. Where temporary access to private lands is essential, the Region may expropriate a Construction Easement. It is the Region's experience that expropriations can take between 6 and 12 months to complete. Project Co shall identify all properties where Project Co requires Consents to Enter (where entry onto private lands is minimal) or Construction Easements (where entry onto private lands is substantial) for the Region to

consider pursuing on behalf of Project Co either by negotiation or by expropriation.

- B. Fee Simple Ownership - Fee Simple Ownership is a condition in which ownership of the property purchased extends radially from the center of the earth outward through specified lateral limits on the surface of the earth to the sky subject to any Crown statutory, or title abstract reservations. Any fee acquisition of lands by the Region shall include sufficient space for the construction, operation, and maintenance of the facility to be constructed, at, above, or below surface. The recommended width incorporates basic track width, drainage, supporting slopes, utilities, and overall effect on the affected property. (Typical examples of Fee Simple Ownership include sites for traction power substations, adjacent streets, highways, and railroads.)
- C. Permanent Easement\* - In some cases, such as within railroad Rights-of-Way or utility easement areas, it may not be advisable economical or possible to acquire timely fee simple interests. In these cases a permanent easement in lieu of fee ownership may be acquired. Permanent Easements are registered on title to the affected property and contain appropriate terms of use, as well as, conditions and covenants that must be fulfilled. Easements typically require the transferee to rectify any physical impacts caused to easement lands as a result of work carried thereon. The transferor of a Permanent easement is typically required to refrain from any action that interferes with the transferee's works or the transferee's ability to access its works from time to time.
- D. Slope Easement\* - A Slope Easement is a permanent easement that is obtained for the specific purpose of supporting slopes for the LRT facility or relocated roads or streets. This easement may be discontinued in the future if the fee simple owner provides alternative support satisfactory to the Region or the owning municipality. This easement shall have definite lateral limits and will be registered on title.
- E. Aerial Easement\* - An Aerial Easement is a permanent easement that provides aerial rights in relation to a portion of the LRT facility. This easement type is registered on title to affected lands and has definite lower and side limits. Upper limits shall be described only where special limiting features exist. The instruments of conveyance for aerial easement shall include language to restrict the use of the surface under the structures to prevent storage of hazardous materials or any usage that may have a detrimental effect on the LRT structure or transit operation.
- F. Construction Easement\* - A Construction Easement (temporary occupancy) is, in most cases, an easement or short-term lease that provides sufficient space to allow for the temporary use of property by Project Co during construction. This easement shall have definite lateral limits and is typically registered on title to affected lands. Construction Easements are advisable where the constructor is required to encroach in more than a de minimus way on private lands that are adjacent to the construction. For purposes such as slope construction and cut-and-cover construction, a Construction Easement may be required over the subsurface easement that shall envelop the structure. Where an aerial easement is

to be acquired, a Construction Easement may be required under the aerial structure. Project Co shall restore the surface to its original condition, unless otherwise directed, at the completion of work within the Construction Easement area. This easement has a defined duration, but is temporary in nature.

- G. Access Easement\* - An Access Easement may be either permanent or temporary. Access Easements are typically registered on title to affected lands and provide temporary or permanent rights of access to a defined area (such an LRT facility) when other access is not available. Access Easements may authorize ingress and egress, as well as, the transportation of materials equipment and people, as necessary. This easement shall have definite lateral limits and, if temporary, shall have a definite duration. If this easement is acquired for Project Co's use, Project Co shall restore the surface to its original condition, unless otherwise directed, at the completion of the use of this easement.
- H. Utility Easement - A Utility Easement is a permanent easement that provides space for the relocation of extension utilities or the installation and maintenance of required utilities. Any Utility Easement acquired for facilities other than those owned by the Region may be transferred to the agency responsible for maintenance of said facility upon completion of construction. Utility Easements are typically registered on title to affected lands.
- I. Drainage Easement - A Drainage Easement shall be considered a Utility Easement.
- J. The instruments conveying permanent easements shall include language to provide for review and approval of plans for all construction over or under the easement. The instruments covering temporary easements shall include the duration of the easement and provide for incremental extensions, should they be required.
- K. \*Reference must be made to easement documents at all material times in order to ensure compliance with applicable terms and conditions. It is to be noted that, among other things, easement agreements may require for certain notices to be provided to the fee simple owner, tenants, or otherwise prior to the use of the easement lands by the transferee of the easement and/or may define the periods in which the easement lands can be accessed by the said transferee. The fee simple owner may have the right to review plans in relation to the works proposed on affected lands.

(iii) Criteria

- A. The following criteria are provided as a guideline for establishing the ROW limits. The dimensions given are for general conditions and are to be modified where engineering or real estate requirements dictate. It is particularly important to avoid taking where possible. This may be accomplished by reducing or increasing the distance from the LRT facility or by stepping the limits around a certain property. The ROW limits shall be established to include any required security fence and its support structure. The following distances are offered only as a guide in establishing the final ROW requirements early in the design and are subject to change as individual circumstances require. All ROW limits shall be horizontal or vertical planes.

- B. It shall be noted that most subsurface easements shall have a maximum loading restriction on the upper limits.
- C. Construction Easements
  - 1. Construction easements shall be delineated to provide sufficient room for the Project Co to actively proceed with the work without adversely impacting adjacent properties. Where necessary to avoid additional taking, it may be advisable to constrain the construction methods and establish tighter easement limits.
  - 2. As construction easements are required for a limited period of time, the duration of the easement shall be defined.

## **2.5 Geotechnical Design Criteria and Parameters**

- (a) Project Co. shall provide a Draft Geotechnical Design Report and Final Geotechnical Design Report for each structure that contain sufficient detail to describe the geotechnical assessments completed to develop the Design, rehabilitation or modification of each structure. Project Co. shall address all Engineer review comments to the satisfaction of the Owner Engineer before issuing the Final Geotechnical Design Report.
- (b) Design Codes, Manuals, and Specifications
  - (i) Unless otherwise specified herein, the geotechnical and foundation design shall be governed by the current editions of the following codes, manuals or specifications:
    - A. The criteria included in this Article;
    - B. The applicable codes used for the structural design shall be as follows:
      - 1. Structures subjected to LRT loading: Canadian Highway Bridge Design Code CAN/CSA-S6-06(R11).
      - 2. Structures subjected to railway loading: CN – Engineering Specifications for Industrial Tracks & AREMA – American RAILWAY Engineering of Maintenance-of Way Association, Manual for Railway Engineering 2012.
      - 3. Other structures: Ontario Building Code (OBC) 2006 & National Building Code (NBC) 2005.
    - C. OPSS and MTO standards
    - D. Canadian Foundation Engineering Manual, 4th Edition
    - E. Region of Waterloo Building codes, by-laws, codes, enforcements, ordinances, permits, policies, procedures, standards, statues, regulations, etc.
- (c) Geotechnical Investigation and Data Analysis
  - (i) The conceptual geotechnical data reports, subsurface investigation data, boring plans and profiles, foundation information and the presentation of boring sheets provide baseline geotechnical information. The geotechnical documents included in the RFP shall not serve as the basis for preliminary nor final design. Project Co. shall plan and perform subsurface investigations and laboratory testing, interpret the results of the field investigations and laboratory testing programs, and conduct studies and analyses that

incorporate the results of these investigations and tests to provide the basis for the geotechnical and foundation design for the LRT. Project Co. shall provide the results of investigations and testing to the Region for review.

- (ii) Except as specified herein, Region standards shall be followed with respect to planning, performing and reporting subsurface exploration programs as defined in the RFP documents. Among the requirements for the borings and laboratory investigations to be performed for the design of the LRT are the following:
    - A. Marking boreholes on site and obtain all utility clearances, including Ontario 1 Call, for all the borehole locations prior to the drilling operation.
    - B. Supervision - All boring and in situ testing inspection and all laboratory classification and testing shall be performed by qualified technicians under the direct supervision of a licensed professional engineer. All boreholes should be backfilled with drill cuttings mixed with bentonite hole plug. The backfill material should be compacted with the drill rig. As such, the boreholes shall be abandoned in accordance with O. Reg. 903 requirements.
    - C. Environmental field screening (visual and photoionization detector) of boring samples shall be completed to assess any additional localized environmental areas of concern. Any areas of concern shall be communicated to the Region immediately.
  - (iii). Location and Ground Surface Elevation - Project Co. shall determine the coordinate location and ground surface elevation for each boring and shall show both the coordinates and the elevation on the individual boring logs
  - (iv) Project Co. shall make an independent interpretation of the available factual information related to subsoil and groundwater conditions, and based on this interpretation, shall select appropriate parameters for the design of temporary and permanent work. The baseline geotechnical data may not present all of the data available for the Project area. Project Co. shall collect and review all available geologic, subsurface, groundwater and foundation information. Project Co. shall propose additional field and laboratory investigation work to supplement available information, as required for both preliminary and final design. All subsurface investigation and laboratory testing shall be performed in accordance with the appropriate ASTM standards.
- (d) Geotechnical Design Report
- (i) The geotechnical Design Report shall, as a minimum include the following data:
    - A. A summary of all geotechnical data and findings, including the results of the review of existing information, results of the field subsurface investigations, results from laboratory tests, geotechnical and foundation analyses and design, shall be prepared in the form of a series of Geotechnical Reports. The reports shall include:
      - 1. Site Description
        - I. Briefly describe the site including general topography, rock outcrops, sinkholes, existing improvements, existing embankments, waterways, underground utilities, cisterns, etc., which could affect

- site development. Give a brief geologic description of soils and bedrock. Describe the subsurface soil conditions based on site borings. Comment on potential for swelling or shrinking, corrosion, landslides, sinkhole, collapse, creeping, and seismic activity / liquefaction known to exist locally and/or at the site. Provide the seismic site class information requested in this Article.
2. Boring Logs: Provide individual boring logs of all test borings on 215.9 mm x 279.4 mm (8½” x 11”) sheets in the report showing:
    - I. ground surface elevation (USGS Datum);
    - II. depth and thickness of various subsurface strata;
    - III. strata classifications;
    - IV. soil classifications per ASTM International (ASTM) D2487 or D2488;
    - V. sampler size;
    - VI. Type And Weight Of Hammer;
    - VII. Distance Of Hammer Drop;
    - VIII. Penetration Resistance Numbers;
    - IX. Description Of Moisture Contents In Soil;
    - X. Core Barrel Size;
    - XI. Core Recovery Ratios;
    - XII. Rock Quality Designation (RQD);
    - XIII. Ground Water Levels; and
    - XIV. Measurement Data.
  3. Groundwater: State whether or not groundwater was observed. If applicable, indicate depth of groundwater from existing grade. Provide recommendations to control groundwater across the site where high groundwater is anticipated during and/or following construction. This shall include the need for a Permit to Take Water or other hydrogeological works.
  4. Boring Location Drawings: On a scaled site plan that includes the proposed alignment, roadway or building/structure location show all boring locations, benchmark location(s), and description. Include the location of additional explorations (test pits or piezometers) on the drawing.
  5. Engineering Analysis and Recommendations: Include recommendations for site development including excavation and fill requirements, foundation types, pavement design, allowable bearing pressures, liquefaction potential, potential static and seismic settlement, recommended fill types, moisture conditioning of soil to be used as fill, and any other information on soil

utilization, or behavior likely to influence the integrity of the proposed Project.

6. Seismic Analysis: Provide all seismic parameters including site class, based on latest CAN/CSA-S6-06(R11) or Ontario Building Code and latest National Building Code, as applicable, for Seismic Hazard Calculation.
7. Lateral Earth Pressure: Provide allowable bearing pressure for site retaining walls if different from building foundations. Provide recommended values of the following parameters for on-site material and for free-draining engineered fill:
  - I. Active pressure;
  - II. At-rest pressure;
  - III. Passive pressure;
  - IV. Coefficient of sliding friction; and
  - V. Ultimate values (no factor of safety included) for the passive earth pressure and coefficient of sliding friction, so state in report;
  - VI. Protection Depth;
  - VII. Potential liquefaction of susceptible granular soils;
  - VIII. Potential settlement problems, potential stability problems; and
  - IX. Recommendation for the excavation, backfilling, and construction comments for dewatering, etc.

(e) Foundation Design

- (i) The criteria set forth herein shall pertain to the geotechnical and foundation design for bridge, at-grade, and retained earth structures and embankments of the track structures, and bridge station platforms supported on the bridge track structure. Foundation and geotechnical design for these facilities shall conform to the applicable design code. Refer to Schedule 15-2, Article 15 Structures among other Project Agreement requirements not mentioned or stated herein.
- (ii) Settlement - Analyses shall be conducted to estimate the soil settlement induced by the foundation loads. Immediate settlements for granular soils and both immediate and primary and secondary consolidation settlements for cohesive soils shall be considered. Shallow foundations shall be designed to keep estimated settlements within the allowable values. Effects of adjacent foundations and surcharge loads shall be considered when evaluating foundation settlements and bearing capacity. Shallow foundations shall be designed such that the resultant load falls within the middle third of the foundation for non-seismic loading. Settlement induced by the deep foundation group in the subsoil shall be evaluated. In addition, settlement of the individual deep foundation elements shall also be evaluated
- (iii) Corrosion Protection - Project Co. shall conduct a corrosion study and evaluate the need for corrosion protection for the foundations of all LRT structures. The study shall be based on available information together with information developed as a result of field



and laboratory investigations conducted by Project Co. The results of these investigations shall be presented in a report. The report shall be submitted to the Region for review. The report shall include conclusions regarding the need for corrosion protection and recommendations concerning the type and extent of the protection required, if any. Based on the findings reported, Project Co. shall modify the proposed protection as directed by the Region.

- (iv) Conventional and non-conventional retaining walls shall be evaluated for use along the LRT alignment. Conventional walls shall include gravity, cantilever, steel sheet-piling, and soldier pile and lagging. Non-conventional walls shall include mechanically stabilized walls consistent with the designs of other elements established by the Region. The lateral pressures on retaining walls shall be evaluated on the basis of anticipated structure movements and site-specific subsurface conditions and construction methods. The design of all earth retaining structures shall conform to current engineering practice. These walls shall be designed to resist all anticipated dead, live, vertical, seismic, and lateral loads. These loads shall include those induced by soil, groundwater, live load, surcharge, and construction equipment.
- (v) Where liquefaction of soils can occur, lateral resistance calculations shall assume zero soil support from the design water level to the bottom of the zone of potential liquefaction. The lateral displacement in either direction at the pile cap level shall be limited to a value consistent with the design limits of the superstructure and expansion joints. A detailed structural analysis shall be provided to include induced foundation lateral and axial loadings as well as vertical loading on batter piles, stability and pile bending stress determinations during the occurrence of liquefaction.

In conjunction with the evaluation of potentially liquefiable zones within the Project area, analyses to establish estimates of seismically induced settlement shall be made by Project Co., during preliminary and final design, to determine the need for soil improvement or other measures to limit such settlement, as required, within at-grade and embankment sections of the LRT. These estimates shall be based on available subsurface information and new subsurface and soil properties information developed as a result of the field and laboratory explorations performed by Project Co.. Project Co. shall utilize the results of the liquefaction evaluation and estimates of seismically induced settlement to establish the most cost-effective design for the LRT. The liquefaction potential shall be evaluated using procedures considered as standard practice in the field of earthquake geotechnical engineering (e.g., Seed et al., 1985), yet accounting for site-specific data and findings of recent research and development.

- (vi) Shallow foundations for retaining walls shall be designed in accordance with recommendations in this Article. Base pressure shall not exceed the allowable soil bearing capacity in accordance with this Article. In order to minimize differential settlement, walls shall be proportioned so the resultant of all forces acting falls within the middle third of the base when on soil. Where the combination of foundation soil compressibility and base pressure is such to produce differential settlement of such a magnitude that outward tilting of walls is excessive, walls shall be proportioned to have the resultant of all forces acting fall closer to the center of the base to provide a more uniform settlement.

- (vii) Where the base pressure exceeds the allowable soil bearing capacity, or where the base pressure is such to produce excessive total or differential settlement; walls shall be founded on piles, provided that a more economical solution cannot be obtained by changing the wall proportions.
  - (viii) External stability analyses shall be conducted in accordance with the applicable Design Code for all retaining structures. The external analyses shall include sliding, overturning, global slope stability, bearing capacity, and local shear failure. Passive earth pressure in front of the foundation shall not be considered in the evaluation of sliding and overturning failures. Mechanically stabilized earth walls shall also be analyzed for internal stability, which shall include tension in the reinforcement and pull-out resistance along the soil-reinforcement interface.
- (f) Pavement Design
- (i) Geotechnical investigations shall be completed in accordance with the data requirements of the TAC Pavement Design and Management Guide.
- (g) Design Loads
- (i) Vertical Loads - The loads used in the design of permanent Work shall be in accordance with the requirements of the relevant design codes and standards, except where herein modified or augmented.
  - (ii) Estimation of loads due to pedestrian, road, or rail traffic shall be in accordance with the requirements of Schedule 15-2 Article 15.
  - (iii) Loads due to soils or backfill shall be derived using the maximum values of the saturated densities. Only where it can be clearly demonstrated the fill is well drained, and shall remain well-drained in the future, shall any reduction in the degree of saturation be allowed. The submerged densities shall be used for soil unless the location is above the standing water table.
  - (iv) Lateral Pressure - Lateral earth pressures shall be estimated on the basis of the anticipated movement of the structure. For yielding retaining structures, Rankine's active pressure theory shall be used. However, for unyielding structures, where the movement of the structures is not sufficient to mobilize active pressures, and/or where compacted backfill is placed behind the structure, the lateral pressure on the structures shall be evaluated on the basis of anticipated movements, site-specific subsurface conditions and construction methods as specified in this Article. The pressure on unyielding structures may be higher than at-rest pressure but in no case shall the pressure be less than at-rest pressure. The earth pressures used in the design of non-conventional walls shall follow established standards for these specialized types of structures.
  - (v) Hydrostatic pressure induced by the groundwater table shall be included in the lateral pressures.
  - (vi) Lateral pressure induced by surcharge loads applied at the ground surface behind the wall shall be included as appropriate. These surcharge loads shall be evaluated on a site-specific basis, and may include uniform surcharges, strip loads, line loads, point loads, area loads, and construction equipment loads. The lateral pressure induced by these surcharges shall be no less than two times the pressure estimated using elastic theory.

- (vii) Dynamic Earth Pressure - Dynamic earth pressure induced by seismic events shall be included in the design of retaining structures. For structures that can displace horizontally, these pressures shall be estimated, in general, using the pseudo-static approach developed by Mononobe and Okabe.
- (viii) The minimum factors of safety that shall be used in the external and internal stability analyses are per the applicable design code.
- (h) Construction Considerations
  - (i) General
    - A. Alternative methods of embankment construction shall be compared for safety and cost-effectiveness. The main consideration shall be to provide an adequate safety factor against bearing capacity failure and to reduce the settlement to within the allowable range.
    - B. Soil Improvement - Consideration of methods of soil improvement shall be allowed in the design. It shall be necessary to demonstrate their suitability for local conditions and installation methods.
    - C. Drainage - Provision shall be made in the design for an adequate system of drainage which incorporates sufficient capacity for the design rainfall run-off.
    - D. Drainage of large areas may be provided by the use of a drainage layer, either a suitable fill material or geotextile. Notwithstanding the requirements of the relevant standards, consideration shall be given to the long-term performance of the drainage system under local conditions.
    - E. Vertical Drains - The use of vertical drains may be included in the design in order to expedite the consolidation of areas, where it is required to increase bearing capacity or reduce post-construction settlements. Selection of the type of vertical drain shall depend on the engineering properties of the subsoil, but factors such as material quality, performance, supply and installation time, and available expertise shall also be considered.
    - F. All vertical drainage systems shall be designed using a recognized method, with allowance being made for installation disturbance.
    - G. Earthwork Supporting Rail Tracks - The track foundation shall consist of ballast, sub-ballast, and, if required because the subgrade consists of fine-grained material subject to saturation, a geotextile suitable for the application shall be provided.
    - H. The design of the geosynthetic shall depend on the ground condition at subgrade level. On embankment, the geosynthetic shall be designed to preclude saturation of the subgrade and prevent migration of fines into the ballast. In cuts where the subgrade could become waterlogged, the geosynthetic shall assist drainage and prevent fines from rising into the ballast under the pumping action of the wheel loading.
    - I. In order to minimize settlement, the track construction depth shall be increased as necessary in cuts or on embankments, depending on the condition of the subgrade. Fill material shall be graded to minimize long-term settlement with the aid of compaction and overfilling.

- J. The subgrade shall be sloped to gradients such that the required slope is maintained after settlement is complete.
  - K. The design of the trackwork foundation shall limit settlement to the allowable design values.
  - L. Drains shall be provided on both sides of the track bed and shall be tied into the Regional stormwater system at reasonable intervals in a manner to minimize surcharging of the storm sewer into the subdrain system.
  - M. Transition Slabs - The transition slab shall have a length not less than 6 metres.
- (ii) The cut-and-cover structures shall be designed for the loading conditions described herein and the Project Agreement. Existing structures over and adjacent to the cut-and-cover structures that shall remain in place shall be considered in the design. Existing structures to remain over the structure shall be underpinned to not transfer any load onto the LRT structure. Each existing structure adjacent to the cut-and-cover construction shall be considered on its own merits when evaluating dead and live loads. The detailed design of the temporary bracing systems shall be the responsibility of Project Co.
  - (iii) Embankments shall be designed such that the bearing capacity of the underlying soil has a minimum safety factor of 3.0 against loads from the embankment and against any train and surcharge loading. Particular attention shall be given to the design of all side slopes, whether temporary or permanent. The analyses shall consider the effects of deterioration and loss of soil resistance due to local climatic and construction conditions. All slopes shall be designed to minimize erosion by rainfall and runoff. Slope stability analyses shall be performed to confirm the embankment slopes have adequate factors of safety against failure under static, dynamic and seismic loads.
  - (i) Instrumentation and Monitoring - The design shall provide and protect all adjacent structures, facilities, plants, utilities and like items against damage due to the construction and upon completion of the permanent Work. Limiting values of movement (horizontal and vertical) and distortion on each building, structure and utility, etc. within the zone of influence of the Work and the work being performed shall be established. To establish these limiting values, the Designer shall consider, inter alia, the nature of the buildings within the sphere of influence of the construction of the LRT, including their foundation systems, structural design and current condition. Records of buildings, structures and utilities, where available, shall be examined during the design stage and, where no records exist, assessments shall be made and clearly stated. These assessments shall be the subject of verification at the commencement of the construction phase prior to the adjacent LRT construction activity. Monitoring of each structure shall be required during construction, as specified herein.
  - (ii) As part of the design of all permanent structures, a system of construction monitoring shall be established to include but not limited to the following:
    - A. Measurement of ground water levels and ground water pressure;
    - B. Measurement of strut loads;

- C. Monitoring of settlement of the permanent structures and surrounding area both prior to, during, and after construction. In all cases, monitoring shall be initiated well in advance of construction to establish baseline readings; and
  - D. Measurement of lateral movement of excavation support walls and permanent structures.
- (iii) The extent of the monitoring program shall depend on the size and type of the facilities, work to be performed, adjacent structures, etc. A detailed monitoring program shall be prepared for each structure affected by the Work, subject to review by the Region.
  - (iv) Where adjacent properties may be affected by the works, the monitoring program shall allow for readings on fixed points on the structures and buildings, to allow both total and differential settlements to be assessed and lateral movements to be determined.
  - (v) The instrumentation and monitoring program shall include appropriate types and quantities of monitoring instruments capable of measuring horizontal and vertical movements, tilt of adjacent structures, soil pore pressures, vibrations, and noise, as applicable. Instrumentation to be used in the monitoring programs to control and assist design and construction shall include:
    - A. Piezometers and observation wells
    - B. Inclinometers
    - C. Survey stations on structures and at ground level locations
    - D. Tiltmeters
    - E. Deep settlement points and extensometers
    - F. Strain and load-measuring devices
    - G. Seismographs and others.
  - (vi) The types and numbers of instruments shall depend on factors including the size, type and location of proposed work. The design and distribution of instrumentation shall demonstrate an understanding of the need, purpose and advantages of using each proposed type.
  - (vii) Responsibilities for design, procurement, installation, recording, maintenance and protection shall be clearly stated in the specifications and Project Agreement Documents. These shall also contain the procedures to be followed when readings, during construction, reach any specified threshold values; or when construction changes are deemed necessary. Threshold values and response plans shall be developed by Project Co., subject to review by the Region.
  - (viii) The design shall include consideration of environmental effects such as temperature, rain, sun, wind, corrodibility, and electromagnetic wave interference.
  - (ix) Test installations shall be performed, as required, to demonstrate the compliance and acceptability of instrumentation in relation to the Project Agreement requirements.
  - (x) Deep Foundation Testing and Monitoring - An adequate amount of testing shall be performed for deep foundations to evaluate foundation capacity and integrity, to verify design assumptions, to determine foundation installation characteristics, to evaluate the

pile driving system performance, and to establish foundation depths. The foundation testing and monitoring shall include all necessary test piles or shafts, dynamic testing, static load testing, non-destructive integrity testing, and quality control testing. A pile driving analyzer shall be used to determine if the energy required by the design is being delivered by each hammer. Each hammer used to drive test piles and production piles shall deliver a minimum of 45 percent of the rated hammer energy. Foundation testing and monitoring shall be performed on both test and production deep foundations, and shall be located so that they shall address all conditions of foundation type, capacity and soil conditions encountered. Project Co shall prepare and submit a detailed description of the proposed foundation testing and monitoring programs in accordance with the requirements of this RFP. The description shall include detailed specifications and plans presenting the type, purpose, number, location, and procedures for each test, and the recording and reporting procedures. The number, location, type, procedures, and extent of testing of the deep foundations shall be subject to review by the Region. Testing and monitoring of deep foundations shall be in accordance with the applicable ASTM specifications.

**2.6 Approvals and Permitting Periods**

(a) General

- (i) Project Co shall be responsible for all planning, design, construction and close-out approvals and permitting including all of the costs of preparing, submitting and review of the permits by the approving authority.
- (ii) The Region of Waterloo will review and sign all permits that require owner consent. This review and signature shall be coordinated with the milestone submissions and review periods designated in the RFP.

(b) Anticipated Permitting

- (i) Refer to PLAA Table.
- (ii) Approval Review Period

Project Co. must ensure that all permit applications are complete and accurate prior to submission for review. All utilities and approval agencies have been notified of the Project and have committed to the following review periods based on complete and accurate submissions:

Review Agency	First Review	Resubmissions
City of Kitchener	10 business days plus 1 day per 100 m of corridor length	Case by Case
City of Waterloo	10 business days plus 1 day per 100 m of corridor length	Case by Case
Grand River Conservation Authority	30 days	30 days
Ministry of Transportation	35 days	20 days

Review Agency	First Review	Resubmissions
CN Rail	20 days	20 days

**2.7 Public Infrastructure Works**

(a) The Region and Municipalities have proposed capital projects that intersect, overlay or are adjacent to the proposed LRT corridor. **“Public Infrastructure Work (PIW)”** is defined as work elements that Project Co has design, construction, testing and acceptance responsibilities but has no responsibility for ongoing maintenance after PIW is accepted for beneficial use by the Authority Having Jurisdiction. Project Co shall be responsible for the maintenance and up keep of all Public Infrastructure Work (PIW) performed by Project Co within the Project Agreement and on behalf of the Region, respective City, railroad, and public agency having jurisdiction and ownership rights of the plant until acceptance and beneficial use of the PIW on or before the commencement of Light Rail Transit revenue operation by Project Co; or until the Region, respective City, railroad, and agency having jurisdiction and ownership rights takes control of the plant in accordance with the Project Agreement “Possession and Use” requirements. This does not include Project Co’s responsibility for control of all maintenance and up keep of the LRT guideway infrastructure. It is the intent of the Region that Project Co complete some or all of these works as part of the overall project to avoid undue or duplication of disruption to residents and businesses along the corridor. Exhibit 2.7-1 illustrates a schematic of the proposed projects. A list of the proposed projects is detailed in Exhibit 2.7-1. Public Infrastructure Works Drawings (Appendix N) illustrates the details of the complementary projects to be completed by Project Co.

**Exhibit 2.7-1 Public Infrastructure Works**

Project No.	Location	Project Co. Scope	Drawing Reference
Region of Waterloo PR 5391	King St. N, Conestoga Parkway (Hwy85) to Northfield Drive	<ul style="list-style-type: none"> <li>•New 3m wide asphalt multi-use trail</li> <li>•Durable marking at intersections</li> <li>•Construct NB left turn lane with 65m storage at Northfield Dr</li> <li>•Conversion of Catchbasins to side inlets, Relocation to be completed under main project scope.</li> <li>•Proposed street lighting on west side of roadway from limit of work to Northfield Dr.</li> <li>•Pavement Reconstruction 450mm Granular B 150mm Granular A 140mm HMA or Superpave</li> </ul>	<p>C-PIW- 001 C-PIW-002 C-PIW-003 C-PIW-004</p>

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
Region of Waterloo PR 7216	King St. N/Conestogo Rd. Intersection Improvements	<ul style="list-style-type: none"> <li>•New 1.8m sidewalk</li> <li>•Street lighting upgrades to comply to Regional Standards</li> <li>•Full Replacement of traffic signals</li> <li>•Revised drop curbs to match new sidewalk layout</li> <li>•Durable markings to comply with Regional Standards</li> <li>•Replace water utility in intersection</li> <li>•Pavement Reconstruction 450mm Granular B 150mm Granular A 140mm HMA or Superpave</li> </ul>	C-PIW-002
Region of Waterloo PR 7316	Northfield Dr., King St. to Kraus Dr.	<ul style="list-style-type: none"> <li>•Dual WB LT lane at king with 50m storage</li> <li>•Resurfacing of pavement, to be supported by geotechnical</li> <li>•Maintain existing 1.5m sidewalk, if removed replace with 1.8m sidewalk</li> <li>•New sidewalk on north side of Northfield</li> <li>•New boulevard landscaping</li> <li>•New lighting on each side of Northfield</li> <li>•Major modernization of traffic signals</li> </ul>	C-PIW-004 C-PIW-401 C-PIW-402



Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
Region of Waterloo PR 5798	Northfield Dr., Davenport Rd. To Kraus St.	<ul style="list-style-type: none"> <li>•Increase storage capacity at existing designated left turn lanes at Northfield and Kraus</li> <li>•Resurfacing of pavement, to be supported by geotechnical</li> <li>•Maintain existing 1.5m sidewalk, if removed replace with 1.8m sidewalk</li> <li>•New sidewalk on north side of Northfield</li> <li>•New boulevard landscaping</li> <li>•New lighting on each side of Northfield</li> <li>•Major modernization of traffic signals</li> <li>•Replacement of traffic signals and traffic equipment upgrades</li> <li>•Revised drop curbs to match new sidewalk layout</li> </ul>	C-PIW-402 C-PIW-403
Region of Waterloo PR 1028	King St. N, North of Northfield	Resurfacing of pavement, to be supported by geotechnical. Minimum 140 mm final asphalt thickness	C-PIW-004 C-PIW-400

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
Region of Waterloo PR 5407	Northfield Dr., King St. N to Tracks	<ul style="list-style-type: none"> <li>•New sidewalk on north side of Northfield</li> <li>•Full replacement of traffic signals</li> <li>•New street lighting on north side of Northfield Dr.</li> <li>•Street lighting upgrades to comply with MTO standards</li> <li>•Guide rail and cables replacement/repair</li> <li>•Tie-in to existing Hwy 85 Ramps, comply with MTO standards</li> <li>•Road Reconstruction                             <ul style="list-style-type: none"> <li>450mm Granular B</li> <li>150mm Granular A</li> <li>140mm HMA or Superpave</li> </ul> </li> </ul>	<p>C-PIW-004 C-PIW-005 C-PIW-006 C-PIW-007 C-PIW-008 C-PIW-009</p>
Region of Waterloo PR 5696	Northfield Dr., Tracks to Weber St.	<ul style="list-style-type: none"> <li>•Widening of Northfield Dr. to include the installation of bike lanes in both sides.</li> <li>•Full reconstruction of sidewalks</li> </ul>	<p>C-PIW-010 C-PIW-406 C-PIW-407 C-PIW-408 C-PIW-409</p>
City of Waterloo PIW	Replace box culvert and headwalls	Remove and replace existing box culvert and head walls at stn 1+670 with a hydraulically equivalent structure	C-PIW-011
Region of Waterloo PR 5389	Erb St. Reconstruction and major rehabilitation	<ul style="list-style-type: none"> <li>•Full pavement reconstruction to be confirmed by geotechnical</li> <li>•Replace storm sewer</li> <li>•Full replacement of traffic signals</li> <li>•Remove brick side walk and install durable ladder type crosswalks at intersections</li> <li>•Bike lanes both sides of road</li> </ul>	C-PIW-035

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
Region of Waterloo PR 5490	Erb St. Reconstruction and major rehabilitation	<ul style="list-style-type: none"> <li>•Bikes lanes added from east limit of work to intersection on Erb St.</li> <li>•Replace watermain from east limit of work to west limit of work on Erb St.</li> <li>•Replace sanitary sewer from east limit of work to limit of intersection work on Erb St.</li> <li>•Replace storm sewer through intersection to east limit of work</li> <li>•Drainage Improvements within intersection of Erb and Caroline</li> <li>•Pavement Reconstruction supported by geotechnical. Min. Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave</li> </ul>	C-PIW-035
City of Waterloo	Uptown Streetscaping Upgrades in addition to in-kind replacement and LRT stop streetscaping upgrades	<ul style="list-style-type: none"> <li>• Pedestrian Level lighting to City Standard as per Section 2.11                             <ul style="list-style-type: none"> <li>○ Spur (Erb/Caroline to King/Urban Sq.),</li> <li>○ King (William to Union),</li> <li>○ Caroline (Erb to Allen,</li> <li>○ Allen (Caroline to King)</li> </ul> </li> <li>• Sidewalk Banding to City Standard as per Detail (Appendix J) or City approved alternate                             <ul style="list-style-type: none"> <li>○ King (William to Union),</li> <li>○ Caroline (Erb to Allen),</li> <li>○ Allen (Caroline to King)</li> </ul> </li> </ul>	No drawing reference – location designations are inclusive of terminal intersections

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
City of Waterloo REF 831	Union St.	<ul style="list-style-type: none"> <li>•Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave</li> <li>•Replace storm sewer from stn. 7+160 to 7+723</li> <li>•Replace sanitary sewer from stn. 7+160 to 7+723</li> <li>•Replace water utilities from stn. 7+160 to 7+723</li> </ul>	C-PIW-043
City of Waterloo REF 764	Willis Way at King St.	Replace 300mm sanitary sewer with 450mm	C-PIW-037
City of Waterloo	Willis Way at Caroline St.	Upsize Sanitary on Willis Way to 450mm	C-PIW-037 C-PIW-101
City of Waterloo		<ul style="list-style-type: none"> <li>•Remove sanitary siphon under Laurel creek culvert.</li> <li>•Re-profile sewer to drain away from culvert, towards Erb St. N</li> <li>•Re-route 375mm and 250mm sanitary at stn 6+330 NB</li> </ul>	C-PIW-035 C-PIW-037
City of Waterloo	King St Sanitary	Upsize sanitary on King St. to 300mm, Erb St to southern limit	C-PIW-037 C-PIW-038 C-PIW-039 C-PIW-040 C-PIW-041 C-PIW-042 C-PIW-043 C-PIW-044 C-PIW-045 C-PIW-046

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
City of Waterloo REF 770/794/795	Caroline St., Allen St. to Erb St.	<ul style="list-style-type: none"> <li>•Replace watermain from Stn. 6+050 to Stn. 6+750</li> <li>•Replace sanitary sewer from Stn. 6+050 to Stn. 6+750</li> <li>•Replace storm sewer from Stn. Stn. 6+050 to Stn. 6+750</li> </ul>	<p>C-PIW-035 C-PIW-101 C-PIW-102 C-PIW-103 C-PIW-104</p>
Region of Waterloo PR 6206	King St. N, Central Market to Union St.	<ul style="list-style-type: none"> <li>•Replace storm and sanitary pipes, and structures</li> <li>•New sidewalks</li> <li>•Road crown and drainage improvements including new curb</li> <li>•Pavement Reconstruction 450mm Granular B 150mm Granular A 140mm HMA or Superpave</li> </ul>	<p>C-PIW-043 C-PIW-044 C-PIW-045 C-PIW-046 C-PIW-047</p>
City of Kitchener	King St. N	<ul style="list-style-type: none"> <li>• Upsize Sanitary on King St to 300mm diameter</li> </ul>	<p>C-PIW-043 C-PIW-044 C-PIW-045 C-PIW-046 C-PIW-047</p>
Region of Waterloo PR 5041	King St., Central Market to Victoria St	<ul style="list-style-type: none"> <li>•Replace storm and sanitary pipes, and structures</li> <li>•New sidewalks</li> <li>•Road crown and drainage improvements including new curb</li> <li>•Illumination upgrades at intersections to conform with regional standards.</li> <li>•Pavement Reconstruction 570mm Granular B 150mm Granular A 140mm HMA or Superpave</li> </ul>	<p>C-PIW-046 C-PIW-047 C-PIW-048 C-PIW-049 C-PIW-050 C-PIW-051</p>
Region of Waterloo PR 9621	King St. N intersection	<ul style="list-style-type: none"> <li>•Traffic signal replacement</li> <li>•Full road reconstruction of Agnes St. intersection</li> </ul>	<p>C-PIW-047</p>

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
City of Kitchener Duke St.	Queen St. to Frederick St.	<ul style="list-style-type: none"> <li>•Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave</li> <li>•Replace watermain</li> <li>•Replace sanitary sewer</li> <li>• New curbs and sidewalks</li> </ul>	C-PIW-056 C-PIW-057
City of Kitchener Duke St.	College St. to Queen Queen St.	<ul style="list-style-type: none"> <li>•Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave</li> <li>• New curbs and sidewalks</li> <li>•Upsize existing 225mm to min. 300mm diameter sanitary sewer at Stn. 9+440</li> <li>•Replace watermain from Stn. 9+200 to Stn. 9+630</li> <li>•Replace sanitary sewer from Stn. 9+200 to Stn. 9+630</li> <li>•Replace storm sewer from Stn. 9+200 to Stn. 9+630</li> </ul>	C-PIW-055 C-PIW-056 C-PIW-057
Region of Waterloo PR 5612	Frederick St. (Lancaster to Duke)	<ul style="list-style-type: none"> <li>•Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave</li> </ul>	C-PIW-057

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
Region of Waterloo PR 5922	Frederick St. (Duke to Charles)	<ul style="list-style-type: none"> <li>•Traffic signal replacement at Charles</li> <li>•Replace watermain from Stn. 9+725 to Stn. 9+985</li> <li>•Replace sanitary sewer from Stn. 9+725 to Stn. 9+985</li> <li>•Replace storm sewer from Stn. 9+725 to Stn. 9+985</li> <li>•New sidewalk, curb and gutter</li> <li>•Pavement Reconstruction                             <ul style="list-style-type: none"> <li>Min. 610mm Granular B</li> <li>Min. 150mm Granular A</li> <li>Min. 140mm HMA or Superpave</li> </ul> </li> </ul>	<p>C-PIW-057 C-PIW-058 C-PIW-059</p>
Region of Waterloo PR 5381	Benton St. (Frederick St.)	<ul style="list-style-type: none"> <li>•Pavement Reconstruction                             <ul style="list-style-type: none"> <li>Min. 610mm Granular B</li> <li>Min. 150mm Granular A</li> <li>Min. 140mm HMA or Superpave</li> </ul> </li> </ul>	C-PIW-059
Region of Waterloo PR 5743	Charles St, Pandora to Kent	New sidewalk on north side of Charles	<p>C-PIW-063 C-PIW-064 C-PIW-065</p>
Region of Waterloo	Charles St., Victoria to Ottawa	Replace Regional 600mm transmission main	<p>C-PIW-059 C-PIW-060 C-PIW-061 C-PIW-062 C-PIW-063 C-PIW-064 C-PIW-065 C-PIW-066 C-PIW-067</p>

Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
City of Kitchener	Charles St	Provide new 300mm watermain from Cedar to Ottawa for servicing, Remove services from 600mm watermain	C-PIW-060 C-PIW-061 C-PIW-062 C-PIW-063 C-PIW-064 C-PIW-065 C-PIW-066 C-PIW-067
City of Kitchener	Ottawa St , Charles to Mill	Replace 150mm with 300mm watermain including 300mm stubs at all intersections and servicing	C-PIW-068 C-PIW-069 C-PIW-070 C-PIW-071 C-PIW-072
City of Kitchener Ottawa St.	Mill St. to Huron Spur	•Replace Watermain and gas main from Mill to Huron Spur..	C-PIW-067
Region of Waterloo PR 5377	Ottawa St. (Mill St. to limit of Work)	•Extra road width for bike lane •Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave	C-PIW-073
City of Kitchener Hayward Ave.	Schneider Creek Bridge to LRT Track Crossing	•Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave •Replace Watermain	C-PIW-079 C-PIW-405



Exhibit 2.7-1 Public Infrastructure Works

Project No.	Location	Project Co. Scope	Drawing Reference
City of Kitchener Hayward Ave.	LRT Track Crossing to Courtland Ave.	•Replace Watermain	C-PIW-079 C-PIW-080 C-PIW-081
Region of Waterloo PR 5750	Courtland Ave., Hayward Ave to Hydro Corridor	Resurfacing of pavement, to be supported by geotechnical Min 140mm final asphalt thickness	C-PIW-081 C-PIW-082 C-PIW-083 C-PIW-084 C-PIW-085 C-PIW-086 C-PIW-087 C-PIW-088
Region of Waterloo PR 5291	Courtland Ave./Hayward Ave. Intersection	•Pavement Reconstruction as supported by geotechnical. Min. 450mm Granular B Min. 150mm Granular A Min. 140mm HMA or Superpave •Replace sanitary sewer •Replace Watermain	C-PIW-081

**Exhibit 2.7-1 Public Infrastructure Works**

<b>Project No.</b>	<b>Location</b>	<b>Project Co. Scope</b>	<b>Drawing Reference</b>
Region of Waterloo PR 7171	Courtland Ave./Blockline Rd. Intersection	Development related left and right turn lanes.	C-PIW-084
City of Kitchener	Courtland Ave Sanitary Sewer	Combine 750mm and 1200mm Sanitary sewer at Stn 14+700	C-PIW-087

**Drawing Revision**

- C-PIW-053 – Replacement of Sanitary, Storm and Water perpendicular to LRT tracks at intersection of Duke and Water St. is not required beyond LRT exclusion zone.
- C-PIW-056 – Replacement of Sanitary, Storm and Water perpendicular to LRT tracks at intersection of Duke and Ontario St. is not required beyond LRT exclusion zone.
- C-PIW-109 – Replacement of Sanitary, Storm and Water perpendicular to LRT tracks at intersection of Charles and Ontario St. is not required beyond LRT exclusion zone.

**Clarification:**

Major Modernization of Traffic Signals – Full replacement of the traffic signals, controls and underground infrastructure.

Traffic Equipment Upgrades – Moving of individual signal poles without replacement of controls or conduit. Refer to Schedule 15-2, Article 18 Construction Criteria, 18.9 Traffic Management Plan for additional information and clarification.

- (b) Charles St. 600 mm transmission watermain is a critical feature in the water supply for the area. Temporary shutdowns of this watermain shall be limited to overnight off peak periods as approved by the Region of Waterloo Water Operations

**2.8 Road Construction**

- (a) The construction of the Project is expected to have direct impacts on the roadway network and related facilities in the Project area. A range of reconstruction and restoration measures are proposed to mitigate these impacts and to re-establish traffic patterns and service levels.
- (b) The Basis of Design Report shall detail the process that has been taken to review and validate the functional design and additional improvements that have been made to maintain effective traffic progression along and crossing the LRT route. Furthermore, design cross-sections and preliminary geotechnical design of the pavement structure along the alignment in key road types (arterial, collector) shall be provided with the basis of design.
- (c) Intent:
  - (i) The intent of the roadway/LRT interaction is to minimize the impact of the LRT on existing road operations and maintain safe vehicle, pedestrian, and bicycle traffic in conjunction with LRT operations.
  - (ii) Segregation of the LRT corridor and vehicle traffic except at designated intersections and entrances including such measures as appropriate to alert/divert vehicular traffic from the LRT corridor (rumble strips, curbing, barriers, etc.).
  - (iii) Road design to allow for the progression of service vehicles (delivery, bus, commercial) without undue delay to passenger vehicles through the use of lay-bys, wide lanes, etc.
  - (iv) Road and curb design to ensure the progression of emergency vehicles using a combination of the roadway and LRT corridor to by-pass queuing traffic.
  - (v) Pedestrian environment to be improved over existing condition to promote the safe access/egress from LRT and other transit facilities.
  - (vi) Pavements, base and subbase materials outside of the LRT corridor shall be preserved and reused where practical. It may be necessary to re-profile the wearing course to meet road drainage requirements. Structural integrity and longevity of the pavement structure shall be the governing criteria for the preservation/replacement of existing materials. Installation of a final wearing course of asphalt shall be required along the entire road alignment and affected intersecting streets or roads, designed and installed by Project Co, prior to the re-opening of any road or street closure. Postponement of the final wear course to the following construction season or year is not acceptable. Refer to Schedule 15-2, Article 18 Construction Criteria for additional information and requirements.
  - (vii) Ontario Provincial Standard Specification (OPSS) shall be the basis for all non-LRT construction design components unless superseded by the DGSSMS.
- (d) Geometric Design of Roadways
  - (i) Wherever existing or proposed grades permit, the Transportation Association of Canada (TAC) Geometric Design Guide for Canadian Roads and the Local Municipal Guidelines shall be used as a basis for the geometric design of roadway facilities. This includes roadways, which, in accordance with Region practice, conform with TAC. In addition, the geometric design standards and criteria of other agencies having jurisdiction over a particular roadway shall be applied to the extent that they do not conflict with or undermine TAC criteria. In cases where application of TAC criteria would result in excessive impacts to adjacent property, Project Co shall, prepare concept design(s) that

achieve roadway conditions as close to the TAC criteria as practical during Phase 1. Project Co shall submit the concept designs to the Region in accordance with [Section 20.3 \(h\)](#) and [Schedule 10 – Review Procedure](#).

- (ii) City of Kitchener Urban Design Manual shall be the basis for all roadway, sidewalk, parking and entrance configurations within the City of Kitchener.
  - (iii) City of Waterloo Urban Design Manual shall be the basis for all roadway, sidewalk, parking and entrance configurations within the City of Waterloo.
  - (iv) MTO Design Standards for Geometry shall be the basis for all roadway, sidewalk and entrance configurations within their jurisdiction.
- (e) Pavement
- (i) All new and/or reconstructed pavements built by the Project shall provide a high-quality durable material and riding surface. They shall also be designed to support the capacity of the projected traffic volumes over the design life of the pavement structure. Pavement designs shall also incorporate provisions aimed at minimizing future maintenance requirements.
  - (ii) The design of pavement structures shall be performed in accordance with the pavement design reference of the agency having jurisdiction over the roadway. For each roadway facility, a range of pavement material alternates, including partial-depth rehabilitation, full-depth asphalt, full-depth concrete, and a composite pavement section, shall be evaluated to determine the most appropriate and cost-effective solution. Project Co is advised that the use of a durable, well jointed with transfer joint bars, and designed concrete pavement, i.e. slip formed or formed, that enables road traffic restoration in a timely manner is not precluded.
  - (iii) Available data on the soil conditions in the Project area shall be examined and supplemented as part of Project Co.'s geotechnical investigations to determine the potential benefits of subgrade drainage and bearing capacity improvement measures.
  - (iv) Project Co shall prepare and submit to the Region a summary of pavement design criteria, in accordance with the Design Standards used by the agency's having jurisdiction over the roadway, local streets and Region roadways.
  - (v) There are areas of the alignment that were originally constructed using concrete paving, brick, and/or cobblestone. Refer to Concrete Mapping (Appendix P)

**Exhibit 2.8-1  
Summary of Geometric Design Criteria – Version 3**

<b>Criterion</b>	<b>Arterial Streets</b>	<b>Collector Streets</b>	<b>Residential Streets</b>
Design Speed (kph)	80 (Note 1)	60	50
Level of Service	C (Note 2)	C (Note 2)	C (Note 2)
Travel Lane Width (metres)	3.25-3.5	3.25-3.5	3 – 3.35
Turning Lane Width (metres)	3.05-3.5 (Note 3)	3.05-3.5 (Note 3)	3.05-3.5 (Note 3)
Shoulder Widths (metres)			
Right	0-1.25	0-1.25	0-1.25
Left	0-1.25	0-1.25	0-1.25
Max. Grade (%)	6.0	6.0	6.0
Min. Grade (%)	0.5	0.5	0.5
Stopping Sight Distance (Hor. & Vert.) (metres)	210 min. (Note 4)	130 min. (Note 4)	65 min.
Height of Eye (metres)	1.2	1.2	1.2
Height of Object (metres)	0.15	0.15	0.15
Radius (metres)	±850	±230	±145
Superelevation Rate (%)	8.0 max.	6.0 max.	---
Normal Pavement Cross Slope (%)	2.0	2.0	2.0 min.
Vertical Clearance (metres)			
-Major Bridge	5.4	5.4	5.4
-Minor Bridge	5.4	5.4	5.4
-Signal Structures	5.0	5.0	5.0
Rollover (%)			
-Between Travel Lanes	4.0	4.0	4.0
-At Pavement Edge	8.0	8.0	4.0
Design Vehicle	WB-20 (Note 5)	WB-20 (Note 5)	LSU (Note 5)
Sidewalk Width (meters)	1.5 – 3.0 (Note 6)	1.5 – 2.1 (Note 6)	1.5 – 1.8
Min. Boulevard Width (metres)	0.3 (Note 7)	0.3 (Note 7)	1.0 (Note 7)

Note 1 – Design Speed for Northfield Drive and Courtland Avenue shall be 80 kph. For the remainder of the arterial roads, 60 kph shall be permissible for areas of two lane traffic and 50 kph for areas of one lane traffic. Project Co. shall identify any areas where this is not achievable.

Note 2 – This is a desirable level of service. Minimum standard for level of service will be as indicated in the Region provided traffic analysis and forecasting.

Note 3 – Turning lane width shall be a minimum of 3.25m where GRT or truck routes are designated. 3.05 m shall be the minimum in other areas as identified on the Project Plan and Profile drawings.

Note 4 – TAC Design Standard for Conventional Braking Trucks. Realignment of roadways to comply with these standards shall be limited to existing available Right-of-Way.

Note 5 – The intent of the design vehicle is for geometric design and pavement design; WB-20 truck turning is required for all existing designated truck routes, however, it is not the intent that Project Co. is to correct all existing areas where trucks cannot stay in their lanes to make the necessary turning movement. The intent is that MSU vehicles should be able to make turning movements within their designated lanes; however, no additional land acquisition is proposed to achieve these turning movements.

Note 6 – Required minimum sidewalk widths are illustrated on the Project Plan and Profile Drawings and Public Infrastructure Works Drawings. Variations from sidewalk widths

Note 7 – Minimum 0.3 m coloured concrete boulevard to be provided. There are areas within the alignment where this is not possible due Right-of-Way limitations. These are illustrated on the Project Drawings and shall be minimized.

Note 8 - Travel Lane – Where the travel lane has curb on both sides of a single lane, the minimum width shall be 3.75 m for snow removal. This shall only apply on King Street between Allen Street and John Street as approved by the Region.

Note 9 - Shoulders – Where the LRT is centre running a 1.25m minimum (1.3m optimal) paved delineated shoulder shall be provided where there is only one travel lane of traffic (3.35m to 3.5m travel lane width) for a curb to curb width of 4.6m to 4.8m (4.8m optimal). The specific areas where this applies are:

1. Northfield Drive – King St. N. to the Waterloo Spurt
2. King St. N. – Allen St. to Victoria St.
3. Charles St. – Benton St. to Borden Ave.

(vi) Acceptable Materials

- A. Asphalt – to OPSS 1150
  1. Residential Roads - minimum 100mm compacted thickness
  2. Arterial and Collector Roads – minimum 140mm compacted thickness
- B. Granular A Base – to OPSS 1010 and OPSS 1004 – minimum 150 mm compacted thickness
- C. Granular B Subbase – to OPSS 1010 and OPSS 1004 – minimum 400mm compacted thickness.

- (vii) Design Loading
  - A. Appendix W of Schedule 15-2 shall be used for the design loading for the travelled lane pavement structure as a minimum standard.
- (f) Curbs and Sidewalks
  - (i) Intent
    - A. Curbing shall be configured consistent with Regional and Municipal guidelines for the roadway curbing to maintain traffic and drainage with appropriate depression or change in type of curbing for entrances, lay-bys, pedestrian crossings and other justifiable conditions.
    - B. Sidewalks shall be configured with the primary objective of the safe and comfortable passage of pedestrians during all seasons in accordance with Regional and Municipal guidelines. Project Co is advised that the Municipal Region of Waterloo and Cities utilizes enclosed single operator controlled motorized sidewalk sweepers and snow plows to clear and deice all sidewalks and multi-use trails on Regional road allowances and City streets and thus all sidewalks and curbs shall be designed to support the widths and loads imposed by this equipment and any adjacent structures are required to provide adequate overhead clearance. Project Co may contact each City to gain the equipment specifications for its use.
    - C. Sidewalks and curbing to be seamlessly integrated into Stop platforms with appropriate transitioning and widening to allow for pedestrian access/egress from the LRT to adjacent sidewalks and intersection pedestrian crossings.
    - D. LRT integration with Bus Stops shall be considered in the design to promote pedestrian flow to and from LRT platforms to adjacent Bus Stops.
  - (ii) The minimum standard shall be a 1.5 metres wide concrete sidewalk in accordance with OPSD 310.010 and OPSS 351. There shall be a requirement for a minimum clearance of 1.7 m (0.85m from centreline) for maintenance vehicles.
  - (iii) Boulevards greater than 900mm in width shall be landscaped in accordance with the governing authority's urban design guidelines and specifications. Boulevards of less than 900 mm width shall be reinstated with coloured and impressed concrete (colour and impression to be pre-approved by the governing authority).
  - (iv) Cast Iron Truncated Dome Strips to be provided at every pedestrian crossing compliant with AODA guidelines and consistent with the Regional Standard.
  - (v) All curbing shall be of concrete cast-in-place construction in accordance with OPSD standards, at a minimum, for the specific curb type.
  - (vi) Connections to existing curbing to be configured with appropriate countersunk dowels. Sawcutting of existing sidewalk shall be at joints and full panels shall be replaced at all locations.
  - (vii) Site Specific Concerns
    - A. Uptown Waterloo - Sidewalks shall be configured as per City of Waterloo Standards within the Uptown Waterloo Area – Union St. to Erb St. as follows:

1. Sidewalk Banding refer to Appendix J. The City of Waterloo is interested in lower maintenance and a simpler construction method alternative to their current standard sidewalk banding. Project Co shall provide an alternative approach that achieves an equivalent aesthetic treatment. Provide the alternative approach in the Basis of Design Report.

2. All pedestrian cross walks at LRT Stops and nearest street intersections shall be enhanced. Acceptable enhancements shall be full depth designed and engineered concrete with stampings, patterns, and colours meeting the urban fabric, AODA requirements, Region, City of Waterloo Urban Design Standards and Project Agreement.

Full depth asphalt, wear course over laid asphalt and laid-in/pressed type products in asphalt pavement for use as cross-walks with patterns, paint and typical painted ladders are not acceptable. Brick and cobble stone are also not acceptable material alternatives due to their long term maintenance and durability, potential for unevenness due to temperature fluctuations, vehicular traffic, freeze thaw and de-icing chemical use among other concerns.

B. Downtown Kitchener – Sidewalks shall be configured as per City of Kitchener Downtown Urban Standards.

1. Sidewalk Banding refer to Appendix J.

2. All pedestrian cross walks at LRT Stops and nearest street intersections shall be enhanced. Acceptable enhancements shall be full depth designed and engineered concrete with stampings, patterns, and colours meeting the urban fabric, AODA requirements, Region, City of Kitchener Urban Design Standards and Project Agreement.

Full depth asphalt, wear course over laid asphalt and laid-in/pressed type products in asphalt pavement for use as cross-walks with patterns, paint and typical painted ladders are not acceptable. Brick and cobble stone are also not acceptable material alternatives due to their long term maintenance and durability, potential for unevenness due to temperature fluctuations, vehicular traffic, freeze thaw and de-icing chemical use among other concerns.

C. Other Areas – In accordance with Region and applicable City Standards. The more stringent Standard shall apply.

(g) Grading

(i) Intent

A. The objectives of the proposed grading design (in order of importance) are to:

1. Minimize disturbance of roadside areas, especially those including vegetation and landscaping.
2. Protect against erosion.
3. Maintenance of existing drainage patterns.



4. Facilitate future maintenance operations.
  5. Provide, where appropriate, suitably graded areas for pedestrian access.
- (ii) Slopes, Retaining Walls, and Pedestrian Grade Changes
- A. The desirable maximum slope ratio to be used in roadside areas shall be 3 horizontal to 1 vertical, with an allowance of 2 horizontal to 1 vertical. Minimum slope ratio shall depend on location, but shall not be less than 4 percent (desirable), or 2 percent (absolute minimum).
  - B. In some areas where maximum slopes cannot be achieved, retaining walls shall be employed as a grading feature. Back and fore slopes shall be designed to minimize the height of the walls, where practical. Architectural treatment of exposed wall surfaces shall be applied to lessen visual impacts of the designed walls. Standard wall architectural types shall be used as appropriate. Typical standard walls within the Region are:
    1. Up to 2.8 m high – GRANDE Wall
      - I. Supplier - Hanson Hardscape Products: RR#2, 1081 Rife Road, Cambridge ON N1R 5S3, Ph: 800 265 6496 or pre-approved equivalent
      - II. Average compressive strength of three coupons cut from units to be greater than 30 MPa with no individual coupon below 27 MPa when tested in accordance with ASTM C140.
      - III. Average absorption of three specimens to be less than 6% with no individual unit greater than 7% when tested in accordance CSA A165-Series.
      - IV. Average loss of three specimens less than 600 g/m<sup>2</sup> (17.7 oz/yd<sup>2</sup>) after 50 freeze-thaw cycles immersed in a 3% saline solution when tested in accordance with OPSS 1352.
      - V. Architectural fall protection and guide railings or fencing shall be provided for all retaining walls higher than 900 mm. Project Co is advised that those retaining walls are subject to the community, urban fabric and the application of the Urban Design Guide manuals from the respective City will dictate whether it is an architectural fall protection and guide railing or fencing. Project Co shall also refer to Schedule 15-2, Article 2 Civil, 2.20 Access Management and Right of Way, Perimeter and Security Fencing Project requirements.
  - C. Project Co shall coordinate, submit, and prepare and provide samples to the Region for review prior to the use of architectural treatments. Drainage shall be provided behind all walls and unless permanent easements are secured, the entire wall and subdrainage layer shall be placed within the LRT corridor Right-of-Way.
  - D. Conceptual renderings have been developed and been accepted by the landowners for several sites along the alignment. Project Co. shall design and construct these features to conform to the accepted conceptual design (Appendix R). Deviations

from the design concept are subject to Region approval. The scope of work for these identified sites shall include the works on private property to complete the full scope as identified on the renderings. The Region shall secure Consent to Enter permissions from these landowners in accordance with Project Co.'s schedule for the work. The properties that have been accepted to date are as follows:

1. 727 King St. West, Kitchener – Scope of work at this site is limited to a stormsewer service connection to property line.
2. 739 King St. West, Kitchener
3. 741 King St. West, Kitchener
4. 787 King St. West, Kitchener
5. 825 King St. West, Kitchener

E. An additional area that has not been detailed is the area on the north side of the King St. Grade Separation. There are potential redevelopment proposals and renovations occurring at both 607 King St. West and 51 Breithaupt St. Project Co. shall coordinate with these landowners to allow for the following options.

1. 607 King St. West – Region will secure a Construction Easement to allow Project Co. to complete the following works on private property:
  - grading and decorative low maintenance landscaping treatment of the slope back onto the subject property rather than constructing a retaining wall between the Grade Separation and the Moore St. intersection
  - Construction of a new entrance to 607 King St. West at a slope that is compliant with City of Kitchener guidelines to maintain access to the site from the Moore St. intersection while minimizing the impact on parking in the area northwest of the Moore St. intersection.
2. 51 Breithaupt St. – Landowner will be evaluating potential for street level access from their basement. Project Co. to coordinate and provide a retaining wall penetration to permit this access. Any work on the existing building shall be by others.

D. Exterior Stairways and Ramps – Stairways and ramps shall confirm to AODA standards and the Ontario Building Code.

(iii) Ditching and Swales

- A. Along the alignment, where the LRT is not street running (i.e. Waterloo Spur, Huron Spur), a rural cross-section will be acceptable using trackside ditching and swales to intercept drainage from adjacent lands and from the trackway.
- B. Ditches shall be constructed within available Right-of-Way using engineered sideslopes up to 2:1 Horizontal to Vertical, steeper slopes up to 1:1 may be considered and engineered with geotechnical supporting information and a method of erosion control/slope stabilization. Ditch inverts shall be configured to

maintain the free drainage of the ballast and sub-ballast materials to the subgrade material. This shall include outlets for track subdrainage without surcharging the subdrainage system. Minimum ditch/swale slopes shall be dictated by the hydraulic cross-section of the proposed ditching and the contributing drainage area.

- C. Calculations and design report information shall be consistent with the requirements for Storm Sewer systems as detailed in Schedule 15-2 Article 3.
- D. Where existing crossings of the rail will be impacted by ditching/swales, a culvert shall be utilized as per OPSD 300.010
- E. Reinstatement of drainage swales and ditches shall promote the establishment of vegetation as soon as possible following construction including the use of erosion control blankets and other methods to minimize soil loss.

**2.9 Streetscaping**

(a) Intent

- (i) The intent of the streetscaping for the Project is to complement and enhance the existing urban environment within the limits of the LRT construction. Streetscaping outside of Uptown Waterloo (Erb to Union, Caroline to King) and defined areas of Downtown Kitchener shall be limited to Stop areas unless otherwise noted on the drawings. The Basis of Design Report must illustrate in terms of drawing designs and renderings of typical proposed streetscape configurations in both the Uptown Waterloo and Downtown Kitchener areas.
- (ii) Uptown Waterloo – Streetscaping Components
  - A. Pedestrian Level Lighting and Appurtenances - As per Section 2.11
  - B. Street Trees and Tree Bed – As per Section 2.14
  - C. Sidewalks and Pedestrian Cross-walks – As per Section 2.8
  - D. Bike Racks – As per City of Waterloo Standard Drawing W-607. Numbers to coordinate with Urban Design Guidelines.
  - E. Bike Share – An allowance of space shall be provided within the streetscape on the east side of King Street between Waterloo Spur at-grade rail crossing and William Street intersection.
  - F. Street Furniture – furnished and installed by others; Project Co shall design and provide space within its design and coordinate with the City of Waterloo these spaces in Uptown Waterloo.
  - G. For Pedestrian Crossings that are adjacent to or on the pedestrian desire lines from/to the proposed LRT Stops, Project Co. shall provide an upgraded aesthetic treatment of the pedestrian crossing consisting of full depth concrete construction and suitable high visibility durable markings/colouring to be consistent with the Stop architectural treatments. A minimum of four crossings shall be provided per Stop.

- (iii) Downtown Kitchener – Streetscaping Components
  - A. Pedestrian Level Lighting and Appurtenances - As per Section 2.11
  - B. Street Trees and Tree Bed – As per Section 2.14
  - C. Sidewalks and Pedestrian Cross-walks – As per Section 2.8
  - D. Bike Racks – Refer to Stop area planning
  - E. Bike Share – Not proposed
  - F. Street Furniture – furnished and installed by others; Project Co shall design and provide space within its design and coordinate with the City of Kitchener these spaces in Downtown Kitchener.
  - G. For Pedestrian Crossings that are adjacent to or on the pedestrian desired lines from/to the proposed LRT Stops, Project Co. shall provide an upgraded aesthetic treatment of the pedestrian crossing consisting of full depth concrete construction and suitable high visibility durable markings/colouring to be consistent with the Stop architectural treatments. A minimum of four crossings shall be provided per Stop.

**2.10 Traffic Signal Infrastructure**

- (a) Components and Operation – The operation and operational components of the traffic signals are addressed in Schedule 15-2 Article 9.
- (b) Project Co shall design the traffic signal layout and configuration in accordance with OTM Book 12 subject to the permitting and approval of the Region of Waterloo Traffic Operations. Project Co shall refer to Article 18 Construction Criteria for additional information to be considered.
- (c) The functional design does not currently show traffic signal islands. Project Co shall design and provide traffic signal islands, as necessary, to comply with the requirements of OTM Book 12 or alternatively provide alternative mounting locations that do not conflict with traffic or LRT operations. The Basis of Design Report shall indicate signal layout (plan and elevation) in areas where median islands may not be available and all intersections with a four lane traffic cross section and greater.
- (d) Wiring – As per Schedule 15-2 Article 9 and Region of Waterloo Standards.
- (e) Components – Exhibit 2.10-1 illustrates the standard components and suppliers used in the Region.

**Exhibit 2.10-1 – Standard Traffic Signal Components**

<b>Equipment</b>	<b>Product Name</b>	<b>Description</b>	<b>Preferred Supplier</b>
Traffic Signal Pole	LACAL	Sectional Steel Pole	Polefab
Traffic Signal Pole	POWCO	Octagonal Steel Pole	Sentinel

**Exhibit 2.10-1 – Standard Traffic Signal Components**

Equipment	Product Name	Description	Preferred Supplier
Handwells	Strongwell, Quazite	Concrete polymer reinforced boxes, no base, no holes, dimensions 13x24x18” deep, Strongwell Cat. No. PT1324BA18 complete with cover type CA, Strongwell Cat. No PT1324CA46, Logo “Traffic Signal”  Concrete polymer reinforced boxes, no base, no holes, dimensions 10x15x18” deep, Strongwell Cat. No. LT1015BA18 complete with cover type CA, Strongwell Cat. No PG1015CA44, Logo “Electric”  Concrete polymer reinforced boxes, no base, no holes, dimensions 17x30x18” deep, Strongwell Cat. No. LT1730BA18 complete with cover type CA, Strongwell Cat. No PG1730CA44, Logo “Electric”	MVA Power Inc.,
Signal Heads	Tendered	Must meet IMSA approved colour specs. OPS staff may add in special conditions.	Fortran, Econolite, Electromega
Hangers		Plumbized hangers are typically ordered in concert with signal head order.	Awarded signal head supplier

(f) Project Co is advised of the following non-signalized intersections along the Project alignment as identified in the Functional Plans.

- King Street South and George Street in the City of Waterloo
- Ottawa Street South and Maurice Street in the City of Kitchener
- Ottawa Street South and Nyberg Street in the City of Kitchener
- Ottawa Street South and Bedford Road. in the City of Kitchener
- Ottawa Street South and Lilac Street in the City of Kitchener
- Ottawa Street South and Acacia Street in the City of Kitchener
- Charles Street and Eby Street in the City of Kitchener
- Caroline Street South and Willis Way in the City of Waterloo
- Caroline Street South and Alexandra Avenue in the City of Waterloo
- Caroline Street South and Fullerton Street in the City of Waterloo
- Caroline Street South and Norman Street in the City of Waterloo
- Caroline Street South and Freemont Street in the City of Waterloo

Project Co shall replace and/or upgrade all existing signalized intersections as stated within the Project Agreement and appropriate Schedules not stated herein.

Project Co shall as a part of its scope and responsibility including but not limited to analyze, verify and confirm signal Warrants, obtain all permits where required, verify and vet all required Warrants, design where required and furnish and install where required based upon those

approved signal Warrants new traffic signals for these non-signalized intersections, as required. Project Co shall also provide all engineering and design Record Documents and investigations among others for those intersections that remain non-signalized at the completion of the Project in accordance with the Project Agreement and appropriate Schedules.

Refer to Appendix Y for further details.

## **2.11 Illumination**

- (a) Facilities that shall require lighting include but not limited to all at-grade rail crossings, LRT guideway where required, OMSF and Yard, roadways, streets and road allowance, sidewalks, passenger LRT Stops and GRT bus integration sites, and parking areas among others. Project Co shall refer to the applicable Schedule 15 Article if not stated herein. Lighting installed by Project Co shall consist of two general types, at a minimum: replacement lighting to restore existing fixtures affected and new lighting for facilities created by the Project. Replacement lighting shall be designed to provide illumination equal or greater than current levels utilizing existing and new materials and compliant with the Region of Waterloo Illumination Policy, as a minimum, for street and roadway lighting. For all other areas, Project Co shall apply the Institute of Illuminating Engineers Standards, Ontario Building Code (OBC) among other Codes, Regulatory requirements and Standards. The Re-use of existing lighting and any new lighting shall be designed to meet or exceed applicable Codes and Standards, including Institute of Illuminating Engineers Standards, electrical codes and the Region of Waterloo Illumination Policy, where applicable.
- (b) Design Criteria
- (i) For greater clarity, Project Co shall consider all LRT alignment locations within any street running environment to be a Region designated and controlled street and/or road allowance even if the street is currently a City street at the time of the RFP Submission. Project Co's lighting designs shall be prepared to provide sufficient illumination for the safe use and operation of the facility to be lighted, and typically involves meeting the minimum criteria for average illumination, and uniformity of illumination applicable to the facility. Design details such as mounting heights, equipment requirements, and system electrical specifications shall be based on the standards, practices, and codes that apply to the facility.
- (ii) Lighting design shall be appropriate and consistent with the environment for both pedestrian and vehicular traffic. In the Uptown Waterloo and Downtown Kitchener area, pedestrian lighting shall be provided in accordance with City Standards and Urban Design Standards and Guides.
- (iii) Project Co shall develop an existing illumination light intensity mapping of the Project alignment and adjoining areas affected by the Project, i.e. photometric, which shall be included in the Basis of Design Report and supplement existing lighting to achieve regulatory light levels for each area, where applicable. Further, Project Co shall also perform a post construction illumination light intensity mapping of the Project alignment and adjoining areas affected by the Project, i.e. photometric, and provided as a Record Document.

- (iv) The Basis of Design Report shall clearly delineate the approach to achieve the required lighting levels including example lighting layout and integration approach to limit pole pollution while maintaining operation and maintenance access.
  - (v) Street and Pedestrian Lighting - Pole clutter should be “**minimized**” at all locations along the LRT alignment including the adjoining road allowance and intersecting streets in keeping with the Region’s and City Policy. Joint use of street lighting and pedestrian lighting shall be “**maximized**” where allowed by Policy, Region, City and the local Hydro practice. Project Co is not precluded from utilizing the LRT catenary as a means of supporting its design for street lighting and pedestrian lighting. However, Project Co will become the sole maintainer of these lights, their appurtenances, and system with the exception of power consumption as stated in the Project Agreement.
- (c) Equipment
- (i) To maintain consistent illumination on a given facility and to simplify future maintenance, the lighting equipment installed by Project Co shall consist of materials which are part of the common inventory of the owner and appropriate maintaining agency and in accordance with Project Co’s approved design for other areas taking into account the facility and Project Co’s maintenance and operations requirements. Lighting designs shall be based on the performance specifications for these materials.
  - (ii) Acceptable Materials:
    - A. Poles
      - 1. City of Waterloo and Waterloo North Hydro Inc. (WNH)
        - (a) Project Co’s design shall apply the Region of Waterloo Illumination Policy along King Street from the Project Limits at Conestoga Mall including Northfield Drive and the Waterloo Spur and Project affected adjoining intersecting streets and at-grade rail crossings including Caroline Street with its intersection with Erb Street, Allen Street, and along King Street from just east of William Street to Union Street (i.e. City of Waterloo Limits) and its adjoining intersections based upon the following:

Project Co, where required and relocated by design, replace existing poles with new poles and add new poles, where required, for all street lighting affected in accordance with the Region’s Policy. The re-use of existing poles is subject to the Region and local Hydro approval after the completion of a field condition assessment and report by Project Co, Region and local Hydro of the poles in question to be retained and re-used by Project Co. However, and for greater clarity, Project Co shall not rely on the re-use of existing poles for the purposes of its Proposal Submission. All poles shall be new materials with the exception of the joint use Caroline Street galvanized steel poles.

For greater clarity, currently Waterloo North Hydro Inc. (WNH) Policy is to utilize fully treated pine wood poles when WNH

primary and/or secondary are on the shared pole with the street lighting with the appropriate and Project Co designed appurtenances. If the street lighting is a standalone pole without WNH primary and/or secondary, concrete poles shall be utilized with the appropriate and designed Project Co appurtenances. Further, Project Co is advised that WNH currently employees the joint use of the primary and secondary along with street lighting on galvanized steel poles on Caroline Street from east of the Caroline/Erb Street intersection to Allen Street. Project Co shall confirm with WNH the application and enforcement and of its Policy prior to replacing and relocating these poles. It is envisioned these poles will be re-used by WNH, if relocated, as a result of Project Co's design and application of the Region's Policy.

- (b) Project Co's design shall apply the Region of Waterloo Illumination Policy and City of Waterloo Standards for street and pedestrian lighting and utilize the City of Waterloo's ornamental and decorative lighting poles and fixtures within Uptown Waterloo for street and pedestrian lighting. This includes the intersection of Caroline Street and Erb Street, the portion of Waterloo Spur from Caroline/Erb intersection and adjacent Uptown Waterloo Square and adjoining Parking lots to King Street at-grade rail crossing, and King Street from the Waterloo Spur at-grade rail crossing to just east of William Street and all affected adjoining streets and intersections.

For greater clarity, Project Co shall design, apply, furnish, install, and provide new City of Waterloo Uptown Waterloo Type D Light Pole pedestrian lighting in accordance with the City of Waterloo Standards at all LRT Stops on the same side of the LRT Stop when side running and on both sides of the street when center running and applied at the Caroline Street LRT Stop, Uptown Waterloo Waterloo Square LRT Stop and King Street and Allen Street LRT Stop. The distance and extent of the City's Standard Type D pedestrian lighting at these LRT Stops shall be based upon the length of the LRT Stop and the nearest pedestrian crossing at both ends of the LRT Stop. When the nearest street intersection is greater than 25 m from either end of a LRT Stop, Project Co shall terminate the Type D pedestrian lighting within a reasonable distance from the ends of the platform.

Project Co shall salvage, store and repair as required to like new condition, and reuse all existing Uptown Waterloo ornamental and decorative poles affected by Project Co's design. New poles shall be furnished and installed by Project Co based upon its approved design to match existing poles. Further, Project Co shall repair or replace all damaged appurtenances, re-ballast and re-lamp the luminaire, clean all lenses or replace cracked,



damaged or missing lenses, replace all ground fault receptacles, paint, where required, among other to like new condition. Refer to Appendix J for the City of Waterloo Uptown Waterloo Type D Light Pole Detail.

- (c) Project Co's scope shall provide and make provisions for within its design, furnish and install including but not limited to an encased conduit duct bank with hand holes spaced at acceptable City of Waterloo Uptown Waterloo Type D Light Pole pedestrian spacing from the intersection of Caroline Street and Erb Street along both sides of Caroline Street to Allen Street intersection, along both sides of Allen Street from Caroline Street to King Street, along both sides of King Street from just east of William Street to Union Street to allow for the extension and expansion of the current ornamental and decorative pedestrian and street lighting and those required Type D lights and stated herein. These duct banks and their hand holes are intended for the future use by the City of Waterloo pedestrian lighting. They shall include pull wire of appropriate design tension for wiring at a future date by the City of Waterloo including all hand hole lids and appurtenances.
  - (d) Project Co shall apply and take into consideration the Institute of Illuminating Engineers Standards, Ontario Building Code (OBC) among other Codes, Regulatory requirements and Standards, City and surrounding community when selecting the poles for the OMSF and Yard and Traction Power Substations (T.P.S.S.) among other facilities required as a result of Project Co's design.
2. City of Kitchener, City of Kitchener Defined Urban Districts and Kitchener-Wilmot Hydro Inc. (KWH) – Kitchener Downtown Standard (65710) refer to Appendix J and Kitchener-Wilmot Hydro Inc. Policy
- (a) Project Co's design shall apply the Region of Waterloo Illumination Policy within the City of Kitchener and Project affected adjoining intersecting streets and at-grade rail crossings. Further, Project Co, where required and relocated by design, replace existing KWH poles with new poles for all street lighting affected. The re-use of existing KWH poles is subject to the Region and local Hydro approval after the completion of a field condition assessment and report by Project Co, Region and local Hydro of the poles in question to be retained and re-used by Project Co. However, and for greater clarity, Project Co shall not rely on the re-use of existing KWH poles for the purposes of its Proposal Submission.

Project Co's design shall apply the Region of Waterloo Illumination Policy and City of Kitchener Standards for street and pedestrian lighting and utilize the City of Kitchener's existing ornamental and decorative lighting poles and fixtures

within Downtown Kitchener for street and pedestrian lighting where they currently exist. Other existing ornamental and decorative poles shall also be re-used and relocated as required by Project Co's design. This includes as an example the intersection of King Street and Victoria Street and the Duke Street area of City Hall among others.

For greater clarity, Project Co shall design, apply, engineer, furnish, install, and provide new City of Kitchener Downtown Standard (65710) street and pedestrian lighting in accordance with the City of Kitchener Standards at all street running LRT Stops on the same side of the LRT Stop when side running and on both sides of the street when center running and applied at all City of Kitchener LRT Stops. The distance and extent of the City's Downtown Standard pedestrian lighting at these LRT Stops shall be based upon the length of the LRT Stop and the nearest pedestrian crossing at both ends of the LRT Stop. When the nearest street intersection is greater than 25metres from a LRT Stop, Project Co shall terminate pedestrian lighting within a reasonable distance from the ends of the platform. Project Co shall for the King Street Grade Separation LRT Stop, i.e. HUB, consider Moore Avenue and Victoria Street as the termination points for the City Downtown Standard (65710). Project Co shall for the Ottawa and Mill Street LRT Stop apply the City Downtown Standard (65710) for street and pedestrian lighting for the entire intersection on Mill Street and Ottawa Street. Further, Project Co shall for the Block Line Road LRT Stop apply the City's Downtown Standard (65710) street and pedestrian lighting to the intersection at Block Line Rod and a reasonable termination distance north of the LRT Stop along Courtland Avenue.

Project Co shall salvage, store and repair as required to like new condition, and re-use all existing City of Kitchener Downtown Standard (65710), refer to Appendix J, and other ornamental and decorative poles affected by Project Co's design. New poles shall be furnished and installed by Project Co based upon its approved design to match the existing Downtown Standard, ornamental or decorative poles. Further, Project Co shall repair or replace all damaged appurtenances, re-ballast and re-lamp the luminaire, clean all lenses or replace cracked, damaged or missing lenses, replace all ground fault receptacles, paint, where required, among other to like new condition. Refer to Appendix J for the City of Kitchener Downtown Standard (65710).

For greater clarity, currently Kitchener-Wilmot Hydro Inc. (KWH) Policy is to utilize fully treated western cedar wood poles when KWH primary and/or secondary are on the shared pole with the street lighting. If the street lighting is a standalone

pole without KWH primary and/or secondary, concrete poles shall be utilized. Project Co shall apply this requirement as stated herein under 2.11.

- (b) Project Co shall apply and take into consideration the Institute of Illuminating Engineers Standards, Ontario Building Code (OBC) among other Codes, Regulatory requirements and Standards, City of Kitchener and surrounding community when selecting the poles for the Traction Power Substations (T.P.S.S.) among other facilities required as a result of Project Co’s design.

**B. Luminaire**

1. LED fixtures for all LRT Stops, LRT pedestrian bollards, and poles associated with the LRT Stops and LRT shelters including any GRT bus integration stop/shelters. Please refer to Article 14 LRT Stops and Stop Equipment. Project Co may use LED fixtures where allowed within the other Schedule 15-2 Articles.
2. OMSF and Yard, Traction Power Substations (T.P.S.S.) as well as other facilities Project Co is responsible for as a part of the Project apply in accordance with Institute of Illuminating Engineers Standards, Ontario Building Code (OBC) among other Codes, Regulatory requirements and Standards. Project Co shall consider the facility, its use, function, worker and public safety, security and respective City and surrounding community when selecting an appropriate luminaire, i.e. HPS, MH, Mercury Vapor or LED.
3. High Pressure Sodium (HPS) fixtures for all street lighting in accordance with the Region of Waterloo Illumination Policy and local Hydro available materials and use as stated herein.
4. City of Kitchener - Kitchener Downtown Standard (65710) refer to Appendix J and use as stated herein and where impacted by Project Co’s design.
5. City of Waterloo – Halophane Fort Washington Series refer to Appendix J and use as stated herein and where impacted by Project Co’s design.
6. Please note the following local Hydro street light materials available for use and consideration by Project Co in its Illumination design:

<b>Exhibit 2.11-1 Waterloo North Hydro (WNH) Typical Street Lighting Material</b>			
<b>Item Description</b>	<b>Manufacturer</b>	<b>Model Number</b>	<b>WNH Reference Number</b>
250W HPS Luminaire	American Electric Lighting	20 25S CT 120 R2 FG M2 CS	870 040 00115

<b>Exhibit 2.11-1 Waterloo North Hydro (WNH) Typical Street Lighting Material</b>			
<b>Item Description</b>	<b>Manufacturer</b>	<b>Model Number</b>	<b>WNH Reference Number</b>
150W HPS Luminaire	American Electric Lighting	20 15S CT 120 R2 FG M2 CS	870 040 00085
100W HPS Luminaire	American Electric Lighting	20 10S CT 120 R2 FG M2 CS	870 040 00080
70W HPS Luminaire	American Electric Lighting	20 07S CT 120 R2 FG M2 CS	870 040 00075
250W Lamp	Phillips	C150S55/ALTO NC HPS	870 030 00016
150W Lamp	Phillips	C150S55/ALTO NC HPS	870 030 00015
100W Lamp	Phillips	C100S54/ALTO NC HPS	870 030 00010
70W Lamp	Phillips	C70S62/ALTO NC HPS	870 030 00005
15' Street Light Arm	USS Manufacturing	TER15MA	870 010 00045
12' Street Light Arm	USS Manufacturing	TER12MA	870 010 00040
10' Street Light Arm	USS Manufacturing	TER10MA	870 010 00035
8' Street Light Arm	USS Manufacturing	TER8MA	870 010 00025
Photo Cell	Lumatrol	120V, 1800VA, ECDV-AP-TD	870 070 00010
Fuse, 5 Amp	Cooper Bussmann	KTK-5	870 020 00005
Fuse Inline Holder	Littelfuse	0LEB00AAX	870 100 00160
Fuse Inline Boot	Littelfuse	WPB1	870 100 00165
On-Pole Breaker, 60 Amp, 22kA	ENASCO	CPL072R	870 100 00150
Cable/Conductor	Nexans, General Cable, Priority Wire & Cable	#4 Al Duplex, 1-#4 Al Polyethylene, 1-#4 ACSR	220 070 00031

<b>Exhibit 2.11-2 Kitchener Wilmot Hydro (KWH) Typical Street Lighting Material</b>			
<b>Hydro No.</b>	<b>Description</b>	<b>Manufacturer Name</b>	<b>Catalog Number</b>
38S071000	Stl-Photoeye&Bracket 811-21		Various Approved

<b>Exhibit 2.11-2 Kitchener Wilmot Hydro (KWH) Typical Street Lighting Material</b>			
<b>Hydro No.</b>	<b>Description</b>	<b>Manufacturer Name</b>	<b>Catalog Number</b>
38S071004	Stl - Bracket RE8MA		Various Approved
38S071005	Stl - Bracket TER10MA		Various Approved
38F088008	Fuse 10 Amp		Various Approved
38F088009	Fuse 15 Amp		Various Approved
38S071016	Stl - Fuse KIt SLK-M	Homac	SLK-M
38S072004	Stl-150 Watt HPS Lamp		Various Approved
38S072005	Stl-200 Watt HPS Lamp		Various Approved
38S072006	Stl-250 Watt HPS Lamp		Various Approved
38S073008	STL-150w HPS F. Lens Luminaire	American Electric	11515SCT120R3FGM2UPCSNRECHKHP
38S073009	STL-200w HPS F. Lens Luminaire	American Electric	12520SCTDT1R3FGM2UPCSNRECHKHP
38S073010	STL-250w HPS F. Lens Luminaire	American Electric	12525SCT120R3FGM2UPCSNRECHKHP
38S074000	STL-Photo Eye Receptacle		Various Approved
38S074001	STL-Photo Eye Cell		Various Approved
38S074011	Stl-Relay 60AMP No Fuse Recept	EPAC	
38S074012	Stl-Relay 60Amp No Fuse No Rec	EPAC	
38S074013	Stl-Relay 60Amp Fuse Recept	EPAC	
38S074004	Stl-Relay 60Amp Fuse No Recept	EPAC	
38S075000	Stl-O/H Duplex 1-2/0, 1#2	OH Aluminum	Various Approved
38S075001	Stl-O/H Duplex #2C-#4	OH Aluminum	Various Approved
38S075002	Stl-Wire 2/C #12		Various Approved

<b>Exhibit 2.11-2 Kitchener Wilmot Hydro (KWH) Typical Street Lighting Material</b>			
<b>Hydro No.</b>	<b>Description</b>	<b>Manufacturer Name</b>	<b>Catalog Number</b>
38S075003	Stl-Wire 2/C #4-1/C #6 UG Copper	Nexans	
38S076001	Stl-Serv Ent Switch 2CCt Red W	Enasco	

- C. Controls – New photocell controlled, consistent, compatible and applicable with the materials stated and noted herein.
- (iii) Acceptable Materials – City of Waterloo
  - A. Uptown Waterloo - Refer to Appendix J Uptown Waterloo Type D Light Pole Detail, its appurtenances, use and applied as stated herein under 2.11.
  - B. All other areas along the LRT alignment, adjoining streets and intersections, and at-grade rail crossings refer to, use and apply the information stated herein under 2.11.
  - C. Other private property ingress/egress lighting – Project Co shall design and coordinate the reuse of the existing lighting and appurtenances as a result of Project Co’s design. Project Co’s scope shall include but not limited to the furnishing and installation of new conduit, cleaning of the existing lighting, new foundations and connections where required, new hand holes with lids, new junction boxes with lids, painting as required, pull wire, re-ballasting and re-lamping, testing, commissioning, wiring, and any required and/or relocated local Hydro metering and fuse/breaker tie-ins among others to like new condition. Damages caused by Project Co will result in the complete replacement of the existing material at no cost to the Region, City and property owner.
- (iv) Acceptable Materials – City of Kitchener and City of Kitchener Defined Urban Districts
  - A. King St. West Corridor – Union Street to King Street Grade Separation to just west of the Moore Street Intersection –
 

Project Co shall apply the Region’s Illumination Policy and replace all existing street and pedestrian lighting with new materials affected by Project Co’s design in accordance with Region and KWH Policy.

Grand River Hospital (GRH) – Project Co shall design, coordinate, salvage and re-use all existing GRH affected access and parking lot lighting affected by Project Co’s design. Project Co’s scope shall include but not limited to the furnishing and installation of new conduit duct bank and encased as required by

Code, cleaning of all equipment and luminaire lenses, new foundations and connections, new hand holes, new junction boxes, painting as required, new pull wire of appropriate tension, replacement of all luminaire ballast and re-lamping, repairing to like new condition, re-installation, testing and commissioning, new wiring, and any required and/or relocated local Hydro metering and fuse/breaker tie-ins. Any damaged lighting and appurtenances caused by Project Co's activities will result in the complete replacement at no cost to the Region, GRH, City and local Hydro.

Other existing City ornamental or decorative pedestrian lighting and private property owner ingress/egress lighting – Project Co shall design, coordinate, salvage and re-use the existing lighting and its appurtenances as a result of Project Co's design. Project Co's scope shall include but not limited to the furnishing and installation of new conduit duct bank, cleaning of all existing equipment and luminaire lenses, new foundations and connections, new hand holes, new junction boxes, new pull wire of appropriate tension, painting as required, replacement of all luminaire ballast and re-lamping, re-installation, repairing to like new condition, testing and commissioning, new wiring, and any required and/or relocated local Hydro metering and fuse/breaker tie-ins among others. Damages caused by Project Co will result in the complete replacement of the existing material at no cost to the Region, City, local Hydro and private property owner.

- B. Warehouse District – King Street Grade Separation from just east of Moore Avenue to Francis Street Intersection (This includes the affected portions of Charles Street and Victoria Street) –

Project Co shall apply the Region's Illumination Policy and replace with new materials all existing street lighting affected by Project Co's design in accordance with Region and KWH Policy. The exception will be the City's ornamental and decorative lighting on King Street and Victoria Street and at intersections. These shall be salvaged, repaired as stated herein under 2.11 and as required, and reinstalled by Project Co

All other existing ornamental or decorative light poles, luminaires and appurtenances and Other private property owner ingress and egress lighting – As stated and noted herein under 2.11.

- C. City Centre District – Francis Street to Frederick/Benton Street Intersection (This includes Charles Street and Duke Street) –

Project Co shall apply the Region's Illumination Policy and replace with new materials all existing street lighting affected by Project Co's design in accordance with Region and KWH Policy.

All existing City of Kitchener Downtown Standard (65710) Appendix J lighting in the vicinity of City Hall and other downtown ornamental or decorative light poles, luminaires and appurtenances and Other private property owner ingress/egress lighting – As stated and noted herein under 2.11.

- D. Market Stop – Frederick/Benton Street to Cedar Street Intersection –

Project Co shall apply the Region's Illumination Policy and replace with new materials all existing street lighting affected by Project Co's design in accordance with Region and KWH Policy.

All existing ornamental or decorative light poles, luminaires and appurtenances and Other private property owner ingress/egress lighting – As stated and noted herein under 2.11

- E. Charles Street from east of the Cedar Street Intersection and Kitchener Market LRT Stop to Borden Street and Ottawa Street, Borden Avenue, Ottawa Street, Mill Street, Hayward Avenue, Courtland Avenue, Balzer Road, Wilson Avenue, all At-Grade Rail Crossings and adjoining streets and intersections -

Project Co shall apply the Region's Illumination Policy and replace with new materials all existing street lighting affected by Project Co's design in accordance with Region and KWH Policy.

All existing ornamental or decorative light poles, luminaires and appurtenances and Other private property owner ingress/egress lighting – As stated and noted herein under 2.11.

(d) Maintenance

- (i) Future maintenance of the lighting systems installed within the LRT Stop areas or within the LRT trackway corridor shall be the responsibility of Project Co. All other lighting shall be maintained by the agency that currently has jurisdiction over the lighted facility.

(e) LRT Stop Area Lighting

- (i) LRT Stop area lighting shall include internal site circulation and access to the LRT Stop. The placement of luminaires shall not obstruct the movement of vehicles or pedestrians. Luminaire placement shall be coordinated with the landscape and site plans to protect light standards located adjacent to roadways and to ascertain that planting shall not obscure the lighting distribution pattern.
- (ii) Project Co. shall coordinate with Schedule 15-2 Article 14 for LRT Stop lighting.

(f) Vehicular Access Lighting

- (i) Vehicular access lighting shall provide a natural lead-in to the bus and kiss-and-ride areas. The illumination on all access and egress roads shall be graduated up or down to the illumination level of the adjacent street or highway.

(g) Parking Lot Lighting

- (i) Lighting poles shall be located generally along the parking barriers and the parking lot perimeter. The placement of poles shall present a minimum obstruction to movement and parking of cars.
- (ii) Parking lot illumination shall be controlled to direct light to the parking areas, while minimizing spillover of illumination to adjacent properties.
- (iii) All parking lot and walkway lighting shall be controlled automatically by photocell and time-clock switch. For security lighting, circuits shall be designed so that approximately 15 to 25 percent of normal parking area and roadway entrance lighting is controlled by



photocells. The remainder of exterior lighting shall be controlled by photocells, but shall be turned on and off by time-clock switches.

- (h) Application of Municipal Region of Waterloo Illumination Policy
  - (i) For greater clarity, Project Co shall apply the Municipal Region of Waterloo Illumination Policy for street and/or road allowance lighting as follows:
    - A. Treat all center running LRT alignment locations as two equivalent vehicular travel lane widths when determining the overall lane configuration of the resulting Project Co design of the street and/or road allowance.
    - B. Treat all side running LRT alignment locations as one equivalent vehicular travel lane width when determining the overall lane configuration of the resulting Project Co design of the street and/or road allowance.
  - (ii) Intersections: signals are lit by installing luminaires on each primary signal head over the crosswalk on the receiving lane. Unsignalized intersections do not require specialized lighting unless there is not adequate coverage from the existing street illumination on the hydro poles.
  - (iii) midblock roadway: The design guidelines prefer to use the local Hydro poles whenever possible. Regional practice is to install the lights at approximately 45m apart (standard Hydro spacing).
  - (iv) pedestrian crossings: Standard regional practice is: intersection crossings are lit by intersection lighting above. Mid-block pedestrian crossings are lit on both sides of the road in advance of the crossing (8-10m).
  - (v) walkways: the policy states that walkways not on the roadway are a local responsibility. Sidewalks/ walkways are not considered. This does not apply to walkways and pedestrian crossings to LRT Stops. Full illumination in accordance with TAC low intensity lighting is required in these areas as a minimum.
  - (vi) GRT stops for both vehicles and pedestrians: not considered, however, GRT stops (along with a sidewalk) do trigger illumination if none exist.
  - (vii) The criteria would be typically a 150w HPS luminaires (different models in Kitchener and Waterloo) spacing of typical 45m, double sided if over 4 lanes and 3.0m arms. Mounting height would typically be  $\pm 9m$  which would put the luminaire around 10.5m. However, Project Co shall apply the Region's Illumination Policy and determine the pole spacing, wattage, arms lengths, among other appurtenances to satisfy Project Co's design and the materials, requirements provided and stated herein under 2.11.

**2.12 Traffic Control Devices**

- (a) The road reconstruction or restoration necessitated by the Project shall require the relocation or replacement of various permanent traffic control devices, including traffic signs, pavement markings, and traffic signals.
- (b) Objectives
  - (i) The design of traffic control devices to be installed by the Project shall seek to restore the conditions in place prior to construction, except where introduction of the LRT requires modifications to the existing conditions. Modifications to the existing traffic controls

shall be designed in accordance with the requirements of the Region, Local Municipality and Manual of Uniform Traffic Control Devices for Canada (MUTCD).

- (ii) In areas of transition of LRT trackway location and at intersections, appropriate signing and warning devices (i.e. rumble strips and coloured concrete) shall be used to prevent vehicle and pedestrians from entering the trackway at any point.
- (c) Signing
- (i) Regulatory, guide, and warning sign panels installed or relocated by the Project shall meet the requirements of the Manual of Uniform Traffic Control Devices for Canada (TAC and Region/Municipal standards). Sign structure, posts, and mounting designs shall meet the criteria and standards of the jurisdictional and maintaining agency. Existing sign bridges and ground-mounted signs shall be relocated as necessary.
  - (ii) Minimum vertical clearances to overhead sign structures shall be based on the type of facility over which the sign is suspended. Where necessary, sign lighting shall be installed. Destination and information signs shall be designed in accordance with Region standards for sign coloring, lettering, and readability. Pedestrian signage shall comply with AODA guidelines and the Active Transportation Master Plan (ATMP). In some instances, municipal and municipal agencies (GRT) signs may be mounted on the LRT structure; the design of the LRT structures shall account for this possibility.
- (d) Pavement Markings
- (i) All pavement delineation devices and materials shall comply with the requirements and specifications of the Manual of Uniform Traffic Control Devices for Canada and Ontario Traffic Manual Book 11 Pavement Markings with OTM Book 11 taking precedence in the event of a conflict between the two manuals.
  - (ii) All pavement markings shall be Durable Pavement Markings and comply with RWSSP 710 and OPSS 710.
  - (iii) Pedestrian Crossings at intersections and LRT stops shall be Ladder Type Durable Pavement Markings.
- (e) Lane/Obstacle Delineation
- (i) Ground mounted high visibility flexible delineators may be used to direct lane transitions where the LRT transitions from centre running to side running and vice versa.
  - (ii) Pavement markings and texture shall be used to clearly delineate areas where vehicle/LRV dynamic envelope conflicts could occur. Particular care should be taken on turns, transitions and complex intersections.

### **2.13 Maintenance and Protection of Traffic**

- (a) As the Project area includes some of the busiest roadways in the Region, construction activities associated with a Project of this magnitude may impact traffic patterns on the adjoining roadways. In some cases, traffic within the limits of construction shall be subject to speed reductions, altered traffic patterns, and reduced levels of service. Refer to Schedule 15-2 Article 18 for the overall traffic management requirements.
- (b) Objectives

- (i) As part of the design process, detailed schemes for the maintenance and protection of traffic (MPT) shall be developed. These schemes shall provide safe temporary operations during construction, while minimizing disruption of traffic and impacts to the adjacent communities.
- (c) References
  - (i) Ontario Traffic Manual – Book 7 – Temporary Conditions
- (d) Design Criteria
  - (i) The following design issues shall be considered in the development of maintenance and protection of traffic schemes in accordance with Region standards:
    - A. Safety of motorists
    - B. Worker safety
    - C. Maintenance of existing traffic patterns
    - D. Maintenance of pedestrian access
    - E. Maintenance of bike access
    - F. Maintenance of parking facilities
    - G. Maintenance of Business access
    - H. Construction vehicle access
    - I. Temporary signing and traffic control
    - J. Utility relocations
    - K. Temporary drainage
    - L. Temporary lighting
    - M. Temporary pavement
    - N. Dust and erosion control/mitigation
    - O. Noise control and mitigation
    - P. Vibration control and mitigation
    - Q. Protection of existing vegetation to remain
    - R. Maintenance of fire protection system (in accordance with NFPA 13, Building
    - S. City of Kitchener and City of Waterloo Standards
    - T. Province of Ontario Regulations
    - U. Maintenance of Emergency Services for Ambulance, Fire and Police

## 2.14 Landscaping

### (a) Intent

- (i) Project Co. shall replace all existing landscaping along the alignment with new landscaping consistent with the specific area requirements as identified by the City's Urban Design Guidelines.
- (ii) A significant length of the corridor does not provide adequate boulevard for plantings or landscape features. Project Co shall identify areas to be set aside for planting and proposed landscaping configurations in accordance with the appropriate municipality's urban design guidelines. In LRT Stop areas, planting areas shall be provided with a source of irrigation water and irrigation system if appropriate; however, in general terms, the preference will be for native plants and xeriscaping
- (iii) The Basis of Design Report shall detail typical landscaping features for Stop areas, median island and tree compensation layouts in both urban and suburban areas.
- (iv) City of Kitchener
  - A. Urban Trees – As per City of Kitchener Tree List – Species selection shall be appropriate for height restrictions associated with the OCS.
  - B. Tree Frame and Grate – As a basis for bid in the RFP and subject to change during negotiations with the successful Proponent, Project Co shall refer to and apply in its design the City of Waterloo, Uptown Waterloo Tree Grate Details shown in Appendix J.
  - C. Tree Bed
    - 1. Urban Boulevard - Silva Cell or approved equal as per City of Kitchener Detail UF.3.3 – Minimum soil volumes to correspond to City of Kitchener Detail UF.3.1
    - 2. Suburban Areas (Huron Spur, Courtland Ave) as per City of Kitchener Detail UF.4.1
  - D. As an alternative to in-kind replacement of built landscaping beds in Downtown Kitchener – King St. Grade Separation to Cedar St. Station Stop, provide moveable planters (Barkman Concrete Products) Contempra Square in Ebony finish gfrc standard Model (105318 – 18"x30", 105320 – 20"x40", 105321 – 35"x17") with the requirement to provide as a minimum equal surface area to current beds.

### (b) Specific Details

- (i) Huron and Waterloo Spur – Topsoil and Hydroseed as per OPSS 802 and 804 or approved native groundcover.
- (ii) All other areas – Topsoil and Sod as per OPSS 802 and 803
- (iii) City of Waterloo
  - A. Urban Trees – As per City of Waterloo Tree List – Species selection shall be appropriate for height restrictions associated with the OCS.
  - B. Tree Frame and Grate – Refer to Appendix J.

- C. Tree Bed
  - 1. Urban Boulevard - Silva Cell or approved equal as per City of Kitchener Detail UF.3.3 – Minimum soil volumes to correspond to City of Kitchener Detail UF.3.1
  - 2. Suburban Areas (Waterloo Spur) as per City of Kitchener Detail UF.4.1
- (iv) As an alternative to in-kind replacement of built landscaping beds in Uptown Waterloo on King St. and Caroline, provide moveable planters (Barkman Concrete Products) Contempra Square in Ebony finish gfrc standard Model (105318 – 18”x30”, 105320 – 20”x40”, 105321 – 35”x17”) with the requirement to provide as a minimum equal surface area to current beds.
- (c) Tree Removal and Reinstatement
  - (i) Project Co. shall complete a tree inventory within the Right-of-Way and any trees whose dripline crosses the Right-of-Way line including species, condition and caliper diameter.
  - (ii) All trees that are to be removed that are greater than 100 mm caliper diameter shall be replaced in kind with suitable soil ball as defined by the Cities and as per Section 2.14 of this Article. In-kind replacement shall be at a ratio of two (2) new trees per removal of one existing tree. Along existing forested areas such as Huron Spur and Waterloo Spur north of Bearinger Drive, trees shall be reinstated to re-establish a vegetated buffer between the LRT and adjacent properties.
  - (iii) Where there is inadequate space within the proposed cross-section for in-kind replacement of trees, Project Co shall coordinate with the appropriate municipalities for in-kind replacement in other areas along the alignment (preferred) or in other areas of the City as necessary.

## **2.15 Bus Transit Integration**

- (a) Project Co. shall be responsible for reinstating or relocating bus stop infrastructure as part of the project scope. This is considered a Public Infrastructure Works component of the project. Design and construct in accordance Grand River Transit Standards. Appendix Q illustrates the alignment specific requirements for the addition/replacement/upgrade of existing local bus stop infrastructure.
- (b) Specific Details
  - (i) Landing Pads – Streetside area for alighting to bus. Landing pads that are integrated with the LRT shall include similar design layouts as defined in Schedule 15-2 Article 14 for the LRT Stops.
    - A. Type 1 – 9.5 m long by boulevard width or 3.0m whichever is greater with connection to adjacent sidewalk.
    - B. Type 2 - 15 m long by boulevard width or 3.0m whichever is greater with connection to adjacent sidewalk.
  - (ii) Shelter Pads – Mounting location for bus shelter

- A. Type 1 – To match existing shelter dimensions – Refer to Drawing C-DET-003 for layout – pad thickness and geotechnical by Project Co.
  - B. Type 2 – To match proposed shelter dimensions – Refer to Drawing C-DET-003 for layout – pad thickness and geotechnical by Project Co.
- (iii) Shelters
- A. Type 1 – Integrated Shelter - This design shall be developed by Project Co to match the urban design objectives of the LRT Stop.
  - B. Type 2 – Glass Shelter – Consistent design to match one of acceptable samples provided (Appendix Q).
  - C. Type 3 – Advertising Shelter – To be provided and installed by others as coordinated by Project Co.
  - D. Type 4 – Building Overhang Existing
- (iv) Power and Communications – For requested bus stops only.
- A. Power – Provide 50mm diameter conduit stubbed up through concrete to 500mm offset from edge of pad in location to be confirmed by Grand River Transit
  - B. Communications – Provide 50mm diameter conduit stubbed up through concrete to 500mm offset from edge of pad in location to be confirmed by Grand River Transit
- (v) Variable Message Signs
- A. To be installed by GRT independent from Project.

**2.16 Miscellaneous Civil**

- (a) A number of infrastructure elements required to be designed may not be described in the preceding Paragraphs, and/or are subject to more specific requirements than discussed above. These components of the Project are described below, along with the design criteria or reference to be used in this design.
- (b) Parking Facilities
  - (i) Grade Level – Relevant Municipality’s Urban Design Guidelines for layout, road construction design for infrastructure components.
  - (ii) Structured Parking – Ontario Building Code
- (c) Driveways - Design according to Regional and Municipal Urban Design Guidelines, as well as specific requirements of jurisdictional agencies.
- (d) Accessibility - According to the Ontario Building Code, Municipal Standards and AODA.
- (e) Fencing – Fencing and railings shall be provided for safety consistent with Municipal Standards and Urban Design Guidelines.

- (i) Pedestrian Railing proximate to LRT trackway and non-ornamental retaining walls shall conform to 915.01.
- (ii) Ornamental Fencing to be addressed on a case by case basis with owners based on renderings provided by the Region.

**2.17 Environmental Considerations**

- (a) Environmental investigations and the Contaminant Management Program shall be in accordance the Project Agreement and Articles contained herein.

**2.18 Noise Mitigation**

- (a) Vibration mitigation shall be in accordance with the requirements of Schedule 17 of the Project Agreement and Articles contained herein.

**2.19 Salvage**

- (a) Salvage of materials as defined in Schedule 15-2 Article 18.
- (b) Demolition/Relocation
  - (i) Project Co. shall be responsible for the demolition and removal of all redundant above and below grade structures within the proposed Right-of-Way. Conduits and pipes underground works where they are not exposed for removal shall be grouted with unshrinkable fill.
  - (ii) Project Co. shall be responsible for the coordination and relocation as appropriate of all private structures that encroach on the proposed Right-of-Way. Signage shall be relocated by the landowner and Project Co. shall be limited to the demolition of the remaining appurtenances as per 2.19(b)(i).

**2.20 Access Management and Right-of-Way, Perimeter and Security Fencing**

- (a) Access management is a set of policies, plans, procedures, personnel, and physical components that provide control and awareness of assets and activities in and around facilities and restricted areas. Access management controls who should be permitted access to facilities and restricted areas; where they can access (e.g., garage or rail yard facilities, vehicles, utility areas within stations or terminals); and when they can access these areas (e.g., certain days of the week or shifts). In addition to controlling passage in and out of facilities or areas, determining who belongs and who does not, access management includes the ability to observe and track movement in and out of controlled areas.

Project Co shall apply reasonable judgement in applying fences and/or railings Project wide. For the Waterloo LRT Project there will be three basic types of fencing, Project Co shall consider: Right-of-Way fences, perimeter fences and security fences. When used, fencing shall be used in conjunction with surveillance and enforcement installation practices to achieve the appropriate level of access control. Perimeter and security type fencing typically encloses to a maximum extent possible the area of concern. Right-of-Way fencing will establish a boundary barrier but due to roadway and pedestrian crossings and passenger stations, a high degree on enclosure is not

practical. Project Co shall consult with Transport Canada and CN regarding fencing requirements along the Huron Park Spur and the Waterloo Park Spurt.

Project Co shall design, construct and maintain Right-of-Way fencing along both sides of the Region's Rights-of-Way in both of these corridors as well as Right-of-Way fencing along the Region's property rights for the Hydro One corridor. In addition to the requirements cited below, Project Co shall adhere to OPSS 1541, OPSS 772, and OPSD 900 Series.

(b) Fencing and Gates

Right-of-Way, perimeter, and security fencing shall be installed as barriers at the following locations and with heights, dimensions, and other requirements, as determined to be necessary by a Threat Vulnerability Assessment (TVA) and agreed to by the Region, including:

- (i) Perimeters of LRT parking lots and structures.
- (ii) Vehicle yards, maintenance depots, etc.
- (iii) Critical facilities and infrastructure (power substations, signal housing, etc.).
- (iv) Along the LRT and railroad track right-of-way (Waterloo Spur, Huron Spur, and Hydro One and where appropriate).
- (v) Fencing can range from high-security grill type fencing to cost-effective chain-link fencing. If the security threat is lower or if aesthetics are a high priority, The Region may request ornamental fencing that is properly designed to prevent scaling as a variation order. Typical fence requirements include:
  - A. Right-of-Way, perimeter fence, and security fences or other barriers shall be located and constructed to deter the introduction of persons, dangerous substances or devices, and shall be of sufficient height and durability to deter unauthorized passage but respectful of visual aesthetics and local concerns.
  - B. Areas adjacent to fences or barriers shall have limited vegetation, objects and debris that could be used to breach the fence or barrier, or hide adversaries or intruders.
  - C. The fence line needs to be inspected regularly for integrity and any damage needs to be repaired promptly.
  - D. If a body of water forms any part of the perimeter barrier, additional security measures shall be provided.
  - E. A fence that is at least 1.4 meters (4.5 feet) high can be used as a Right-of-Way fence or barrier to guide pedestrian movements.



- F. Proper signage shall be posted along the fence or barrier line advising of the danger of entering LRT Rights-of-Way. Signage shall be spaced no greater than 250 meters and shall provide a contact phone number as well as warning information.

(c) Clear Zones

Perimeter and Security Fences shall be constructed so that an unobstructed area or “clear zone” is maintained on both sides of the barrier to make it more difficult for a potential intruder to be concealed from observation. Clear zones for security fences shall meet the following requirements:

- (i) Whenever practical, exterior and interior clear zones shall be 3 meters (10 feet) or more.
- (ii) The clear zone shall be free of any object or feature that would offer concealment, such as a physical structure or parking area, or which could facilitate unauthorized access such as an overhanging tree limb.
- (iii) When a clear zone is not practical, other compensatory measures may be necessary to control access to restricted or secured areas. Appropriate supplemental protective measures include increasing the height of portions of the fence, providing increased lighting, CCTV surveillance cameras monitored from a remote location, installation of intrusion-detection system sensors and security patrols.
- (iv) If required, the design shall consider an additional line of security fencing a minimum of 3 meters to 6 meters (10 ft to 20 feet) inside the perimeter fence to create a controlled area and room for sensors or a patrol road between the fences.

(d) Fence Fabric

Fence fabric shall meet the following requirements designed to increase fence performance:

- (i) Fences, including gate structures, shall be 2.9 mm (9-gauge) or heavier chain-link fabric. Fabric shall be aluminum or zinc-coated steel wire chain link with mesh openings not larger than 5.08 cm (2 inches) on a side.
- (ii) Fence fabric shall be attached to the exterior side of line posts using not less than 2.9 mm (9-gauge) steel ties at the top and bottom of the fence fabric and intermediate ties spaced no greater than 200 mm.
- (iii) Perimeter Fence height shall be a minimum of 1.8 meters (6 feet) to deter unauthorized passage. Security Fence height shall be a minimum of 1.8 meters (6 feet) and may also have barbed-wire/razor wire outrigger extension of 0.3 meters (1 foot). Perimeter fencing and gates for Traction Power Substations shall be 8 foot in height and shall be constructed with materials which provide screening of the TPSS from a street level viewpoint.

- (iv) If barbed wire is to be installed atop a fence, it shall be on the outward facing top guard outrigger at a 45 degree angle to at a minimum of 0.3 m (1 foot) protrusion. The posts for the fence shall accordingly be set back from the property line, if necessary to accommodate such a protrusion
- (v) The distance between the bottom of the fence fabric and firm packed ground shall not exceed 5.08 cm (2 inches)
- (vi) There shall be a top rail and a bottom rail to all fences. The bottom rail shall be properly anchored to prevent intruders from forcing the mesh or fence fabric to crawl under it
- (vii) When the fencing is being installed on soft ground, the fabric shall reach below the surface sufficiently to compensate for shifting soil. To prevent individuals or objects from intruding or penetrating under the fence, a cement apron not less than 15.2 cm (6 inches) thick can be installed under the fence fabric. The fence fabric can also be extended below the bottom rail and set in the concrete. The exposed surface of concrete footings shall be crowned to shed water
- (viii) Pipe framing can be installed on the fabric where it touches the ground, or 0.6 meter (2-foot) long U-shaped stakes can be used to fasten the fabric to the ground
- (ix) Fence fabric shall be attached to terminal posts with stretcher bars that engage each fabric link. The stretcher bars shall be held to the fence post with clamps in such a way as to hold the fabric taut
- (x) If exterior intrusion-detection or a Wayside Intrusion Detection System (WIDS) are provided to be mounted (WIDS), the constant fabric tension shall be maintained at a minimum horizontal tension of 4.45 kN (1,000 pounds) to reduce sensor vibration.
- (xi) To reduce vibrations for a more effective WIDS a tension wire may be stretched from end to end of each section of fence and fastened to the fence fabric. Taut reinforcing wires, a minimum of 2.95 mm (9-gauge), shall be installed and interwoven with or affixed with 2.30 mm (12-gauge) fabric ties spaced 305 mm (12 inches) apart along the fence fabric.
- (xii) On 1.8 meter (6 foot) high fencing the salvage shall be twisted and barbed at top and bottom and shall be knuckled salvage on 1.4 meter (4 foot) fencing.
- (xiii) Metal fencing shall be electrically grounded
- (xiv) If a masonry wall is used as the perimeter or security barrier, it shall be at least 2.44 meters (8 feet) high. Use of additional measures such as installing with broken glass set on edge and cemented to top surface and/or with a top guard of barbed wire shall be determined by a Threat Vulnerability Assessment (TVA) for the facility secured by the perimeter barrier

- (xv) Barbed or razor tipped wire formed into concertina coils shall be considered for top guards on fences or barriers, only if approved by the Region and if in compliance with building codes
- (xvi) The Right-of-Way fence shall be a color polymer coated chain-link fabric to enhance visibility, especially at night.

(e) Posts and Hardware

All fence posts, supports, fasteners, and other hardware for Right-of-Way, perimeter and security fences shall meet the following requirements:

- (i) All fastening and hinge hardware shall be secured against attempts at unauthorized removal by peening or spot welding to allow proper operation of the components but deter disassembly of fence sections or removal of gates
- (ii) The bolts securing the clamps to the posts shall be peened or otherwise modified in a manner to deter attempts at unauthorized removal
- (iii) All posts and structural supports shall be located on the interior of the fence. Posts shall be spaced not more than 3 meters (10 feet) apart and shall be embedded in bell-shaped concrete footings to a depth of 0.61 meters (3 feet) to prevent shifting or sagging. The top of concrete footing shall be 25 to 50 mm above the adjacent soil and troweled to a smooth surface to shed water away from the fence post.
- (iv) The minimum diameter or dimension of fence posts shall be 60.3 mm (2.375 inch) for a line post and 73 mm (2.875 inch) for a terminal post (end, corner, or pull), in accordance with ASTM F-2611 -06. All post shall be capped. The design diameter or dimension shall be determined by a Threat Vulnerability Assessment (TVA) and all corner or end posts shall be braced.

(f) Openings in Fences

The following requirements are required for maintaining the fence's integrity when traversing culverts, troughs, ditches, or other openings:

- (i) Openings shall terminate well within the restricted or secure areas defined by the perimeter security fence barriers. Right-of-Way fencing shall have access gates with a minimum of clear opening of 650 mm spaced approximately every 250 meters. All posts adjacent to openings shall be braced.
- (ii) If perimeter and security fence barriers must traverse culverts, troughs, ditches, or other openings 619.4 sq cm (96 square inches) or greater in area and larger than 1.8 meters (6 feet) in any one dimension, the opening shall be protected by an extension of the fence

construction. This extension may consist of iron grills or other barrier structures designed to prevent unauthorized access

- (iii) Bars and grills shall be installed in such a way that they do not impede required drainage
- (iv) Hinged security grills used with an approved high security hasp, shackle, and padlock, which can be opened when necessary, are often a workable solution to securing drainage structures

(g) Right-of-Way, Perimeter, and Security Gates

The number of Right-of-Way, perimeter and security gates designated for active use shall be kept to the absolute minimum required for operations. The design shall take into account sufficient entrances to accommodate the peak flow of both pedestrian and vehicular traffic, as well as adequate lighting at egress and ingress points. Gates shall follow the following requirements:

- (i) Gates shall be of such material and installation as to provide protection equivalent to the perimeter barriers of which they are a part.
- (ii) The type/operation of security gates (sliding, automatic, etc.), shall be determined as part of design and functionality in conjunction with a Threat Vulnerability Assessment (TVA).
- (iii) The space between the bottom edge of the gate and the pavement or firm ground shall not exceed 5.08 cm (2 inches).
- (iv) All entry gates shall be capable of being locked and secured when closed or guarded at all times, or shall have an effective entry detection alert system, and be capable of being controlled and monitored at local gate house and at the control centres.
- (v) Gates over 1.8 meters (6 feet) in height shall have locks at the top and bottom to ensure that the gate cannot be pried open a sufficient distance to allow unauthorized entry
- (vi) The space between the bottom edge of the gate and the pavement or firm ground shall not extend more than 5.08 cm (2 inches).
- (vii) Vehicular gates shall be set well back from the public highway or access road in order that temporary delays caused by identification control checks at the gate will not cause undue traffic congestion. Sufficient space is provided at the gate to allow for spot checks, inspections, searches, and temporary parking of vehicles without impeding traffic flow
- (viii) At least one vehicle gate that is at least 4.3 meters (14 feet) wide for each enclosure shall be provided to permit entry of emergency vehicles, or its width shall be determined by the turning radius of the longest emergency vehicle expected to pass through the gate.
- (ix) A small gatehouse can be provided at the main entrance of maintenance facilities. Fenced facilities employing electronic card access systems shall consider configuring the main

employee entrance gate with an automated entry control system with CCTV for visual assessment capability

- (x) Gates shall be designed to be consistent with the fencing or other access control for the purpose of the gate. The materials for the gate shall be consistent or be complementary with the material used for fencing or other access control. The minimum diameter or dimension of gate posts shall be 73 mm (2.875 inch) for a terminal post (end, corner, or pull), in accordance with ASTM F-2611 -06. The design diameter or post dimensions and other dimensions of gates shall be determined by a Threat Vulnerability Assessment (TVA)
  - (xi) Gate posts should be as tall in height as the material it supports; be of sufficient strength to hold the gate in place; gate posts shall be braced and be firmly set in the ground to prevent shifting by wind, erosion, or other environmental conditions.
  - (xii) Gate frames should be durable enough to hold the fencing material in place and are connected to the fencing system by hinges attached to line or end posts. Operational necessity is a function of gate width and framing.
  - (xiii) Outriggers are used to hold barbed, razor, or concertina wire or tape in place at the top of a gate system. The arm length, designed to be vertical to clear the fencing system when the gate system is opened, can increase overall height of gate system (also referred to as “Outriggers”).
  - (xiv) Strands of barbed wire should be attached to outriggers at the top of the gate. Barbed wire may be securely fastened vertically or horizontally to the gate’s outrigger, but should be attached in strands of three or more.
  - (xv) Stretched out coils may be attached to the top of gate or to pre-installed strands of barbed wire installed to the top of gate. However, coils connected to the gate should be installed to prevent removal or shifting by winds, or other environmental conditions. (Also referred to as “Barbed Tape, Barbed Concertina Wire, or Razor Wire”).
  - (xvi) Gate mesh fabric should be securely fastened to gate framing and supporting hardware (e.g., bracing bars, rods, wire, etc) to prevent sag, sway, or removal. The smaller the mesh opening – the more difficult it would be to cut; attain a foothold or handgrip. Horizontal gate rails should be secured in place to prevent removal.
  - (xvii) Gates should be at least the height of the posts supporting it. Gates installed in a security environment should always be at least the height of the supporting post.
  - (xviii) All gate hardware and components (nails, screws, nuts, bolts, hinges, bracing, rods, wire, latch, etc.) should be installed on the inside of the gate system.
- (h) Unattended/Inactive Gates

The following are requirements for unattended/inactive perimeter or security gates:

- (i) Unguarded gates shall be securely locked at all times
- (ii) Lighting shall be provided to deter attempts at tampering during the hours of darkness
- (iii) Perimeter intrusion-detection system (PIDS) and CCTV protective measures are appropriate when necessary to meet identified risk control requirements during those periods when the gate is not under the direct visual observation and control of a security officer