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N1 GENERAL REQUIREMENTS

N1.1 Introduction

The purpose of these guidelines is to outline the general design criteria and best practices for design, construction, and inspection of Municipal Street and Walkway Lighting Systems within the City of Markham (City). The guidelines are to provide direction and outline expectations to the Design Engineers and Contractors. The guidelines are not to be considered absolute and following these guidelines shall not relieve the Developer / Design Engineer of the responsibility of the design, constructing, and completing the municipal streetlighting system as a finished product of competent engineering design, construction, and good engineering practices.

N1.2 General

This document provides guidelines for the streetlighting systems Design Engineers working within the City. The Guidelines are provided for selecting streetlighting design criteria, specifications, approval process, construction and installation, inspection guidelines, and best engineering principles and practices to be used in order to produce the most suitable systems for each application. The guidelines are based on and recommended practices for roadway lighting published by Illuminating Engineering Society of North America (IESNA).

This document is not intended to be a complete instruction manual for the design of streetlighting. The Design Engineers are required to refer to the referenced publications for additional information.

N1.3 References

The following published documents have been used as the basis for establishing streetlighting design criteria:

ANSI / IES RP-8-14	Roadway Lighting American National Standard Institute (ANSI) Approved
IESNA TM-3-95	A discussion of Appendix E-"Classification of Luminaire Light Distributions"
IESNA LM-67-94	Calculation Procedures and Specifications of Criteria for Lighting Calculations
IES LM-79-08	Approved method for Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80-08	Approved method for Measuring Lumen Maintenance of LED Light Sources
IES LM-82-12	Approved method for the Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature
IESNA TM-10-00	Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) in Conjunction with Roadway Lighting
IESNA TM-11-00	Light Trespass; Research, Results and Recommendations
IESNA TM-15-11	Luminaire Classification System for Outdoor Luminaires
IES TM-21-11	Projecting Long Term Lumen Maintenance of LED Light Sources
TAC	Guide for the Design of Roadway Lighting (Transportation Association of Canada)
IES / IDA MLO	Model Lighting Ordinance
CSA C653-13	Photometric Performance of Roadway and Streetlighting Luminaires

N1.4 Professional Certification

Streetlighting and walkway system designs shall be completed by a Professional Engineer in good standing with the Professional Engineering Society of Ontario (PEO) who is licensed to practice professional engineering in the Province of Ontario with expertise in this field.

All drawings submitted to the City for acceptance shall be signed and sealed by a Professional Engineer of a Design Engineering Firm. The City shall be accepting the drawings "As to form in reliance upon the professional skill and ability of the Design Engineering firm, as to design and specification."

N1.5 General Definitions

DESIGN ENGINEER	The Design Engineer means Electrical Design Engineer hired by the Developer/Civil Consulting Engineer to prepare streetlighting design. Requirements for designation as a Design Engineer are: ➢ a PEO member in good standing ➢ have at least five years of experience satisfactory to Council, in excess of the four-year experience requirement for licensure ➢ be "primarily engaged" in the independent practice of professional engineering in Ontario for the past two years ➢ hold a Certificate of Authorization from PEO, or be a partner or employee of a firm holding a Certificate of Authorization ➢ Derive a significant portion of revenues from fees related to the practice of professional engineering ➢ Have no conflict of interest that might influence independent professional judgment
CITY STANDARDS	City's Engineering Standards including the City's Design Criteria and Standard Drawings
LOCAL	Roadway network system used for direct access to residential commercial or industrial developments, including Laneways.
COLLECTORS	Roadways servicing traffic between the "Arterial" and "Local" roadways - Minor or Major Collector.
ARTERIALS (City or Regional owned)	Roadway system serving as the principal network for through traffic in and out of the City.
OPPOSITE SPACING	A lighting arrangement wherein all lighting poles are designed to be directly paired to one another on either side of the street.
SET POLE LOCATIONS	"Set" pole locations refer to specific locations on the roadways where a luminaire shall be placed.
SINGLE SIDED SPACING	A lighting arrangement wherein all lighting poles are designed to be on the same side of the street.
STAGGERED SPACING	A streetlighting arrangement wherein all streetlighting poles are designed to alternate between one side of the street and the other.

N1.6 Lighting Definitions

AVERAGE ILLUMINANCE	Average Illuminance, generally referred to as "Eavg" and measured in "Lux", is the arithmetical average of individual illuminance values calculated at predetermined points within an area, in accordance with IES recommended practices.
ESA	The Electrical Safety Authority. The inspection authority for the Province of Ontario responsible for the issuance of electrical codes and inspections of all non hydro authority owned electrical systems.
FOOTCANDLE	The English unit of illuminance; illuminance on a surface one square foot in area on which there is uniformly distributed a light flux of one lumen. One footcandle equals 10.76 lux.
GLARE	The sensation produced by the luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visibility or visual performance.
IESNA	The Illuminating Engineering Society of North America. The recognized technical authority on lighting in North America.
ILLUMINANCE	The luminous flux (light) incident on unit area of a surface. It is measured in lux.
INITIAL LAMP LUMENS	Initial lumen output of a light source.
LUMEN	A unit of measure of the quantity of light. One lumen is the amount of light which falls on an area of one square foot every point of which is one foot from the source of one candela. A light source of one candela emits a total of 12.57 lumens.
LUMINAIRE	A complete unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, to control the lamp operation to ANSI specifications, and to connect the lamps to the power supply.
LUMINANCE	Luminance of a roadway surface is the intensity of reflected light per unit area of the surface in the direction of the viewer. Luminance indicates the "brightness" of the roadway surface ahead of the observer when viewed from a given location in a given direction. Luminance at any location (point) on the roadway surface varies with the incident angles of light from various light sources on to the surface, the reflectance properties of the pavement and the viewing angle of the stationary observer at the point.
LUX	The SI unit of illuminance; defined as the amount of light on a surface of one square meter all points of which are one meter from a uniform source of one candela. One lux equals 0.0929 footcandle.

MAINTAINED AVERAGE ILLUMINANCE / LUMINANCE	Light output of a roadway lighting system deteriorates over time due to many factors. Though many of these factors are complex in nature to quantify, three major factors are depreciation of lamp lumen output due to its age (referred to as Lamp Lumen Depreciation or "LLD"), accumulation of dirt inside the luminaire as well as on the outside of the optical lens (referred to as Luminaire Dirt Depreciation or "LDD"), and the degree to which the ballast operates the lamp relative to its design wattage (referred to as Ballast Factor or "BF"). The product of these three factors is referred to as Light Loss Factor or "LLF".
SKY GLOW	The term used to describe the added sky brightness caused by the scattering of extraneous light reflecting from the dust particles in the atmosphere.
SPILL LIGHT	Spill light can be defined as illumination of an area beyond the primary area (the City's ROW) that the light source is intended to illuminate. Light spillage involves actual contribution of horizontal and vertical illuminance on to a private property.
UNIT POWER DENSITY (UPD)	The average power used to light one section of road surface by dividing the input power to the luminaire by the area of the road surface covered by one luminaire. UPD (w/m^2) = $\frac{\text{Wattage}}{\text{Spacing x Pavement Width}}$
UNIFORMITY	The variance between the average and minimum illuminance values or the average to minimum and maximum to minimum luminance values on a given section of roadway.
VEILING LUMINANCE	Also known as Disability Glare, it is the direct luminance superimposed on the retina by external light sources, which causes a "veil" of light and reduces contrast of an image. The veiling luminance is produced by roadway luminaires in the field of vision, headlights of an oncoming vehicle, advertising signs along the roadway and stray commercial/residential lighting adjacent to the roadway. The lighting design criteria calculation for the veiling luminance ratio (Lv) includes only the candlepower of the roadway luminaires being used in the lighting calculations and the average pavement luminance.
VISIBILITY	The quality or state of being perceivable by the eye. In roadway lighting, it is usually defined in terms of the distance at which an object can just be perceived.

N2 DESIGN CRITERIA

N2.1 Introduction

(a) The Streetlighting systems along public roadways and other City owned lands (e.g. walkways) shall be in accordance with this Design Criteria, the City Policy, the Illuminating Engineering Society of North America's (IESNA) Recommended Practices, and the Electrical Safety Authority (ESA), in a cost effective manner and which complements the communities to which it serves.

(b) This section sets standards for the amount and quality of streetlighting required on a particular class of roadways and walkways. In addition, guidelines are provided to assist the Design Engineer in the selection of the appropriate streetlighting criteria.

(c) The lighting "criteria" are based on various roadway classification types and pedestrian conflict levels within the City's jurisdiction. The minimum required lighting levels are based on the IES recommendations for drivers' visual needs while travelling on these various classes of roadways. The visual need or task changes with the classification of the roadway and the level of pedestrian usage - higher lighting levels required for higher classification of the roadways and / or pedestrian usage and lower lighting levels required for the lower classification of roadways and / or pedestrian usage.

N2.2 Design Recommendations

(a) The streetlighting system shall be designed to meet the average maintained luminance level, and to not exceed the uniformity and the veiling luminance ratios for each type of roadway. The streetlighting system shall also be designed to meet the average maintained illuminance level, and to not exceed the uniformity for walkways. In addition, all sidewalks along the City streets shall be illuminated to a minimum average of 1.8 Lux and as specified in Section N2.13 for sidewalks along Regional roads.

(b) In case of infill subdivisions, the Design Engineer shall match the existing streetlight installation.

(c) When locating streetlighting poles, the Design Engineer shall pay close attention to the "set" pole locations. When approaching an intersection from each direction, a luminaire is usually placed in the far right quadrant. These luminaires may be placed on joint use traffic signal / roadway streetlighting poles if the intersection is signalized. It is preferable to use joint use poles in order to minimize the clutter of the street furniture. Other "set" pole locations are as below:

- one pole on the far side of a pedestrian cross-walks when approaching from each direction
- within 10.0 m of un-signalized commercial entrances (either side)
- within one (1) mounting height on the approach side of an underpass structure

(d) The Design Engineer shall determine at the beginning of the design what restrictions are in place due to safety reasons or other physical restrictions. Utilities such as Gas and Hydro have regulations in place restricting pole placement within a certain off-set from the outer edges of pipes or conductors. Pole placement near overhead hydro lines is also governed by the Ontario Electrical Code based on the voltage present in the conductors.

(e) A minimum off-set of 1.7 m shall be maintained between the face of the curb and the centre of the pole for all local roads with a 5.0 m boulevard. For roadways with 6.0 m boulevard, the off-set shall be 2.5 m as per the Standard Drawings.

(f) **Light Arrangement Styles:**

There are several options acceptable to the City as long as the streetlighting design complies with the standards for roadway, sidewalks, and intersection light level requirement. These optional arrangements are:

- Single Sided Spacing
- Staggered Spacing
- Paired Spacing

Median lighting is allowed when the median is of sufficient size to allow for the installation of a light standard while meeting the clear zone requirements and / or there are barriers in place.

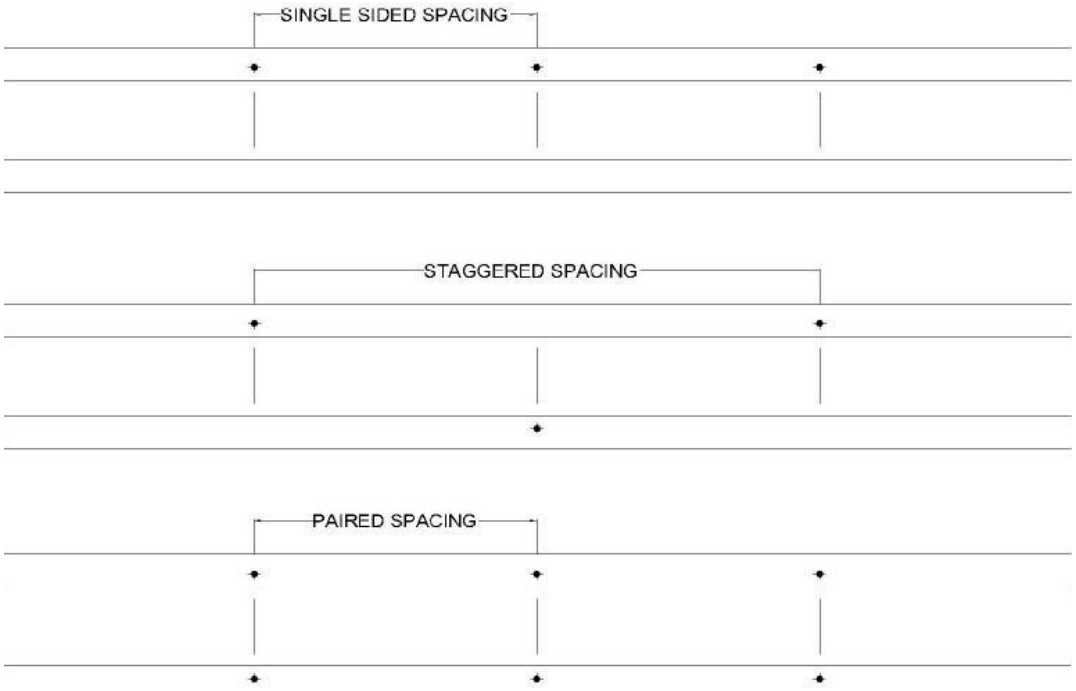


FIGURE 1: SPACING ARRANGEMENTS

(g) Photometric analysis shall be submitted on the Engineering Drawings. Recommended street and walkway light spacing shall be based on the currently accepted light assemblies and the City's ROWs. The recommended spacing noted can be single sided, staggered, or opposite as per Figure 1. Tables A1 - A12 and B1 - B5 are provided as a guide to assist the Design Engineer in the design. It is the Design Engineer's responsibility to ensure that the average light levels, uniformity, and veiling luminance ratio requirements are met.

(h) Where deviations from the recommended spacing are required due to site specific occurrences (i.e.: widening, turn lanes, intersections, etc), the Design Engineer shall submit to the City supporting documentation including photometric calculations justifying the proposed design. The design must remain within IES recommendations.

(i) The Design Engineer shall provide design justification for streetlighting installed on center medians, specifying traffic clearances, and other minimum requirements.

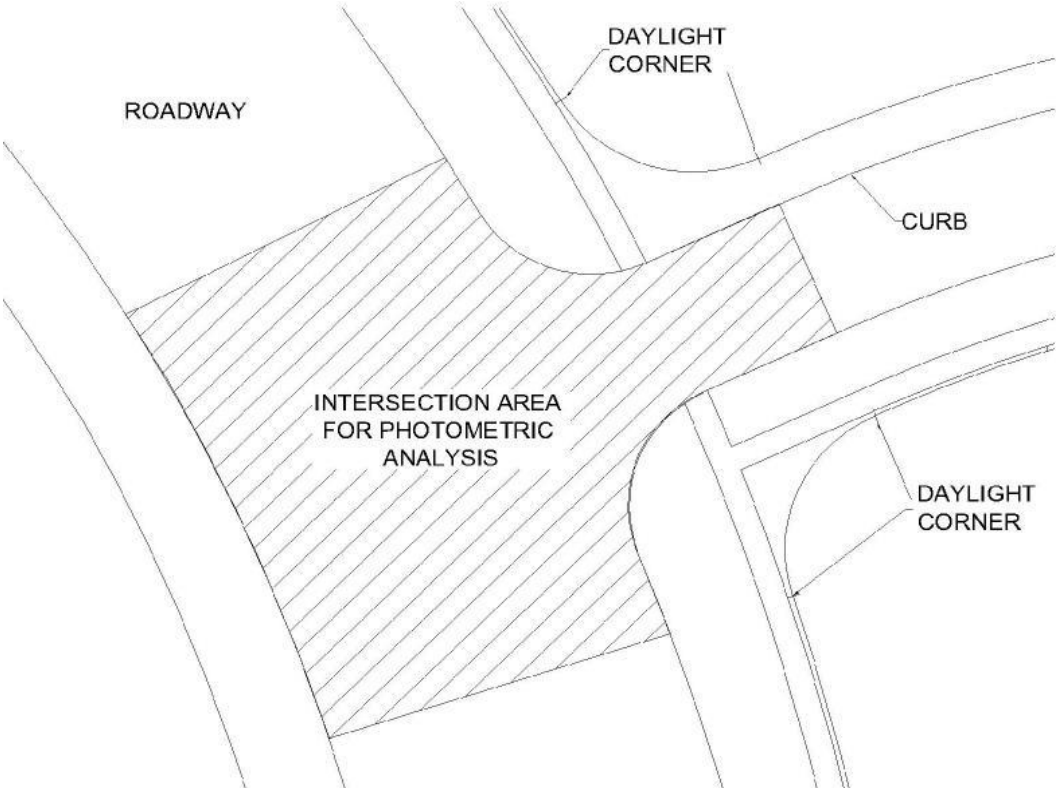


FIGURE 2: INTERSECTION AREA FOR PHOTOMETRIC ANALYSIS

(j) **Intersections:**

(i). For the purpose of photometric analysis, asphalt within the limits of the daylight corners of intersections shall constitute the intersection, as per Figure 2.

(ii). Placement of lights at intersections shall be balanced and symmetrical and in accordance with ANSI / IES RP-8-14 Recommended Practice.

(iii). Intersections shall be designed to have an average illumination level and uniformity meeting or exceeding the recommendations listed in ANSI / IES RP-8-14, Table 8.

(iv). The Minimum Maintained Average Illuminance at an intersection shall be equal or exceed the levels listed in ANSI / IES RP-8-14, Table 8.

(v). The lighting level and uniformity of the lighting at an intersection shall be taken to be those required by the criteria for the roadway with the higher classification.

(k) **Streetlight Placement:**

(i). Determining an appropriate physical location for the streetlight pole depends on a number of often conflicting requirements. The streetlighting design will determine an appropriate spacing, but this has to be worked into the plan for the subdivision, where there are many other facilities and structures which also need to be accommodated.

(ii). The Developer / Civil Consultant shall provide a drawing (CUP) of the proposed subdivision showing all pertinent structures including water and sewer lines, catch basins, fire hydrants, lot lines, and proposed locations of driveways.

(iii). To effectively light each intersection, a light will typically be placed as close as possible to the intersection. Lights will then be spaced according to the lighting design starting at the intersection.

(iv). Streetlight poles are typically installed on the property line between residential lots. This will likely result in an adjustment from the optimum streetlight spacing as determined by the streetlighting design. Where large multi-family units are planned, placement of streetlight poles between lot lines may be necessary.

(v). Driveways are often designed to be adjacent to one another; streetlights shall not be placed between them, but moved to the next lot line where there is no driveway.

(vi). Placement of streetlights near fire hydrants and catch basins shall be avoided. This is required to mitigate conflicts that may occur should excavation be required to repair hydrants or drains in the future. This shall also be considered when placing underground conductors.

(vii). When using one sided streetlighting arrangement along a continuous roadway, streetlight poles shall remain on the same side along the entire length of the road. The lights shall not change sides from block to block.

(viii). Underground feeds shall originate from a pedestal, or transformer, located at the end of the block, on the same side of the road as the streetlights. Side lot easements shall be avoided. Street crossings with underground conductors shall be avoided. If a two sided streetlighting arrangement is used, the lights shall be fed from conductors running on both sides of the road. When road crossings are required, they shall cross the road adjacent to an intersection and cross perpendicular to the roadway. Angled, or diagonal crossings are not permitted.

(ix). Installations on the outside of a curve shall be avoided, due to the increased possibility of being struck by a vehicle running off the road. Where other constraints force the installation of streetlight poles on the outside of a curve, Break-away bases may be required even though the speed limit is reduced in these areas as a part of due diligence.

FIGURE 3: INSTALLATION OF STREETLIGHT LOCATION AT CURVE

(l) Streetlights shall be located on the extension of side lot lines wherever possible and shall be coordinated with the Composite Utility Plan (CUP). Off-setting of the lights up to 2.0 m from the side lot line is permitted. Lot flankages and intersections are excluded from this stipulation. On flankages, the Design Engineer shall place streetlights such that they do not interfere with front entrances, should the house be oriented to face the flankage. Refer to Figure 4 and Figure 5 for examples. In these cases, the uniformity of lighting is the paramount design consideration.

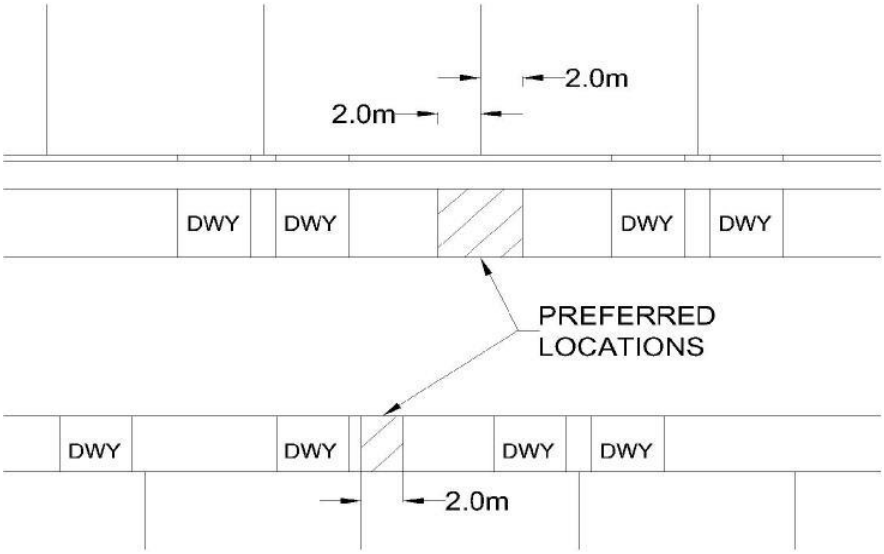


FIGURE 4: PREFERRED STREETLIGHT LOCATIONS ON STANDARD LOTS

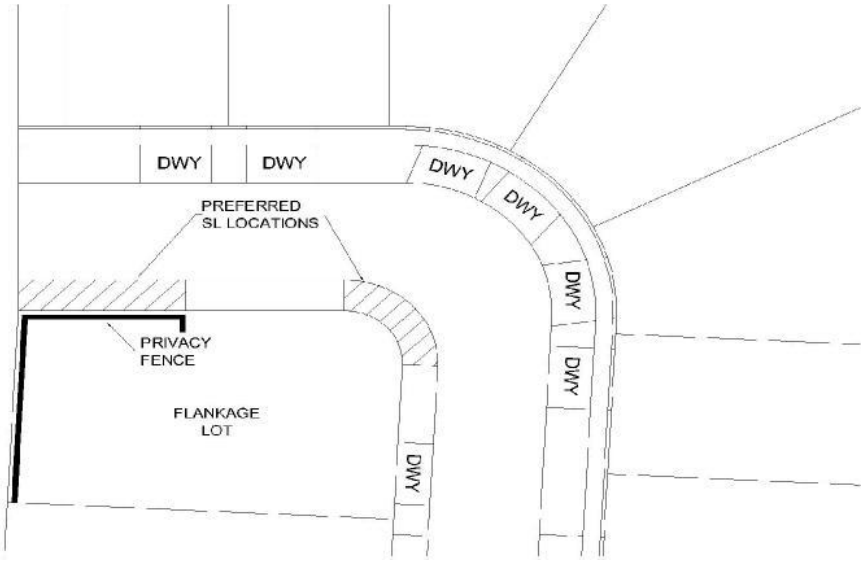


FIGURE 5: PREFERRED STREETLIGHT LOCATIONS ON FLANKAGE LOTS

(m) For laneways, if the first laneway light is within the daylight corner, the roadway light shall be used as the first pole for aesthetic consistency, wherever possible.

(n) The Design Engineer shall minimize placement of multiple lights on a single lot (i.e. balance homeowner concerns and streetlighting design).

(o) Streetlighting installation shall be coordinated with other streetscape furniture (i.e. review for physical conflicts), per CUP requirements. The Design Engineer shall ensure that the proposed streetlighting system is circulated to the Developer's Civil Consulting Engineer responsible for preparing the CUPs.

(p) **Clearances:**

(i). A minimum clearance of 3.0 m shall be required from the centre of the streetlight to the centre of a fire hydrant.

(ii). In locations where both fire hydrants and streetlights are to be co-located, each shall be off-set 1.5 m from the property line to achieve the 3.0 m separation.

(iii). A minimum clearance of 1.5 m shall be required from the centre of the streetlight to the edge of a driveway.

(iv). A minimum clearance of 1.5 m shall be required from the centre of the streetlight to the centre of a storm, sanitary or water lateral.

(v). A minimum clearance of 3.0 m shall be required from the center of the streetlight to the center of street trees.

(vi). Where two pieces of specific equipment (i.e. Transformers) have independent minimum clearance criteria, the greater minimum clearance shall be in effect (i.e. Clearances are not cumulative).

(vii). For walkway lighting systems, where four or more lights are to be installed, a metered disconnect pedestal shall be installed to supply power to the walkway lighting system. Where fewer than four lights are to be installed, the walkway lights may be powered from the streetlighting system, in accordance with the ESA and local hydro authority.

(viii). For park lighting systems, the same metering provisions shall apply as for walkway systems, with the additional possibility that the pedestal may also provide power to the park for irrigation, seasonal lighting, or other municipal requirements.

(ix). Where Municipal Walkway systems intersect with the municipal ROW, the Design Engineer shall ensure that there is either a walkway light or a streetlight located within 3.0 m of the end of the walkway.

(x). Walkway lights shall be installed 1.5 m off the edge of the walkway, with cabling for the walkway installed 1.0 m off the edge of the walkway, in accordance with Figure 6.

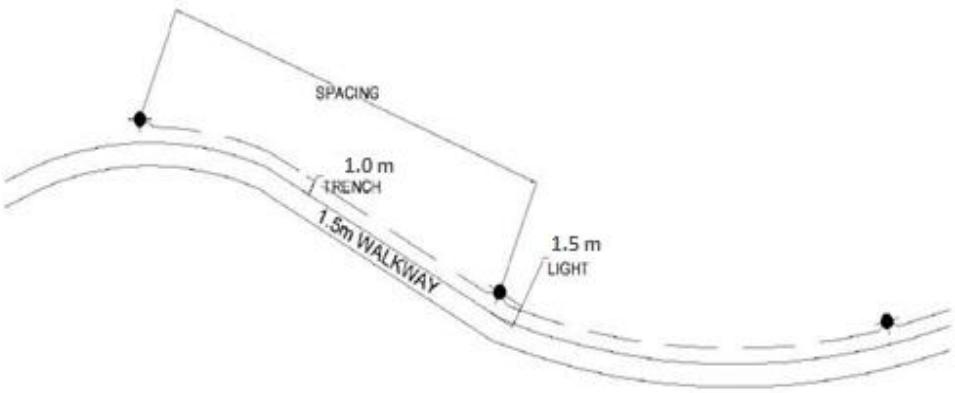


FIGURE 6: WALKWAY LIGHT INSTALLATION

(q) The Design Engineer shall use an optimization program to determine the preliminary pole layout to confirm the actual lighting levels produced on the roadways. Actual pole spacing shall not exceed 95% of the optimized pole spacing.

(r) The Design Engineer shall use the preliminary pole layout to confirm the actual lighting levels produced on the roadways.

(s) If the roadway is divided into smaller calculation grids, the location of the grid shall be carefully selected to ensure accurate results. Calculation grids and grid points shall comply with section A.9 and Figure A4 of ANSI / IES RP-8-14.

(t) The levels for the total length of the roadway within the project limits shall be verified unless symmetric sections can be isolated.

(u) If the roadway is divided into smaller calculation grids, the location of the grid shall be carefully selected to ensure accurate results.

(v) Each grid shall cover a whole pole cycle (or whole multiples of one pole cycle).

(w) The City prefers the use of an In-Pole, Handhole Breaker over free standing pedestal type disconnects along municipal ROW Depending on the specific installation, it may be advantageous to utilize free standing pedestal type disconnects.

(x) Any development within a Non-Standard Area shall be reviewed by the City for acceptability prior to submission consistent with Section N2.3 Table A and Section N2.4 Table B - Lighting Standards, Details and Typical Usage.

(y) All development in new areas shall conform to an appropriate existing MST 1 to MST 17 Streetlighting Standards.

(z) Location of streetlights shall be as per the City Standards MR1 to MR13.

N2.3 Basic Principles of Streetlighting Design

There are five basic principles to consider when carrying out streetlighting design.

(a) Safety - pedestrian and driver safety. Creating sufficient lighting level, uniformity, and glare control so that drivers are aware of any pedestrians and / or objects on or near the roadway.

(b) Security - providing a setting that will deter some forms of criminal activity through the use and placement of lights.

(c) Limit the amount of Light Trespass - avoiding over lighting of areas such as in residential neighborhoods where the backlight may shine on houses.

(d) Environmental Responsibility - consideration shall be given to the following:

(i). Energy usage

(ii). Lighting levels - to determine the correct level of light output required as per ANSI / IES RP-8-14 and the City Standards recommendations, which use the following criteria:

- road classification
- pedestrian conflict activity
- pavement material type
- calculation of lighting

(iii). Luminaire type - through the use of one of the listed LED luminaires that are approved by the City and can comply with lighting standard requirements as per the roadway classification.

(e) To provide uniformity and consistency in streetlighting designs throughout the City while meeting the standards.

N2.4 Design Considerations

(a) It is the responsibility of the Design Engineer doing a streetlighting design to make sure they are making reference to ANSI / IES RP-8-14 or any later edition.

(b) When starting a streetlighting design, attention to the surrounding area and any special requirements must be taken into consideration, (i.e.) schools, shopping districts, or community centers.

(c) It is important to note that only Luminance design method can be used for calculating the roadway lighting levels within the City. Exceptions allow for the use of the Illuminance design method for curved road sections, sidewalks, and intersections. Both of these methods are fully explained in the 2014 edition of the ANSI / IES RP-8-14, American National Standard Practice for Roadway Lighting. The appropriate application stating when and where to use each design method is stated in Section N2.5 - Streetlighting Design Methodology.

N2.5 Streetlighting Design Methodology

(a) The Luminance design method shall be used for straight streets and roadways, and the Illuminance design method shall be used for intersections, curved streets (radius of curvature less than 600 m) and cul-de-sacs. Streetlighting designs for streets with greater than 600 m curve radius shall be evaluated as if it were a straight section.

(b) All design calculations must be completed by using AGI32 software. **The City will not accept any other lighting calculation software programs. Roadway Optimizer can only be used to determine the maximum pole spacing. The final streetlighting design shall be based on calculation grids as per Section N2.10 on actual road design and walkways using AGI32 software.**

(i). For the detail design, the Design Engineer shall use a maximum pole spacing of 95% of pole spacing obtained from Roadway Optimizer.

N2.6 Pedestrian Conflict

According to ANSI / IES RP-8-14, there are three types of classifications:

(a) Low pedestrian conflict area: Areas with very low volumes of night pedestrian usage, and typified by suburban streets with single family dwellings, very low density residential developments, and rural or semi-rural areas.

(b) Medium pedestrian conflict areas: Areas where a number of pedestrians utilize the streets at night and typified by downtown office areas, blocks with libraries, schools, apartments, neighbourhood shopping, industrial parks, and streets with transit lines.

(c) High pedestrian conflict areas: Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. Examples are downtown retail areas, near theatres, concert halls, stadiums, and transit terminals.

Pedestrian Conflict is assumed to be the total number of people on both sides of a street within a given section (200 m).

N2.7 Light Loss Factors (LLF)

Light Loss Factors (LLF) are multiplier values to estimate the overall performance at different times during the life of the streetlighting system. LLF values reflect the performance of the light source and luminaire as well as the maintenance level of a streetlighting system. The LLF is made up of Lamp Lumen Depreciation (LLD), Luminaire Dirt Depreciation (LDD), and Luminaire Ambient Temperature Factor (TF).

The Light Loss Factor is defined as: LLF = LLD x LDD x TF

For existing conditions, where TM-21 data is not available, LLF can be assumed as follows:

- LLF (for LED) = 0.82
- LLF (for HPS) = 0.77

(a) Lamp Lumen Depreciation (LLD)

LLD is the reduction in the light output as the lamp ages. The City requires that the LLD be provided by the luminaire manufacturer calculated using IES TM-21-11 methodology and calculated at 25°C and 90,000 hours of usage for the specific luminaire wattage, drive current, and distribution type. This can be derived from either lumen depreciation curves or tables.

(b) Luminaire Dirt Depreciation (LDD)

LDD takes into account the luminaire output depreciation due to an accumulation of dirt on the luminaire after a predetermined period of time. The Design Engineer shall pick a 'clean' LDD value in most situations unless in an area of heavy manufacturing or areas prone to dust storm use moderate LLD value. The typical LDD value for a five year maintenance cycle adopted by The City is 0.90.

(c) Luminaire Ambient Temperature Factor (TF)

TF accounts for variations in lumen output based on ambient temperature. LED luminaires are not affected significantly by ambient night time temperature, the TF adopted by the City is 1.0.

Light Loss Factor = LLD x LDD x TF

= LLD x 0.90 x 1.0

N2.8 Pavement Classification

Pavement classification is described by the type of pavement surface. Reflectivity (R) tables are listed in ANSI / IES RP-8-14 and are a measure of the reflectivity characteristics of the roadway surface. A typical City roadway is represented by a R3.

N2.9 Area Classifications

In order to determine appropriate lighting criteria, it is important to consider what the land adjacent to the roadway is being used for, and in particular to identify the amount of pedestrian and vehicular traffic. There are three classifications:

(a) **Commercial:** A business area of a municipality where ordinarily there are many pedestrians during night hours. The definition applies to densely developed business areas outside, as well as within, the central part of municipality. The area contains land use which attracts a relatively heavy volume of night time vehicular and / or pedestrian traffic on a frequent basis.

(b) **Intermediate:** Those areas of a municipality often characterized by moderately heavy night time pedestrian activity such as in blocks having libraries, community recreation centers, large apartment buildings, industrial buildings or neighborhood retail stores.

(c) **Residential:** A residential development, or mixture residential and small commercial establishments, characterized by few pedestrians at night. This definition includes areas with single family homes, town houses, and / or small apartment buildings.

N2.10 Light Calculation Grid

(a) Setting up a grid in lighting design software shall be as per ANSI / IES RP-08-14. Using more or less points will alter the calculations and proper lighting levels may not be achieved. As well any change of the grid spacing's will also have an effect upon the calculations.

(b) The calculation grid for a roadway shall consist of two grid lines per lane located ¼ of the distance from the edge of each lane. The following criteria shall be applied:

(i). The grid shall be based on the number of lanes for the majority of the length of roadway.

(ii). In the event that the roadway width and number of lanes change, then a revised grid shall be used for the new length of roadway.

(iii). In the longitudinal direction, the distance between grid points shall be one-tenth (1/10) of the spacing between luminaires, but no more than 5m, The starting point for the gridlines shall not be located directly under a pole, but shall start instead at a point one-half (1/2) of the grid cell size from the luminaire pole.

(iv). When calculating lighting on curves, all curves with a wide radius (i.e., 600 m or greater) may be treated as a straight roadway section. Curves with a radius of less than 600 m require separate illuminance calculations.

(c) The same principles shall be followed to create illuminance calculation grids for curved sections of roadway as for straight sections.

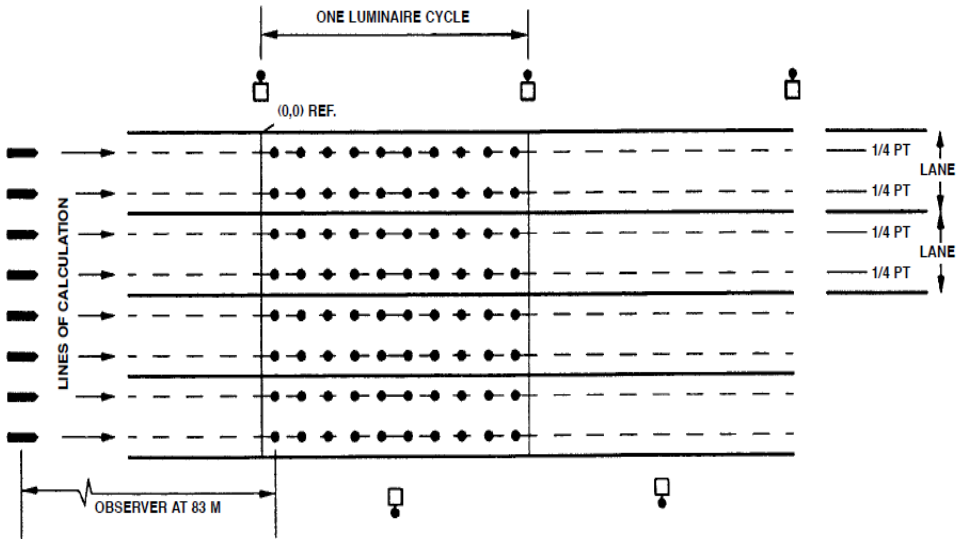


FIGURE 7: LIGHT CALCULATION GRID DEFINITIONS

N2.11 Placing Luminance and Veiling Luminance Grids in AGI32

(a) Place both Luminance and Veiling Luminance Grids in the same locations using the Roadway Luminance Grid in AGI32.

(b) Place the grid parallel to the direction of travel. Grid points 1 & 2 define the direction of travel.

(c) Specify the Number of Lanes in the Direction of Travel and (if applicable) in the Opposite Direction. (Some standards considered the lanes in both directions; others consider only the lanes in the Observer's direction of traffic flow.) If there is a median, only specify the lanes in the Direction of Travel; use 0 for the number of lanes in the Opposite direction.

(d) Place the grid width so it includes the widest section of roadway traveling in the same direction. Include all pedestrian features in this calculation if they were included in the illuminance calculations.

(e) Place the first grid point on the right edge line of the start of the design area. Place the second point downstream (direction of travel) on the right edge line of the end of the design area. Place the third point at the left edge of the design area (in the direction of traffic).

(f) Evaluate the results from each set of grids independently.

(g) Follow steps (b) – (f) for all directions of travel including the minor approaches.

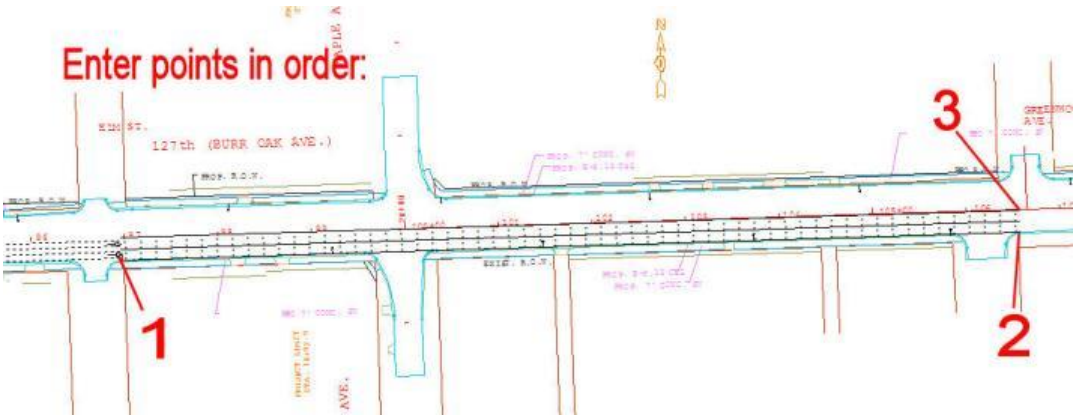


FIGURE 8: PLACING LUMINANCE AND VEILING LUMINANCE GRIDS

N2.12 Light Pollution

Light pollution is becoming an increasing concern and typically takes one of two forms:

(a) Light trespass or back lighting where there is an excessive amount of light towards a residence. Certain homeowners are particularly sensitive to light coming into their homes from streetlights and complain of sleep disruption, etc. The City's approved luminaires do a reasonable job of controlling the light toward the residence; however there have been complaints from homeowners regarding excessive light trespass. Mitigation may require selection of different luminaires, repositioning luminaires or the addition of light shields to block the light.

(b) Up-lighting where there is excessive light upwards from the luminaire. This will impact visibility of the night sky. The International Dark-Sky Association (IDA) promotes the use of cobra-head style luminaires with zero up light (i.e. Full Cut-off). Traditional Coach Light Style luminaires (No Glass) must comply with the "U" limitations from the luminaire BUG rating as described in the IES / IDA Model Lighting Ordinance (MLO). The City is Dark Sky Compliant and any Luminaire selected for streetlighting design must meet the above requirements.

N2.13 Recommended Light Levels

(a) Lighting Design Criteria for Streets:

Roadway Type	Pedestrian Conflict	Luminance Lavg (cd/m^2)	Avg. Uniformity (Lavg/Lmin)	Max. Uniformity (Lmax/Lmin)	Max. Veiling Luminance (Lvmax/Lavg)	Sidewalk Illuminance (Lux)
		(min)	(max)	(max)	(max)	(min-ave)
Local	Low	0.3	6.0	10.0	0.4	1.8
	Medium	0.5	6.0	10.0	0.4	1.8
	High	0.6	6.0	10.0	0.4	1.8
Collector (Minor/ Major)	Low	0.4	4.0	8.0	0.4	1.8
	Medium	0.6	3.5	6.0	0.4	1.8
	High	0.8	3.0	5.0	0.4	1.8
Arterial (City)	Low	0.6	3.5	6.0	0.3	1.8
	Medium	0.9	3.0	5.0	0.3	1.8
	High	1.2	3.0	5.0	0.3	1.8
Arterial (Regional)	Low	0.6	3.5	6.0	0.3	3.0
	Medium	0.9	3.0	5.0	0.3	5.0
	High	1.2	3.0	5.0	0.3	20.0

(b) Illumination for Intersections:

Functional Classification	Average Maintained Illumination at Pavement by Pedestrian Area Classification in Lux / fc (Minimum Maintained Average Values)			Average Uniformity (Eavg/Emin) (max)
	High	Medium	Low	
Local/ Local	18.0 / 1.8	14.0 / 1.4	8.0 / 0.8	6.0
Collector / Local	21.0 / 2.1	16.0 / 1.6	10.0 / 1.0	4.0
Collector / Collector	24.0 / 2.4	18.0 / 1.8	12.0 / 1.2	4.0
Arterial / Local	26.0 / 2.6	20.0 / 2.0	13.0 / 1.3	3.0
Arterial / Collector	29.0 / 2.9	22.0 / 2.2	15.0 / 1.5	3.0
Arterial / Arterial	34.0 / 3.4	26.0 / 2.6	18.0 / 1.8	3.0

(c) Illumination for Off-Roadway Walkways:

Classification	Average Maintained Illumination in Lux (Minimum Maintained Average Values) as per DG5 Design Guide	Average Uniformity (Eavg/Emin) (max)	Maximum Mounting Height (m)
Walkways	5	10	3.5

N2.14 Streetlighting Design Submission Requirements

Streetlighting design submissions requirements to the City shall include two hard copies and one electronic copy of the following:

(a) The Design Engineer Certification Letter (see Appendix C) confirming that the Streetlight design has been completed in accordance with ANSI/ IESNA Recommended Practice RP-8-14, and the Electrical Safety Authority (ESA) requirements.

(b) Completed Streetlight Design - Checklist (see Appendix C1 and Appendix C2) for all continuous streets and intersections.

(c) Details of proposed luminaires, poles, and arms including Manufacturers' technical data sheets, photometric file and TM-21 data.

(d) Pole setback from curb and maximum pole spacing based on Roadway Optimizer calculation. Actual pole spacing not to exceed 95% of the optimized value.

(e) Calculations and distribution diagrams as per the City's Standards including photometric analysis (AGI32) in electronic format for all streets and intersections.

(f) Streetlighting layout and electrical drawings in AUTOCAD and Tiff format showing streetlight design results compared to the City criteria and showing location and full description of poles, luminaires, standard drawings and specifications used.

(g) Photometric files in electronic .ies format from the luminaire manufacturer.

(h) Load Summary (see Appendix "H").

N2.15 Certification and Documentation Requirements at Various Stages

The following documents shall be submitted to the City at various stages:

Stage 1 - Building Permit Stage:

The following documents shall be submitted to the City at the Building Permit Stage:

1) The Design Engineer Certification Letter (see Appendix "D1") confirming that:

   (a) The streetlighting system has been installed in accordance with the approved streetlighting drawings, specifications, and the City Standards, Electrical Safety Authority (ESA) requirements and all applicable electrical code

   (b) All streetlighting poles have the appropriate buried depth

   (c) All streetlights are functional and operational on all streets, lanes, and walkways

   (d) Actual lighting levels taken within three (3) to eight (8) weeks after completion of streetlight installation are in accordance with the City Standards and IES RP-8-14 Recommended Practice, Section A.9.1.2 and Figure A4

2) If the actual pole location deviates more than two (2) metres from the proposed design location, the Design Engineer shall carry out the photometric analysis again to confirm that the required lighting levels are met as per the City / IES RP-8-14 Standards.

3) Municipal Streetlighting Inventory (see Appendix "E") complete with luminaries packing slip, sufficient to establish manufacturers' warranty commencement.

4) Record (scan) Outdoor Lighting Control (OLC) Nodes barcodes during luminaire installation with associated Global Position System (GPS) X, Y coordinates of the streetlight poles and submit to the City's Engineering Department (for the City to connect into the StarSense monitoring system).

5) Copies of shop drawings for all installed materials including poles, luminaries, and bracket arms complete with the Design Engineer's signature and stamp.

6) Submit copies of the Design Engineer's Daily Construction Log Report for streetlighting installation works including night inspection to confirm operation (see Appendix "F").
7) Submit copies of the Design Engineer's pre-construction material inspection report and confirmation that installed materials are in accordance with the accepted drawings and specifications.
8) ESA Inspection Certificate
9) Connection Order and Load Letter from PowerStream
10) Load Calculation Summary (see Appendix "H")

Upon submitting the above listed documents, the City will reduce the streetlighting security to 30%.

Stage 2 - Maintenance Acceptance Stage:

The following documents shall be submitted to the City at the Maintenance Acceptance Stage:

1) As-Constructed drawings - 1 hard copy + electronic files in AUTOCAD and Tiff format:
   (a) As-Constructed drawings shall be in accordance with the City's Design Criteria - Section J, Paragraph J 2.6 and 2.7, including all other information included in the approved design drawings
   (b) Global Position System (GPS) X, Y Co-ordinates of newly installed poles in a tabular format
   (c) Include offsets, if streetlight cables are not installed in joint utility trench
   (d) Pole Identification Tags: Upon the civic address being allocated by the Planning Department, Asset Management will provide Tag IDs to Engineering Inspection Group / Developer
2) Streetlighting- Maintenance Acceptance Checklist (see Appendix "G")
3) The Design Engineer Certification Letter (see Appendix "D2") certifying the following:
   (a) The streetlighting system has been installed in accordance with the approved streetlighting drawings, specifications, and the City Standards, Electrical Safety Authority (ESA) requirements and all applicable electrical code
   (b) All streetlights are functional and operational on all streets, lanes, and walkways
   (c) All streetlighting poles are plumb / straight
   (d) All pole identification tags are installed
   (e) All streetlighting luminaries are washed and provision of date of wash
   (f) All streetlighting luminaries are re-lamped (HPS luminaries only) and provision of date of re-lamping
   (g) All pedestals have been locked
   (h) Grades around poles and pedestals have not settled
   (i) All handhole covers are secured
   (j) All poles, mounting hardware, and streetlights are visually inspected
   (k) All deficiencies are corrected

Upon submitting the above listed documents and payment of all outstanding the City energy and maintenance cost invoices, the streetlighting security will be reduced to 20%.

Stage 3 – Assumption Stage:

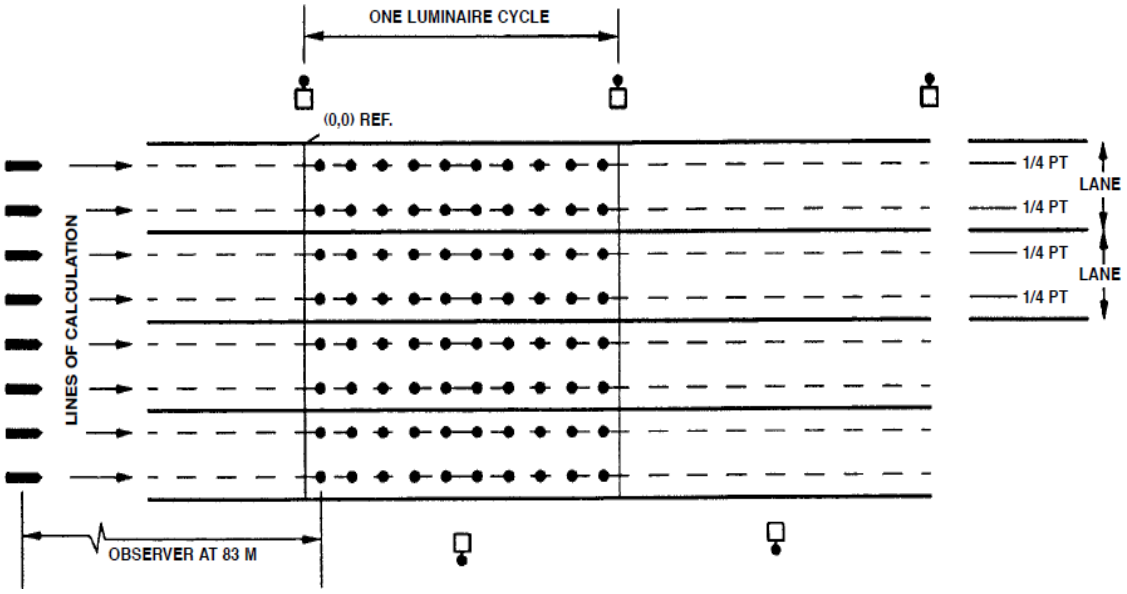
The following documents shall be submitted to the City at the Assumption Stage:

1) The Design Engineer Certification Letter (see Appendix "D3") certifying the following:
   (a) The streetlighting system has been installed in accordance with the approved streetlighting drawings, specifications, and the City Standards, Electrical Safety Authority (ESA) requirements and all applicable electrical code
   (b) All streetlights are functional and operational on all streets, lanes, and walkways
   (c) All streetlighting poles are plumb / straight
   (d) All pole identification tags are installed
   (e) All pedestals have been locked
   (f) Grades around poles and pedestals have not settled
   (g) All handhole covers are secured
   (h) All poles, mounting hardware, and streetlights are visually inspected
   (i) All deficiencies are corrected

Upon submitting the above listed documents and payment of all outstanding City energy and maintenance cost invoices, the streetlighting security will be reduced to zero.

N2.16 As-Constructed Site Inspection

(a) Actual lighting Levels shall be taken within three (3) to eight (8) weeks after completion of installation and in accordance with ANSI / IES RP-8-14 Recommended Practice Section A.9.1.2 and Figure A4 - see diagram below.



(b) Illumination levels and uniformity will be accepted as the measurement protocol for compliance to design calculations.

(c) Compliance measurements shall be taken at locations on the street that are typical of the streetlighting design and at such other locations as may be deemed necessary by the City where changes in street geometry may indicate lighting level or uniformity changes.

(d) For streets with poles mounted on one side only, the grid shall start at the midpoint between the first and second pole and continue to the midpoint between the second and third pole. For streets with poles on both sides, the location of the measurement points shall comply with the diagram above.

(e) Although the IES does not specify a sample size for the measurement of in-situ illuminance or luminance measurements, it is good practice to follow the guidance given in paragraph (c) above to ensure that the measurements taken are representative of the actual lighting conditions on each tested street.

N2.17 Cobra-Head Style LED Luminaires

Table A – Lighting Standards, Details and Typical Usage

Standards	Pole	Arm	Luminaire	Typical Usage
MST 1	10.67 m Concrete Pole	2.4 m Arm	LED	Commercial / Industrial
MST 2	12.2 m Concrete Pole	2.4 m Arm	LED	Commercial / Industrial
MST 10	7.62 m Octagonal Pole	0.2 m Arm	LED	Lane

Spacing on Tables A1 through A12 apply each of the above configurations to each roadway cross-section per the lighting requirements of the IES. Calculations assume a straight, flat road with equal pole spacing. Designs which exceed the spacing tables by a significant margin shall be supported by additional analysis provided by the Design Engineer.

Table A1: Residential Local Road (MR2 & MR3) (IES: Local Residential)

Two 4.25 m Lanes with Sidewalk on one side

Recommended Street Luminance: ≥ 0.3 Candelas/m² Average ≤ 6:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 10:1 Uniformity (Lmax:Lmin) ≤ 0.19 Unit Power Density (Watts per m²)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	37-45	78 - 89

1. *Single Sided Spacing are for MR2 ONLY.*

Table A2: Residential Local Road (MR4, MR4 A3) (IES: Local Residential)

Two 4.25 m Lanes with Sidewalks on both sides

Recommended Street Luminance: ≥ 0.3 Candelas / m^2 Average ≤ 6:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 10:1 Uniformity (Lmax:Lmin) ≤ 0.20 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	N / R	85 - 110

1. *Photometrics for MR4A to be determined on a case-by-case basis to accommodate the specific pavement width.*
2. *Single sided design not applicable with sidewalks on both sides.*

Table A3: Residential Collector Road (MR5) (IES: Collector Residential)

Two 3.5 m Lanes with Parking Lane and Sidewalks on both sides

Recommended Street Luminance: ≥ 0.4 Candelas/m^2 Average ≤ 4:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 8:1 Uniformity (Lmax:Lmin) ≤ 0.25 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	N / R	70 - 85

1. *Single sided design not applicable with sidewalks on both sides.*

Table A4: Residential Collector Road (MR6) (IES: Collector Residential)

Two 4.25 m lanes with Parking Lane and Sidewalks on both sides

Recommended Street Luminance: ≥ 0.4 Candelas / m^2 Average ≤ 4:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 8:1 Uniformity (Lmax:Lmin) ≤ 0.24 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	N / R	75 - 105

1. *Single sided design not applicable with sidewalks on both sides.*

Table A5: Residential Collector Road (MR7) (IES: Collector Residential)

Two 4.25 m lanes with Parking Lane, Bicycle Lane and Sidewalks on both sides

Recommended Street Luminance: ≥ 0.4 Candelas / m^2 Average ≤ 4:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 8:1 Uniformity (Lmax:Lmin) ≤ 0.30 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	N / R	71-76

1. *Single sided design not applicable with sidewalks on both sides.*

Table A6: Major Collector Road (MR8) (IES: Collector Intermediate)

Four 3.5 m Lanes with Sidewalks on both sides

Recommended Street Luminance: ≥ 0.6 Candelas/m² Average ≤ 3.5:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 6:1 Uniformity (Lmax:Lmin) ≤ 0.25 Unit Power Density (Watts per m²)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	N / R	70 - 82
MST 2	12.2 m Pole, 2.4 m Arm	N / R	82 - 94

1. *Single sided design not applicable with sidewalks on both sides.*

Table A7: Major Collector Road (MR9) (IES: Collector Intermediate)

Four 3.5 m Lanes with Central Median and Sidewalks on both sides

Recommended Street Luminance: ≥ 0.6 Candelas / m² Average ≤ 3.5:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 6:1 Uniformity (Lmax:Lmin) ≤ 0.25 Unit Power Density (Watts per m²)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 1	10.7 m Pole, 2.4 m Arm	N / R	70 - 85
MST 2	12.2 m Pole, 2.4 m Arm	N / R	82 - 93

1. Single sided design not applicable with sidewalks on both sides.

Table A8: Residential Laneways (MR10, MR10A) (IES: Collector Residential)

Two 2.75 m lanes (no sidewalk)

Recommended Street Luminance: ≥ 0.3 Candelas / m² Average ≤ 6:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 10:1 Uniformity (Lmax:Lmin) ≤ 0.19 Unit Power Density (Watts per m²)		**Recommended Spacing (m)**	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 10	7.6 m Pole, 0.2 m Arm	50 - 53	N / R

1. Staggered spacing in laneways is not applicable.

Table A9: Non-Residential Laneways (MR13) (IES: Collector Intermediate)

Two 2.75 m lanes (no sidewalk)

Recommended Street Luminance: ≥ 0.3 Candelas / m² Average ≤ 6:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 10:1 Uniformity (Lmax:Lmin) ≤ 0.23 Unit Power Density (Watts per m²)		**Recommended Spacing (m)**
Standards	**Reference Configuration**	**Single Sided**
MST 10	7.6 m Pole, 0.2 m Arm	40 - 46

Table A10: Industrial / Commercial Collector (MR11) (IES: Collector Medium)

Two 5.00 m lanes with Sidewalks on both sides

Recommended Street Luminance: ≥ 0.6 Candelas / m^2 Average ≤ 3.5:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 6:1 Uniformity (Lmax:Lmin) ≤ 0.27 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Staggered**	**Paired**
MST 1	10.7 m Pole, 2.4 m Arm	91 - 115	N / R
MST 2	12.2 m Pole, 2.4 m Arm	107 - 135	N / R

1. *Paired spacing is not recommended.*

Table A11: Industrial / Commercial Collector (MR12) (IES: Collector Medium)

Two 3.75 m lanes and Centre Turn Lane with Sidewalks on both sides

Recommended Street Luminance: ≥ 0.6 Candelas / m^2 Average ≤ 3.5:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 6:1 Uniformity (Lmax:Lmin) ≤ 0.36 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Staggered**	**Paired**
MST 1	10.7 m Pole, 2.4 m Arm	102 - 108	N / R
MST 2	12.2 m Pole, 2.4 m Arm	104 - 125	N / R

1. *Paired spacing is not recommended.*

Table A12: Walkways (IES: Walkway)

Recommended Illuminance: 5.0 Lux Average		**Recommended Spacing (m)**		
Standards	**Reference Configuration**	**Single Sided**	**Staggered**	**Paired**
MST 10	7.6 m Pole, 0.2 m Arm	35-40	75-80	N / A

1. *Paired spacing on walkways is not applicable.*

N2.18 Traditional Coach Light LED Luminaires

Table B - Streetlighting Standards, Details and Typical Usage

Standards	Pole	Arm	Luminaire	Typical Usage
MST 3	7.6 m Octagonal Pole	1.5 m Arm	LED	Residential
MST 4	9.1 m Octagonal Pole	1.5 m Arm	LED	Residential
MST 5	9.9 m Octagonal Pole	1.5 m Arm	LED	Residential
MST 6	7.7 m Communication Pole	1.5 m Arm	LED	Residential
MST 7	9.8 m Communication Pole	1.5 m Arm	LED	Residential

Spacing on Tables B1 through B5 apply each of the above configurations to each roadway cross-section per the lighting requirements of the IESNA. Calculations assume a straight, flat road with equal pole spacing. Designs which exceed the spacing tables by a significant margin shall be supported by additional analysis provided by the Design Engineer.

Table B1: Residential Local Road (MR21 & MR3) (IES: Local Residential)

Two 4.25 m Lanes with Sidewalk on one side

Recommended Street Luminance: ≥ 0.3 Candelas / m^2 Average ≤ 6:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 10:1 Uniformity (Lmax:Lmin) ≤ 0.19 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standard	**Reference Configuration**	**Single Sided**	**Staggered**
MST 3	7.62 m Pole, 1.5 m Arm	N / A	70 - 73
MST 4	9.1 m Pole, 1.5 m Arm	38 - 41	90 - 102
MST 5	9.9 m Pole, 1.5 m Arm	N / A	95 - 105
MST 6	7.7 m Pole, 1.5 m Arm	30 - 35	70 - 77
MST 7	9.8 m Pole, 1.5 m Arm	N / A	95 - 105

1. *Designs for MR2 are for Single Sided ONLY.*

Table B2: Residential Local Road (MR4, MR4A2) (IES: Local Residential)

Two 4.25 m Lanes with Sidewalks on both sides

Recommended Street Luminance: ≥ 0.3 Candelas / m^2 Average ≤ 6:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 10:1 Uniformity (Lmax:Lmin) ≤ 0.18 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided[3]**	**Staggered**
MST 3	7.6 m Pole, 1.5 m Arm	N / A	70 - 74
MST 4	9.1 m Pole, 1.5 m Arm	N / A	95 - 102
MST 5	9.9 m Pole, 1.5 m Arm	N / A	95 - 105
MST 6	7.7 m Pole, 1.5 m Arm	N / A	70 - 75
MST 7	9.8 m Pole, 1.5 m Arm	N / A	90 - 105

1. *Photometrics for MR4A to be determined on a cas- by-case basis to accommodate the specific pavement width.*
2. *Single sided design not applicable with sidewalks on both sides.*

Table B3: Residential Collector Road (MR5) (IES: Collector Residential)

Two 3.50 m Lanes with Parking Lane and Sidewalks on both sides

Recommended Street Luminance: ≥ 0.4 Candelas / m^2 Average ≤ 4:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 8:1 Uniformity (Lmax:Lmin) ≤ 0.29 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 3	7.6 m Pole, 1.5 m Arm	N / A	60 - 63
MST 4	9.1 m Pole, 1.5 m Arm	N / A	65 - 71
MST 5	9.9 m Pole, 1.5 m Arm	N / A	70 – 78
MST 6	7.7 m Pole, 1.5 m Arm	N / A	60 - 64
MST 7	9.8 m Pole, 1.5 m Arm	N / A	65 - 70

1. *Single sided design not applicable with sidewalks on both sides.*

Table B4: Residential Collector Road (MR6) (IES: Collector Residential)

Two 4.25 m lanes with Parking Lane and Sidewalks on both sides

Recommended Street Luminance: **≥** 0.4 Candelas / m^2 Average ≤ 4:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 8:1 Uniformity (Lmax:Lmin) ≤ 0.29 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 4	9.1 m Pole, 1.5 m Arm	N / A	60 - 65
MST 5	9.9 m Pole, 1.5 m Arm	N / A	60 - 64
MST 7	9.8 m Pole, 1.5 m Arm	N / A	60 - 64

1. *Single sided design not applicable with sidewalks on both sides.*

Table B5: Residential Collector Road (MR7) (IES: Collector Residential)

Two 4.25 m lanes with Parking Lane, Bicycle Lane and Sidewalks on both sides

Recommended Street Luminance: ≥ 0.4 Candelas / m^2 Average ≤ 4:1 Uniformity (Lavg / Lmin), Lv ≤ 0.4 ≤ 8:1 Uniformity (Lmax:Lmin) ≤ 0.35 Unit Power Density (Watts per m^2)		**Sidewalk Illuminance:** 1.8 Lux min-average	
		Recommended Spacing (m)	
Standards	**Reference Configuration**	**Single Sided**	**Staggered**
MST 4	9.1 m Pole, 1.5 m Arm, 100W Lum.	N / A	50 - 53
MST 5	9.9 m Pole, 1.5 m Arm, 150W Lum.	N / A	50 - 56
MST 6	7.7 m Pole, 1.5 m Arm	N / A	45 - 51
MST 7	9.8 m Pole, 1.5 m Arm, 100W Lum.	N / A	50 - 56

1. *Single sided design not applicable with sidewalks on both sides.*

N3 MATERIAL SPECIFICATIONS

The following Section outlines the Streetlight and Walkway Light Material Specifications:

N3.1 Canadian Standards Association

(a) All streetlighting materials shall be CSA approved where and as applicable.

N3.2 Warning Tape

(a) 150 mm wide RED “CAUTION” tape shall be placed half way between the top of the upper most streetlights duct and final grade over all streetlight ducts.

N3.3 Ducts

(a) Duct for streetlighting shall be either CSA Type 50 mm PVC DB2 Type Duct or 50 mm Flex Duct or approved alternate, per PowerStream STD 17-200: Main Trench Details for Direct Buried Cables in Ducts With or Without Gas.

(b) When utilizing PVC DB2, 50 mm Black Poly Pipe shall be used to protect the cable entering the below grade wiring aperture in the concrete pole.

(c) Duct shall extend into the pole from the below grade aperture to the handhole.

N3.4 Streetlighting System Supply Cables

(a) Streetlighting System Supply Cables from transformer to Power Supply Pedestal shall be 3-1/C #2 AWG Copper RWU-90. [NOTE: Jacket colors shall be Black (Line), Red (Line), and White (Neutral)] and shall be the property of PowerStream.

(b) Ground wire shall not be connected between transformer and pedestal disconnect.

(c) Streetlighting Cables from Power Supply Pedestal to hand hole in pole shall be 3-1/C #6 AWG Copper RWU-90 complete with 1-1/C #6 stranded copper green jacketed ground wire [NOTE: Jacket colors shall be Black (Line), White (Neutral), and Green (Ground)].

(d) Streetlighting Cables from hand hole in pole to fixture (Bus Riser) shall be 2-1/C #12 AWG Copper RWU-90 complete with 1-1/C #12 AWG stranded copper green jacketed ground wire [NOTE: Jacket colors shall be Black (Line), White (Neutral), and Green (Ground)] such that the entire circuit has an acceptable voltage drop.

N3.5 Streetlighting Disconnects

(a) Within the handhole of the pre-cast concrete pole, an ESA approved breaker shall be utilized as the streetlights disconnect.

(b) The breaker shall be rated for 15Amp 22k.

(c) Grounding shall be in accordance with all applicable ESA standards and specifications.

(d) Access to the disconnect shall be limited by use of tamper-proof screws attaching the cover plate to the hand-hole.

(e) Externally visible marking shall be placed on the handhole containing the breaker.

N3.6 Streetlighting Power Supply Pedestal (base mounted)

(a) Pedestal shall have a steel, weatherproof lockable enclosure factory finished in powder coat green.

(b) Base shall be an approved pre-cast base suitable for power supply pedestal.

(c) Panel shall have 100 Amp 22k Air Main Breaker rating circuit as required, 120/240V. 1 Ph, 3 W as shown on the drawings for the streetlighting feeds.

(d) Two ground rods shall be installed in accordance with all applicable ESA standards and specifications.

(e) Pedestal may have to be metered if required by PowerStream (typical for Park Services, not required for streetlights).

(f) City lock (supplied by the City) shall be installed on all power supply pedestals after energizing of streetlights or supply to pedestals.

N3.7 Fusing

(a) Each fixture shall be protected through the use of in-line fuses within each handhole. The line side of the streetlight circuit shall be individually fused in each handhole utilizing 10 Amp KTK in-line fuse holder.

N3.8 Streetlighting Monitoring System

As part of the HPS cobra-head LED conversion project, the City installed a state of the art streetlighting control and monitoring system. The Philips StarSense Streetlighting Control and Monitoring System, a proprietary IEEE802.15.4 914Mhz RF based, mesh network control system (existing) that is linked to the data server through the existing cellular telephone network via segment controller cabinets installed at key locations in the City. **The Design Engineer shall consult with the City's Asset Management staff to determine the type of equipment being deployed for a specific geographical location as described below:**

(a) The existing StarSense RF system utilizes existing Segment Control Cabinets (LFC7310) to connect the RF mesh formed by the Outdoor Lighting Control (OLC) nodes and report status and allow for remote control and scheduling back to the management and control software. The Segment Controllers are existing and installed as part of the HPS cobra-head LED conversion program.

(b) It is the intent of the City to utilize the latest Philips technology, where applicable. Additions to the City's StarSense system, the City shall also utilize the CityTouch Connector Node (CTCN) that communicates directly via the cellular network (no segment controller required) to connect to the management and control software.

Each location shall be checked via the CityTouch server system by the City's Asset Management staff to determine if the location is functioning properly. The City's Asset Management staff shall provide a list of locations to the Design Engineer/Developer/Contractor who is reporting a fixture or OLC fault.

N3.9 Individual Outdoor Lighting Controller (OLC Nodes)

Each fixture shall be controlled by an OLC mounted on the fixture's **NEMA 5 pin twist lock receptacle**. Outdoor lighting controllers shall be Philips StarSense NEMA OLC or CityTouch Cellular Connector Node (CTCN) as shown in the Table below. When available, all LED luminaires shall be supplied with an approved version of the Philips StarSense NEMA OLC or CTCN with provision for control of a 0-10V DC dimmable driver and the appropriate control receptacle.

Philips Outdoor Lighting Controller Ordering Codes:

Control Node Type	Catalog Code	Order Code	Description
StarSense RF OLC Node	LLC7320	913701261202	STARSENSE NA NEMA LOW VOLT (DIM) Grey 120-277V
StarSense RF OLC Node	LLC7321	913701264002	STARSENSE NA NEMA LOW VOLT (DIM) BLK 120-277V
CityTouch Cellular Connector Node (CTCN)	LLC7260	913700363303	City Touch Connector Node (CTCN) LOW VOLT (DIM) 120-277V

Current models of OLCs do not have GPS capability. Poles X, Y coordinates has to be input in the system to locate the OLC.

City Touch Cellular Connector Node (CTCN) has GPS capability and automatically picks up pole's X, Y coordinates to locate the CTCN node.

Protocol for Installing Outdoor Lighting Controller (OLC) Nodes:

(a) Outdoor Lighting Control (OLC) shall be mounted on each luminaire so that the Bar Code numbers associated with each OLC is captured accurately.

(b) OLC comes with three (3) nos Bar Code Stickers, one stickers shall be pasted firmly on the OLC, second sticker shall be pasted inside the handhole in visible sight and the third sticker shall be carefully pasted on following table.

Pole ID (as per dwg)	**Pole Tag ID**	**X, Y Coordinates** *(Required on for StarSense RF OLC Node)*		**OLC/ CTCN Nodes Sticker** *(Paste here)*

(c) The OLC's/CTCN's will turn the fixture on for one day night cycle at the initial power application. An on board photocell will then engage until the device is commissioned by the server. The developer/ contractor should inform the City representative as soon as the streetlights are energized.

N3.10 Light Sources

(a) All light sources shall be Light Emitting Diode (LED) type, unless otherwise approved by the Director of Engineering.

(b) All LED light sources shall be rated for a minimum life of 90,000 hours.

(c) Luminaire wattages shall be specified by the Design Engineer in conformance with the standards and specifications of the City.

N3.11 Connectors

(a) All connectors shall be CSA approved and in accordance with ESA standards and specifications.

(b) All connectors shall be sized appropriately for the gauge and number of conductors connected.

N3.12 Grounding

(a) All ground rods shall be 3.0 m x 20 mm Type 2 Copper Clad CSA C83.41.

(b) Ground Wire to Rod Connector shall be Figure 8 Copper suitable for connecting # 8 - # 2 AWG Stranded Bare Copper to above referenced Ground Rod.

(c) Where ground rods cannot be utilized, CSA Approved Ground Plates may be utilized in complete accordance with the latest ESA standards and specifications.

(d) All ground rod connections shall be per ESA.

(e) Pedestal grounding in conjunction with transformer grounding shall be per the City's MST18A and B, and MST19A and B.

(f) Underground handholes or pull chambers are not allowed unless approved by the Director of Engineering.

N3.13 Mounting Arms

(a) Reference MST1 to MST17 for approved manufacturer descriptions and catalogue numbers.

(b) All decorative arms shall be powder coated.

N3.14 Luminaires

(a) All LED luminaire drivers shall be rated for 120 - 277V unless specified otherwise.

(b) Each fixture shall be controlled by an Outdoor Lighting Control (OLC) mounted on the fixture's twist lock receptacle. Outdoor lighting controllers shall be as specified in Section N3.9.

(c) All luminaires shall be dark sky compliant with zero uplight in the case of "cobra-head" style fixtures or shall comply with the uplight ("U") component of the BUG rating from TM-15 latest edition for post-top or decorative fixtures.

(d) All luminaires shall be provided with fauna shields to prevent ingress of birds.

(e) Refer to MST 1 to MST 17 for approved manufacturer descriptions and catalogue numbers.

(f) All decorative fixtures shall be powder coated.

N3.15 Concrete Poles

(a) The cable runway in the pole shall be of sufficient diameter to accommodate a double run of streetlighting cable.

(b) All non-communication poles shall have two properly bonded hand holes, one directly above the other, to accommodate both the handhole breaker in the lower one and the streetlighting circuit connectors and fusing in the upper one.

(c) Non-communication pole handholes shall be box type of 50,000 P.S.I. High Density Cast Zinc A.S.T.M. ingot spec. # B669-82 or equivalent, complete with a close fitting inset cover (flush with the outside of the pole) of the same material and tamperproof screws having an inside diameter of 267 mm x 89 mm.

(d) Communication Pole handhole boxes shall be box type of 50,000 P.S.I. High Density Cast Zinc A.S.T.M. ingot spec. # B669-82 or equivalent, complete with a close fitting inset cover (flush with the outside of the pole) of the same material and tamperproof screw with an inside diameter of 368 mm x 114 mm.

(e) The City encourages the use of non-conductive handhole materials as an alternate.

(f) The pole shall have a copper ground wire at the handhole in accordance with CSA Standards.

(g) Manufacturer's name plate shall be positioned no more than 254 mm above top most handhole, per MST 1 to MST 17.

(h) The Manufacturer's name plate shall contain the following information:

- Manufacturer's Name
- Style / Class / Height
- Date of Manufacture

N4 MATERIAL SPECIFICATION LIGHT EMITTING DIODE (LED) – COBRA-HEAD STYLE ROADWAY LUMINAIRES

This specification is for the evaluation and purchase of Light Emitting Diode (LED) roadway lighting luminaires for mounting on mast arms attached to power utility poles or independent streetlighting concrete, wood or aluminum poles. Applications shall include municipal standard local, collector, and arterial roadways, and intersections. Luminaires must meet the general requirements of this specification Part I and demonstrate satisfactory energy and photometric performance as described in Part II.

N4.1 General Specification

N4.1.1 References

The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by their basic designation only.

1. American National Standards Institute (ANSI)
   (a) ANSI C136.2-2004 (R2009), American National Standard for Roadway and Area Lighting Equipment - Luminaire Voltage Classification
   (b) ANSI C136.3-2005, American National Standard for Roadway and Area Lighting Equipment - Luminaire Attachments
   (c) ANSI C136.10-2006, American National Standard for Roadway Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacle Physical and Electrical Interchangeability and Testing
   (d) ANSI C136.25-2009, American National Standard for Roadway and Area Lighting Equipment – Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures
   (e) ANSI C136.31-2001, American National Standard for Roadway Lighting Equipment – Luminaire Vibration
   (f) ANSI C136.41, 2014, American National Standard for Photocontrol Receptacles
2. American Society for Testing and Materials International (ASTM)
   (a) ASTM B117-97 – Standard Practice for Operating Salt Spray (Fog) Apparatus
3. Illuminating Engineering Society (IES) The Consortium will monitor progress of the draft IES DG-22-10 (Design Guide for Residential Streetlighting)
   (a) DG-4-03, Design Guide for Roadway Lighting Maintenance (DG-4-11 is being voted on)
   (b) LM-79-08, IES Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products
   (c) LM-80-08, IES Approved Method for Measuring Lumen Maintenance of LED Light Sources
   (d) LM-82-12, IES approved Method for the Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a function of Temperature
   (e) RP-8-14, ANSI / IES American National Standard Practice for Roadway Lighting
   (f) RP-16-05 and addenda, “Nomenclature and Definitions for Illuminating Engineering” (The Consortium may eventually add its own Glossary / Definitions section.)
   (g) TM-15-11, “Luminaire Classification System for Outdoor Luminaires”
   (h) TM-21-11, “Projecting Long Term Lumen Maintenance of LED Light Sources”

4. Institute of Electrical and Electronic Engineers (IEEE)

   (a) ANSI / IEEE C62.41.2-2002 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits
   (b) ANSI / IEEE C62.45-2002 – IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (100 V or less) AC Power Circuits.

5. National Electrical Manufacturers Association (NEMA)

   (a) ANSI / NEMA / ANSLG C78.377-2008 – American National Standard for the Chromaticity of Solid State Lighting Products

6. Underwriters Laboratories (UL)

   (a) UL 1449, Surge Protective Devices
   (b) UL 1598, Luminaires

7. Canadian Standards Association

   (a) CSA Standard C22.2 No. 250.0-08, Luminaires (Tri-national standard with UL-1598 and NMX-J-307 / 1-ANCE)

N4.1.2 LED Luminaire Specification

1. Housing (Cobra-Head Style)

(a) The housing shall be of rugged, highly corrosion resistant, light weight die cast aluminum alloy.

(b) The luminaire housing shall be painted with a durable polyester powder coat. Castings shall be pre-treated using a 5-stage iron phosphate system to assure adhesion. Color shall be neutral grey.

(c) Luminaire components and applied finishes shall pass the 1000 hour salt test per ASTM B117 standard.

(d) Luminaires shall be horizontal mast arm mountable and allow for continuous adjustment in the vertical plane of + / - 3 deg. A four bolt hex head clamping assembly shall provide secure attachment of the luminaire to the supporting mast arm. The assembly shall accommodate 1.25 to 2 inch pipe size mast arms.

(e) Where small metal machine screw fastening hardware is utilized in the luminaire assembly it shall be of a material that is corrosion resistant and compatible with the housing material. The hardware will have a Robertson or hex head drive. Flat or Philips head drives are not acceptable.

(f) Internal system components, clamping assembly, and terminal block shall be accessible without the use of tools. Access doors shall be latched, swing down to the open position and be mechanically secured to the main housing. Drivers and LED array modules must be mounted internally, be modularly replaceable, and be easily accessible for replacement.

(g) The luminaire shall be CSA or cUL listed for wet locations. The LED optical module shall be sealed and tested to IEC spec 529 to meet a rating of IP66 for particulate and moisture ingress. Power supply / driver unit shall also be rated IEC IP66. The housing shall contain measures that prevent the entry of birds.

(h) The outer exposed surface of the optical system shall be designed so that there will be no adhesion of snow and minimal dirt collection that will block normal egress of light. The system exterior shall also be easy to clean by hand. All light transmitting materials must be high UV stabilized or glass so as not to discolor due to sunlight or high luminous flux transmission over its expected operational life.

(i) The luminaire and all subcomponents are to be free of designated hazardous substances that would otherwise prevent it from being disposed of in a normal regulated Ontario landfill site or recycled without any special type of treatment or disassembly.

(j) The luminaire shall operate within specifications for an operating ambient temperature range of -30° C to + 40° C.

(k) Luminaire shall meet ANSI C136.31 (current version) for 3.0 G vibration for use on normal roadways and bridges.

(l) The Vendor shall indicate the extent and nature of operational type testing for which the luminaire has been evaluated for the following:

- Ambient thermal cycling. (i.e. freeze - thaw)
- Ice formation and build-up.

(m) Each luminaire shall be safety certified to CSA C22.2 No. 250.0-08 or have an equivalent listing from a recognized testing laboratory for the approved sale and use in Canada. Applicable labels shall be applied inside each unit.

(n) Each luminaire shall have a label permanently fixed inside the unit that identifies the manufacturer's essential product information including, date of manufacture, electrical schematic diagram, and operating specifications.

2. Photometric Performance

(a) The luminaire LED light source shall emit white to cool white light with a nominal CCT in the range of 4000°K ± 200°K. Colour variation from the nominal luminaire rating over the operating life is to observe tolerance ranges consistent with ANSI standard C78.377-2008 "Specifications for the Chromaticity of Solid State Lighting".

(b) The luminaire zonal lumen distribution above 90° vertical shall be zero (0).

(c) Color Rendering Index (CRI) shall be ≥ 65.

(d) The luminaire shall be tested for photometric and electrical performance in accordance with the IES LM-79-08 "Approved Method for the Electrical and Photometric Measurements of Solid State Lighting Products". The test laboratory must hold National Voluntary Laboratory Accreditation Program (NVLAP) accreditation for the IES LM-79 test procedure. For more information, see:

http://www1.eere.energy.gov/buildings/ssl/test_labs.html.

(e) A copy of the manufacturer's LM-79 photometric report shall be submitted for review.

(f) The luminaire shall maintain a minimum of 85% of initial lumen output (L85) at 90,000 hours when operated within specified operating parameters at an ambient temperature of 25°C. The manufacturer shall indicate the actual lamp lumen depreciation (LLD) at 90,000 hours and at an ambient temperature of 25°C as calculated using procedures outlined in IES TM-21-11 (Projecting Long Term Lumen Maintenance of LED Light Sources). The manufacturer shall provide a total assembled luminaire system (LED package, housing, optical & electrical components) lumen depreciation curve or table for each separate wattage, drive current, and distribution type proposed.

(g) The LED chip manufacturer shall have tested the lumen maintenance characteristics of the LED chip in accordance with the guidelines of IES LM-80-08 "Approved Method for Lumen Maintenance Testing of LED Light Sources". A copy of the manufacturer's LM - 80 reports shall be submitted for review.

3. Electrical

(a) The Luminaire shall contain a surge protection device (SPD) to protect all electrical and electronic components from harmful line transient voltage surges as a result of utility line switching, lightning strikes, or other electrical supply system disturbances. The SPD for luminaires to be wired at 120V shall meet a 10 KA, 10 KV surge level and meet application and testing requirements per ANSI / IEEE C.62.41.2 for Category C High operation and ANSI / IEEE C62.45. For luminaires to be wired at a higher voltage (i.e. 240 or 347V) the SPD shall be rated for Category C Low. SPDs shall be designed to fail in the off position so as to help identify failed units and to continue to protect LED drivers and light engines from future power surges.

(b) Utility supply wiring to the luminaire shall terminate in a barrier-type terminal block secured to the housing. The terminal block shall have wire grips suitable for No. 14 AWG to no. 6 AWG wire sizes. All internal wiring shall be copper, 600V rated and insulated to class N, 200°C.

(c) The Luminaire shall be provided with a NEMA photoelectric control receptacle especially suited for the Philips StarSense dimming OLC. The receptacle shall be a five-prong twist lock type conforming to ANSI standard C136.41 and capable of being adjustable directionally without tools.

(d) The nominal operating voltage shall be 120 VAC +/- 10%, 60 Hz.

(e) The LED driver shall be designed to operate maintenance-free for a minimum of 100,000 hours at 25° C ambient.

(f) The LED driver shall have a power factor ≥ 0.90.

(g) The THD (current and voltage) induced into the AC supply line shall not exceed 20%.

(h) Luminaire driver electrical / electronic component devices shall comply with Industry Canada ICES Interference Causing Equipment Standards for RF emissions.

(i) 0 - 10VDC dimmable drivers are required to be controlled by a wireless monitoring / metering / dimming system.

(j) It is the intention of the City to dim cobra-head style LED luminaires during night-time operating hours; therefore it is required to have units with a dimming capability. Dimming control will be through a wireless control system already approved and in use.

4. Quality Assurance

(a) Before bulk purchase, the City may request to inspect one or more standard-production-model luminaire samples identical (including LED package) to product proposed to be installed. Owner may request independent testing of sample luminaires to verify luminaire performance and compliance with the specifications.

(b) After installation, the City may perform field measurements and / or send luminaires to an independent laboratory for testing to confirm photometric performance.

5. Packaging & Shipping

(a) The luminaire shall be shipped as a single self-contained unit in its own boxed container. The luminaire shall be fully assembled at the factory and not require any on site assembly. Each unit shall include installation and operating instructions.

6. Manufacturers' Warranty

(a) The manufacturer shall warrant the replacement of any component due to manufacturing defect or failure of that component (including LED array and LED driver) for a period of **10 years from the date of delivery**. Alternatively, the manufacturer may opt to replace the entire luminaire at no cost to the City.

N4.2 Luminaire Photometric and Energy Performance Evaluation

N4.2.1 Design Standards

1. It is of primary importance to the City that LED roadway lighting equipment conforming to this specification achieves significant energy usage reduction over the currently used High Pressure Sodium roadway lighting systems while meeting or exceeding ANSI / IES RP-8-14, Table 3 photometric performance for luminance level, uniformity, and glare control while also providing a minimum of 1.8 lux average maintained illuminance to adjacent sidewalks within the City Streets and as specified in Section N2.15 for sidewalks along Arterial (Regional) roads.
2. It is the intent of this specification to have Vendors, as part of the prequalification process, perform streetlighting installation photometric and energy usage calculations for typical municipal roadways using their selected product. The City will evaluate to what extent the product can deliver the required energy and lighting performance required for its roadways. **Table 1** summarizes these example typical roadways. **Table 2 - Sample Roadway Calculation Summary** lists **Typical Roadway Sections 1 - 11** depicting eleven (11) typical municipal roadway geometries to be used for evaluation purposes by the Vendor. The "typical" calculations will be used to evaluate the product's suitability to light the roadways under the following three construction scenarios:
   (a) New Construction - Independent stand-alone streetlighting system with optimized pole spacing and luminaire selection. Fixed mounting heights and mast arm lengths shall be observed.
   (b) New Construction - New streetlighting luminaires installed onto new electric utility distribution poles. Fixed mounting heights, and pole spacing shall be observed.
   (c) Retrofit Programs - New streetlighting luminaires for retrofit onto existing poles and mast arms. Fixed mounting heights, pole spacing, and mast arm lengths shall be observed.
3. Design Restrictions
   (a) In reference to the **Table 2, Typical Roadway Sections 1 - 11**; it is not intended to deviate from the indicated mounting heights for cobra-head style luminaires due to a reluctance to change from current construction and equipment standards. It is also not possible to change the location of the poles as indicated relative to the edge of pavement as this is mandated by the City to avoid underground and surface utility location conflicts.
4. Energy Usage
   (a) Since, unlike HPS luminaires, LED luminaires are available in many wattage variations, vendors shall base their designs on the most efficient use of power and shall calculate the total unit power density (UPD) for streets depicted in Tables 1 – 11. UPD values shall not exceed the limits indicated in each of the **Table 2, Typical Roadway Sections 1 – 11 nor the Tables A1 – A12.**
5. Light Loss Factors
   (a) It is the responsibility of each manufacturer to provide a calculation of Lamp Lumen Depreciation (LLD) for each photometric file used. LLD shall be based on calculated

lumen depreciation values reached at 90,000 hours at 25° C luminaire ambient and as proven by LM-80 support information and as calculated using the procedures outlined in TM-21-11 and LM-82.

(b) For this evaluation, the LDD attributable to accumulation of ambient airborne particulates onto the Luminaire's exposed light emitting surfaces shall be 0.90. The LDD figure of 0.90 was derived from Figure 2 in IES DG-4-03 corresponding to a 5 year exposure time and the "very clean" dirt condition curve. It is the City's intent to continue to clean the exterior of the light emitting shield / refractors once every 5 years. Airborne particulate levels (PM 2.5) as recorded in 2009 by the Ontario Ministry of the Environment did not exceed 150 micro grams per cubic meter in the Markham area.

6. Installation Life

(a) It is the City's expectation that the in-service life of a typical LED luminaire installation will be 20 years. This corresponds to an 88,000 hour on-time operation annually.

7. Lighting Performance

(a) Lighting levels, uniformity ratios, and veiling luminance ratios are from the ANSI / IES RP-8-14 Recommended Practice Table 3 and are required to be met for streets depicted in **Table 2, Typical Roadway Sections 1 - 11.** These lighting requirements are indicated in **Table 1.**

(b) The indicated lighting levels in **Table 1** are those to be present at the end of the 20-year luminaire useful life. They shall observe the 25 deg. C ambient operating temperature, the manufacturer's light engine LLD and the 0.90 LDD attributable to accumulation of operating ambient particulates.

(c) Photometric calculations shall recognize only photopic lumens and will not incorporate any mesopic multiplier factor. Calculations shall observe current IES calculation and measurement methods.

N4.2.2 Required Submittals for Each Luminaire Type

1. Product cut-sheets

(a) Shall indicate a complete and unique catalogue number for each product submitted

(b) All components of catalogue numbers shall be identifiable as options and explained

(c) Luminaire input current, LED drive current, and nominal Correlated Color Temperature (CCT) shall be clearly indicated. NOTE: Luminaire input current is different from LED drive current. LED drive current is an important factor in estimating LED useful lifetime.

(d) Shall include complete specifications for LED light source(s), including make/model #

(e) Shall include complete specifications for LED driver(s), including make / model #

(f) Shall include complete specifications for any integral controls, including make/model #

(g) Shall include documentation supporting claims of luminaire recyclability

2. Luminaire photometric report per IES LM-79 including:

(a) Name of independent test laboratory

(i) The test laboratory must hold National Voluntary Laboratory Accreditation Program (NVLAP) accreditation for the IES LM-79 test procedure. For more information, see http://www1.eere.energy.gov/buildings/ssl/test_labs.html.

(b) Report number

(c) Date

(d) Complete luminaire catalogue number, consistent with submitted product cut-sheet

(e) Description of luminaire, LED light source, and LED driver(s)

(f) Photometry

(g) Colorimetry

3. Computer-generated point-by-point photometric analysis of maintained light levels as per **Table 1.**

   (a) Calculations shall be for maintained values, i.e. Light Loss Factor (LLF) < 1.0, where LLF = LLD x LDD

      i) Lamp Lumen Depreciation (LLD); determined by the process outlined in Design Standards Section N2.7.

   (b) Luminaire Dirt Depreciation (LDD) = 0.90, as per IES DG-4-03 for an enclosed and gasketed roadway luminaire installed in an environment with airborne particulate matter less than 150 micro g / m3 and cleaned every five years.

   (c) Calculation / measurement points shall be as per ANSI / IES RP-8-14 Figure A4.

4. Documentation supporting claims of expected L85 useful life, as per IES RP-8-14 Appendix A

   (a) Provide IES LM-80 report from manufacturer of LED chip used in luminaire

   (b) Provide ISTMT report

   (c) Provide TM-21-11 computed charts illustrating interpolation between TMP curves from LM-80 data for lumen maintenance at TMP from ISTMT report

      i) TMP interpolation is only valid for the same drive current

5. Written manufacturers' product warranty per section below.

6. Safety certification and file number per the CEC. Recognized Testing Laboratories include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

N4.2.3 Manufacturers' Product Warranty

1. Provide a written **five year manufacturers' warranty covering material**, workmanship, and fixture finish. Finish warranty shall include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or excessive fading.

2. Provide a written ten year manufacturers' replacement material warranty for defective or non-starting LED source assemblies (Light engines). Light engine failure will be defined as the failure of ≥ 15% of the individual LED chips.

3. Provide a written ten year manufactuerers' replacement material warranty on all drivers (power supplies).

4. Warranty period shall begin on date of receipt of material from the supplier. The supplier / manufacturer shall provide the City with appropriate manufacturers' warranty certificates and shipping documents as proof of date of shipment.

N4.2.4 Vendor Evaluations

Vendors shall be required to tabulate energy and photometric calculation results in **Table 3** for each roadway. If the indicated streetlighting requirements cannot be met by the proposed luminaire for the given parameters, the Vendor shall indicate the best that could be achieved. The vendor shall also calculate the maximum achievable spacing for each Typical Section. This will be used to develop updated optimized spacing for new construction applications.

Table 1 - Example Typical Roadways to be evaluated

Typical Section No.	Roadway Type	Pedestrian Conflict	Luminance cd / m²	Uniformity Avg / Min	Uniformity Max / Min	Veiling Luminance Lv_{max} / L_{avg}	Sidewalk Illuminance (Lux)
			(min)	(max)	(max)	(max)	(min-ave)
1	Local	Low	0.3	6.0	10.0	0.4	1.8
2	Local	Low	0.3	6.0	10.0	0.4	1.8
3	Collector	Low	0.4	4.0	8.0	0.4	1.8
4	Collector	Low	0.4	4.0	8.0	0.4	1.8
5	Collector	Low	0.4	4.0	8.0	0.4	1.8
6	Collector	Medium	0.6	3.5	6.0	0.4	1.8
7	Collector	Medium	0.6	3.5	6.0	0.4	1.8
8	Local	Low	0.3	6.0	10.0	0.4	1.8
9	Collector	Medium	0.6	3.5	6.0	0.4	1.8
10	Collector	Medium	0.6	3.5	6.0	0.4	1.8
11	Local	Medium	0.5	6.0	10.0	0.4	1.8

Table 2 - Sample Roadway Calculation Summary

Date: _____
Vendor: _____

Typical Section 1: Cobra-Head Style – Drawing MR 3; Local Low: 2 Lane – 4.25 m Lane width,

Maximum UPD; 0.19 W / m². Sidewalk on one side,

Two sided (staggered), fixed 89 m spacing, 9.2m MH, 1.7 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Avg cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 2: Cobra-Head Style – Drawing MR 4; local Low: 2 Lane – 4.25 m lane width,

Maximum UPD; 0.20 W / m². Sidewalk on two sides,

Two-side (Staggered), fixed 110 m spacing, 9.2m MH, 1.7 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 3 Cobra-Head Style – Drawing MR 5; Collector Low: 2 Lane – 3.5 m lane width, Plus 2.5 m Parking bay

Maximum UPD; 0.25 W/m². Sidewalk on two sides,

Two sided (Staggered), fixed 85 m spacing, 9.2m MH, 2.5 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd/ m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Table 2 - Sample Roadway Calculation Summary (Cont'd)

Typical Section 4: Cobra-Head Style – Drawing MR 6; Collector Low: 2 Lane – 4.25 m lane width, Plus 2.5 m Parking bay

Maximum UPD; 0.24 W / m². Sidewalk on two sides,

Two sided (Staggered), fixed 105 m spacing, 9.2m MH, 2.5 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 5: Cobra-Head Style – Drawing MR 7; Collector Low: 2 Lane – 3.5 m lane width, Plus 2.5 m Parking bay & 1.5 m Bike lane

Maximum UPD; 0.30 W / m². Sidewalk on two sides,

Two sided (Staggered), fixed 76m spacing, 9.2m MH, 2.5 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 6: Cobra-Head Style – Drawing MR 8; Collector Medium: 4 Lane – 3.5 m lane width

Maximum UPD; 0.25 W / m². Sidewalk on two sides,

Two sided (Staggered), fixed 94 m spacing, 10.4 m MH, 2.5 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Table 2 - Sample Roadway Calculation Summary (Cont'd)

Typical Section 7: Cobra-Head Style – Drawing MR 9; Collector Medium: 4 Lane – 3.5 m lane width with centre 1.5 m Median strip

Maximum UPD; 0.25 W / m². Sidewalk on two sides,

Two sided (Staggered), fixed 93 m spacing, 10.4 m MH, 2.5 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 8: Cobra-Head Style – Drawing MR 10; Local Low Lane: 2 Lane – 2.75 m lane width, One side, fixed 51 m spacing, 6.1 m MH, 1.2m setback, 0.2m arm.

Maximum UPD; 0.19 W / m²

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 9: Cobra-Head Style –Drawing MR 11; Collector Medium: 2 Lane – 5.0 m lane width

Maximum UPD; 0.27 W / m². Sidewalk on both sides

Two side (staggered), fixed 135 m spacing, 10.4 m MH, 2.5 m setback, 2.4 m arm.

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Table 2 - Sample Roadway Calculation Summary (Cont'd)

Typical Section 10: Cobra-Head Style – Drawing MR 12; Collector Medium: 2 Lane – 3.75 m lane width with Centre turn lane

Maximum UPD; 0.36 W / m². Sidewalk on two sides,

Two sided (Staggered), fixed 125 m spacing, 10.4 m MH, 2.5 m setback, 2.4 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 11: CobraHead Style – Drawing MR 13; Local Medium Lane: 2 Lane – 3.5 m lane width, One side, fixed 49 m spacing, 6.1 m MH, 1.45 m setback, 0.2m arm.

Maximum UPD; 0.23 W / m²

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Average cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Table 3 - Summary of Performance

Test No.	Model No.	Input Watts	Calculated LLD From TM-21	Meets Photometric Performance Requirements Yes / No	Additional Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

N5 MATERIAL SPECIFICATION LIGHT EMITTING DIODE (LED) - TRADITIONAL COACH LIGHT STYLE ROADWAY LUMINAIRES

This specification is for the evaluation and purchase of Light Emitting Diode (LED) roadway lighting luminaires for mounting on mast arms attached to power utility poles or independent street-lighting concrete, wood or aluminum poles. Applications shall include municipal standard local, collector, and arterial roadways, and intersections. Luminaires must meet the general requirements of this specification Part I and demonstrate satisfactory energy and photometric performance as described in Part II.

N5.1 General Specification

N5.1.1 References

The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by their basic designation only.

1. American National Standards Institute (ANSI
   (a) ANSI C136.2-2004 (R2009), American National Standard for Roadway and Area Lighting Equipment - Luminaire Voltage Classification
   (b) ANSI C136.3-2005, American National Standard for Roadway and Area Lighting Equipment - Luminaire Attachments
   (c) ANSI C136.10-2006, American National Standard for Roadway Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacle Physical and Electrical Interchangeability and Testing
   (d) ANSI C136.25-2009, American National Standard for Roadway and Area Lighting Equipment – Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures
   (e) ANSI C136.31-2001, American National Standard for Roadway Lighting Equipment – Luminaire Vibration
   (f) ANSI C136.41, 2014, American National Standard for Photocontrol Receptacles

2. American Society for Testing and Materials International (ASTM)
   (a) ASTM B117-97 – Standard Practice for Operating Salt Spray (Fog) Apparatus

3. Illuminating Engineering Society (IES)
   (a) DG-4-03, Design Guide for Roadway Lighting Maintenance (DG-4-11 is being voted on)
   (b) LM-79-08, IES Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products
   (c) LM-80-08, IES Approved Method for Measuring Lumen Maintenance of LED Light Sources
   (d) LM-82-12, IES approved Method for the Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a function of Temperature
   (e) RP-8-14, ANSI / IES American National Standard Practice for Roadway Lighting
   (f) RP-16-05 and addenda, “Nomenclature and Definitions for Illuminating Engineering” (The Consortium may eventually add its own Glossary / Definitions section.)
   (g) TM-15-11, “Luminaire Classification System for Outdoor Luminaires”
   (h) TM-21-11, “Projecting Long Term Lumen Maintenance of LED Light Sources”

4. Institute of Electrical and Electronic Engineers (IEEE)
   (a) ANSI / IEEE C62.41.2-2002 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits
   (b) ANSI / IEEE C62.45-2002 – IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (100 V or less) AC Power Circuits.

5. National Electrical Manufacturers Association (NEMA)
   (a) ANSI / NEMA / ANSLG C78.377-2008 – American National Standard for the Chromaticity of Solid State Lighting Products

6. Underwriters Laboratories (UL)
   (a) UL 1449, Surge Protective Devices
   (b) UL 1598, Luminaires

7. Canadian Standards Association
   (a) CSA Standard C22.2 No. 250.0-08, Luminaires (Tri-national standard with UL-1598 and NMX-J-307 / 1-ANCE)

N5.1.2 LED Luminaire Specification

1. Housing (Traditional Coachlight Style)

(a) The upper housing and lower cage shall be of rugged, highly corrosion resistant, light weight die cast aluminum alloy.

(b) The upper housing and lower cage shall be painted with a durable polyester powder coat. Castings shall be pre-treated using a 5-stage iron phosphate system to assure adhesion. Color shall be either semi-gloss black, shibui brown, heritage blue, or some other color which may from time to time be specified by the City.

(c) Luminaire components and applied finishes shall pass the 1000 hour salt test per ASTM B117 standard.

(d) The bottom section of the housing shall be hinged to the top section and allow access to the electrical compartment without the use of tools.

(e) Luminaires shall be either horizontal mast arm mountable or post-top mountable

(f) Post-top mounted luminaires shall be designed to mount on existing pole tenons.

(g) Where small metal machine screw fastening hardware is utilized in the luminaire assembly it shall be of a material that is corrosion resistant and compatible with the housing material. The hardware will have a Robertson or hex head drive. Slot or Phillips head drives are not acceptable. All externally exposed hardware shall be painted to match the exterior or the luminaire except for any quarter-turn fasteners.

(h) Internal system components, clamping assembly and terminal blocks shall be accessible without the use of tools. Drivers and LED array modules must be mounted internally, be modularly replaceable, and be easily accessible for replacement.

(i) The luminaire shall be CSA or cUL listed for wet locations. The LED optical module shall be sealed and tested to IEC spec 529 to meet a rating of IP66 for particulate and moisture ingress. Power supply / driver unit shall also be rated IEC IP66. The upper housing shall contain measures that prevent the entry of birds and insects.

(j) Outer side and bottom lenses are not required by the City. If supplied and required for the correct optical performance of the luminaire, they shall be made of impact resistant glass and attached to the frame with reinforcing channels and sealed to prevent ingress of dirt or moisture.

(k) The post-top version shall be provided with a decorative imitation candle to be located in the base of the lower housing assembly.

(l) The luminaire and all subcomponents are to be free of designated hazardous substances that would otherwise prevent it from being disposed of in a normal regulated Ontario landfill site or recycled without any special type of treatment or disassembly.

(m) The luminaire shall operate within specifications in an ambient temperature range of -30° C to + 40° C.

(n) Luminaire shall meet ANSI C136.31 (current version) for 3.0 G vibration for use on normal roadways and bridges.

(o) The Vendor shall indicate the extent and nature of operational type testing for which the luminaire has been evaluated for the following:

- Ambient thermal cycling. (i.e. freeze - thaw)
- Ice formation and build-up.

(p) Luminaire shall be safety certified to CSA C22.2 No. 250.0-08 or have an equivalent listing from a recognized testing laboratory for the approved sale and use in Canada. Applicable labels shall be applied inside each unit.

(q) Each luminaire shall have a label permanently fixed inside the unit that identifies the manufacturer's essential product information including, date of manufacture, electrical schematic diagram, and operating specifications.

2. Photometric Performance

(a) The luminaire LED light source shall emit white to cool white light with a nominal CCT in the range of 4000°K ± 200°K. Color variation from the nominal luminaire rating over the operating life is to observe tolerance ranges consistent with ANSI standard C78.377-2008 "Specifications for the Chromaticity of Solid State Lighting".

(b) The luminaire zonal lumen distribution above 90° vertical shall comply with the “U” rating for the geographical and land usage zones as defined by IES technical memorandum TM-15-11, "Luminaire Classification System (LCS) for Outdoor Luminaires".

(c) Color Rendering Index (CRI) shall be ≥ 65.

(d) The luminaire shall be tested for photometric and electrical performance in accordance with the IES LM-79-08 "Approved Method for the Electrical and Photometric Measurements of Solid State Lighting Products". The test laboratory must hold National Voluntary Laboratory Accreditation Program (NVLAP) accreditation for the IES LM-79 test procedure.

For more information, see: http://www1.eere.energy.gov/buildings/ssl/test_labs.html.

(e) A copy of the manufacturer's LM-79 photometric report shall be submitted for review.

(f) The luminaire shall maintain a minimum of 85% of initial lumen output (L85) at 90,000 hours when operated within specified operating parameters at an ambient temperature of 25°C. The manufacturer shall indicate the actual lamp lumen depreciation (LLD) at 90,000 hours and at an ambient temperature of 25°C as calculated using procedures outlined in IES TM-21-11 (Projecting Long Term Lumen Maintenance of LED Light Sources). The manufacturer shall provide a total assembled luminaire system (LED package, housing, optical & electrical components) lumen depreciation curve for each separate wattage, drive current and distribution type proposed.

(g) The LED chip manufacturer shall have tested the lumen maintenance characteristics of the LED chip in accordance with the guidelines of IES LM-80-08 "Approved Method for Lumen Maintenance Testing of LED Light Sources". A copy of the manufacturer's LM - 80 reports shall be submitted for review.

3. Electrical

(a) The Luminaire shall contain a surge protection device (SPD) to protect all electrical and electronic components from harmful line transient voltage surges as a result of utility line switching, lightning strikes, or other electrical supply system disturbances. The SPD for luminaires to be wired at 120V shall meet a 10 KA, 10 KV surge level and meet application and testing requirements per ANSI / IEEE C.62.41.2 for Category C High

operation and ANSI / IEEE C62.45. For luminaires to be wired at a higher voltage (i.e. 240 or 347V) the SPD shall be rated for Category C Low. SPDs shall be designed to fail in the off position so as to help identify failed units and to continue to protect LED drivers and light engines from future power surges.

(b) Utility supply wiring to the luminaire shall terminate in a barrier-type terminal block secured to the housing. The terminal block shall have wire grips suitable for No. 14 AWG to no. 6 AWG wire sizes. All internal wiring shall be copper, 600V rated, and insulated to class N, 200°C.

(c) The Luminaire shall be provided with a NEMA photoelectric control receptacle especially suited for the Philips StarSense dimming OLC. The receptacle shall be a five-prong twist lock type conforming to ANSI standard C136.41 and capable of being adjustable directionally without tools.

(d) The nominal operating voltage shall be 120 VAC +/- 10%, 60 Hz.

(e) The LED driver shall be designed to operate maintenance-free for a minimum of 100,000 hours at 25° C ambient.

(f) The LED driver shall have a power factor ≥ 0.90.

(g) The THD (current and voltage) induced into the AC supply line shall not exceed 20%.

(h) Luminaire driver electrical / electronic component devices shall comply with Industry Canada ICES Interference Causing Equipment Standards for RF emissions.

(i) Drivers shall be provided with 0 – 10VCD dimmable drive current operation over the twenty-year expected life of the luminaires.

4. Quality Assurance

(a) Before bulk purchase, the City may request for inspection one or more standard-production-model luminaire samples identical (including LED package) to product proposed to be installed. Owner may request independent testing of sample luminaires to verify luminaire performance and compliance with the specifications.

(b) After installation, the City may perform field measurements and / or send luminaires to an independent laboratory for testing to confirm photometric performance.

5. Packaging and Shipping

(a) The luminaire shall be shipped as a single self-contained unit in its own boxed container. The luminaire shall be fully assembled at the factory and not require any on site assembly. Each unit shall include installation and operating instructions.

6. Manufacturers' Warranty

(a) The manufacturer shall warrant the replacement of any component due to manufacturing defect or failure of that component (including LED array and LED driver) for a period of **10 years from date of delivery**. Alternatively, the manufacture may opt to replace the entire luminaire at no cost to the City.

N5.2 Luminaire Photometric and Energy Performance Evaluation

N5.2.1 Design Standards

1. It is of primary importance to the City that LED roadway lighting equipment conforming to this specification achieves significant energy usage reduction over the currently used High Pressure Sodium roadway lighting systems while meeting or exceeding ANSI / IES RP-8-14

Table 3 photometric performance for luminance level, uniformity, and glare control while also providing a minimum of 1.8 lux average maintained illuminance to adjacent sidewalks within the City Streets and as specified in Section N2.13 for sidewalks along Arterial (Regional) roads.

2. It is the intent of this specification to have Vendors, as part of the prequalification process, perform lighting installation photometric and energy usage calculations for typical municipal roadways using their selected product. The City will evaluate to what extent the product can deliver the required energy and lighting performance required for its roadways. **Table 4** summarizes these typical.
3. Example roadways in **Table 5, Typical Sections 1 - 5** depict, five (5) typical municipal roadway geometries to be used for evaluation purposes by the Vendor. The "typical" calculations will be used to evaluate the product's suitability to light the roadways under the following three construction scenarios:
   (a) New Construction - Independent stand-alone streetlighting system with optimized pole spacing and luminaire selection. Fixed mounting heights and mast arm lengths shall be observed.
   (b) New Construction - New streetlighting luminaires installed onto new electric utility distribution poles. Fixed mounting heights, and pole spacing shall be observed.
   (c) Retrofit Programs - New streetlighting luminaires for retrofit onto existing poles and mast arms. Fixed mounting heights, pole spacing, and mast arm lengths shall be observed.
4. Design Restrictions
   (a) In reference to the **Table 5, Typical Sections 1 - 5**; it is not intended to deviate from the indicated mounting heights for Traditional Coach Light style luminaires due to a reluctance to change from current construction and equipment standards. It is also not possible to change the location of the poles as indicated relative to the edge of pavement as this is mandated by the City to avoid underground and surface utility location conflicts.
5. Energy Usage
   (a) Since, unlike HPS luminaires, LED luminaires are available in many wattage variations, vendors shall base their designs on the most efficient use of power and shall calculate the total unit power density (UPD) for streets depicted in Tables B1- B5. UPD values shall not exceed the limits indicated in each of the **Table 5, Typical Sections 1 - 5** nor the **Tables B1 - B5.**
6. Light Loss Factors
   (a) It is the responsibility of each manufacturer to provide a calculation of Lamp Lumen Depreciation (LLD) for each photometric file used. LLD shall be based on calculated lumen depreciation values reached at 90,000 hours at 25° C luminaire ambient and as proven by LM-80 support information and as calculated using the procedures outlined in TM-21-11 and LM-82.
   (b) For this evaluation, the LDD attributable to accumulation of ambient airborne particulates onto the Luminaire's exposed light emitting surfaces shall be 0.90. The LDD figure of 0.90 was derived from Figure 2 in IES DG-4-03 corresponding to a 5 year exposure time and the "very clean" dirt condition curve. It is the City's intent to continue to clean the exterior of the light emitting shield / refractors once every 5 years. Airborne particulate levels (PM 2.5) as recorded in 2009 by the Ontario Ministry of the Environment did not exceed 150 micro grams per cubic meter in the Markham area.
7. Installation Life
   (a) It is the City's expectation that the in-service life of a typical LED luminaire installation will be 20 years. This corresponds to a 90,000 hour on-time operation annually.

8. Lighting Performance

   (a) Lighting levels, uniformity ratios, and veiling luminance ratios are from the ANSI / IES RP-8-14 Recommended Practice Table 3 and are required to be met for roadways depicted in **Table 5, Typical Roadway Sections 1 - 5**. These lighting requirements are indicated in Table **4.**

   (b) The indicated lighting levels in **Table 4** are those to be present at the end of the 20-year luminaire useful life. They shall observe the 25 deg. C ambient operating temperature, the manufacturer's light engine LLD and the 0.90 LDD attributable to accumulation of operating ambient particulates. (Refer to Item 4 above)

   (c) Photometric calculations shall recognize only photopic lumens and will not incorporate any mesopic multiplier factor. Calculations shall observe current IES calculation and measurement methods.

N5.2.2 Required Submittals for Each Luminaire Type

1. Product cut-sheets

   (a) Shall indicate a complete and unique catalogue number for each product submitted

   (b) All components of catalogue numbers shall be identifiable as options and explained Luminaire input current, LED drive current, and nominal Correlated Color Temperature (CCT) shall be clearly indicated

   (c) Shall include complete specifications for LED light source(s), including make/model #

   (d) Shall include complete specifications for LED driver(s), including make / model #

   (e) Shall include complete specifications for any integral controls, including make / model #

   (f) Shall include documentation supporting claims of luminaire recyclability

2. Luminaire photometric report per IES LM-79 including

   (i). The test laboratory must hold National Voluntary Laboratory Accreditation Program (NVLAP) accreditation for the IES LM-79 test procedure. For more information, see http://www1.eere.energy.gov/buildings/ssl/test_labs.html.

   (a) Report number

   (b) Date

   (c) Complete luminaire catalogue number, consistent with submitted product cut-sheet

   (d) Description of luminaire, LED light source, and LED driver(s)

   (e) Photometry

   (f) Colorimetry

3. Computer-generated point-by-point photometric analysis of maintained light levels as per **Table 4.**

   (a) Calculations shall be for maintained values, i.e. Light Loss Factor (LLF) < 1.0, where LLF = LLD x LDD

      (i). Lamp Lumen Depreciation (LLD); determined by the process outlined in Design Standards Section N2.10

      (ii). Luminaire Dirt Depreciation (LDD) = 0.90, as per IES DG-4-03 for an enclosed and gasketed roadway luminaire installed in an environment with airborne particulate matter less than 150 micro gram / m^3 and cleaned every five years.

   (b) Calculation / measurement points shall be as per ANSI / IES RP-8-14 Figure A4.

4. Documentation supporting claims of expected L85 useful life, as per ANSI / IES RP-8-14 Appendix A
   (a) Provide IES LM-80 report from manufacturer of LED chip used in luminaire
   (b) Provide ISTMT report
   (c) Provide TM-21-11 computed charts illustrating interpolation between TMP curves from LM-80 data for lumen maintenance at TMP from ISTMT report
      (i). TMP interpolation is only valid for the same drive current
5. Written manufacturers' product warranty per section below.
6. Safety certification and file number per the CEC. Recognized Testing Laboratories include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

N5.2.3 Manufacturers' Product Warranty

1. Provide a written **five year manufacturers' warranty covering material**, workmanship, and fixture finish. Finish warranty shall include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or excessive fading.
2. Provide a written **ten year manufacturers' replacement material warranty** for defective or non-starting LED source assemblies (Light engines). Light engine failure will be defined as the failure of ≥ 15% of the individual LED chips.
3. Provide a written **ten year manufacturers' replacement material warranty** on all drivers (power supplies).
4. Warranty period shall begin on date of receipt of material from the supplier. The supplier / manufacturer shall provide the City with appropriate warranty certificates and shipping documents as proof of date of shipment.

N5.2.4 Vendor Evaluations

Vendors shall be required to tabulate energy and photometric calculation results in **Table 5** for each roadway section. If the indicated lighting requirements cannot be met by the proposed luminaire for the given parameters, the Vendor shall indicate the best that could be achieved. The vendor shall also calculate the maximum achievable spacing for each Typical Section. This will be used to develop optimized spacing for new construction applications.

Table 4 - Example Typical Roadways to be evaluated

Typical Section No.	Roadway Type	Pedestrian Conflict	Luminance cd / m²	Uniformity Avg/Min	Uniformity Max/Min	Veiling Luminance Lv_{max}/L_{avg}	Sidewalk Illuminance (Lux)
			(min)	(max)	(max)	(max)	(min-ave)
1	Local	Low	0.3	6.0	10.0	0.4	1.8
2	Local	Low	0.3	6.0	10.0	0.4	1.8
3	Collector	Low	0.4	4.0	8.0	0.4	1.8
4	Collector	Medium	0.6	3.5	6.0	0.4	1.8
5	Collector	Low	0.4	4.0	8.0	0.4	1.8

Table 5 - Sample Roadway Calculation Summary

Date: _____
Vendor: _____

Typical Section 1: Traditional Style – Drawing MR3; Local Low: 2 Lane – 4.25 m Lane width, Sidewalk on one side

Two sided (staggered), fixed 100 m spacing, 7.6 m MH, 1.7 m setback, 1.5 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Avg cd m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 2: Traditional Style – Drawing MR4; Local Low: 2 Lane – 3.75 m lane width, Sidewalks on both sides

Two-side (Staggered), fixed 75 m spacing, 7.6 m MH, 1.7 m setback, 1.5 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Avg cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 3: Traditional Style – Drawing MR5: Collector Low: 3 Lane – 3.2 m lane width, Sidewalks on both sides

Two sided (Staggered), fixed 75 m spacing, 7.6 m MH, 2.5 m setback, 1.5 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Avg cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Table 5 - Sample Roadway Calculation Summary (Cont'd)

Typical Section 4: Traditional Style – Drawing MR6; Collector Medium: 3 Lane – 3.7 m lane width, Sidewalks on both sides

Two sided (Staggered), fixed 79 m spacing, 7.6 m MH, 2.5 m setback, 1.5 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Avg cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Typical Section 5: Traditional Style – Drawing MR7; Collector Low: 3 Lane – 4.2m lane width, Sidewalks both sides

Two sided (Staggered), fixed 59 m spacing, 7.6m MH, 2.5 m setback, 1.5 m arm

Manufacturer & Model	Total Unit Input Watts	Sidewalk Illuminance Lux	Photometric Performance - Luminance			
			L Avg cd / m²	Uniformity L avg/L min	Uniformity L max/L min	Veiling Luminance

Table 6 - Summary of Performance

Test No.	Model No.	Input Watts	Calculated LLD From TM-21	Meets Photometric Performance Requirements Yes / No	Additional Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

N6 CONSTRUCTION AND INSTALLATION SPECIFICATIONS

The following Section outlines the Construction and Installation.

N6.1 Ducting

(a) All streetlighting cables shall be installed in CSA Type 50 mm PVC Type 2 Direct Buried Ducts (DB2) in the main trench from the power source to the streetlighting location.
(b) From the main trench to the inside of the streetlighting aperture, the streetlighting cables shall be installed in black poly pipe or 50 mm flex duct, per ESA
(c) All ducts shall be solvent welded together as part of the installation procedure.
(d) Where streetlighting conductors cross the road, the 50 mm duct shall be installed through the road crossing duct in a continuous installation.
(e) All turning radii in duct shall be sized sufficiently so as to facilitate the pulling of the streetlighting conductors.
(f) In certain instances, concrete encasement of the ducts around bends may be required to act as a thrust block. Any concrete encasement requirement shall be noted on the design drawings.
(g) Ducting shall extend into the pole to the handwell.

N6.2 Trenching

(a) Streetlighting ducts shall be co-located in Joint Use Trenches with other shallow service utilities wherever possible.
(b) All Streetlighting trenches shall be mechanically compacted to 98% Standard Proctor Density (SDP) to avoid settlement and 100% SPD under roadways and sidewalks.
(c) Trenches shall provide a minimum cover of 750 mm over the direct buried streetlighting duct.
(d) Streetlighting ducts shall be surrounded by a 150 mm thick sand envelope.
(e) Warning tape shall be installed over all streetlighting duct locations at a depth half way between the final grade and the top of the upper most duct in accordance with the latest Electrical Safety Authority Standards and specifications.

N6.3 Cabling

(a) Streetlighting cables shall only be installed through ducts after trench is backfilled.
(b) Streetlighting cables shall not be spliced.
(c) All cabling shall be in accordance with the ESA and sized so that voltage drop meets the ESA requirement of 5% maximum voltage drop to last light on circuit.

N6.4 Connections

(a) All connections are to be per ESA standards and specifications.
(b) All connections to circuit breakers / pole breakers are to be inspected and certified by ESA prior to energization.

N6.5 Disconnects

(a) A suitable disconnect (Pole Breaker or Pedestal) shall be installed in accordance with ESA
(b) A Pole Breaker disconnect shall be installed on the first streetlight pole in each circuit or a pedestal shall be installed to provide power to the streetlighting circuit per PowerStream Standards 31-200 and 31-201, Latest.

N6.6 Fusing

(a) Streetlighting cables shall be fused in the transformer and in the streetlighting hand hole.

N6.7 Streetlighting Pole Installation

(a) Poles shall be installed via auger method of installation utilizing a boom truck to place the pole. Should field conditions prevent the use of the auger method of installation, then the Streetlighting System Inspector shall dictate an alternate method.

(b) Poles shall be backfilled and compacted to 95% SPD.

(c) Poles shall be verified plumb prior to Acceptance of Maintenance and Assumption by the City.

N6.8 Grounding

(a) Streetlighting pedestals shall be grounded to ESA requirements by utilizing two ground rods at the disconnect.

(b) A continuous jacketed green ground from the disconnect to the last light on each circuit shall be installed with the streetlighting conductor.

(c) Every fifth and / or last streetlighting on each circuit from the disconnect shall be grounded with a ground rod / ground plate.

(d) Ground wire shall not be installed between the transformer and the disconnect.

N7 INSPECTION GUIDELINES

(a) Streetlighting Inspection shall be completed by the Electrical Safety Authority. Notwithstanding any direction from the City or the Design Engineer, all work shall fully conform to all Electrical Safety Authority Codes.

(b) It is the Installing Contractors responsibility to notify all Inspecting Authorities of construction schedules a minimum of 72 hours prior to commencement of works. The City does not provide full time construction inspection services; however, a City Inspector shall perform periodic inspections or as required to generally monitor the quality and progress of the works.

N7.1 City Inspectors (or Designated Representative)

(a) The City Inspector shall endeavor to:

(i). Liaise with the Design Engineer on matters pertaining to the construction process and progress.

(ii). Provide periodic site inspections during the construction of the works to ensure that the City Standards are being adhered to and that the work being performed is in accordance with the approved drawings.

(iii). In conjunction with the Design Engineer, inspect constructed streetlighting system.

(iv). Participate in joint inspections with the Design Engineer / PowerStream and Contractor for purposes of building permit release, streetlighting system repairs, acceptance for maintenance and final assumption of municipal services.

(b) The City Inspector shall investigate any complaints pursuant to the construction process received by the City and forward the information to the Developer / Contractor for corrective action.

(c) The City Inspector shall report any infractions related to the above items to the Developer / Design Engineer for necessary corrective actions. Should the Developer / Design Engineer fail to initiate the required corrective actions in a reasonable time, the City Inspector may make arrangements to have the corrective actions undertaken by City forces and / or contract services. Should this action be taken, all related costs, and administrative fees shall be charged back to the Developer.

N7.2 Contractors

(a) Contractor shall notify the Design Engineer a minimum of 72 hours prior to construction to arrange for a pre-construction meeting.

(b) Contractor shall apply for ESA Inspection prior to commencing installation of plant.

(c) The obtaining of an ESA Connection Authorization shall be the sole responsibility of the installing Contractor. The Contractor shall provide a copy of the ESA Inspection Certificate to the Design Engineer upon receipt from the ESA.

N7.3 Design Engineer

(a) The Design Engineer shall carry out daily inspection and supervision of all constructed municipal infrastructure during the course of installation of the Streetlighting System and complete the Daily Construction Log Report (see Appendix '"F").

(b) Upon completion of construction and subsequent Energization, the Design Engineer shall perform both day and night inspections to verify that the streetlighting system has been installed and is operating per design.

(c) In the event that the site inspections reveal any deficiencies, the Design Engineer shall inform the contractor of the deficiencies and re-inspect.

(d) Once all outstanding deficiencies have been corrected, the Design Engineer shall complete Certification Letters (see Appendix "C", "D1", "D2", and "D3") and submit it to the City as part of the As-Constructed Submission process.

N7.4 ESA Inspection

(a) The Contractor shall arrange for and pay for ESA inspection throughout the entire scope of work in accordance with the latest ESA standards and specifications.

(b) Should the ESA have any questions or concerns relating to the Streetlighting System shown on the "Approved for Construction" Drawings, the Contractor shall notify the Design Engineer who shall then be responsible for resolving the matter.

(c) In accordance with the latest Electrical Code, the ESA inspector shall inspect the installation of the streetlighting system, all hand hole connections, bonding and fusing, and any other portion of the streetlighting system works that is deemed necessary.

(d) No streetlighting system can be connected and energized without the ESA Connection Order issued by the ESA. Contractor to submit ESA Connection Order to PowerStream for connection energization with copy to the Design Engineer.

(e) The Contractor shall provide the ESA Inspection Certificate to the Design Engineer.

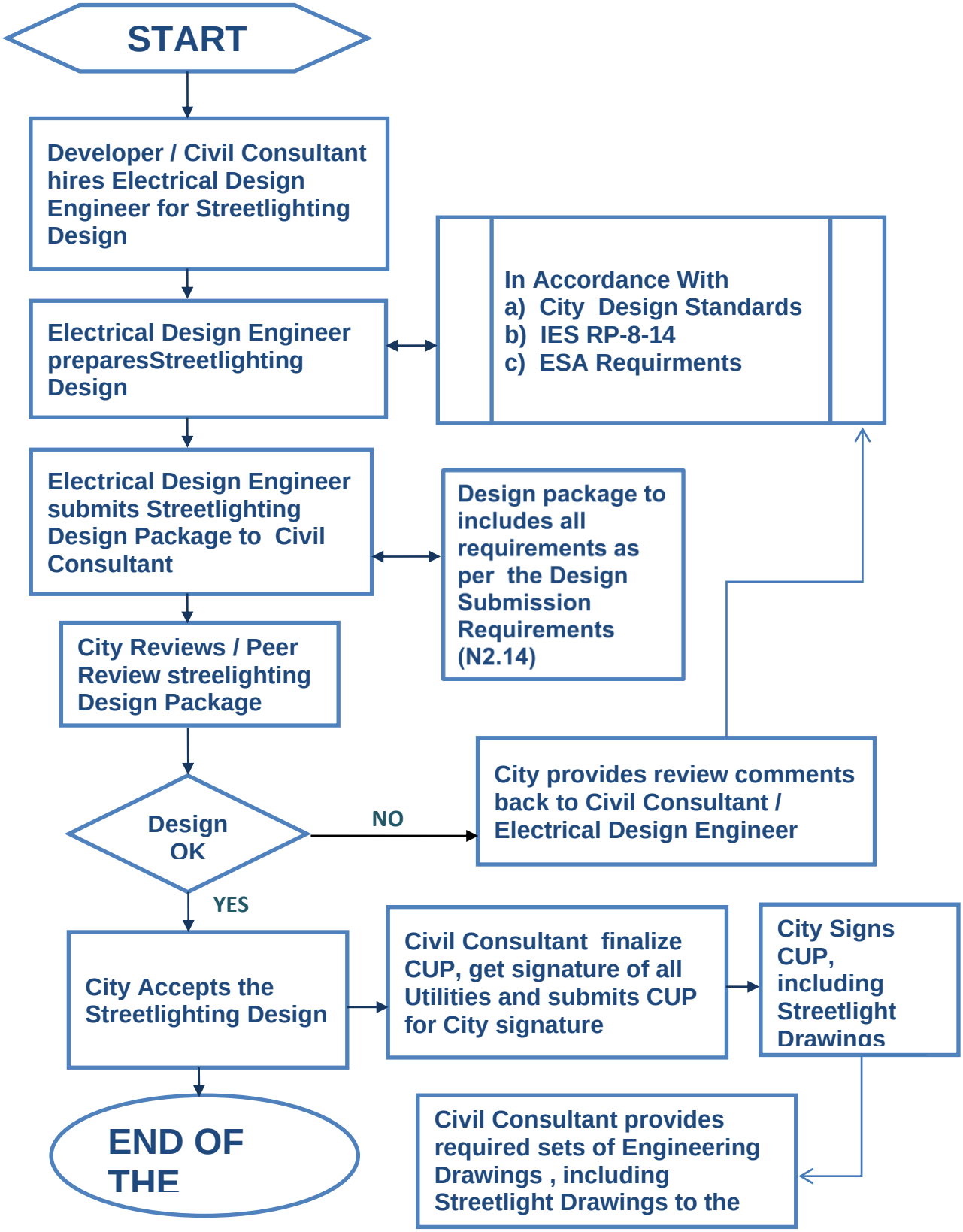
N7.5 PowerStream Energization Requirements

(a) The Design Engineer shall complete the Streetlighting Work Report (see Appendix "H"), in conjunction with the Transformer Load Summary.

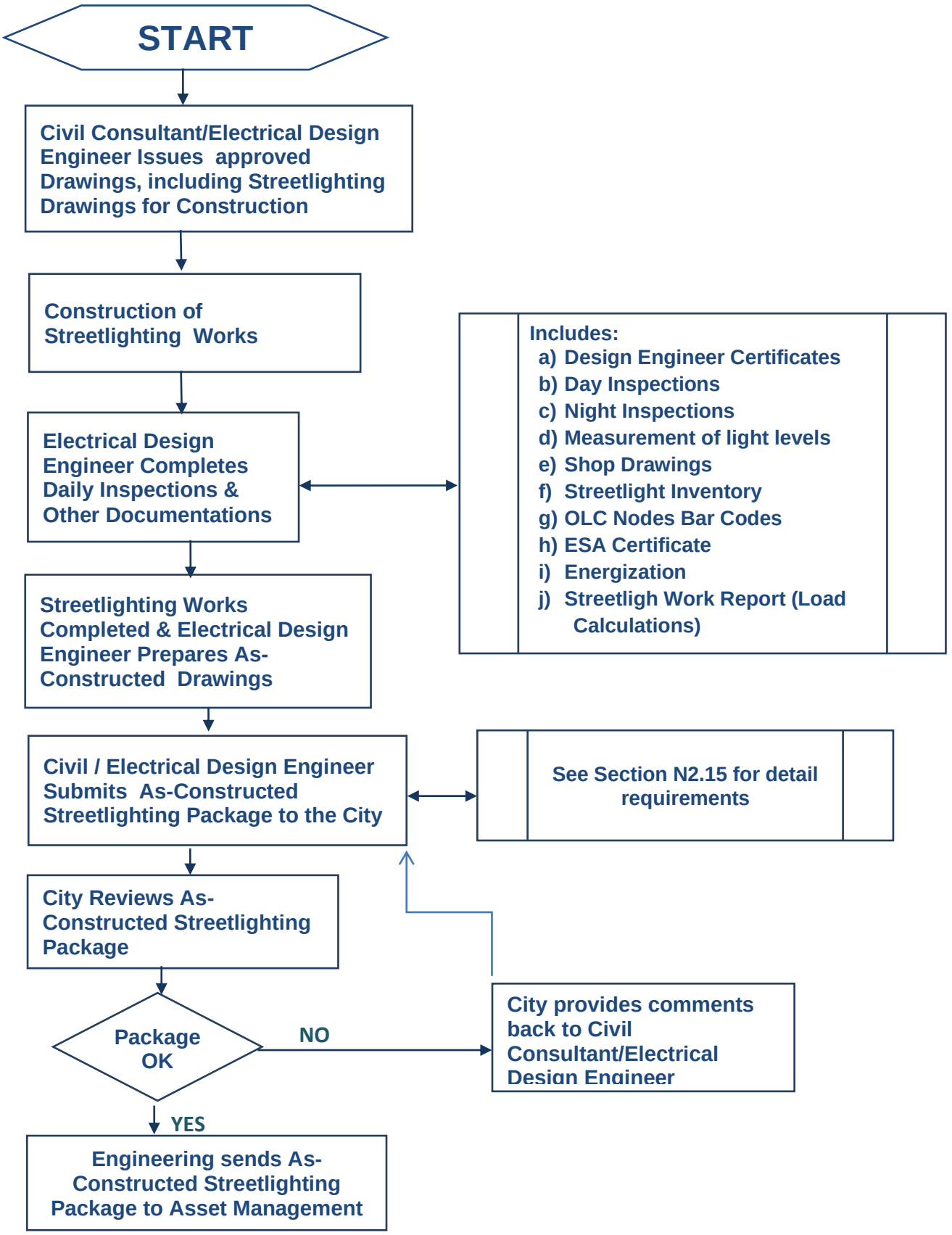
(b) This report shall be submitted to PowerStream for billing purposes to the City.

N8 PROCESSES

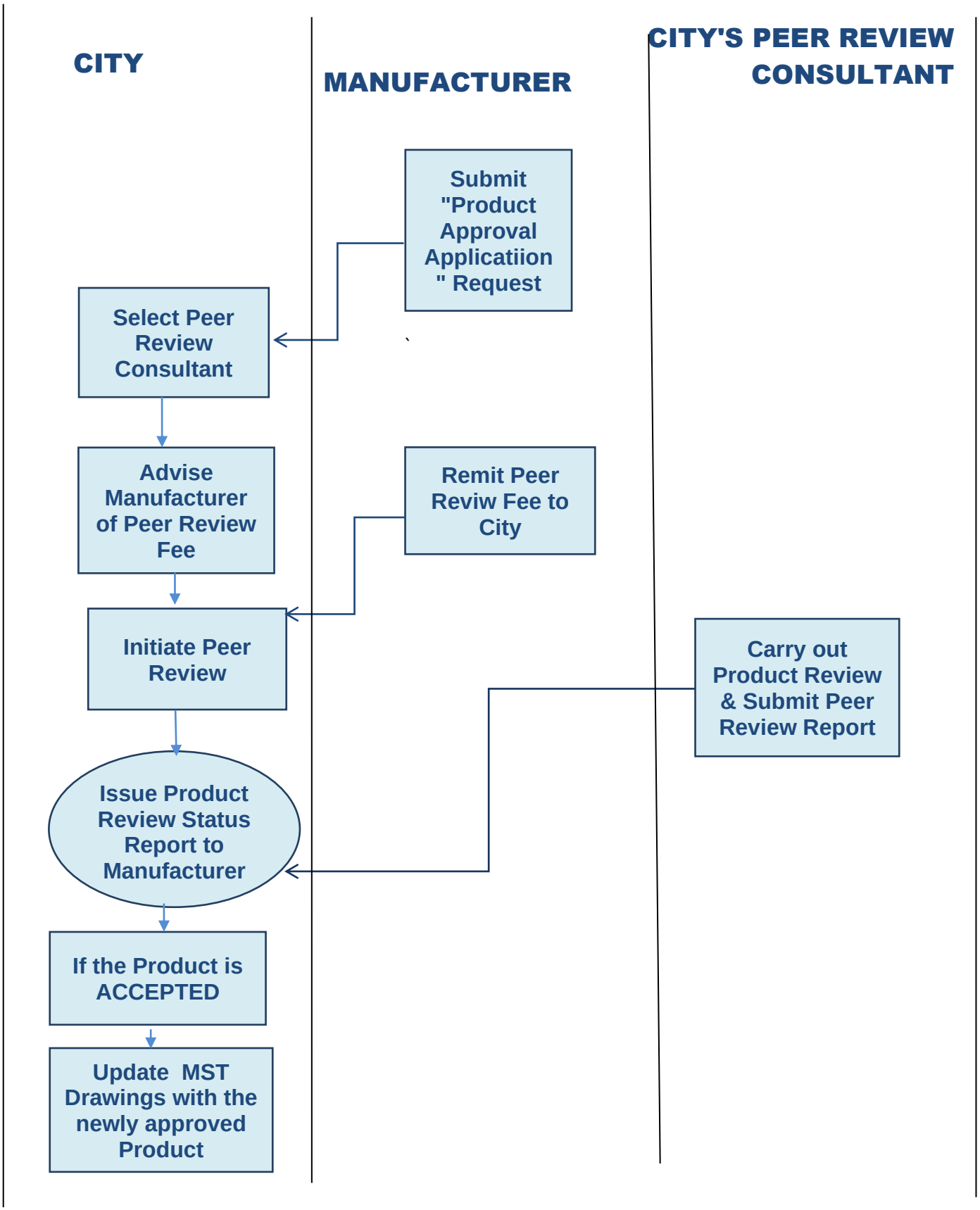
N8.1 Streetlighting Design Review and Drawings Acceptance Process



N8.2 Construction and As-Constructed Drawing Process



N8.3 New Product Approval Process



(a) The Manufacturer / Supplier shall submit a completed Product Approval Application Request to the City, per the Product Approval Application Process (see Appendix "B"), requesting approval of their product(s) and shall provide six (6) sets of complete product information for review.

(b) The City shall select an appropriate Peer Review Consultant.

(c) The Manufacturer / Supplier shall remit the peer review fee to the City.

(d) Upon receipt of the fee, the City shall undertake a review of the product(s) using a Peer Review Consultant hired by the City at the manufacturer's cost. Payment of the peer review fee does not imply or guarantee acceptance of the product(s) by the City.

(e) The Peer Review Consultant shall conduct the product peer review and submit the Peer Review Report to the City.

(f) The City shall issue a Product Approval Status Report. Acceptance of the product(s) is at the sole discretion of the City.

(g) All new products that are accepted for use in the City shall have probationary approval for five (5) years.

(h) During the five (5) years, the appropriate Sub-Committee(s) shall review the Product for full approval or rejection. This probationary approval can be cancelled or extended subject to the performance of the product and the level of product support provided by the Manufacturer / Supplier. If the Product is rejected for use, the Manufacturer / Supplier shall wait for one (1) year from the date of previous application before re-submission. If a Product is removed from the Approved Manufacturers' Products List, the Manufacturer / Supplier shall wait one (1) year from the date of removal for re-submission.

(i) Final approval shall be based upon the in-field performance of the product. If the product is not placed in use by the City or a private contractor within the first two years, the probationary period may be extended or the product may be rejected. The supplier is encouraged to provide the City with sample products to ensure that the product can be evaluated in-service within two years.

(j) The Manufacturer / supplier is also encouraged to have the product evaluated by the Canadian Construction Materials Centre (CCMC) of the National Research Council of Canada prior to final approval. The City may, at its discretion, have the product independently evaluated to determine suitability for its intended purpose and conformance to applicable standards.

(k) All approved products are subject to periodic review by City staff. Unsatisfactory performance, including product availability, shall result in the product being removed from the Approved Product List.

(l) Manufacturers shall inform the City of any product change that affects the form, fit, or function of their product.

(m) Any such change shall drive a part number change and may result in the product being subjected to a new review. All changes shall be accepted by the City through confirmation to the Manufacturer prior to the approval of the changed product.

(n) For selection of Alternate Streetlighting, refer to Council Report "Streetlights Selection Criteria for Alternate Streetlighting on Public Right-of-Way" February 07, 2006 (see Appendix "A").

APPENDIX "A"

Council Report "Street Light Selection Criteria for Alternate Streetlighting on Public Right-of-Way" February 07, 2006

DEVELOPMENT SERVICES COMMITTEE

TO:	Mayor and Members of Council
FROM:	Jim Baird, Commissioner of Development Services Valerie Shuttleworth, Director of Planning & Urban Design
PREPARED BY:	Elizabeth Wimmer, ext. 2750 Senior Urban Design Planner, West District
DATE OF MEETING:	February 7, 2006
SUBJECT:	Streetlight Selection Criteria for Alternative Street Lighting on Public ROWs

RECOMMENDATION:
That the report entitled, "Street Light Selection Criteria for Alternative Street Lighting on Public Right of Ways", dated February 7, 2006 be received;

That the "Street Light Selection Criteria" be endorsed as the guideline for the consideration of alternative street light fixtures and poles in the Town of Markham.

PURPOSE:
The purpose of this report is to bring forward "Street Lighting Selection Criteria" by which proposals for alternative light fixtures and poles in new communities will be screened, prior to approval by Town Staff.

BACKGROUND:

The need to establish a process for the selection and approval of alternative light fixtures and poles in the Town of Markham

The Town of Markham "Engineering standards" endorse a defined range of street light fixture and pole styles for implementation in public right of ways. In the recent past, alternative style street light fixtures and poles have been approved for use in special areas such as Heritage Districts and Markham Centre. In the early stages of development of "OPA 5" communities such as Angus Glen, Wismer, Berzcy, Greensborough and Cornell, the "Carriage Style" light fixture and pole was introduced. This alternative style fixture and pole has now become a "standard" in new urban areas of Markham. To date, the Town of Markham has approximately eight types of street light standards in place. This requires coordination between the Town and our current maintenance provider (Power Stream) to stock replacement parts for all eight models.

Proposals for the use of alternative style street light fixtures and poles often are initiated by developers during the "Community Design Plan" stage of new community development. In recent months, a request has been received from the owner of "Cathedraltown" to install alternative style light fixtures and poles. In responding to this and future requests, it has become apparent that a process is necessary to guide Urban Design, Asset Management and Engineering Departments in the selection of these alternative fixtures and to minimize the need to stock multiple replacement parts.

Urban Design Objectives

It is the objective of the Urban Design Group to reinforce and enhance new and existing streetscapes in the Town of Markham. Street lighting, decorative paving and street tree planting are primary methods of enhancement in the public realm. There is a need to expand our existing portfolio of street light fixtures and poles in order to respond to the needs of individual communities while respecting the operational aspects of maintaining numerous model types. It also has become apparent that a Town wide process and set of "criteria" is required. In this regard, a set of criteria has been drafted, together with the Asset Management and Engineering Departments, which will guide the selection of appropriate light fixtures and poles.

DISCUSSION

The Owner of "Cathedraltown" is seeking Council approval for two alternative light fixtures and poles

The owner of "Cathedraltown" is committed to the delivery of a community with an innovative concept, which incorporates elements of historical urban planning and design to create a distinct, vibrant community. It is the intent that the community will resemble a traditional European Cathedral Town. It is the owner's desire to support this vision through all aspects of design and construction. The two light fixtures proposed are historically based and the designs are reminiscent of fixtures existing in European Cathedral Towns.

<u>The Proposed Street Lighting Selection Criteria</u>

The following street light criterion was established with consideration of the interests of the City's Engineering, Urban Design and Asset Management Departments. It is intended that the criteria will be applied by City staff to endorse or deny developer proposals for alternative lighting/ pole selections within City owned rights of way.

Street Light Selection Criteria
The proposed light fixture must satisfy all listed criteria

<u>Financial Requirements</u>
In order to ensure the cost of the proposed lights/poles remains competitive they must be available from two or more suppliers. The cost of the proposed fixtures/poles shall be consistent with cost of existing lighting fixtures/poles within the Town. The developer shall be

required to pay to the Town five percent (5 %) of the cost of the original street light/pole placements for the cost of future replacements and maintenance by the Town.

Location Requirements

It is the intent of the criteria to permit alternate styles of light fixtures and poles in select areas of the Town. The Urban Design, Asset Management and Engineering Departments support the idea of introducing new light fixtures and poles into communities in order to support and create unique identities.

1. Financial Requirements:	**Yes / No**
a) The proposed luminaire / pole is available from 2 or more sources.	
b) The cost of the luminaire / pole is consistent with approved fixtures / poles in the City.	
2. Location Requirements:	
a) The proposed location / community is a designated heritage district. OR the community centre is based on "New Urbanist Planning Principals" (e.g. Markham Centre, Cornell Centre, Milliken Mills, Main Street, Yonge Street, Greensborough City Centre). OR the proposed location / community is focused on a unique regional feature or acts as a community focus.	
3. Lighting Plan:	
a) The proposed design of the luminaire and pole are acceptable to the Urban Design, Engineering and Capital Asset Departments.	
b) A detailed lighting plan / design has been approved by the Urban Design, Engineering and Capital Asset Departments as part of the Engineering submission. The plan should provide details and specifications for the luminaires and poles. The lighting plan shall be signed, stamped, and certified by a lighting professional.	
c) The proposed luminaire and pole manufacturers are acceptable to the City Urban Design, Engineering and Capital Asset Departments.	
4. Environmental Considerations:	
a) Luminaire lighting levels shall satisfy City, IES (Illuminating Engineering Society) and the manufacturer industry standards.	
b) In order to achieve "Dark Sky" compliance, the luminaire must meet the uplight "U" limits from IES TM-15 latest edition	
c) The energy consumption of proposed luminaires must meet City standards.	
5. Functional Considerations / Long term Maintenance:	
a) Five (5) % of the cost of the original placements shall be paid to the City for future replacement or repair	
b) The lighting fixture and replacement parts are distributed and readily available in the G.T.A.	

Lighting Plan

The request for usage of alternative light fixtures/poles shall be initiated at the time of the Community Design Plan process. The request shall be in writing to the Commissioner of Development Services and shall be subject to the application of the above criteria. Upon

approval of alternative Street lighting, the design and layout will be identified on the Composite Utility Plans which form part of the engineering submission to be approved prior to the execution of the subdivision agreement. The light fixture/pole details and specifications shall be submitted for approval as part of this submission.

Environmental Considerations

The Town Operations and Asset Management Department recommended in a report to General Committee on May 24, 2005 that the "Illuminating Engineering Society of North America (IESNA) Standards be adopted for town-wide lighting design. These standards are being used by the Town's Engineering and Operations & Asset Management departments. The IESNA Standards are the most recognized and are used by almost all municipalities throughout Ontario, Canada and the United States. The standards outline quantity and quality requirements for illumination which include light pollution goals, objectives and design requirements.

Functional Considerations

The proposed light standards/poles must be available through two manufacturers or suppliers. Sample light fixtures and poles are required to be set up for review and comparison by Town staff. The proposed fixtures and poles must look the same and must be interchangeable within the desired streetscape. The light fixture replacement parts which are most commonly repaired, such as, the ballast and the bulb must be consistent with components that are widely utilized in other existing light fixtures within the Town.

FINANCIAL CONSIDERATIONS:

The Street Lighting Selection Criteria includes financial considerations.

ENVIRONMENTAL CONSIDERATIONS:

The Street Lighting Selection Criteria includes environmental considerations.

ACCESSIBILITY CONSIDERATIONS:

There are no concerns relative to accessibility.

BUSINESS UNITS CONSULTED AND AFFECTED:

The Community Services Commission, Asset Management Department and the Engineering Department have been consulted in the preparation of this report.

Valerie Shuttleworth, M.C.I.P., R.P.P.
Director of Planning & Urban Design

Jim Baird, M.C.I.P., R.P.P.
Commissioner of Development Services

APPENDIX "B"

Product Approval Application

Product Approval Application request shall be sent to:

Director of Engineering,
City of Markham
Engineering Department
101 City Centre Boulevard
MARKHAM ON L3R 9W3
905-477-7000

The request application, together with six (6) copies of descriptive and technical information shall be submitted to the Product Approval Committee.

The applicant shall be notified by the City of any fees applicable to the Product Approval Application.

The applicant shall be notified by the Product Approval Committee of the outcome of the evaluation within four (4) months from the date of receipt of the application. The approval or rejection of a product shall be at the sole discretion of the City.

APPENDIX 'C"

Design Engineer Certification - Sample Letter

(To be printed on Design Engineering Firm Letterhead)

DD / MM / YYYY

City of Markham
101 City Centre Boulevard
MARKHAM ON L3R 9W3

Attention: Director of Engineering

Reference: Development Name
Registered Plan:
City Amanda File No.:

Streetlighting Design Certification

Dear Sir:

We hereby certify that the streetlighting system has been designed in accordance with the City Standards, recommended practices for roadway lighting published by Illuminating Engineering Society of North America ANSI / IES RP-8-14, Electrical Safety Authority (ESA) requirements and all applicable electrical codes in a cost effective manner.

The following documents are provided as part of the final streetlighting design submissions:

1. Design Criteria used:
   (a) Road Classification: Local / Minor or Major Collector / Arterial
   (b) Pedestrian Conflict: Low / Medium / High
   (c) Reference to the City's MR and MST drawings (No. of Lanes / Pavement width, ROW width)
2. Streetlighting Layout and Electrical Drawings in AUTOCAD and Tiff format showing streetlighting design results compared to the City's Design Criteria. Also include the following:
   (a) Descrption of poles, luminaires and bracket arms.
   (b) Arm Length and Luminaire Mounting Height
3. Calculations and distribution diagram as per the City Standards including photometric analysis (AGI32) in electronic format for all continuous streets and each intersection.
4. Load Summary.
5. Standard drawings and specification.
6. Details of proposed poles, luminaires, and bracket arms including manufacturer's technical data sheets including TM-21 data.
7. Pole setback from curb and maximum pole spacing based on Roadway Optimizer calculation. Actual pole spacing not to exceed 95% of optimized value.
8. Completed Streetlighting Design Checklists for each Continuous Streets / Bends (Appendix "C1") and Intersections (Appendix "C2").
9. Two (2) hard copies and one electronic copy.

Yours truly,

Design Engineer Name, P.Eng.
SIGNED ENGINEER SEAL

APPENDIX 'C1"

STREETLIGHTING DESIGN – CHECKLIST (CONTINOUS STREETS / BENDS)

Date			
Project / Subdivision ID			
Developer			
Electrical Engineering Firm			
Design Engineer			
Street Name			
No. of Lanes		**Lane Width (m)**	
Design Criteria (Lighting level Requirement as per the City's / IES RP-8-14 Recommendations)			
Street Classification	☐ Local	☐ Collector	☐ Major
Pedestrian Conflict	☐ Low	☐ Medium	☐ High
Area Classification	☐ Residential	☐ Intermediate	☐ Commercial
City's Drawing Reference	MR # _____	MST# _____	
Minimum Luminance (L_{avg})	_____ cd / m^2		
Maximum Uniformity Ratio	L_{avg} / L_{min} _____	L_{max} / L_{min} _____	
Maximum Veiling Luminance Ratio (L_{vmax} / L_{avg})	_____		
Maximum Unit Power Density (UPD)	_____ W/m^2		
Sidewalk	☐ One side	☐ Two side	
Sidewalk Illuminance	_____ Lux		
Pole / Arm Details			
Manufacturer		☐ On Approved List	
Pole Height	_____m		
Luminaire Mounting Height	_____m		
Bracket Arm Length	_____m		
Max Pole Spacing based on Roadway Optimizer	_____m		
Luminaire Details			
Manufacturer		☐ On Approved List	
Input Wattage	_____W		
Photometric File	☐ Attached	Photometric File No._____	
Lamp Lumen Depreciation (LLD)			
Luminaire Dirt Depreciation (LDD)	0.90		
Light Loss Factor (LLF = LLD X LDD)			

Attachments		**DESIGN RESULTS**	
Streetlighting Layout Drawings (2 hard copies)	☐ Attached		
Streetlighting Layout Drawings (electronic file)	☐ Attached	Average Luminance (L_{avg})	____ cd / m^2
AGI32 (electronic format)	☐ Attached	Uniformity Ratio	L_{avg} / L_{min} ____ L_{max} / L_{min} ____
Load Summary	☐ Attached	Veiling Luminance (L_{vmax}/L_{avg})	___
Standard Drawings and Specifications	☐ Attached	Sidewalk Illuminance	___ Lux
Manufacturer's Technical Details	☐ Attached	Unit Power Density	_____ W/m^2

APPENDIX 'C2"

STREETLIGHTING DESIGN – CHECKLIST (INTERSECTIONS)

Date			
Project / Subdivision ID			
Developer			
Electrical Engineering Firm			
Design Engineer			
Intersection Street Names			
No. of Lanes		**Lane Width (m)**	
Design Criteria (Lighting level Requirement as per the City's / IES RP-8-14 Recommendations)			
Street Classification	☐ Local	☐ Collector	☐ Major
Pedestrian Conflict	☐ Low	☐ Medium	☐ High
Area Classification	☐ Residential	☐ Intermediate	☐ Commercial
City's Drawing Reference	MR # _____	MST# _____	
Average Maintained Illuminance	_____ Lux (MIN)		
Average to Minimum Uniformity (E_{avg} / E_{min})	_____ (MAX)		
Sidewalk	☐ One side	☐ Two side	
Sidewalk Illuminance	_____ Lux		
Pole / Arm Details			
Manufacturer	_____	☐ On Approved List	
Pole Height	_____m		
Luminaire Mounting Height	_____m		
Bracket Arm Length	_____m		
Luminaire Details			
Manufacturer	_____	☐ On Approved List	
Input Wattage	_____W		
Photometric File	☐ Attached Photometric File No. _____		
Lamp Lumen Depreciation (LLD)			
Luminaire Dirt Depreciation (LDD)	0.90		
Light Loss Factor (LLF = LLD X LDD)			
DESIGN RESULTS			
Average Maintained Illuminance	_____ Lux		
Average to Minimum Uniformity (E_{avg} / E_{min})	_____		

APPENDIX "D1"

Installation Certification - Sample Letter (Stage 1 - At the time of Building Permit) Application)
(To be printed on Design Engineering Firm Letterhead)

DD / MM / YYYY

City of Markham
Engineering Department
101 Town Centre Boulevard
Markham, Ontario, L3R 9W3

Attn: Supervisor, Development Inspections & Grading

Re: Streetlighting Installation Certification – Building Permit Application Stage
Project Name
Phase Number (if applicable)
Registered Plan No. 65M-
City Engineering File No.
Amanda File No.

We hereby certify that the streetlighting system has been installed in accordance with the approved streetlighting drawings, specifications, and the City Standards, Electrical Safety Authority (ESA) requirements, and all applicable electrical code.
In addition, we also confirm the following:

1) The streetlighting system has been inspected, all applicable components tested and the material and installation is in conformance with the approved streetlighting design.
2) All streetlighting poles have the appropriate buried depth.
3) All streetlights are functional and operational on all streets, lanes, and walkways.
4) All streetlights were installed at locations as per the approved streetlighting design (+/- 2.0m) Or Streetlight(s) #____ was / were installed at locations differ from the design.
   - Attached is the revised photometric analysis confirming the lighting levels as per the City Standards
5) Actual lighting levels taken within three (3) to eight (8) weeks after completion of streetlighting installation are in accordance with the City Standards and IES RP-8-14 Recommended Practice, Section A.9.1.2 and Figure A4.
6) Attached following for the City records:
   (a) Streetlighting inventory complete with luminaries packing slip to establish manufacturers' warranty commencement (see Appendix "E")
   (b) Record (scan) Outdoor Lighting Control (OLC) Nodes barcodes during luminaries installation with associated Global Position System (GPS) X, Y coordinates of the poles as per Section 3.9 (b)
   (c) Copies of shop drawings for all installed materials including poles, luminaries and bracket arms complete with the Design Engineer's signature and stamp
   (d) Copies of the Design Engineer's Daily Construction Inspections reports for streetlighting installation works including night inspection to confirm operation (see Appendix "F")
   (e) Copies of the Design Engineer's pre-construction material inspection report and confirmation that installed materials are in accordance with the accepted drawings and specifications
   (f) ESA Inspection Certificate
   (g) Connection Order and Load Letter from PowerStream
   (h) Load Calculation Summary (see Appendix "H")

Regards,

Design Engineer Name, P.Eng.
SIGNED ENGINEER SEAL

APPENDIX "D2"

Installation Certification - Sample Letter (Stage 2 - At the time of Maintenance Acceptance)

(To be printed on Design Engineering Firm Letterhead)

DD / MM / YYYY

City of Markham
Engineering Department
101 Town Centre Boulevard
Markham, Ontario
L3R 9W3

Attn: Supervisor, Development Inspections & Grading

Re: Streetlighting Installation Certification – Maintenance Acceptance Stage
Project Name
Phase Number (if applicable)
Registered Plan No. 65M-
City Engineering File No.
Amanda File No.

We hereby certify that the streetlighting system has been installed in accordance with the approved streetlighting drawings, specifications, and the City Standards, Electrical Safety Authority (ESA) requirements, and all applicable electrical code.

In addition, we also confirm the following:

1. The streetlighting system has been inspected, all applicable components tested, and the material and installation is in conformance with the approved streetlighting design.
2. All streetlights are functional and operational on all streets, lanes, walkways.
3. All streetlighting poles are plumb / straight.
4. All pole identification tags are installed.
5. All streetlighting luminaries are washed on ……. (date).
6. All streetlighting luminaries are re-lamped on ……. (date) - HPS luminaries only.
7. All pedestals have been locked.
8. Grades around the poles and pedestals have not settled.
9. All handhole covers are secured.
10. All poles, mounting hardware and streetlights are visually inspected.
11. All deficiencies are corrected.

Regards,

Design Engineer Name, P.Eng.
SIGNED ENGINEER SEAL

APPENDIX "D3"

Installation Certification - Sample Letter (Stage 3 - At the time of Assumption)

(To be printed on Design Engineering Firm Letterhead)

DD / MM / YYYY

City of Markham
Engineering Department
101 Town Centre Boulevard
Markham, Ontario, L3R 9W3

Attn: Supervisor, Development Inspections & Grading

Re: Streetlighting Installation Certification – Assumption Stage
Project Name
Phase Number (if applicable)
Registered Plan No. 65M-
City Engineering File No.
Amanda File No.

We hereby certify that the streetlighting system has been installed in accordance with the approved streetlighting drawings, specifications, and the City Standards, Electrical Safety Authority (ESA) requirements, and all applicable electrical code.

In addition, we also confirm the following:

1. The streetlighting system has been inspected, all applicable components tested and the material and installation is in conformance with the approved streetlighting design.
2. All streetlights are functional and operational on all streets, lanes, walkways.
3. All streetlighting poles are plumb / straight.
4. All pole identification tags are installed.
5. All pedestals have been locked.
6. Grades around the poles and pedestals have not settled.
7. All handhole covers are secured.
8. All poles, mounting hardware and streetlights are visually inspected.
9. All deficiencies are corrected.

Regards,

Design Engineer Name, P.Eng.
SIGNED ENGINEER SEAL

MUNICIPAL STREETLIGHTING INVENTORY **APPENDIX "E"**

Name of Subdivision: **Date:**
Developer: **City Subdivision No.:**
Electrical Consultant: **AMANDA File No.:**
Electrical Contractor: **Registered Plan No.:**

Item	Quantity	Type	Colour	Material	Banner Holder (Yes/ No)	Height / Length	Foundation Type (Base *Mount / Direct Buried*)	Manufacturer	Catalogue Number	Photometric File No.	Installation Date	Packing Slip Included (Yes / No)	Outdoor Lighting Controller (OLC) Nodes scanned (Yes/No)	Wattage
Street Light Assembly	**(Eng. Std No. MST-)**													
Street Light Pole														
Mounting Bracket														
Luminaire														
Segment Controller														
Pedestal														
Street Light Assembly	**(Eng. Std No. MST-)**													
Street Light Pole														
Mounting Bracket														
Luminaire														
Segment Controller														
Pedestal														

Pole Type: Round / Octogonal / Trafalgar etc.
Pole Material Concrete / Aluminum / Steel etc.
Bracket Type Tapered Elliptical / Decoratice Scroll / Laneway Mounting etc.
Luminaire Type LED Cobrahead / LED Traditional Black etc.

APPENDIX "F"

Daily Construction Log Report

Project Name: _____

Municipal File Number: _____

Installing Contractor: _____

Inspecting Design Engineer: _____

Date: _____

COMMENTS AND DESCRIPTION OF WORK COMPLETED THIS DAY:

_____

_____

_____

_____

_____

_____

1. CHECKLIST FOR TRENCHING:

a)	Trench Excavated in Accordance with Approved Drawings	
b)	All Ducts Solvent Welded Where Required	
c)	All Ducts Mandrelled and Cleaned Prior to Cable Pulling	
d)	Mechanical Compaction of Trench to 95% SPD	

2. CHECKLIST FOR MATERIALS:

a)	Type of Duct Being Used	
b)	Type of Wire Being Used from TX to Breaker	
c)	Type of Wire Being Used from Breaker to Pole and Pole to Pole	
d)	Type of Wire Being Used from Hand Hole to Fixture	
e)	Type of Breaker	
f)	Streetlights Assemblies Conform to Approved Shop Drawings	
g)	Size of Fusing in Hand Hole	
h)	All Materials CSA	

3. CHECKLIST FOR INSTALLATION:

a)	Pole Location in accordance with Approved Drawings	
b)	Pole Installation in accordance with Standards	
c)	Hydraulic Hand Packer used to Compact Screenings	
d)	Cables fully ducted through below grade aperture	
e)	Fusing in place at each Hand Hole	
f)	Proper Connections at each Hand Hole	
g)	Grounding of System per Standard	

_____ _____

Inspecting Design Engineer Contractor Foreman

APPENDIX "F" (Cont'd)

GUIDANCE TO COMPLETE DAILY SITE INSPECTION LOG FOR REPORT

Project Name: Name of the Subdivision

Municipal File Number: Municipal File Number

Installing Contractor: Name of the Contractor

Inspecting Design Engineer: Name of the Design Engineering Firm

Date: Date of the Inspection

COMMENTS AND DESCRIPTION OF WORK COMPLETED THIS DAY:

Write a brief synopsis of what work is being completed the day of the inspection. For instance Standard trenching operations on the west side of Street "A" or Streetlighting Pole Installation on Streets "C" and "D". If there is something that is not done properly or to the inspector's satisfaction it shall be noted in this area.

The following information shall be used as a guideline for Daily Site Inspections. It would be impossible for any list to be all encompassing for every subdivisions and it is therefore expected that the Inspector uses discretion in ensuring the standards are met.

1. CHECKLIST FOR TRENCHING:

(b) Trench Excavated In Accordance with Approved Drawings

(i). Ensure that the excavation is in accordance with the Standard ROW for the Street (Trench off-set in Boulevard).
(ii). Ensure that the excavation is in accordance with the Standard Trench Cross Section (Depth of Streetlight Duct and Associated Warning Tape).
(iii). Ensure that proper clearances are being maintained between Streetlight duct and other Utilities.

(c) All Ducts Solvent Welded Where Required

(i). All ducts shall be continuous and therefore may require splicing. All splices shall be completed using a solvent welding to ensure that the ends of the ducts do not separate.

(d) All Ducts Mandrelled and Cleaned Prior to Cable Pulling

(i). All ducts shall be cleaned and shown to be continuous prior to cable pulling. Failure to clean the ducts may cause the cable jackets to be compromised and a fault may ultimately occur.

(e) Mechanical Compaction of Trench

(i). Trenches shall be backfilled in 15 cm lifts and mechanically compacted to provide 95% SPD.
(ii). Compaction and Poles compacted to 95% SPD.

APPENDIX "F" (Cont'd)

2. CHECKLIST FOR MATERIALS:

(a) Confirm on Inspection Log the type of materials being used and that they are all CSA approved per the City Standards.

3. CHECKLIST FOR INSTALLATION:

(a) Pole Location in Accordance with Approved Drawings

(i). Inspector to confirm that the poles are installed at the correct off-set in relation to curb, street line and lot lines.

(b) Pole Installation in accordance with Standards

(i). Inspector to confirm that poles are installed to proper burial depth as specified by the manufacturer on shop drawings via auger and boom truck for non-communications poles and via excavator and boom truck for communications poles. Excavation shall be approximately 100 mm wider than the base of pole to ensure proper amounts of limestone screenings are compacted around base.

(c) Hydraulic Hand Packer used to Compact Screenings

(i). In general, all compaction of screenings around a pole shall be completed using a hydraulic hand packer.

(d) Cables Fully Ducted Through Below Grade Aperture

(i). Inspector to confirm that all ducts are extended into the raceway of the pole to avoid the possibility of cables being scratched by the edge of the aperture below grade. Failure to protect the cables in this way may result in future cable faults.

(e) Fusing in Place at Each Hand Hole

(i). Inspector shall confirm that the line side of all circuits is properly fused at each hand hole including the one with the In Pole Breaker. The line shall be connected using a fuse, fuse holder, and boot cover.

(f) Proper Connections at Each Hand Hole

(i). Inspector to confirm that all cables are connected utilizing split bolt connectors on the ground and marettes for the line and neutral.

(g) Grounding of System per Standard

(i). Inspector to ensure that ground system is properly connected and ground rods or plates are used where specified on the drawing.
(ii). Installation of City's locks on all pedestals

APPENDIX "G"

STREETLIGHTING - MAINTENANCE ACCEPTANCE CHECKLIST

Date					
Project / Subdivision					
Developer					
Design Engineer					
Electrical Contractor					
Pole Manufacturer		**Pole Type**		**Pole Height**	
Luminaire Manufacturer					
Luminaire Type		**Catalogue No**			
Luminaries Installation Date					
OLC Nodes		**Product No**			

The Design Engineerhas inspected the Streetlighting system and confirms the following:

	Streetlighting system installed as per the approved streetlighting drawings, specifications, and the City Standards		
	Segment Controllers are installed		
	OLC Nodes are installed		
	OLC Barcode List is provided		
	All streetlights are functional and operational on all streets, lanes, walkways		
	Streetlighting poles, bracket arms, and heads are straight and perpendicular to roadway		
	Streetlighting poles are numbered as per design		
	Wattage stickers have been installed on the luminaire		
	All pole identification tags are installed		
	Lamps have been date stamped with Re-Lamp date (HPS luminaries only)		
	All streetlighting luminaries are re-lamped (HPS luminaries only)	Date of washing (dd / mm / yyyy)	
	All pedestals have been labeled and locked		
	Grades around the poles and pedestals have not settled		
	All handhole covers are secured with proper screw		
	All poles, mounting hardware, and streetlights are visually inspected		
	Streetlighting lenses are clean complete	Date of washing (dd / mm / yyyy)	
	Utility temporary overhead wires are removed		
	Underground faults repaired		
	Boulevard restoration around streetlighting plant is complete		
	Streetlighting system energized	Date of energization (mm / dd / yyyy)	

I certify that the above streetlighting works have been inspected and completed.

Name: (Please Print) _____

Position: _____

Signature: _____

Design EngineerName and Seal

APPENDIX '"H"

Streetlighting Work Report (Load Calculation)

Street Light Work Report - Load Calculation

Project/Subdivision Name:			
Location:			
Grid Number:			
Work Order No:			
Date This Report Prepared:		**Report completed by:**	
Drawing Number:			
Lights Installed By:			
Energy Cost Bill To:	City of Markham		

Light Installed	HID Light Removed	LED Luminaire Wattage Installed	HID Lamp Wattage Removed	HID Ballast Loss (W). SEE NOTE 1	Watts Installed (W)	Watts Removed (W)	Disconnect Location (Pedestal or Pole Breaker) (where available)	Transformer Number	Energization Date	Streetlight Municipal Address (closest)	GPS X	GPS Y	LED Ref No. SEE NOTE 2
1	1	44	100	32	44	132	PB FLANKAGE OF LOT 42	25TP-480	Sep 23 13	15 Anystreet Rd	43.85803	79.23377	1
TOTAL					44	132							

Connected Load Installed - kW / Month -	**0.044**	
Connected Load Removed - kW / Month -		**0.132**

NOTE 1: Ballast Losses are fixed as per PowerStream Specification No. PS SL-01-2006.
These numbers are entered in the CIS and the Billing is based on these losses.
NOTE 2: See Tab 'Street Light Input Power ' for detailed LED model type

Revision: 11-Nov-13

File: 10. Street Light Work Report

Page No 1

APPENDIX "H" (Cont'd)

HPS STREETLIGHT BALLAST LOSSES

Purpose: Billing **25-July-13**

SIZE	TYPE	M.E.A BALLAST LOSSES
(WATTS)		(WATTS)
50	HPS	23
70	HPS	26
100	HPS	32
150	HPS	36
200	HPS	41
250	HPS	50
400	HPS	70
125	MV	33
175	MV	27
250	MV	-
400	MV	-

CALCULATION EXAMPLE USING STREETLIGHT PROFILE

MONTHLY BILLING EXAMPLE: 400W HPS c / w BALLAST = 482W

482W X 392 (dark hours in month) = 189 kWh / month

February as example with 392 Dark Hours

Month	Dark Hours
January	465
February	392
March	403
April	330
May	279
June	240
July	279
August	310
September	330
October	403
November	420
December	465

APPENDIX "I1"

LIST OF APPROVED LED COBRA-HEAD LUMINAIRES

SIZE (Watts)	TYPE	MANUFACTURER	PART NUMBER	TOTAL INPUT POWER
32	LED	GE	ERL10-04C140AGRAYL	32
34	LED	LRL	NXT-12C-850mA-2ES	34
41	LED	GE	ERL10-05B140AGRAYL	41
46	LED	LRL	NXT-24S-600mA-2es	46
47	LED	PHILIPS	GPLS-40W49LED4K-ES-LE3	47
56	LED	PHILIPS	RVS-55W32LED4K-R-LE2	56
56	LED	PHILIPS	RVS-55W32LED4K-R-LE3	56
60	LED	LRL	NXT-36S-525mA-2ES	60
67	LED	GE	ERL10-07C140AGRAYL	67
73	LED	PHILIPS	GPLS-65W49LED4K-ES-LE3	73
73	LED	PHILIPS	GPLS-65W49LED4K-ES-LEH2	73
81	LED	PHILIPS	RVS-80W48LED4K-R-LE2	81
88	LED	GE	ERS10-08E140AGRAYL	88
90	LED	GE	ERS10-10C140AGRAYL	90
102	LED	PHILIPS	GPLS-90W49LED4K-ES-LE2	102
104	LED	PHILIPS	RVS-110W64LED4K-R-LE2	104
108	LED	GE	ERS10-11C140AGRAYL	108
113	LED	LRL	NXT-60M-600MA-3ES	113
119	LED	PHILIPS	GPLM-105W79LED4K-ES-LEH2	119
135	LED	ACUITY	ATBO 30BLEDE13 XXXXX R2	135
143	LED	ACUITY	ATB2 40BLEDE 10 XXXXX R2	143
157	LED	GE	ERS20-18B140AGRAYL	157
160	LED	PHILIPS	RVM-160W96LED4K-LE2	160
162	LED	GE	ERS20-19A140AGRAYL	162
204	LED	PHILIPS	GPLM-180W98LED4K-ES-LEH2	204
209	LED	PHILIPS	RVM-215W128LED4K-LE3	209

Note:
The Luminaires listed above are approved; however the designer can use any wattage or light distribution type from the following approved series which meets City's LED Luminaires Specification Section N4 and N5.

Philips:	Roadview Series and Roadstar Series
GE:	Evolve Series
LRL:	NXT Series
Acuity Brands:	ATB Series

APPENDIX "I2"

LIST OF APPROVED LED DECORATIVE (COACH) LUMINAIRES

SIZE (Watts)	TYPE	MANUFACTURER	PART NUMBER	TOTAL INPUT POWER
50	LED	King Luminaire	K601-S/P-FAFL-III-50(8000)SSL-120-4500K	50
51	LED	Acuity Brands	GRSCL 30BLEDE53 MVOLT 4K R3 P5 NL CLO	51
51	LED	Cooper Lighting	SDL B02 LED DU SL3 MAR - Type 3 distribution	51
66	LED	Acuity Brands	GRSCL 30BLEDE70 MVOLT 4K R3 P5 NL CLO	66
70	LED	Cooper Lighting	SDL B03 LED DU SL2 MAR - Type 2 distribution	70
71	LED	King Luminaire	K601-S/P-FAFL-III-75(8000)SSL-120-4500K	71
92	LED	King Luminaire	K601-P4FL-III-100 (SSSL)-8060	92
129	LED	Cyclone	HUDT4A-NL-DIST-WATT-4K-MVOLT-10KV-PTL-BK-TX	129
129	LED	Cyclone	HUDS4A-NL-DIST-WATT-4K-MVOLT-10KV-PTL-BK-TX	129

APPENDIX "I3"

LIST OF APPROVED LED LUMINAIRES (SHOEBOX) FOR LANEWAYS

SIZE (Watts)	TYPE	MANUFACTURER	PART NUMBER	TOTAL INPUT POWER
32	LED	PHILIPS	RVS-32W32LED4K-R-LE2	32
56	LED	PHILIPS	RVS-55W32LED4K-R-LE2	56

APPENDIX "I4"

LIST OF APPROVED LED LUMINAIRES FOR OFF-ROADWAY WALKWAYS

SIZE (Watts)	TYPE	MANUFACTURER	PART NUMBER	TOTAL INPUT POWER
14	LED	LRL	NXT-12S-350mA-2ES	14

CALCULATION EXAMPLE USING STREETLIGHTING PROFILE FOR LED LUMINAIRE

MONTHLY BILLING EXAMPLE: 44W LED = 44W

44W X 392 (dark hours in month) = 17.25 kWh / month

February as example with 392 Dark Hours/month