Roadway Lighting Design Standards

2020 Rev1

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1.0 Introduction and Objectives

The Regional Municipality of Niagara (Niagara Region) is responsible for the design and installation of roadway lighting on all roadways under the Region's jurisdiction.

The Niagara Region Roadway Lighting Design Standards has been created to define the design requirements for roadway lighting systems. The standard is intended to be used by both Niagara Region employees and outside consultants. In this document, roadway lighting designers will also be referred to as the Consultant.

The following shall be considered the objectives of a roadway system design: The provision of adequate and uniform lighting levels for roadways, adjacent bikeways and pedestrian ways on Niagara Region Roads.

The requirements of recognized lighting standards shall be achieved wherever economically and physically possible.

Roadway lighting systems shall be energy efficient and cost effective.

It is assumed that those involved with the design and installation of roadway lighting have prior education, knowledge and experience in this field.

In this regard, this standard has been prepared in order to provide qualified practitioners with the required information to successfully design roadway lighting systems to the Region's satisfaction. As this standard does not cover every situation that may be encountered in the field, it is the responsibility of the practitioner to exercise professional engineering judgment during every stage of the design process.

1.1 Organization of the Standards

The standard is divided into three sections:

- **Section 1.0 – Introduction and Objectives**

- **Section 2.0 - Niagara Region Roadway Lighting Design Requirements:**
  This section outlines the specific requirements that shall be incorporated into a Roadway Lighting Design.

- **Section 3.0 - Work Tasks of the Consultant:**
  This section outlines the work tasks of the Consultant and the specific deliverables required for a roadway lighting design.

1.2 Definitions

AADT – Annual average daily traffic count. It is the total volume of vehicle traffic of a road for a year divided by 365 days.

Candela (cd) – Candela is the unit of light intensity. The strength of light emitted in a certain direction. Symbol:

Lux (lx) – Lux is the SI unit of Illuminance – the measure of intensity of light arriving on a surface.

Illuminance – Light that reaches the road surface and other objects. Illuminance is a measure of the incident light and is expressed in lux.

Lumen (lm) – Lumen is the unit of flux. The quantity of light produced by a source.

Luminance – Light perceived by a motorist on a roadway. Luminance is a measure of the reflected light and is expressed in candela/m2.

Pedestrian Conflict – A measure of the number of people that will be walking in the area.

Reflectance – the ratio of the reflected lighting flux (or luminance) to the incident flux (or luminance).

Small Target Visibility – is a method of design that determines of the visibility of an array of targets on the roadway. The weighted average of the visibility level of these targets result in the Small Target Visibility.

Skyglow – is the unintended illumination of the night sky.

Unit Power Density (UPD) – Electrical energy used per unit of area. Usually expressed in watts per square meter.

1.3 Reference Standards

The following standards will be referred to by this document:

- ANSI/IES RP-8-14 (Reaffirmed 2014), American National Standard Practice for Roadway Lighting as published by the Illuminating Engineering Society of North America.

- TAC 2006, Guide for the Design of Roadway Lighting as published by the Transportation Association of Canada.

- Ontario Electrical Safety Code (latest edition).

The requirements of the above noted standards will be used to set the performance and installation criteria for the lighting systems. The Niagara Region recognizes that there may be physical conditions or economic constraints in certain projects in which the requirements of the standards will be difficult to achieve.

The Consultant, during the execution of a project design, may identify specific instances where the requirements of the above noted standards cannot be met. The Consultant shall contact the Region Project Manager in writing and list the areas in which the standard is not met. The Consultant shall provide suggestions on how to proceed. The Region will then review the situation and give direction to the Consultant.

1.4 List of Figures

The following drawings are included in this document:

- Lighting Pole Placement Alternatives. **Figures 1 to 4.**
- Plan of typical roadway with location of roadway lighting poles, duct banks and power supplies. **Figures 5 and 6.**
- Duct Bank Details. **Figures 7 and 8**.

2.0 Niagara Region Roadway Lighting Design Requirements

2.1 Designation of Areas to be Illuminated

The Niagara Region has a variety of different types of roads in its jurisdiction and it is not the Region's objective to install roadway lighting on all of these roads. At the commencement of a project, Niagara Region engineering staff shall designate the areas of the project that will require roadway lighting to be installed.

2.2 Lighting Design Criteria and Methodology

The following lighting design criteria and methodology is based on the design methods that are outlined in TAC (2006) and RP-8-14 (2014).

The three accepted design methods in RP-8 are Illuminance, Luminance and Small Target Visibility. The Consultant shall utilize each method as follows:

The Illuminance method shall be used at intersections and curved sections of roadway of less than or equal to 600 meter radius.

The Luminance method shall be used in straight sections of roadway or curves greater than 600 meter radius.

The Small Target Visibility method shall only be used as an alternative method to assess different lighting designs.

2.3 Roadway Classification

Vehicle counts will be used to determine the classification of the Roadway for determining the target Illuminance, Luminance and Small Target Visibility values. The Consultant shall obtain the latest traffic counts (AADT values) from the Region and use the traffic counts to classify the roadways according to the following:

- Collector 0 - 4,999 AADT
- Major > 5,000 AADT

The Consultant shall confirm the classification of the Roadway with the Region Project Manager before proceeding with the design.

2.4 Pedestrian Conflict

Pedestrian classifications shall be set to coincide with the pedestrian volume information per each road segment. Except for Downtown areas, which shall be high.

2.5 Light Trespass and Skyglow

In some geographic situations there may be significant spill light from a roadway lighting design on to adjacent properties, structures or roadways. The Consultant shall review the roadway lighting design and identify such areas. In these situations the Consultant shall calculate the amount of spill light and adjust the design to minimize the light trespass or recommend the installation of an externally mounted shield. In all of these cases the Consultant shall contact the Region Project Manager and discuss the situation. This review shall apply to all adjacent land use types and shall include front, side and rear yards.

Skyglow shall be minimized through the use of cut-off style fixtures. (skyglow will be controlled for the most part by the fixture selection, which is a Region specified item). However, tilt of the fixture will increase the upward component of light). The Consultant shall avoid the use of tilt in LED roadway fixture layout.

2.6 Pavement Classification

Normally an R3 classification shall be used (asphalt surface with dark aggregates). However, in some situations an alternate type of asphalt with a different reflectance value or concrete may be used. The Consultant shall confirm with the Region Project Manager the pavement classification that is to be used in the lighting calculations for the project.

2.7 Luminaire Placement

One of the Region's desired objectives for a roadway lighting design is to provide adequate roadway lighting in the most economical manner. The Region has determined that mounting luminaires on utility poles and utilizing the utility secondary power bus is an economical method of installation.

In the predesign phase of a project, the Consultant shall examine the feasibility of mounting roadway luminaires on an existing utility pole line that is adjacent to the roadway and utilizing the utility secondary power lines for luminaire power supply.

In some roadway designs it may be necessary to install roadway lighting on both sides of the roadway. In these situations it may be necessary to utilize a combination of luminaires mounted utility poles and Region owned poles.

2.8 Lighting Pole Placement

The Regional Niagara preferred roadway lighting pole arrangements are as follows.

One sided arrangement.

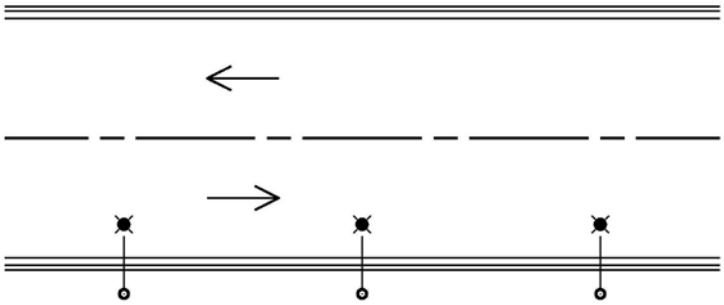

Figure 1 – One Sided Roadway Lighting Pole Arrangement

Two sided staggered arrangement.

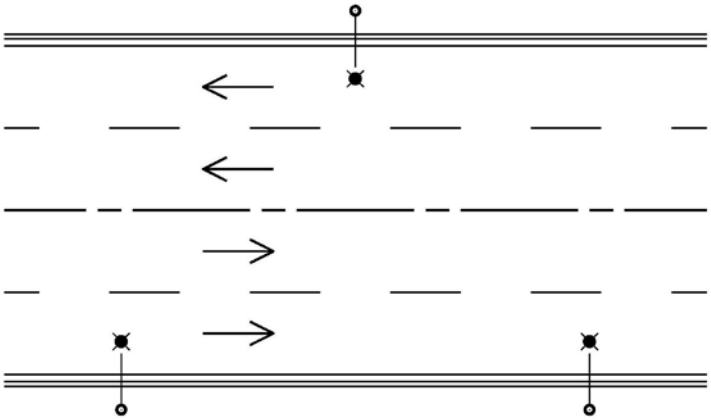

Figure 2 – Two Sided Staggered Roadway Lighting Pole Arrangement

Median pole mounting with double elliptical roadway lighting arm arrangement.

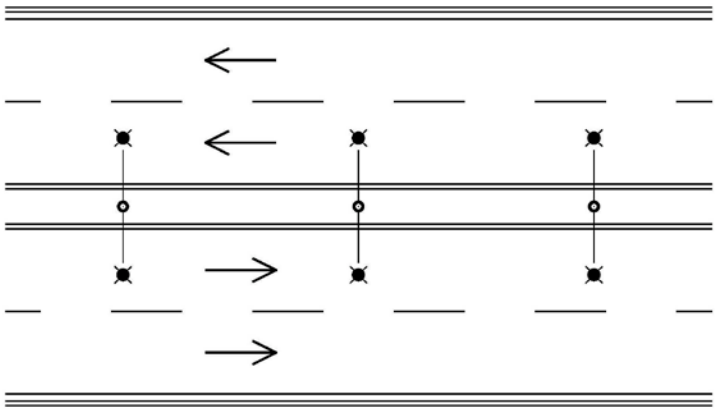

Figure 3 – Median Roadway Lighting Pole Arrangement

Combination of two sided staggered arrangement and median pole mounted double elliptical roadway lighting arm.

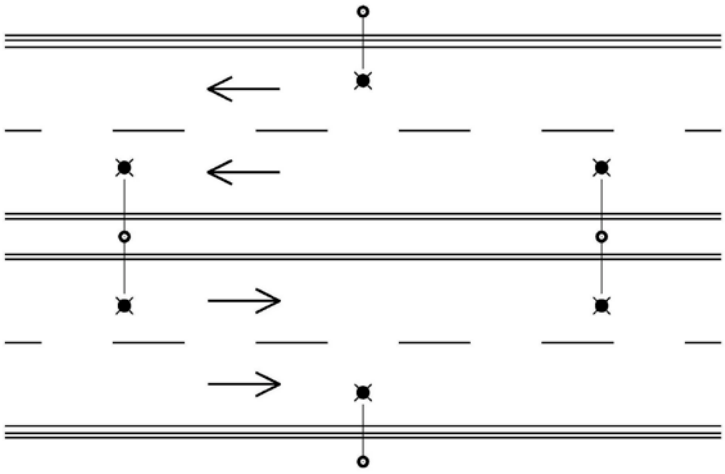

Figure 4 – Combination Roadway Lighting Pole Arrangement.

In some roadway layouts another style of lighting pole arrangement may be more suitable. The Consultant shall confer with the Region Project Manager if in the Consultant's opinion this is the case. The Region Project Manager shall give direction on the required pole placement to be used in the project.

2.9 Materials

All materials used in the project shall be those as listed on the most recent edition of the Niagara Region Approved Materials Listing. The latest version of the Approved Materials Listing.

2.10 Roadway Lighting Fixture

The Niagara Region material list includes a LED roadway luminaire specification that is to be used for consistency in all Region roadway projects. The Consultant shall obtain the latest photometric file (IES file) for the fixture. This photometry is to be used in all lighting calculations.

2.11 Poles

Sectional steel poles shall be used for lighting installations where the roadway lighting is not installed on utility poles. Sectional steel poles require a concrete foundation. In soft surfaces (ie, sod) where physical or budgetary limitations exist, section steel poles may be direct buried with the approval of the Project Manager.

Overhead span cables shall not span to or from direct buried roadway lighting poles.

Junction boxes shall be provided at each proposed pole

Refer to section 2.11.1 for installation criteria of decorative steel and concrete poles.

Region owned roadway lighting poles should be installed in accordance with the arrangement as shown in **Figures 5 and 6**.

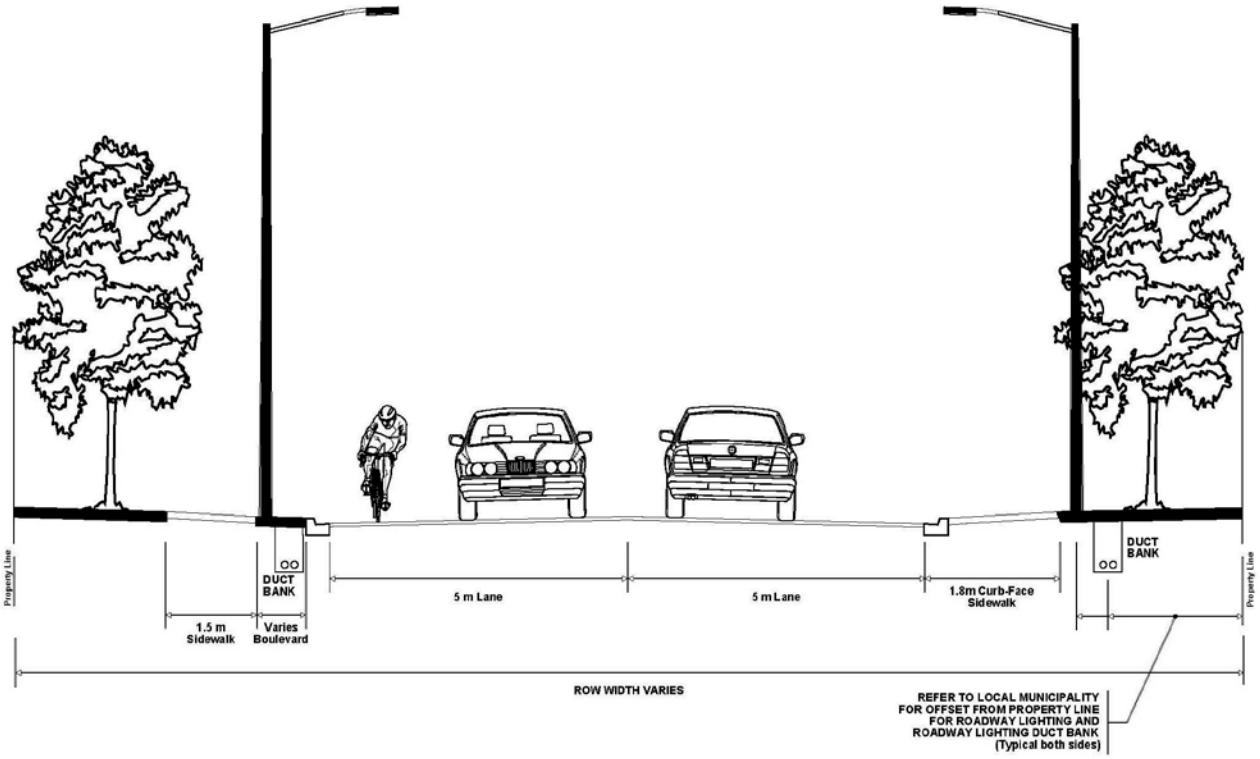

Figure 5 – Region Owned Roadway Lighting Poles on Boulevard

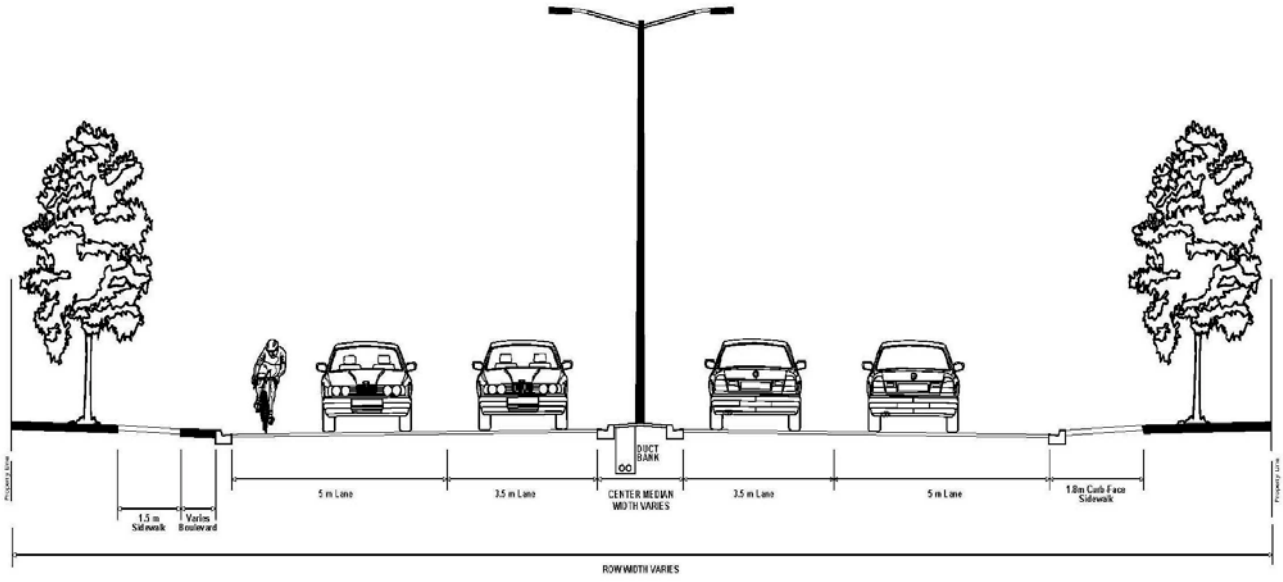

Figure 6 – Region Owned Roadway Lighting Poles in Median

2.11.1 Decorative Steel and Concrete Poles

The option is available to municipalities in the Niagara Region to request that decorative (steel or concrete) poles be used for roadway lighting. The Region Project Manager will contact the particular municipality during the design phase of a project to determine if the municipality requests the use of decorative poles.

The municipality will be required to fund the additional costs involved with the use of decorative poles. If a request is made for decorative poles, Region staff will internally consult and determine if decorative poles will be used on the project. The Region Project manager will direct the Consultant if decorative poles are to be used on a project.

The selection of the type of pole shall be in accordance with the following:

- Concrete poles; if requested, must meet Clear zones as prescribed in the Transportation Association of Canada (TAC) – Geometric Design Guide for Canadian Roads, June 2017.
-
- Concrete poles shall be the direct buried type.

2.11.2 Decorative Poles – Receptacles for Seasonal Features

When decorative poles are used for roadway lighting, the option is available for a local municipality to request that the Region provide 120 Volt receptacles for seasonal features that are temporarily mounted on the poles. When decorative poles are being used on a project, the Region Project Manager will consult with the local municipality to determine if the receptacles are required.

The maximum allowable load per pole for a seasonal feature of 150 watts. Separate circuits and wiring including fusing at each pole shall be provided for the seasonal feature receptacles.

Niagara Region Standard Drawing # NRS 2522 details dimensions for decorative appurtenances on lighting poles.

2.12 Roadway Lighting Systems Power Supply and Distribution

The roadway lighting electrical power requirements are dependent on whether the roadway lighting is installed on utility poles or Region owned poles.

2.12.1 Roadway Lighting on Utility Poles – Power Supply

Where roadway lighting is installed on utility poles, the utility supplied secondary bus shall be used for the luminaire power. All luminaires are rated at 120 Volt, 60 Hz. input. Each luminaire is to be connected to the secondary bus using the approved fuse assembly. All wiring from the fuse assembly to the luminaire shall be installed in the elliptical roadway lighting arm.

2.12.2 Roadway Lighting on Region Owned Poles – Power Supply

Where roadway lighting is installed on Region owned poles, power supply points shall be installed in locations determined by the Consultant. A power supply point shall consist of a direct buried sectional steel pole with an overhead or underground power connection to the utility. Refer to Niagara Region Standard Drawing NRS 2130. Power supply poles may be supplied by the Niagara Region to be installed by the contractor in the designated locations. The Niagara Region will dress each power supply pole with the necessary appurtenances, which include, but are not limited to distribution panel with 100 Ampere rating, 120/240 Volt, 1 Phase, line side meter, photo electric sensor and above ground conduit required for connection to hydro source.

A roadway lighting project may include a signalized intersection. A power supply point as described above will be installed at the signalized intersection by Niagara Region forces.

The Consultant shall utilize this power supply for roadway lighting installations that are adjacent to the intersection. Additional power supply points shall be installed as per the requirements of the voltage drop calculations. The voltage drop at a fixture shall not exceed 5%. The Consultant shall review the power supply points with the Region Project Manager and the Utility.

All wiring to the roadway lighting poles is to be installed underground in raceway systems as per the requirements of the details shown in **Figures 7 and 8**.

Surface mounted conduit on concrete or wooden poles shall be installed as per Niagara Region Standard drawings NRS 2800 and NRS2810 respectively.

Underground conduit entering concrete or steel direct bury poles shall be installed as per Niagara Region Standard NRS2820.

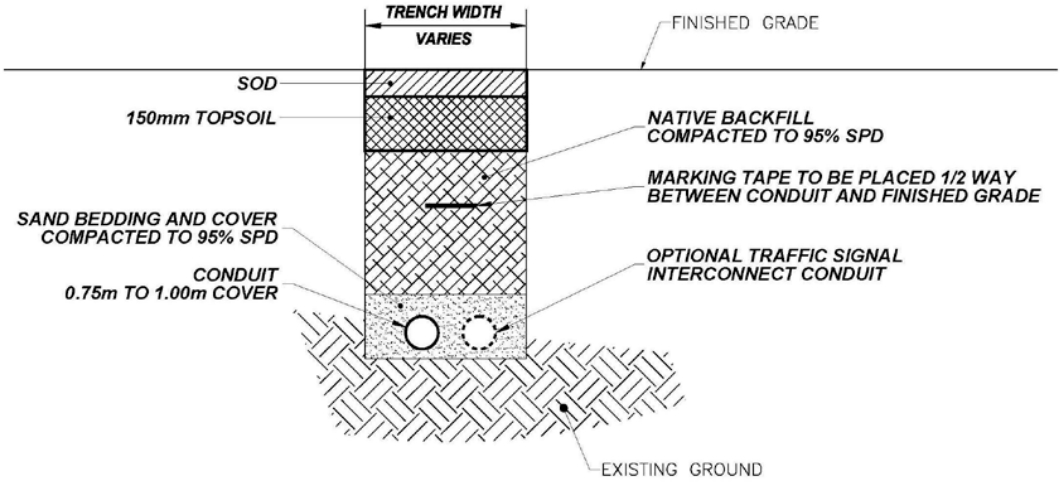

Figure 7 – Trench Located on Side of Roadway

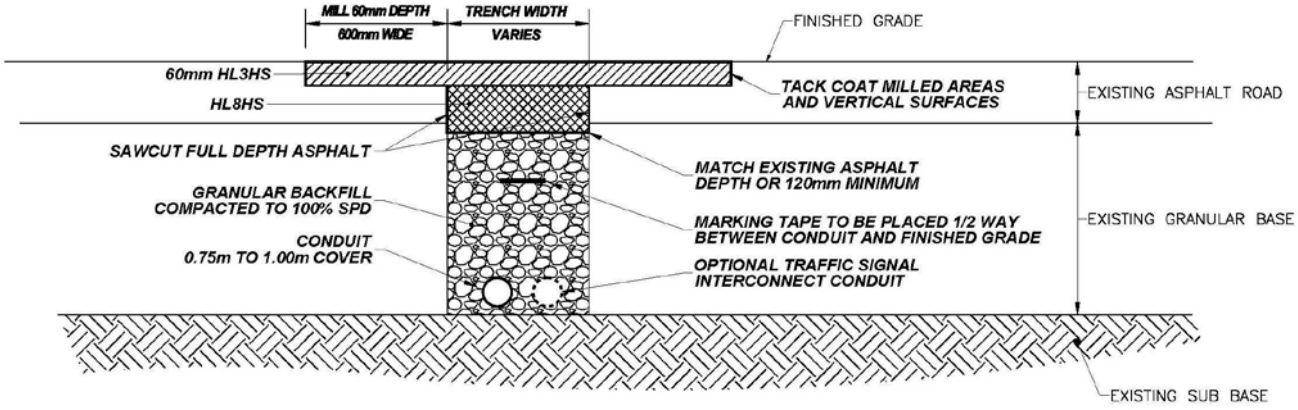

Figure 8 – Trench in Road Crossing

The Consultant shall design the distribution based on Electrical Safety Authority requirements. Wiring conductors shall be copper in the range of #6 AWG (minimum) to #2 AWG (maximum), RW90 insulation. All conductors shall be colour coded. The Consultant shall select the conductor size based on the voltage drop calculations. The maximum voltage drop at a fixture shall not exceed 5% based on the supply voltage at the distribution panel.

2.13 Grounding

When concrete poles are installed, the third pole located away from the power supply point is to be grounded using a 3m long 19 mm diameter copper clad ground rod. Every third pole thereafter is to be grounded in a similar fashion. In addition, the last pole in a distribution run shall be grounded.

All sectional steel poles shall be individually grounded using a 3m long, 19 mm diameter copper clad ground rod. The ground rod shall be connected to the ground lug on the pole using #6 AWG RW 90 XLPE Insulated (green colour) Copper wire and mechanical connectors.

3.0 Work Tasks of the Consultant

This section details the tasks required to be completed by the Consultant during the design phase of a Roadway Lighting Project.

3.1 Design Units

All drawings and calculations shall be prepared using the International System of Units (SI) system. All lighting calculations are to be presented in lux and candela/m2.

3.2 Review of Project Area

The Consultant shall review the area of the project to identify any properties adjacent to the project that are of special use and that could be affected by the installation of roadway lighting. These types of properties include schools, shopping centres, arenas and residential backyards.

The Consultant shall perform a physical survey of the area to identify any existing roadway lighting and physical plant associated with the existing lighting that will need to be demolished. Prepare drawings and necessary details identifying the existing lighting plant that will require demolition.

3.3 Base Drawings

The Consultant shall utilize the base drawings prepared for the project by the roadway designer. If a roadway designer is not part of the project, the Consultant shall prepare base drawings for the existing roadway to be used for the roadway lighting design.

All plans of the roadway for new construction shall be prepared with a minimum scale of 1:500. A larger scale such as 1:200 shall be used, if necessary to show more detail in certain areas. The Region Project Manager shall have the option of specifying the scale to be used in the drawings.

3.4 Utilization of Utility Poles

During the initial design process the Consultant shall determine if there is an existing or new electrical utility pole line adjacent to the road. The consultant shall also determine if new poles are planned by the electrical utility, prior to construction. If there is a utility pole line present, or proposed, the Consultant shall determine the suitability of using the utility poles as supports for the roadway lighting fixtures. The Region Project Manager will provide the utility contact information to the Consultant. The Consultant shall contact the utility and determine the mounting height for pole mounting arms.

The Consultant shall prepare an elevation sketch of a typical pole, showing the mounting location of the elliptical roadway lighting arm, the typical length of the arm and rise of the elliptical roadway lighting arm. This sketch will confirm if the necessary clearances are present for the lighting equipment in relation to the high voltage wiring on that pole. The clearance distance between the luminaire and closest phase of the high voltage wiring shall clearly indicated. This sketch shall be forwarded to the Region Project Manager for review.

3.5 Preliminary Design

In the initial design process the Consultant shall consider the alternatives available for roadway lighting for the project and perform preliminary calculations to evaluate the suitability of the alternatives. Once the Consultant has completed the preliminary design phase, a submission shall be made to the Region Project Manager with a summary of the alternatives and a recommendation from the Consultant as to which alternative he/she considers best suited for the project. The Region Project Manager will review the alternatives, select the appropriate one and provide direction to the Consultant.

3.6 Lighting Design Calculation Software

The Consultant shall then proceed with the preparation of detailed design drawings and specifications for the project. The preferred lighting design software is AGI32. The Region may accept other lighting design software which provides the required calculations at equal accuracy to the AGI32 application.

The Consultant shall pay particular attention to using light calculation grids and calculation point spacings that are in accordance with the requirements of TAC Guide for the Design of Roadway Lighting section 9.6.2 and 9.6.4, and IESNA RP-8-14.

3.7 Lighting Calculations

The Consultant shall utilize computer design software to prepare a roadway lighting system design to meet or exceed the maintained average horizontal luminance and average to minimum and maximum to minimum uniformity ratios, as well as the veiling luminance recommendations for the type of roadway. Curves with a radius of 600 meters or greater are to be treated as straight roadways. The Consultant shall perform separate illuminance calculations for curves with a radius of less than 600 meters.

The Consultant shall also perform lighting calculations for sidewalks and multi-use paths that are adjacent to the roadway using a combination of horizontal and vertical illuminance. These calculations should be made with a separate calculation grid as outlined in TAC Guide for the Design of Roadway Lighting section 9.6.4.

The lighting design calculations shall be made using a representative light loss factor for the designated luminaire. The composite light loss factor (LLF) for the LED roadway

lighting fixtures shall be composed of the product of the Lamp Lumen Depreciation (LLD) and Luminaire Dirt Depreciation (LDD). LLF = LLD X LDD.

The Lamp Lumen Depreciation factor shall be based on the light output of the fixture at 60,000 hours (14.4 years of use) at an average night time temperature of 10° C.

The Luminaire Dirt Depreciation factor can vary for different local environmental situations depending on the location of the roadway. The Consultant shall use a LDD based on the local environment and on the fixture manufacturer's recommendations.

The LLF used for the design shall be clearly stated on the design calculation submission to the Region Project Manager.

The Consultant shall forward the completed lighting design calculations to the Region Project Manager for review. The Region Project Manage will review the designs and either request changes or provide written acceptance of the design to the Consultant.

3.8 Roadway Lighting Power Distribution

The next step in the project is to design a distribution system scheme for the project. The distribution system scheme shall minimize the number of electrical service locations required. The Consultant shall contact the local utility to identify potential locations for power supplies. Using these potential locations, the Consultant shall refine the design and select power supply locations in consultation with the Region Project Manager. Traffic signal power supplies may be used for roadway lighting only when the installation is totally owned by the Region. The Consultant shall confirm with Region that existing traffic signal power distribution cabinets offer sufficient connection points for additional roadway lighting circuits.

3.9 Tender Package Requirements

Once the Region has accepted the design, the Consultant shall proceed with the preparation of drawings and specifications for tender and construction. The project manager shall provide templates/examples of drawings, documents and specifications.

The drawings shall include:

- Plans of the project with the location of each roadway lighting pole, junction box and luminaire each to be identified with a unique sequential number.

- A schedule showing the following information for each pole: pole number, type of lighting fixture, height of pole, type of pole foundation, height of fixture, elliptical roadway lighting arm length, ground rod required, underground junction box required, voltage drop at the pole, Field Adjustable Wattage Selector (FAWS) setting, number of fixtures. (but not limited to)

- A wiring schematic indicating the following: proposed and existing plant, wire identification, junction box, pole and fixture numbers, grounding locations, circuit identification, connection points, power supply appurtenances, and legend. (but not limited to)

- All roadway lighting system drawings shall be reviewed and stamped by a Professional Engineer licensed to practice in the Province of Ontario.

The specifications shall include sections describing the following items:

- General work methods, trench construction details, backfill and compaction requirements, details for pole foundations.
- Material list of items supplied by the Region.
- Instructions to contractors on how and where to pick up Region material.
- Material list and specifications for items not supplied by the Region.
- Details for record (as built) drawings
- Requirements for maintenance manuals
- Identification requirements of Subcontractors
- Identification of equipment (labeling)
- Layout requirements of poles and power supply locations.
- List of work items for Contractor and Region.
- Schedule of quantities for the tender form.
- Schedule of quantities with the Consultant's estimate of construction costs.

3.10 Table – Roadway Lighting Design Process

The following table is a summary of the roadway lighting design process and includes the responsibilities of the participants.

TASK	ACTIVITIES	ACTION BY:
Design Initiation	Region staff to identify roadway areas to be lit.	Region staff
Pre-Design Meeting	Region staff, road designer and lighting designer meet to discuss the project and determine criteria for lighting design.	Prime consultant to schedule, organize meeting, prepare and distribute minutes.
Initial design	Lighting designer to review lighting criteria and determine alternatives suitable for lighting the project. Submit summary of available alternatives and recommended alternative to Region Project Manager	Lighting designer
Selection of preferred lighting method	The roadway lighting alternatives to be reviewed and the preferred method to be selected. The selected approach to be conveyed in writing to the lighting designer.	Region staff
Detailed design	The design of the roadway lighting system to proceed based on preferred approach.	Lighting designer
Design review 90%	Roadway lighting plans, schedules, photometrics and specifications completed to 90% level are to be submitted to the Region Project Manager for review and comment.	Lighting designer
Design approval	The review comments by Region staff to be conveyed in writing to the lighting designer.	Region staff
Final design	The design is modified based on comments. Documents are completed to the 100% level and forwarded to Region Project Manager for final check. Final changes are made.	Lighting designer
Completion of documents and issuance for tender	Documents are completed and issued for tender and construction process.	Lighting designer

3.11 Chart of Work Tasks of the Consultant

This chart is a list of work tasks of the Consultant listed in a sequential manner.

Define limits of roadway to be illuminated.
Establish lighting design criteria. • Roadway classification from AADT value. • Pedestrian conflict classification. • Pavement reflectance classification.
Review suitability of using utility poles for luminaire mounting.
Review adjacent properties to roadway for special requirements.
Perform preliminary lighting calculations to determine possible pole layouts and spacing.
Present roadway lighting alternatives to Region Project Manager
Proceed with detailed design based on selected alternative.
Prepare photometric analysis based on selected pole layout.
Perform voltage drop calculations and determine power supply locations.
Liaison with Region and utility to define limits of roadway to be illuminated.
Confirm power supply locations.
Prepare distribution drawings.
Review site and prepare demolition drawings.
Prepare luminaire schedule.
Prepare specifications.