Standard Engineering Practice Section 4

ROADWAY LIGHTING DESIGN GUIDE

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1. Objectives

The purpose of "Roadway Lighting Design Guide" is to provide guidelines and information required to design roadway lighting systems that achieves the following objectives in an economical and cost-effective manner:

-To provide an energy efficient lighting system that will meet standard design criteria with the minimum possible Unit Power Density (UPD) as per TAC 2006 – guide for the Design of Roadway Lighting.
-To provide adequate and uniform lighting levels on our roadways for drivers and pedestrians safety.

2. Scope of the Standard

The Classification of Roadways and their Recommended Luminance Light Levels as per IESNA RP-8-14 and TAC- 2006 –Guide for the Design of Roadway Lighting

2.1. Luminaires Available

SaskPower supplies and installs roadway lighting to customers within our franchise area. The lighting materials supplied are limited to stock coded items. Should a customer wish to install luminaires and poles other than our stock coded items, they are required to procure, install and maintain the luminaires. SaskPower would provide a meter point to supply the lighting.

2.2. High Mast Lighting

Since the Ministry of Highways and Infrastructure install and maintain their own lighting around major interchanges, High Mast Lighting as typically required around these interchanges is not covered in this document. This would be customer owned lighting, and SaskPower would only provide a meter point.

3. Glossary

Candela (cd) - Candela is a unit of measure for Luminous Intensity - the strength of light emitted in a certain direction. The concept of Luminous Intensity is represented by the symbol *I*.

Cutoff - A luminaire's light distribution is designated as cutoff when the measured candela output is less than 2.5% of rated lumens at 90˚ above nadir and less than 10% of rated lumens at 80˚above nadir.

Footcandle (fc) - Footcandle is a unit of measure for Illuminance - the measure of light arriving on a surface. 1 fc = 1 lm/ft^2

Full Cutoff - "Flat Lens" – A luminaire's light distribution is designated as full cutoff when the measured candela output is 0 at 90˚ above nadir and less than 10% of rated lumens at 80˚ above nadir.

Illuminance - Light that reaches the road surface and other objects. Illuminance is a measure of the incident light, and is expressed in lux or footcandles. The concept of Illuminance is represented by the symbol *E*.

Lumen (lm) - Lumen is a unit of measure for Luminous Flux - the quantity of light produced by a source. The concept of Luminous Flux is represented by the symbol Φ.

Luminance - Light perceived by a motorist on a roadway. Luminance is a measure of the reflected light and is expressed in candela/m^2 or candela/ft^2. The concept of Luminance is represented by the symbol *L*.

Lux (lx) - Lux is a unit of measure for Illuminance - the measure of light arriving on a surface. 1 lx = 1 lm/m^2.

Nadir - the vertical projection directly beneath the apparent light source of a luminaire.

Non-Cutoff - A luminaire's light distribution is designated as Non-Cutoff when there is no specific luminous limitation in any direction.

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

Reflectance - the ratio of the reflected flux (or luminance) to the incident flux (or illuminance) – expressed in a percentage. The concept of Reflectance is represented by the symbol ρ.

Semi-Cutoff - "Sag Lens" - A luminaire's light distribution is designated as Semi-Cutoff when the measured candela output is less than 5% of rated lumens at 90˚above nadir and less than 20% of rated lumens above 80˚ nadir.

Small Target Visibility - is a method of design that determines 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

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

4. Basic Principles of Streetlight Design

There are six basic principles to consider when doing a lighting design.

1. Safety – pedestrian and driver safety. Creating a lighting level sufficient that drivers are aware of any pedestrians and or objects near the roadway.
2. Security – providing a setting that will deter some forms of criminal activity through the use and placement of lights.
3. Limit the amount of Light Trespass – avoiding the over lighting of areas such as in residential neighbourhoods where the backlight may shine on houses.
4. Environmental Responsibility – consideration should be given to the following:
   - Energy usage
   - Lighting levels – to determine the correct level of light output required as per Transportation Association of Canada (TAC) recommendations, which use the following criteria:
     - road classification
     - pedestrian conflict activity
     - road type
     - calculation of lighting
   - Lamp type – through the use of one of four different luminaires that can provide varied lighting patterns. These types are: Full Cutoff , Cutoff, Semi-cutoff, and Non-cutoff
     - It is a SaskPower requirement to only install full cutoff luminaires and all other types are being phased out
5. To provide uniformity and consistency in lighting designs throughout the province while meeting the industry standard.
6. Cost – Take into account the initial capital cost of the installation as well as long term maintenance. The cheapest cost up front may not be the cheapest over the life of the luminaire.

5. Design Considerations

It is the responsibility of the individual doing a lighting design to make sure they are making reference to TAC and using the latest version. At the time of the creation of this document TAC 2006 was used.

When starting a lighting design, attention to the surrounding area and any special requirements must be taken into consideration, ie…schools, shopping districts, or airports.

It is important to note that there are three different design methods that can be used for calculating the roadway lighting levels. Each method may produce different designs and provide different amounts of lighting levels through luminaire spacing and configurations. The three types are the Illuminance Method, Luminance Method and Small Target Visibility Method. All three of these methods are fully explained in the 2014 edition of the IESNA RP-8, American National Standard Practice for Roadway Lighting. The appropriate application stating when/where to use each design method is stated in Section 5.4 Basic Lighting Design of this document.

5.1. *Customer Requirements*

SaskPower's standard practice is to design roadway lighting as per TAC standards. There are situations where a customer may not wish to have streetlights designed to this standard, often due to the cost. If a customer does not want to meet TAC requirements, they can have a meter point provided and install their own lights however they see fit.

When the customer specifically requests lighting that does not meet TAC and does not want to install their own lighting from a meter point, SaskPower can offer less than TAC standards but will require the customer to sign an acknowledgement as part of the quote letter. The acknowledgement letter should mention that SaskPower recommended a lighting system according to TAC standards but the customer is willingly requesting less. The design drawings should also state that the lighting doesn't meet TAC standards.

5.2. *Light Pollution*

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

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. While our typical luminaires do a reasonable job of controlling the light toward the residence, 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.

Up-lighting where there is excessive light upwards from the luminaire. This will impact visibility of the night sky and is a particular concern among astronomers. The International Dark-Sky Association (IDA) is an organization which promotes the use of luminaires with zero uplight (ie. Full Cut-off). They will assess luminaires and provide a Fixture Seal of Approval (FSA) for luminaires which meet their requirements for Uplighting. For more information on the International Dark-sky Association see www.darksky.org.

For all street light designs, the use of full cut-off luminaires is required.

5.3. *Airports*

Installations in close proximity to airports may pose a hazard to airplanes or helicopters. For this reason attention to pole heights and light spill is required, as well as approval from Transport Canada and NAV Canada. The required forms are available on-line at each of the agency web-sites. It is the responsibility of the person doing a light study to research any restrictions that may be imposed on the lighting design.

Transport Canada
Aerodromes & Air Navigation (RAEM)
1100-9700 Jasper Ave., N.W.
Edmonton, Alberta T5J 4E6
Tel: 780-577-0247

Fax: 780-495-5190

It will also be necessary to contact NAV Canada and obtain the most recent land use proposal submission form. This form is to be completed and submitted to NAV Canada. The approval process may take up to 30 days.

NAV Canada
1601 Tom Roberts Road
P.O. Box 9824, Station T
Ottawa, Ontario K1G 6R2
Tel: 866-577-0247
Fax: 613-248-4094
e-mail: landuse@navcanada.ca
website: www.navcanada.ca

*****Note: The land use office prefers to receive proposal submissions electronically.**

The Transport Canada Aeronautical Assessment Form for Obstruction Marking and Lighting can be found at https://www.tc.gc.ca/eng/civilaviation/regserv/cars/part6-standard-standard621-3868.htm in Appendix C.
The NAV Canada Land Use Form can be found at http://www.navcanada.ca/EN/products-and-services/Pages/land-use-program-submission.aspx.

5.4. Basic Lighting Design

5.4.1. Roadway Terminology

This section includes general terminology associated with typical roadways in Saskatchewan.

Roadway – The portion of the road surface, including shoulders, for vehicular use.

Traveled Way – The portion of the roadway provided for the movement of vehicles, exclusive of shoulders, auxiliary lanes and bicycle lanes.

Median – The portion of the roadway separating the traveled way for accommodation of stopped vehicles for emergency use, and for lateral support of the base and surface courses.

Shoulder – The portion of the roadway adjacent with the traveled way for accommodation of stopped vehicles for emergency use and for lateral support of the base and surface courses.

Sidewalk – An exterior pathway with a prepared surface (concrete, bituminous, brick, stone, etc.) intended for pedestrian use.

Setback – The distance from the streetlight pole to the front of the curb.

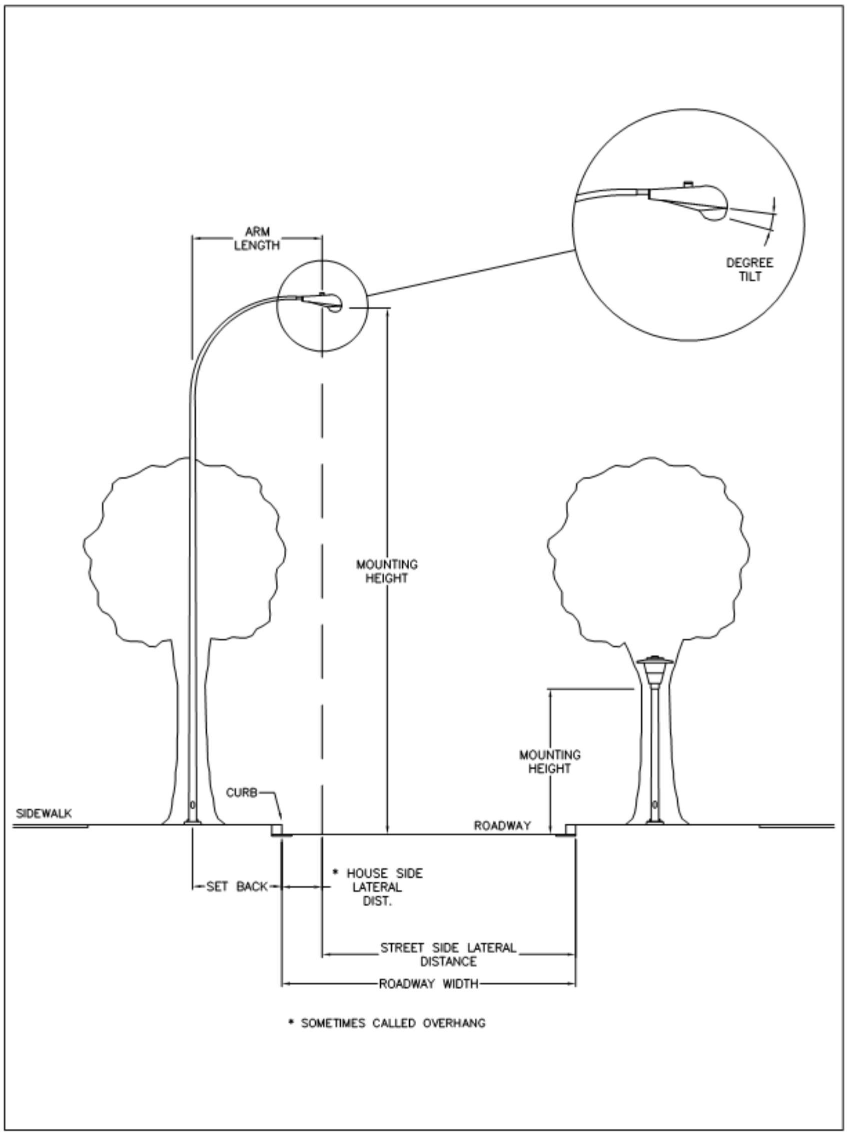
Arm Length – The distance from the approximate location of the bulb to the center of the vertical part of the light standard/pole. The typical arm length is 2.40m.

House-side Lateral Distance – The distance from the imaginary vertical line directly below the luminaire and running back toward the adjacent curb. Also referred to as “Overhang”.

Street-side Lateral Distance – The distance from the imaginary vertical line directly below the luminaire to the curb on the opposite side of the roadway.

Mounting Height – The distance from the location of the bulb to the road surface directly below. The typical steel streetlight standard heights are: 25’, 30’, 35’, 40’, and 45’. The typical decorative streetlight standard heights are: 14’ and 16’. There are also typical wood pole mounted streetlights.

Figure 5-1 Roadway Terminology



5.4.2. Lighting Design Methodology

There are three lighting design methodologies – Luminance, Illuminance and Small Target Visibility (STV). Illuminance measures the incident lighting on the roadway while luminance is a measure of the reflected light.

Small Target Visibility (STV) differs from Illuminance and Luminance design in that values are given in terms of a weighted average visibility level. This is a design method adopted in 2000 by IESNA and has come under scrutiny within roadway lighting community. STV recommended values are no longer included in the latest version of IESNA RP-8 and therefore should not be used for light calculations anymore.

The Luminance method shall be used for roadway and interchange, the Illuminance method shall be used for intersections and cul-de-sacs. Lighting designs for curved sections with greater than 600m radius should be evaluated as if it were a straight section, otherwise they should be evaluated as an intersection.

The IESNA RP-8-14 section 5.1.2 refers to classifying driveways off of roadways as intersections in some situations, which would therefore require them to be designed with the Illuminance method. As this can cause roadways to be unnecessarily overlit, each situation should be looked at on a case by case basis. In general, any driveways that are not widely used do not require them to be classified as intersections.

When calculating Illuminance or Luminance values in light design software, a ± 10% tolerance on the recommended values may be used if light levels cannot be met. Where possible, the recommended light levels should be used. This will be up to the discretion of the designer.

5.4.3. Pedestrian Conflict

The next step in developing a Roadway Lighting Design is to identify the amount of pedestrian traffic in the area to establish which values are used from the recommended light level tables 5-4 and 5-5.

- According to IES RP-8-14, there are three types of classifications.
    - Low conflict area: residential
    - Medium conflict areas: schools, recreational centers
    - High conflict areas: restaurants, shopping, theatres

Pedestrian Conflict is assumed to be the total number of people on both sides of a street within a given section (200 meters). This number also includes those people crossing the street between the hours of 18:00 and 19:00.

Table 5-1 Classification of Pedestrian Conflict

LOW	: 10 or fewer pedestrians
MEDIUM	: 11 to 100 pedestrians
HIGH	: over 100 pedestrians

5.4.4. Light Arrangement Styles

There are several options available for the placement of lighting standards. Some of these are as follows:

Figure 5-2 One Sided Arrangement

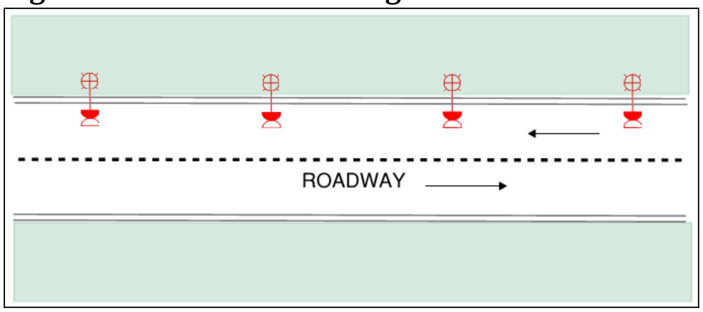


Figure 5-3 Two Sided Opposite Arrangement

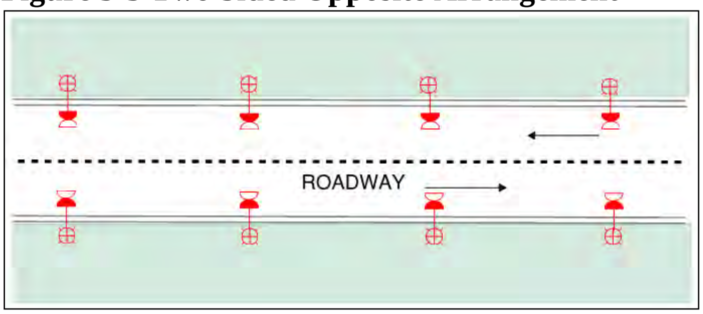


Figure 5-4 Two Sided Staggered Arrangement

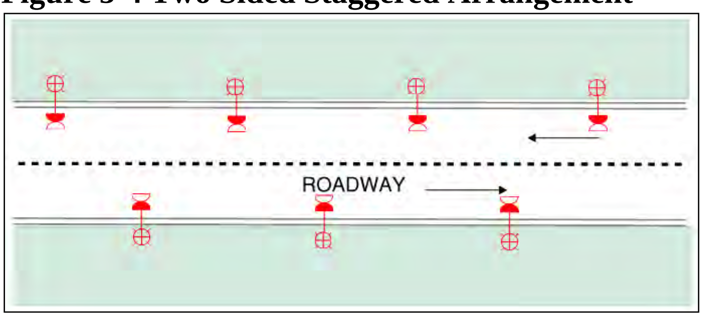


Figure 5-5 Double Davit Median Arrangement

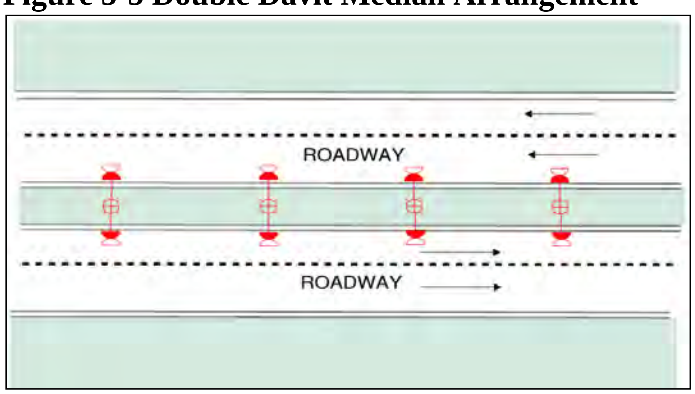


Figure 5-6 Double Davit Opposite Arrangement

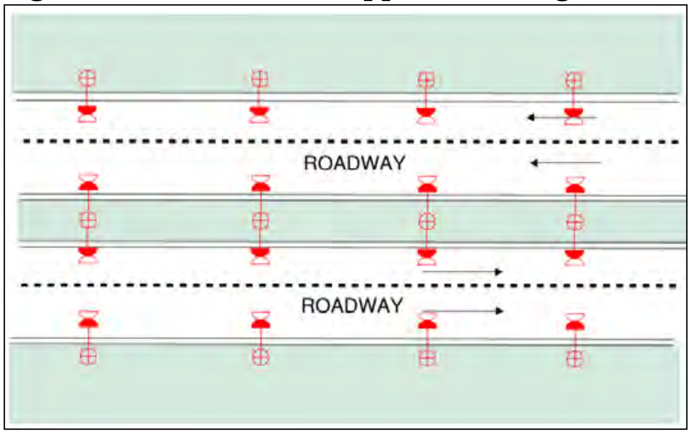
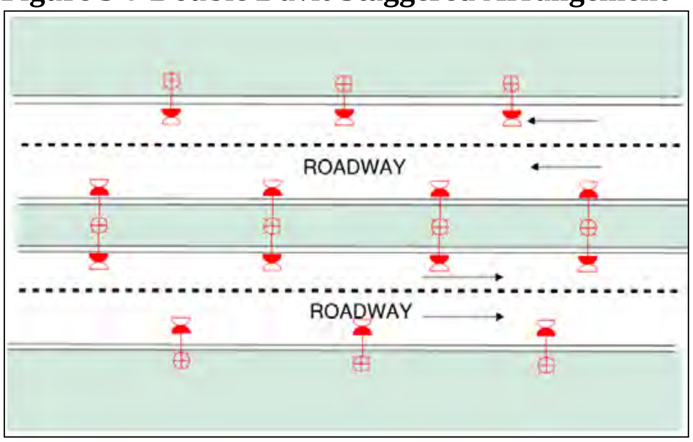


Figure 5-7 Double Davit Staggered Arrangement



Typically a one-sided spacing is used on roadways with one to three lanes, staggered spacing on roadways with three to six lanes, and opposite spacing on roadways with five or more lanes. Median lighting is typically used 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.

5.4.5. Pavement Classification

The first step in developing the Roadway Lighting Design is to determine the Pavement Classification. Pavement classification is a measure of how reflective the roadway surface is to establish the lighting levels required. The pavement classification will establish the Q_0 Mean Luminance Coefficient.

The four pavement classifications in TAC are R1, R2, R3, and R4. The R represents the reflective quality of the pavement. For SaskPower, a typical roadway would be represented by a R3 classification.

Table 5-2 Pavement Classification

CLASS	QO	DESCRIPTION OF ROADWAY SURFACE	MODE OF REFLECTANCE
R1	0.10	Portland cement concrete road surface. Asphalt road surface with a minimum of 15 percent of the aggregate composed of artificial brightener *(e.g. Synopal) aggregates (e.g. Labradorite, quartzite)	Mostly Diffuse
R2	0.07	An asphalt road surface with an aggregate comprised of minimum 60% gravel (size greater than 10mm). Asphalt road surface with 10-60% artificial brightener in aggregate mix.	Mixed (diffuse and specular)
R3	0.07	An asphalt road surface (regular and carpet seal) with dark aggregates (e.g. trap rock, blast furnace slag); rough texture after some month of use (typical highways).	Slightly Specular
R4	0.08	Asphalt road surface with very smooth texture	Mostly Specular

Copied from TAC 2-37 2006

5.4.6. Roadway Classifications

In order to establish appropriate lighting levels for a given road, a classification system is used to separate roadways based on traffic volumes and use. The definitions below are based upon TAC 2006 9.1.2 and Table 9-1 *Roadway Classification Designations:*

Freeway

A Freeway is defined as a fully-controlled access roadway for through traffic, with a classification of **RFD** or **UFD** (see Table 9-1 – *Roadway Classification Designations).* Freeways are typically characterized by the presence of interchanges which allow motorists to enter and exit the freeway in a fully controlled fashion onto local, collector and arterial roads. As defined in the *TAC Geometric Design Guide for Canadian Roads,* interchanges have various configurations and spacing. Typical interchange configurations include diamond, cloverleaf, parclo, trumpet and rotary. Freeways are typically high-speed facilities with a posted speed of 90km/h, or greater.

Expressway
Expressway-highway is defined as a roadway for through traffic with full or partial control of access via interchanges, intersections or roundabouts. Classifications include **REU**, **RED**, **UEU**, or **UED** (see *Table 9-1 – Roadway Classification Designations*). An expressway-highway may have at grade signalized or unsignalized intersections of roundabouts. In some cases an expressway-highway may have interchanges similar to those for freeways.

Arterial
An arterial is defined as a roadway primarily for high volume through traffic with classification of **RAU**, **RAD**, **UAU**, or **UAD** (see *Table 9-1 Roadway Classification Designations*). An arterial will typically have partially-controlled access via traffic signals or roundabouts or non-controlled access via intersections or driveways.

Collector
A collector is defined as a roadway feeding an arterial classification of **RCU**, **RCD**, **USU**, or **UCD** (see *Table 9-1 Roadway Classification Designations*). A collector will typically have partially-controlled access via traffic signals or roundabouts or non-controlled access via intersections or driveways.

Local
A local is defined as a roadway feeding a collector or arterial, with classification of **RLU**, or **ULU** (see *Table 9-1 Roadway Classification Designations*). A local roadway will typically have partially-controlled access via traffic signals or roundabouts or non-controlled access via intersections or driveways.

Alleyway
An alleyway is defined as a non-controlled access roadway located along the rear of, or between buildings for servicing or access purposes. Alleyways typically connect to local or collector roads. Where lighting is desired for alleyways it should meet the criteria for local roads.

Table 5-3 Roadway Classification Designations

FIRST LETTER		SECOND LETTER		THIRD LETTER	
R	Rural	L	Local	U	Undivided
U	Urban	C	Collector	D	Divided
		A	Arterial		
		E	Expressway		
		F	Freeway		

Copied from Table 9-1 TAC 2006

This Design Guide does not cover lighting for areas other than Roadway such as Alleys, Sidewalks, Pedestrian Walkways and Bikeways. Recommendations on these types of installations can be found in TAC.

Table 5-4 RP-8 Recommended Light Levels For Luminance

Road Classification	Pedestrian Conflict Area[1]	Lav (cd/sq.m)	Lav/ Lmin	Lmax/Lmin	LVmax/ Lavg
Freeway Class A	N/A	0.6	3.5	6	0.3
Freeway Class B	N/A	0.4	3.5	6	0.3
Express Way	N/A	1	3	5	0.3
Major	High	1.2	3	5	0.3
	Medium	0.9	3	5	0.3
	Low	0.6	3.5	6	0.3
Collector	High	0.8	3.0	5	0.4
	Medium	0.6	3.5	6	0.4
	Low	0.4	4.0	8	0.4
Local	High	0.6	6	10	0.4
	Medium	0.5	6	10	0.4
	Low	0.3	6	10	0.4

NOTES: 1. Low = 10 or fewer pedestrians, Medium = 11 to 100, High = >100
Copied from Table 2 and 3 in IESNA RP-8-14

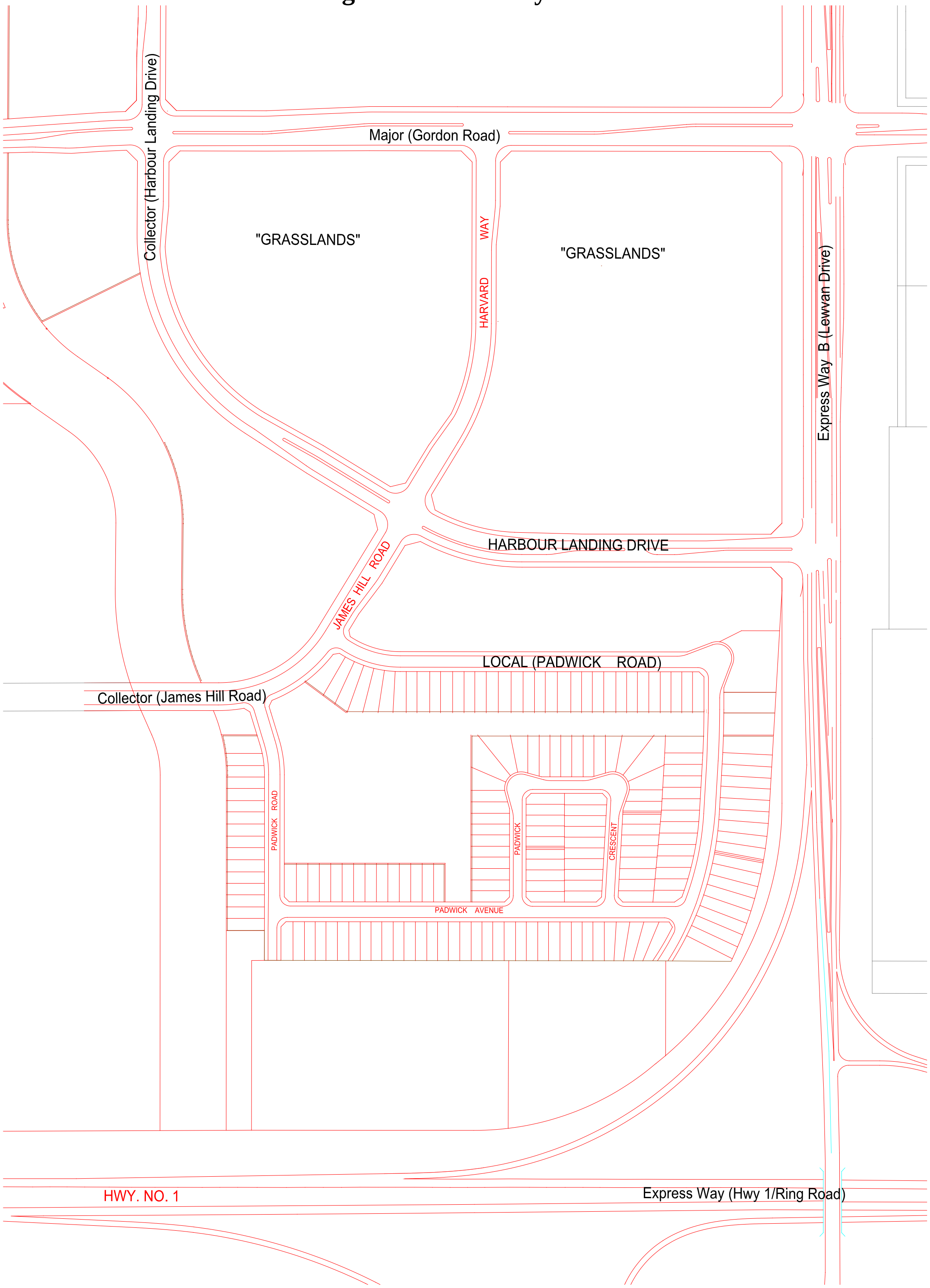
Table 5-5 Illuminance for Intersections

Functional Classifications	Average Maintained Illumination at Pavement by Pedestrian Area Classification (lx/fc)			E_{avg}/E_{min}
	High	Medium	Low	
Major/Major	34.0/3.4	26.0/2.6	18.0/1.8	3.0
Major/Collector	29.0/2.9	22.0/2.2	15.0/1.5	3.0
Major/Local	26.0/2.6	20.0/2.0	13.0/1.3	3.0
Collector/Collector	24.0/2.4	18.0/1.8	12.0/1.2	4.0
Collector/Local	21.0/2.1	16.0/1.6	10.0/1.0	4.0
Local/Local	18.0/1.8	14.0/1.4	8.0/0.8	6.0

Copied from Table 8 in IESNA RP-8-14

Figure 5-8 Roadway Classifications shows the southwest portion of the City of Regina, with roads classified according to TAC.

Figure 5-8 Roadway Classifications



5.4.7. Area Classifications

In order to determine appropriate lighting levels, 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:

1) 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 traffic vehicular and or pedestrian traffic on a frequent basis.
2) 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 neighbourhood retail stores.
3) Residential. A residential development, or a 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.

5.4.8. Light Calculation Grid

Setting up a grid in lighting design software should be as per IESNA RP-8-14. Using more or less points will alter the calculations and you may or may not achieve the proper lighting levels. As well any change of the grid spacing's will also have an effect upon the calculations.

The following is taken from TAC 9.6.2
The calculation grid for a roadway should consist of two grid lines per lane located ¼ of the distance from the edge of each lane as shown in TAC Figure 9-16 – Grid Points For Luminance Calculations and Illuminance Measurements on Roadways. The following criteria should be applied:

- The grid should be based on the number of lanes for the majority of the length of roadway.
- In the event that the roadway width and number of lanes change, then a revised grid should be used for the new length of roadway.
- In the longitudinal direction, the distance between grid lines should be one-tenth (1/10) of the spacing between luminaires, or 5.0m, whichever is smaller. The starting point for the gridlines should not be located directly under a pole, but should start instead at a point one-half (1/2) of the grid cell size from the luminaire pole.

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

The same principles should be followed to create luminance calculation grids for curved sections of roadway as for straight sections. The main issue will be the location of the observer point, which shall be located on the road as per CIE standards, but with observer distance at 83.07m as shown in TAC Figure 9-17 – Luminance Calculation Grid Geometry for Curved Roadway Sections (this observer point distance is consistent with IESNA standards for a tangent section of road: the CIE practice uses a 60.0m observer point).

Table 5-6 Light Calculation Grid Definitions

Area	Grid Spacing's
ROADWAY: both straight and curved sections	2 grid lines per lane, centered on the roadway, extending laterally from the lane edge to lane edge
INTERSECTIONS	2.0m grid, centered on the intersection, extending laterally from lane edge to lane edge
BRIDGES AND OVERPASSES	2 grid lines per lane, centered on the roadway, extending laterally from the lane edge to lane edge
INTERCHANGES	Interchange components as described above
REST AREAS AND VEHICLE INSPECTION STATIONS	2.0m grid, to cover the entire travel portion of the roadway and parking area
SIGNS	300mm grid on the face of the sign
VEHICLE TUNNELS	Refer to IESNA RP - 22

5.4.9. Typical Pole Height and Spacing

Tables 5-7, 5-8, and 5-9 show the typical mounting spacing and arrangements using the Luminance method with corresponding cost index and unit power density for different Roadway Classifications. Table 5-7 is for when full cut-off HPSV luminaires are used, Table 5-8 is for when drop lens HPSV luminaires are used, and Table 5-9 is for when LED luminaires are used. These tables are for reference and estimating purposes only and light design software should be used to determine the best fit for each application.

Table 5-8 for drop lens HPSV luminaires is no longer to be used due to the company mandate to use only full cut-off luminaires. The values are left for reference purposes only.

Table 5-9 for LED luminaires was copied from the spacing values for HPSV drop lens luminaires and not specifically designed around one type of LED luminaire. The material specification LS-5713 states LED luminaires shall meet or exceed the HPSV drop lens spacing. As this is the baseline for approval, all LED luminaires purchased through SaskPower will meet IES RP-8 light levels at the same spacing, but it cannot be guaranteed that they will exceed this. Wider spacing may be achieved but must be done on a case by case basis through light design software.

The cost index was evaluated by using the combined material and labor costs for the luminaire and pole, and also factoring in energy costs over a 30 year period. All rates were calculated using a present value formula with a hurdle rate of 7.5% per year. The cost index numbers are ranked by setting the lowest $/m cost for that scenario at 1.0, and all others are shown as a multiplier of the lowest (ie. If lowest $/m is $10 and the next two are $15 and $20, they would be ranked 1.5 and 2.0 respectively). This also assumes that the max spacing is used. For more in-depth costs, contact SEP 4 committee.

As the LED luminaires do not have a set wattage and may vary over time between different suppliers, a base wattage needed to be chosen to get UPD and cost index values. The wattages chosen match the LED luminaires purchased on the 5 year RFP signed in 2017:
Stock code 34212 – 46W (70/100W HPSV equivalent)
Stock code 34217 – 48W (150W HPSV equivalent)
Stock code 34228 – 75W (250W HPSV equivalent)
Stock code 34242 – 180W (400W HPSV equivalent)

All spacing values were calculated using AGi32 software and are based off of Roadway Optimizer recommended spacing calculations. All photometric files used are located in R:\TD\Field Services Shared\Distribution Standards\Photometric Files.

Table 5-7 Roadway Lighting Design by Luminance Method for Full Cut-Off HPSV Luminaires

Road and Pedestrian Conflict Area		Luminance Criteria	Lamp Wattage	Input Wattage	Mounting Height	Arrangement	Spacing	Cost Index	UPD
Road	Pedestrian Conflict Area	(Cd/ m^2)			(m)		(m)		(W/m^2)
Freeway "B" 2 lane (7.5m)	N/A	0.4	250	300	12.2	One side	73	1.00	0.548
			150	190	9.1	One side	45	1.10	0.563
			100	130	12.2	One side	35	1.46	0.495
Freeway "B" 3 lane (11.25m)	N/A	0.4	250	300	10.7	One side	68	1.00	0.392
			150	190	9.1	One side	40	1.42	0.422
			100	130	10.7	One side	29	1.70	0.398
Freeway "B" 4 lane (15m)	N/A	0.4	250	300	12.2	Staggered	112	1.00	0.357
			150	190	9.1	Staggered	62	1.40	0.409
			100	130	10.7	Staggered	54	1.44	0.321
Major 13.4m	High	1.2	400	465	13.7	Staggered	113	1.00	0.614
			250	300	9.1	Staggered	55	1.56	0.814
			150	190	9.1	Staggered	26	2.59	1.091
	Medium	0.9	400	465	13.7	Staggered	126	1.00	0.551
			250	300	10.7	Staggered	64	1.43	0.700
			150	190	9.1	Staggered	34	2.05	0.834
	Low	0.6	400	465	13.7	Staggered	158	1.00	0.439
			250	300	10.7	Staggered	93	1.19	0.481
			150	190	9.1	Staggered	55	1.64	0.516
Major 15.8m	High	1.2	400	465	13.7	Staggered	103	1.00	0.571
			250	300	9.1	Staggered	44	1.52	0.863
			150	190	9.1	Staggered	24	2.29	1.002
	Medium	0.9	400	465	13.7	Staggered	111	1.00	0.530
			250	300	9.1	Staggered	55	1.25	0.690
			150	190	9.1	Staggered	32	1.75	0.752
	Low	0.6	400	465	13.7	Staggered	127	1.00	0.463
			250	300	10.7	Staggered	82	1.07	0.463
			150	190	9.1	Staggered	48	1.36	0.501
Major 22m	High	1.2	400	465	12.2	Staggered	83	1.00	0.509
			250	300	9.1	Staggered	34	1.77	0.802
			150	190	9.1	Staggered	20	2.33	0.864
	Medium	0.9	400	465	13.7	Staggered	96	1.00	0.440
			250	300	9.1	Staggered	45	1.52	0.606
			150	190	9.1	Staggered	26	2.07	0.664
	Low	0.6	400	465	13.7	Staggered	106	1.00	0.399
			250	300	10.7	Staggered	64	1.14	0.426
			150	190	9.1	Staggered	39	1.42	0.443
Collector 13.4m	High	0.8	250	300	9.1	Staggered	64	1.00	0.700
			150	190	9.1	Staggered	39	1.28	0.727
			100	130	9.1	Staggered	33	1.30	0.588
	Medium	0.6	250	300	10.7	Staggered	93	1.00	0.481
			150	190	9.1	Staggered	55	1.38	0.516
			100	130	9.1	Staggered	44	1.48	0.441
	Low	0.4	250	300	10.7	Staggered	139	1.00	0.322
			150	190	9.1	Staggered	77	1.15	0.368
			100	130	10.7	Staggered	64	1.40	0.303
Collector 14.8m	High	0.8	250	300	9.1	Staggered	63	1.00	0.644
			150	190	9.1	Staggered	37	1.38	0.694
			100	130	9.1	Staggered	31	1.39	0.567
	Medium	0.6	250	300	10.7	Staggered	84	1.00	0.483
			150	190	9.1	Staggered	55	1.15	0.467
			100	130	9.1	Staggered	41	1.35	0.428
	Low	0.4	250	300	10.7	Staggered	131	1.00	0.309
			150	190	9.1	Staggered	74	1.34	0.347
			100	130	10.7	Staggered	64	1.40	0.274

Road and Pedestrian Conflict Area		Luminance Criteria	Lamp Wattage	Input Wattage	Mounting Height	Arrangement	Spacing	Cost Index	UPD
Road	Pedestrian Conflict Area	(Cd/ m²)			(m)		(m)		(W/m²)
Local 8.7m	High	0.6	150	190	7.6	One side	34	1.00	0.642
			100	130	9.1	One side	28	1.06	0.534
	Medium	0.5	150	190	7.6	One side	40	1.00	0.546
			100	130	9.1	One side	34	1.02	0.439
	Low	0.3	150	190	9.1	One side	55	1.00	0.397
			100	130	10.7	One side	47	1.12	0.318
Local 11m	High	0.6	150	190	7.6	One side	31	1.00	0.557
			100	130	9.1	One side	26	1.05	0.455
	Medium	0.5	150	190	7.6	One side	38	1.00	0.455
			100	130	9.1	One side	31	1.09	0.381
	Low	0.3	150	190	9.1	One side	55	1.00	0.314
			100	130	10.7	One side	40	1.32	0.295

Note: Highlighted lines represent lowest $/m option

Table 5-8 Roadway Lighting Design by Luminance Method for Drop Lens HPSV Luminaires (No Longer Available, For Reference Only)

Road and Pedestrian Conflict Area		Luminance Criteria	Lamp Wattage	Input Wattage	Mounting Height	Arrangement	Spacing	Cost Index	UPD
Road	Pedestrian Conflict Area	(Cd/ m²)			(m)		(m)		(W/m²)
Freeway “B” 2 lane (7.5m)	N/A	0.4	250	300	10.7	One side	69	1.02	0.580
			150	190	10.7	One side	42	1.42	0.603
			100	130	9.1	One side	48	1.00	0.361
Freeway “B” 3 lane (11.25m)	N/A	0.4	250	300	12.2	One side	73	1.00	0.365
			150	190	10.7	One side	42	1.27	0.402
			100	130	9.1	One side	41	1.07	0.282
Freeway “B” 4 lane (15m)	N/A	0.4	250	300	12.2	Staggered	124	1.00	0.323
			150	190	12.2	Staggered	73	1.46	0.347
			100	130	9.1	Staggered	68	1.10	0.255
Major 13.4m	High	1.2	400	465	10.7	Staggered	111	1.00	0.625
			250	300	9.1	Staggered	55	1.37	0.814
			150	190	9.1	Staggered	30	2.10	0.945
	Medium	0.9	400	465	10.7	Staggered	112	1.00	0.620
			250	300	9.1	Staggered	69	1.33	0.649
			150	190	9.1	Staggered	40	2.01	0.709
	Low	0.6	400	465	12.2	Staggered	147	1.00	0.472
			250	300	10.7	Staggered	94	1.21	0.476
			150	190	9.1	Staggered	55	1.72	0.516
Major 15.8m	High	1.2	400	465	10.7	Staggered	77	1.00	0.764
			250	300	9.1	Staggered	47	1.40	0.808
			150	190	9.1	Staggered	28	1.85	0.859
	Medium	0.9	400	465	12.2	Staggered	126	1.00	0.467
			250	300	9.1	Staggered	62	1.41	0.612
			150	190	9.1	Staggered	37	2.01	0.650
	Low	0.6	400	465	13.7	Staggered	153	1.00	0.385
			250	300	10.7	Staggered	87	1.42	0.436
			150	190	9.1	Staggered	51	1.87	0.472
Major 22m	High	1.2	400	465	10.7	Staggered	77	1.00	0.549
			250	300	9.1	Staggered	36	1.78	0.758
			150	190	9.1	Staggered	23	2.27	0.751
	Medium	0.9	400	465	12.2	Staggered	100	1.00	0.423
			250	300	9.1	Staggered	48	1.41	0.568
			150	190	9.1	Staggered	31	1.83	0.557
	Low	0.6	400	465	13.7	Staggered	123	1.00	0.344
			250	300	12.2	Staggered	73	1.37	0.374
			150	190	9.1	Staggered	43	1.68	0.402

Road and Pedestrian Conflict Area		Luminance Criteria	Lamp Wattage	Input Wattage	Mounting Height	Arrangement	Spacing	Cost Index	UPD
Road	Pedestrian Conflict Area	(Cd/ m^2)			(m)		(m)		(W/m^2)
Collector 13.4m	High	0.8	250	300	9.1	Staggered	78	1.00	0.574
			150	190	9.1	Staggered	45	1.48	0.630
			100	130	9.1	Staggered	37	1.66	0.524
	Medium	0.6	250	300	9.1	Staggered	94	1.00	0.476
			150	190	9.1	Staggered	55	1.46	0.516
			100	130	9.1	Staggered	55	1.28	0.353
	Low	0.4	250	300	10.7	Staggered	125	1.00	0.358
			150	190	10.7	Staggered	80	1.22	0.354
			100	130	9.1	Staggered	74	1.21	0.262
Collector 14.8m	High	0.8	250	300	9.1	Staggered	74	1.00	0.548
			150	190	9.1	Staggered	44	1.27	0.584
			100	130	9.1	Staggered	35	1.42	0.502
	Medium	0.6	250	300	9.1	Staggered	98	1.00	0.414
			150	190	9.1	Staggered	55	1.46	0.467
			100	130	9.1	Staggered	47	1.56	0.374
	Low	0.4	250	300	10.7	Staggered	117	1.00	0.347
			150	190	10.7	Staggered	78	1.22	0.329
			100	130	9.1	Staggered	70	1.21	0.251
Local 8.7m	High	0.6	150	190	7.6	One side	39	1.00	0.560
			100	130	7.6	One side	34	1.01	0.439
			70	95	7.6	One side	25	1.24	0.437
	Medium	0.5	150	190	7.6	One side	39	1.35	0.560
			100	130	7.6	One side	46	1.00	0.325
			70	95	7.6	One side	29	1.42	0.377
	Low	0.3	150	190	10.7	One side	55	1.33	0.397
			100	130	9.1	One side	62	1.00	0.241
			70	95	9.1	One side	44	1.26	0.248
Local 11m	High	0.6	150	190	7.6	One side	37	1.00	0.467
			100	130	7.6	One side	31	1.00	0.381
			70	95	7.6	One side	22	1.32	0.393
	Medium	0.5	150	190	9.1	One side	39	1.06	0.443
			100	130	7.6	One side	37	1.00	0.319
			70	95	7.6	One side	27	1.25	0.320
	Low	0.3	150	190	9.1	One side	54	1.14	0.320
			100	130	9.1	One side	55	1.00	0.215
			70	95	9.1	One side	40	1.33	0.216

Note: Highlighted lines represent lowest $/m option

Table 5-9 Roadway Lighting Design by Luminance Method for LED Luminaires

Road and Pedestrian Conflict Area		Luminance Criteria	Nominal Lumens	Input Wattage	Mounting Height	Arrangement	Spacing	Cost Index	UPD
Road	Pedestrian Conflict Area	(Cd/ m^2)			(m)		(m)		(W/m^2)
Freeway “B” 2 lane (7.5m)	N/A	0.4	15000	75	10.7	One side	69	1.00	0.145
			8000	48	10.7	One side	42	1.57	0.152
			5500	46	9.1	One side	48	1.19	0.128
Freeway “B” 3 lane (11.25m)	N/A	0.4	15000	75	12.2	One side	73	1.00	0.091
			8000	48	10.7	One side	42	1.36	0.102
			5500	46	9.1	One side	41	1.24	0.100
Freeway “B” 4 lane (15m)	N/A	0.4	15000	75	12.2	Staggered	124	1.00	0.040
			8000	48	12.2	Staggered	73	1.62	0.044
			5500	46	9.1	Staggered	68	1.27	0.045
Major 13.4m	High	1.2	30000	180	10.7	Staggered	111	1.00	0.121
			15000	75	9.1	Staggered	55	1.36	0.102
			8000	48	9.1	Staggered	30	2.34	0.119
	Medium	0.9	30000	180	10.7	Staggered	112	1.00	0.120
			15000	75	9.1	Staggered	69	1.32	0.081
			8000	48	9.1	Staggered	40	2.24	0.090
	Low	0.6	30000	180	12.2	Staggered	147	1.00	0.091
			15000	75	10.7	Staggered	94	1.18	0.060
			8000	48	9.1	Staggered	55	1.85	0.065
Major 15.8m	High	1.2	30000	180	10.7	Staggered	77	1.00	0.148

			15000	75	9.1	Staggered	47	1.38	0.101
			8000	48	9.1	Staggered	28	2.06	0.108
	Medium	0.9	30000	180	12.2	Staggered	126	1.00	0.090
			15000	75	9.1	Staggered	62	1.35	0.077
			8000	48	9.1	Staggered	37	2.15	0.082
	Low	0.6	30000	180	13.7	Staggered	153	1.00	0.074
			15000	75	10.7	Staggered	87	1.37	0.055
			8000	48	9.1	Staggered	51	1.98	0.060
Major 22m	High	1.2	30000	180	10.7	Staggered	77	1.00	0.106
			15000	75	9.1	Staggered	36	1.76	0.095
			8000	48	9.1	Staggered	23	2.52	0.095
	Medium	0.9	30000	180	12.2	Staggered	100	1.00	0.082
			15000	75	9.1	Staggered	48	1.35	0.071
			8000	48	9.1	Staggered	31	1.97	0.070
	Low	0.6	30000	180	13.7	Staggered	123	1.00	0.067
			15000	75	12.2	Staggered	73	1.38	0.047
			8000	48	9.1	Staggered	43	1.78	0.051
Collector 13.4m	High	0.8	15000	75	9.1	Staggered	78	1.00	0.072
			8000	48	9.1	Staggered	45	1.67	0.080
			5500	46	9.1	Staggered	37	2.04	0.093
	Medium	0.6	15000	75	9.1	Staggered	94	1.00	0.060
			8000	48	9.1	Staggered	55	1.64	0.065
			5500	46	9.1	Staggered	55	1.57	0.062
	Low	0.4	15000	75	10.7	Staggered	125	1.00	0.045
			8000	48	10.7	Staggered	80	1.37	0.045
			5500	46	9.1	Staggered	74	1.46	0.046
Collector 14.8m	High	0.8	15000	75	9.1	Staggered	74	1.00	0.068
			8000	48	9.1	Staggered	44	1.43	0.074
			5500	46	9.1	Staggered	35	1.75	0.089
	Medium	0.6	15000	75	9.1	Staggered	98	1.00	0.052
			8000	48	9.1	Staggered	55	1.64	0.059
			5500	46	9.1	Staggered	47	1.92	0.066
	Low	0.4	15000	75	10.7	Staggered	117	1.00	0.043
			8000	48	10.7	Staggered	78	1.37	0.042
			5500	46	9.1	Staggered	70	1.46	0.044
Local 8.7m	High	0.6	8000	48	7.6	One side	39	1.00	0.141
			5500	46	7.6	One side	34	1.11	0.156
	Medium	0.5	8000	48	7.6	One side	39	1.23	0.141
			5500	46	7.6	One side	46	1.00	0.115
	Low	0.3	8000	48	10.7	One side	55	1.23	0.100
			5500	46	9.1	One side	62	1.00	0.085
Local 11m	High	0.6	8000	48	7.6	One side	37	1.00	0.118
			5500	46	7.6	One side	31	1.10	0.135
	Medium	0.5	8000	48	9.1	One side	39	1.00	0.112
			5500	46	7.6	One side	37	1.03	0.113
	Low	0.3	8000	48	9.1	One side	54	1.04	0.081
			5500	46	9.1	One side	55	1.00	0.076

Note: Highlighted lines represent lowest $/m option

5.4.10. Light Loss Factors

Light Loss Factors (LLF) are multiplier values to estimate the overall performance at different times during the life of the lighting system. LLF values reflect the performance of the lamp and luminaire as well as the maintenance level of a lighting system. The LLF are:

Lamp Lumen Depreciation (LLD)
Luminaire Dirt Depreciation (LDD)
Luminaire Ambient Temperature Factor (TF)
Ballast Factor (BF)
Equipment Factor (EF)

The Light Loss Factor can be summed up as: LLF = LLD x LDD x TF x BF x EF

LLD Lamp Lumen Depreciation (TAC 2-39)
LLD is the reduction in the light output as the lamp ages. The rated Lumens are provided by the manufacturer based upon 100 hours of usage. The can be shown as 'Lumen Depreciation curves". The typical LLD factor for high pressure sodium vapour based on 5 year maintenance group re-lamping program is 0.78. The LLD for LED luminaires is based off of the calculated lumen maintenance from IESNA TM-21 at the end of rated life. Based on the current material specs LS-5713, the minimum LLD is 0.85. This number may vary between suppliers.

LDD Luminaire Dirt Depreciation (TAC 2-40)
LDD takes into account the luminaire output depreciation due to an accumulation of dirt on the luminaire and in the air. The designer should 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 SaskPower is 0.88. TAC doesn't provide any values past the 5 year maintenance cycle so 0.88 is still used for LED luminaires, even though they don't require maintenance.

TF Luminaire Ambient Temperature Factor (TAC 2-42)
TF accounts for variations in lumen output based on ambient temperature. HPSV and LED luminaires are not affected significantly by ambient temperature, the TF adopted by SaskPower is 1.0.

BF Ballast Factor (TAC 2-42)
BF is meant to cover reductions in light output due to the ballast. For HID and LED sources it is assumed to be 1.0 unless otherwise noted by the manufacturer.

EF Equipment Factor (TAC 2-42)
EF is used to account for other reductions in light output due to the equipment used such as:

- manufacturing tolerances for both the luminaire and lamp
- luminaire depreciating over time (reflective surface)
- input voltage that varies from location to location

SaskPower has adopted an Equipment Factor of 0.95 for HPSV and 1.0 for LED.

Table 5-10 Light Loss Factors

Area	Light Source	Lamp Lumen depreciation (LLD)	Luminaire Dirt Depreciation (LDD)	Equipment Factor [2]	Total Light Loss Factor
General	HPSV	0.78[1]	0.88[1]	0.95	0.65
General	LED (Cobrahead)	0.85 Min.	0.88	1.0	0.75 Min.

Notes:

(1) Based upon a 5 year maintenance program.
(2) Effect of ambient temperature, voltage fluctuations, and the ballast and lamp factors.

LDD is based upon a clean area, if installing lights in an area that is prone to high pollution, an alternative factor must be applied to the calculation in order to determine the correct Total Light Loss Factor. See chart in TAC 2006 page 2-41.
LLD is based upon an approximate assumption of approximately 4,000 hours of usage per year. See TAC 2006 chart on page 2-40.

5.5. Luminaire Selection

5.5.1. Lateral Light Distribution

Lateral Light Distribution is the lighting pattern the luminaire puts out on the roadway. There are five types classified as Type I through V. With LED technology, there are essentially an unlimited amount of light distribution patterns available now and may not always fall into these five categories. These patterns are still a good starting point for the distribution pattern required, but the ultimate goal is to direct as much light onto the roadway surface as possible and wasting the least amount of light in other directions. For that reason, LED luminaires may not fit into these patterns all the time.

Type I – Usually used for median mounting.

Type I, Four Way – Mainly used for intersection lighting. This light provides four beams of light from one light standard. An uncommon item and not very popular, would be placed in middle of intersection for proper lighting.

Type II – Used to light the street front, not much light provided on the back side of the luminaire.

Type II, Four Way – Mainly used for intersection lighting. Provides four beams of light and is installed on a corner. This is an uncommon item and not very popular for lighting.

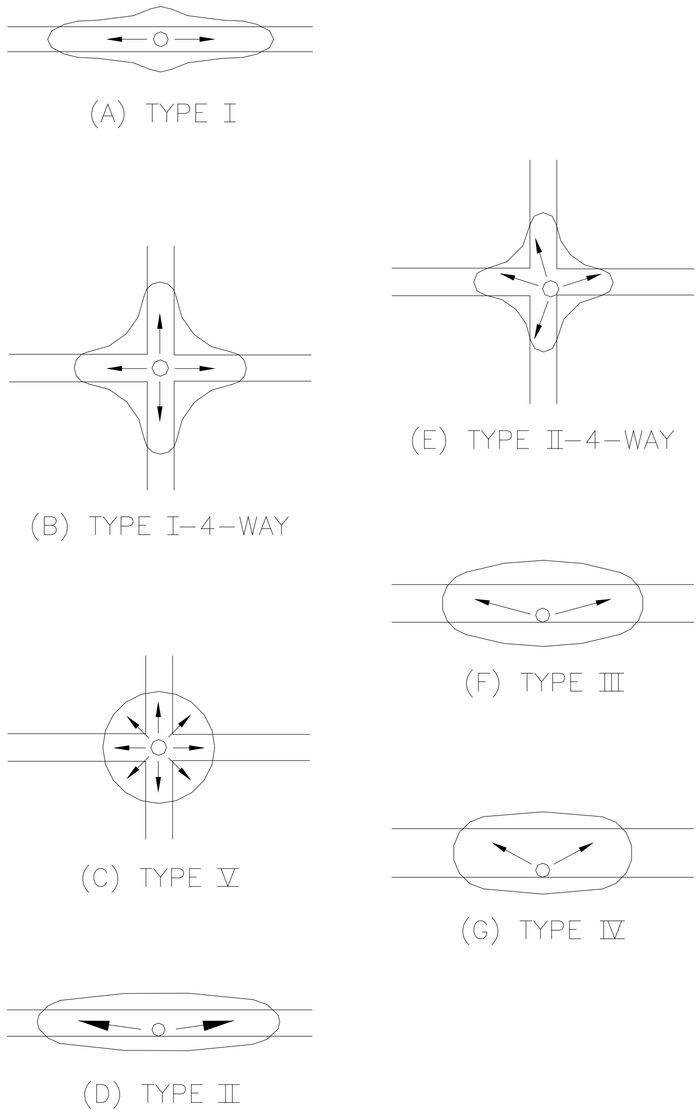
Type III – Provides the majority of light to the roadside of the luminaire while the backside does not project as much light.

Type IV – Provides the majority of light to the roadside of the luminaire while the backside does not project as much light. The Type IV puts light out further from the curb than a Type III.

Type V – Ideal to be installed in the center of the intersection and puts out a light pattern that is evenly dispersed around its axis.

Type V Quadrate – has a square form of light pattern around its axis.

Figure 5-9 IES Pattern Types



5.5.2. Vertical Light Distribution

Vertical light distribution is divided into three categories, Short, Medium and Long as illustrated in Figure 5-10. Classification is on the basis of the distance from the luminaire to where the beam of maximum candlepower strikes the roadway surface. The classifications are:

Short Distribution – The maximum candlepower beam strikes the roadway surface between 1.0 and 2.25 times mounting heights distance from the luminaire. See Figure 5-11.

Medium Distribution – The maximum candlepower beam strikes the roadway surface between 2.25 and 3.75 times mounting height distance from the luminaire.

Long Distribution – The maximum candlepower beam strikes the roadway surface between 3.75 and 6.0 times mounting height from the luminaire.

On the basis of the vertical light distribution, theoretical maximum candlepower beams from adjacent luminaires are joined on the roadway surface. With this assumption, the maximum spacing of luminaires are:

Short Distribution – 4.5 X mounting heights

Medium Distribution – 7.5 X mounting heights

Long Distribution – 12.0 X mounting heights

From a practical standpoint, the medium distribution is predominantly used in practice, and the spacing of luminaires normally does not exceed five to six times mounting heights. Short distribution is not used extensively for economic reasons, because extremely short spacing is required. At the other extreme, the long distribution is not used to any great extent because the high beam angle of maximum candlepower often produces glare.

Figure 5-10 Vertical Light Distribution

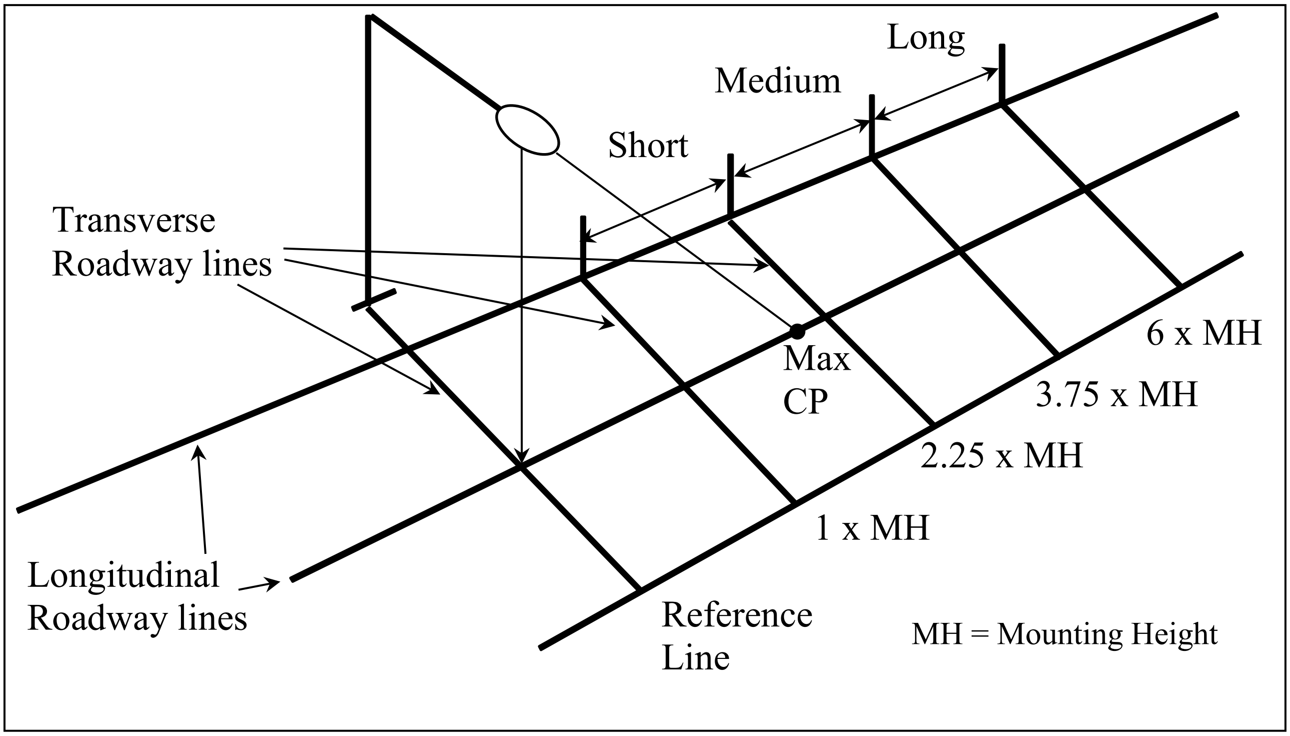


Figure 5-11 Half Maximum Candlepower Projection

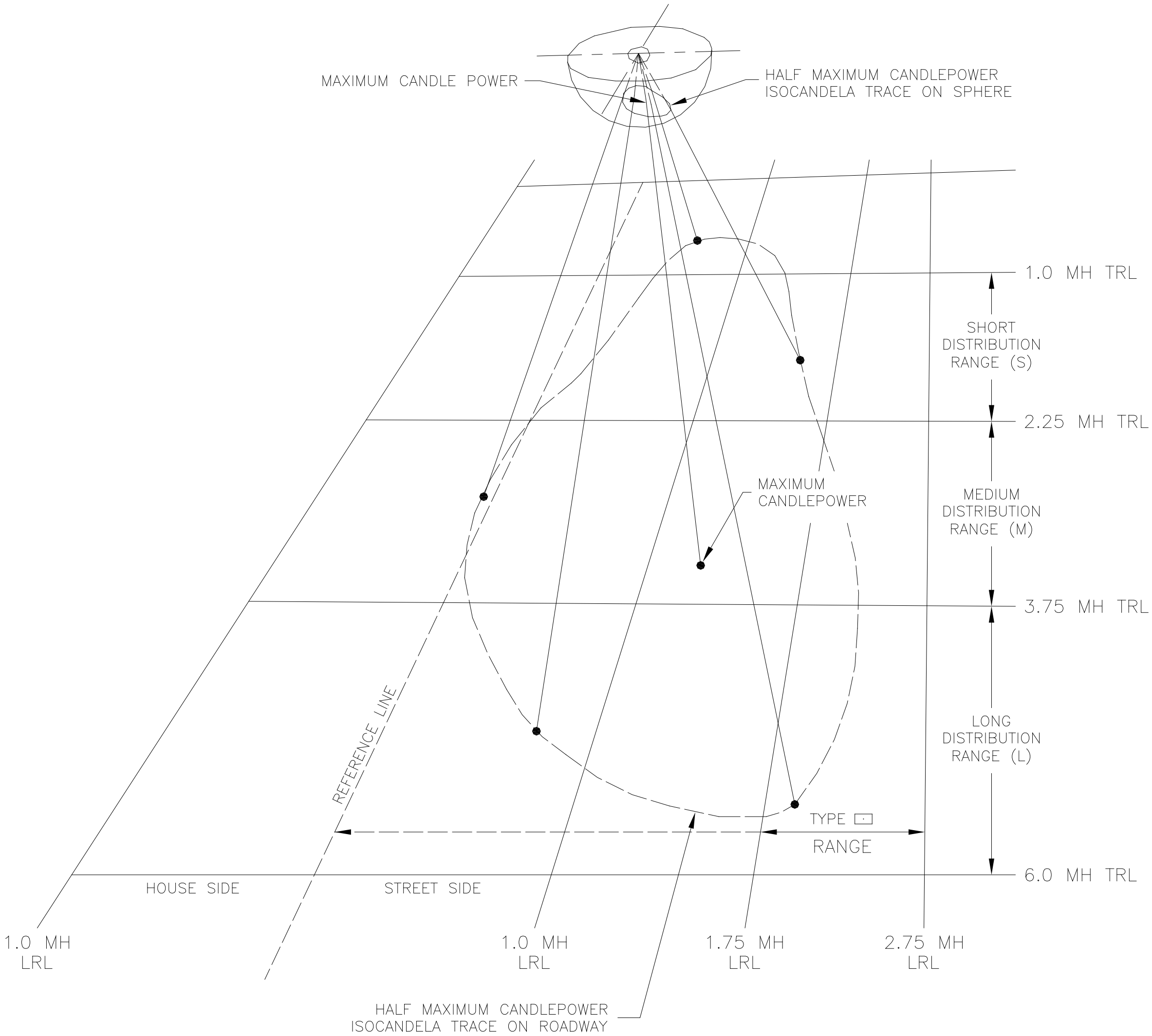
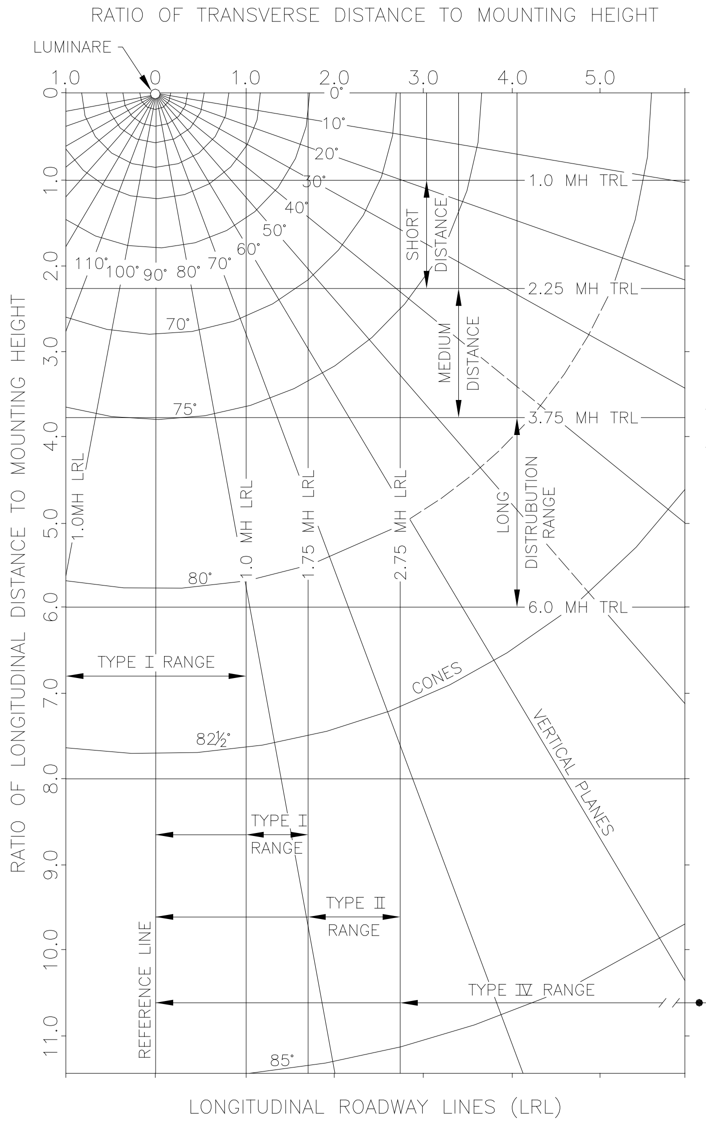


Figure 5-12 Lateral Light Distribution



5.5.3. Cutoff Optics

The amount of glare generated by a luminaire is strongly influenced by the intensity (candle-power) emitted at angles close to the horizontal. The cutoff classification is based on the intensity of rays emitted at 80-degrees and 90-degrees vertical angle. As the intensity of either of these angles will vary in different vertical planes for typical roadway luminaires, the maximum intensity considering all planes is used. (see TAC 2.8.1)

Non-Cutoff

- no intensity limits apply.
- are designed to allow for light to be emitted in all directions. These are the least efficient of the four types to light a roadway due to the amount of light pollution and glare they produce. Post-top lights without shrouds or shielding are often Non-Cutoff.

Semi-Cutoff

- are designed so that the intensity at 80 degrees vertical angle must not exceed 20% of the rated lamp lumens, and the intensity at 90 degrees must not exceed 5 % of the rated lamp lumens.
- are designed to allow the majority of light to be emitted below 90 degrees, with up to 5% allowed to be emitted above 90 degrees. The most common type of light that fits this description is the Cobrahead.

Cutoff

- has more controlled emitted light than semi-cutoff. Less than 2.5% of the emitted light is allowed to escape the fixture above 90 degrees. The light spread is greater than a full cutoff, and the spacing is not as far apart as a semi-cutoff.
- are designed so that the intensity at 80 degrees vertical angle must not exceed 10% of the rated lamp lumens, and the intensity at 90 degrees must not exceed 2.5% of the rated lamp lumens.

Full Cutoff

- are designed so that light will only hit the ground below with no light escaping above 90 degrees.
- are designed so that the intensity at 80 degrees vertical angle must not exceed 10% of the rated lamp lumens, and no light can be emitted at 90 degrees or above. Full cutoff normally requires that the luminaire have a flat bottom opening.
- Full Cutoff luminaires may have an International Dark Sky Fixture Seal of Approval (see section 5.2 Light Pollution).

Figure 5-13 Luminaire Cutoff Classification

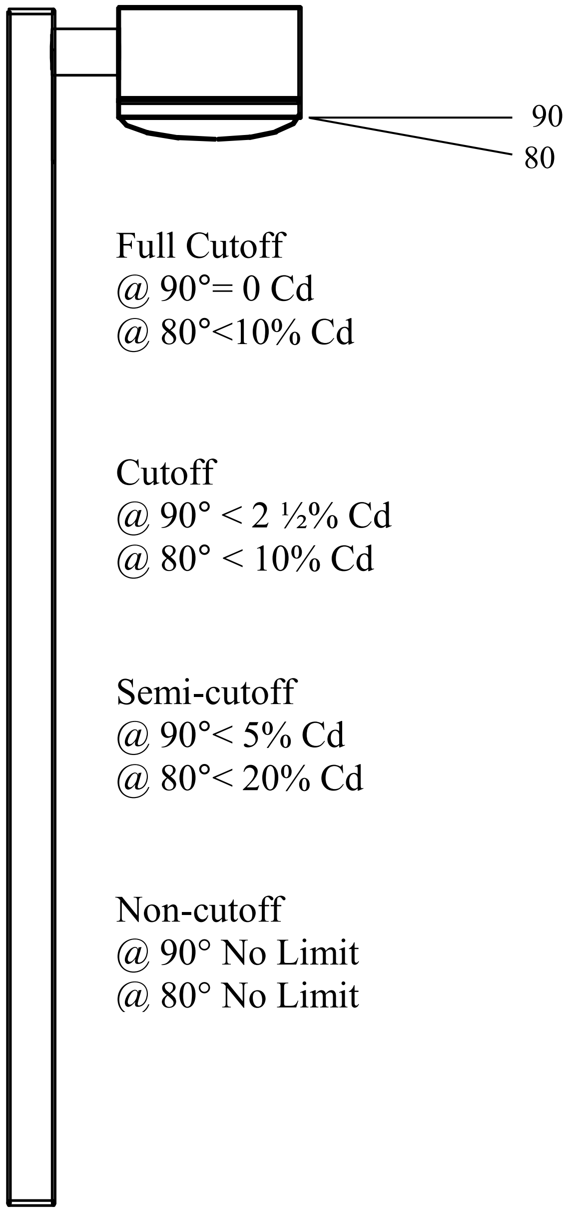


Figure 5-14 Reduction of Glare with Full Cutoff Luminaire

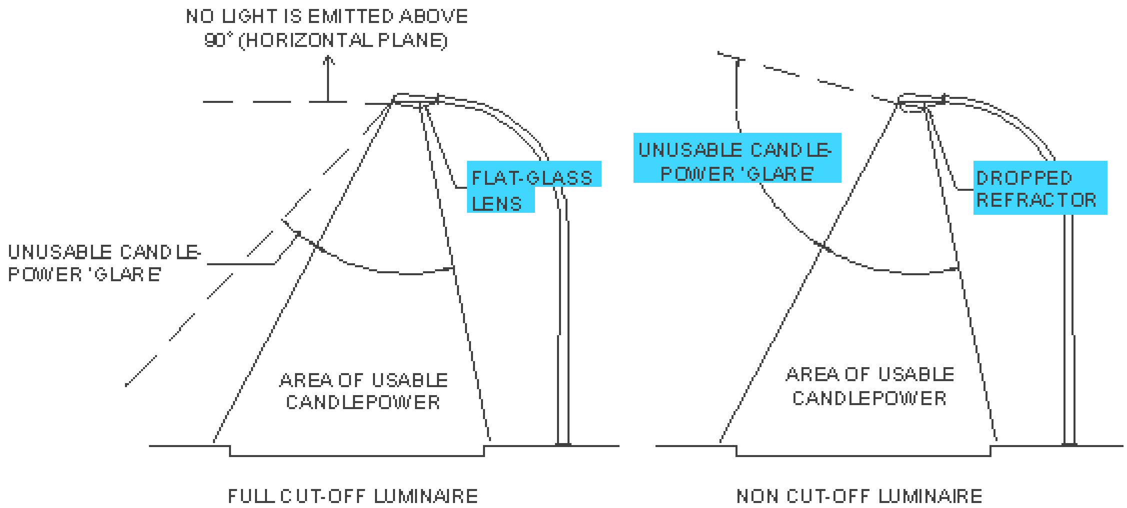
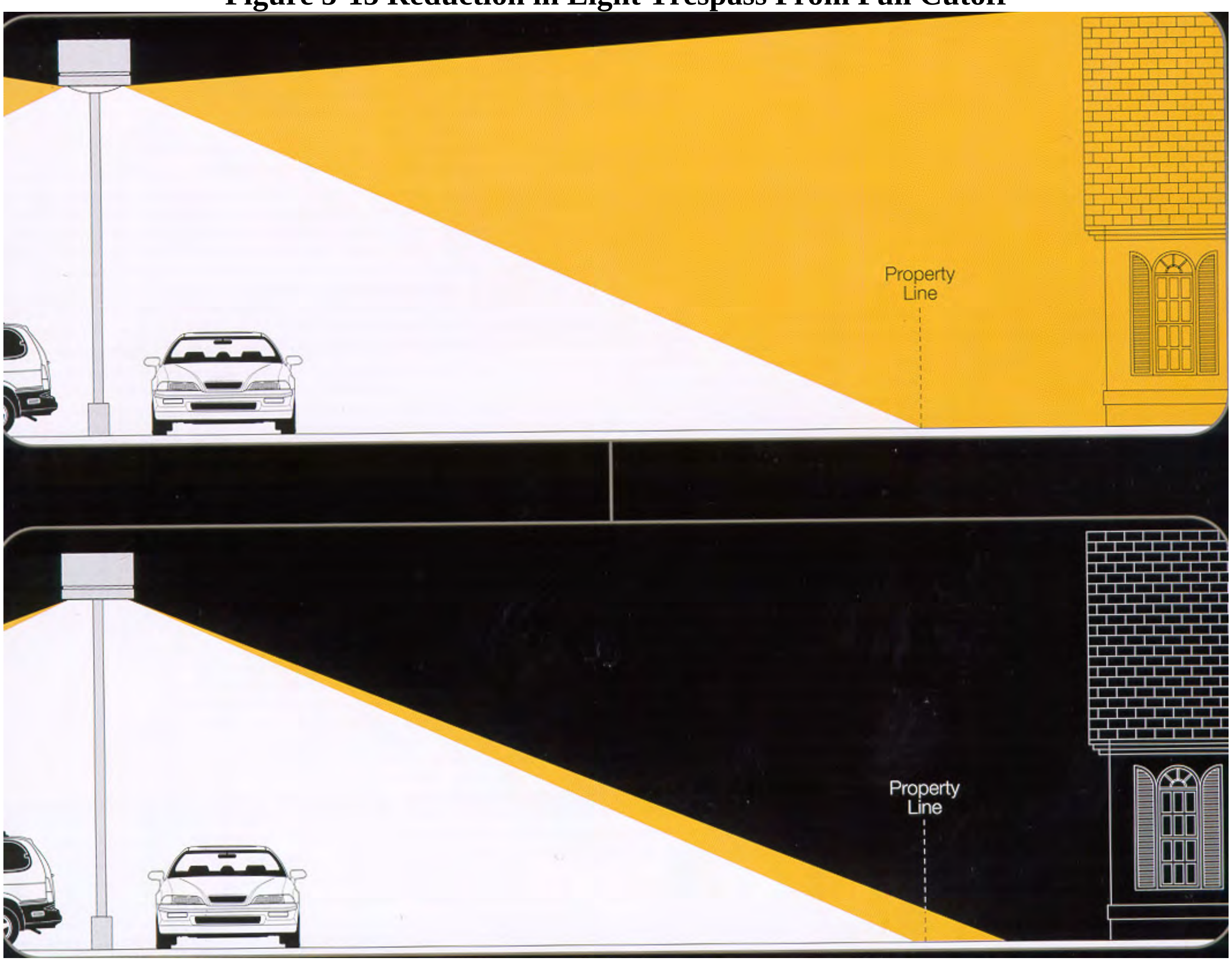


Figure 5-15 Reduction in Light Trespass From Full Cutoff

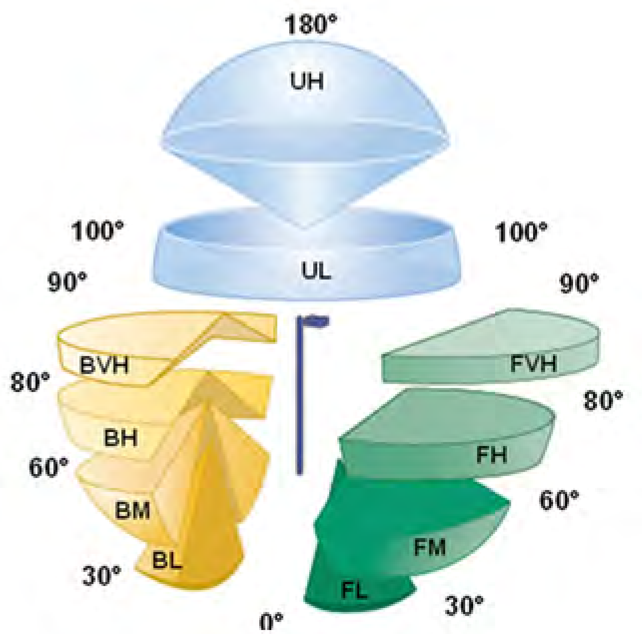


5.5.4. BUG Rating

The BUG system is the most recent way to classify a luminaire's optics and has been adopted by the IESNA. The BUG system has replaced the cutoff classifications described in section 5.5.3 although both classifications may still be used by suppliers, so it helps to understand each system. The IESNA has released a technical memorandum (TM-15) that explains these classifications in detail. A brief description will be given below.

BUG stands for "Backlight", "Uplight" and "Glare." The acronym describes the types of stray light escaping from an outdoor lighting luminaire. There are different zones that are used to determine where the light is distributed and how it affects each rating.

Figure 5-16 BUG Lighting Zones



Backlight, which creates light trespass onto adjacent sites. The B rating takes into account the amount of light in the BL, BM, BH and BVH zones, which are direction of the luminaire OPPOSITE from the area intended to be lighted.

Uplight, which causes artificial sky glow. Lower uplight (zone UL) causes the most sky glow and negatively affects professional and academic astronomy. Upper uplight (UH) is mostly energy waste. The U rating accounts the amount of light into the upper hemisphere with greater concern for the lower uplight angles in UL.

Glare, which can be annoying or visually disabling. The G rating takes into account the amount of frontlight in the FH and FVH zones as well as BH and BVH zones.

The BUG system takes all the lighting zones into consideration and uses tables to determine what the BUG rating will be. The BUG rating will then be listed in terms of a number between 0 and 5, with 0 being the lowest and 5 being the highest. Ultimately we would prefer to see the lowest values for all three ratings in order to reduce light pollution. For more in-depth information on calculating these, refer to IES TM-15.

In order for a luminaire to be considered ‘full-cutoff’ in the BUG system, the U rating must be 0 to designate zero uplight. These values should be available from the luminaire supplier and can be found in the luminaires IES file as well.

5.5.5. Lighting Sources

High Pressure Sodium (HPS) lamps, a member of the high intensity discharge (HID) lamp family, are the most efficient white light source commercially available today. HPS lamps were developed and introduced in 1968 as energy-efficient source for exterior, security and industrial lighting applications and are particularly prevalent in street lighting applications. Due to their high efficiency and long life, today’s HPS lamps are also suitable for many interior applications, particularly where color rendering is not a crucial concern. HPS lamps are offered in sizes ranging from 35 to 1000 watts. Efficacies are between 70 to 120 lumens/watt (including ballast), increasing with wattage. Electronic ballasts, under development, could provide a small increase in system efficacy. Lamp life is typically 24,000 hours or 6 years. The Color Rendering Index (CRI) for HPS is 25.

Metal Halide (MH) Lamps are also a member of the high intensity discharge (HID) lamp family. Compared to other lighting sources such as incandescent or high-output fluorescent, they have significantly higher efficiency and longer lives. Among HID lamps, metal halide lamps are not the most energy efficient but the produce the whitest light with the best color rendition, and are generally selected for that characteristic. Like most HID Lamps, Metal Halide lamps are slow to start and restart. The two primary types of metal halide lighting are standard and pulse-start. The pulse-start type is more efficient, starts more quickly, and starts more reliably in cold spaces and stabilizes color rendition over time. Efficacies are between 60 and 100 lumens/watt. Lamp life is typically 12,000 hours or 3 years based on 4,000 burning hours/year. The color rendering index is 80.

Induction light is a light source in which the power required to generate light is transferred from outside the lamp envelope to inside via electromagnetic fields, in contrast with a typical electrical lamp that uses electrical connections through the lamp envelope to transfer power. There are three advantages of eliminating electrodes:

- Extended lamp life, because the electrodes are usually the limiting factor in lamp life.
- The ability to use light-generating substances of higher efficiency that would react with metal electrodes in normal lamps.
- Improved collection efficiency because the source can be made very small without shortening life, a problem in electroded lamps

Luminous efficacy is between 70 and 90 lumens/watt and excellent light quality. Luminaire system life expectancy is rated at 60,000 hours or about 15 years based on 4000 burning hrs/year. The color rendering index is 80.

Light Emitting Diode (LED) is a type of solid-state device that emits a light when a voltage is applied. They use semiconducting materials that combine in a way to release energy in the form of visible light. LED technology has been constantly improving and becoming more efficient as the industry continues to research new ways to manufacture LEDs and control the light distribution through various optic systems. They have now become a viable option as a replacement for HPS luminaires and are now the new standard for street lighting going forward at SaskPower. LEDs used in roadway applications come in a variety of different color correlated temperatures (CCT) ranging from 3000K to 5000K. At higher CCT values, the efficiency of the LEDs is usually higher, but the glare also tends to go up. Luminous efficacy is between 90 to 120 lumens/watt although this continues to improve. Luminaire life expectancy is around 100,000 hours or 25 years based on 4000 burning hours per year. The color rendering index is minimum 70.

5.5.6. SaskPower Luminaire Models

The luminaires currently available for SaskPower lighting installation/designs are identified below. Only full cutoff luminaires are to be used for new construction.

Figure 5-17 HPSV Cobra Head (Semi-Cutoff Lens)

Figure 5-18 HPSV Cobra Head (Full Cutoff Lens)

Figure 5-19 LED Cobra Head

Table 5-11 SaskPower HPSV Cobrahead Luminaires

Item Code	Manufacturer Model Number: American Electric *Cooper Lighting*	Wattage	Light Distribution	IES TYPE
3 42 07*	115 07S CT 120 R2 DPCS *OVZ70SCF2E4PSASK*	70 w	Semi-Cutoff	II
3 42 08*	115 07S CT 120 RX DGCS *OVZ70SCF2E4PASASK*	70 w	Semi-Cutoff	II- 4 way
3 42 10*	115 10S CT DT1 R2 DPCS *OVZ10SCF2E4PSASK*	100 w	Semi-Cutoff	II
3 42 11	115 10S CT DT1 R2 FGCS *OVH10SCF2D4GA-SASK*	100 w	Full Cutoff	II
3 42 15*	115 15S CT DT1R3DP *OVZ15SCF3E4PASASK*	150 w	Semi-Cutoff	III
3 42 16	115 15S CT DT1 R3 FG CS *OVH15SCF3D4GA-SASK*	150 w	Full Cutoff	III
3 42 25*	125 25S CT DT1 R3 DGCS *OVZ25SCF3E4GASASK*	250 w	Semi-Cutoff	III
3 42 26	125 25S CT DT1 R3 FG CS	250 w	Full Cutoff	III
3 42 40*	125 40S CT DT1 R3 DG CS *OVX40SWF3E4GSASK*	400 w	Semi-Cutoff	III
3 42 41	125 40S CT DT1 R3 FG	400 w	Full Cutoff	III

*Not for new construction due to uplight

Table 5-12 SaskPower Metal Halide Cobrahead Luminaires

Item Code	Manufacturer Model Number: American Electric *Cooper Lighting*	Wattage	Light Distribution	IES TYPE
3 42 27	125 25M CA MT1 R3 FGCS *OVH25MWF3D4AU*	250 w	Full Cutoff	III

Table 5-13 SaskPower LED Cobrahead Luminaires

Item Code	Manufacturer Model Number:	Lumen Output	Light Distribution	IES TYPE
3 42 12	Leotek GCJ1-20H-MV-WW-2R-GY-700-PCR7-WL-RWG	5500 lm	Full Cutoff	II
3 42 17	Leotek GCM2-30H-MV-WW-3R-GY-530-PCR7-WL-RWG	8000 lm	Full Cutoff	III
3 42 28	LED Roadway Lighting LH-16S-5-7-2ES-3-S-GY-3-UL-2-S-B-0381	15000 lm	Full Cutoff	III
3 42 42	LED Roadway Lighting L0-60M-5-7-2ES-9-S-GY-3-UL-2-S-B-0381	30000 lm	Full Cutoff	III

Figure 5-20 Sentinel Luminaire

(3 43 46 , 3 43 50)

Table 5-14 HPSV Sentinel Luminaires

Item Code	Manufacturer Model Number: American Electric *Cooper Lighting*	Wattage	IES TYPE
3 43 46*	DTD 07S CA MT1 R3 BP CS NL *VAN70SW233-SASK*	70 w	III
3 43 50*	DTD 10S CA MT1 R3 BP CS NL *VAN10SW233-SASK*	100 w	III

*Not for new construction due to uplight

Figure 5-21 Post Top Luminaires

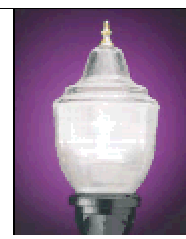
					
Colonial (3 43 10) Not for new construction	Washington (3 43 15, 3 43 30) Not for new construction	Accessory Ribs Bands and Medallions for Washington (3 43 40) Not for new construction	Arlington (3 43 20, 3 43 35) Not for new construction	Acorn (3 43 16, 3 43 31, 3 43 42) Not for new construction	LED Acorn (3 43 41) Not for new construction

Table 5-15 Post Top Luminaires

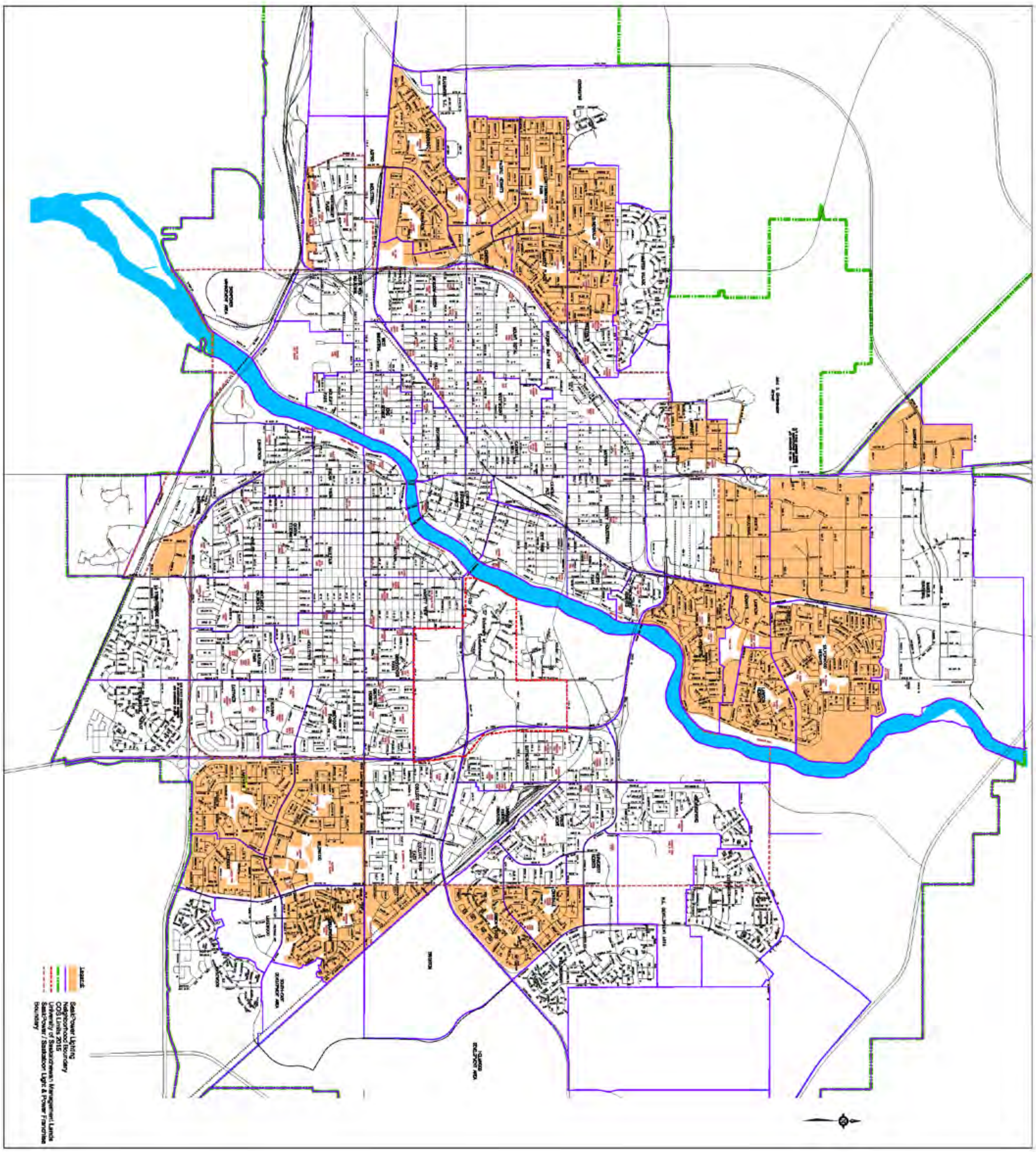
Item Code	Manufacturer and Model Number	Wattage	Description	IES Type
3 43 10*	American Electric 24520SCA-120R5PYBKT2RSCF Cooper - MPW10SH25547	100 w	HPSV - Post Top – Colonial	II
3 43 15*	Holophane Lighting AWU15AHP12B3NCUHPTR	150 w	HPSV - Post Top Washington	III
3 43 16*	King Luminaire K425R-EAR-III-150W(MOG)-HPS-120-K24-PR-HSS	150 w	HPSV - Post Top Acorn	III
3 43 20*	Holophane Lighting ARU15AHP12BA3SHP	150 w	HPSV - Post Top Arlington	III
3 43 30*	Holophane Lighting AWU175WMH12BA3H	175 w	MH - Post Top Washington	III
3 43 31*	King Luminaire K425R-EAR-III-175W(MOG)-MH-120-K24-PR-HSS	175 w	MH - Post Top Acorn	III
3 43 35*	Holophane Lighting ARU175WMH12BA3H	175 w	MH - Post Top Arlington	III
3 43 42*	King Luminaire K424R-EAR-III-165-IND-120-K14-TR	165 w	Induction - Post Top Acorn	III

*Not for new construction due to uplight

The IES file for a given fixture will be named by the code number (eg 34207.ies) All IES files for stock coded luminaires can be found in
R:\TD\Field Services Shared\Distribution Standards\Photometric Files.

5.6. Saskatoon Franchise Area

SaskPower provides street lighting to the majority of the province and maintains the lighting. In Saskatoon, there is a portion of the city where the street lights are owned and maintained by the City of Saskatoon. See the franchise map for locations where SaskPower owns lights throughout Saskatoon. Double click on the map below when viewing this document digitally to zoom in on the map clearly.



6. Streetlight Mounting Options

6.1. Streetlight Poles

Table 6-1 shows the effective mounting heights for steel davit arms mounted on wood poles as per CSM A-20-05. Note that pole keys are to be used for overhead spans greater than 25m (code 1 01 92).

Table 6-1 Wood Pole Mounting Heights

Pole Length	Setting Depth	Height of Pole Top	Attachment Point *	Arm Rise **	Mounting Height
30' (9.1m)	5' (1.5m)	25' (7.6m)	1' (0.3m)	5' (1.5m)	29' (8.8m)
35' (10.6m)	5.5' (1.7m)	29.5' (9.0m)	1' (0.3m)	5' (1.5m)	33.5' (10.2m)
40' (12.2m)	6' (1.8m)	34' (10.4m)	1' (0.3m)	5' (1.5m)	38' (11.6m)
45' (13.7m)	6.5' (2.0m)	38.5' (11.7m)	1' (0.3m)	5' (1.5m)	42.5' (12.9m)

*Attachment Point is measured down from top of pole.
** Assuming 3.0m (10') Streetlight Bracket (3 05 30)
If using Sentinel luminaire (3 43 46 or 3 43 50) or 0.6m (2') Streetlight Bracket (30502) the mounting height is effectively the height of the pole top.
Mounting Height = Height of pole top - point of attachment + arm rise

Table 6-2 shows the mounting heights for steel and concrete poles, and corresponding precast bases and break-away bases (where required) as per CSM B-20-25, B-20-41 and B-20-42. Installation of the precast bases and breakaway bases is shown on CSM B-20-15.

Table 6-2 Steel and Concrete Standard Mounting Heights

	Poles	Height	Code #	Precast Base	Break-away Base
Single Davit	Galvanized Steel	7.6m (25')	36026	39000	39010
		9.1m (30')	36031	39000	39010
		10.7m (35')	36037	39000	39010
		12.2m (40')	36141	39002	39012
		13.7m (45')	36146	39002	39012
	Green	7.6m (25')	36025*	39000	39010
		9.1m (30')	36030*	39000	39010
		10.7m (35')	36035*	39000	39010
		12.2m (40')	36140*	39002	39012
		13.7m (45')	36145*	39002	39012
	Self Weathering	10.7m (35')	36036*	39000	39010
Double Davit	Galvanized Steel	9.1m (30')	36032	39000	39010
		10.7m (35')	36038	39000	39010
		12.2m (40')	36142	39002	39012
		13.7m (45')	36147	39002	39012

Post Top	Black	4.28m (14')	36014	39000	39010
	Self Weathering	4.28m (14')	36015*	39000	39010
Decorative	Black Steel	4.88m (16')	36016	39000	39010
	Black Concrete	4.88m (16')	36156	Included	N/A
Shroud	Trillium		36020		
	Florentine		36021		
* These items are not for new construction Note: one must factor in any ground level difference between the streetlight base and the top of the road surface.					

6.2. Breakaway Bases

Breakaway bases consist of safety devices installed between the pole base plate and the concrete base, allowing the pole to break away when impacted by a vehicle. They consist of a reaction plate with couplers that have a designed weak point in the form of a machined groove. The coupler will shear off at the groove when struck with sufficient force.

Breakaway bases must only be used where there is sufficient room for the pole to fall or not impact other structures or traffic lanes in the event of a collision. They are typically used on davit-style poles up to 18m high.

Based on the departure angle of an errant vehicle (20 degrees), the minimum light pole offset for a breakaway base pole should be approximately one third of the pole height to lessen the potential of the pole falling into the travel lane. Breakaway bases are typically used on poles located within the clear zone see section 7.2.

7. Physical Layout Considerations

7.1. Streetlight Placement

Determining an appropriate physical location for the streetlight pole depends on a number of often conflicting requirements. The lighting 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.

The developer should provide a drawing of the proposed subdivision showing all pertinent structures including water and sewer lines, catch basins, fire hydrants, lot lines and proposed locations of driveways.

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.

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 lighting design. Where large multifamily units are planned, placement of streetlight poles between lot lines may be necessary.

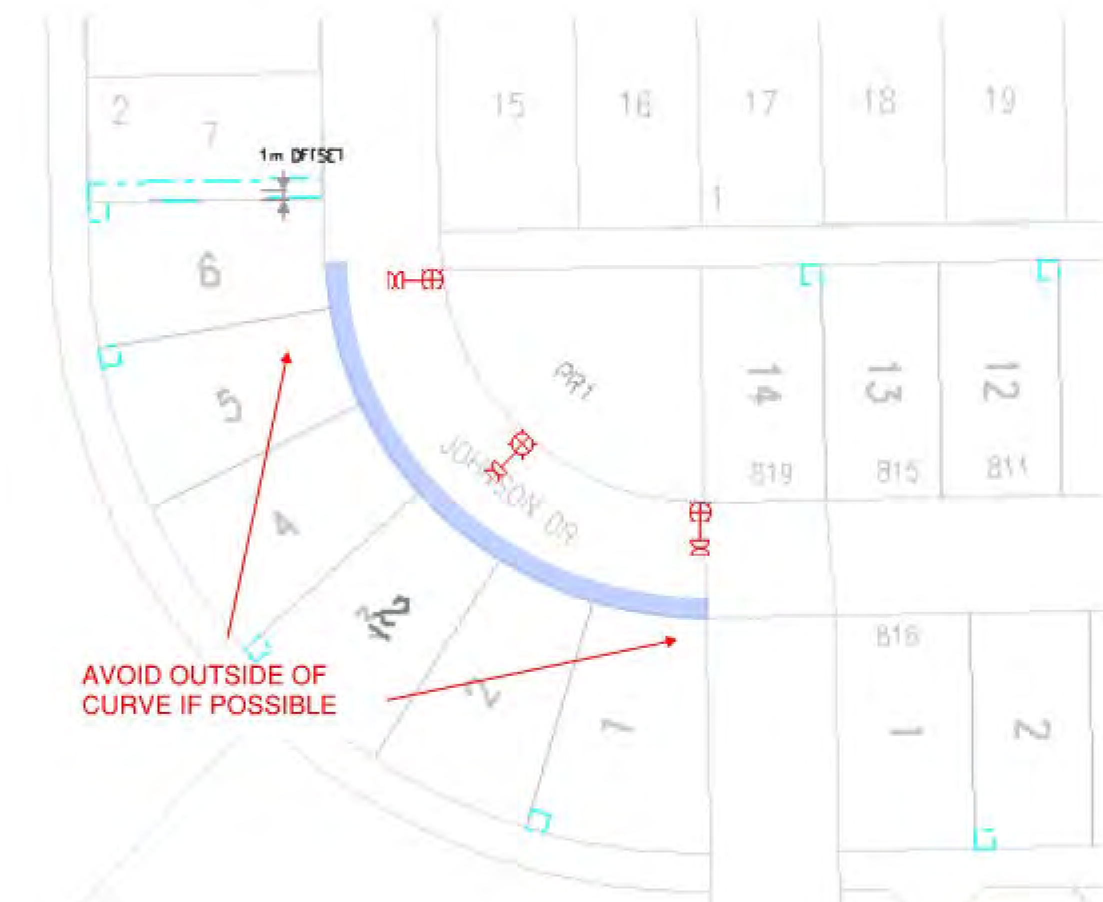
Driveways are often designed to be adjacent to one another, streetlights should not be placed between them, but moved to the next lot line where there is no driveway.
Placement of street lights near fire hydrants and catch basins should be avoided. This is to mitigate conflicts that may occur should excavation be required to repair hydrants or drains in the future. This should also be considered when placing underground conductors.

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

Underground feeds should originate from a pedestal, or transformer, located at the end of the block, on the same side of the road as the street lights. Side lot easements should be avoided. Street crossings with underground conductors should be avoided. If a two sided lighting arrangement is used, the lights should be fed from conductors running on both sides of the road. When road crossings are required, they should cross the road adjacent to an intersection and cross perpendicular to the roadway. Angled, or diagonal crossings are not permitted. All concrete or asphalt road crossings should be installed in duct (2”) to allow for easier future maintenance without having to dig up the road.

Any underground feeds between decorative or post top standards shall be included in duct (2”). In the event of a cable failure, it is not possible to string temporary overhead wiring and including duct allows for another cable to be pulled much easier. Duct shall be run between lights and stub up to the 2” poly pipe in the concrete base. A coupler may be required to connect the poly pipe to the duct. For concrete decorative poles, the duct can be run directly into the base and no coupler is required.

Installations on the outside of a curve should 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.



7.2. Clear Zone

The clear zone is defined as the area adjacent to the roadway which is to be kept clear of fixed objects. Its purpose is to minimize the risk of vehicles leaving the road striking the object, and causing significant harm to passengers and vehicles.

Determining the clear zone is a complex calculation based on several factors, including traffic speed and volume and road geometry. The *TAC Geometric Design Guide for Canadian Roads* has the calculation methodology for determining the clear zone. Many of these factors would have to be provided by the local municipality. In most cases, however, these calculations are unnecessary for the poles that SaskPower installs as discussed below.

On local streets, with low speed limits (60 km/hr or less), parking lanes, and sidewalks, the clear zone is typically only 2.5m meters, and easily achievable, so no further consideration is necessary.

On roadways with speed limits equal to or greater than 70 km/hr, the clear zone will be several meters. With the luminaires that SaskPower uses, many streetlight poles need to be installed within the clear zone and the danger from being struck by vehicles needs to be mitigated. There are several solutions proposed in TAC, but SaskPower utilizes breakaway bases (see section 6.2) on our steel streetlight poles. Concrete and wood streetlight poles which are direct embedded must be either located outside the clear zone, or some other method of protection must be utilized, such as traffic barriers or crash cushions. As of the writing of this document, the only concrete streetlight poles SaskPower utilizes are post-top style which are typically only used on local streets and outside of the clear zone.

There are a couple situations where the use of breakaway bases needs further consideration. One is the possibility of pedestrian traffic. A streetlight pole on a breakaway base that is struck by a vehicle leaving a roadway may then strike a pedestrian. Roadways with speeds greater than or equal to 70km/hr typically have limited pedestrian access, so this may not be a concern.

Another situation is for poles mounted in the median, where there is a possibility of a pole falling into the traffic lane on the opposite side and must be avoided.

If either of these situations arises, the lighting designer should consult with the local municipality to evaluate the situation and develop solutions. These may be to establish what the clear zone is, and locate the streetlight outside of the zone, or to have the municipality install traffic barriers.

7.3. Clearances

For future maintenance and operations of the streetlights, and to minimize damage from the activities of others it is important to maintain certain minimum separations or clearances. In addition to SaskPower's clearance requirements, the Municipality may also have requirements. To determine the proper clearance, both SaskPower and if available, the Municipality's clearance standard must be considered. The proper clearance to be used is the greatest between the two. For example, if the SaskPower clearance is 1.0m and the Municipality's is 3.0m, use the 3.0m clearance.

Table 7-1 shows the clearances required from streetlight facilities to other objects. See also CSM sections C-24-02 and C-26-02 for other clearance requirements.

Table 7-1 Streetlight Clearances

	STREET LIGHT BASE	STREET LIGHT CABLE
Fire Hydrants	1.0m	1.0m
Pedestals	1.0m	1.0m
Misc. above ground facilities	1.0m	1.0m
Curbs/sidewalks	0.6m*	1.0m
Roadway without curbs/sidewalks	1.5m*	1.0m
Buried high voltage cables	1.0m	n/a
Property pins	1.0m	1.0m
Streetlight base	n/a	0.5m
Residential Driveway	1.0m	n/a
Commercial Driveway	3.0m	n/a

* See also section 7.2 Clear Zone

In addition to these separations the following should also be followed:

For maintenance reasons, there must be a separation of 0.6m from the edge of the sidewalk/curb to the streetlight pole. Greater offset is desirable, particularly where there is a probability of snowplows clearing snow in the winter.

This 0.6m offset may not be feasible in downtown areas, or where sidewalk extends all the way to a building. Wherever this cannot be implemented, check with the Municipality for their requirements.

8. Electrical Design

8.1. Streetlight Power Supply

The supply for a streetlight may be from either an overhead transformer (see CSM B-20-21) or underground transformer or a service pedestal (see CSM B-20-35).

A maximum of three connections can be made in a streetlight (ie: one circuit coming in and two may branch out to feed lights in different directions).

The voltage drop is not to be more than 8% (as per URD voltage drop spreadsheet).

SaskPower luminaires are designed for use at 120V or 240V, and are configured for 120V operation when shipped. LED luminaires are typically capable of self-adjustment and no wiring changes are required to switch between 120V and 240V.

8.2. Fusing/Protection

All street light supplies are to be fused at either the transformer or the pedestal where the power supply to the circuit is being provided.

Fusing at each luminaire is to be a (3 45 51) inline fuse holder with (3 45 50) 6 amp fuse. Any problems on an existing streetlight fuse should be replaced with this new fuse holder and fuse. See CSM A-20-04, A-20-05, B-20-16

Fusing of overhead streetlight feeds, if required, should be at the source point. Use a 30 amp fuse (7 53 30) and weatherproof fuse holder (71 01 10). See CSM B-20-21.

Fusing at a supply pedestal requires a 30 amp fuse holder (71 01 10) and 30 amp fuse cartridge (7 53 30) as default. Refer to B-20-35 for mounting of fuse holder in the pedestal. Below are some additional fuse sizes if required. If using larger than a 30A fuse, a larger fuse holder (71 01 25) will be required.

Table 8-1 Fuses and Fuseholders

Item #	Use with	Amps
7 53 02	C30A Holder	2
7 53 04	C30A Holder	4
7 53 06	C30A Holder	6
7 53 10	C30A Holder	10
7 53 15	C30A Holder	15
7 53 20	C30A Holder	20
7 53 30	**C30A Holder**	**30**
7 53 50	C60A Holder	50
7 53 60	C60A Holder	60

8.3. Specifications

Table 8-2 shows the maximum operating current for HPS luminaires. This can be used to determine the appropriate feeder cables for a given section of streetlights. Supply current for other types of luminaires to be determined from the manufacturer.

Table 8-2 Maximum Luminaire Operating Current HPSV

	HIGH PRESSURE SODIUM VAPOUR				
LUMINAIRE TYPE	**70 W**	**100W**	**150W**	**250W**	**400W**
120V	0.85	1.16	1.70	2.80	4.20
240V	0.43	0.58	0.85	1.40	2.10

Taken from CSM A-20-00
Note: See section A-22, Service Drops, for voltage drop information and allowable length of street light supply conductors.

The maximum operating current for LED luminaires doesn't include any additional factors and is calculated easily by Ohm's law. The input wattage of the luminaire will be listed on a label on the outside of the luminaire as well as on the internal nameplate. Divide the wattage by the input voltage to obtain the current draw of the luminaire.
Some typical wattages are listed below. These values are to be used for reference purposes only. Confirm the wattage of the luminaire prior to design as the wattage is not always consistent for all LED luminaires.

Table 8-3 Maximum Luminaire Operating Current LED

LUMINAIRE TYPE	5500Lm (46W)	8000Lm (48W)	15000Lm (75W)	30000Lm (180W)
120V	0.38	0.4	0.63	1.5
240V	0.19	0.2	0.31	0.75

Table 8-4 and Table 8-5 show the properties of the buried and aerial cables used as streetlight feeder cables. SaskPower uses a #12 duplex cable (stock code 3 12 14) to individual streetlight luminaires for all types of streetlight installations (steel, concrete and wood poles).

Table 8-4 Secondary Buried Cable Ampacities

Stock Code	Description	Direct Buried 100% LF amps	In Duct 100% LF amps
2 94 51	2 x #4	145	125
2 94 62	3 x #2	150	130
2 94 64	3 x 1/0	200	175

Taken from CSM B-22-11

Table 8-5 Aerial Insulated Secondary Conductor Electrical Properties

CONDUCTOR - NEUTRAL	CODE NO.	AMPACITY (AMPS)	R_{AC} PHASE OHMS/Km	R_{AC} NEUTRAL OHMS/Km
#6 AL Duplex - #6 ACSR	3 12 02	92	2.692	2.461
#4 AL Triplex - #6 ACSR	5 38 03	97	1.692	2.461
1/0 AL Triplex - #2 ACSR	5 38 17	169	0.6692	1.013

Taken from CSM C-24-04.03

9. Decorations on Streetlight Poles

Frequently municipalities and other groups desire to attach decorations such as flags, flower pots, and seasonal lighting on streetlight poles. The rules regarding such attachments are contained in Directive 08-00 in the SaskPower Business Administration Manual and SaskPower CSM B-20-27.

10. Appendix A: LED Luminaire Conversion Design Guide

10.1. Introduction & Background

10.1.1. Purpose

The purpose of this document is to provide Distribution Engineering with a design guideline for brownfield (existing) streetlight conversion from high pressure sodium vapour (HPSV) luminaires to LED luminaires. It is recognized that it would be a large engineering effort to assess the lighting adequacy of every legacy streetlight installation in the province in advance of a bulk conversion deployment, and therefore would not be feasible to complete without severely hampering SaskPower's ability to deploy and take advantage of the benefits.

The information within this document is intended to be used to define the engineering assessment areas to focus on for each deployment project, which is driven by the balance between SaskPower's risk tolerance and a desire to obtain the economic and environmental benefits. This criterion shall then be used to achieve a design that is economical and cost-effective, while maintaining a focus on public safety.

10.1.2. Background, Business Case

Many utilities and municipalities across the world are in the process of implementing Light Emitting Diode (L.E.D.) technology into their streetlighting infrastructure. This is being driven by the opportunity to achieve significant energy and maintenance savings when compared to traditionally used luminaires.
In North America, the typical electricity consumption for roadway streetlighting is made up of 20-30% of the municipalities cost. To date, in the province of Saskatchewan alone we have over 97,000 streetlights where energy costs, maintenance and generation efforts are being consumed. The anticipated lifecycle cost savings of an LED luminaire relative to conventional high pressure sodium vapour luminaire ranges from $400-700 depending on the luminaire. For SaskPower's streetlight inventory it is expected that approximately 4.5MW of demand savings, 39.7MW.hrs of energy savings, and a total life cycle cost savings of $44.5M can be achieved. Furthermore, this helps SaskPower reduce its carbon footprint along with additional environmental benefits due to less vehicle operating hours (maintenance time) and less lighting materials such as lamps and photoeyes in our landfills.
The ability to have adaptive streetlight control technology with L.E.D. luminaires can add to the benefits of this lighting strategy by providing asset management, operation and service response for each streetlight. The use of dimming controls can extend the life of the luminaire components and support additional energy savings of 50% - 70% on average over conventional HPSV lighting.

10.1.3. Present day Standards

Saskpower uses Standard Engineering Practices documentation to help guide the streetlight design from scratch. The SEP 4 documentation covers all the streetlight design practices and is available to all users and engineering staff as required. The user should reference this design standard as required while completing their bulk conversion design, however this document will govern. A brief overview description is to design the roadway based on size, location and installation design options.

There are mainly basic principles to consider when doing a lighting design. Safety, security and the amount of light trespass are just a few of the principles are listed in the *SEP4* document to provide uniformity and consistency in the streetlight design.
The Classification of Roadways and their Recommended Luminance Light Levels as per IESNA RP-8-14 and TAC- 2006 –Guide for the Design of Roadway Lighting are also standards referenced within the SEP4 engineering standard.

Lighting photometric software tools are to be used to create and simulate proper lighting levels, layout, wattages and rule spans to meet lighting SEP4 standards.
(example: "AGi32"(https://www.agi32.com/index.php?id=11)

10.1.4. Present Conflicts

The Engineering Standard in the past for lighting designs used more of a rule of thumb design method and was mainly based on previous lighting layouts. With the adoption of the TAC guidelines as part of our design standard and the maturity of these guides over time has resulted in causing many conflicts in regards to our lighting layouts within Roadways and Intersections. These areas have a higher standard now to meet proper lighting coverage.

10.1.4.1. Roadways

Due to the above description on conflicts, roadways have not met the standard mainly due to dark spots found when a photometric's study was performed on our existing lighting layouts.

10.1.4.2. Intersections

Intersections were found to have insufficient light levels as the standard to cover a proper illuminance level within the intersection has changed from previous engineering methods.

10.1.4.2.1. Legacy Installations

Roadway areas in the planned plot for the current LED conversion scope may not meet the current photometric standard. SaskPower – Distribution Asset Management & Planning acknowledge these legacy area conditions. The majority of legacy installations shall remain as is with the exception of some specific areas that warrant a closer look in the interest of public safety.

These legacy areas will be designed for head for head replacement to conversion of an equivalent new LED fixture as per the existing luminaire in Electric Office. In locations where a lighting adequacy assessment is recommended and results in insufficient lighting levels, the engineering designer may use ways to mitigate this, for example:

i. Include an increase of wattage/ lumen output at the site(s). Proximity to residential homes should be considered when applying higher lumen output luminaires. The height of the Steel Standard or Wood Pole should also be considered when increasing the lumen output. The output should not be increased to the 400W LED equivalent if the mounting height is less than 40ft.
    a. If the increase in light output still results in insufficient light at the location, then a recommendation shall be made to Distribution Asset Management for the addition of another structure to meet the design guidelines (step ii).

ii. A recommendation can be made to Distribution Asset Management for the addition of another structure to meet the design guidelines.

10.1.4.2.2. Roadway Widening

In areas where roadways have widened, and the above measures cannot resolve the lighting conflicts, additional future construction designs may be required. The Ross Avenue corridor in Regina SK is a good example of this (Ross Ave. Regina SK. Lat / Long 50.464982, -104.557924).

This roadway was previously designed as single, two way drive lane widths. The lighting layouts were installed on one side of the roadway. Within the last few years this Ross Ave roadway has changed to double lanes each way with a median strip added to the width of this roadway, yet the lighting layout was never enhanced.

The LED bulk deployment program will not address these design issues. If there are known instances of this, it is recommended that the designer notify SaskPower's Distribution Asset Management & Planning department and recommend that the layout be reviewed. Asset Management will discuss this issue with the Customer Relations Manager responsible for the area to determine the customer's interest in addressing this issue through a future project.

10.1.4.3. Uniformity Standard

Definition: The ratio of the illuminance in the brightest-lit spots to that in the dimmest areas (max/min), or of the average illuminance of the whole area to that of the dimmest spots (avg/min). The best results as far as visual acuity result when the uniformity ratio is close to one.

A lower uniformity ratio means more evenly distributed light throughout your venue. An adequate level of uniformity is required to create balanced lighting conditions so that people's eyes do not continually have to adapt to different light levels.

The bulk LED deployment program **will not** correct these legacy issues, unless it is within a high pedestrian conflict location. Refer to section 2.5 for details.

10.1.4.4. Light Loss Factor (LLF)

Light Loss Factors (LLF) are multiplier values to estimate the overall performance at different times during the life of the lighting system. LLF values reflect the performance of the lamp and luminaire as well as the maintenance level of a lighting system.

10.1.4.4.1. Recommended Value of LLF for LED Conversions

It is expected that the new LED luminaires will have a much improved LLF over the present day HPSV luminaires in use. This enhancement will cause a different result in calculation and photometric modelling.

The new LED luminaire specification requires a LLD of 0.85 (w/o dust) which is a great improvement over the present day lighting.

SaskPower Distribution Asset Management suggests conducting design photometric simulations using a ***Total Light Loss Factor = 0.75.*** This value was selected based on the LLD of the LED light in conjunction with the luminaire dirt depreciation factor. The equipment factor was removed as the LED technology is not expected to be impacted by lamp, ballast, voltage, or temperature fluctuations as much as HPSV technology. More details can be found in SEP 4 section 5.4.10.

10.1.5. Risk Tolerance

The design criterion is developed to enable a reasonable deployment schedule through targeted engineering analysis in high risk zones only. By approval of this document, SaskPower accepts the risk that there may be some legacy locations overlooked that may not meet recommended design guidelines.

10.1.6. SaskPower Standard Engineering Practice (SEP4) Application

10.1.6.1. Bulk Conversion of Existing Streetlights to LED

This document is to govern the design review requirements for bulk LED conversion projects. The SaskPower SEP4 does not apply, with the exception of circumstances that are not covered by this document.

10.1.6.2. New Construction Using LED Technology

New construction and design shall follow SEP4. As previously mentioned, photometric modelling and design shall still use equivalent High Pressure Sodium Vapour equivalent in the lighting layout. It is recognized that there may be cost savings associated with increased structure spacing and reduced quantities of lights by using actual photometric layouts. However, one cannot guarantee that the same light or better will be used in future maintenance, therefore it shall be designed to meet the minimum output requirements which is equivalent to a specific wattage HPSV luminaire.

10.2. Recommended Design Criterion

10.2.1. Source Data for Designs

Reference data for design simulations shall be streetlight locations and luminaire wattages as modelled in Electric Office. Other design aid tools such as Google Earth and StreetView can be used to gain confidence in the model. In the event that the designer does not have reasonable confidence in the accuracy of the structure locations and/or existing luminaire head wattage, a field check is recommended.

Designs shall attempt to utilize a luminaire head (HPSV) for luminaire head (LED) direct replacement approach as much as possible. Existing locations where adequate lighting cannot be achieved will not prevent the deployment of LED luminaires.

10.2.2. Design Simulations

Vendor specific IES photometric files SHALL NOT be used to conduct design simulations in targeted locations. Rather, design simulations shall be completed using the equivalent high pressure sodium vapour (HPSV) wattage luminaire.

The SaskPower technical specification requires that the LED luminaires meet the equivalent HPSV photometric layout as a minimum requirement therefore it is recommended that this be used. It is not recommended that vendor specific photometric layouts be used for the following reasons:

a) Inconsistent Vendor Use: Designing consistently using the same photometric layout that meets minimum requirements, will ensure a sufficiently lit location. If a design is completed using Vendor A, which has a superior photometric layout, however the light is required to be replaced by Vendor B in the future under corrective maintenance which only meets minimum requirements, then the net result may be location that does not meet lighting standards.

b) Photometric File Management: Furthermore, it would be difficult for designers to maintain a complete reference of all of the various IES photometric files to use, therefore these are all kept in a shared folder for designer use (this is mentioned in *SEP4*).

10.2.3. Average Luminance: Intersections

All roadway intersections as defined in *SEP4* section 5.4.6 shall have an average illuminance design simulation performed. Local/Local intersections do not require a design assessment for the bulk LED Conversion program.

All intersections, regardless of class of the roads, shall have average illuminance design simulation performed in high pedestrian conflict zones *(Designers should use table 5-5 Illuminance for Intersections)*

Intersections where SaskPower lights are mixed with Municipal owned lights do not require a design simulation or assessment for the bulk LED Conversion program.

10.2.3.1. Insufficient Light Levels (Intersections)

Designers shall attempt to mitigate insufficient average illuminance levels at intersections via:

i. Increasing Luminaire Lumen Output: Efforts shall be taken to mitigate insufficiently lit areas by increasing the light output at the existing structure locations. Proximity to residential homes should be considered when applying higher lumen output luminaires. The lumen output should **not** be increased to a **400W** equivalent LED if the existing steel standard or pole **is less than 40ft** in height.
If this attempt at mitigation still results in an insufficient light level, then proceed to step ii.

ii. Recommending Future Structure Locations & Wattages: In the event that the previous step does not solve the average luminance requirements, then recommendations for additional structure locations and luminaire output shall be made to Distribution Asset Management & Planning for future capital program consideration.

Intersection locations with insufficient lighting after exhausting opportunities for increasing luminaire lumen output shall not prevent the planned bulk LED deployment. All luminaire heads in the planned scope of work should be converted to LED in order to keep cost estimations accurate and avoid areas of mixed HPS & LED lights. In most cases, the existing lumen levels have been there for many years without incident. If there is more than 1 location, a comprehensive list shall be submitted in MS Excel format.

10.2.4. Average Luminance: Roadways / Corridors

Photometric simulations are not required on any roadway classes with exception of these following high risk and or high pedestrian conflict locations.

10.2.4.1. High Risk Zones

- School Zones
- Hospital Zones

*Note: The zones above will cover a 1 block radius around the facility

10.2.4.2. High Pedestrian Conflict Zones

- Downtown cores in urban settings
- Public sporting areas and locations (i.e. stadiums, hockey rinks, aquatic centers etc)
- Parks

10.2.4.3. Insufficient Light Levels (All Roadways)

Designers shall attempt to mitigate insufficient average luminance levels at high risk and high pedestrian conflict roadways via:

i. Increasing Luminaire Lumen Output: Efforts shall be taken to mitigate insufficiently lit areas by increasing the light output at the existing structure locations. Proximity to residential homes should be considered when applying higher lumen output luminaires. The lumen output should **not** be increased to a **400W** equivalent LED if the existing steel standard or pole **is less than 40ft** in height. If this attempt at mitigation still results in an insufficient light level, then proceed to step ii.

ii. Recommending Future Structure Locations & Wattages: In the event that the previous step does not solve the average luminance requirements, then recommendations for additional structure locations and luminaire output shall be made to Distribution Asset Management & Planning for future capital program consideration. If there is more than 1 location, a comprehensive list shall be submitted in MS Excel format.

Roadway locations with insufficient lighting after exhausting opportunities for increasing luminaire lumen output shall not prevent the planned bulk LED deployment. All luminaire heads in the planned scope of work should be converted to LED in order to keep cost estimations accurate and avoid areas of mixed HPS & LED lights. In most cases, the existing lumen levels have been there for many years without incident.

10.2.5. Uniformity Criteria Assessments

The uniformity criteria shall only be analyzed for High pedestrian conflict zones. Failure to meet a uniformity criterion will not prevent conversion of HPSV to LED. Rather, such instances shall be reported to SaskPower's Distribution Asset Management & Planning department as consideration for a future capital project.

10.2.6. Vegetation

All design simulations and lighting adequacy assessment cases are to assume there are no vegetation issues. Although this may not be realistic, it would be next to impossible to design for vegetation impacts. The design shall assume the vegetation is well maintained and does not conflict with light dispersion.

10.3. Conclusion

In all efforts the design criteria to convert to L.E.D. lighting is to use a head for head straight replacement method. While in design the engineering efforts for every roadway in the plan will not be the focus but rather to simulate a select random area within the Distribution Asset Management conversion area where the above report states as a high risk or high pedestrian conflict zones. All efforts to increase wattage or other methods should be exercised before additional structures and lighting construction layouts as per this report states.