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Prepared by the

Lighting Research Center

Implementation of Decision-Making Tools that Address Light Pollution for Localities Planning Street Lighting

EFFICIENT STREET LIGHTING DESIGN GUIDE

March 12, 2003

SCOPE OF DESIGN GUIDE

This guide is designed for Connecticut Light and Power (CL&P) to aid municipalities in designing and specifying energy efficient street lighting to meet their illumination goals. This document is provided in conjunction with a white paper entitled *Efficient Street Lighting and Light Pollution* and a checklist entitled *Street Lighting Design Checklist*. The intent of this guide is to provide illustrative examples of typical street lighting designs and present alternative options. Although all possible outdoor lighting scenarios cannot be illustrated in this document, it was developed as a tool to identify practical approaches to design efficient street lighting that considers light pollution issues.

CL&P's *Decision-Making Tools for Localities Planning Street Lighting: Efficient Street Lighting Design Guide* is a valuable reference document that will aid municipalities in making informed decisions and communicating with vendors and contractors. These design patterns supplement, but do not replace, existing standards and industry-accepted practices for street and roadway lighting design. Planners are encouraged to consult these sources, including:

- *American National Standard Practice for Roadway Lighting*, RP-8-00, Illuminating Engineering Society of North America, 2000.
- *Recommended Practice for Outdoor and Environmental Lighting*, RP-33-99, Illuminating Engineering Society of North America, 1999.
- *Informational Guide for Roadway Lighting*, American Association of State Highway Transportation Officials, 1984.

Other excellent sources of guidance for street lighting practice include:

- *Street Lighting Manual*, 3rd Edition, Edison Electric Institute, 1988.
- *The Outdoor Lighting Pattern Book*, Russell P. Leslie and Paula A. Rodgers, McGraw-Hill, 1996.

INTRODUCTION

The design patterns in this guide were chosen as representative outdoor lighting scenarios encountered by many Connecticut municipalities. Connecticut state legislation requiring full cutoff luminaires for new or replacement luminaire installations reduces the luminaire choices available to many municipalities unless otherwise waived. Therefore, this design guide focuses on typical lighting situations with full cutoff luminaires.

The designs in this guide use luminaires, lamp types, lamp wattages, luminaire heights, and luminaire spacings commonly used in Connecticut. The two luminaires used in the design examples are available from CL&P and are often used in these types of lighting scenarios. This guide is not designed as a comparison between luminaires. Such a comparison would include many more luminaires in a wider variety of applications, mounting heights, wattages, and source types. The National Lighting Product Information Program (1993) and the International Dark-Sky Association (2003) are two examples of resources available to learn more about luminaire types.

The goal of this guide is to provide representative examples of lighting in Connecticut using full cutoff luminaires. Therefore, the examples in this design guide may not meet IESNA recommended light levels. The intent is to illustrate the lighting distributions resulting from full cutoff luminaires, in very specific applications.

This design guide shows examples for four outdoor street lighting applications:
Example I: CUL-DE-SAC - A cul-de-sac in a residential setting
Example II: INTERSECTION - A residential or commercial intersection
Example III: RURAL ROAD - A rural state or municipal road
Example IV: RESIDENTIAL ROAD - A residential road with underground utilities

Definitions and clarifications about the recommendations used, types of lamps and luminaires, and assumptions about the roadway surfaces are provided in the appendix. All lighting calculations were performed using the lighting calculation software AGI32.

HOW TO USE THIS GUIDE

The examples in this design guide are for specific applications such as an intersection, or a residential road. Lighting choices should be made for the given application in the context of the surroundings. Each individual luminaire or lighting installation is a part of the environment in which it exists.

The guide is laid out with each street lighting example in a standard format. Each example is comprised of a number of lighting schemes. First, the guide provides a description of the example and why it was chosen. A sketch of the lighting scene is presented for visualization.

A detailed list of lighting design parameters and a sketch of the luminaire used for the typical case is then given. This includes information about the luminaire, lamp wattage and type, pole height, and pole spacing, where appropriate. Next a figure showing the light distribution on the roadway is provided. This includes a plan view of the lighting example superimposed with ground illuminance levels. In this figure, each black circle represents a lighting luminaire, the black and blue lines represent constant values of illuminance levels which are often outlined at 1 footcandle (fc) or 0.5 fc, and the numbers in the image represent illuminance values at that point on the road or ground surface in footcandles. This format is then repeated for each lighting scheme in the example. Finally, a table is given that summarizes each scheme. The information provided in the table includes:

- **Luminaire** – Manufacturer and product name.
- **IESNA Cutoff Classification** - Semicutoff, cutoff, or full cutoff.
- **Arrangement** - Is the luminaire used alone or in combination with other luminaires?
- **Lamp Type and Wattage** – Type of lamp source (high pressure sodium (HPS) or metal halide (MH)) and lamp power in watts.
- **Pole Height (ft)** – Height of luminaire from the ground in feet.
- **Lumens** – Total initial light emitted by the lamp in lumens.
- **Light Loss Factor (LLF)** - Light emitted by the luminaire as a percent of initial lamp output. Takes into account lamp lumen depreciation, luminaire dirt depreciation, and the ballast factor. A LLF of 0.70 means that the luminaire emits 70% of its initial lumens when the lamp is at 40% of life.

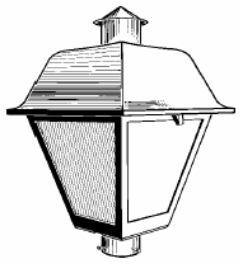
- **Maximum (fc)** – The maximum illuminance value on the roadway in footcandles (fc).
- **Avg/Min** - The uniformity of the light distribution on the roadway in terms of the average illuminance divided by the minimum illuminance.
- **Max/Min** - The uniformity of the light distribution on the roadway in terms of the maximum illuminance divided by the minimum illuminance.

Example I: CUL-DE-SAC

Example I illustrates a number of different methods to provide lighting for a residential cul-de-sac. Two examples are illustrated. The first example (scheme A) uses a cutoff lantern style luminaire. The second example (scheme B) uses a full cutoff cobrahead luminaire. For scheme A an alternate option is provided and two different lamp wattages are illustrated. For scheme B an alternate option using a full cutoff cobrahead luminaire is provided and two different lamp wattages are illustrated. Two different lighting options are provided since lantern style luminaires are typically mounted at fourteen feet whereas cobrahead style luminaires are typically mounted at twenty-seven feet. The diameter of the cul-de-sac is approximately 53 feet. An illustration of the cul-de-sac is found in Picture 1.

Picture 1. Example **c**ul-de-sac in a residential neighborhood.

Example I: CUL-DE-SAC



Lighting Scheme A

Luminaire: GE Salem

Lamp: 70W HPS

Luminaire Height: 14'

Luminaire Description: Traditional, decorative, cutoff luminaire

The GE Salem luminaire is used to illuminate the intersection using a 70W HPS lamp source with the luminaire mounted at 14 feet. Ground illuminance values are illustrated in Figure 1. A maximum of 2.4 fc is achieved with this luminaire, the max/min ratio is 24.0 and avg/min ratio is 7.3. The spread of the luminaire for the GE Salem extends about halfway into the cul-de-sac.

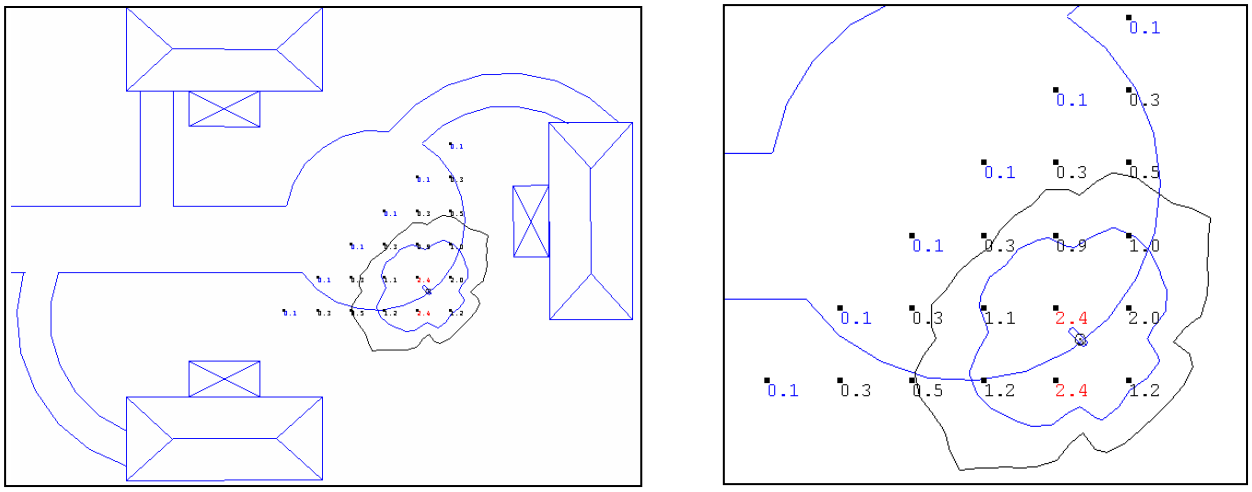
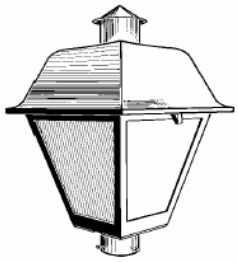


Figure 1. Illuminance values in the cul-de-sac from the 70W GE Salem luminaire.

Example I: CUL-DE-SAC



Alternate Lighting Scheme A

Luminaire: GE Salem

Lamp: 50W HPS

Luminaire Height: 14'

Luminaire Description: Traditional, decorative, cutoff luminaire

In this alternate lighting option, the lamp wattage is reduced to 50W. Ground illuminance values are illustrated in Figure 2. A maximum of 1.6 fc is achieved with this luminaire, the max/min ratio is 16.0 and the avg/min ratio is 5.1. The spread of the luminaire for the GE Salem extends about halfway into the cul-de-sac.

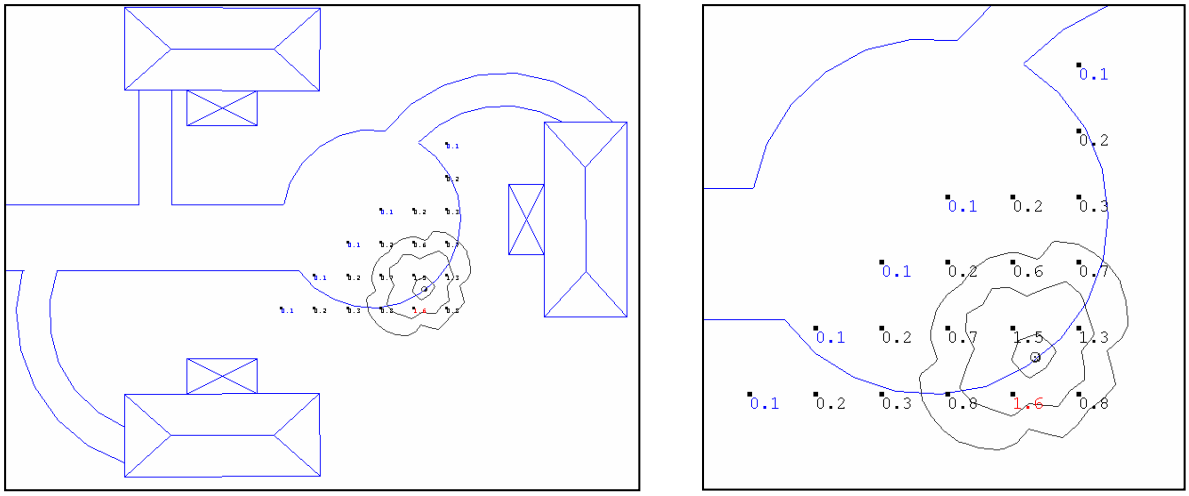


Figure 2. Illuminance values in the cul-de-sac from the 50W GE Salem luminaire.

Discussion of Scheme A

Reducing the wattage to 50W in the GE Salem luminaire provides a beam distribution similar to the 70W example, but the maximum illuminance decreases.

Example I: CUL-DE-SAC

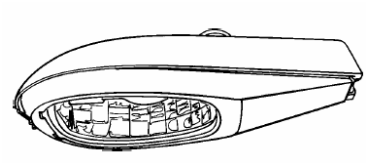
Lighting Scheme B

Luminaire: GE Cobrahead

Lamp: 70W HPS

Luminaire Height: 27’

Luminaire Description: Full cutoff luminaire



The GE Cobrahead full cutoff luminaire is used to illuminate the intersection using a 70W HPS lamp source with the luminaire mounted at 27 feet. Ground illuminance values are illustrated in Figure 3. A maximum of 1.5 fc is achieved with this luminaire, with a max/min ratio of 15.0 and an avg/min ratio of 4.1. The spread of the luminaire covers most of the cul-de-sac.

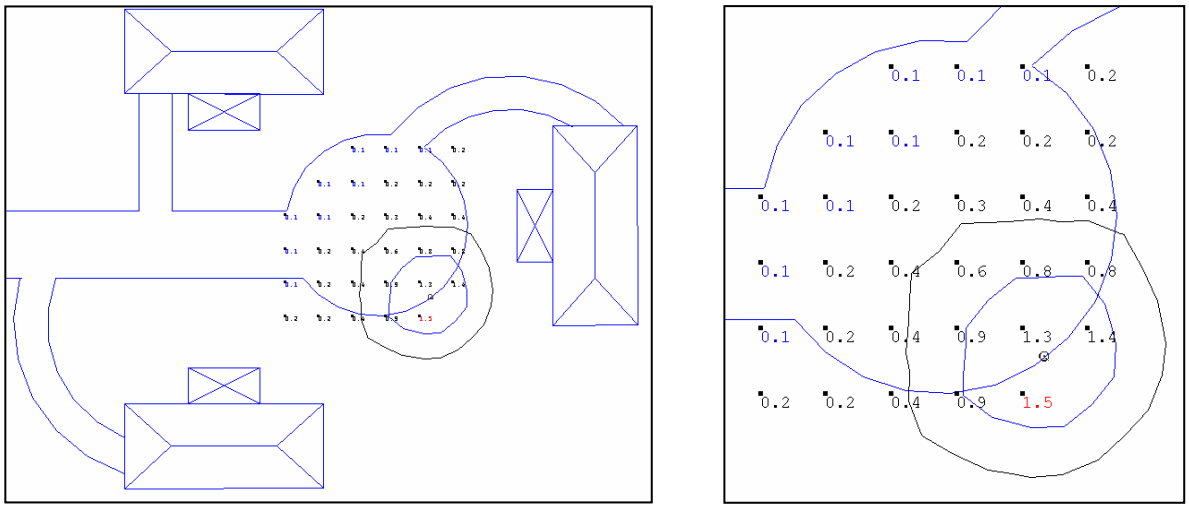


Figure 3. Illuminance values in the cul-de-sac from the 70W GE Cobrahead full cutoff luminaire.

Example I: CUL-DE-SAC

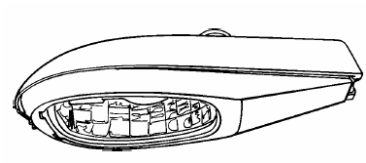
Alternate Lighting Scheme B

Luminaire: GE Cobrahead

Lamp: 50W HPS

Luminaire Height: 27’

Luminaire Description: Full cutoff luminaire



In this alternate lighting option, the lamp wattage is reduced to 50W. Ground illuminance values are illustrated in Figure 4. A maximum of 1.0 fc is achieved with this luminaire, with a max/min ratio of 10.0 and an avg/min ratio of 2.9. The spread of the luminaire extends approximately three-fourths of the way into the cul-de-sac.

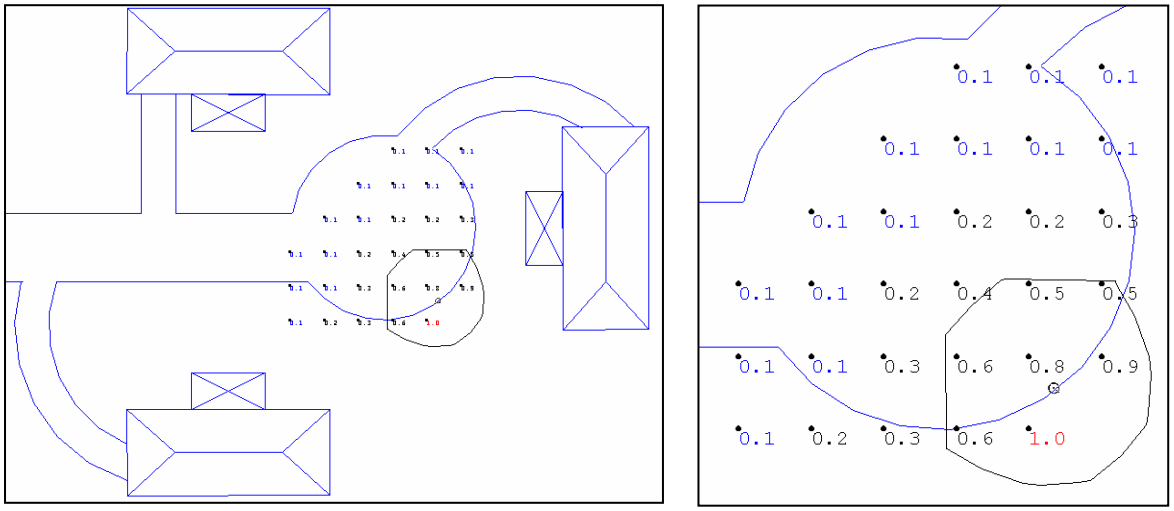


Figure 4. Illuminance values in the cul-de-sac from the 50W GE Cobrahead full cutoff luminaire.

Discussion of Scheme B

Reducing the wattage to 50W in the GE Cobrahead full cutoff luminaire provides a beam distribution similar to the 70W luminaire, with a reduction in the maximum illuminance.

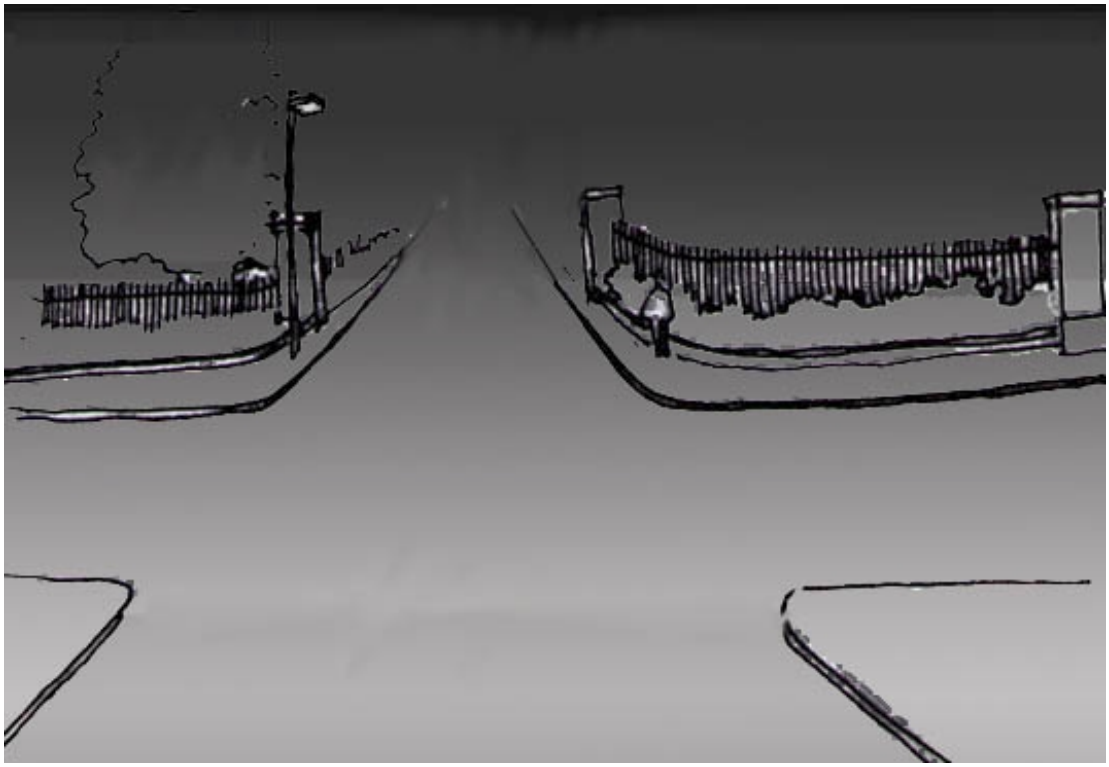
A summary of ***Example I: CUL-DE-SAC*** lighting is provided in Table 1.

Table 1. Cul-de-sac lighting example summary.

Example	Luminaire	Optics classification	Arrangement	Lamp Type and Wattage	Pole Height (ft)	Lumens	LLF	Maximum (fc)	Avg/Min	Max/Min
Lighting Scheme A	GE Salem	Cutoff	Single	70W HPS	14	6300	0.70	2.4	7.3	24.0
Alternate A	GE Salem	Cutoff	Single	50W HPS	14	4000	0.70	1.6	5.1	16.0
Lighting Scheme B	GE Cobrahead	Full cutoff	Single	70W HPS	27	6300	0.70	1.5	4.1	15.0
Alternate B	GE Cobrahead	Full cutoff	Single	50W HPS	27	4000	0.70	1.0	2.9	10.0

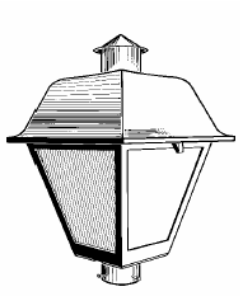
Example II: INTERSECTION

Example II illustrates a number of different methods to provide lighting for an intersection in a residential or commercial area. Two examples are illustrated which are considered typical. The first example (scheme A) uses a cutoff lantern style luminaire. The second example (scheme B) uses a full cutoff cobrahead luminaire. For each of these examples a lower wattage is considered for comparison. Two different lighting options are provided because lantern style luminaires are typically mounted at fourteen feet whereas cobrahead style luminaires are typically mounted at twenty-seven feet. An illustration of the intersection is found in Picture 2. The road width in this example is 40 feet wide.



Picture 2. Intersection in a residential or commercial area.

Example II: INTERSECTION



Lighting Scheme A:

Luminaire: GE Salem

Lamp: 70W HPS

Luminaire Height: 14'

Luminaire Description: Traditional, decorative, cutoff luminaire

In the typical lighting scheme, a 70W GE Salem luminaire mounted at a height of 14 feet is used to light the intersection. Ground illuminance values are illustrated in Figure 5. A maximum of 2.4 fc is achieved with this luminaire, the max/min ratio is 24.0 and the avg/min ratio is 4.7. The spread of the luminaire for the GE Salem extends about halfway into the intersection.

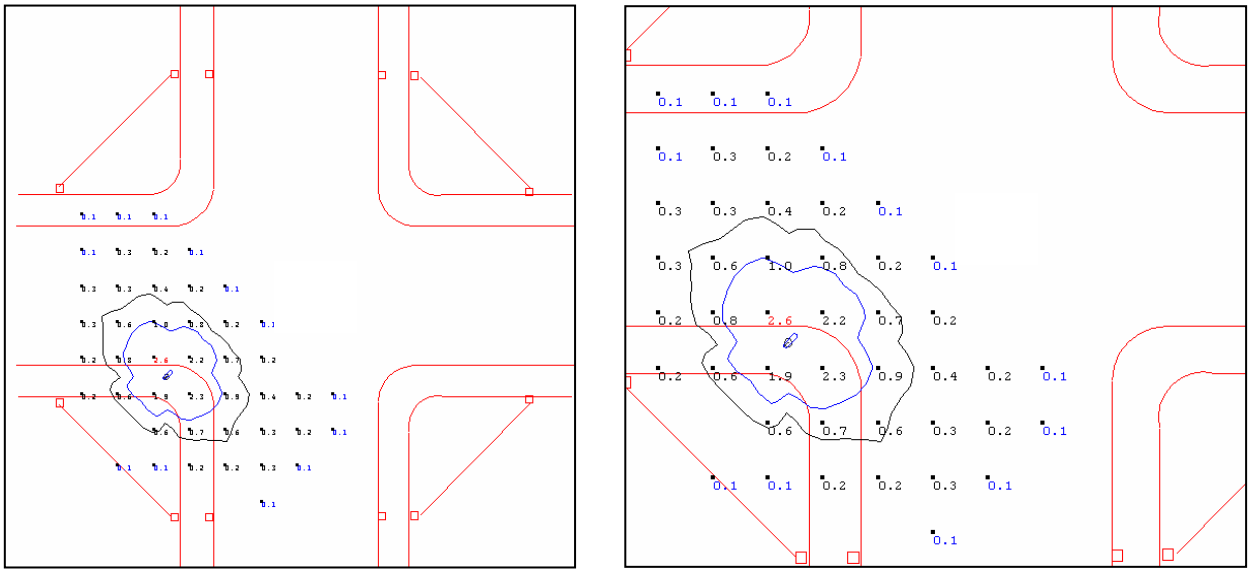
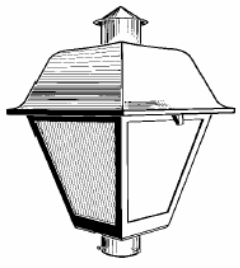


Figure 5. Illuminance values in the intersection from the 70W GE Salem luminaire.

Example II: INTERSECTION



Alternate Lighting Scheme A:

Luminaire: GE Salem

Lamp: 50W HPS

Luminaire Height: 14'

Luminaire Description: Traditional, decorative, cutoff luminaire

In this alternate lighting option, the lamp wattage is reduced to 50W. Ground illuminance values are illustrated in Figure 6. A maximum of 1.3 fc is achieved with this luminaire, the max/min ratio decreases to 13.0 and avg/min ratio decreases to 3.6. The spread of the luminaire for the GE Salem extends less than halfway into the intersection.

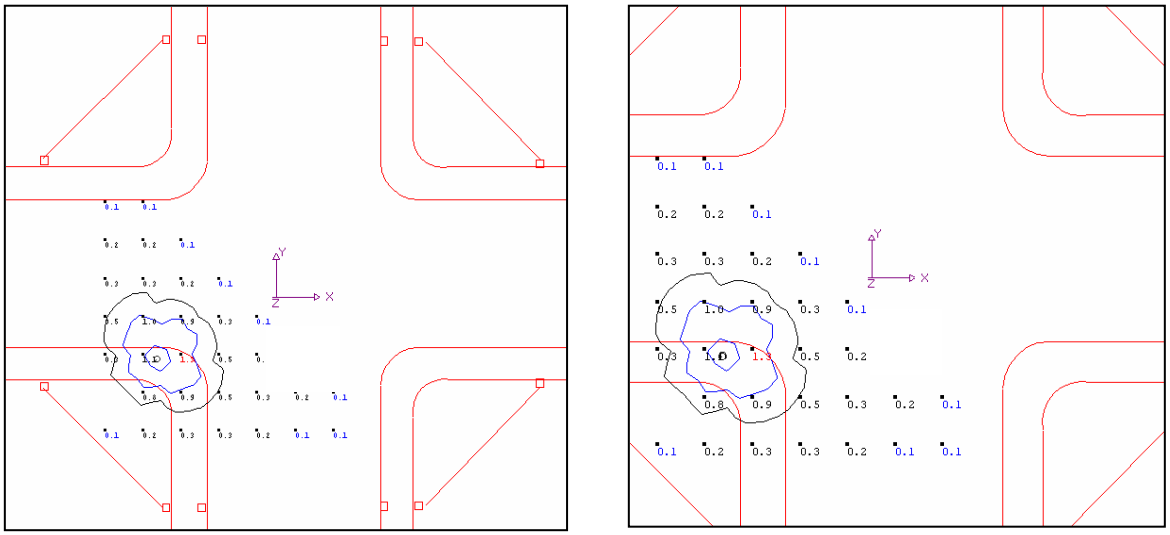


Figure 6. Illuminance values in the intersection from the 50W GE Salem luminaire.

Example II: INTERSECTION

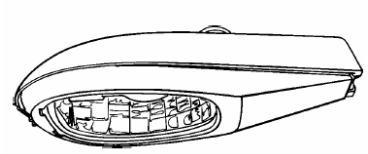
Lighting Scheme B

Luminaire: GE Cobrahead

Lamp: 70W HPS

Luminaire Height: 27’

Luminaire Description: Full cutoff luminaire



In the typical lighting scheme, a 70W GE Cobrahead full cutoff luminaire mounted at 27 feet is used to light the intersection. Ground illuminance values are illustrated in Figure 7. A maximum of 1.6 fc is achieved with this luminaire, the max/min ratio is 16.0 and the avg/min ratio is 3.4. The spread of this luminaire extends more than halfway into the intersection.

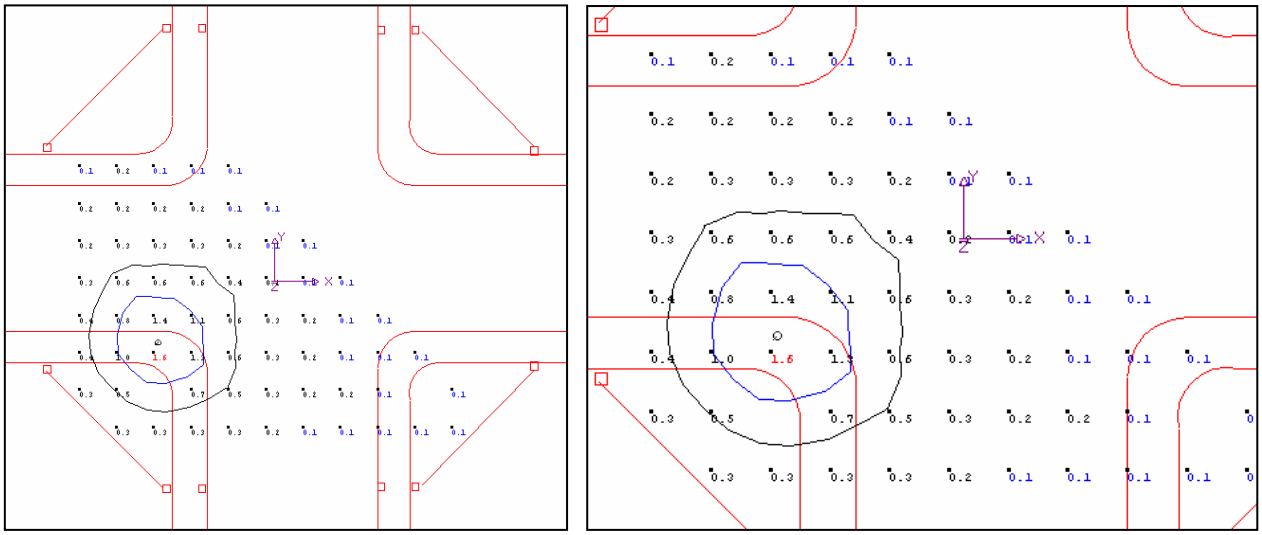


Figure 7. Illuminance values in the intersection from the 70W GE Cobrahead full cutoff luminaire.

Example II: INTERSECTION

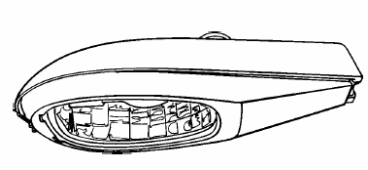
Alternate Lighting Scheme B1

Luminaire: GE Cobrahead

Lamp: 50W HPS

Luminaire Height: 27’

Luminaire Description: Full cutoff luminaire



In this alternate lighting option, the lamp wattage is reduced to 50W. Ground illuminance values are illustrated in Figure 8. A maximum of 1.0 fc is achieved with this luminaire, the max/min ratio decreases to 10.0 and avg/min ratio decreases to 2.6. The spread of this luminaire extends about halfway into the intersection. The beam distribution of the 50W full cutoff luminaire is similar to the 70W luminaire, with a reduction in the maximum illuminance.

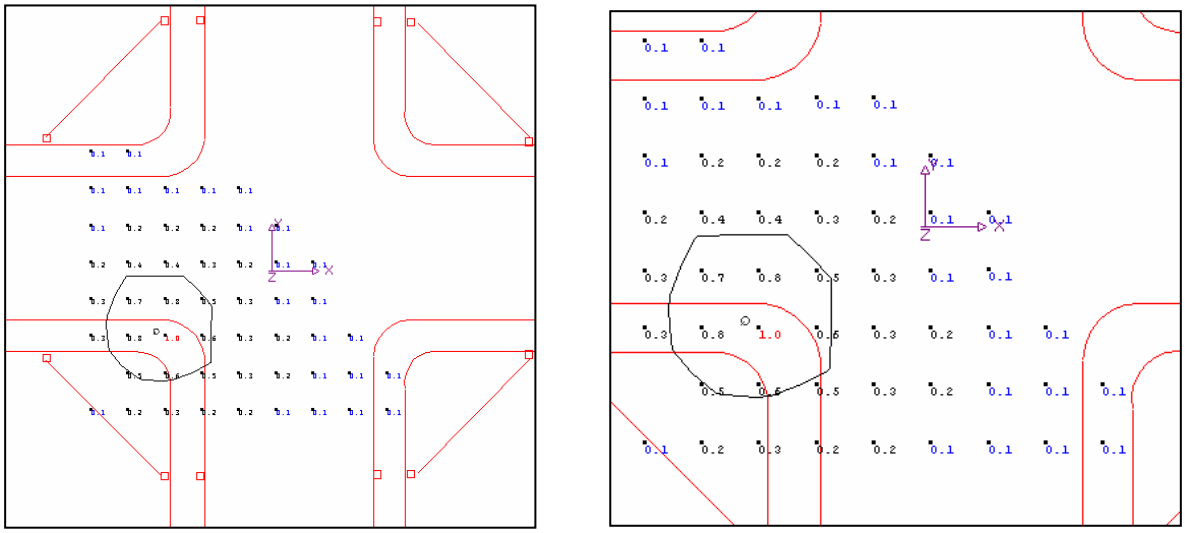


Figure 8. Illuminance values in the intersection from the 50W GE Cobrahead full cutoff luminaire.

Example II: INTERSECTION

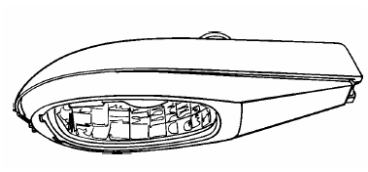
Alternate Lighting Scheme B2

Luminaire: GE Cobrahead

Lamp: 250W HPS

Luminaire Height: 27’

Luminaire Description: Full cutoff luminaire



In this alternate lighting option, the lamp wattage is increased to 250W. Ground illuminance values are illustrated in Figure 9. A maximum of 7.0 fc is achieved with this luminaire, the max/min ratio increases to 70.0 and the avg/min ratio increases to 10.8. The spread of this luminaire covers most of the intersection. The light distribution for the 250W full cutoff luminaire illuminates three of the four corners of the intersection.

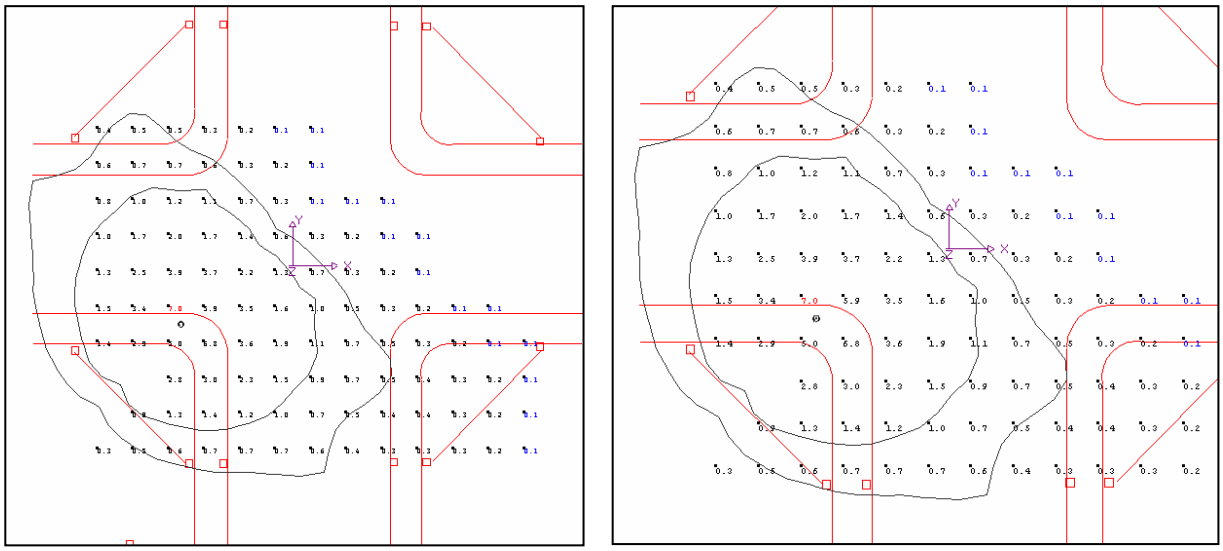


Figure 9. Illuminance values in the intersection from the 250W GE Cobrahead full cutoff luminaire.

Example II: INTERSECTION

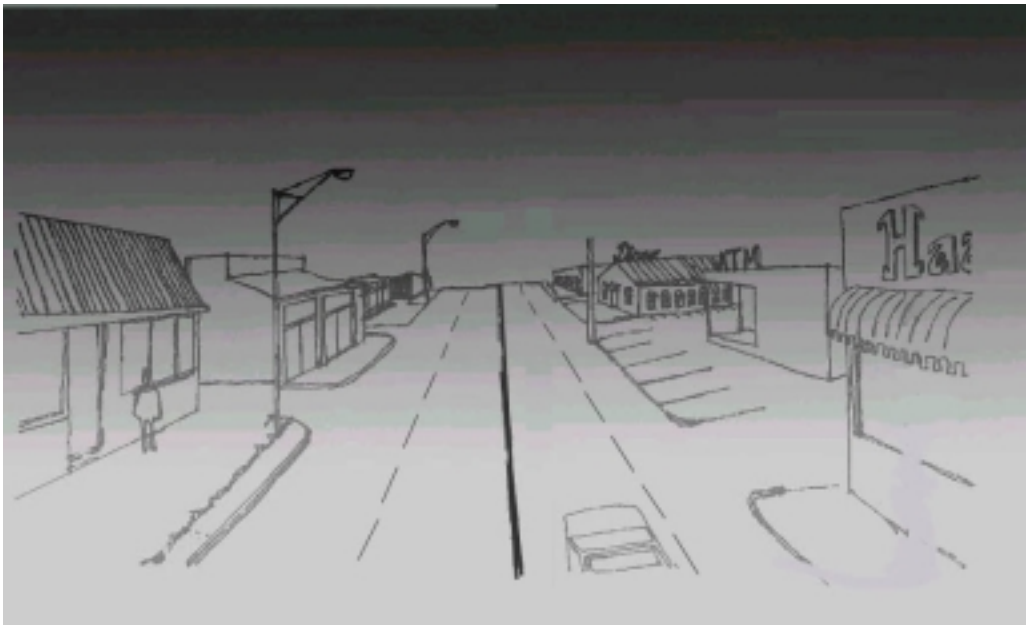
A summary of Example II: INTERSECTION lighting is provided in Table 2.

Table 2. Intersection lighting example summary.

Example	Luminaire	Optics classification	Arrangement	Lamp Type and Wattage	Pole Height (ft)	Lumens	LLF	Maximum (fc)	Avg/Min	Max/Min
Lighting Scheme A	GE Salem	Cutoff	Single	70W HPS	14	6300	0.70	2.6	4.9	26.0
Alternate A	GE Salem	Cutoff	Single	50W HPS	14	4000	0.70	1.3	3.6	13.0
Lighting Scheme B	GE Cobrahead	Full cutoff	Single	70W HPS	27	6300	0.70	1.60	3.4	16.0
Alternate B1	GE Cobrahead	Full cutoff	Single	50W HPS	27	4000	0.70	1.0	2.6	10.0
Alternate B2	GE Cobrahead	Full cutoff	Single	250W HPS	27	27000	0.70	7.0	10.8	70.0

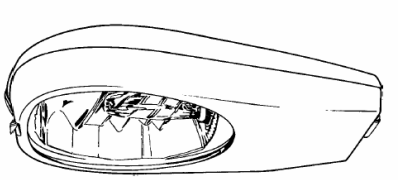
Example III: DOWNTOWN COMMERCIAL AREA ROAD

Example III illustrates lighting for a downtown or commercial area road. This example was chosen to be representative of street lighting in Connecticut. The road is a two lane road that is 60 feet wide and the lighting is provided by 250W HPS GE Cobrahead full cutoff luminaires at a height of 27 feet with a spacing of 100 feet. An illustration of an example road is found in Picture 3.



Picture 3. Lighting of a downtown commercial area road.

Example III: DOWNTOWN COMMERCIAL AREA ROAD



Lighting Scheme

Name of Luminaire: GE Cobrahead

Lamp: 250W HPS

Luminaire height: 27’

Luminaire description: Full cutoff luminaire

Luminaire spacing: Every 100’

The IESNA provides recommendations for continuous roadways. If this roadway is assumed to be a collector road with a low pedestrian conflict and a pavement classification of R2/R3, the IES recommended illuminance level is a minimum of 0.6 fc and the uniformity (avg/min) ratio should not exceed 4. In this example, the GE Cobrahead full cutoff luminaires are used with HPS lamp wattages of 250W at a height of 27 feet. Ground illuminance values are illustrated in Figure 10. Based on the calculations, lighting with full cutoff cobrahead luminaires results in a minimum illuminance level of 0.1 fc, a max/min ratio of 62.0, and an avg/min ratio of 14.1. The illuminance level and uniformity ratio do not meet the recommended IESNA values.

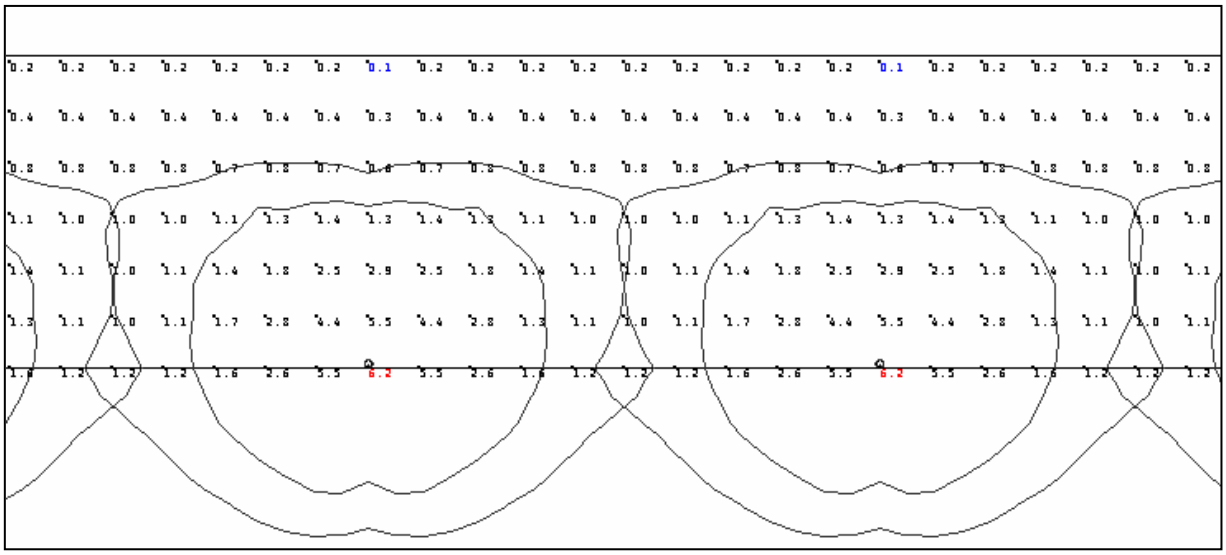


Figure 10. Illuminance values on the roadway from the 250W GE Cobrahead full cutoff luminaires 100’ apart.

Example III: DOWNTOWN COMMERCIAL AREA ROAD

A summary of the **Example III:** ***DOWNTOWN COMMERCIAL AREA*** **ROAD** lighting is provided in Table 3.

Table 3. Rural state or municipal road lighting example summary.

Luminaire	Optics classification	Arrangement	Spacing (ft)	Lamp Type and Wattage	Pole Height (ft)	Lumens	LLF	Minimum (fc)	Avg/Min	Max/Min
GE Cobrahead	Full cutoff	Single	100	250W HPS	27	25600	0.70	0.10	14.1	62.0

Example IV: RESIDENTIAL ROAD

Example IV illustrates three different methods to provide lighting for a residential road with underground utilities, similar to what might be expected in a new development in Connecticut. The typical example uses 70W GE Salem full cutoff luminaires spaced every 200' beginning at the intersection. This scenario is similar to placing lighting at every other property line, a situation common in Connecticut. The first alternative replaces the 70W luminaires with 50W luminaires. A second alternative lighting scenario is presented that provides lighting only at the intersection and at the curve in the road. The road is 30 feet wide and the luminaires are at a height of 14 feet. An illustration of the residential road is found in Picture 4. The objective of this example is to consider the objectives of the lighting. As the following examples show, continuous lighting is not achievable with lantern style luminaires mounted at 14 feet and spaced 200 feet apart. Therefore, it may be advantageous to light only the intersection and the curve in the road.

Picture 4. Lighting of a residential road with underground utilities.

Example IV: RESIDENTIAL ROAD

<u>Typical Lighting Scheme</u>

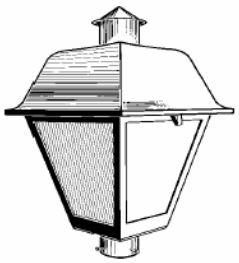
Name of Luminaire: GE Salem

Lamp: 70W HPS

Luminaire Height: 14’

Luminaire Description: Traditional, decorative, cutoff luminaire

Luminaire Spacing: Every 200’



The IESNA provides recommendations for continuous lighting on roadways. If this roadway is assumed to be a local road with a low pedestrian conflict and a pavement classification of R2/R3, the IES recommended illuminance level is a minimum of 0.4fc and the uniformity (avg/min) ratio should not exceed 6. Based on the calculations, the lighting scenario described in this example has a minimum illuminance level of 0.1 fc, a max/min ratio of 27.0, and a uniformity (avg/min) ratio of 4.8. Ground illuminance values are illustrated in Figure 11. The minimum illuminance level and the uniformity ratio for this typical lighting design do not meet the recommended IESNA values. In most cases the light from each luminaire does provide lighting to the opposite side of the street, relative to the luminaire.

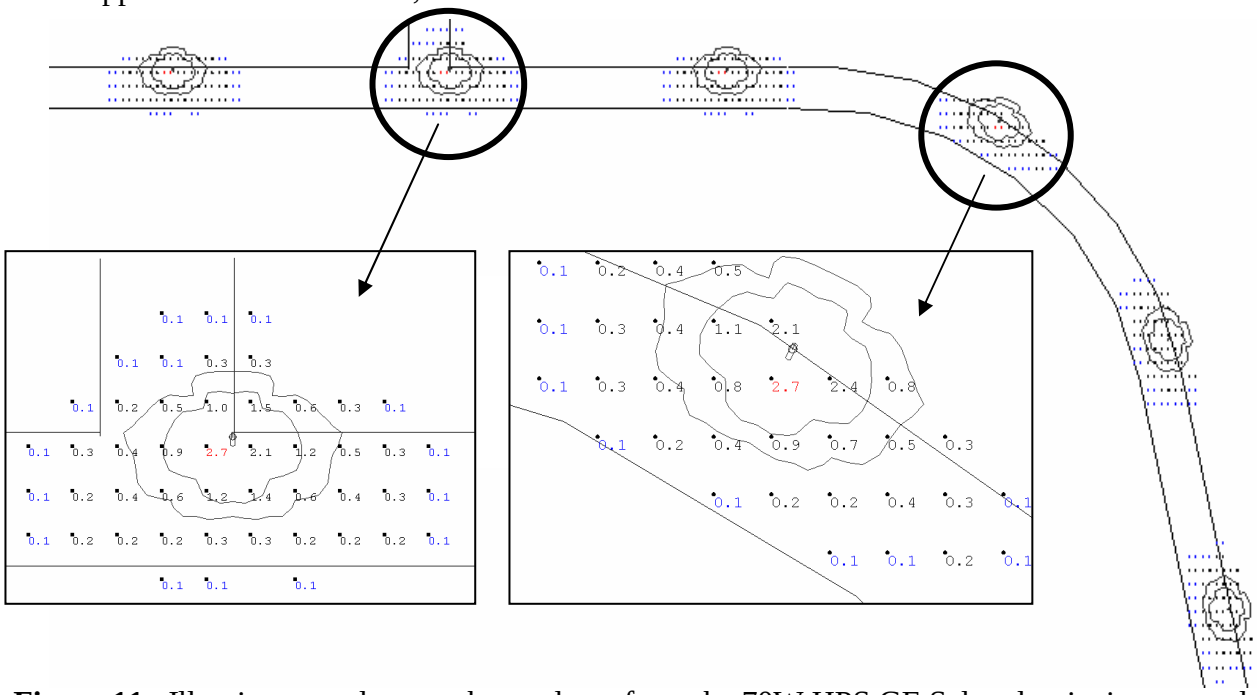


Figure 11. Illuminance values on the roadway from the 70W HPS GE Salem luminaires spaced every 200’.

Example IV: RESIDENTIAL ROAD

Alternate Lighting Scheme 1

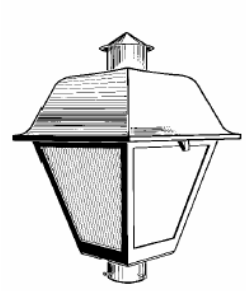
Name of Luminaire: GE Salem

Lamp: 50W HPS

Luminaire Height: 14’

Luminaire Description: Traditional, decorative, cutoff luminaire

Luminaire Spacing: Every 200’



In this example, the lamp wattage of the GE Salem luminaires is reduced from 70W to 50W. Ground illuminance values are illustrated in

Figure 12. Based on the calculations, the lighting scenario described in this example results in a minimum illuminance level of 0.1 fc, the max/min ratio decreases to 15.0, and the avg/min ratio decreases to 3.4. The illuminance level and uniformity ratio do not meet the recommended IESNA values. In some cases the lighting does not reach the other side of the roadway, in relation to the luminaire.

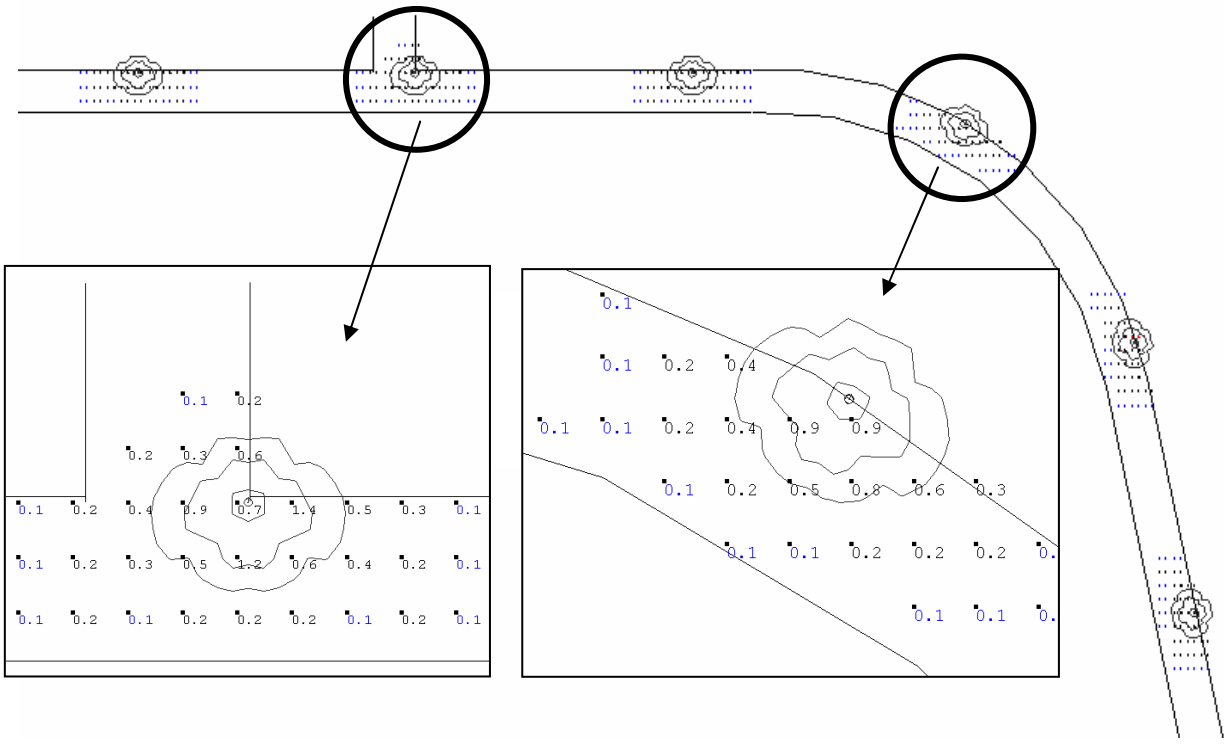


Figure 12. Illuminance values on the roadway from the 50W HPS GE Salem luminaires spaced every 200’.

Example IV: RESIDENTIAL ROAD

Alternate Lighting Scheme 2

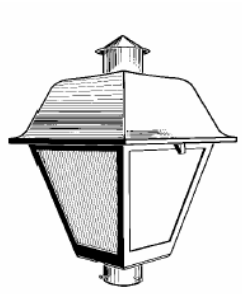
Name of Luminaire: GE Salem

Lamp: 150W HPS

Luminaire Height: 14’

Luminaire Description: Traditional, decorative, cutoff luminaire

Luminaire Spacing: Staggered, every 50’



In this example, 150W GE Salem luminaires are placed at the intersection and the curve only. The wattage was chosen to provide illumination that reaches the opposite side of the street, in relation to the position of the luminaire. Ground illuminance values are illustrated in Figure 13. Based on the calculations, the intersection has a maximum illuminance of 4.7 fc, a max/min ratio of 47.0 and an avg/min ratio of 9.0. The spread of the luminaire extends completely into the intersection to the opposite side of the road. The curve in the road has a maximum illuminance of 5.7 fc, a max/min ratio of 57.0 and an avg/min ratio of 9.2. The spread of the luminaire extends to the opposite side of the road.

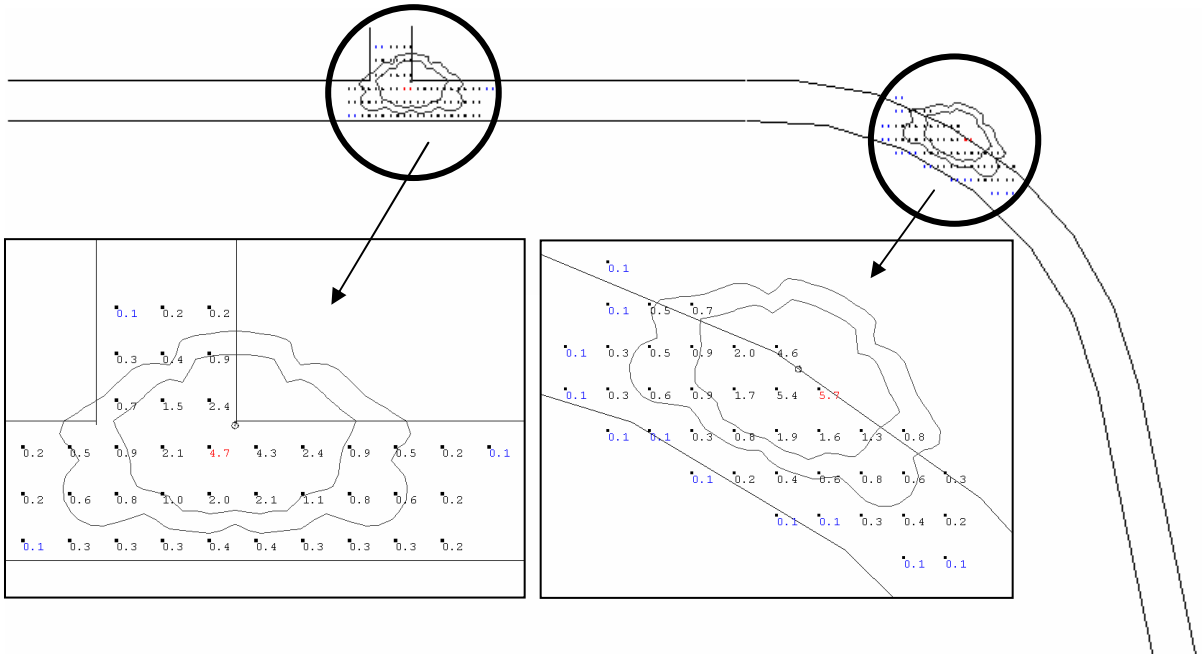


Figure 13. Illuminance values on the roadway from the 150W HPS GE Salem luminaires positioned at the intersection and at the curve in the road.

Example IV: RESIDENTIAL ROAD

A summary of the ***Example IV: RESIDENTIAL ROAD*** lighting is provided in Table 4.

Table 4. Residential road with underground utilities lighting example summary.

Example	Luminaire	Optics classification	Arrangement	Spacing (ft)	Lamp Type and Wattage	Pole Height (ft)	Lumens	LLF	Minimum (fc)	Avg/Min	Max/Min
Typical	GE Salem	Cutoff	Single	200	70W HPS	14	6300	0.70	0.1	4.8	27.0
Alternate 1	GE Salem	Cutoff	Single	200	50W HPS	14	4000	0.70	0.1	3.4	15.0
Alternate 2 Intersection	GE Salem	Cutoff	Single	--	150W HPS	14	13500	0.70	0.1	9.0	47.0
Alternate 2 Curve	GE Salem	Cutoff	Single	--	150W HPS	14	13500	0.70	0.1	9.2	57.0

REFERENCES

Barrett, James. 1993. *Parking Lot Luminaires.* Troy, NY: National Lighting Product Information Program. Update expected Fall 2003. Accessed 5 March 2003 at http://www.lrc.rpi.edu/nlpip/

International Dark-Sky Association, *Good Lighting Fixtures and Where to Get Them*, Accessed 5 March 2003 at http://www.darksky.org/fixtures/manuf.html

APPENDIX I - DEFINITIONS AND EXPLANATIONS

ANSI / IESNA RP-8-00: This design guide refers to the recommended illuminance values specified in Table 2 of ANSI / IESNA RP-8-00. The illuminance method "determines the amount of light incident on the roadway surface from the roadway lighting design". The illuminance criteria stated in terms of the uniformity ratio (E_{avg} / E_{min}) provides recommendations for average maintained illuminance for various road and area classifications depending on the pavement type used.

Cutoff classification: The purpose of the cutoff classification is to provide a system of classifying the distribution of light from a luminaire. The IESNA has several classifications for outdoor lighting luminaires that limit the luminous intensity of light emitted directly above the horizontal and in addition limit the luminous intensity of light emitted between 80º and 90º from nadir. The term nadir is defined as a vertical line extending from the bottom of the luminaire to the ground. Angles referenced by the IESNA cutoff classifications and the term nadir are illustrated in Figure 14.

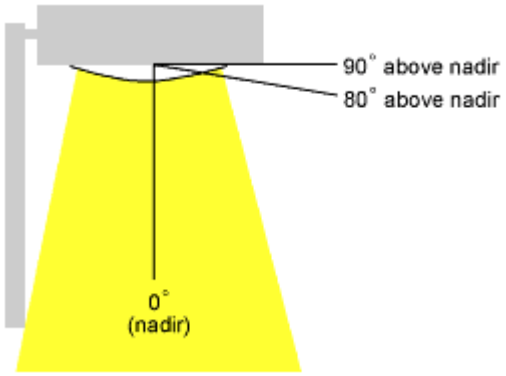


Figure 14. Angles addressed by the IESNA Cutoff Classifications.

The two most stringent classifications are cutoff and full cutoff luminaires. Full cutoff luminaires emit no light upward and tend to emit very little at angles near horizontal. Cutoff luminaires may emit some light upward and also tend to emit little light near horizontal. The semicutoff classification is the least stringent and tends to permit the most light upward and at angles near the horizontal.

Lamp types: Most exterior lighting installations will use one of the three types of high-intensity discharge (HID) lamps; high pressure sodium (HPS), metal halide (MH) and mercury vapor

(MV) lamps. HPS is the most commonly used light source for exterior applications. HPS lamps produce a yellowish-white light having fair color rendering properties (CRI is usually around 22). Despite their less-than-optimal appearance, HPS lamps are quite efficient (from 80 to 100 lm/W, including ballast power), long-lived (most are rated for at least 24,000 hours) and maintain their light output well for long periods of time.

MH lamps are the most commonly used alternative to HPS in new installations. MH lamps are also quite efficient (70 to 90 lm/W) and provide white light with good color rendering (CRI is 65 or higher).

MV lamps are the least efficient of the HID types, having luminous efficacies of only 40 to 60 lm/W. Furthermore, MV lamps have long operating lives but fairly poor lumen maintenance, so many MV lamps in use are drawing full input power while generating little useful light.

HPS lamps were chosen for this guide because they are commonly used in street lighting applications.

Selection of the Luminaires: Appropriate luminaires for both a typical lighting and an alternate lighting schemes were chosen for each application from the list of approved luminaires provided by CL&P.

Type of Road: The ANSI/IESNA RP-8-00 follows the pavement reflectance characteristics of the CIE Four Class System (Table 1). The classification is based on the specularity of the pavement (S1), and a scaling factor Qo as determined by the overall “lightness” of the pavement. For the purpose of this guide, pavement classifications of R2 and R3 have been chosen, which have reflectance factors of 0.07. R2 represents an asphalt road surface with an aggregate composed of a minimum of 60 percent gravel. The mode of reflectance for an R2 roadway is mixed (diffuse and specular). R3 represents an asphalt road surface with dark aggregates and a rough texture after some months of use (typical highways). The mode of reflectance for an R3 roadway is slightly specular.