Illuminating
ENGINEERING SOCIETY

ANSI/IES **RP-8-14**

Roadway Lighting

Approved American National Standard
ANSI

ANSI/IES RP-8-14

Roadway Lighting

Publication of this Recommended Practice
has been approved by the IES.
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This standard practice is dedicated to the memory of Richard E. Stark whose contributions to the committee and society are greatly appreciated.

Cover: Ringling Bridge, Sarasota, FL
Image by Edward J. Kramer, EJKramer Consulting, LLC.

Contents

FOREWORD

(This Foreword is not part of the *American National Standard Practice for Roadway Lighting*, ANSI/IES RP-8-2014, but is included for informational purposes only.)

During the 85-year existence of the IES Committee on Roadway Lighting, the night use of public ways has grown greatly. Traffic has changed in speed and density. Studies have established a substantial relationship between good fixed lighting and traffic safety. In addition, understanding of the principles of good lighting has advanced. The following earlier publications of the committee reflect progress of the roadway lighting technique through the years.

- Principles of Streetlighting 1928
- Code of Streetlighting 1930
- Code of Streetlighting 1935
- Code of Streetlighting 1937
- Recommended Practice of Streetlighting 1940
- Recommended Practice of Street and Highway Lighting 1945
- American Standard Practice for Street and Highway Lighting 1947
- American Standard Practice for Street and Highway Lighting 1953
- American Standard Practice for Roadway Lighting 1963
- American Standard Practice for Roadway Lighting 1972
- American Standard Practice for Roadway Lighting 1977
- American Standard Practice for Roadway Lighting 1983
- American Standard Practice for Roadway Lighting (reaffirmed) 1993
- American Standard Practice for Roadway Lighting (reaffirmed 2005) 2000

The present Practice has evolved from these earlier documents, and considers the latest research, international standards, experience, and equipment technology.

An American National Standard represents the consensus of all groups having an essential interest in the provisions of the Standard Practice. The IES, as a sponsor, must have the viewpoints of groups interested in roadway lighting represented on the Roadway Lighting Committee.

1.0 INTRODUCTION

1.1 Purpose of this Standard Practice

The primary purpose of this Standard Practice is to serve as the basis for design of fixed lighting for roadways, streets, adjacent bikeways, and pedestrian ways. The Standard Practice deals entirely with lighting design and does not give advice on construction. Its primary purpose is to provide recommended practices for designing new continuous lighting systems for roadways and streets. It is not intended to be applied to existing lighting systems until such systems are completely redesigned. It has been prepared to advance the art, science, and practice of roadway and street lighting in North America. Roadway and street lighting includes pedestrian and bikeway lighting when it is associated with the public right-of-way.

In those circumstances where there is any doubt as to whether the provision of new or updated roadway lighting would provide a benefit at a particular location, a decision should be made based on a study of local conditions. Once a decision has been made to provide lighting, this publication provides the basis for designing an appropriate system. The AASHTO Lighting Design Guide provides guidance for warranting.

1.2 Purpose of Roadway and Street Lighting

The principal purpose of roadway and street lighting is to allow accurate and comfortable visibility at night of possible hazards in sufficient time to allow appropriate action. For a pedestrian, this can mean better visibility of the surrounds and the sidewalk, while for the driver of a motor vehicle, it will mean time to stop or to maneuver around an obstacle. Good lighting has been shown to significantly reduce the night proportion of accidents; especially on urban freeways and on major streets. For most streets and sidewalks, good lighting has been reported to increase the feeling of personal security of pedestrians.

The benefits of lighting should be considered against the drawbacks; engineering, capital and maintenance costs, energy use, appearance--particularly of overhead wires, but sometimes also of poles--the added fixed object hazard of poles, plus spill light on adjacent residential or commercial (i.e., outdoor dining) property and into the sky (affecting astronomical observations). Thus, lighting is 'good' when it is economical in equipment, energy and maintenance costs, and meets a proven or reasonably predictable need, with a minimum of adverse effect. This Practice has been developed to provide guidance to experienced engineers in designing such lighting.

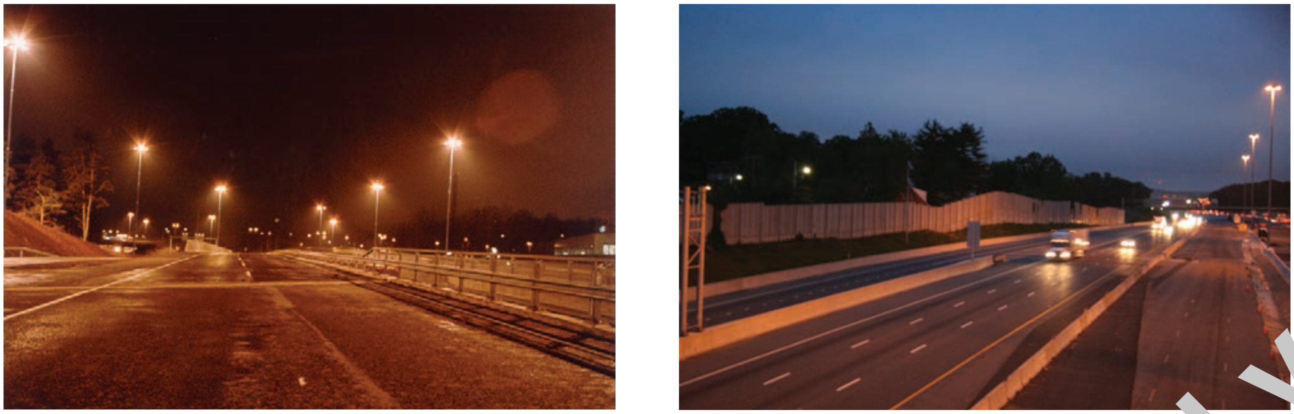

Fig. 1a - Typical roadway lighting installations. (Images courtesy of Paul Lutkevich, Parsons Brinckerhoff)

Fig. 1b - Typical street lighting installations. (Images courtesy of Paul Lutkevich, Parsons Brinckerhoff.)

1.3 Roadway Lighting and Street Lighting

Two different types of roadway lighting systems are defined in this recommended practice - roadway lighting and street lighting.

Roadway lighting is provided for freeways, expressways, limited access roadways, and roads on which pedestrians, cyclists, and parked vehicles are generally not present. The primary purpose of roadway lighting is to help the motorist remain on the roadway and help with the detection of obstacles within and beyond the range of the vehicles headlights.

Street lighting is provided for major, collector, and local roads were pedestrians and cyclists are generally present. The primary purpose of street lighting is to help the motorist identify obstacles, provide adequate visibility of pedestrians and cyclists, and assist in visual search tasks, both on and adjacent to the street.

1.4 Related Documents

There are several documents that possibly cover areas related to roadway or pedestrian lighting that are not covered in this Recommended Practice. Other documents are listed for reference purposes. These documents include:

AASHTO GL-6	*Roadway Lighting Design Guide*
IES HB-10-11	*IES Lighting Handbook, 10th Edition*
CIE 191	Recommended System for Mesopic Photometry Based on Visual Performance
IES DG-5-94	*Recommended Lighting for Walkways and Class 1 Bikeways*
IES DG-10-12	*Choosing Light Sources for General Lighting**
IES DG-19-08	*Design Guide for Roundabout Lighting*
FHWA-SA-11-22 2012 FHWA	Lighting Handbook
IES G-1-03	*Guideline for Security Lighting for People, Property, and Public Spaces*

IES LM-50-13 — *Photometric Measurement of Roadway and Street Lighting Installations*

*IES RP-20-98** — *Lighting for Parking Facilities*

ANSI/IES RP-22-11 — *Standard Practice for Tunnel Lighting*

*IES RP-33-99** — *Lighting for Exterior Environments*

IES TM-11-00/R11 — *Light Trespass: Research, Results and Recommendations*

IES TM-12-12 — *Spectral Effects of Lighting on Visual Performance at Mesopic Light Levels*

IES TM-15-11 — *Luminaire Classification System for Outdoor Luminaires*

Note: The Light Source Annex in the previous version of RP-8 was outdated and has been removed. Since light sources are evolving so rapidly the reader is referred to *IES DG-10-12 Choosing Light Sources for General Lighting*, for up to date information.

Note: *withdrawn - contact IES for the latest version or a copy of the withdrawn document.

2.0 CLASSIFICATIONS AND DEFINITIONS

The definitions used in this practice might be used and defined differently by other documents, zoning bylaws, building codes, and agencies. For lighting design purposes, the classification for any street or roadway should best fit the descriptions contained within this recommended practice and not how classified by other sources.

2.1 Roadway, Pedestrian Walkway, and Bikeway Classifications

Freeway: A divided highway with full control of access.

Freeway A: Roadways with great visual complexity and high traffic volumes. Usually this type of freeway will be found in major metropolitan areas in or near the central core and will operate at or near design capacity through some of the early morning or evening hours of darkness.

Freeway B: All other divided roadways with full control of access.

Expressway: A divided highway with partial control of access.

Major: That part of the roadway system that serves as the principal network for through-traffic flow. The routes connect areas of principal traffic generation and important rural roadways entering and leaving the city. These routes are often known as “arterials,” “thoroughfares,” or “preferentials.” They are sometimes subdivided into primary and secondary; however, such distinctions are not necessary in roadway lighting. These routes primarily serve through traffic and secondarily provide access to abutting property.

Collector: Roadways servicing traffic between major and local streets. These are streets used mainly for traffic movements within residential, commercial and industrial areas. They do not handle long, through trips. Collector streets may be used for truck or bus movements and give direct service to abutting properties.

Local: Local streets are used primarily for direct access to residential, commercial, industrial, or other abutting property. They make up a large percentage of the total street system, but carry a small proportion of vehicular traffic.

Alley: Narrow public ways within a block, generally used for vehicular access to the rear of abutting properties.

Sidewalk: A paved or otherwise improved area for pedestrian use, located within public street rights- of-way, which also contain roadways for vehicular traffic.

Pedestrian Walkway: A public walk for pedestrian traffic, not necessarily within the right-of-way of a vehicular traffic roadway. Included are skywalks (pedestrian overpasses), sub-walks (pedestrian tunnels), and walkways giving access through parks or block interiors.

Crosswalk: any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which may be supplemented by contrasting pavement texture, style, or color.

Isolated Interchange: A grade-separated roadway crossing with one or more ramp connections between the crossing roadways, which is lighted and is not part of a continuous roadway lighted system.

Isolated Intersection: A lighted area in which two or more non-continuously lighted roadways join or cross at the same level. This area includes the roadway and roadside facilities for traffic movement in that area. A special type is the channelized intersection, in which traffic is directed into definite paths by islands with raised curbing.

Isolated Traffic Conflict Area: A traffic conflict area is an area on a road system where an increased potential exists for collisions between vehicles, vehicles and/or pedestrians, and vehicles and fixed objects. Examples include intersections, crosswalks and merge areas. When this area occurs on a roadway without a fixed lighting system (or separated from one by 20 seconds or more of driving time), it is considered an isolated traffic conflict area.

Bikeway: Any road, street, path, or way that is specifically designated as being open to bicycle travel, regardless of whether such facilities are designed for the exclusive use of bicycles or are to be shared with other transportation modes. Five basic types of facilities are used to accommodate bicyclists:

Shared lane: shared motor vehicle/bicycle use of a “standard”-width travel lane.

Wide outside lane: an outside travel lane with a width of at least 4.2 m (13.8 ft.).

Bike lane: a portion of the roadway designated by striping, signing, and/or pavement markings for preferential or exclusive use of bicycles.

Shoulder: a paved portion of the roadway adjacent to the edge stripe.

Separate bike path: a facility physically separated from the roadway and intended for bicycle use (see *IESNA DG-5-94, Lighting for Walkways and Class 1 Bikeways** for requirements in these areas. *See note on previous page.)

Median: The portion of a divided roadway physically separating the traveled ways for traffic in opposite directions.

2.2 Pedestrian Conflict Area Classifications

The major, collector and local street classifications appropriately describe general conditions of vehicular traffic conflict in urban areas. However, a second type of conflict, which is responsible for a disproportionate number of nighttime fatalities, is the vehicle/pedestrian interaction. The magnitude of pedestrian flow is nearly always related to the abutting land use. Three classifications of pedestrian night activity levels and the types of land use with which they are typically associated are given below:

High - Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. Examples are downtown retail areas, near theaters, concert halls, stadiums, and transit terminals.

Medium - Areas where lesser numbers of pedestrians utilize the streets at night. Typical are downtown office areas, blocks with libraries, apartments, neighborhood shopping, industrial, parks, and streets with transit lines.

Low - Areas with very low volumes of night pedestrian usage. These can occur in any of the cited roadway classifications but may be typified by suburban streets with single family dwellings, very low density residential developments, and rural or semi-rural areas.

The choice of the appropriate pedestrian activity level for a street is an engineering decision. If needed, one hour pedestrian counts can be taken during the first hour of darkness on some selected days, to establish the estimated average pedestrian traffic counts. A section of typical land use can be sampled by counting one or two representative blocks, or a single block of unusual characteristics can be counted, perhaps at a different hour, such as discharge from a major event. The volume of pedestrian activity during the hour of count that warrants increased lighting levels is not fixed and represents a local option. Guidelines for possible local consideration are:

Low –	10 or fewer pedestrians/hour
Medium –	1 to 100 pedestrians/hour
High –	over 100 pedestrians/hour

These volumes represent the total number of pedestrians walking in both directions in a typical block or 200 meter (660 ft.) section.

2.3 Pavement Classifications

The calculation of either pavement luminance or Small Target Visibility (STV) requires information about the directional surface reflectance characteristics of the pavement. Studies have shown that most common pavements can be grouped into a limited number of standard road surfaces having specific reflectance characteristics. This data has been experimentally determined and presented in r-Tables. See **Annex A** for copies of the tables.

For purposes of this Practice, pavement reflectance characteristics follow the CIE (Commission International de l’Éclairage) Four Class system (ref. CIE 140-2000). A description of road surface classifications is given in **Table 1**. The classification is based on the specularity of the pavement (S1), and a scaling factor $\mathbf{Q_o}$ as determined by the overall “lightness” of the pavement. The normalized $\mathbf{Q_o}$ is given in **Table 1** for each of the pavements described. Greater accuracy in predicting Visibility Level (VL) and pavement luminance can be achieved by evaluating specific pavements as to their S1 ratio and specific Q∘ and then choosing the correct r-Table. The S1 ratio and specific Q∘ for a pavement can be determined in one of two ways: (1) a core sample can be removed from the pavement and photometrically tested by a qualified laboratory; (2) a field evaluation can be made (for further information see **Annex D**, Reference 9). Actual pavement reflectance and specularity will vary with pavement age and wear.

Table 1. Road Surface Classifications

Class	Q∘	Description	Mode of Reflectance
R1	0.10	Portland cement concrete road surface. Asphalt road surface with a minimum of 12 percent of the aggregates composed of artificial brightener (e.g. Synopal) aggregates (e.g. labradorite, quartzite)	Mostly Diffuse
R2	0.07	Asphalt road surface with an aggregate composed of a minimum 60 percent gravel (size greater than 1cm.). Asphalt road surface with 10 to 15 percent artificial brightener in aggregate mix. (Not normally used in North America)	Mixed (diffuse and specular)
R3	0.07	Asphalt road surface (regular and carpet seal) with dark aggregates (e.g. trap rock, blast furnace slag); rough texture after some months of use (typical highways).	Slightly Specular
R4	0.08	Asphalt road surface with very smooth texture	Mostly Specular

2.4 Luminaire Classification System (LCS)

The IES classification of luminaires is provided in *IES TM-15-11, Luminaire Classification System for Outdoor Luminaires*. The LCS system defines the distribution of light from the luminaire within three primary solid angles; including uplight, backlight, and forward light, as illustrated in **Figure 2a**.

The primary areas are further divided into 10 secondary solid angles, illustrated in **Figure 2b**.

An LCS luminaire report for a typical cobra-head style luminaire is shown in **Figure 3**. The percent of luminaire lumens is noted in each of the zones allowing the designer to understand more fully the impact and performance of the luminaire. A B-U-G rating is given to assist the designer in understanding the backlight, uplight, and glare characteristics of the luminaire.

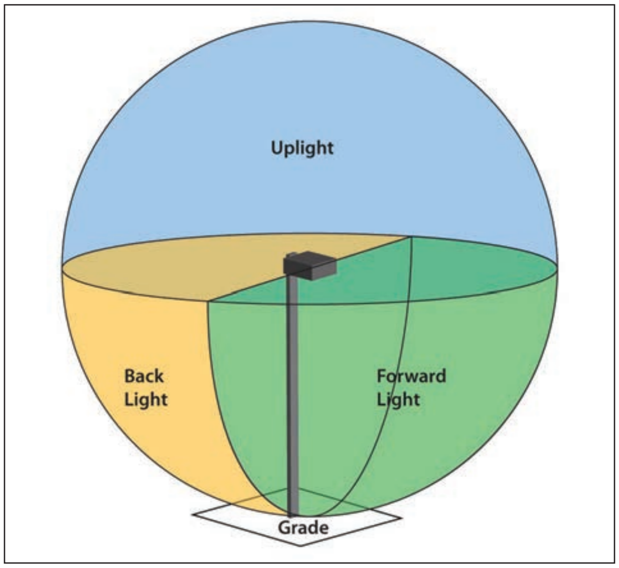

Figure 2a: LCS main solid angles. (© Illuminating Engineering Society of North America)

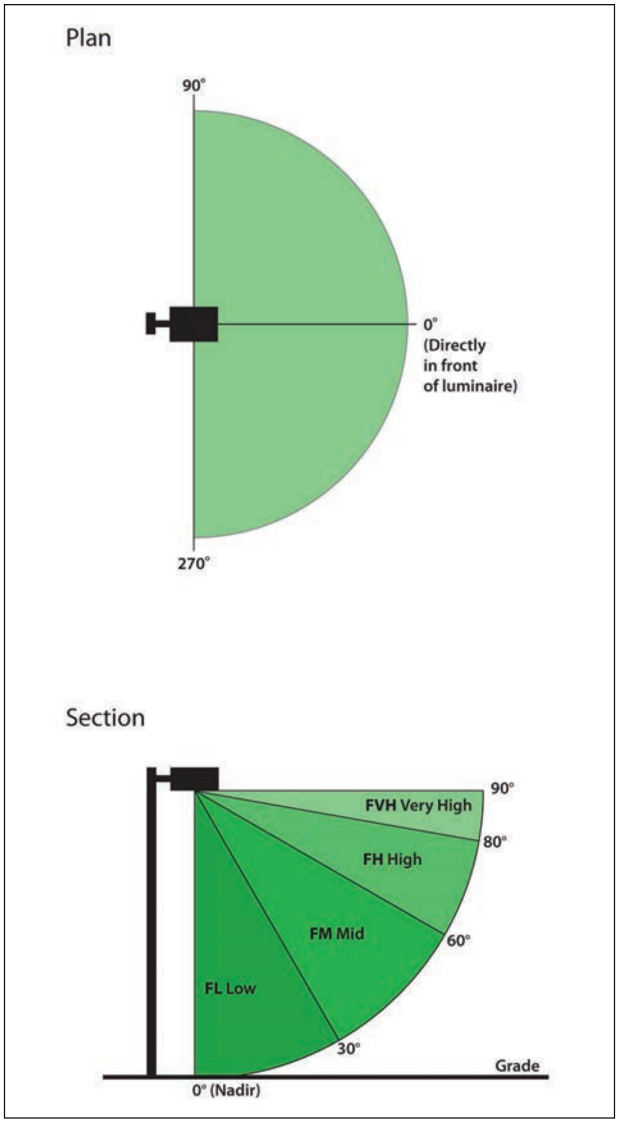

Figure 2b: Secondary solid angles. (© Illuminating Engineering Society of North America)

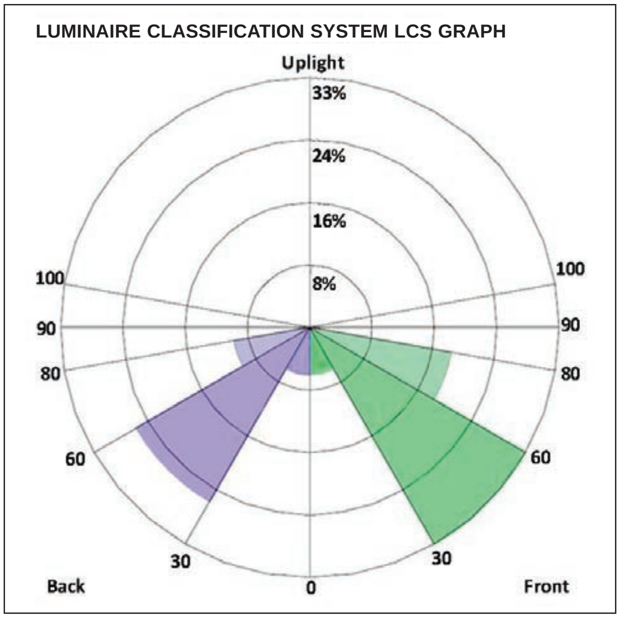

Figure 3: Cobrahead style luminaire LCS plot. (Graphic courtesy of Rick Kauffman)

LCS Rating: F6-33-19-1, B6-26-10-1, U0-0.
Front: Low=6 1%, Medium=32.6%, High=18.7%, Very High=0.1%.
Back: Low=6.1%, Medium=26.2%, High=10.0%, Very High=0.2%.
Uplight: Low=0.0%, High=0.0%.

Since this method of luminaire classification has replaced the previous classification system of vertical light control--cutoff, semi-cutoff, and non-cutoff-- the IES Roadway Lighting Committee is evaluating its applicability and suggested limits for inclusion in *ANSI/IES RP-8-14*. Since the LCS system is based on the percent of luminaire lumens within the zones of solid angles of a sphere and the previous system is based on light intensities on a lateral and transverse grid on a target area, there is no direct correlation between the two systems. The former system was defined in *IES TM-3* (withdrawn) and is now given for reference in **Annex E** of this practice.

3.0 DESIGN CONSIDERATIONS

3.1 Design Issues

There are several major issues that affect driver visibility differently between rural and urban areas, and also between limited access and uncontrolled access roads. These include differences in speed, levels of background luminance, frequency of intersections and driveways, presence of curb parking, and most importantly, the number of pedestrians present. Because of the increase in pedestrian and vehicular traffic, and level of traffic control, a motorist's rate of travel is typically slower in urban areas. The higher levels of background lighting found in urban areas can augment roadway illuminance provided by lighting systems, but can also produce glare and distraction. Thus, off-road light sources can either assist or disorient drivers.

3.2 Appearance and Scale

In areas with heavy pedestrian traffic, luminaire height and pole design should consider and respond to the human scale. This often results in the use of lower pole/mounting heights for street lighting, 3 to 6 meters (10 to 25 ft.), instead of more typical roadway lighting pole heights of 10 to 15 meters (25 to 50 ft.). In some cases a combination of mounting height ranges are used to meet the needs of the pedestrian as well as the driver. Controlling glare and maximizing system efficiencies are difficult with lower mounting heights. Because of this and other reasons described in this practice the cost of the lighting system in these areas is greater than in lower pedestrian use areas.

3.3 Visual Task

An effort should be made to completely understand the visual task in a given setting[48]. Too often the designer thinks only in terms of the driving task. When designing for areas of congestion or significant interest, allowance needs to be made for the myriad of tasks. These would include seeing pedestrians, dropping off passengers, viewing elements within the streetscape, dealing with traffic tie-ups, reading signs, or other driving tasks related to urban areas. Other users of the urban street right of way, such as pedestrians and bicyclists, will also require adequate lighting for their tasks. The recommendations included in this practice are for typical situations. If the designer notes unusual situations when considering these items then reasonable engineering judgment should be applied when applying the recommendations in this standard practice.

3.4 Integration with Non-Lighting Elements

In urban areas, particularly in medium to high pedestrian usage areas, many elements might have to be integrated and coordinated with the lighting system. Some of these elements are noted in **Figure 4**. The locations of light poles need to be coordinated with the street furniture and landscaping. An assessment might be required of the impact that these objects will have on the performance of the lighting system. The designer and owner of the lighting system should look at the installation with all of the non-lighting elements and work to resolve conflicts.

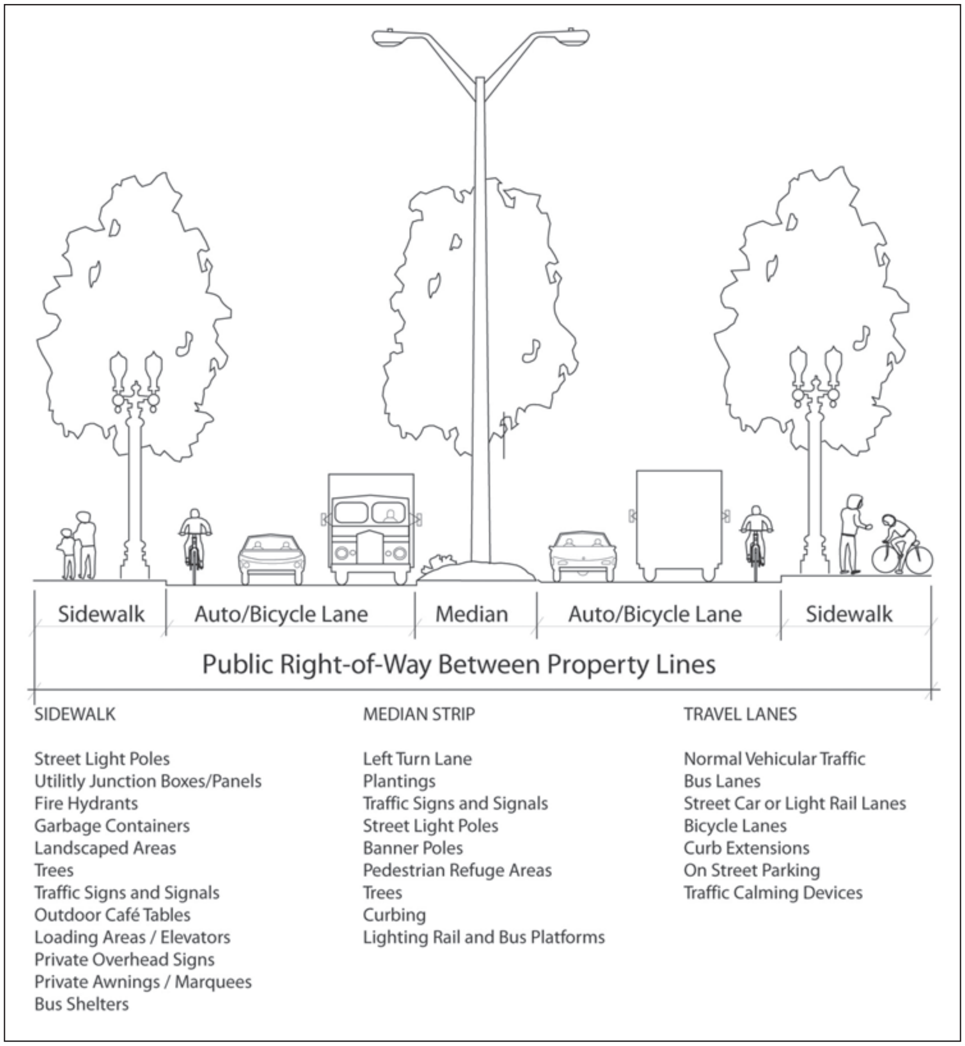

Figure 4: Elements of the lighted Right-of-way.

3.5 Vertical Surface Illumination

Illuminated building faces can provide a sense of security and mitigation for the shadows (off the street) created by roadway fully shielded luminaires in standard layouts. Adding a small percentage of higher vertical angle light to the photometric distribution of the luminaire can provide “fill light” to enliven the architectural facades at night. Care should be exercised in selection of the optical type and equipment placement to avoid creating an obtrusive condition for the motorist or the abutting property users. Vertical illumination also plays a critical role in producing visibility of pedestrians, cyclists, and objects within street environments.

3.6 Glare and Sky-Glow Issues

Roadway lighting systems are under increasing scrutiny from various sectors of the public. While the general public is not usually aware of specific design requirements of roadway lighting systems, observations of glare, light trespass, and sky-glow, are widely perceived and might be subject to criticism. Lighting designers should become familiar with these issues and be prepared to design a lighting system that meets the needs of the client/owner, while also considering the effect of the lighting system on the environment.

The common term "glare", as it affects human vision, is subdivided into two components, disability glare, and discomfort glare. Disability glare is the glare that results in reduced visual performance and visibility. It often is accompanied by discomfort. Discomfort glare is the glare producing a sense of annoyance or pain. It does not necessarily reduce the ability to see an object, but produces a sensation of discomfort due to high contrast of a non- uniform distribution in the field of view. The criterion used for roadway lighting to address disability glare is limiting the veiling luminance ratio of a lighting system.[16,17]

Light trespass is the amount of light that leaves a specific site and enters another site. While many roadway lighting systems cannot effectively limit or contain light to just the roadway or pedestrian areas, designs should be performed to limit the amount of trespass light. *IES TM-11-00(R2011) Light Trespass: Research, Results, and Recommendations*, provides guidelines on limitations for light trespass.

Sky glow is the luminance that is created in the night sky by light scattered within the atmosphere directed back towards an observer, thereby diminishing or completely obscuring the view of the night sky. One method to limit sky glow is to limit the amount of light directed towards the sky. This includes limiting the amount of total light used in an area, and limiting uplight from luminaires (see CIE Report 126, 1997, *Guidelines for Minimizing Sky Glow* for more guidance).

Figure 5 a,b,c: Examples of light trespass and sky glow. (Images courtesy of International Dark Sky Association IDA.)

The impact of lighting is different in relative terms depending on the surrounding area. The addition of a lighting system using the higher end of the recommended horizontal and vertical lighting levels will not have the same impact in an urban area with extensive ambient lighting from stores, signs, parking lots, etc., as it will in a rural area with low ambient lighting levels. In order to differentiate areas the IES has developed Lighting Zones describing different ambient lighting conditions. The appropriate lighting level restrictions at each of the above Lighting Zones is currently under review by the IES Roadway Lighting Committee but were not validated and available at the time of this revision. See the *Joint IDA/IES Model Lighting Ordinance (MLO), IES RP-33 Outdoor Environmental Lighting* or the *IES Lighting Handbook, 10th Edition*, for more information.

3.7 Impact of Headlights

Headlights are the primary system intended to assist drivers with seeing objects on and along the road. The ability of headlights to provide for detection of objects at higher vehicle speeds may not be adequate. It is known that at higher speeds the safe sight stopping distance can exceed the visual detection distance provided by low beam headlights.[44,45,46]

Computer modeling has been performed, using available photometric files for low beam headlights, to determine when headlights alone would provide sufficient illumination to meet the requirements of this recommended practice. The parameter evaluated in the analysis was the vertical illuminance criteria for the pedestrian areas adjacent to the roadway.

Based on the analysis, it appears that vehicle headlights alone may meet the lighting requirements for roadways with speeds below 30 mph (approx. 50 km/h) and with little or no pedestrian activity. Because this was a limited analysis, based on computer modeling, and many variables are involved in the decision to provide supplemental lighting, the designer and governing authority shall decide whether lighting is warranted.

3.8 Impact of Trees on Lighting

Trees are an important and valued element for the social, economic and environmental benefits they provide for all users. However, if the size and shape of mature trees are not taken into consideration as part of the lighting design, then roadway and roadside functions and safety can be compromised. Tree location and species selection can reduce lighting levels below the thresholds intended to maintain the safety of the roadway or the safety and security of pedestrians, bicyclists and transit users, and can prove to be a detriment to the intended functions and safety of the roadway and roadside. Likewise, lighting location and design that is incompatible with trees may require excessive tree trimming, which could prove to be unsustainable in terms of maintenance and operations costs and detrimental to the intended function and health of the trees.

In an investigation conducted in Minnesota[43], trees were found to have a significant impact on the lighting system and delivered lighting levels. Lighting level measurements were taken at two test locations in the summer when leaves were present on the trees and in the winter when these deciduous trees had lost their leaves. In these tests horizontal lighting levels on the sidewalks were shown to be reduced 19 to 33 percent and vertical lighting values were reduced 21 percent to 65 percent by the foliage.

The effect of trees on lighting levels is not sufficiently quantified to develop exact modifications for designs, but this report suggests an additional light loss factor of 10 to 20 percent be included in design when new or existing trees are in close proximity to the lighting. Although this is a least desirable option, (see **Section 5.11.2**). As a minimum, the lighting system should be coordinated with any new or existing landscaping. Lighting designers should also consider consulting with arborists to evaluate the potential long-term impact of specific species of trees.

3.9 Spectral Considerations

IES TM-12-12, Spectral Effects of Lighting on Visual Performance at Mesopic Light Levels, discusses