District of Columbia

STREETLIGHT POLICY AND DESIGN GUIDELINES

District Department of Transportation
55 M Street, SE, 4th Floor
Washington, DC 20002

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District Department of Transportation

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION

d. Office of the Director

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I am very pleased to announce the completion of the revision of the *District of Columbia Streetlight Policy and Design Guidelines*. The original document published in 2005 by the District Department of Transportation (DDOT) has been used by the District for the past several years. This revision aligns the guidelines with changes in technology, updated DDOT practices and government initiatives on maximizing energy-efficiency.

Streetlighting in urban areas supports multiple objectives. Its primary objective is to provide the light necessary for safe passage of motorists and pedestrians at night. In addition, it is an important aesthetic element of the street furniture and its appearance often represents the significance and history of the area.

Washington is the nation's capital with its characteristic magnificent buildings and many historic areas. Pierre-Charles L'Enfant designed the City's basic layout and plan, with features from the Capitol building to parks. In terms of the City's importance, it houses the US Capitol, the White House, the Supreme Court and many other important government buildings and national landmarks. This uniqueness and historical significance of the City must be reflected through all aesthetic elements including the appearance of streetlights.

I am confident that the use of this document will ensure that DDOT meets its commitments to preserving the aesthetics needs of the City while promoting the safety of the citizens.

Sincerely,

Terry Bellamy
Director
District Department of Transportation

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EXECUTIVE SUMMARY

This report is an update of *District of Columbia Streetlight Policy and Design Guidelines* which provides a framework for a uniform streetlight policy throughout the City. The original document was published in 2005 by the District Department of Transportation (DDOT) which has been used by the District for the past several years for all new projects. This updated report takes into account the changes in technology and practices of DDOT over recent years. This report encompasses research on technology, design principles, and policies; review of existing DDOT practices; and recommendations for implementation.

A summary of the policy recommendations is presented below.

OVERVIEW OF MAJOR CHANGES IN THE GUIDELINES

The following significant deviations from the previous practices were adopted in the initial Guidelines and this update:

1. White-light lamps may replace the yellow-light, high-pressure sodium lamps (optional for alleys), if their life-cycle cost is comparable to that of yellow-light lamps.

   Light Emitting Diode (LED) light fixtures produce desired white light and are becoming more common in the lighting industry due to the longer life and lower energy consumption as compared to most other lighting fixtures. LED light fixtures have been extensively implemented within the District.
2. The usage of Mercury Vapor and Incandescent light fixtures is being phased out within the District. It is the intent of DDOT to eliminate the usage of these fixtures by the Year 2015.
3. The widely-used Cobrahead fixtures may be substituted (except for 5A Alley poles) by a Teardrop fixture with decorative arm. Teardrop fixture is preferred because of its aesthetic and architectural qualities for outdoor lighting. However, the extent of the substitution of the Cobrahead fixtures with Teardrop fixtures depends on the funding situation and priority.
4. Refractive, prismatic globes have been accepted for replacing the currently used plain globes. Refractive globes are a major achievement in the field of optical technologies and provide greater level of illumination with minimal light “loss” by redirecting lights in the desired direction. The prismatic optical system directs the light into the desired pattern, allows maximum spacing with excellent uniformity, and minimizes upward wasted light. The refractive globe is expected to reduce direct glare by softening and spreading the light being distributed from the light source. However, the usage of prismatic globes has not been a practice in Washington yet.

HARDWARE RECOMMENDATIONS

Various types of streetlight hardware are recommended based on the following street categories for both underground and overhead power lines:

1. Non-historic streets
2. Historic streets
3. Special Streets

Some hardware selection will also be based on the context of the surroundings.

For non-historic areas with underground power lines, the citizens will continue to be given an opportunity to select either a Decorative Teardrop (alternatively Cobraheads, if cost prohibits) or Upright poles in place of the existing Cobrahead pendant poles. The pendant poles are recommended for non-historic streets, as they are economical. For non-historic areas with overhead power lines, the lighting arm is the only option for selection. A Decorative Teardrop arm is preferred; however, Cobraheads can be used, if cost prohibits.

The use of upright poles (e.g., Numbers 14, 16, 18) will continue for historic streets.

Several important streets were previously designated as Special Streets (alternatively known as Capital Avenues), for which Twin-20 poles were generally recommended. A decorative Teardrop arm can be used where overhead power lines exist.

The developed guidelines will apply to the City in general; however, areas with their own regulations are exempt from these requirements or portions thereof. These exempt locations include, but are not limited to, the Downtown Streetscape Area, Business Improvement Districts (BIDs), and Monumental Core Area. DDOT reserves the right to exempt certain areas on a case-by-case basis and select any special streetlight fixture.

DESIGN PRINCIPLES

The following design principles are made part of the policy:

1. The guidelines of the American Association of State Highway and Transportation Officials (AASHTO) are adopted as the District's policy for lighting criteria.
2. The design should use maximum spacing of streetlight poles. A minimum spacing between poles of 60 ft has been specified; however, it is not a recommendation, but only an absolute minimum. The designer should ensure that the spacing fulfills the following objectives, yet meeting the AASHTO guidelines:
   - Minimum number of poles
   - Lowest acceptable wattage
   - Maximum possible spacing
3. The design should be based on lower wattage lamps so as to provide flexibility for using higher level of illumination in the future, if necessary. This can be easily done by replacing lower wattage lamps with higher wattage. For example, No. 16 poles should be designed for a maximum 250 Watt while up to 400 Watt is allowed; No. 14 poles should be designed for a maximum of 100 Watt while up to 150 Watt is allowed. While these wattage specifications refer to HPS lights, it will apply to similar equivalents of LED fixtures.

4. The design should avoid using 400-Watt conversion kits in residential areas.
5. The height of the pole should be determined based on the context of the surroundings, such as the height of buildings, roadway width, sidewalk width, etc.
6. The design must consider reduction of glare into drivers' and pedestrians' eyes, and enhancement of visibility. Appropriate refractive globes can effectively reduce direct glare by softening and spreading the light distribution. Shields can also be used to aim the lights so that they are not directly visible from the alleys, pathways, and windows, as needed.
7. The designer should not use of incandescent and mercury vapor luminaires since these fixtures will be phased out by the Year 2015.

CONCLUSIONS

DDOT should periodically review these guidelines and make any necessary modifications within the general framework. AASHTO has recently developed an updated street lighting guideline and the appropriate elements of these updated guidelines have been incorporated into this document.

DDOT should also assess the overall technology and its cost-effectiveness from time to time to take advantage of new developments offering enhanced safety, economy and aesthetics. An extensive use of Teardrop remains a question of funding availability and agency priority. Similarly, the use of LED, metal halide or other similar white light-producing lamps is also a question of cost; therefore, their costs should be monitored.

1. INTRODUCTION

This report is an update of *District of Columbia Streetlight Policy and Design Guidelines* which provides a framework for a uniform streetlight policy throughout the City. The original document was published in 2005 by the District Department of Transportation (DDOT) which has been used by the District for the past several years for all new projects. This updated report takes into account the changes in technology and practices of DDOT over recent years. This report encompasses research on technology, design principles, and policies; review of existing DDOT practices; and recommendations for implementation.

In 2005, DDOT undertook the original study to develop a set of streetlighting policies so that a uniform streetlight deployment can occur throughout the City. This study was aimed at providing the District with well-defined, updated guidelines for future streetlight construction. The guidelines have been implemented in an evolutionary fashion along with new road construction and streetscape projects. This document outlines a policy and not a regulation or standard.

Streetlighting in urban areas supports multiple objectives. Its primary and fundamental objective is to provide the light necessary for safe passage of motorists and pedestrians at night. In addition, it is an important aesthetic element of the street furniture and its appearance often represents the significance and history of the area. Therefore, it is important that the streetlight fixtures follow certain standards based on the needs and settings of the area. In the past, the lack of a policy has resulted in non-uniform lighting hardware and illumination levels throughout the city.

Washington is the nation's capital with an area of 68.25 square miles and a population of approximately 618,000 (Year 2011). Pierre-Charles L'Enfant designed the City's basic layout and plan, which features from the Capitol building to parks. In terms of the City’s importance, it houses the US Capitol, the White House, the Supreme Court, and many other important government buildings, national landmarks, museums and memorials. In terms of look, this city is very different than other US cities with its characteristic magnificent buildings with limited heights and many historic areas. This uniqueness and the historic significance of the City must be reflected through all aesthetic elements including the appearance of streetlights.

This document contains a set of strategic policy recommendations for future construction of streetlights in the District of Columbia. It includes four other chapters in addition to this Introduction (Chapter 1). Chapter 2 presents background information and basic definitions for streetlights. Chapter 3 describes the existing DDOT practice. Chapter 4 describes the illumination standards recommended for the District. Chapter 5 discusses the streetlight hardware recommendations and presents a simplified streetlight design illustration of roadways going through various types of areas. Chapter 6 discusses the recommendations for the future.

2. BACKGROUND INFORMATION

This chapter presents definitions of key terminologies related to streetlight design. It also discusses fundamental concepts related to lighting.

2.1 DEFINITIONS

The definitions provided here are broadly classified in two different groups: 1) optics, and 2) streetlight hardware. The definitions in each group are described below.

2.1.1 Optics

Average Initial Illuminance: The average level of horizontal illuminance on the pavement area of a traveled way at the time the lighting system is installed with new lamps and clean luminaries; expressed in average footcandles (lux) for the pavement area.

Average Maintained Illuminance: The average level of horizontal illuminance on the pavement when the output of the lamp and luminaire is reduced by the maintenance factors; expressed in average footcandles (lux) for the pavement area.

BUG: The acronym stands for Backlight, Uplight and Glare. BUG describes the types of stray light escaping from an outdoor lighting luminaire that was developed by the Illuminating Engineering Society (IES). BUG will soon be a standard criterion when describing the characteristics of lighting fixtures. The acronym describes the types of stray light escaping from an outdoor luminaire. “B” stands for backlight, or the light directed in back of the mounting pole. “U” stands for uplight, or the light directed above the horizontal plane of the luminaire, and “G” stands for glare, or the amount of light emitted from the luminaire at angles know to cause glare. It is expected that BUG values will be published by luminaire manufacturers so lighting specifiers, designers or purchasers can tell at a glance how well a certain luminaire controls stray light or compares with other luminaires under consideration for an installation.

The BUG system was developed by the Illuminating Engineering Society (IES) to make comparing and evaluating outdoor luminaires fast, easy and more complete than older systems. The new system divides the sphere around a luminaire into zones assigning values according to expected environmental impact. This rating system offers the most complete evaluation of the total light emitted from luminaires to date. A point to remember, however, is that while the values assigned by the new system are good indicators, they may not in all cases directly correlate to light pollution. It still depends upon the site, the application and how the luminaire is installed.

Candela: The unit of luminous intensity. The term “candle” was formerly used.

Candlepower: The luminous intensity in a specified direction; which is expressed in candelas.

Color rendering: A general expression used for the effect of a light source on the color appearance of objects in conscious or subconscious comparison with their color appearance under a reference light source.

Color Rendering Index (CRI): A measure of the color shift the objects undergo when illuminated by the light source as compared with those same objects when illuminated by a reference source of comparable color temperature.

Cutoff angle (of a luminaire): The angle that is measured up from nadir, between the vertical axis and the first line of sight at which the bare source is not visible.

Footcandle: The illuminance on a one-square-foot surface in area, on which there is a light flux of one lumen that is uniformly distributed. One footcandle = 10.76 lux.

Foot Lambert: The uniform luminance of a surface emitting or reflecting light at the rate of one lumen per square foot. It is a unit of luminance or brightness.

Glare: The sensation produced within the visual field by luminance that exceeds the eye's ability to adapt. This can cause annoyance, discomfort, or loss in visual performance and visibility.

a. **Nuisance glare:** It is known as annoyance glare that causes complaints. The Illuminating Engineering Society of North America (IESNA) defines nuisance glare as the "light shining in my window" phenomenon.
b. **Discomfort glare:** The glare that causes physical discomfort but does not keep the viewer from seeing an object.
c. **Disability glare:** The effect of a bright light source that causes the stray light to scatter in the eye. The stray light obscures the primary image on the retina and restricts the viewer from seeing the object.

Illuminance: The time rate of flow of light is defined as luminous flux. Illuminance is the density of the luminous flux incident on a uniformly illuminated surface.

LED: Light emitting diode is a semiconductor light source with lower energy consumption and has a longer life than typical light sources.

Light Pollution: The haze or "glow" that reduces the ability of a person to view the nighttime sky. It is the stray light from luminaire, which is directed up into the skies; it is also referred to as "sky glow."

Light Trespass: The light from a luminaire that falls onto neighboring space, or into windows of adjacent building. It is also referred to as "spill light."

Louver (or louver grid): A series of baffles used to shield a source at certain angles, to either absorb or block unwanted light, or to reflect or redirect light. They are usually arranged in a geometric pattern.

Lumen: A unit of measure of the quantity of light. The amount of light that falls on an area of one square foot, every point of which is one foot from the source (i.e., a sphere) of one candela (candle), is defined as one lumen. A light source of one candela emits a total of 12.57 lumens.

Lumen depreciation: The decrease in lamp lumen that occurs as a lamp is operated until failure.

Luminaire: A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps and ballast (where applicable), and to connect the lamps to the power supply.

Luminaire dirt depreciation: The dirt or dust that accumulates on luminaires decreasing the total output of light, lowering the overall efficiency of the system.

Luminaire efficiency: The ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used therein.

Luminance: The luminous intensity of a surface in a given direction per unit of that surface as viewed from that direction.

Luminous Efficacy: The rate of converting the electrical energy into visible energy, which is measured in lumens per watt.

Lux: The International System (SI) unit of illuminance. It is defined as the amount of light on a surface of one square meter all points of which are one meter from a uniform source of one candela. One lux = 0.0929 footcandle.

Uniformity of Illuminance: The ratio of average footcandles (lux) of illuminance on the surface area to the footcandles (lux) at the point of minimum illuminance on the pavement. It is generally called the uniformity ratio.

Uniformity of Luminance: The Average-Level-To-Minimum Point method uses the average luminance on a surface of the roadway design area between two adjacent luminaries, divided by the lowest value at any point in the area. The Maximum-To-Minimum Point method uses the maximum and minimum values between the same adjacent luminaires. The uniformity of luminance (avg/min and max/min) considers the traveled portion of the roadway, except for divided highways that has different designs on each side.

Uplight: The percentage of lamp lumens directed at or above 90 degrees from a luminaire.

Veiling Luminance: A luminance superimposed on the retinal image that reduces its contrast, resulting in visual performance and decreased visibility; produced by bright areas in the visual field.

2.1.2 Streetlight Hardware

Ballast: A coil of wire and/or related electronic components used to limit the amount or electric current flowing through a lamp. Almost all lamps used in street lighting require ballasts except incandescent lamps.

Base: A lower part of a streetlight pole that supports the shaft.

Bracket (mast arm): An attachment to a pole from which a luminaire is suspended.

Breakaway Base: A base designed to yield when struck by a vehicle, thereby minimizing injury to the occupants of the vehicles and damage to the vehicle itself.

Head: The part of the luminaire that holds the lamp socket and mounting hanger or collar. The assembly will be referred as either the head or the body, when the mounting collar is part of, or attached directly to, the reflector housing, as in a clamshell style.

High-Mast Lighting: The illumination of a large area by means of a group of luminaires mounted on fixed orientation at the top of a high mast, generally 65 ft or higher. **Lamppost:** A standard support provided with the necessary internal attachments for wiring and the external attachments for the bracket and luminaire.

Photocontrol: The device that is usually cylindrical and the size of a tin can, contains a light sensitive element and other electromechanical or electronic components to turn the lights on at night and off during the day.

Reflector: Any polished or light colored object used in optical control to change the direction of light rays as opposed to just block or absorb it.

Refractor: A transparent panel or dish that also serves as a lamp cover and has molded ridges to bend the light in desired directions.

Streetlight Pole: A pole used for the purpose of supporting street luminaire(s). The luminaire(s) may be either installed on (upright poles) or suspended from the pole (pendant poles). Figure 1 shows the different components of poles. The upright poles include Nos. 18, 16, 14 and Twin-20; and the pendant poles include Cobrahead, 5A Alley Pole and Teardrop.

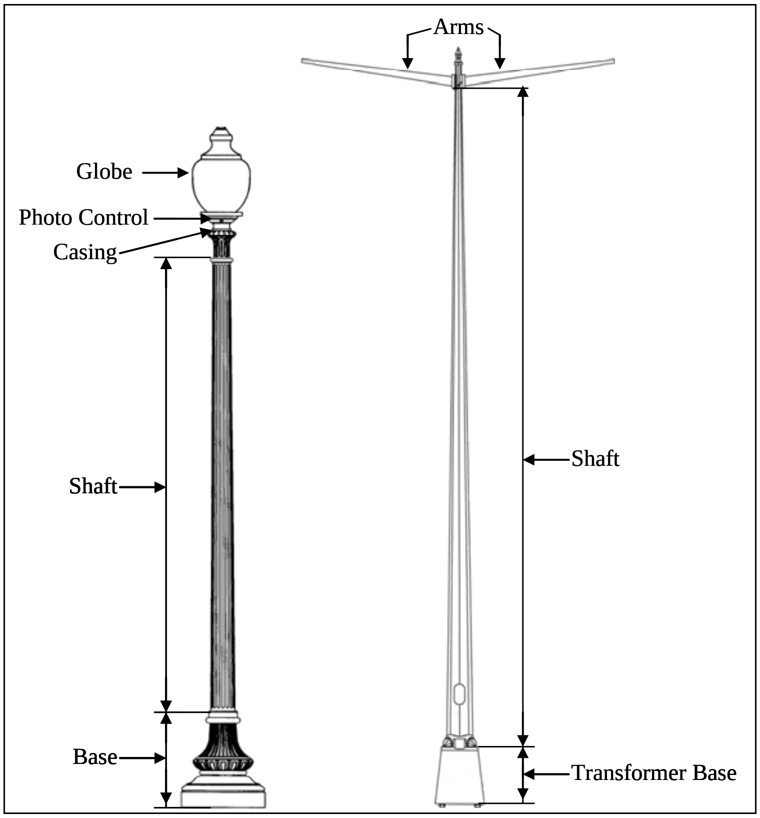


Figure 1. Components of Streetlight Poles - Upright and Pendant

2.2 AASHTO ROADWAY LIGHTING REQUIREMENTS

American Association of State Highway and Transportation Officials (AASHTO) and Illumination Engineers Society (IES) of North America recommend Table 1 and Table 2 as the guidelines for lighting design. These tables establish some threshold values, which a roadway lighting designer meets by using either the illuminance technique or the luminance technique. It should be noted that the 2005 *Roadway Lighting Design Guide* AASHTO update was utilized and many of the following tables were modified to reflect the latest standards.

Table 1. AASHTO-Suggested Maintained Luminance Values for Roadways

Roadway Classification		Luminance			Veiling Luminance Ratio
		L_{avg}	Uniformity		
		(cd/m²)	L_{avg}/L_{min}	L_{max}/L_{min}	$L_{v(max)}/L_{avg}$
Principal Arterials-Interstate and Other Freeways	Commercial	0.4 to 1.0	3.5:1	6:1	0.3:1
	Intermediate	0.4 to 0.8	3.5:1	6:1	
	Residential	0.4 to 0.6	3.5:1	6:1	
Other Principal Arterials	Commercial	1.2	3:1	5:1	0.3:1
	Intermediate	0.9	3:1	5:1	
	Residential	0.6	3.5:1	6:1	
Minor Arterials	Commercial	1.2	3:1	5:1	0.3:1
	Intermediate	0.9	3:1	5:1	
	Residential	0.6	3.5:1	6:1	
Collectors	Commercial	0.8	3:1	5:1	0.4:1
	Intermediate	0.6	3.5:1	6:1	
	Residential	0.4	4:1	8:1	
Local	Commercial	0.6	6:1	10:1	0.4:1
	Intermediate	0.5	6:1	10:1	
	Residential	0.3	6:1	10:1	
Alleys	Commercial	0.4	6:1	10:1	0.4:1
	Intermediate	0.3	6:1	10:1	
	Residential	0.2	6:1	10:1	

Source: *Roadway Lighting Design Guide*, AASHTO, 2005.

Table 2. AASHTO-Suggested Maintained Illuminance Values for Roadways

Roadway Classification		Average Illuminance Pavement Classification						Uniformity avg/min
		R1		R2 & R3		R4		
		Foot-candles	Lux	Foot-candles	Lux	Foot-candles	Lux	
Principal Arterials-Interstate and Other Freeways	Commercial	.6 to 1.1	6 to 12	.6 to 1.1	6 to 12	.6 to 1.1	6 to 12	3:1 or 4:1
	Intermediate	.6 to .9	6 to 10	.6 to .9	6 to 10	.6 to .9	6 to 10	
	Residential	.6 to .8	6 to 8	.6 to .8	6 to 8	.6 to .8	6 to 8	
Other Principal Arterials	Commercial	1.1	12	1.6	17	1.4	15	3:1
	Intermediate	0.8	9	1.2	13	1.0	11	
	Residential	0.6	6	0.8	9	0.8	8	
Minor Arterials	Commercial	0.9	10	1.4	15	1.0	11	4:1
	Intermediate	0.8	8	1.0	11	0.9	10	
	Residential	0.5	5	0.7	7	0.7	7	
Collectors	Commercial	0.8	8	1.1	12	0.9	10	4:1
	Intermediate	0.6	6	0.8	9	0.8	8	
	Residential	0.4	4	0.6	6	0.5	5	
Local	Commercial	0.6	6	0.8	9	0.8	8	6:1
	Intermediate	0.5	5	0.7	7	0.6	6	
	Residential	0.3	3	0.4	4	0.4	4	
Alleys	Commercial	0.4	4	0.6	6	0.5	5	6:1
	Intermediate	0.3	3	0.4	4	0.4	4	
	Residential	0.2	2	0.3	3	0.3	3	
Sidewalks	Commercial	0.9	10	1.3	14	1.2	13	3:1
	Intermediate	0.6	6	0.8	9	0.8	8	4:1
	Residential	0.3	3	0.4	4	0.4	4	6:1
Pedestrian Ways and Bicycle Lanes		1.4	15	2.0	22	1.8	19	3:1

Source: *Roadway Lighting Design Guide*, AASHTO, 2005.

A compilation of Table 1 and Table 2 for the AASHTO recommendations is shown in Table 3. Generally, the illuminance technique is used for streetlighting design. The selection of threshold values is based upon several factors, as stated below:

1. Functional classification of the facility (e.g., arterial, collector, etc.)
2. Type of land use (e.g., commercial, residential, etc.)
3. Classification of pavement (e.g., R1, R2, etc., based on type of pavement material)

Table 3. AASHTO Suggested Maintained Illuminance and Luminance Values for Roadways

Roadway and Walkway Classification	Off-Roadway Light Sources	Average Maintained Illuminance								Minimum Illuminance		Illuminance Uniformity Ratio	Average Maintained Luminance			Veiling Luminance Ratio
		R1		R2		R3		R4					L_{avg}	Uniformity		
	General Land Use	(Lux)	(Foot-candles)	(Lux)	(Foot-candles)	(Lux)	(Foot-candles)	(Lux)	(Foot-candles)	(Lux)	(Foot-candles)	avg/min	cd/m^2	L_{avg}/L_{min}	L_{max}/L_{min}	$L_{v(max)}/L_{avg}$
		(min)	(min)	(min)	(min)	(min)	(min)	(min)	(min)			(max) [b]	(min)	(max)	(max)	(max) [d]
Principal Arterials																
Interstate and other freeways	Commercial	6 to 12	0.6 to 1.1	6 to 12	0.6 to 1.1	6 to 12	0.6 to 1.1	6 to 12	0.6 to 1.1	2	0.2	3:1 or 4:1	0.4 to 1.0	3.5:1	6:1	0.3:1
	Intermediate	6 to 10	0.6 to 0.9	6 to 10	0.6 to 0.9	6 to 10	0.6 to 0.9	6 to 10	0.6 to 0.9	2	0.2	3:1 or 4:1	0.4 to 0.8	3.5:1	6:1	0.3:1
	Residential	6 to 8	0.6 to 0.8	6 to 8	0.6 to 0.8	6 to 8	0.6 to 0.8	6 to 8	0.6 to 0.8	2	0.2	3:1 or 4:1	0.4 to 0.6	3.5:1	6:1	0.3:1
Other Principal Arterials (partial or no control of access)	Commercial	12	1.1	17	1.6	17	1.6	15	1.4	As uniformity ratio allows	As uniformity ratio allows	3:1	1.2	3:1	5:1	0.3:1
	Intermediate	9	0.8	13	1.2	13	1.2	11	1.0			3:1	0.9	3:1	5:1	0.3:1
	Residential	6	0.6	9	0.8	9	0.8	8	0.8			3:1	0.6	3.5:1	6:1	0.3:1
Minor Arterials	Commercial	10	0.9	15	1.4	15	1.4	11	1.0			4:1	1.2	3:1	5:1	0.3:1
	Intermediate	8	0.8	11	1.0	11	1.0	10	0.9			4:1	0.9	3:1	5:1	0.3:1
	Residential	5	0.5	7	0.7	7	0.7	7	0.7			4:1	0.6	3.5:1	6:1	0.3:1
Collectors	Commercial	8	0.8	12	1.1	12	1.1	10	0.9			4:1	0.8	3:1	5:1	0.4:1
	Intermediate	6	0.6	9	0.8	9	0.8	8	0.8			4:1	0.6	3.5:1	6:1	0.4:1
	Residential	4	0.4	6	0.6	6	0.6	5	0.5			4:1	0.4	4:1	8:1	0.4:1
Local	Commercial	6	0.6	9	0.8	9	0.8	8	0.8			6:1	0.6	6:1	10:1	0.4:1
	Intermediate	5	0.5	7	0.7	7	0.7	6	0.6			6:1	0.5	6:1	10:1	0.4:1
	Residential	3	0.3	4	0.4	4	0.4	4	0.4			6:1	0.3	6:1	10:1	0.4:1
Alleys	Commercial	4	0.4	6	0.6	6	0.6	5	0.5			6:1	0.4	6:1	10:1	0.4:1
	Intermediate	3	0.3	4	0.4	4	0.4	4	0.4			6:1	0.3	6:1	10:1	0.4:1
	Residential	2	0.2	3	0.3	3	0.3	3	0.3			6:1	0.2	6:1	10:1	0.4:1
Sidewalks	Commercial	10	0.9	14	1.3	14	1.3	13	1.2			3:1	Use illuminance requirements			
	Intermediate	6	0.6	9	0.8	9	0.8	8	0.8			4:1				
	Residential	3	0.3	4	0.4	4	0.4	4	0.4			6:1				
Pedestrian Ways and Bicycle Lanes	All	15	1.4	22	2.0	22	2.0	19	1.8			3:1				

Source: *Roadway Lighting Design Guide*, AASHTO, 2005.

[a] Use R3 requirements for walkway/bikeway surface materials other than the pavement types shown.

[b] Higher uniformity ratios are acceptable for elevated ramps near high mast poles.

[c] Meet either the Illuminance design method requirements or the Luminance design method requirements and meet veiling luminance requirements for both the Illuminance and the Luminance design methods.

[d] $L_{v(max)}$ occurs at initial lumens, therefore, use L_{ave} initial, not L_{avg} maintained .

<u>Note:</u>

1 There may be situations when higher level of illuminance is justified.

2 Physical roadway conditions may require adjustment of spacing determined from the base levels of illuminance indicated above.

The factors used in the above tables are discussed below.

Functional Classification of the Facility

The following classifications are those recommended by the Illuminating Engineering Society of North America[1] and AASHTO[2].

1. **Freeway:** This is a divided major roadway with full control of access and with no crossing at grade. It applies to toll as well as non-toll roads.
   a. Freeway A: This designates roadways with greater visual complexity and high traffic volumes. This type of freeway is usually found in major metropolitan areas in or near the central core. It operates through much of the early evening hours of darkness at or near design capacity.
   b. Freeway B: This designates all other divided roadways with full control of access where lighting is needed.
2. **Expressway:** A divided major roadway for through traffic with partial control of access and generally at major crossroads with interchanges. Parkways are generally known as expressways for non-commercial traffic within parks and park-like areas.
3. **Major/Principal Arterial:** That part of the roadway system serving as the principal network for through traffic flow. The routes connect important rural highways entering the city and areas of principal traffic generation.
4. **Minor Arterial:** The roadway that provides relatively high speeds and least interference to through traffic flow with little or no access control. It provides direct access to abutting properties, have frequent at-grade intersections, have pedestrian movements along and across the roadway, accommodate bicyclist unless specifically limited and support public transportation.
5. **Collector:** The roadways servicing traffic between major and local roadways. These are roadways used mostly for traffic movements within residential, commercial, and industrial areas.
6. **Local:** The roadways used mainly for direct access to residential, commercial, industrial, or other abutting property. They do not include roadways that carry through traffic. The long local roadways are generally divided into short sections by collector roadway systems.
7. **Alley:** A narrow public ways within a block, which is generally used for vehicular access to the rear of abutting properties.
8. **Sidewalk:** A paved or otherwise improved areas for pedestrian use, located within the public street right-of-way, which also contains roadways for vehicular traffic.
9. **Pedestrian Walkway:** A public facility for pedestrian traffic not necessarily within the right-of-way of a vehicular traffic roadway. They include skywalks (pedestrian

[1] *American National Standard Practice for Roadway Lighting*, ANSI/IES RP-8.1983; Illuminating Engineering Society of North America.
[2] *Roadway Lighting Design Guide,* AASHTO, 2005.

overpasses), subwalks (pedestrian tunnels), walkways giving access to parks or block interiors, and midblock street crossings.

10. **Bicycle lane:** A portion of roadway, or shoulder, or any facility that has been explicitly designated for the use by bicyclists.

Area Classifications

1. **Commercial**: A business development of a municipality where ordinarily there are many pedestrians during night hours. This definition applies to densely developed business areas outside, as well as within, the central section of a municipality. The area contains land use that attracts a relatively heavy volume of nighttime vehicular traffic or pedestrian traffic, or both, on a frequent basis.
2. **Intermediate**: Those areas often characterized by moderately heavy nighttime pedestrian activities such as in blocks having libraries, community recreation centers, large apartment buildings, industrial buildings, or neighborhood retail stores of a municipality.
3. **Residential**: A residential area, or a mixture of residential and small commercial establishments characterized by few pedestrians at night. This includes areas with single-family homes, townhouses, and small apartment buildings.

Certain land uses, such as office and industrial parks, may fit into any of the above classifications. The classification selected should be consistent with the expected nighttime pedestrian activities.

Road Surface Classification

The road surface classifications (as shown in Table 4) are used when designing a roadway lighting system. It is divided into four categories (R1, R2, R3 and R4) depending on the reflectance characteristics of the pavement. Each category has its own values of reflectance for specified angles.

Table 4. Road Surface Classification[3]

Class	Q_o*	Description	Mode of Reflectance
R1	0.10	Portland cement concrete road surface. Asphalt road surface with minimum of 15 percent of the aggregate 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 10 millimeters) 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 month of use (typical highways)	Slightly specular
R4	0.08	Asphalt road surface with very smooth texture	Mostly specular

* Q_o = representative mean luminance coefficient

[3] Source: *American National Standard Practice for Roadway Lighting.* ANSI/IES RP-8-00; Illuminating Engineering Society of North America.

2.3 LIGHT SOURCES

The light source is the most important element of illumination equipment. It is the principal determinant of visual quality, illumination efficiency, energy conservation, and the economic aspects of the lighting system. There are numerous types of light sources that are being used in roadway lighting. They include Mercury Vapor (less common), Metal Halide, High-Pressure Sodium (HPS), Low-Pressure Sodium, Fluorescent, Incandescent (less common), and LED.

The light sources are generally compared on the basis of four major characteristics:

1. Luminous efficacy (i.e., the number of lumens produced per watt of energy)
2. Color rendition (i.e., color quality)
3. Lamp life (i.e., number of operating hours)
4. Optical control

As mentioned earlier, HPS, Metal Halide, Mercury Vapor, Fluorescent, Incandescent, and LED lamps are generally used. LED is the most efficient option with a long life, while Metal Halide has an excellent color rendition. Incandescent and Mercury Vapor are less common and are being phased out, and it is recommended that the usage of these fixtures be completely eliminated by the Year 2015 and replaced with other fixtures as identified above. The comparison of various lamp types is shown in Table 5.

Table 5. Comparison of Lamps

Option	Method	Advantages	Disadvantages
LED	▪ Solid state lamp that uses light emitting diodes (LED) as the source of light	▪ Can be made interchangeable with other types of lamps. ▪ Directly interchangeable with incandescent bulbs. ▪ Offers long service life and high energy efficiency. ▪ Resistant to vibration and impact.	▪ Higher initial costs than fluorescent and incandescent lamps. ▪ Limited lighting output.
Incandescent	▪ Lamps which produce light by using electric current to heat a filament	▪ Instant on ▪ Low initial cost ▪ Excellent color rendition ▪ Can be dimmed ▪ Compact in size	▪ Short life (500-5,000 hrs) ▪ Inefficient to operate ▪ High heat output
Fluorescent	▪ Lamps that pass electricity through a gas enclosed tube to create light ▪ Usually used indoor and in some cases for signage	▪ Twice the light and less than half the heat of an Incandescent bulb of equal wattage. ▪ Long life (10,000-15,000 hrs) ▪ Efficient ▪ Good color rendition	▪ Temperature sensitive
Mercury Vapor	▪ A high-intensity discharge device producing light by excitation of mercury vapors (or passing electricity through a gas) to emit a bluish white light	▪ Long life (16,000-24,000 hrs) ▪ Low initial cost	▪ Inefficient operation ▪ Light output drops over life (2-3 yrs) ▪ Delayed hot restart
Metal Halide	▪ High intensity discharge arc tube in which light is produced by radiation of exited Metal Halide	▪ Excellent color rendition ▪ Sparkling white light that imitates daylight conditions, used in sports stadiums, car dealer lots, etc. ▪ 100-watt bulb lasts 10K hrs ▪ Works well with CCTV	▪ Hot restart can take several minutes ▪ High initial cost ▪ Most expensive light to install and maintain
High Pressure Sodium	▪ High intensity discharge arc tube in which light is produced by radiation from sodium vapor operating under pressure	▪ Very long life (20K-28K hrs) ▪ Can cut through fog and allow greater visibility (used on street and parking lots) ▪ In some cases, it can be used with CCTV	▪ High initial cost of fixtures ▪ Hot restart can take several minutes

A summary of properties of various lamps is presented in Table 6. The number of hours the lamp remains functional is considered as the life of the lamp. The efficacy is a measure of the "efficiency" of a lamp, measured in lumens per watt (i.e., knowing how much light is given out for a given amount power input), allows comparisons of energy efficiency to be made. The Color Rendering Index (CRI) is a relative measure of the shift in surface color of an object when lit by a particular lamp, compared with how the object would appear under a reference light source of similar color temperature. The higher the CRI of the light source, the "truer" it renders color.

Table 6. Summary of Lamp Properties

Option	Life (hrs)	Efficacy (lpw)	Color Rendering Index	Color of light
LED	35,000-50,000	30-300	≥70	White (for roadway application)
High Pressure Sodium	20,000-24,000	50-110	≤40 (approx. 22)	Orange
Metal Halide	6,000-15,000	72-76	75-90	White
Mercury Vapor	16,000-24,000	30-50	40-60	Blue-White
Fluorescent	10,000-24,000	40-140	20-80	White

A lamp's lumen output declines rapidly during its life; therefore, a designer should initially provide more lumens than is required so that as the lamp declines with age, a sufficient amount of light is still available. Figure 2 shows typical lamp lumen depreciation over time for four light sources – Low Pressure Sodium (LPS), High Pressure Sodium (HPS), Metal Halide Pulse Start Horizontal (MH) and Light Emitting Diode (LED).

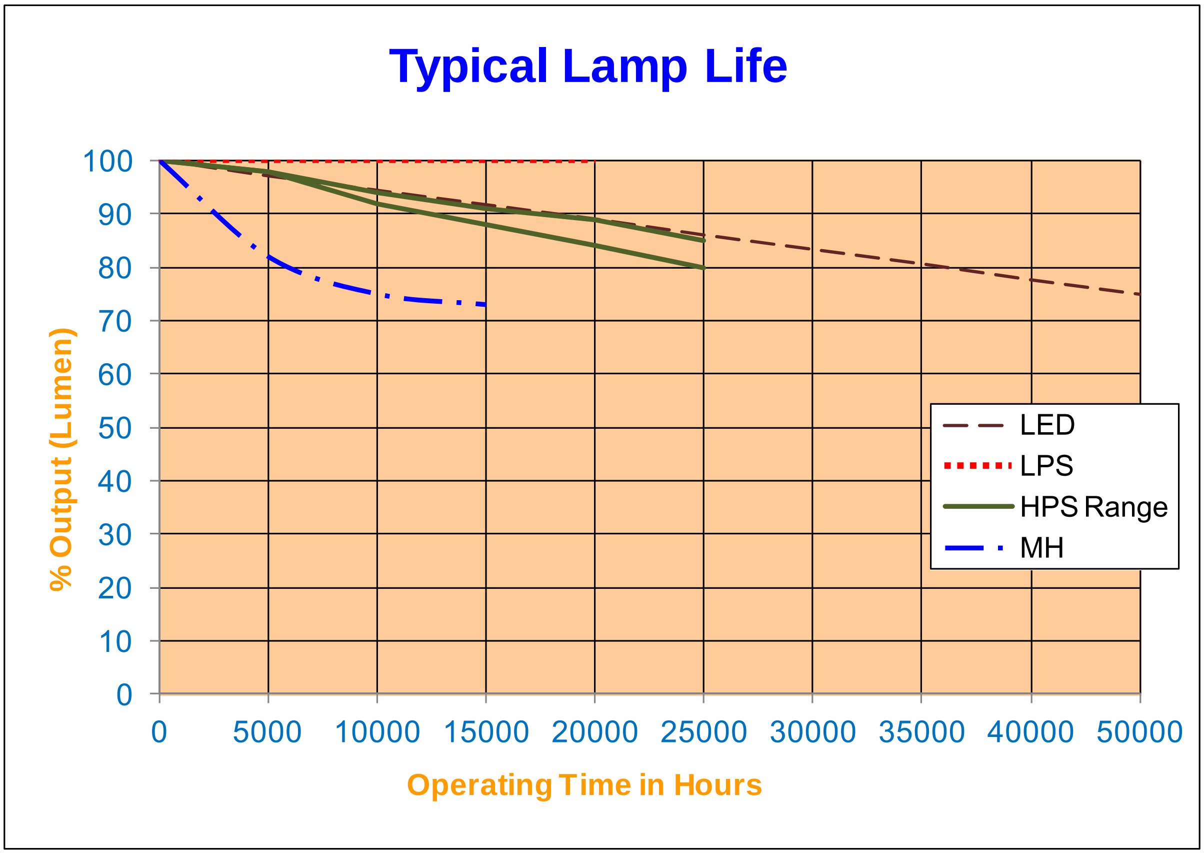


Figure 2. Typical Lamp Lumen Depreciation

Advances in HPS lamp technology have led to the development of a new color corrected HPS lamp. Color corrected HPS lamps are made by using optical coatings; however, the coating often gets burnt out. Even with greatly improved Color Rendering Index (about 80), the color corrected HPS lamp still delivers yellow light for lengthy periods of time when the bulb is switched on, and is not as white as the Metal Halide. It has been further reported that the color coating becomes ineffective at about half-life of the lamp.

In Europe, induction lamps are widely used and have a number of advantages. It has a long life – 100,000 hours rated average life[4]. It provides a Color Rendering Index of 80+ CRI, which is almost twice as much as that of mercury vapor (45 CRI) and almost four times as much as that of HPS (21 CRI). Even though it has a higher initial cost, its long life reduces the operations and maintenance costs. Starting operation is instant with no flickering. The disadvantages include the unavailability of moderate to high wattage lamps. The lamp will not "burn out" but will just get so dim that it no longer supplies adequate light for a given application. Although it has a long life, the ballasts may fail sooner, requiring the replacement of both the lamp and the ballast.

LED currently represents the best opportunity to provide a long life light source that uses the least amount of power as compared to other conventional light sources. One of the key advantages of LED-based lighting sources is high luminous efficacy.

2.4 POLES

There are four types of poles used for luminaire support; these are Fiberglass, Aluminum, Steel and Concrete poles. The advantages and disadvantages are discussed in Table 7. The District mostly uses steel poles and is phasing out Fiberglass.

[4] Based on 11 hours average usage per day, 7 days a week.

Table 7. Comparison of Poles

Option	Advantages	Disadvantages
Fiberglass Pole	▪ Direct burial pole is easy to install, and requires no waiting for concrete to cure. Some fiberglass poles are available for mounting to an anchor base. ▪ Electrically non-conductive ▪ Corrosion resistant ▪ Fiberglass materials should be 'solid-core' so that scratches and gashes in the pole will be less noticeable ▪ Lower cost option than many metal poles ▪ Lighter, less expensive to ship to sites ▪ Should have above ground access door, otherwise it's a maintenance problem	▪ Needs to be painted every 15 years because the color fades with time ▪ Appears to be cheaper and less durable than metal poles ▪ Pole has texture that looks un-metallic if standard paint finish is applied. Smooth paint finishes help to get rid of turn marks ▪ Weed whackers beat up the base of fiberglass poles ▪ If not stored carefully, heat can warp the pole
Aluminum Pole	▪ Good quality appearance. Fluting and other relief details are easy options. ▪ Factory-installed paint finish often more durable than fiberglass pole finish. The pre-treatment and base coating of the pole is critical to paint and pole durability. ▪ With good-quality multi-stage paint finish in factory, corrosion is minimal, especially when low-copper aluminum alloy is used ▪ Moderate cost: Tapered aluminum poles are less expensive than straight aluminum poles in sizes greater than 14' ▪ Aluminum has scrap value at the end of its life	▪ Electrically conductive ▪ More difficult to install than fiberglass because it requires anchor base
Steel Pole	▪ Low initial cost	▪ Electrically conductive ▪ Corrodes easily. Needs frequent painting ▪ More difficult to install because it requires anchor base ▪ Heavier to ship to jobsite than either aluminum or fiberglass poles
Concrete Pole	▪ Durable, non-corroding ▪ Electrically non-conductive ▪ Easy, direct burial installation, that requires no waiting for concrete to cure ▪ Several color options for appearance ▪ Can function as a barrier against vehicular traffic for pedestrians, but will not breakaway if struck by vehicle	▪ Non-traditional appearance (doesn't look like metal) ▪ Must be re-coated with preserving finish every 15 years ▪ Hard to add accessories such as banners or parking signs. Requires stainless steel bands around the pole unless pole is pre-drilled for these attachments. ▪ Limited number of appearance options beyond color and aggregate ▪ Higher initial cost than fiberglass or aluminum poles

2.5 PHOTOSENSOR

The streetlight has a photosensor that turns off when exposed to light and vice versa. There are two types of photosensors- button type and twist-lock. The button type photosensors need to be avoided as they have a high failure rate. This must be installed in the luminaire and should be done in the factory as the field personnel complain that it is too difficult and time consuming to install it in the field. The 'Twist-lock' photosensors are preferred and are mounted to bracket arms on the poles rather than the luminaire.

2.6 STREETLIGHT REMOTE MONITONRING SYSTEM

With the availability of new technologies, DDOT recently started using streetlight monitoring electronic photo control devices, which not only act as photosensors but also help in efficient maintenance of streetlights. These wireless devices will be able to report fixture status to a remote central monitoring system via gateway field devices.

2.7 GLOBES

The Washington globes are made either of glass or plastic. The glass globes were originally being used, but were discontinued, as they are not safe. Therefore, the District went from glass to plastic. The cost of a glass globe is approximately $300, an acrylic globe is $125 and a prismatic acrylic globe is $200. The comparisons between the globes are shown in Table 8.

Table 8. Comparison of Globes

Option	Facts	Advantages	Disadvantages
Plastic (Acrylic) Globe	▪ 'DR Acrylic' is tougher form of acrylic that will not yellow from UV radiation. Not as resistant to breakage as polycarbonate. Excellent choice for both MH and HPS lamps. This impact resistant acrylic will last 10-15 years.	▪ Acrylic does not yellow with exposure to UV radiation from either daylight or lamps.	▪ Standard acrylic is easily cracked and broken, so it is not recommended to be used as post-top lighting
Plastic (Polycarbonate) Globe	▪ Seldom used with MH lamps because MH emits larger amount of UV rays than HPS lamps do. ▪ Polycarbonate lenses and globes have a life of only 5-10 years.	▪ Very tough form of plastic	▪ Yellows when expose to UV radiation and become brittle with time.
Glass Globe	▪ Plain Glass	▪ Very durable material that does not change color (yellow) over time	▪ Very heavy ▪ Not safe, as it could tear the car's tires or harm someone when broken.

2.8 LATERAL DISTRIBUTION PATTERNS

The Illuminating Engineering Society (IES) establishes a series of lateral distribution patterns designated as Types I, II, III, IV and V. Types I and V represent symmetric lighting distribution and the luminaires are usually mounted over the center of the roadway. Types II, III and IV are asymmetric distribution and the luminaires are usually mounted near the edge of the roadway. Type I applies to rectangular patterns on narrow street, Type II to narrow streets, Type III to street of medium width, Type IV to wide streets and Types V to areas where light is to be distributed evenly in all directions. These are illustrated in the Figure 3.

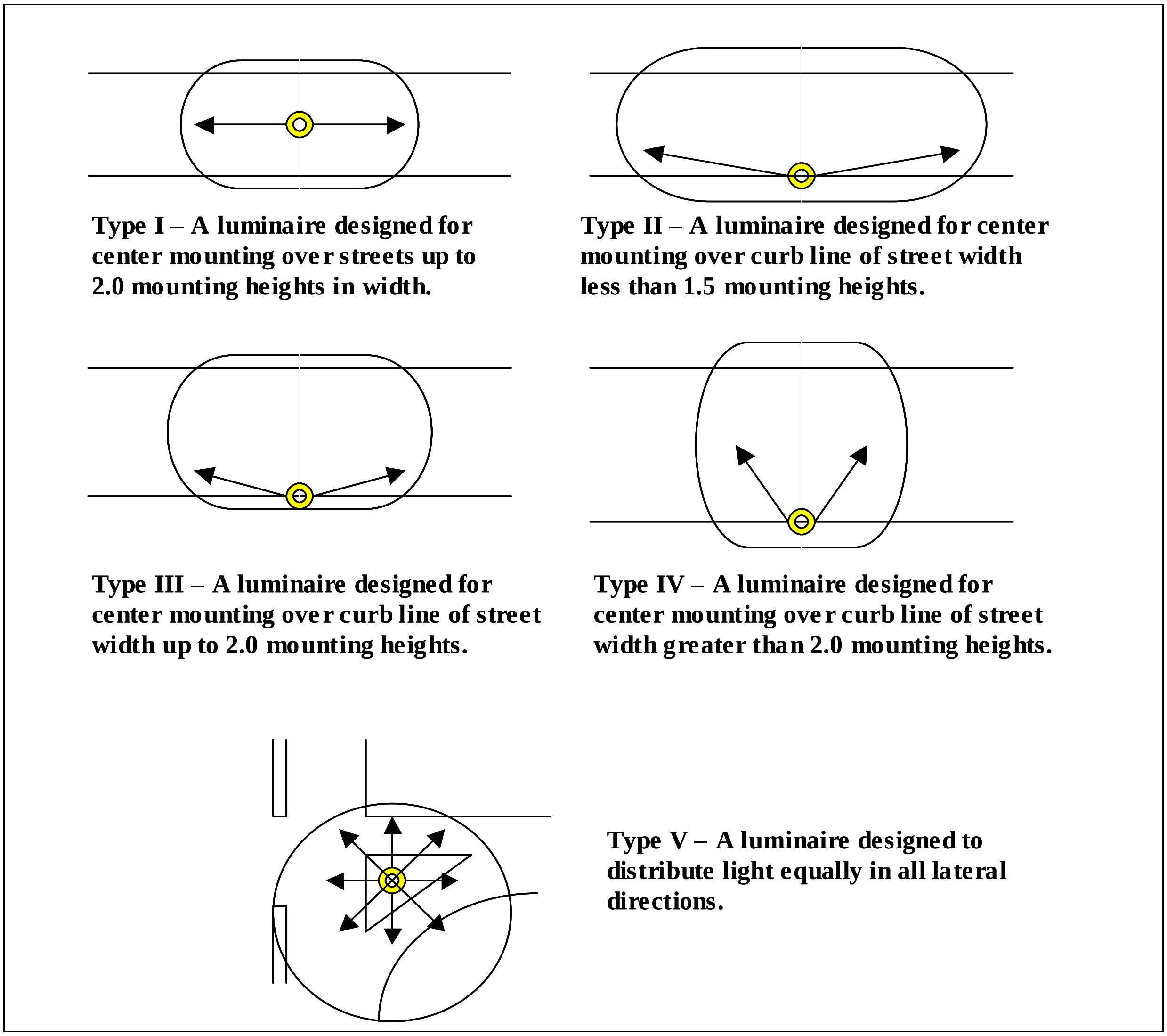


Figure 3. Type of Lighting Distribution[5]

2.9 POLE PLACEMENT CONFIGURATIONS

The luminaire placement is an integral part of an effective street-lighting design. The luminaires are mounted at a given height above the roadway, depending on the lamp output and characteristics of the roadway to be lighted at specific points along the roadway. Roadways with no medians may have the luminaires installed in a “house-side” location, which may be further described as a “one-side” system, a “staggered” system, or an “opposite” system. Roadways with wide medians and barriers may have the luminaire installed on a “median lighting” system, which provides very effective lighting at less cost because of the savings in luminaire supports and electrical conductors. The pole can be placed in various configurations as shown in Figure 4.

[5] Source: *American National Standard Practice for Roadway Lighting.* ANSI/IES RP-8.1983; Illuminating Engineering Society of North America.

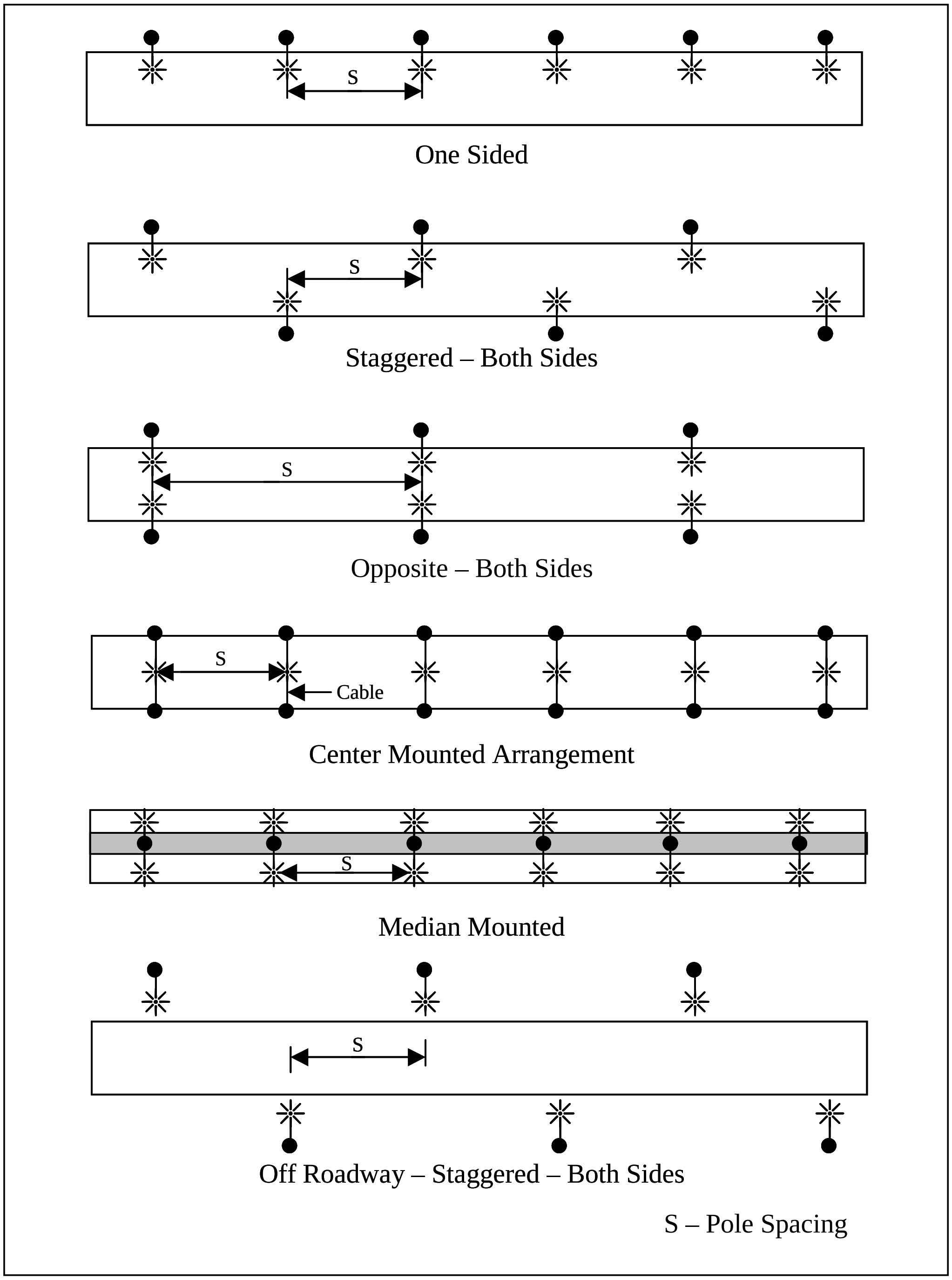


Figure 4. Typical Mounting Configurations[6]

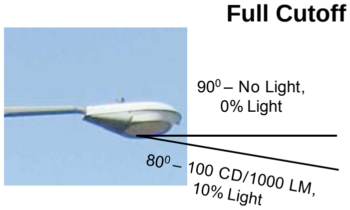
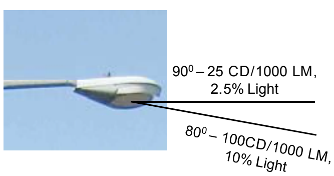
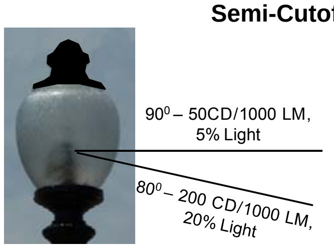
2.10 <u>CUTOFF FIXTURES</u>

It is important to control the distribution of light flux emission above the beam of maximum candlepower. At higher vertical angles, light flux emission generally contributes substantially

[6] Source: *Roadway Lighting Handbook*, Washington, DC, U.S. Department of Transportation, 1983.

to increased pavement brightness, but it also contributes greatly to increased disability and discomfort glare. The light flux emission above the beam of maximum candlepower needs to be controlled to achieve balanced performance. The categories of control are presented in Table 9 with some facts, advantages and disadvantages of each option.

Table 9. Comparison of Cutoff Levels

Options for Cutoff Levels	Facts	Advantages	Disadvantages
Full Cutoff 	▪ A luminaire light distribution with zero candela (intensity) at an angle of 90° or above. ▪ The candela per 1000 lamp lumens is $\leq$ 100 (10%) at 80° vertical angle ▪ No uplight allowed	▪ Perceived reduction in 'sky glow' ▪ Excellent light control at property line ▪ Limits spill light ▪ Reduces perceived glare	▪ Reduces pole spacing, increases pole and luminaire quantity ▪ Least cost effective of all cutoff categories ▪ Concentrated down light component results in maximum reflected uplight ▪ Decreased uniformity due to higher light levels under pole
Cutoff 	▪ A luminaire light distribution where the candela per 1000 lumens is $\leq$ 25 (2.5%) at an angle of 90° or more. ▪ The candela per 1000 lamp lumens does not exceed 100 (10%) at a vertical angle of 80°. ▪ 0% to 16% uplight	▪ Small increase in high-angle light compared to full cutoff ▪ Good light control at property line ▪ Potential for increased pole spacing and lowering overall power consumption when compared to full cutoff	▪ Can allow uplight, a problem where uplight is not desired ▪ Light control at property line less than full cutoff ▪ Higher amount of reflected light off pavement can contribute to sky glow
Semi-Cutoff 	▪ A luminaire light distribution where the candela per 1000 lumens is $\leq$ 50 (5%) at 90° angle or above. ▪ The candela per 1000 lamp lumens is $\leq$ 200 (20%) at 80° vertical angle ▪ 1% to 32% uplight	▪ Potential for increased pole spacing and lowering overall power consumption when compared to full cutoff ▪ High angle light accents taller surfaces ▪ Less reflected light off pavement than cutoff luminaires ▪ Vertical illumination increases pedestrian security and safety	▪ Greater potential for direct uplight component than cutoff ▪ Light trespass a concern near residential areas ▪ Increased high angle light compared to cutoff
Non-Cutoff 	▪ A luminaire light distribution there is no candela restriction at any angle. ▪ No restriction on uplight	▪ Potential for increased pole spacing and lowering overall power consumption when compared to full cutoff ▪ Accents taller surfaces ▪ Highest vertical illumination increases pedestrian safety & security ▪ Potential for excellent uniformity ▪ Least amount of reflected light off pavement ▪ 'Open visual environment' provides vertical surface visibility	▪ Greater potential for direct uplight component than cutoff ▪ Least control of uplight ▪ Increased high angle light compared to cutoff

Source: HOLOPHANE

3. EXISTING DDOT PRACTICE

This chapter presents the current District practice for streetlight usage. It includes types of poles, lamps, wattages, illumination levels, special requirements, etc.

3.1 POLES

Figure 5 through Figure 7 show the various streetlight poles used in the District (referred to as Washington Family of Streetlight Poles in this document). Several streetlight poles are being phased out or have already been rendered obsolete. The different types of poles are described below.

Older Types

Figure 5 shows some obsolete poles. The *10th Street Mall* poles have a few installations in L 'Enfant Plaza and are being phased out. The *New York Avenue Rotary Type* poles are no longer used and the *RLA* poles are being phased out.

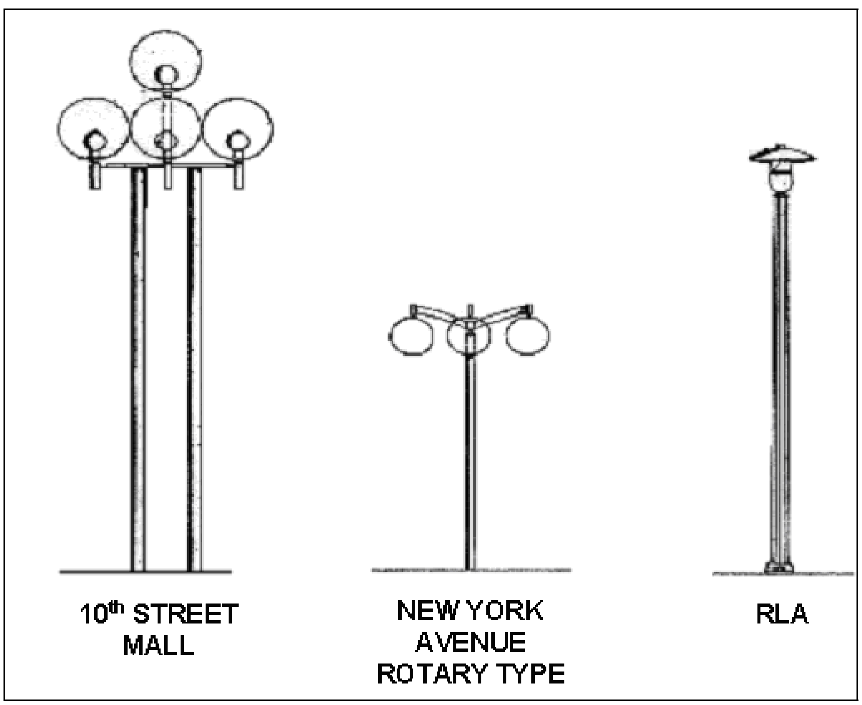


Figure 5. Washington Family --Older Types

Washington Upright Poles

This group includes Nos. 716, 16, 18, 13N, 14, 17M, 19M, Twin-20 and State Department Twin-20. The Nos. 13N, 17 M, 19M and State Department Twin-20 poles are now obsolete.

The Washington Upright poles (e.g., Nos. 716, 14, 16, 18, and Twin-20) are used in the historic districts/streets. No. 16 is the most commonly used upright pole; No. 716 is considered to be an inexpensive version of No.16 ($5000 vs. $2500). In the Downtown area near Foggy Bottom, No. 18 poles are used. The Twin-20 poles are used in Downtown, in historic districts and several entry points into Washington, DC.

The Nos. 16 and 18 poles use 24-inch bases and 15-inch bolt circles and can accommodate 70-400 Watt lamps. The No. 14 pole, on the other hand, uses a 17-inch base and 10.5-inch bolt circles and can accommodate 70-150 Watt lamps, since it is limited by the size of the casing. 716 poles are steel octaflute with a 9.5 inches bolt circle. AD11 poles, a variation of No. 716 poles, are used for traffic signals.

In a pole, the shaft is always made of steel, whereas the base, arm and casing can be cast iron or aluminum. In the past, fiberglass poles were used, but are obsolete now. All the poles in DC are powder coated and most of the times have a breakaway base (except near signalized intersections).

Figure 6. Washington Family – Upright Poles

<u>Pendant Post and 5A Alley Poles</u>

The Pendant Post poles are installed citywide and can accommodate 70-400 Watt lamps with either single or twin arm(s). The District typically uses Cobrahead type arms and fixtures (although there are limited installations of Teardrop fixtures, another type of Pendant Post implementation). Pendant Post poles have an octaflute type of cross-section.

The most widely used Pendant Post poles are 28 feet –6 inches tall; 38 feet-6 inches tall poles are also used. There are a few high-mast (70 feet-100 feet tall) Pendant Post poles in the City that use 1000 Watt High Pressure Sodium (HPS) lamps.

The 5A Alley post is widely used in alleys.

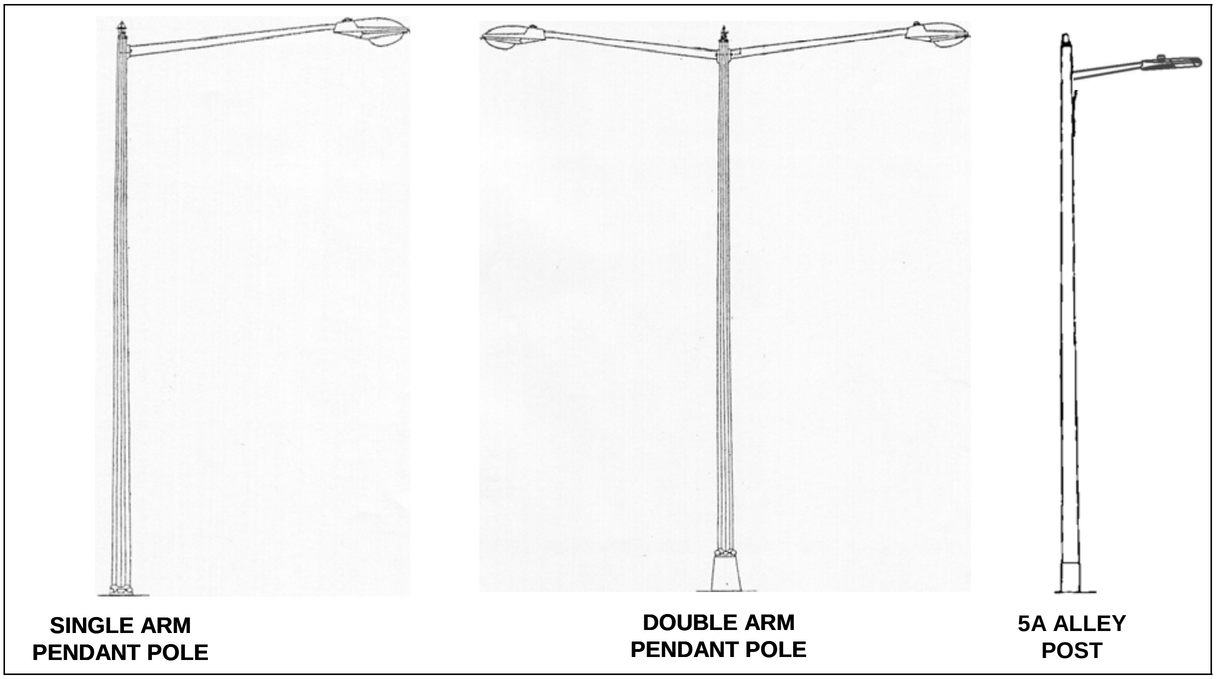


Figure 7. Washington Family – Pendant Posts and 5A Alley Poles

<u>Teardrop Fixture with Decorative Arm</u>

Figure 8 shows the Teardrop fixture with decorative arm, as a recommendation from the earlier *Policy Guide* teardrop fixtures has been adopted in streetlighting design throughout the District.

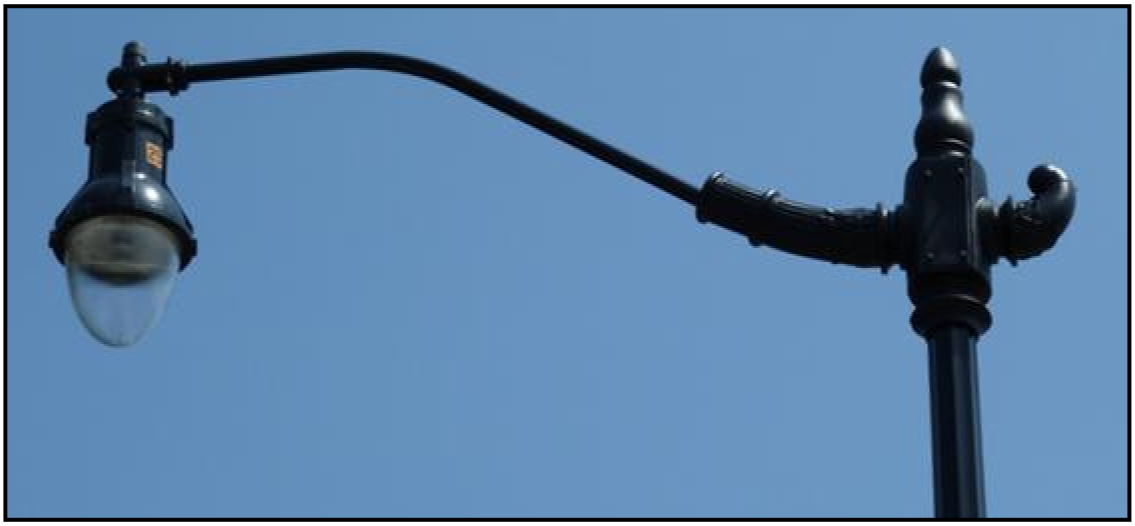


Figure 8. Teardrop Fixture with Decorative Arm

LED Fixture on Pendant Pole

Figure 9 shows DDOT approved LED fixture on a Pendant Pole. DDOT recently approved and started using these LED fixtures in the District.

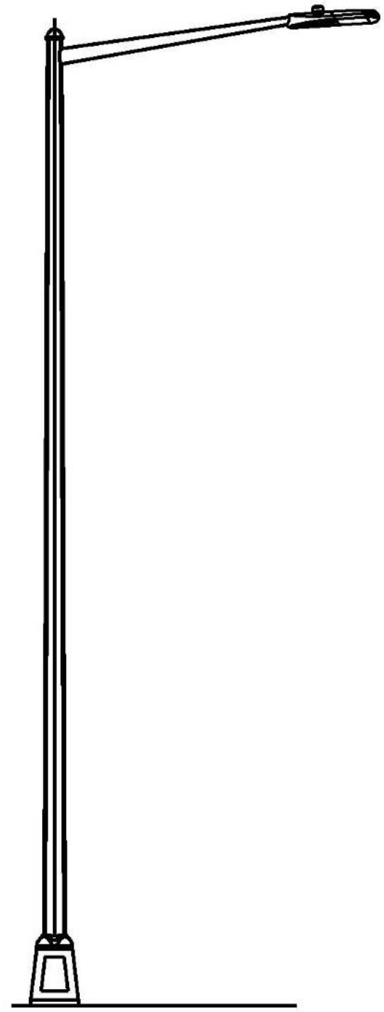


Figure 9. LED Fixture on a Pendant Pole

3.2 LAMPS

The lamps generally used in the District are HPS, Metal Halide (MH), Mercury Vapor, Fluorescent and Incandescent. HPS is extensively used for sign and streetlighting. Because of its relatively low maintenance requirement, the District has been using HPS universally, except for the Monumental Core. MH lamps currently have very limited use (only in the Monumental Core area). Twenty (20) percent of the existing lights use incandescent lamps. Mercury Vapor is used for sign lighting and Florescent is used for underpasses. LED fixtures have been introduced in the City and have been implemented in the alleys. Mercury Vapor and Incandescent lights are being phased out and replaced by HPS.

3.3 WATTAGE

The District is currently considering a policy to design streetlights based on a lower wattage, so as to keep an extra cushion for higher level of illumination in future. If needed in future, the lower wattage lamps can be replaced by higher wattages. For example, No. 16 poles should be designed for a maximum of 250 Watt (while allowed is up to 400 Watt) and No. 14 poles should be designed for a maximum of 100 Watt (while allowed is up to 150 Watt). This will provide the flexibility of using higher wattages in future.

DDOT also discourages using 400 Watt conversion kits in residential areas.

3.4 ILLUMINATION LEVELS

DDOT uses AASHTO guidelines for roadway lighting for any new design.

3.5 SPECIAL REQUIREMENTS

The Downtown Streetscape Regulation determines the streetlight poles, spacing and pattern in downtown area. There are several Business Improvement Districts (BIDs) in DC. These include Adams Morgan Partnership, Capitol Hill, Capitol Riverfront, Downtown DC, Georgetown, Golden Triangle, Mount Vernon Triangle, and North of Massachusetts Avenue (NOMA) BIDs. The No. 18 poles are generally used in the BIDS. The Downtown BID specifies the pole type and the Golden Triangle BID specifies the color of the pole to be black (Federal 27038).

The Monumental Core area uses black upright poles (No. 16 or Twin-20) with 400 Watt MH conversion kits. In the District, MH lights are currently being used only in Monumental Core.

The District has defined Gateways (i.e., significant entry points) into the city. There are approximately 55 Gateways into the District. The Twin-20 poles have been used on Georgia Avenue (inside the DC line), New York Avenue (inside the City) and 16th Street.

4. ILLUMINATION STANDARDS RECOMMENDATIONS

4.1 GENERAL STANDARDS FOR ILLUMINATION LEVELS

AASHTO guidelines have been adopted as a basis for DC streetlight illumination standards. The design values proposed in the current Ballot Draft version of AASHTO guide is used in this policy. Any subsequent future modifications in AASHTO standards will be reviewed by DDOT for inclusion in this policy.

Table 10 lists the recommended ranges for the average maintained illuminance levels for the various roadway classifications as defined by DDOT. The average maintained illuminance represents the output of the lamp and luminaire, after reduced by the maintenance factors (e.g., light loss depreciation and dirt depreciation); expressed in average foot-candles (lux) for the pavement area. The light loss depreciation is defined as the decline in the light lumen that occurs as a lamp is operated over time. Dirt accumulates on luminaires, decreases the total output of light and lowers the overall efficiency of the system. This process is called luminaire dirt depreciation. The table is derived for all types of road surface classification. Most of the roadway pavements in the District are either R2 or R3 class.

Table 10. Recommended Average Maintained Illuminance for District Roadways[7]

DC Street Classification	Land Use	Recommended Average Maintained Illuminance (foot-candle)		
		R1	R2 & R3	R4
Interstate and Other Freeways	Residential Intermediate Commercial	0.6 to 0.8 0.6 to 0.9 0.6 to 1.1	0.6 to 0.8 0.6 to 0.9 0.6 to 1.1	0.6 to 0.8 0.6 to 0.9 0.6 to 1.1
Other Principal Arterials	Residential Intermediate Commercial	0.6 0.8 1.1	0.8 1.2 1.6	0.8 1.0 1.4
Minor Arterials	Residential Intermediate Commercial	0.5 0.8 0.9	0.7 1.0 1.4	0.7 0.9 1.0
Collectors	Residential Intermediate Commercial	0.4 0.6 0.8	0.6 0.8 1.1	0.5 0.8 0.9
Local Streets	Residential Intermediate Commercial	0.3 0.5 0.6	0.4 0.7 0.8	0.4 0.6 0.8
Alleys	Residential Intermediate Commercial	0.2 0.3 0.4	0.3 0.4 0.6	0.3 0.4 0.5

For illuminated sidewalk areas, the following average maintained illumination levels should be designed along all DDOT roadway classifications for either R2 or R3 class with the criteria based on the level of commercial development.

[7] Recommendations based on *Roadway Lighting Design Guide*, AASHTO, 2005.

***Table 11. Recommended Average Maintained Illuminance for Sidewalks*[8]**

DC Sidewalk Locations	Recommended Average Maintained Illuminance (foot-candle)		
	R1	R2 & R3	R4
Residential Areas	0.3	0.4	0.4
Intermediate Areas	0.6	0.8	0.8
Commercial Areas	0.9	1.3	1.2

4.2 OTHER STANDARDS AND DESIGN CRITERIA

4.2.1 Uniformity Ratios

For the DDOT roadway classifications shown below, the following uniformity ratios (average-to-minimum) should be used as a guideline in the design of the lighting system.

***Table 12. Recommended Average-to-Minimum Uniformity Ratios*[8]**

DC Street Classification	Average-to-Minimum Uniformity Ratio
Interstate and other Freeways	3:1 or 4:1
Other Principal Arterials	3:1
Minor Arterial	4:1
Collector	4:1
Local Street	6:1
Alleys	6:1

4.2.2 Veiling Luminance Ratios

AASHTO states that the veiling luminance ratio requirement should be used as a design guideline along with uniformity ratios in the design of the lighting system. The veiling luminance ratio will need to be satisfied in order to insure that the disability glare is minimized to reduce the blinding effect from light shining directly into the eyes of drivers and pedestrians. The veiling luminance ratios shown in Table 13 are from the current version of AASHTO guide. DDOT will review any future modification in AASHTO standards for inclusion in this policy.

***Table 13. Recommended Veiling Luminance Ratios*[8]**

DC Street Classification	Veiling Luminance Ratio
Interstate and other freeways	0.3:1
Other Principal Arterials	0.3:1
Minor Arterial	0.3:1
Collector	0.4:1
Local Street	0.4:1
Alleys	0.4:1

[8] Recommendations based on: *Roadway Lighting Design Guide*, AASHTO, 2005.

4.2.3 Vertical Light Distribution Patterns[9]

For residential areas, mixed-use and commercial areas, all luminaires must have a Full cutoff luminaire light distribution with zero candelas (intensity) at an angle of 90 degrees or above, or a Cutoff luminaire light distribution where the candela per 1,000 lumens does not exceed 25 (2.5%) at an angle of 90 degrees or above.

By establishing the standards for lighting fixtures in residential, intermediate, and commercial areas, rear obtrusive light can be minimized.

4.2.4 Lateral Light Distribution Patterns

The following lateral light distributions should be used for the DDOT roadway classifications:

Table 14. Recommended Light Distribution Patterns[10]

DC Street Classification	Lighting Distribution Pattern
Interstate Roadway	Type III or Type IV
Freeway/Expressway	Type III or Type IV
Principal Arterial	Type III or Type IV
Minor Arterial	Type III
Collector	Type III
Local Street	Type II or Type III
Alleys	Type II

If lighting poles are located in the medians of roadways or within islands that have traffic flows on both sides of island, a Type V lateral lighting distribution pattern may be used.

4.2.5 Minimum Light Pole Spacing

For all DDOT roadway classifications, a pole height and lighting fixture must be chosen to meet the average maintained illumination levels and uniformity ratios identified earlier, and to have pole spacings at 60 feet or greater. In cases where lighting designs require pole spacings to be less than 60 feet to reach the desired illumination levels and uniformity ratios, a different pole and/or lighting fixture must be considered first to meet or exceed a 60- foot minimum spacing requirement. For pole spacing less than 60 feet, exceptions must be approved by DDOT.

4.2.6 Sign Lighting

In general, overhead signs are lighted since typical car headlights cannot adequately illuminate overhead signs. Shown in Table 15 are illuminance and luminance levels for sign lighting recommendations as per AASHTO depending upon the ambient lighting conditions of the surrounding areas.

[9] Recommendations based on: *City and County of Denver Rules and Regulations for Outdoor Lighting*.
[10] Recommendations based on: *American National Standard Practice for Roadway Lighting*.

Table 15. Illuminance and Luminance Levels for Sign Lighting*

Ambient Luminance	**Sign Illuminance**		**Sign Luminance****	
	Footcandles	**Lux**	**Candelas per Square Meter**	**Candelas per Square Foot**
Low	10-20	100-200	22-44	2.2-4.4
Medium	20-40	200-400	44-89	4.4-8.9
High	40-80	400-800	89-78	8.9-17.8

*Adapted from The IESNA Lighting Handbook, Reference & Application, 9th Edition, Illuminating Engineering Society of North America.

**Based on a maintained reflectance of 70 percent for white sign letters.

4.3 LIGHTING ILLUMINATION OF SPECIAL AREAS

For special areas of the City, as defined by DDOT, higher average maintained illumination levels than those identified earlier might be desirable to draw special attention to the area. These could include, but not be limited to, Gateways of the City, Monumental Core Areas, and BID Areas. If these locations have their own regulations regarding the level of illumination, designs should be based on those regulations. Furthermore, DDOT will make the determination whether an area should be designed with different lighting criteria than those identified above (BIDS, National Park Service, Monumental Core, etc., are exempted as of the publication of this report).

5. GENERAL HARDWARE RECOMMENDATIONS

This chapter presents recommendations for the streetlight hardware. The selection of hardware was mostly performed through a series of Streetlight Policy Advisory Committee meetings. The selection has been made as specific as possible, yet some flexibility for final selection has been left to the citizens.

The recommendations are made for all neighborhoods in general; however, areas within the District, having their own regulations will be exempt from the requirements of this policy guideline. A separate discussion is provided in this chapter on these exempt locations, which override this guideline.

In addition, historic and new bridges may deviate from these guidelines and may be designed with special decorative streetlight hardware to signify their importance.

5.1 OVERVIEW OF MAJOR CHANGES

The following deviations from the current and old practices are deemed significant and hence noted:

1. White-light lamps may replace the yellow-light, high-pressure sodium lamps in the future (optional for alleys), if their life-cycle cost is comparable to that of yellow-light lamps.

   Light Emitting Diode (LED) light fixtures produce desired white light and are becoming more common place in the lighting industry due to the longer life and lower energy consumption as compared to most other lighting fixtures. LED light fixtures have been extensively implemented within the District.

2. The usage of Mercury Vapor and Incandescent light fixtures is being phased out within the District. It is the intent of DDOT to eliminate the usage of these fixtures by the Year 2015.

3. The widely used Cobrahead fixtures may be substituted (except for 5A Alley poles) by a Teardrop fixture with decorative arms. Teardrop fixture was naturally preferred because of its aesthetic and architectural qualities for outdoor lighting. However, the extent of the substitution of Cobrahead with Teardrop fixtures depends on the funding situation and priority, which the District Government should evaluate before establishing the policy. A cost comparison is shown below.

   Table 16 presents a vendor-provided comparison between a Teardrop and a Cobrahead installation, for a particular scenario (40' wide street, 30' high pole, 6' arm and 2' offset from the curb). The use of this data results in per-mile capital costs of pole and fixture (excluding conduits, cables, etc.) to be $119,000 and $140,400, respectively, for Cobrahead and Teardrop.

Table 16. Comparison between Teardrop and Cobrahead

Comparison Criteria	Teardrop	Cobrahead
Spacing	318 feet	294 feet
Initial Cost	$ 800	$ 400
Lamp Life	6 Years	6 Years
Ballast Replacement Cost	$ 100	$ 90
Photocell Life	10 Years	10 Years
Globe Replacement Cost	$ 100	$ 60
Fixture Life Expectancy	30 Years	20 Years

* Lamp Life presented is for HPS. LED lamp life is approximately twice as much.

4. Refractive, prismatic globes have been accepted for replacing the currently used plain globes. Refractive globes are a major achievement in the field of optical technologies and provide greater level of illumination with minimal light "loss" by redirecting lights in the desired direction. The prismatic optical system directs the light into the desired pattern, allows maximum spacing with excellent uniformity, and minimizes upward wasted light. The refractive globe is expected to reduce direct glare by softening and spreading the light being distributed from the light source. However, the usage of prismatic globes has not been a practice in Washington yet.

5.2 MISCELLANEOUS ISSUES

The following miscellaneous items are included in the policy:

1. DDOT reserves the right to exempt certain areas on a case-by-case basis and pick any special streetlight fixture.
2. Prismatic globes will be used for new designs only. Since the prismatic globes have a different photometric pattern, it cannot replace a plain globe one to one and therefore, it cannot be retrofitted into existing light poles.
3. Alleys have a different illumination level requirement and hardware recommendation than streets. However, there are alleys that serve as access to households and therefore, regular requirements for alleys may not apply to them. The illumination level can be higher for such alleys and regular roadway requirements can be used. However, pole type will still have to be typical direct-buried type alley light pole (i.e., 5A Alley Pole), since alleys do not have additional right-of-way for the pole foundations. The fixtures and arms of the pole (other than regular 5A arm and cobrahead) can be selected on a case-by-case (such as a 3' decorative arm with teardrop fixture) depending on zoning, usage and historic significance of the alley.
4. The policy for house side shields and painting the globes black depends on the citizens and will be considered on a case-by-case basis.

5.3 FACTORS INFLUENCING THE HARDWARE SELECTION

A number of factors contribute to the determination of streetlight hardware requirements. They include the following:

- Context
- Historic significance
- Significance of the streets
- Location of electrical power line

5.3.1 Context

Another important factor for streetlight hardware selection is the context of the surrounding. The heights of the pole, lamp wattage, shielding method are based on the surrounding. The context of the surrounding includes the characteristics of a street, such as:

1. Roadway Width
2. Sidewalk Width
3. Height of the building
4. Setback of the building

5.3.2 Historic significance

Washington's significance is attributed to the national landmarks and monuments as well as the historic neighborhoods and local landmarks that make the city unique. The city had ninety-six historic places that bring the 200 years of history of the city to life. The preservation of the historic attributes of these areas is an important goal of the City. Street lighting hardware is a significant element of these attributes.

The streets in the City can be broadly classified into two groups – *historic* and *non-historic*. As the name implies, historic streets need to preserve the tradition of the City in terms of streetlight hardware appearance. Non-historic streets do not have that requirement; however, certain standards are set up for these to promote uniformity and consistency.

The historic streets, shown in Figure 10, are defined to include:

1. Road network within the designated historic areas
2. Other streets designated as historic (i.e., in non-historic areas)

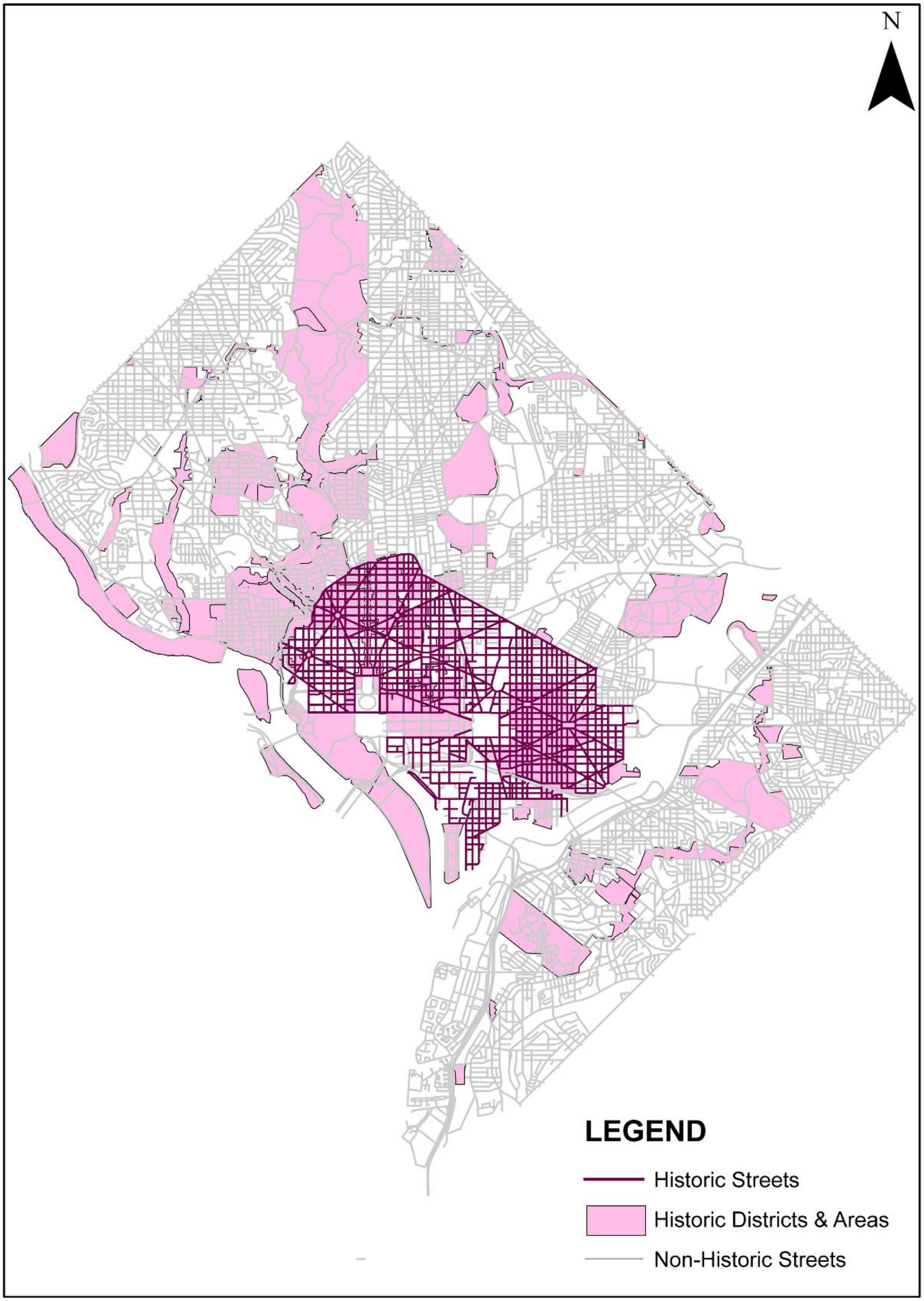


Figure 10. Historic Streets in Washington, DC

Furthermore, certain streets are designated as the monumental core streets and are shown in Figure 11.

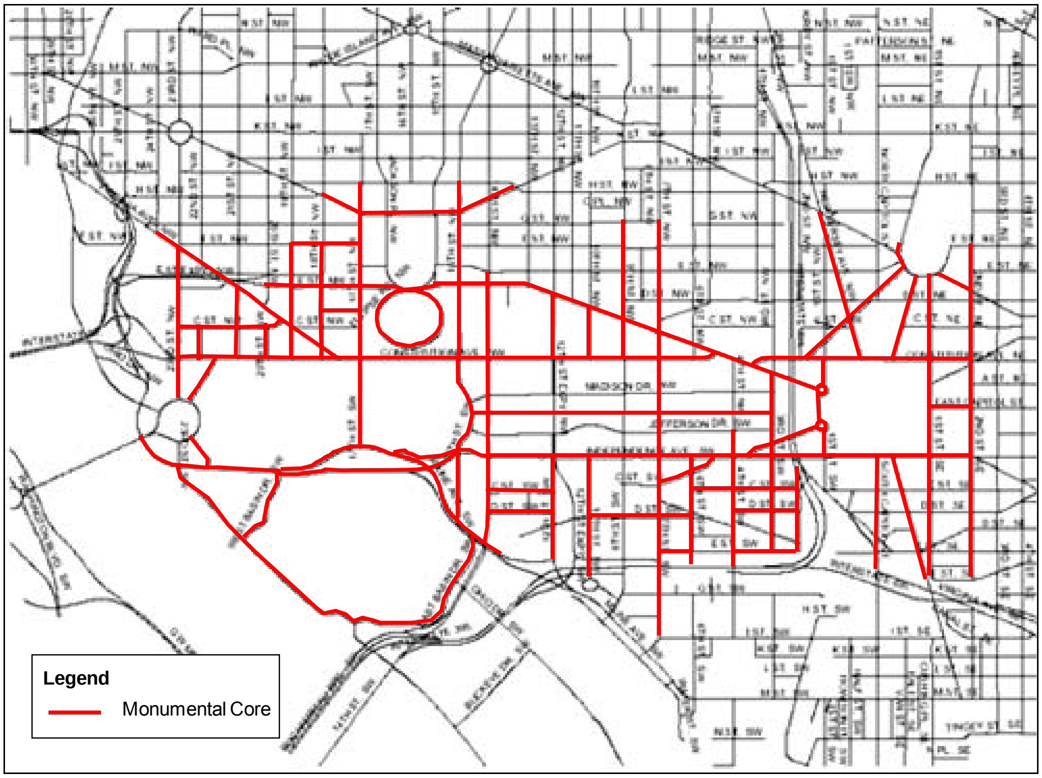


Figure 11. Monumental Core Streets

5.3.3 <u>Significance of street</u>

Another factor for the streetlight hardware selection is the *significance* of the street. A set of streets has been designated as *Special Streets* (alternatively, *Capital Avenues*), as shown in Figure 12 and Table 17. The list includes roads playing significant role in carrying motorists and tourists in and out of the City as well as several streets belonging to the historic L 'Enfant Plan. The following categories of streets are included in this group[11]:

1. <u>National Highway System (NHS) streets</u>. These streets are federally designated streets of importance (with respect to nation's economy, defense, and mobility) that receive federal aid. Nationally, the Federal Government has designated approximately 160,000 miles (256,000 kilometers) of NHS streets.
2. <u>Gateway streets</u>. The District has designated key entry points to the City as Gateways. These gateways lead motorists and tourists into the heart of the City through major streets. These routes have been included in the Special Street category.

[11] Designated by the Streetlight Policy Advisory Committee in the meeting on May 19, 2004 and subsequently modified through reviewers' feedbacks during the original study.

3. Other important streets. Part of historic L' Enfant Plan is included in the Special Street designation. Several other key streets that have been identified in District community development plans were also included in the list.

The *Special Streets* have been designated to have Washington signature streetlight treatment.

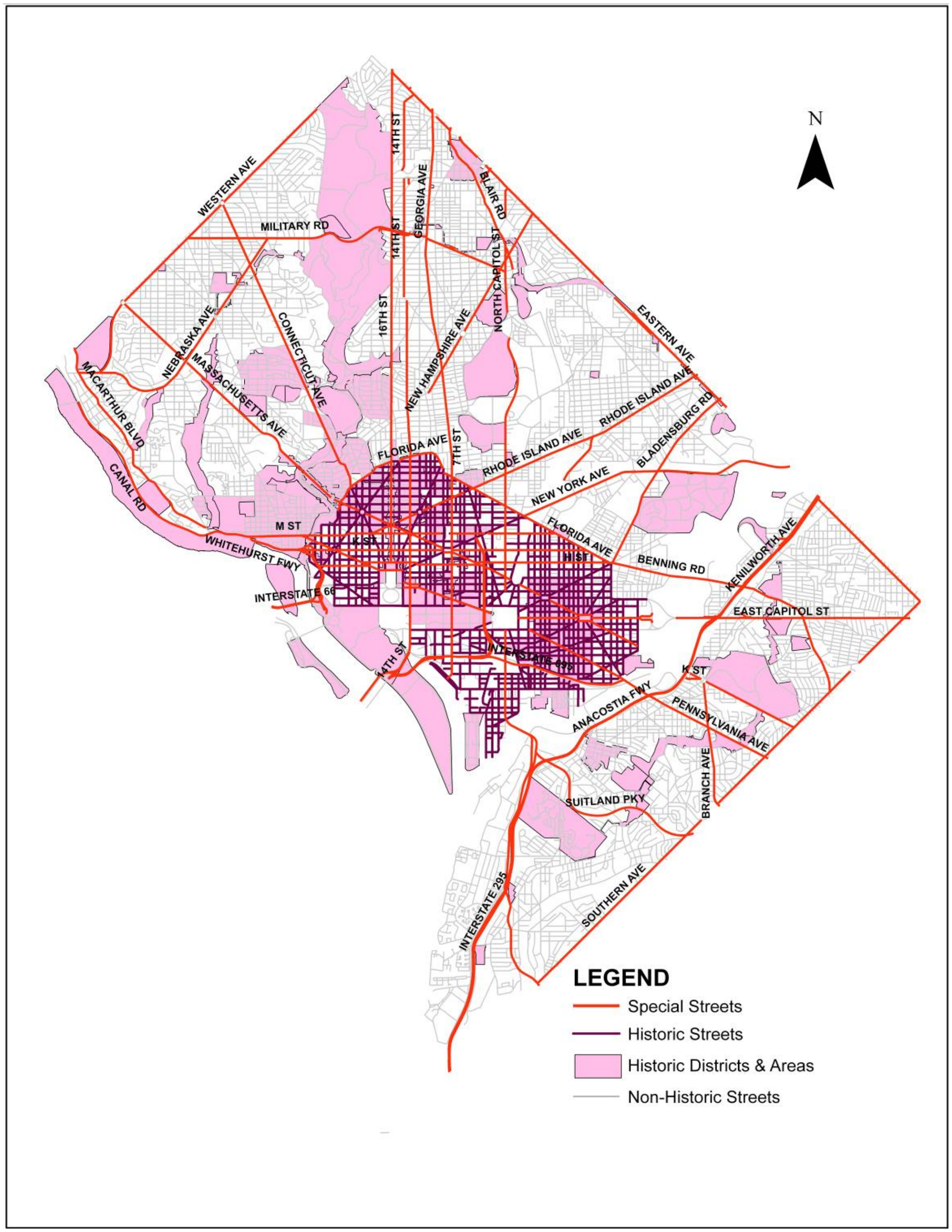


Figure 12. Special and Historic Streets in Washington, DC

Table 17. List of Special Streets

Special Streets	Start[a]	End[a]
14th Street	14th Street Bridge, SW	DC Line, NW
16th Street	H Street, NW	DC Line, NW
Benning Road	H Street, NE	DC Line, SE
Bladensburg Road	H Street, NE	DC Line, NE
Blair Road	DC Line, NW	Hamilton Street, NE
Branch Avenue	Randle Circle, SE	DC Line, SE
Brentwood Road[b]	T Street, NE	Rhode Island Avenue, NE
Canal Road	Chain Bridge, NW	M Street, NW
Connecticut Avenue	H Street, NW	DC Line, NW
Dalecarlia Parkway	DC Line, NW	Loughboro Road, NW
East Capitol Street	1st Street, NE/SE	DC Line, NE/SE
Eastern Avenue	16th Street, NW	Southern Avenue
Florida Avenue	P Street, NW	Benning Road, NE
Georgia Avenue – 7th Street	Maine Avenue, SW	DC Line, NW
H Street[b]	Virginia Avenue,	15th Street, NE
Interstate 295-Anacostia Freeway-Kenilworth Avenue	DC Line, SE	DC Line, NE
Interstate 395	14th Street Bridge, SW	New York Avenue, NE
Southeast-Southwest Freeway	I-395, SW	Pennsylvania Avenue, SE
Interstate 66	Ohio Dr., NW (Approx.)	26th Street, NW (Approx.)
K Street[b]	Wisconsin Avenue, NW	Florida Avenue, NE
Laurel Street	Blair Road, NE	DC Line, NE
Loughboro Road	McArthur Boulevard, NW	Foxhall Road, NW
M Street[b]	Canal Road, NW	Florida Avenue, NE
MacArthur Boulevard	DC Line, NW	Foxhall Road, NW
Massachusetts Avenue	DC Line, NW	DC Line, SE
Military Road	DC Line, NW	16th Street, NW
Missouri Avenue	16th Street, NW	North Capitol Street
Nebraska Avenue	Foxhall Road, NW	Oregon Avenue, NW
New Hampshire Avenue	Park Road, NW	DC Line, NE
New York Avenue	14th Street, NW	DC Line, NE
North Capitol Street	D Street, NE/NW	Blair Road, NE/NW
Pennsylvania Avenue	M Street, NW	DC Line, SE
Rhode Island Avenue	Connecticut Avenue, NW	DC Line, NE
South Capitol Street	DC Line, SE/SW	Independence Avenue, SE/SW
Southern Avenue	South Capitol Street, SE	Eastern Avenue, NE
Suitland Parkway	South Capitol, SE	DC Line, SE
Western Avenue	Massachusetts Avenue, NW	Oregon Avenue, NW
Whitehurst Freeway	M Street, NW	K Street, NW
Wisconsin Avenue	DC Line, NW	South of K Street, NW (Up to Potomac River)

NOTES:

[a] No limits are assigned to the special streets and generally, the designations end at the physical ends of the roadways or at DC line. Therefore, the "start" and "end" do not represent any limits, but the actual physical ends of the roadways.

[b] There are other short segment(s) of the roadway beyond the start and end points. However, these segments have different contexts and therefore, are not included as *Special Streets*. The streetlight designs for these segments will be based upon their contexts.

5.3.4 Location of electrical power line

Another factor in the selection of streetlight hardware in the District is whether the PEPCO power line is *underground* or *overhead*. For areas with underground power line, streetlight power feeds may also be routed through underground conduits and, as a result, standard poles (with arms) can be used as necessary.

In areas with overhead PEPCO power lines, there is an abundance of wooden utility poles. In order to minimize the cost, the utility poles are used for mounting streetlight fixtures, with direct overhead power feeds from PEPCO lines. Thus, no separate streetlight poles are necessary in these areas and, therefore, only arm and luminaire are specified.

5.4 Exempt Locations

The guidelines presented in the preceding chapters apply to the City in general; however, areas with their own regulations are exempt from these requirements or portions thereof, which will be overridden by the area-specific regulations. These exempt locations include, but are not be limited to:

1. Downtown streetscape area
2. Business Improvement Districts (BIDs)
3. Monumental Core area

The Downtown Streetscape Regulations dictates the standard streetlight fixtures for the Downtown Streetscape Area. The upright poles No. 16, 18, and Twin 20 are used for midblock and pendant poles for intersections. The regulation specifies the color of the pole as black for upright poles and battleship gray for pendant poles. The arm of a Twin 20 pole should be parallel to the curb. The Downtown Streetscape Area boundaries are as shown in the Figure 13.

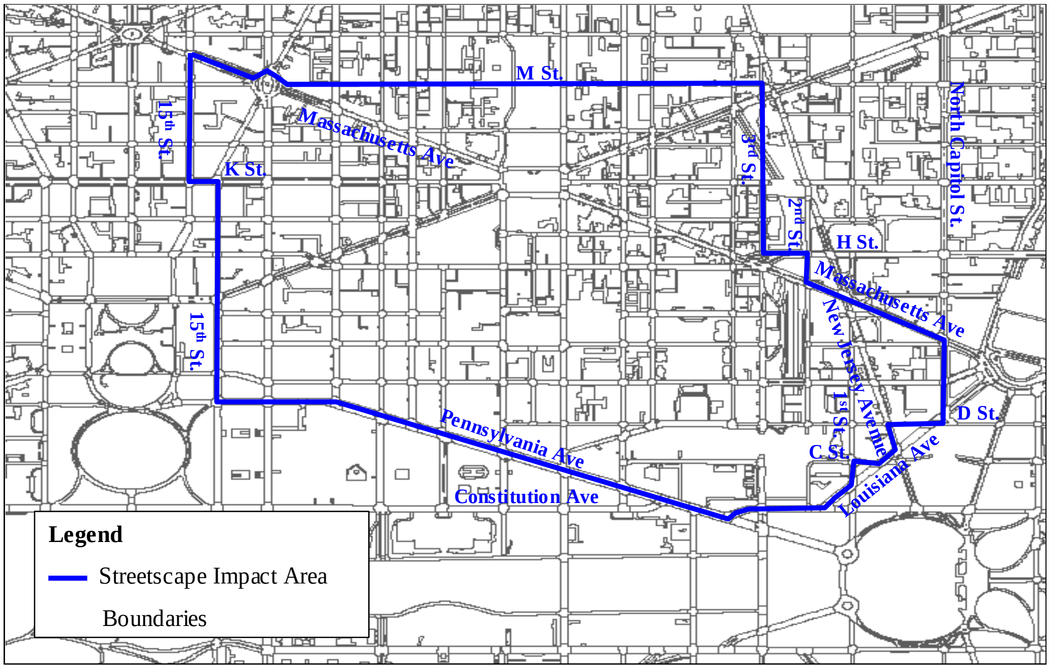


Figure 13. Downtown Streetscape Area Boundaries

There are several BIDs in the District, and as of the publication date of this document, the following BIDs are considered exempt from this guideline - Georgetown, Downtown, Golden Triangle and North of Massachusetts Avenue (NOMA). The No. 18 poles are generally used in the BIDs. The Georgetown and Downtown BIDs specify the wattage used and the Golden Triangle BID specifies the color of the pole to be black (Federal Chip 27038). DDOT will make determination on the exempt status on any future new BIDs.

The Monumental Core area, as specified in the Inter-Mall Roads Streetscape Plan, uses black upright poles (No. 16 or Twin 20) with 400-Watt Metal Halide conversion kits. In the District, Metal Halide lights are currently being used only in Monumental Core.

5.5 HARDWARE RECOMMENDATIONS

Hardware recommendations have been derived for the following scenarios:

1. Non-historic streets
    - Underground power line
    - Overhead power line
2. Historic streets
3. Special streets

The hardware recommendations for these scenarios are described in the following paragraphs.

1. Non-Historic Areas

   Table 18 shows the streetlight hardware standards for the non-historic areas with underground power lines. In residential areas, the citizens will be given the choice to select either a Decorative Teardrop (alternatively Cobraheads if costs prohibit) or Upright poles in place of the existing Cobrahead poles. The Pendant Posts are recommended for non-historic streets, as they are economical.

   The standards for the non-historic areas with overhead power lines are shown in Table 19. Bridges and tunnels/underpasses are not applicable to this scenario. The lighting arm is the only option for overhead power lines, as it is attached to the utility wooden poles. A Decorative Teardrop arm is preferred; however, Cobraheads can be used if cost prohibits.

2. Historic Areas

   Table 20 presents the standards for historic areas and streets with underground power lines. The requirements do not apply to Tunnels/Underpasses and alleys.

   The standards for historic areas and streets with overhead power lines are shown in Table 21. Bridges and tunnels/underpasses are not applicable to historic areas and streets with overhead power lines.

3. Special Streets

   Table 22 and Table 23 present standards for special streets with underground and overhead power lines, respectively. A decorative teardrop arm is used for special streets with overhead power lines. The requirements do not apply to alleys and Tunnels/Underpasses for special streets with underground power lines. Bridges, alley and tunnels/underpasses are not applicable to special streets with overhead power lines.

New streetlights in new developments should use LED fixtures.

Table 18. Standards for Non-Historic Streets with Underground Power Lines

Item	Roadway/Area Type: Commercial	Roadway/Area Type: Intermediate (Mixed Use)	Roadway/Area Type: Residential[b]	Bridges[c,e]	Alley	Freeway	Tunnels/ Underpasses	Comments
Lighting Hardware Type	Cobra-head (Alt. Decorative Teardrop[a]), Upright[f]	Cobra-head (Alt. Decorative Teardrop[a]), Upright[f]	Cobra-head (Alt. Decorative Teardrop[a]), Upright[f]	Decorative Teardrop, Upright[f]	Cobrahead (5A)	Cobrahead	▪ Wall packs or other viable options (Note 1) for vehicular Tunnels ▪ Upright[f] for pedestrian tunnels	Citizens are to choose from available choices (text in bold is preferred choice)
Cutoff Criteria	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	
Color of Pole	Gray	Gray	Gray	To be selected based on Bridge Design	Gray	Gray	N/A	
Preferred Orientation	Staggered	Staggered	Staggered	Opposite	Staggered	Staggered	N/A	▪ Staggered chosen for uniformity of light ▪ Opposite for bridge for aesthetics and symmetry
Min Spacing between Poles[d]	60 ft min (on one side) – all orientations						N/A	
Height of Pole	Depends on Pole Type						N/A	
Base of Pole	Depends on Pole Type						N/A	
Material of Pole	Depends on the prevailing technology						N/A	

a Although Teardrop has aesthetic appeal, Cobrahead should be considered in cost-prohibitive situations and for viable LED implementations.
b Replace Upright in kind and Cobrahead changes to Teardrop or Upright.
c Replace Upright in kind and Cobrahead changes to Teardrop. The pole can be any special decorative pole designed particularly for a bridge, but it cannot be Cobrahead.
d For Special Case, the spacing can be less than recommended, but it must be justified. Minimum spacing between poles (60 ft) is not a recommendation, but an absolute minimum.
e Bridges may deviate from these guidelines and may be designed with special decorative streetlight hardware to signify their importance, especially in the entry to the City.
f #14, #16, #18 Poles depending on the height of surroundings.

Note: 1. DDOT-Approved LED fixtures, if available, are an option for all above-mentioned lighting alternatives.

Table 19. Standards for Non-Historic Streets with Overhead Power Lines

Item	Roadway/Area Type			Bridges	Alley	Freeway	Tunnels/ Underpasses	Comments
	Commercial	Intermediate (Mixed Use)	Residential					
Lighting Hardware Type	Cobrahead (Alt. Decorative Teardrop[a])	Cobrahead (Alt. Decorative Teardrop[a])	Cobrahead (Alt. Decorative Teardrop[a])	N/A	Cobrahead (5A)	Cobrahead	N/A	▪ Only lighting arm is to be used
Cutoff Criteria	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	Full Cutoff or Cutoff	Full Cutoff, Cutoff	N/A	
Color of Arm	Gray	Gray	Gray	N/A	Gray	Gray	N/A	▪ Currently used
Preferred Orientation	Staggered	Staggered	Staggered	N/A	Staggered	Staggered	N/A	▪ Staggered chosen for uniformity of light
Min Spacing between Poles[b]	60 ft min (on one side) - all orientations			N/A	60 ft min (on one side) - all orientations	60 ft min (on one side) - all orientations	N/A	
Height of Pole	Depends on Pole Type			N/A	Depends on Pole Type	Depends on Pole Type	N/A	
Base of Pole	Depends on Pole Type			N/A	Depends on Pole Type	Depends on Pole Type	N/A	
Material of Pole	Depends on the prevailing technology			N/A	Depends on the prevailing technology	Depends on the prevailing technology	N/A	

a Although Teardrop has aesthetic appeal, Cobrahead should be considered in cost-prohibitive situations and for viable LED implementations.
b For Special Case, the spacing can be less than recommended, but it must be justified. Minimum spacing between poles (60 ft) is not a recommendation but an absolute minimum.
Note: 1. DDOT-Approved LED fixtures, if available, are an option for all above-mentioned lighting alternatives.

Table 20. Standards for Historic Streets with Underground Power Lines

Criteria	Roadway/Area Type: Commercial	Roadway/Area Type: Intermediate (Mixed Use)	Roadway/Area Type: Residential	Bridges[c]	Alley	Freeway	Tunnels/ Underpasses	Comments
Lighting Hardware Type	#14, #16, #18, Twin 20[b]	#14, #16, #18, Twin 20[b]	#14, #16, #18	#14, #16, #18, Twin 20[b] *(Note: Replace Historic Upright in kind)*	Cobra-head (5A)	Cobra-head	▪ Wall packs or other viable options (Note 4) for vehicular Tunnels ▪ #14, #16, #18 for pedestrian tunnels	Upright poles are currently used for historic areas. They are truly historical to DC and aesthetically more pleasing
Cutoff Criteria	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	
Color of Pole	Black	Black	Black	Depends on Bridge Design	Black	Black	N/A	▪ Existing color
Preferred Orientation	Staggered	Staggered	Staggered	Opposite	Staggered	Staggered	N/A	▪ Staggered chosen because of uniformity of light ▪ Opposite for bridge for aesthetics and symmetry
Min Spacing between Poles[a]	60 ft min (on one side) – all orientations						N/A	
Height of Pole	Depends on Pole Type						N/A	
Base of Pole	Depends on Pole Type						N/A	
Material of Pole	Depends on the prevailing technology						N/A	

a For Special Case, the spacing can be less than recommended, but it must be justified. Minimum spacing between the poles (60 ft) is not a recommendation but only an absolute minimum.
b Twin 20 not necessarily desirable unless it is a Special Case.
c Bridges may deviate from these guidelines and may be designed with special decorative streetlight hardware to signify their importance, especially in the entry to the City.

<u>Notes:</u>

1. For Signalized Intersections, if mast arm is not required, for upright poles (#14, #16 & #18), #18 combination pole should be used; and for Twin 20, the same should be used as combination pole.
2. For Signalized Intersections, if mast arm is required, Pendant pole should be used as combination pole; decorative arm with Teardrop fixture can be used.
3. For Unsignalized Intersections, the same pole should be used at the intersections. If the selected pole doesn't illuminate the intersection uniformly, the next taller pole that illuminates the intersection uniformly should be selected.
4. DDOT-Approved LED fixtures, if available, are an option for all above-mentioned lighting alternatives.

Table 21. Standards for Historic Streets with Overhead Power Lines

Criteria	Roadway/Area Type Commercial	Roadway/Area Type Intermediate (Mixed Use)	Roadway/Area Type Residential	Bridges	Alley	Freeway	Tunnels/ Underpasses	Comments
Lighting Hardware Type	Decorative Teardrop (Alt. Cobrahead[a])	Decorative Teardrop (Alt. Cobrahead[a])	Decorative Teardrop (Alt. Cobrahead[a])	N/A	Cobrahead (5A)	Cobrahead	N/A	▪ Only lighting arm is to be used
Cutoff Criteria	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	
Color of Arm	Black	Black	Black	N/A	Black	Black	N/A	▪ Existing color
Preferred Orientation	Staggered	Staggered	Staggered	N/A	Staggered	Staggered	N/A	▪ Staggered chosen because of uniformity of light
Min Spacing between Poles[b]	60 ft min (on one side) – all orientations			N/A	60 ft min (on one side) – all orientations	60 ft min (on one side) – all orientations	N/A	
Height of Pole	Depends on Pole Type			N/A	Depends on Pole Type	Depends on Pole Type	N/A	
Base of Pole	Depends on Pole Type			N/A	Depends on Pole Type	Depends on Pole Type	N/A	
Material of Pole	Depends on the prevailing technology			N/A	Depends on the prevailing technology	Depends on the prevailing technology	N/A	

a Although Teardrop has aesthetic appeal, Cobrahead should be considered in cost-prohibitive situations and for viable LED implementations.
b For Special Case, the spacing can be less than recommended, but it must be justified. Minimum spacing between the poles (60 ft) is not a recommendation but only an absolute minimum.
Note: DDOT-Approved LED fixtures, if available, are an option for all above-mentioned lighting alternatives.

Table 22. Standards for Special Streets with Underground Power Lines

Criteria	Roadway/Area Type: Commercial	Roadway/Area Type: Intermediate (Mixed Use)	Roadway/Area Type: Residential	Bridges[c]	Alley	Freeway	Tunnels/ Underpasses	Comments
Lighting Hardware Type	Twin 20	Cobrahead (Alt. Decorative Teardrop[a])	Cobrahead (Alt. Decorative Teardrop[a])	Twin 20	N/A	Cobrahead (Alt. Decorative Teardrop[a])	▪ Wall packs or other viable options (Note 4) for vehicular Tunnels ▪ #14, #16, #18 for pedestrian tunnels	▪ Twin 20s are DC signature poles and aesthetically more pleasing
Cutoff Criteria	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	Full Cutoff or Cutoff	N/A	
Color of Pole	Black	Black	Black	Depends on Bridge Design	N/A	Black	N/A	
Preferred Orientation	Opposite	Opposite	Opposite	Opposite	N/A	Staggered	N/A	▪ Opposite may be aesthetically more pleasing
Min Spacing between Poles[b]	60 ft, min (on one side) - all orientations				N/A	60 ft, min (on one side) - all orientations	N/A	
Height of Pole	Depends on Pole Type				N/A	Depends on Pole Type	N/A	
Base of Pole	Depends on Pole Type				N/A	Depends on Pole Type	N/A	
Material of Pole	Depends on the prevailing technology				N/A	Depends on the prevailing technology	N/A	

a Although Teardrop has aesthetic appeal, Cobrahead should be considered in cost-prohibitive situations and for viable LED implementations.

b For Special Case, the spacing can be less than recommended, but it must be justified. Minimum spacing between the poles (60 ft) is not a recommendation but only an absolute minimum.

c Bridges may deviate from these guidelines and may be designed with special decorative streetlight hardware to signify their importance, especially in the entry to the City.

Note:

1. For Signalized Intersections, if mast arm is not required, Twin 20 should be used as combination pole.
2. For Signalized Intersections, if mast arm is required, Pendant pole should be used as combination pole; decorative arm with Teardrop fixture can be used.
3. For Unsignalized Intersections, the same pole should be used at the intersections. If the selected pole doesn't illuminate the intersection uniformly, the next taller pole that illuminates the intersection uniformly should be selected.
4. DDOT-Approved LED fixtures, if available, are an option for all above-mentioned lighting alternatives.

Table 23. Standards for Special Streets with Overhead Power Lines

Criteria	Roadway/Area Type: Commercial	Roadway/Area Type: Intermediate (Mixed Use)	Roadway/Area Type: Residential	Bridges	Alley	Freeway	Tunnels/ Underpasses	Comments
Lighting Hardware Type	Cobrahead (Alt. Decorative Teardrop[a])	Cobrahead (Alt. Decorative Teardrop[a])	Cobrahead (Alt. Decorative Teardrop[a])	N/A	Cobrahead (5A)	Cobrahead	N/A	
Cutoff Criteria	Full Cutoff or Cutoff	Full Cutoff or Cutoff	Full Cutoff or Cutoff	N/A	N/A	Full Cutoff or Cutoff	N/A	
Color of Arm	Black	Black	Black	N/A	N/A	Black	N/A	
Preferred Orientation	Opposite	Opposite	Opposite	N/A	N/A	Staggered	N/A	▪ Opposite may be aesthetically more pleasing
Min Spacing between Poles[b]	60 ft, min (on one side) - all orientations			N/A	N/A	60 ft, min (on one side) - all orientations	N/A	
Height of Pole	Depends on Pole Type			N/A	N/A	Depends on Pole Type	N/A	
Base of Pole	Depends on Pole Type N/A			N/A	N/A	Depends on Pole Type	N/A	
Material of Pole	Depends on the prevailing technology			N/A	N/A	Depends on the prevailing technology	N/A	

a Although Teardrop has aesthetic appeal, Cobrahead should be considered in cost-prohibitive situations and for viable LED implementations.

b For Special Case, the spacing can be less than recommended, but it must be justified. Minimum spacing between the poles (60 ft) is not a recommendation but only an absolute minimum.

Note: 1. DDOT-Approved LED fixtures, if available, are an option for all above-mentioned lighting alternatives.

The minimum spacing between poles (i.e., 60 ft) is not a recommendation, but only an absolute minimum. The designer should ensure that the spacing fulfills the following objectives, yet meeting the AASHTO standards:

- Minimum number of poles
- Lowest acceptable wattage
- Maximum possible spacing

The height of the pole should be determined based on the context of the surroundings, such as the height of building, roadway width, sidewalk width, etc.

The order of precedence also influences the hardware selection and is as follows:

1. Exempt locations, such as Monumental Core/BIDS/Downtown Streetscape
2. Special streets
3. Historic streets
4. Non-Historic streets

The Washington Upright poles Nos. 14, 16, 18 and Twin-20 that are recommended in the standards are shown below.

Figure 14. Types of Upright Poles for Use in DC (#14, #16, #18 and Twin-20)

The Pendant poles recommended for the District are Cobrahead, 5A Alley Post and Decorative Teardrop (shown in Figure 12). The Cobrahead and 5A Alley Poles are installed citywide.

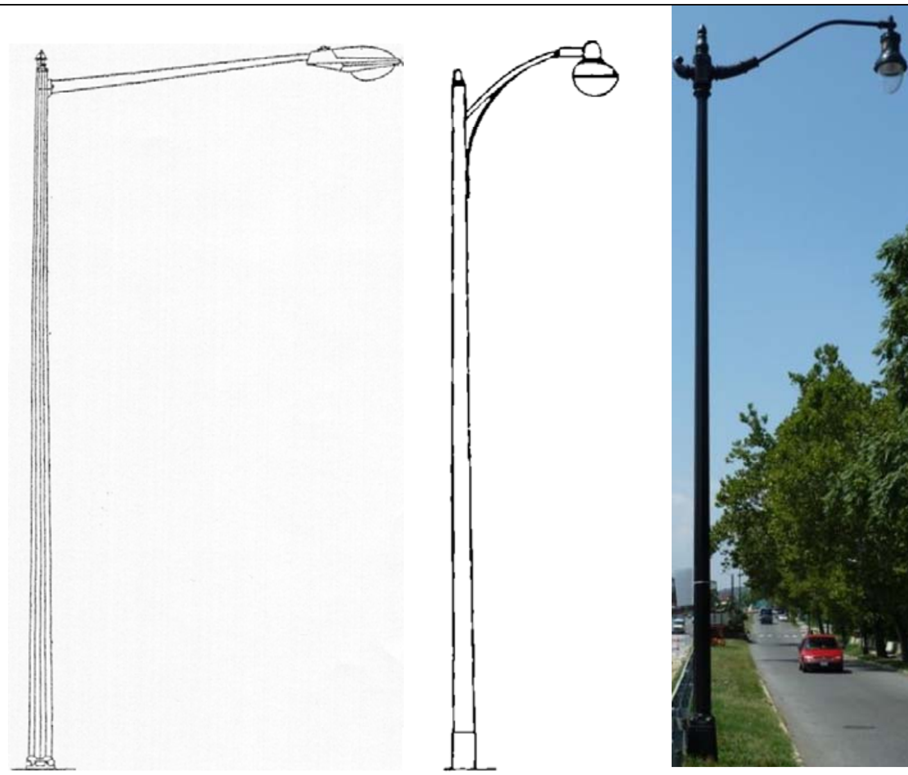


Figure 15. Types of Pendant Poles for Use in DC (Cobrahead, 5A Alley Post and Teardrop)

5.6 <u>DESIGN PRINCIPLES</u>

The following design principles should be observed during any streetlight design process and are made part of the policy:

1. The design must be based on AASHTO recommendations for the average maintained illuminance levels for the various roadway classifications defined by DDOT (Table 24). Table 25 presents the required average maintained illumination levels for illuminated sidewalk areas, along all DDOT roadway classifications, with the criteria based on the type of land use. Table 26 presents the criteria for required uniformity and veiling luminance ratios.

***Table 24. Recommended Average Maintained Illuminance for District Roadways*[12]**

DC Street Classification	Land Use	Recommended Average Maintained Illuminance (foot-candle)		
		R1	R2 & R3	R4
Interstate and other freeways	Residential Intermediate Commercial	0.6 to 0.8 0.6 to 0.9 0.6 to 1.1	0.6 to 0.8 0.6 to 0.9 0.6 to 1.1	0.6 to 0.8 0.6 to 0.9 0.6 to 1.1
Other Principal Arterials	Residential Intermediate Commercial	0.6 0.8 1.1	0.8 1.2 1.6	0.8 1.0 1.4
Minor Arterials	Residential Intermediate Commercial	0.5 0.8 0.9	0.7 1.0 1.4	0.7 0.9 1.0
Collectors	Residential Intermediate Commercial	0.4 0.6 0.8	0.6 0.8 1.1	0.5 0.8 0.9
Local Street	Residential Intermediate Commercial	0.3 0.5 0.6	0.4 0.7 0.8	0.4 0.6 0.8
Alleys	Residential Intermediate Commercial	0.2 0.3 0.4	0.3 0.4 0.6	0.3 0.4 0.5

***Table 25. Recommended Average Maintained Illuminance for Sidewalks*[12]**

DC Sidewalk Locations	Recommended Average Maintained Illuminance (foot-candle)		
	R1	R2 & R3	R4
Residential Areas	0.3	0.4	0.4
Intermediate Areas	0.6	0.8	0.8
Commercial Areas	0.9	1.3	1.2

***Table 26. Recommended Average-to-Minimum Uniformity and Veiling Luminance Ratios*[12]**

DC Street Classification	Average-to-Minimum Uniformity Ratio	Veiling Luminance Ratio
Interstate and other freeways	3:1 or 4:1	0.3:1
Other Principal Arterials	3:1	0.3:1
Minor Arterials	4:1	0.3:1
Collectors	4:1	0.4:1
Local Street	6:1	0.4:1
Alleys	6:1	0.4:1

2. The design should use maximum spacing of streetlight poles. A minimum spacing between poles (i.e., 60 ft) has been specified; however, it is not a recommendation, but only an absolute minimum. The designer should ensure that the spacing fulfills the following objectives, yet meeting the AASHTO standards:

[12] Recommendations based on *Roadway Lighting Design Guide* , AASHTO, 2005.

- Minimum number of poles
- Lowest acceptable wattage
- Maximum possible spacing

3. The design should be based on lower wattage lamps, so as to keep an extra cushion for higher level of illumination in future, if necessary, which can be easily done by replacing the lower wattage lamps with higher wattages. For example, No. 16 poles should be designed for a maximum 250 Watt, while up to 400 Watt is allowed; No. 14 poles should be designed for a maximum of 100 Watt, while up to 150 Watt is allowed.
4. The design should avoid using 400 Watt conversion kits in residential areas.
5. The height of the pole should be determined based on the context of the surroundings such as the height of building, roadway width, sidewalk width, etc.
6. The design must consider reduction of glare into drivers' and pedestrians' eyes, and enhancement of visibility. Appropriate refractive globes can effectively reduce direct glare by softening and spreading the light distribution. Shields can also be used to aim the lights so that they are not directly visible from the roads, alleys, pathways, and windows, as needed.
7. As noted previously, incandescent and mercury vapor luminaires should generally be avoided in new designs since it these fixture will be phased out by the Year 2015.

5.7 DESIGN EXAMPLES

A simplified streetlight design, based on this policy, for North Capitol Street and Michigan Avenue/Columbia Road is illustrated in Figure 16. The entire North Capitol Street segment shown belongs to the Special Street category. On the other hand, Michigan Avenue/ Columbia Road is a minor arterial that changes from Non-historic to Historic and back to Non-historic. In the figure below, the ‘Existing’ refers to the existing condition and ‘Proposed’ refers to the design as per this streetlight policy guideline.

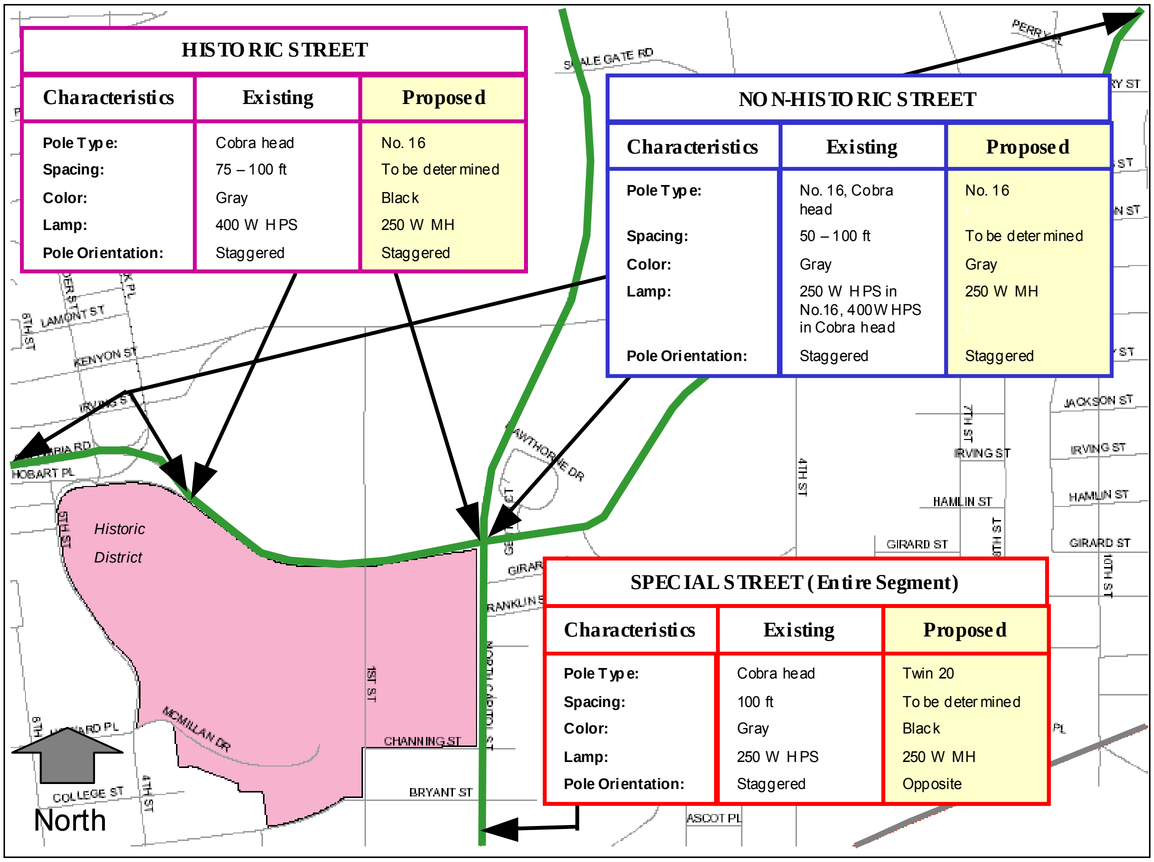


Figure 16. Illustration of North Capitol Street and Michigan Avenue/Columbia Road

Another illustration of streetlight design for Cathedral Avenue and Connecticut Avenue (Old Woodley Park Area) is shown in Figure 17. The entire Connecticut Avenue segment shown belongs to the Special Street category. On the other hand, Cathedral Avenue is a collector road that changes from Non-historic to Historic. At the intersection, the roadway right-of-way (ROW) controls the color and other properties of the street lighting hardware. The Special Streets supersede Historic Streets/Districts and Historic Streets supersede Non-Historic Streets. When a Special Street passes through any Historic District, it will continue to have the color and other properties of Special Street. At the intersection of a Historic Street with a Non-Historic Street, the ROW will control the color and other properties as shown at the bottom of the figure.

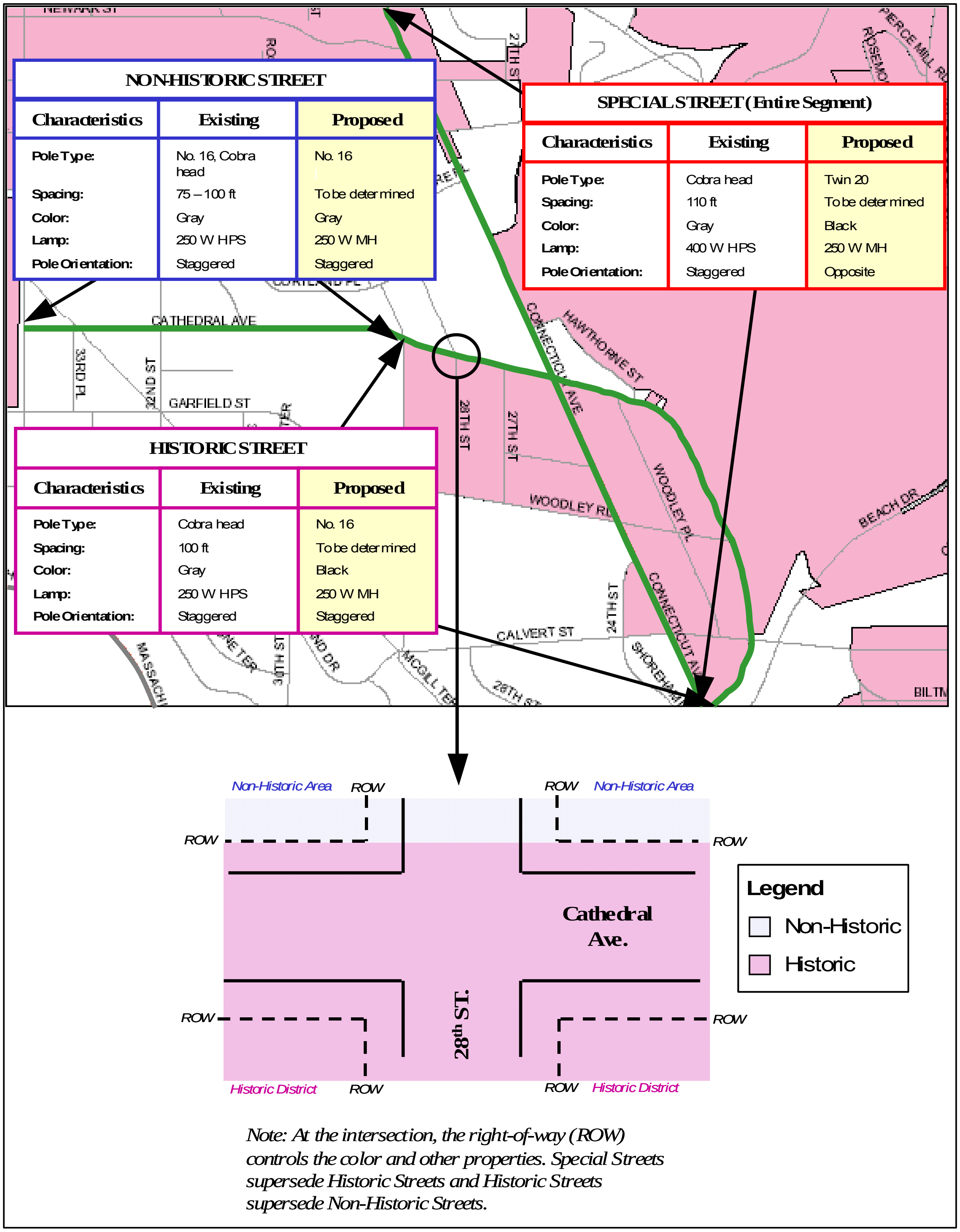


Figure 17. Illustration of Cathedral Avenue and Connecticut Avenue (Old Woodley Park)

6. NEXT STEPS

DDOT should follow certain next steps, as listed below for successful implementation of this strategic plan:

1. DDOT should periodically review these guidelines and make any necessary modifications within the general framework.
2. Continual monitoring is required to review lamp technologies and related costs in the future. Currently, LED technology is becoming viable as a white light source compared to widely-used HPS lamps and it is improving at a rapid pace. Special attention also needs to be paid to other white light sources (such as metal halide or other future technologies) to determine when their life-cycle costs become comparable.
3. As advances are made to improving LED luminaires, the usage of LED luminaires should be increased to provide the most economic longer term lighting strategy.
4. The overall technology should be assessed from time to time to take advantage of new developments offering economy and safety. For example, poles of various materials are becoming available and some may offer a safer environment (such as non-conductive pole base).
5. DDOT needs to evaluate its funding situation and priorities to determine the usage of Teardrop fixtures over Cobraheads. A complete substitution of Cobrahead by Teardrop fixtures is likely to be cost-prohibitive.