231 Lighting

231.1 General

Roadway lighting benefits motorists by improving their ability to see roadway geometry and other vehicles at extended distances ahead. Intersection lighting allows for greater visibility of pedestrians that may be in the crosswalk. The design and layout of lighting should complement the basic highway design.

Light poles are permitted in the median only when lighting from the outside cannot meet the criteria shown in ***Table 231.2.1*** without being supplemented by median lighting. Additionally, the barrier requirements in ***FDM 215.2.9*** must be met.

This chapter provides the process and criteria to be used in the development of lighting designs on the SHS.

231.1.1 Design Luminaires

Use only luminaires listed on the Department's ***Approved Products List*** (***APL***) for the corresponding usage cases. Obtain photometric information from manufacturers to use in the lighting design and resulting design luminaire selection. Include the design luminaire information with the Lighting Plans per the requirements of ***FDM 326***.

Where practical, use consistent luminaire models with the same input/output properties per new lighting location (e.g., per corridor, intersection, interchange, sidewalk, etc.).

231.1.2 Structural Supports

AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and the ***FDOT Modifications to LRFDLTS-1*** provide structural design criteria.

Refer to ***FDM 261*** for information regarding structural support requirements. Refer to ***FDM 326*** for information regarding Lighting Plans requirements.

231.1.3 Attachments to Barriers

Refer to ***FDM 215*** for information regarding proposed attachments to bridge traffic railings, concrete median barrier walls, concrete shoulder barrier walls or the evaluation of existing attachments.

231.1.4 Voltage Drop Criteria

When determining conductor sizes for lighting electrical circuits, the maximum allowable voltage drop, measured from the power company's transformer through the last device on any one circuit, must not exceed 5%.

231.1.5 Grounding

The grounding requirements for lighting systems, as shown in the ***Standard Plans*** are as follows:

(1) Install 20' of ground rod at each conventional height light pole and at each pull box.

(2) Install 40' of ground rod at each electrical service point.

(3) At each high mast pole, install an array of 6 ground rods 20' in length, as shown in the ***Standard Plans***, ***Index 715-010***.

The above lengths of ground rod will be installed at each pole, pull box and service point, and the cost will be incidental to the unit or assembly being installed.

231.2 Design Criteria

Use the illuminance method for the light level design. The design values for light levels given by the ***AASHTO Roadway Lighting Design Guide*** are maintained values. These maintained values have been adjusted for Department assigned light loss and maintenance factors. These values are provided in ***Table 231.2.1*** as required light level criteria.

The ***AASHTO Roadway Lighting Design Guide*** permits either the illuminance technique or the luminance technique to be used in the design of highway lighting. The luminance technique requires a complex design process and knowledge of the reflective characteristics of the pavement surface used. These reflective characteristics change as the pavement ages and with variations in weather conditions. It is for these reasons that the luminance technique is not used for the light level design.

Mounting height (M.H.) for conventional lighting is the vertical distance from the roadway surface at the edge of the travel lane to the luminaire's light source, regardless of lateral placement of the pole. Pole setback is the horizontal distance from the edge of the travel lane to the pole.

Table 231.2.1 Lighting Initial Values

Roadway Classification	Illumination Level Average Foot Candle		Illumination Uniformity Ratios		Veiling Luminance Ratio
Or Project Type	**Horizontal (H.F.C.)**	**Vertical (V.F.C.)**	**Avg./Min.**	**Max./Min.**	**$L_{V(MAX)}/L_{AVG}$**
Corridor Lighting					
Limited Access Facilities	1.5	N/A	4:1 or Less	10:1 or Less	0.3:1 or Less
Major Arterials	1.5				
Other Roadways	1.0				
High Mast Lighting					
All Roadway Classifications	0.8 to 1.0	N/A	3:1 or Less	10:1 or Less	N/A
Signalized Intersection and Roundabout Lighting					
New or Reconstruction	3.0 Std. 1.5 Min.	1.5 Std. 1.2 Min.	4:1 or Less	10:1 or Less	N/A
Lighting Retrofit	1.5 Std. 1.0 Min.	1.5 Std. 1.0 Min.			
Unsignalized Intersection Lighting					
All Project Types	1.0 to 1.5	1.5 Std. 1.0 Min.	4:1 or Less	10:1 or Less	N/A
Midblock Crosswalk Lighting					
Low Ambient Luminance	N/A	1.5	N/A	N/A	N/A
Medium & High Ambient Luminance		2.3			
Sidewalks and Shared Use Paths					
Facilities Separated from the Roadway	2.5	N/A	4:1 or Less	10:1 or Less	N/A
Sign Lighting					
Low Ambient Luminance	15-20	N/A	N/A	6:1	N/A
Medium & High Ambient Luminance	25-35				
Rest Area Lighting					
All Roadways and Parking Areas	1.5	N/A	4:1 or Less	10:1 or Less	N/A

Table 231.2.1 Lighting Initial Values cont.

Roadway Classification	Illumination Level Average Foot Candle		Illumination Uniformity Ratios		Veiling Luminance Ratio
Or Project Type	**Horizontal (H.F.C.)**	**Vertical (V.F.C.)**	**Avg./Min.**	**Max./Min.**	**$L_{V(MAX)}/L_{AVG}$**
Wildlife-Sensitive Conventional Lighting					
Limited Access Facilities	0.8-1.0	N/A	4:1 or Less	10:1 or Less	0.3:1 or Less
Arterials and Collectors	1.0-1.5	N/A			
Signalized Intersection - New	1.5-3.0	1.0 Min.	4:1 or Less	10:1 or Less	N/A
Signalized Intersection - Retrofit	1.0-1.5	1.0 Min.			
Midblock Crosswalk	N/A	1.0 Min.	N/A	N/A	N/A

Notes:
(1) Illumination Uniformity Ratios do not apply to V.F.C.
(2) Standard (Std.) values must be met unless doing so raises the accompanying H.F.C. or V.F.C. result in excess of double its required illumination level.

Do not tilt arm-mounted fixtures. Pole top-mounted fixtures may be tilted:

- Up to 5 degrees for roadway lighting projects.
- Up to 15 degrees only when used at weigh stations, agricultural stations, or rest areas.

Lights installed within the clear zone must be breakaway or shielded by an approved barrier unless they are bridge or barrier wall mounted. Refer to ***FDM 215*** for additional information on roadside safety design.

Conventional lighting generally includes standard fixtures for basic roadside placement, excluding the specialized fixtures used for high mast, underdeck, sidewalk, shared used path, and sign lighting. Specify mounting heights for conventional lighting in accordance with ***Table 231.2.2***. Ensure that the maximum candela of the design luminaire does not exceed the maximum candela for the associated minimum mounting height.

Table 231.2.2 Minimum Mounting Heights Based on Maximum Candela

Minimum Mounting Height (ft.)	Maximum Candela of Luminaire		
	Long Distribution	Medium Distribution	Short Distribution
20 or Less	5,000	10,000	15,000
25	10,000	15,000	20,000
30	15,000	20,000	25,000
35	20,000	25,000	30,000
40	25,000	30,000	35,000
45	30,000	35,000	40,000
50	35,000	40,000	45,000

Notes:

(1) "Distribution" refers to the longitudinal distribution of the luminaire output per The Illuminating Engineering Society of North America (IESNA).

(2) "Maximum Candela" is generally provided with the manufacturer's luminaire specific "IES" file for AGi32® design software.

231.2.1 Environmental Lighting

Wildlife areas of concern are identified by the District's environmental managers or permit coordinators on a project-specific basis. For lighting within these areas, follow the requirements for Wildlife-Sensitive Conventional Lighting listed in ***Table 231.2.1*** along with ***FDM 231.3.*** Where practical, use only Wildlife-Sensitive Conventional Luminaires listed on the ***APL***, and orient lighting away from the wildlife-sensitive areas.

For consideration of sea turtle nesting beaches, the Office of Environmental Management (OEM) provides additional resources on the ***Protected Species and Habitat*** website or through the ***FGDL*** metadata explorer. The *Data Tools for Turtle Lighting* provide GIS shape files and Google Earth™ map layers showing the areas of concern where lighting may be visible from light-sensitive sea turtle nesting beaches. For projects within these areas, coordinate with the District's environmental managers or permit coordinators to evaluate proposed lighting impacts to sea turtles on nesting beaches. Where the lighting is visible from nesting beaches, the following requirements apply.

For Wildlife-Sensitive Buffer Areas:

(1) Orient lighting away from nesting beaches to avoid direct lighting and consider light shielding, where practical.

(2) Follow criteria for Wildlife-Sensitive Conventional Lighting per ***Table 231.2.1***. Use only Wildlife-Sensitive Conventional Luminaires as listed on the ***APL***.

(3) For night-time work zone lighting within the wildlife-sensitive buffer area that will occur during sea turtle nesting season, meet the requirements of ***FDOT Standard Specifications Workbook 8-4.1***.

For Dark-Sky Buffer Areas:

(1) Follow International Dark-Sky Association recommendations where practical, including the topics of light orientation and light shielding.

(2) Use Luminaires with a 3000K CCT or lower. Use traditional luminaires as listed on the ***APL***; specify CCT in Lighting Plans.

231.3 Design Methodology

Use the polygon method for all photometric calculations. Establish illumination points within the polygon at the following intervals:

(1) For Roadway Segments: 15 feet longitudinally and 5 feet transversely along the roadway

(2) For Signalized Intersections: 5 feet longitudinally and 5 feet transversely along the roadway.

Refer to ***RCI Features & Characteristics Handbook***, Urban Classification – Feature 124 for additional information concerning urban designations Urban 1 through Urban 5.

231.3.1 Analysis Zones

Establish independent analysis zones for each signalized intersection and for each roadway segment between signalized intersections. Roadway lighting for roadway segments, signalized intersection segments, and pedestrian lighting are to meet the criteria shown in ***Table 231.2.1.***

Analyze signalized intersection segments using one analysis zone bounded by the back of sidewalks and the signalized intersection stop bars on each approach.

The termini for each roadway segment will be either the lighting project limits, or the signalized intersection stop bars. The boundary of each roadway segment is described as follows:

Flush Shoulder Roadways:

(1) Analyze divided roadway segments with grassed medians using two analysis zones (i.e., one for each direction of travel). Each zone will be bounded by the outside and median shoulder breaks.

(2) Analyze multi-lane undivided roadway segments using two analysis zones (i.e., one for each direction of travel). Each zone will be bounded by the outside shoulder break and the centerline of the roadway.

(3) Analyze two and three lane roadway segments as one analysis zone bounded by the outside shoulder breaks.

Curbed Roadways:

(4) Analyze divided roadway segments with grassed medians using two analysis zones (i.e., one for each direction of travel). Each zone will be bounded by the back of sidewalk and the back of the median curb.

(5) Analyze multi-lane undivided roadway segments, including roadways with two-way left turn lane, using two analysis zones (i.e., one for each direction of travel). Each zone will be bounded by the back of sidewalk and the centerline of the roadway.

Limited Access Facilities:

Establish independent analysis zones for the mainline roadway segments, ramp segments and crossroad segments at interchanges.

The termini for each mainline roadway segment will be the lighting project limits. Logical termini for the other segments will be determined by the designer. The boundary of each segment is described as follows:

(1) Analyze divided mainline roadway with grassed median using two analysis zones, one for each direction of travel (i.e., one zone for each direction of travel). Each zone will be bounded by the outside and median shoulder breaks.

(2) Analyze barrier separated mainline roadway as one analysis zone bounded by the outside shoulder breaks of each direction of travel.

(3) Analyze each ramp segment as one analysis zone bounded by the shoulder breaks. For interchange lighting where there is no continuous mainline roadway

lighting, the average illuminance criteria must be maintained to the end of the ramp tapers.

(4) Analyze crossroad segments based on the criteria given above for flush shoulder or curbed roadways.

231.3.2 Intersections

231.3.2.1 Signalized Intersections

For new or reconstructed signalized intersections within context classifications C3 through C6, provide lighting meeting the requirements of ***Table 231.2.1***. For all other signalized intersection contexts, lighting may be provided at the District's discretion. Vertical illuminance is the primary design value used to measure driver visibility of pedestrians. Research has determined that visibility of pedestrians in crosswalks at intersections is a function of the following:

(1) Background illuminance

(2) Luminaire location in relation to the approach vehicle

(3) Luminaire mounting height

(4) Distance from the luminaire to the crosswalk

(5) Photometrics of the luminaire

The vertical illuminance calculation method to be used at intersections will be the variable light meter aimed toward the driver's location. This calculation will provide the vertical illumination level of a pedestrian which the driver sees approaching the crosswalk. This type of vertical illumination calculation is outlined in the ***IESNA Design Guide for Roundabout Lighting (DG-19-08)***. When performing this calculation, the driver's location from the crosswalk must be established. Use the stopping sight distance for the nearside approach based on the posted speed of the near approach roadway. Use the stopping sight distance for the turning movement approaches based on the operating speed for each specific turning radius.

The vertical illuminance must be calculated for three movements for each intersection approach. The first is the thru movement and the near side crosswalk; the second is the right turn movement and crosswalk on the adjacent side street; and the third is the left turn movement and the crosswalk on the side street. ***Figures 231.3.1*** through ***231.3.3*** indicate each of these three movements and the corresponding crosswalk area that must be analyzed. The vertical illuminance grid points are to be on a line centered in the crosswalk with a horizontal point spacing of 1.65 feet at a height of 5 feet above the

pavement. The grid points are oriented toward the approaching driver, which is different from the vertical grids for sidewalks where the grids are parallel to the main pedestrian flow.

See ***FDM 231.3.2.1.1*** for projects where pedestrian lighting improvements are desired, but the existing intersection infrastructure will remain and be supplemented to achieve the desired improvements.

231.3.2.1.1 Intersection Lighting Retrofit

For existing signalized intersections where a full signal upgrade is not occurring, the existing infrastructure may restrict the placement of additional lighting structures necessary to meet the New and Reconstructed criteria of ***Table 231.2.1***. With these challenges considered, ***Table 231.2.1*** provides reduced illumination requirements for Lighting Retrofit designs. Lighting Retrofits provide safety benefits of improved lighting without the full reconstruction of light and signal structures.

Lighting Retrofits should be considered for use at existing signalized intersections that have a history of nighttime pedestrian crashes. Lighting Retrofits may be included with RRR and minor intersection improvement projects that do not include full signal reconstruction. A Lighting Retrofit operation may include replacing older luminaire types with LED luminaires, adding additional light poles, adding luminaire support arms to existing structures, and any other minor modifications needed to meet the Lighting Retrofit requirements of ***Table 231.2.1***. Lighting Retrofits generally do not include removing or replacing existing structures such as light poles and signal structures.

For Lighting Retrofit designs, the vertical illuminance requirement of ***Table 231.2.1*** only applies to the near side thru movement (see ***Figure 231.3.1***).

Existing, low-mounted sidewalk lighting is generally not intended to meet the lighting requirements of ***Table 231.2.1***. To prevent increased glare, do not increase light output at existing luminaire locations with mounting heights less than 30 feet.

Independent maintenance operations that update existing fixtures to LED fixtures are not considered Lighting Retrofits, so the illumination criteria of ***Table 231.2.1*** is not required for these cases.

231.3.2.2 Unsignalized Intersections

Provide lighting for unsignalized intersections consistent with any connecting corridors that meet warranting requirements of ***FDM 231.4.***

Consider adding lighting for unsignalized intersections with a history of nighttime pedestrian crashes, particularly for marked crosswalks on uncontrolled approach legs. For marked crosswalks at such intersections, the vertical illuminance requirement of ***Table 231.2.1*** is only required for the near side thru movement (see ***Figure 231.3.1)***.

231.3.3 Roundabouts

Provide lighting for roundabouts as required per ***FDM 213***.

The roundabout lighting criteria for new or reconstruction in ***Table 231.2.1*** applies where pedestrian features are provided. Use conventional corridor lighting criteria for roundabouts where pedestrian traffic is not anticipated. Calculate the vertical illuminance for crosswalks on each near side approach and for each right turn movement in accordance with the methodology outlined in ***FDM 231.3.2***.

231.3.4 Midblock Crosswalks

Provide lighting for midblock crosswalks as required per ***FDM 222***. Where midblock crosswalks are placed to serve a facility that generates pedestrian crossings only during daylight hours, this lighting requirement may be omitted at the District's discretion.

Lighting criteria for midblock crosswalks are provided in ***Table 231.2.1***. Calculate the vertical illuminance for the crosswalk on each near side approach in accordance with the methodology outlined in ***FDM 231.3.2***.

231.3.5 Sidewalks and Shared Use Paths

Lighting criteria for sidewalks and shared use paths are provided in ***Table 231.2.1***. These values are only intended for facilities separate from the roadway.

When sidewalk or shared use path lighting affects an adjacent roadway, then the sidewalk or shared use path illumination requirements are reduced to match those of the adjacent roadway. When such lighting is mounted below a height of 30 feet, use full cutoff luminaires with low output. Include the effects of this sidewalk or shared use path lighting when meeting the roadway's lighting requirements in ***Table 231.2.1***, including the veiling luminance check for glare.

231.3.6 Underdeck Bridge Lighting

The light levels for underdeck lighting should be equal to the adjacent roadway lighting. In general, the only luminaire to be used for underdeck lighting is a wall-mount fixture located on the pier or pier cap.

Figure 231.3.1 Vertical Illuminance Calculation for Near Side Movement

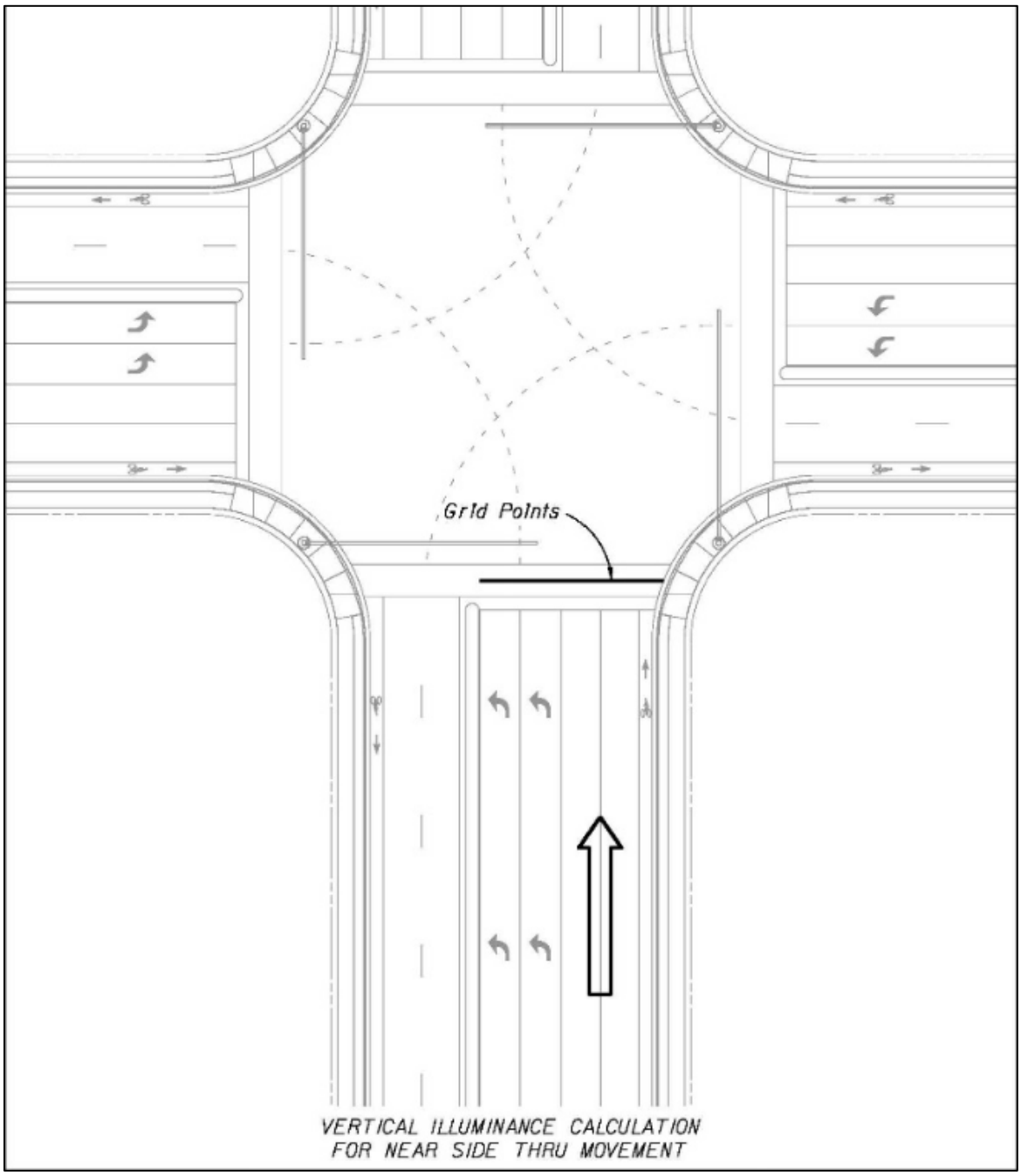


Figure 231.3.2 Vertical Illuminance Calculation for Right Turn Approach

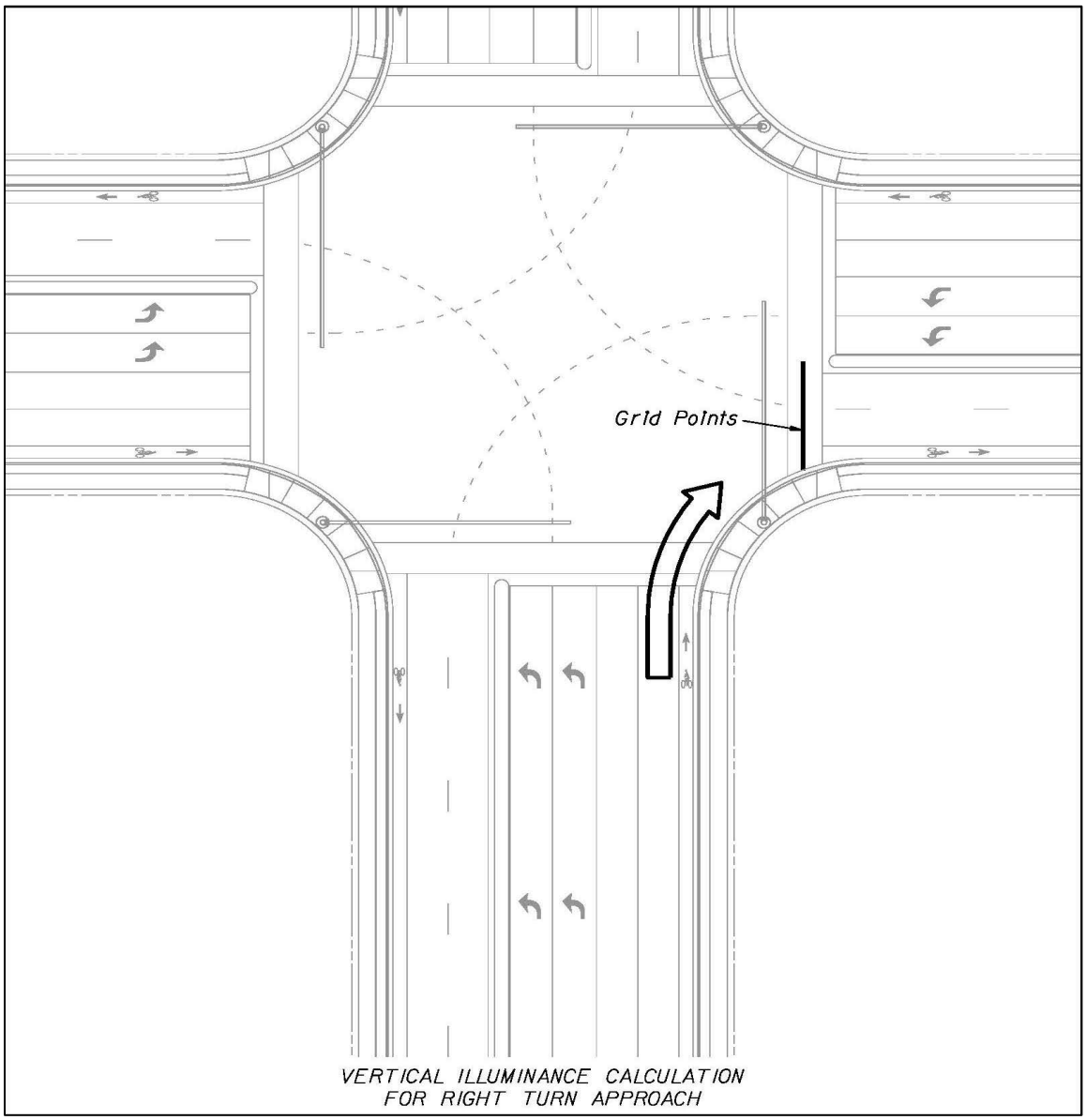


Figure 231.3.3 Vertical Illuminance Calculation for Left Turn Approach

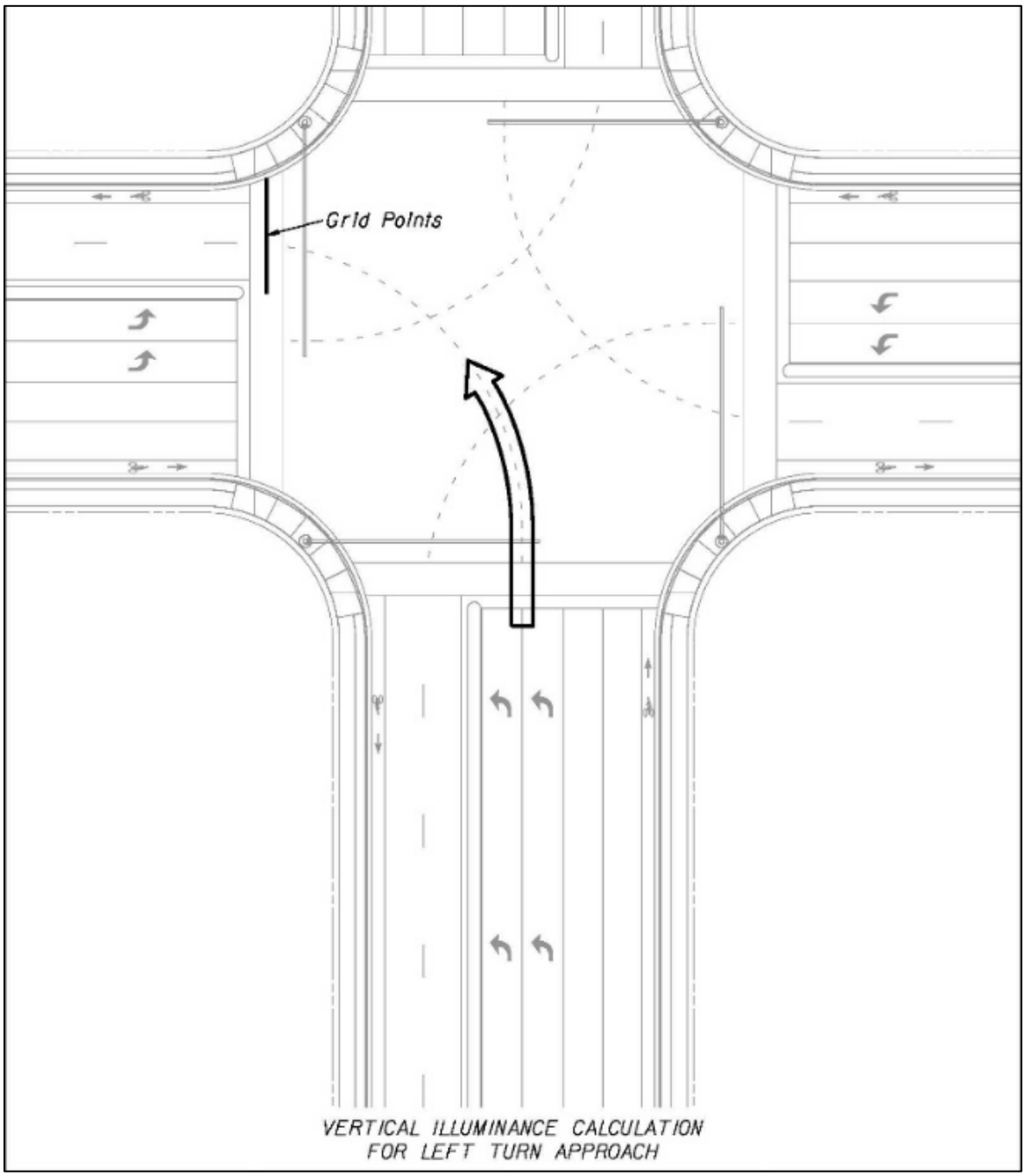
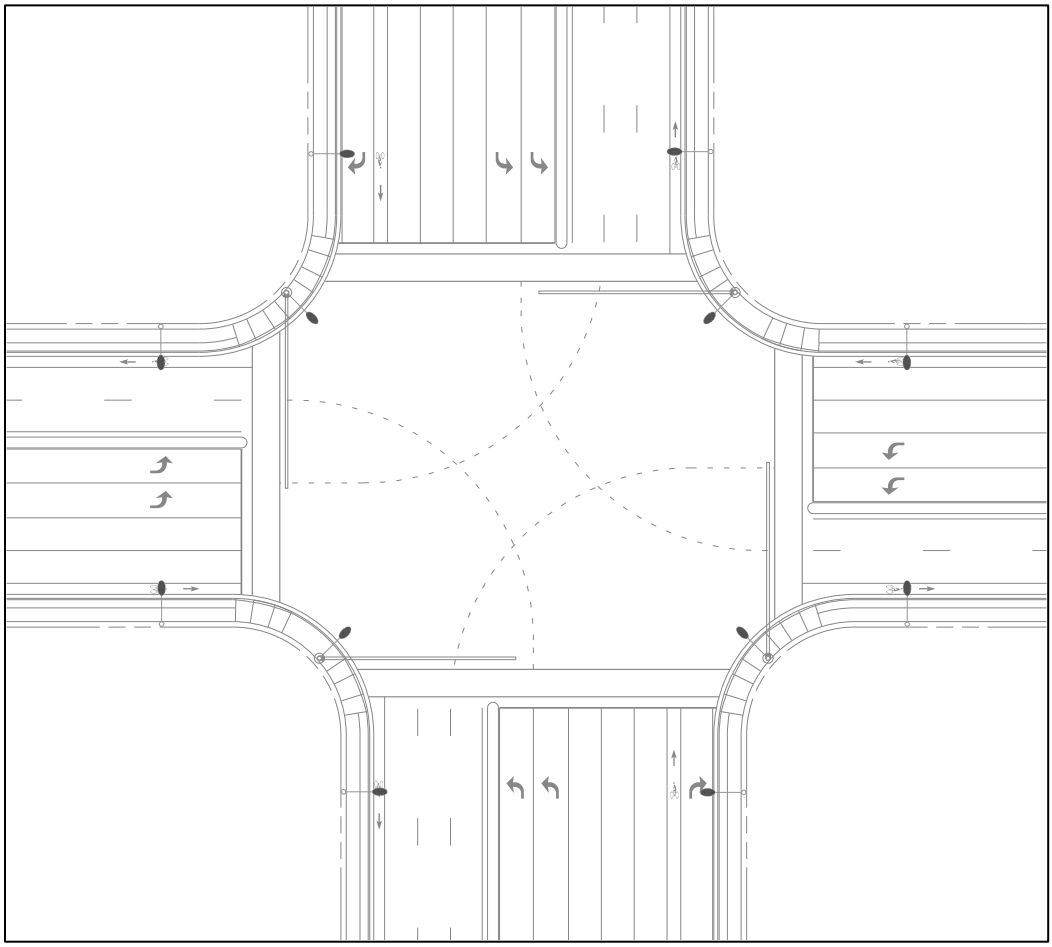


Figure 231.3.4 shows the typical lighting layout for a large intersection. The crosswalk and luminaire locations must be coordinated to optimize the vertical illumination level.

Figure 231.3.4 Typical Lighting Layout for Large Intersection



231.4 Lighting Justification

The Department follows the warrants for lighting of corridors and interchanges established by ***AASHTO***. The warrants are based on benefit-cost ratios determined from the Average Daily Traffic (ADT), the ratio of night to day crashes, initial cost, and maintenance.

Interchanges that are not on the interstate highway system will require a warrant analysis. A benefit-cost ratio of 2.0 or greater is the threshold for lighting usage at these interchanges.

Interchanges that are on the interstate highway system must all be lighted to assure consistency and to meet driver expectations. A warrant analysis is still required for funding evaluation and information, but it will not be used as the determining factor for lighting usage at these interchanges.

A lighting justification must be completed in accordance with ***Manual on Uniform Traffic Studies (MUTS), Chapter 14***.

231.5 Existing Lighting During Construction

The maintenance of existing lighting will be the responsibility of the contractor only if the lighting is affected by the construction. The contractor is not expected to replace lamps and pole knockdowns or to repair wiring if these problems are not caused by the construction work.

The plans are to specify the scope of the contractor's responsibility for the maintenance of existing lighting.

231.6 Lighting Design Coordination

Agency Coordination Document:

Contact applicable local construction, power, and maintaining agencies to confirm roles of lighting stakeholders. Prior to developing the Lighting Plans, create a document entitled "Lighting Agency Coordination", and include the following information:

- Project ID, roadway name, and limits
- Lighting designer or EOR

- Local agencies and personnel contacted
- List of local agency requirements, including structural, electrical, and aesthetic requirements that will substitute for FDOT requirements
- Lighting EOR that will accept the above local agency requirements as an equivalent substitute for FDOT requirements
- A brief summary of expected operating and maintenance agreement, including responsible parties and term lengths

Include "Lighting Agency Coordination" document with the project documentation. All local agency requirements listed must later be included with the details or notes of the Lighting Plans. The "Lighting Agency Coordination" document may be updated as design work progresses, but the latest version must be saved and included with the project documentation.

General Coordination: Contact the District Utilities Engineer when the pole locations are set and the electrical load has been determined. The designer should coordinate with the utility company providing power on the preferred location for the electrical service.

Coordinate with the Drainage Section to assure that high water tables, stormwater retention areas, or other water bodies will not be a problem with the proposed location of light poles and the light pole pull boxes.

Coordinate locations and attachments of lights and conduits on bridge structures with the bridge structural designer. Include light and conduit locations, and attachment details in the plans. Refer to ***Structures Design Guidelines***, ***Section 1.9*** for details and restrictions related to bridge attachments.

Typically, the District Maintenance Engineer in conjunction with the District Utilities Engineer obtains the required maintenance agreements. The designer should coordinate with these offices to ensure that this activity is either underway or scheduled.

Any lighting project, especially high mast, adjacent to or in the vicinity of an airport, may present a potential conflict. For poles located within 3 miles of airports, check coordinates of light pole structures with the FAA website tool to determine if further filing and coordination with the FAA is necessary.

Modification for Non-Conventional Projects:
Delete ***FDM 231.6*** and replace with the following: **231.6 Lighting Project Coordination**

The Lighting Engineer of Record is responsible for all necessary coordination.

231.7 Lighting Design Analysis Report

Prepare a Lighting Design Analysis Report (LDAR) that provides a photometric analysis for each signalized intersection lighting design, mainline typical section, ramp typical section, interchange, and structure with underdeck lighting. All analyses, including horizontal and vertical illumination analyses, should be shown on separate photometric plan sheets.

Provide a summary statement on cost-effectiveness of the lighting design. In general, the system with the largest pole spacing that meets design requirements and avoids detrimental light spill will be the most cost-effective design. Also, provide information for at least three luminaire models/manufacturers considered, and explain why the final design luminaire was chosen based on cost-effectiveness.

Provide voltage drop calculations, load analysis calculations for each branch circuit, and lighting calculations for each lighting system.

Include FAA coordination documents where applicable.

For all LDAR components, provide sufficient detail in print format (e.g., PDF) so that reviewers do not require compatible design software to check all inputs and results of calculations.