Roadway Lighting Environmental Assessment Fact Sheet

Introduction

This document provides a basic summary of environmental resources that may require assessment for the potential of roadway lighting to produce adverse effects. Introductory guidelines for completing roadway lighting effects assessments, including ways to avoid and minimize effects, and supporting regulations and policies are included. Definitions for common terms and electrical equipment are found at the end of this Fact Sheet.

General Considerations

Caltrans projects may add new lighting or modify the type and properties of existing lighting to improve visibility at night for vehicles, bicyclists, and pedestrians. Understanding the changes to lighting during project development can be an essential component of the project's overall environmental assessment. Consideration must be given to any other environmental impacts potentially caused by installing lighting, such as trenching for electrical connections or installing concrete foundations for luminaires. Lighting effects result from night work and other temporary illumination, such as temporary traffic signals, needed during construction. Identification of concerns about the environmental impacts of lighting early in the project development process is a best practice to avoid last-minute design modifications, costs, and delays to the project.

Caltrans standard roadway lighting now includes luminaires using light-emitting diode (LED) fixtures. LEDs can be manufactured to produce a broad range of light output and light qualities. LEDs are very energy efficient and long-lasting compared to traditional fixtures, such as incandescent, fluorescent, or high-pressure sodium lights. Caltrans LED roadway lighting is expanding to improve night visibility along roadways, and when new lighting is proposed, it may need to undergo environmental review.

The anticipated strength and distribution of new roadway lighting on environmental resources can be accurately modeled during project development. In general, adverse impacts from artificial night light can take several forms including light trespass or spill, sky glow, and glare.

- Light trespass, also referred to as light spill, occurs when unwanted artificial light enters an adjacent area that would otherwise be dark.
- Sky glow is the bright halo that appears over urban areas at night. It is caused from reflectance of lights on objects on the ground and by scattered water droplets or particles in the air. Sky glow is intensified when there is a low cloud ceiling or foggy conditions because light refracts off water particles in the air. Sky glow may be perceived as the presence of brightness within a field of view and can include directly viewing a light source.

- Glare is created by bright sources of light in the visual field. Light is scattered in the human eye, resulting in a visual haze within the eye, often referred to as "veiling luminance," reducing visibility. When lighting within the visual field is greater than what eyes are adapted to it can result in annoyance glare, discomfort glare, or disability glare, depending on the size, position, and intensity of a light source, the number of light sources, and the luminance to which the eyes are adapted.
    - Annoyance glare causes complaints and is also known as nuisance glare.
    - Discomfort glare is the presence of glare over time that may cause a sense of pain or may increase blink rate or even cause tears.
    - Disability glare can reduce visibility and prevent an individual from seeing adequately. An example of disability glare is a driver's reduced visibility caused by the headlights of an oncoming car.

Potential adverse environmental effects from project lighting are most likely when threatened and endangered wildlife habitat, significant historical resources, communities with "dark sky" ordinances, or other sensitive environmental conditions exist. The effects of roadway lighting on environmental resources can be avoided and minimized with cooperative efforts within the Project Development Team (PDT).

CEQA/NEPA

Both CEQA and NEPA require an assessment of environmental effects caused by a proposed action. Adverse effects to some environmental resources can result from roadway lighting. When there are impacts to people, communities, sensitive, and protected resources, they must be assessed and documented in CEQA/NEPA environmental documents, and minimization measures may be required. Other state and federal laws (such as the California Endangered Species Act, Public Resources Code 5024, etc.) will be considered during CEQA/NEPA compliance.

Working with the PDT, specific information on the type and location of proposed lighting on each project should be obtained, and engineers can model the anticipated strength and distribution of new lighting on environmental resources. Important aspects to consider for specific environmental resources are described in their respective sections below.

The project setting is important to assessing lighting for CEQA/NEPA. The assessment of environmental effects from new roadway lighting in an urban setting with many existing sources of artificial lighting may be very different from the same new roadway lighting located in a remote wilderness setting.

Biological Resources

The Biologist must determine when sensitive species, habitats, and other natural resources may be affected by a proposed project. When new roadway lighting is proposed, the need for a detailed lighting assessment could be triggered when the following sensitive environmental resources are present:

- Nesting birds are protected by California Fish and Game Code (FGC) and both the California and Federal Migratory Bird Treaty Acts. Birds nest in trees, shrubs, grasses, and on bare ground scrapes and are very sensitive to visual disturbance during nesting activities. New lighting has the potential to disturb active nesting and historic nesting habitat.
- Bats and bat roosts are protected by FGC and several species of these small, nocturnal mammals are Species of Special Concern. Their life cycle depends on roosts, or resting places, for normal metabolism and raising young. Lighting can cause bats to alter normal behavior and avoid or abandon roosts, which could lead to failed reproduction.
- Plants rely on seasonal day and night natural lighting to signal growth and reproduction phases essential to their life-history. Roadway lighting reaching plants can affect their growth and possibly their ability to complete normal reproductive cycles.
- Nocturnal and crepuscular wildlife and insects rely on low-light conditions. They can experience negative effects when new roadway lighting is introduced. The habitats they use for foraging, breeding, and rearing young may be affected.
- Threatened and endangered species may experience adverse effects from minor changes to habitats or permanent alternation of habitats from roadway lighting, and for some threatened and endangered species these effects need detailed assessments. Threatened and endangered nocturnal wildlife, such as salamanders and owls, can experience permanent habitat loss from new roadway lighting. Threatened and endangered plants, insects, and wildlife may have different positive and negative effects caused by LED roadway lighting, and the effects may be very different based on the timing, spread, intensity, and color-temperature of the chosen LEDs. Bright-white and blue-white color-temperature LEDs have been shown to have greater effects than yellow-white or amber-white LEDs of 2700K or less.

A project biologist may determine the need for a detailed lighting effects assessment to federal and/or state threatened and endangered species, their habitat, or other sensitive habitats if roadway lighting may result in adverse effects.

When the Biologist determines the need for a detailed lighting effects assessment, they should work with the PDT to request details on luminaire types, heights, placements, glare shielding, and LED output in lumens and color-temperature. Engineers can use software to model the extent and intensity of proposed lighting alternatives (Figure 1). When potential effects of proposed roadway lighting to sensitive biological resources are identified, a non-standard special provision (NSSP) may be required to specify luminaires with 2700K color-temperature and/or glare shields to reduce impacts. Additional details on avoidance and minimization of roadway lighting effects are below.

Compensatory mitigation may be required when new or updated roadway lighting is determined to have permanent, negative effects to threatened and endangered species, their habitat, or federally designated critical habitats. Projects that can't avoid and minimize roadway lighting into sensitive and protected habitats should plan for resources and budget to comply with compensatory mitigation requirements of permits and agreements.

Community Impacts

The Environmental Planner (Generalist) should be aware that a Community Impact Assessment (CIA) includes roadway lighting and should build on the analysis from the Visual Impact Assessment (VIA). Communities can experience aesthetic effects when roadway lighting affects views in the area, community character effects when lighting may cause a rural community to take on a more urban character, and there are potential effects from greenhouse gas (GHG) emissions caused by generating the electricity for new lighting.

Aesthetics

When selecting the type of lighting to be used, the environmental Generalist and Landscape Architect should work with the PDT to address question 1d of the CEQA Checklist under Aesthetics; whether the project would "create a new source of substantial light or glare which would adversely affect day or nighttime views in the area." Potential impacts will need to be addressed in both the VIA by the Landscape Architect and in the environmental determination or environmental document by the environmental generalist. Substantial new light or glare impacting nearby residences or community facilities may affect quality of life and/or human health. Removing peoples' ability to see the night sky and the stars is an impact that may need to be addressed.

Aesthetic changes can also result from the luminaries, or light standards, if they are changed or newly installed. The placement and design qualities of roadway lighting structures and the required electrical infrastructure needed to operate them, can adversely affect views in an area.

Roadway lighting aesthetics assessments should consider the equity of roadway lighting placement. Homes and other structures near the state highway system most impacted by lighting may be low-income or disadvantaged communities, and the proportion of aesthetic effects on these areas should be considered when determining the overall project impacts.

Community Character

Lighting may change the character of a community though luminaire design aspects, the effects on dark skies, and giving a rural area a more urban character. Luminaire designs can match existing or historic structures to preserve or enhance community character. New roadway lighting can alter the “dark skies” valued by a community. Many communities have “dark skies” ordinances to protect their residents from unnecessary lighting and preserve the more rural occurrence of viewing abundant stars at night. Adding lighting can be seen as changing the nature of a rural area of a community by giving it a more urbanized feel.

Equity of roadway lighting must be considered when assessing community character. Homes and other structures near the state highway system most impacted by lighting may be low-income or disadvantaged communities, and the proportion of effects on these areas should be considered when determining the overall community character impacts.

Greenhouse Gas (GHG) Emissions

Electricity generation can be a source of GHG emissions. Substantial addition of new lighting should be evaluated for the potential to increase energy usage. The PDT should evaluate choices that would lead to the most energy efficient lighting, such as LEDs. There is even the potential of using solar power, such as micro-grid solar systems, to power a segment of new lighting.

Cultural Resources

The Cultural Resource specialist must determine when significant cultural resources may be adversely affected by a proposed project. Roadway lighting projects may affect cultural resources if:

- Roadway lighting fixtures themselves are historically significant, either alone or as part of a larger historical resource (e.g. historic district, landscape).
- New Roadway lighting fixtures are introduced that alter the character and setting of a significant cultural resource.
- There is a potential for archaeological resources to be present that may be affected by installation of new lighting or removal of existing facilities.

When the Cultural Resources Specialist determines that a proposed action has the potential to adversely affect significant cultural resources, they should work with the PDT to determine if design changes are possible that would avoid or minimize the adverse effect.

Mitigation may be required when new or updated roadway lighting is determined to have an adverse effect on significant cultural resources. Projects that can’t avoid or minimize a substantial adverse effect should plan for resources and budget to comply with mitigation requirements of agreements.

Coastal Resources

The Coastal Act requires that the scenic and visual qualities of coastal areas to be considered and protected as a resource of public importance, and this includes transportation projects which have lighting components. Projects must be consistent with state and local coastal program (LCP) policies to receive Coastal Development Permits. Sections 30230, 30240, and 30251 of the Coastal Act form the basis for lighting considerations for projects in the coastal zone and adjacent to biological resources in both marine and land environments. In particular, Section 30251 states:

> “*The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural landforms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastline Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting.*”

The Caltrans Coastal Liaison must determine whether coastal resources could be negatively impacted by a proposed project. Examples of adverse impacts include:

- Negative affects to navigational patterns and behavior of birds, nocturnal animals and other species.
- Sensitive habitats such as wetlands, lagoons and shorelines, especially in rural areas, are of particular concern.

When a proposed project has the potential to adversely impact coastal resources, the Caltrans Coastal Liaison should work with the PDT to determine if design changes or alternatives could avoid or minimize impacts.

Working with Design to Avoid & Minimize Lighting

Coordination within the PDT on new roadway lighting environmental effects should begin early in the project development process and continue through construction. If issues concerning the lighting are not recognized early in the project development process, changes to designs can result in delays or costly modifications to the project. The PDT should work together to identify potential lighting impacts or requirements related to environmental resources ensuring that the project complies with applicable state and federal laws and regulations.

Engineers and Design staff can utilize roadway lighting analysis software to perform lighting level analysis in areas of concern (Figure 1). Mapping overlays of lighting levels with sensitive environmental resources can provide detailed assessments of potential effects. These maps should be developed early in project delivery when sensitive environmental resources exist.

Electrical Design engineers can assist with design alternatives and other measures to avoid and minimize lighting effects. Example measures for reducing impacts due to lighting are included within Caltrans' internal Roadway Lighting Manual in Chapter 1.10. These, and additional measures, may include:

a. <u>Modifying overall designs.</u> Impacts can be reduced through detailed evaluation of options on location, spacing, and number of light poles while achieving the purpose and need of the project. Evaluate the entire suite of impacts; power supply, trenching for conduit, footprint of new luminaires, and intensity and trespass of light and resulting glare. Refining the initial design to minimize visual and other environmental impacts can take time, so starting the evaluation process as early as possible is a best practice for success.

b. <u>Reducing correlated color temperature (CCT) of proposed lighting fixtures</u>. Current Caltrans Standard Specifications require a nominal CCT of 3000 K, which may result in disturbance to some resources. Lighting options exist in the Caltrans Accepted Materials List that produce CCT of 2700 K, which represents a reduction in CCT and often a reduction in effects to environmental resources. For example, the 2700 K CCT has been required in some threatened and endangered species permits and agreements to reduce lighting effects to less than significant.

c. <u>Installation of luminaire glare shields.</u> Glare shields consist of solid materials placed near the luminaire source, typically behind the luminaire, and result in a directional reduction or elimination of the spread of lighting. Glare shields can effectively reduce lighting spread onto sensitive resources behind the luminaire without affecting the light reaching the roadway travel lanes.

d. <u>Lowering luminaire mounting heights.</u> The overall spread of lighting from luminaires can be minimized to avoid sensitive areas by moving the light source, and lowering the luminaire mounting height may be a viable option. For example, lighting of a multi-use pathway adjacent to vehicle travel lanes reduced the luminaire heights to the height of the barrier handrail to avoid and minimize spread of lighting into nearby sensitive habitats.

e. Reflective paint. Enhanced reflective paint striping and lettering on signage can improve night visibility of roadway features without using new luminaires or other lighting. In the San Elijo Lagoon in San Diego, Caltrans decided ultimately not to illuminate the overhead sign in the lagoon viewshed, and instead use reflective lettering which resulted in the reduction light impacts on the adjacent dark skies in the lagoon.

f. Technological advancements in lighting. Advances in lighting technologies can lead to reduce impacts. LEDs can be specified in custom CCT values, specific lighting elements can be on programmable timers, and wireless signals can be used instead of underground trenched conduit, for some applications. Using programmable timers on lights to preserve early evening twilight foraging and feeding periods of shorebirds could occur in those specific locations within a transportation corridor. Temporary traffic signals for one-way travel through construction can be connected through wireless signals, eliminating the need for conduit between them. As new innovations become available new solutions can be found.

Requesting some of these changes above requires a Non-Standard Special Provision (NSSP) within Section 87, Electrical, subsection 87-2, Lighting Systems, within the project specifications. The NSSP package goes to the Office Engineer for Headquarters approval. Consult HQ Structures if non-standard lighting standards are used.

Caltrans projects must use lighting approved and published in the Authorized Materials List (https://dot.ca.gov/programs/engineering-services/authorized-materials-lists). The Authorized Materials List for LED luminaires was updated July 2021 (https://dot.ca.gov/-/media/dot-media/programs/engineering/documents/mets/led-luminaire-jul2021-a11y.pdf) to include lighting manufacturers that can supply luminaires that have a CCT of 2700 K and have glare shields available for most LED models.

Figure 1: Diagram of Light Intensity and Spread

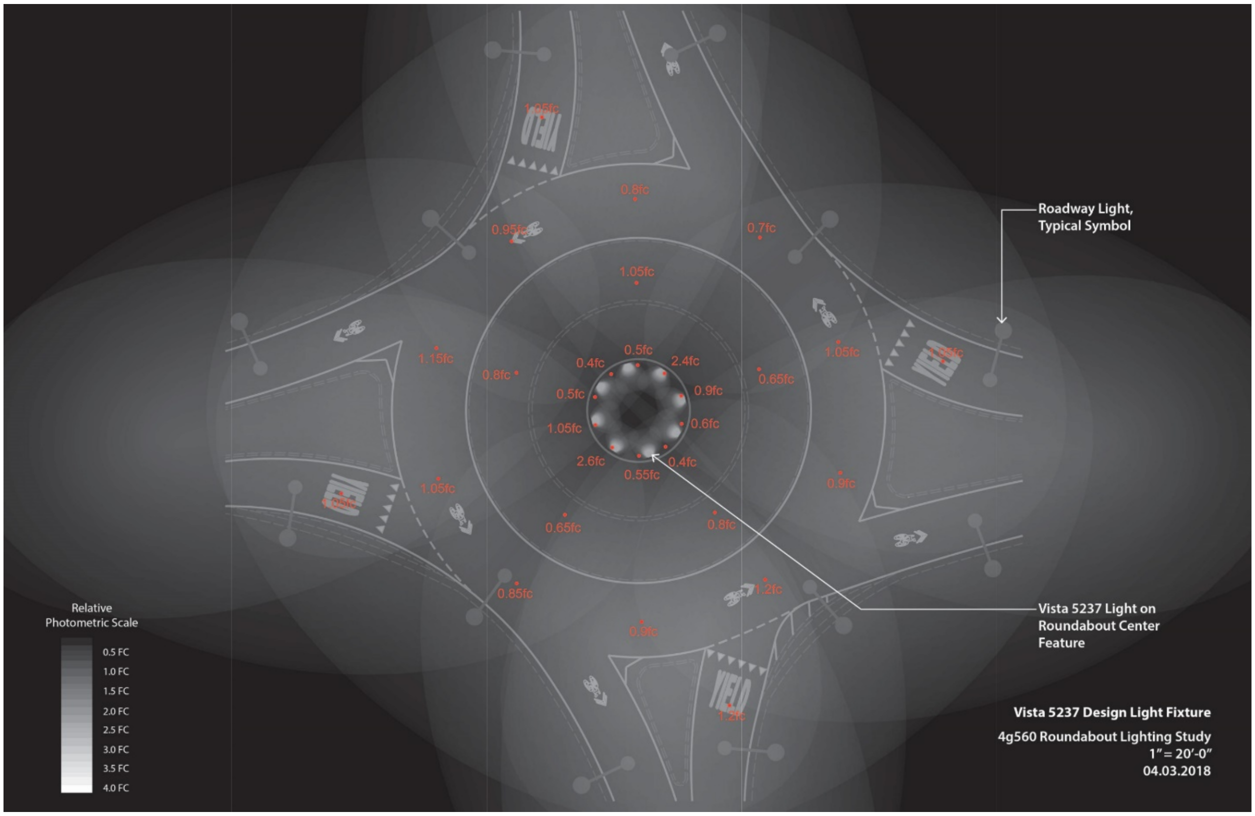

Figure 1 was produced using roadway lighting analysis software to perform endangered species effects analysis. The analysis was used to avoid, minimize, and mitigate for permanent effects to the California tiger salamander (*Ambystoma californiense*) from new roadway lighting.

References & Links

Duncan S.T. Enright, in Mechanical Engineer's Reference Book (Twelfth Edition), 1994

Caltrans Roadway Lighting Manual, Division of Traffic Operations, First Edition, July 2021.

FHWA Roadway Lighting Resources
https://safety.fhwa.dot.gov/roadway_dept/night_visib/roadwayresources.cfm

Glossary of Terms

candela (abbreviation cd): The International System of Units (SI) unit of luminous intensity. The term 'candle power' designates a luminous intensity expressed in candelas.

Correlated color temperature (CCT): unlike the color rendering index (CRI), which describes how faithfully a light source represents other objects, the correlated color temperature (CCT) describes the color output of the lamp itself. Some common CCT values include:

- 2700K, with a warm tinge of yellow that creates appealing and relaxing environments
- 4000K, a neutral white tone that strikes just the right balance between relaxation and concentration
- 6500K, with a slight tinge of blue, which has an energizing effect

Although the correct technical term is correlated color temperature, it is often shortened to only color temperature. It is also important to note that the CCT is not the real operating temperature of a lamp; it is the temperature to which you would have to heat a black body to make it glow with the same color. For example, an LED bulb with a CCT of 5000K glows in the same color as a black body heated to a real temperature of 5000K, but the LED bulb itself does not reach that temperature.

footcandle (abbreviation fc): unit of illuminance when a foot is taken as the unit of length. It is the illuminance on a surface that is one square foot in area, on which there is a uniformly distributed flux of one lumen. Or it is the illuminance produced on a surface of all points that are one foot from a directionally uniform point source of one candela.

glare: sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility. Visual impairment caused by a bright source of light, directly visible or reflected by a surface. There are several types of glare:

- Annoyance glare causes complaints and is also known as nuisance glare.
- Discomfort glare causes an instinctive reaction to close the eyes and look away. The presence of discomfort glare over time may cause a sense of pain or may increase blink rate or even cause tears. This is the type of glare felt when exposed to a potent high-intensity discharge (HID) light or when the sun is directly visible through a window.

- Disability glare impairs vision and reduces visibility to prevent an individual from seeing adequately. If a light source gets reflected on your laptop screen, for example, it does not bother your eyes but distinguishing objects on the screen may be impossible.

illuminance: density of luminous flux incident on a surface, measured in footcandles, or fc (or lux, lx). The illuminance requirements of built environments are determined by their intended purpose, and there are two common units of measurement:

- Lux - Equivalent to one lumen per square meter.
- Footcandle - Equivalent to one lumen per square foot.

Higher illuminance levels make surfaces appear brighter to the human eye and improve visibility.

illumination: The process of lighting an object.

illumination value (symbol E): The luminous flux incident on a surface, per unit area.

Initial value of illumination: The mean value of illumination averaged over the working area before depreciation has started, i.e., when the lamps and fittings are new and clean and when the room is freshly decorated.

illumination vector: A term used to describe the flow of light. It has both magnitude and direction. The magnitude is defined as the maximum difference in the value of illumination at diametrically opposed surface elements of a small sphere centered at the point under consideration. The direction of the vector is that of the diameter joining the brighter to the darker element.

kelvin: The kelvin is the SI unit of thermodynamic temperature, equal in magnitude to the degree Celsius, and denoted by the symbol K.

LED (light-emitting diode): solid-state component that emits light when exposed to electric current. LED lighting represents the state-of-the-art in the industry, outclassing most other types of lighting in terms of energy efficiency, design flexibility, and colors of light available. The LED is the new standard for Caltrans lighting luminaires, replacing types of incandescent luminaires that are less energy efficient.

light: visually evaluated radiant energy.

lumen (abbreviation lm): The SI unit of luminous flux used in describing the total light emitted by a source or received by a surface. (A 100-watt incandescent lamp emits about 1200 lumens.)

luminaire: a complete lighting unit. A luminaire includes the lamp, the ballast or driver, internal wiring, reflectors, lens and any additional components required to deliver light. 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 to connect the lamps to the power supply. Sometimes includes ballasts and photocells. Assembly that houses the light source and controls the light emitted from the light source.

luminous flux (symbol ϕ): The light emitted by a source such as a lamp or received by a surface, irrespective of direction.

luminous intensity: The quantity which describes the illuminating power of a source in a particular direction. More precisely, it is the luminous flux emitted within a very narrow cone containing that direction divided by the solid angle of the cone.

lux (abbreviation lx): The SI unit of illumination value; it is equal to one lumen per square meter. A key component of lighting design is achieving a suitable illuminance level depending on the application at hand. A lux is the illuminance on a surface of one square meter in area on which there is a uniformly distributed flux of one lumen, or the illuminance produced at a surface where there is one lumen at all points that are at one meter from a uniform point source. Conversion Formula: fc x 10.8 = Lux.

mounting height: vertical distance between the roadway surface and the center of the apparent light source of the luminaire.

subjective brightness: subjective attribute of any light sensation given rise to the perception of luminous intensity, including the whole scale of qualities of being bright, lightness, brilliant, dim, or dark.

visibility: quality or state of being perceivable by the eye. In many outdoor applications, visibility is sometimes defined in terms of the distance at which an object can be just perceived by the eye. In indoor and outdoor applications, it is usually defined in terms of the contrast or size of a standard test object, observed under standardized viewing conditions, having the same threshold as the given object.

watt: measurement unit for the electric power consumption of lighting fixtures, or any other appliance that runs with electricity. In lighting, lumens can be compared to miles traveled and watts can be compared to fuel consumption.