New Mexico State Parks
Best Management Practice 3: Interim Outdoor Lighting Guidelines

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I. Overview

A. Purpose and Need

New Mexico State Parks (Parks) has lacked agency-wide outdoor lighting guidelines. The need for better quality lighting and guidance to parks is evident in the variable quality of lighting installations found throughout various parks and an increased concern that park lighting is degrading the night environment. This guideline is meant to help parks immediately address lighting concerns and to guide development and compliance. This guideline is modeled on the Interim Outdoor Lighting Guidelines established by the National Park Service (NPS) in 2007.

Natural Resource Management Policy

Parks adopted its first comprehensive Natural Resource Management Policy in December 2008. That policy identifies night skies as natural resources worth protecting. Natural darkness is more than a visitor resource and a scenic value, it has important links to cultural landscapes, ecological integrity, operational efficiency and sustainability. The policy also calls for development of a natural resource management manual containing best management practices and resource-specific guidelines to assist parks in managing natural resource situations that may arise.

Lightscape Management

Parks will preserve, to the greatest extent possible, the natural lightscapes of parks. Natural lightscapes are natural resources and have values that exist in the absence of human-caused light. Humans are influenced by stars, planets and earth's moon, which are visible during clear nights. Many kinds of animals, such as birds that navigate by stars or prey animals that reduce their activities during moonlit nights, also are influenced by lightscapes. Improper outdoor lighting can impede views and visitor enjoyment of a natural dark night sky. Recognizing the roles that light and dark periods and darkness play in natural resource processes, Parks will protect natural darkness and other components of the natural lightscape in parks. To prevent loss of dark conditions and natural night skies, Parks will minimize light that emanates from park facilities and seek cooperation from park visitors, neighbors and local government agencies to prevent or minimize intrusion of artificial light into night scenes of park ecosystems.

Parks will not use artificial lighting where its presence would disrupt a park's dark-dependent natural resources. Parks will:

- *restrict use of artificial lighting in parks to areas where security, basic human safety, and specific cultural resource requirements must be met;*
- *use minimal-impact lighting techniques;*
- *shield artificial lighting where necessary to prevent disruption of the night sky, physiological processes of living organisms, and similar natural processes.*

The decision whether or not to install artificial lighting in particular circumstances is left to the discretion of the park superintendent and is made through the planning process.

Existing Standards and Codes
A variety of lighting standards already exist, many of them in conflict and each focusing on a specialized aspect of lighting. Most are too complex to be applied at small or medium sized parks; few recognize the unique lighting needs of parks; and most do not address rising concerns about light pollution. Other codes and standards being developed include the International Dark-sky Association Model Lighting Ordinance (IDAMLO) and the New Buildings Institute Lighting Guidelines. The National Park Service recently researched and consolidated several current and developing guidelines and adopted Service-wide Interim Outdoor Lighting Guidelines.

Lighting recommendations put forth here produce illumination levels sometimes much lower than recommended by Illuminating Engineers Society of North America (IESNA). The trend in newer guidelines, such as the IDAMLO, is toward less illumination, especially in darker ambient environments. In most cases, parks have ambient light levels lower than what was considered when many existing guidelines were developed. Lower ambient light levels often require less light, thus the disparity between IESNA standards and recommendations in this document.

Guideline Objectives
Objectives of this lighting guideline are to provide parks a planning framework and best management practices for outdoor lighting. This document balances the need for safety with the need to protect parks' nocturnal environments. It focuses on "off the shelf" solutions, although new technologies like LEDs soon will allow parks to more precisely manage outdoor lights. Ease of understanding and implementing these guidelines received more weight than details of lighting design, visibility research and energy efficiency. Specific objectives include:

- Curtail and reverse degradation of the nighttime visual environment and night sky.
- Minimize glare, light trespass, obtrusive light, and artificial sky glow by limiting outdoor lighting that is misdirected, excessive or unnecessary.
- Ensure "good neighbor lighting" by minimizing light trespass.
- Minimize suspected health risks to humans from adverse exposure to light at night.
- Help protect natural ecosystems from damaging effects of night lighting.
- Allow reasonable use of night lighting for safety, utility, security and productivity.
- Help conserve energy and resources.
- Minimize maintenance and operating costs.
- Provide flexibility for architectural and artistic lighting within the above constraints.

Scope
This guideline is intended to address outdoor lighting within park boundaries, including developed areas and concessions. It does not address transportation rights of way where state and federal transportation codes may supersede park authority. Complex facilities and lighting situations may require more guidance than is found here. In those cases, consultation with additional guidelines, lighting engineers and outside experts is encouraged.

B. Outdoor Lighting in Park Settings

Virtually all parks need some outdoor lighting. In every case of outdoor lighting it is important to specify the need and choose a lighting design that meets that need. Too often, lighting is absent where it should exist, the quality of lighting is poor, or brightness levels exceed what is needed.

Less Can Be Better
Research by NPS indicates that levels much lower than IESNA recommended practices are adequate and appropriate for park environments, even heavily used parks. When combined with Parks own experience retrofitting outdoor lighting and with emerging ethics in the lighting field, these findings lead to design approaches that balance positive and negative attributes of light by using higher performance designs at lower illumination levels.

Human Needs
Lighting serves objective and subjective human needs. Objectively, light is used to provide adequate visual perception in low light. A healthy human eye is capable of adequate visual perception in very low light levels, but it cannot easily transition from bright (e.g., indoors) to dark (e.g., outside at night) conditions. Full dark adaptation can take several minutes and that adjustment is facilitated by outdoor lighting at low illumination. The more detailed the visual task, the more light is typically needed. It must be noted that human eyes function by reference to contrast, not absolute illumination. At night, an eye can perceive that 10 footcandles (a common measure of illumination) is twice as bright as 5 fc, but it cannot quantify the amount of light. If those lights were gradually dimmed by 50% each, the eye may not distinguish any change. The setting that a light fixture is in - the ambient light level, lighting uniformity, glare, and contrast in that setting - is more important than absolute illumination level. Strict adherence to engineering standards without considering setting is ill-advised. Overall, visual performance in an artificial lighting environment is more closely tied to lighting *quality* than lighting *quantity*.

Safety can be defined as *freedom from danger*, an objective requirement of lighting. Security can be defined as *freedom from worry*, a subjective aspect of lighting. Lighting can provide both, but how does one gage the type, amount and quality of light needed for adequate security? People often associate more or brighter light with *safer* surroundings, but too much or poorly directed light actually decreases visibility. For example, a light that is too bright or misdirected can prevent people from discerning important details because of the *high brightness contrast* or glare. At first glance, appropriate park outdoor lighting may not seem to some visitors to meet their security needs, especially if they associate a glary environment with security, but such quality lighting has several advantages.

Transitions
In urban environments people move among multiple lit areas, but parks usually have large naturally dark spaces surrounding few isolated lit areas. Ambient light levels are much lower in parks, visitors expect fewer amenities, and self reliance is emphasized (i.e., people carry flashlights). Low ambient light levels mean *less* light is needed to provide visibility and security, but transitions between lit and unlit areas are important and glare must be properly controlled.

Accessibility Standards
Parks must provide accessible routes meeting standards set by the Americans with Disabilities Act (ADA). The ADA does not give guidelines on appropriate lighting levels for accessible routes, so lighting on accessible routes should follow the general guidelines stated here. To accommodate people with impaired vision, lighting should produce continuous illumination, minimize glare, and not create a spotty effect.

C. Problems with Light

Light is not innocuous. It is an alteration of our environment like many other human products, but only recently is it recognized to have environmental consequences. As seen in many images of Earth from space, outdoor lights have sprung up across the globe. The fact that light is visible from space, directly overhead, shows how easily this human artifact leaks into the environment.

Light Pollution

Upward spill of light is often called light pollution. Light emitted into the atmosphere is scattered and reflected by dust, water vapor and other particles, creating sky glow. Light escaping directly upward into the sky is a major contributor to loss of night darkness: light from even a few fixtures can create an unnatural glow over a wide area; city light can be visible more than 200 miles away; even a streetlight in the countryside can be seen for tens of miles. Most of the upward flux is from light escaping the fixture horizontally or upward. A small fraction (~15%) of light pollution is caused by reflection off the ground and other surfaces. Control direct uplight by using *full cut-off* (shielded) fixtures, which reduce direct uplight by 75%. Control the reflected component by using the least illumination level needed. Minimizing sky glow helps maintain a natural nocturnal lightscape and sets an example for park visitors and neighboring communities.

Light Trespass and Glare

Light shining sideways (horizontally) from a fixture is not only a source of light pollution, but it is likely to trespass into areas where light is unwanted. This low-angle light also is the main source of glare. Light reflected from lit surfaces carries information about depth, texture, detail, color, and shape, but glare light strikes the eye directly and carries no visual information. Glare's effects vary from minor discomfort to complete disabling of an eye's ability to see properly. Even at low levels it causes the pupil to constrict, diminishing the remaining light in the visual field. Glare always should be minimized to improve lighting quality and to minimize light trespass. Solutions for glare include: use full or partial cut-off fixtures, aim lights downward or away from typical observation angles, increase lighting uniformity, and reduce brightness levels. Interior lights shining outside a structure cause the same effect as poor quality outdoor lights.

Ecological and Health Impacts

Artificial light affects biological rhythms of plants and animals. Effects on wildlife can include avoidance or attraction behavior with significant consequences affecting not only the species themselves, but also their predators and prey. Nocturnal predators are particularly affected by artificial light, either positively or negatively, which can have resultant impacts on their prey species. Birds, many of which migrate at night, are prone to disorientation by artificial lights. Research to date has concentrated on effects of artificial light on birds and insects, but light probably affects larger animals, too. Mammals (e.g., mountain lions) that travel long distances to find food or mates may avoid links between natural areas if the links emit artificial light. Wetlands, ponds, shorelines, alpine areas, deserts and grasslands are thought to be particularly sensitive. Humans are animals too, and a solid and growing body of research links artificial light at night (as well as insuficient daytime light exposure) to health problems.

D. Sustainability

Outdoor lighting is the last appliance to be scrutinized for energy efficiency. Though different types of lamps are well studied (e.g., a 4x energy savings is realized by replacing a traditional

incandescent light bulb with a compact fluorescent), questions of what type of fixture, how much light, and if an area should be lit at all, have not had much examination. The portion of light shining upward and creating light pollution in the US is estimated to represent $2 to $5 Billion annually. Thus, proper lighting can have large economic and energy benefits.

Designing for Efficiency

Basic tenets of efficiency are to use light only when, where needed, and in the amount needed, then use the most efficient source meeting the need. Lamp technology has evolved much and efficiencies can be improved 2x-5x by using modern lamp types. Reducing light level can yield efficiencies if less illumination still meets the need. Full cut-off shielding reflects downward all light that otherwise would go into space, further improving efficiency. Technologies such as timers, motion sensors, computer controlled lighting and LED lamps, also add efficiency.

Maintenance Cost

That which is energy efficient almost always is cost efficient, but maintainability is another aspect of cost. Lighting design should consider workload needed for upkeep. Compare capital cost with energy efficiency and maintenance intervals to get a true picture of lighting cost. Too often, lighting choices are based only on fixture cost. A $40 "yardblaster" available at a hardware store compares favorably to a fixture costing $400, but if the "yardblaster" uses 175 watts to the full cut-off luminaire's 18 watts, the blaster's capital cost will be offset by energy savings in 4 years. Over a 20-year lifetime the difference becomes $1200. A similar comparison can be made with lamp lifetimes. A typical incandescent lamp lasts about 1500 hours, compared to 10,000 hours for a compact fluorescent lamp (CFL). The old-fashioned bulb will be changed 6 or 7 times before the CFL burns out, more than making up for the higher initial cost of a CFL.

E. Design

Lighting is an important design element in architecture and landscapes. It can emphasize spaces, highlight landscapes, and serve purposes beyond basic visibility needs. Lighting may be part of a design vision at a park. Design issues can include pole height and pole spacing, fixture appearance, illumination pattern, light level or light color. Although lighting can be an important design element, architectural and artistic lighting may not be appropriate in parks. Exceptions may exist, but washes of light on buildings, lit statues, or dramatically lit boulders are usually not consistent with missions and goals of the agency or of individual parks.

Lamp Color

Color of light receives causes some professional disagreement, but this can be resolved by affirming the purpose for the light. High Pressure Sodium (HPS) and Low Pressure Sodium (LPS) lamps produce yellow light. This color-biased, monochromatic light is thought to be less harmful to nocturnal wildlife, but it does not render colors properly to human eyes and some feel it has an industrial character. Yellow light scatters less in the atmosphere and interferes less with human night vision than white light, which help maintain dark night skies. HPS and LPS lights are more efficient (produce more lumens/watt) than white sources such as Metal Halide (MH), Mercury Vapor (MV), or even Compact Fluorescent Lamps (CFL). Research shows that less light (thus less energy) is needed for the human eye to see efficiently with a white (blue/green) light source than with a yellow source. High color rending ability and better visibility of white lights contrast with its lower energy efficiency and higher impacts to wildlife and night skies.

This guideline recommends parks use yellow light sources when available, unless a need for better color rendition is demonstrated.

Historic Integrity
Historic structures and cultural landscapes have special lighting needs that may not be addressed in this document. Light fixtures themselves and the character of light they produce both are of concern. Often there is too much emphasis on selecting fixtures that look of the appropriate period, while the nighttime scene is neglected though just as important to historic integrity.

II. Lighting Guidelines

A. Approaches

Lighting guidelines can take one of two forms: prescriptive, where the type, size, lamp, etc. of the light is defined; or performance, where resulting illumination levels are defined. The latter is more accurate, but requires computer modeling and photometric data on each light fixture. A prescriptive approach is used here because expertise to run computer models is not available and most park fixtures are low cost units lacking custom or photometric designs.

Several aspects of lighting design can be controlled and defined. Those prescribed in this guideline are limited for simplicity (see table below).

Prescriptive Parameters	Performance Parameters
Lumens	Illumination (minimum, avg., max)
Watts	Glare or Glare Ratio
Power density	Uniformity (average : minimum)
Lumen density	Uplight and light distribution
Pole spacing	Spill light/light trespass
Pole height	Transition
Fixture shielding and aiming	

B. Lighting Zones

Lighting zones should be established in each park consistent with the existing Parks' BMP for Land Management Zones. Permanent outdoor lighting is allowed within the guidelines in LMZ classes 1 and 2. No permanent light fixtures are permitted in LMZ classes 3 and 4.

Typical Lighting Zones	Description	State Parks LMZ Class
No Outdoor Lighting	All wildland areas and viewpoints	3, 4
Lighting Allowed	Developed facilities area	1, 2

C. Planning and Compliance

Lighting has been considered a routine maintenance practice and therefore has escaped most planning and compliance processes. This leads to situations where parks themselves contribute to light pollution. Lighting should be part of park planning and natural resource planning efforts. This interim guideline is meant to ease this process while providing more autonomy to facility managers when working within the guideline.

Cumulative Effect
Cumulative effect is not directly addressed in this guideline, but it is recommended that parks consider not only the specifications of an individual light, but the total impact that a new or expanded lighting project would have. These guidelines mitigate negative impacts as much as possible, but dramatic increases in installed lights will have a noticeable adverse impact on nocturnal lightscapes. For parks with an existing base of mixed quality lights, impacts from new lighting projects can be offset by retrofitting existing poor quality lights.

D. Lighting Applicability

Lights should not be installed where visitors or employees expect darkness or where people are generally prepared for darkness, either through dark adaptation or by carrying their own lights.

Lights should be installed as an illumination transition on commonly used building egress points, where outdoor work is done at night, where critical information is posted, to draw night visitors to key information or a safety point (e.g., phone booth), where there is a clear need to protect assets, where there is a known safety hazard, or where facilities are often used at night.

When deciding whether to light an area, consider cumulative effects of the action as well as whether the illumination will achieve its purpose. Also consider lighting transitions; an isolated light may effectively light a small area, but will render the surrounding dark area less visible.

Security lighting where no patrols exist (e.g., a remote storage yard) often is counterproductive, inviting crime without the opportunity to intercede.

E. Requirements

Exterior Lighting
All permanent exterior lighting shall be fully shielded and use proper illumination levels. Articulating fixtures, such as PAR floodlamps, must have directional shields, must be aimed within 45° of downward, and must not illuminate areas beyond intended targets.

Special Use Lighting
Unshielded and partially shielded fixtures under 7 watts each are permitted for low voltage LED pathway lights, under-canopy lights at phone booths, and other guidance lighting.

F. Prescriptions

These prescriptions are directed toward types of activities regardless of where they take place. For example, lighting recommendations for pedestrian walkways are relevant to any place people typically walk: from campsite to comfort station; from parking lot to building; any trail. Areas and functions typically not lit because users are expected to provide their own lighting include: campgrounds, campsites, trails, walkways and parking areas.

Maximum Lamp Lumens
7000 lumens is the maximum allowable lamp output (except for emergency lighting). In most cases, 500-1500 lumens will be sufficient.

Pedestrian Walkways (including amphitheatres, trails, sidewalks)	
Maximum Lamp Lumens	1000
Recommended Light Types	Typically not lit. If required, use low voltage LED way-finding lighting or low lumen fully shielded lamps. Higher illumination for steps or uneven ground.
Recommended Illuminated Area	Pathway and area immediately adjacent to path.
Recommended Duty Cycle	Timer for operation during frequently used times.

Park Staff Housing (private buildings)	
Maximum Lamp Lumens	2000
Recommended Light Types	CFL 500-1000 lumens
Recommended Illuminated Area	Light dispersal limited to residential boundary
Recommended Duty Cycle	Mix of switches (for occasional use) and motion sensors

Building Egress Points (public and staff buildings)	
Maximum Lamp Lumens	3000
Recommended Light Types	CFL 500-1500 lumens; Forward throw fully shielded fixture
Recommended Illuminated Area	Egress point and approach; transition from lit to dark area should be gradual with no hard shadows
Recommended Duty Cycle	Night operation at critical safety, frequently used, visitor contact points; motion sensors or user accessible switches for other tasks

Parking Lots	
Maximum Lamp Lumens	7000
Recommended Light Types	Not generally recommended; if required, use LPS or HPS lamps of 3500-7000 lumens (depending on pole height)
Recommended Illuminated Area	Portion of parking lot used at night
Recommended Duty Cycle	Switched with timers to prevent all-night operation

Safety and Work Areas (fueling station, generator bay, maintenance yard, etc)	
Maximum Lamp Lumens	7000
Recommended Light Types	CFL of 1200-3000 lumens for most applications; fully shielded
Recommended Illuminated Area	Only immediate work area
Recommended Duty Cycle	User controlled switches or power-interrupt sensor

Boating Facilities (ramps, docks, marinas)	
Maximum Lamp Lumens	7000
Recommended Light Types	CFL of 1200-3000 lumens for most applications; fully shielded
Recommended Illuminated Area	Portions used at night
Recommended Duty Cycle	Timers or power-interrupt sensor

Group Shelters	
Maximum Lamp Lumens	3000
Recommended Light Types	CFL of 1200-3000 lumens for most applications; fully shielded, usually at top of canopy under roof
Recommended Illuminated Area	Shelter interior and approaches
Recommended Duty Cycle	User controlled switch or power-interrupt sensor

Outdoor Evening Venues (patios, restaurants)	
Maximum Lamp Lumens	2000
Recommended Light Types	CFL of 500-1000 lumens for way-finding applications; CFL of 500-1000 lumens for table uses; all fully shielded;
Recommended Illuminated Area	Walkways should use amber low voltage LED; table tops should use CFL of 500-1000 lumens
Recommended Duty Cycle	User controlled switch, timer, or power-interrupt sensor

G. Lamp Selections

The standard lamp shall be a cold-start compact fluorescent lamp (CFL), ideal for its high energy efficiency and range of wattages. These should be less disruptive to nocturnal species and the human experience of night than a 70-watt High Pressure Sodium (HPS) lamp, provided the CFL lamps are 26 watts or less. Incandescent lamps may be used with motion sensor lights. Lighting requiring more than 2000 lumens should use HPS lighting.

H. Other Situations

Sign Lighting

Internally illuminated signs should use light lettering on a dark background and should not be lit after the related facility has ceased operation for the night. Externally illuminated signs should be lit from the top downward with fully or partially shielded fixtures using the minimum amount of light necessary. No specific guidelines are established in this interim guideline, but signs should be lit only where it is clearly necessary and then luminance should be limited to <1000 lumens per side per modest size sign, depending on viewing distance and ambient light level.

Flag Lighting
The preferred practice is to raise and lower the American flag daily at staffed facilities. There is a growing misconception that flags should be up all night and should be lit. At active sites there is little excuse to not honor the flag daily by its raising and lowing. The Patriot Act of 1976 requires nighttime flags to be lit, but does not in any way indicate a preference for leaving the flag up during darkness. Recently some top-down lighting solutions for flags have come to market. This would allow full compliance of flag lighting if there is such a need.

I. Exempt Lighting

1) Where OSHA states that specific lighting levels are necessary for work situations, these are considered exempt from the Lighting Guidelines. Although the lighting levels for the actual work environment must meet OSHA requirements, all measures outlined in this document must be taken to exercise best energy practices and shield the light from the surrounding environment.

2) Emergency lighting is exempt from these controls provided it is not used for routine maintenance or scheduled functions. Typically, emergency lighting is used once a year or less and is necessary for human safety in emergency or unforeseen circumstances.

3) Traffic safety warning lights and speed indicators are NOT automatically exempt but should be considered on a case by case basis.

4) Holiday lighting provided it is in operation only during the holiday period.

5) Special event lighting provided it is shielded and in operation only during the event.

J. Implementation and Relation to Planning Processes

These guidelines must be consulted when considering any new park lighting project, to ensure adherence to guidelines; when any park is identifying land management zones to accurately map or designate unlit areas; during park management planning to schedule retrofits for existing lighting as may be needed; and at any time to evaluate, design and upgrade park lighting.

Appendices

Glossary

Fully shielded - a fixture that throws light downward only and in which the lamp itself is shielded so it cannot be seen except from under the fixture.

Full-cut-off – a fixture that is fully shielded and has virtually no part (or a negligible amount) of the fixture lit below the horizontal.

Cut-off - a fixture that shields upward light causing light to shine both downward and sideways only.

Luminance – the quantity of light reflected or emitted toward an observer, i.e., the light an observer sees.

Illuminance – a measure of light in either foot-candles (imperial) or lux (metric). Technically described as flux density per unit area.

Brightness – a subjective sensation to measured luminance.

Glare –

- ***Disability Glare*** (veiling luminance) – is stray light scattered within the eye reducing the contrast of the image.
- ***Discomfort Glare*** – is high contrast or non-uniform distribution of luminance in the field of view.
- ***Nuisance or annoyance glare*** – is not quantified but is basically annoying light such as "the light shining in the window."

Visual Adaptation to Light –

- ***Photopic Vision*** – is the eye's response at high light levels when cones are used to determine color and to focus on objects.
- ***Scotopic Vision*** – is the eye's response at low light levels such as moon-light when rods are used. Peripheral vision is strong and everything appears in shades of gray.
- ***Mesopic Vision*** – is a combination of photopic and scotopic Vision.

Lamp Characteristics

Lamp types should be carefully chosen. Proper lumen output, efficiency, and spectral characteristics should be key elements in the decision. Other factors to consider should be lamp life, lamp available and cost, aesthetics, and appropriateness.

The following are allowed under these guidelines when specifically permitted.

Typical Lamp Characteristics

Lamp	Watts	Lumens (initial output)	Lumens/watt (efficiency)	Lifetime (hours)	Color Rendering
A-Lamp Incandescent	40	500	12	1000	100
	60	850	15	1000	100
	100	1600	16	1000	100
Compact Fluorescent	7	400	57	10000	85
	13	775	60	10000	85
	23	1400	60	10000	85
	26	1650	65	10000	85
	42	2800	65	10000	85
Metal Halide	39	2800	72	6000	85
	50	3700	75	6000	85
	100	7500	75	6000	85
	150	10500	70	6000	85
High Pressure Sodium	35	2200	50	24000	40
	50	3700	60	24000	40
	70	6200	75	24000	40
	100	8000	80	24000	40
	150	14500	85	24000	40
Low Pressure Sodium	18	3800	150	18000	0
	35	6800	150	18000	0
	90	15300	150	18000	0

Note: High color rendering combined with total brightness typically results in higher impact to nocturnal environment.