Outdoor Lighting Code Handbook

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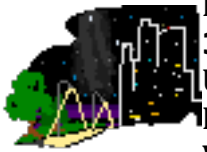

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Abstract

This Handbook discusses issues relative to outdoor lighting codes, their effectiveness, implementation, and enforcement. A "pattern code" is included, both as a starting point for communities who wish to consider a lighting code and as a way of discussing many of the issues that arise. This pattern code is not to be considered as a model code to be implemented as-is. Each community will have different needs and different priorities. The Handbook is written mainly for communities in the USA, but many of the issues are the same for other applications, such as state codes or codes outside the USA. Appendices include forms useful for administering a code, descriptions of several recently adopted lighting codes, and other information. The Handbook is intended to be a dynamic document, and it will be revised regularly as new information is developed in the effective application of lighting codes, and the science and art of outdoor lighting.

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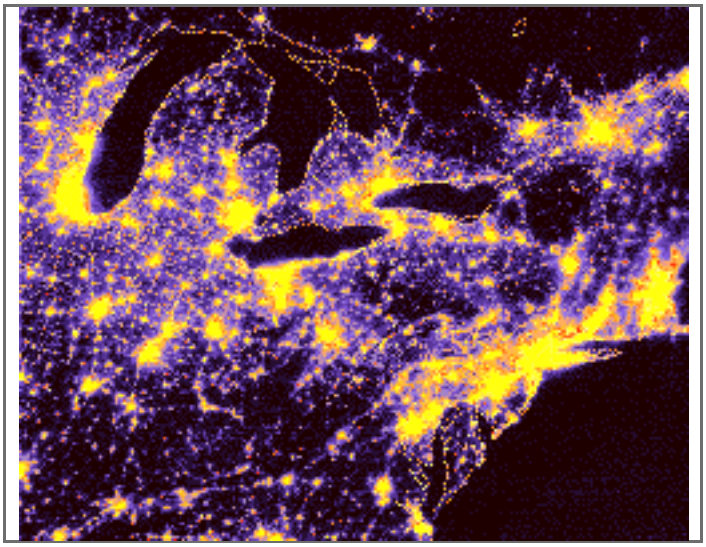


1 Introduction

Though comprehensive outdoor lighting codes originated with the pioneering efforts of western American communities with significant astronomical research facilities, the issues are much broader than the darkness of the night sky and the effectiveness of astronomical research, making lighting codes relevant for all communities. All of us live under the sky (even non-astronomers), and all of us need quality outdoor lighting (even astronomers). Careless use of outdoor lighting damages the night time environment in many ways for everyone, often decreasing security and safety or even creating hazards through glare and distraction where none would exist without the lighting. But the loss of the naturally dark star-filled sky is a tragic consequence for the environment and the human soul, akin to the loss of our forested landscapes or even the loss of fresh air to breathe. The night sky has been a canvas of our hopes and inspirations since we have been aware enough to raise our eyes from the ground. But our children are more and more growing up never seeing the stars, robbed of this inspiration of the ages.

It need not happen.

Careful and considered use of lighting at night, using light only when it is really needed, where it is needed, and as much as is needed and no more, would unblanket the stars in all but the largest cities. Compared to typical outdoor lighting practices, such "quality lighting" on average puts less than half the light into the sky, in some cases even less than one-tenth as much. Imagine it - in a city of 100,000 residents, effective lighting could bring back the starry skies of a town of 10,000. The town of 10,000 might see the endless skyways of a village of 1,000. The universe above could return to our towns and homes, to inspire the coming generations as it inspired the creators of Orion the Hunter with the Golden Fleece of stars tightly in his grip.

Quality lighting brings other substantial benefits as well. Lack of glare and excessive contrast brings improved visibility, especially to the aging eye. Elimination of wasted light saves money, energy and resources, which in turn reduces air pollution, water pollution and carbon dioxide emissions caused by energy production and resource extraction. Good lighting returns a sense of balance to the night, and gives a quality appearance to our towns and cities when the sun goes down.

But poor lighting practice is rampant. Careless and excessive use of lighting in our outdoor environments causes extensive damage to the aesthetics of the night, at the same time that it compromises safety and utility, the very uses for which it is usually installed. Bad lighting hurts everyone. It starts a cascade of negative consequences - beginning with the loss of our views of the heavens, continuing through falling levels of safety and utility, irritation of neighbors and wildlife, disturbance of the rhythms of day and night that are vital to many natural systems, damage to the aesthetic appearance of our communities, wasted monetary and natural resources used to

produce wasted light, and increased air pollution and carbon dioxide levels from wasted fossil fuels. There is nothing good that comes from bad lighting.
Most bad lighting can be blamed on the fact that the user is unaware of the issues of visibility and utility, how they are enhanced by good lighting and compromised by bad. Much is known about how lighting affects our ability to see, to be safe, and to use the nighttime environment. Much remains to be learned. Though the science of lighting has made tremendous strides in the understanding of quality lighting and visual perception, our communities will not benefit from this knowledge until we raise our awareness and expectations, and demand both quality lighting and dark skies.
A lighting code is the vehicle for a community to express its expectation for quality lighting and dark skies. If it is well written, implemented and enforced, the amount of improvement that can be achieved for most communities is nothing short of phenomenal, both in reduction of sky glow and improvement in visibility on the ground. Effective shielding standards, as recommended in this Handbook, will reduce the amount of light escaping into the sky by fifty percent or more compared to typical unregulated lighting practice. In the majority of cases, these shielding standards will also virtually eliminate glare. In applications where overlighting has become a common practice, such as in service station canopy and much convenience store lighting, the overall lighting limits recommended in the USA Pattern Lighting Code, expressed as lumens per acre caps, will reduce unnecessary lighting, glare and stray light by even greater proportions. And, unlike other forms of pollution, the elimination of light pollution in all its forms actually saves money. Quality lighting costs less than bad lighting, in the long term and even usually in the short term. Everyone wins when lighting is done right.
The IDA Lighting Code Handbook is a response to the many requests for information on lighting codes and assistance in composing lighting codes from the increasing numbers of communities interested in addressing these issues in outdoor lighting. Many issues related to outdoor lighting use and the means of decreasing obtrusive side effects of its use through effective regulation are discussed. The Handbook is not a guide to other related issues or subjects such as efficient energy use, lighting system construction, design standards in general, or interior lighting. It is intended as an aid to communities that are recognizing the value and beauty of dark skies and the effectiveness of quality outdoor lighting, that are seeking to take control of their outdoor lighting, to "take back the night" that is being lost unnecessarily to careless and excessive use of outdoor lighting.

2 Structure of the Handbook

The next section (*How to Use the Handbook and USA Pattern Lighting Code*) is a general overview of how the Handbook can be used as an aid in the process of drafting an outdoor lighting code. Following this is a section (*Topics in Outdoor Lighting and Lighting Codes*) with discussions of several general issues related to lighting and lighting codes, and the approaches that are most effective and why. There are no perfect lighting code solutions to all lighting problems, and several problem areas are discussed in *Practical Issues and Problem Areas for Lighting Codes*. After adoption of a lighting code, the issues of ongoing enforcement and adaptation

must be addressed, and the section on *Ongoing Education in Outdoor Lighting* describes an effective way to keep the community involved.
Next is the *USA Pattern Lighting Code*, a generic code embodying the principles of light pollution control described in the Handbook. All section titles within the Pattern Code are linked to *Section Overviews*, where general issues related to the section are described.
Within each section are links to *Notes* that follow the USA Pattern Lighting Code, each addressing specific issues related to the code text, such as alternative versions, issues that should be considered if the text is modified, and examples of codes that use similar text or from which the pattern text has been borrowed. Different communities will have different goals and priorities, and alternatives may be offered where a different emphasis or approach can be taken. Sometimes the implications of alternative approaches or modifications may not be obvious, and the notes will describe some of these. Examples are used to show what has worked, where, and why.
All such links are indicated by the usual hyperlink color and underline convention using *this color* (if not yet "visited") and *this color* (if already "visited"), and also by *italics,* so that they may be evident in black and white hardcopies.
Following the *Notes* are short sections covering a few technical *definitions* used in the Handbook but not included in the Pattern Code Definitions - if you come across a term you don't understand in the Handbook, check for it here and in *Section 16*; a brief description of the primary reference sources and organizations serving as background for the Handbook; and an example *Lighting Advisory Committee Proposal*.
Next are Appendices. *Appendix A: Administrative Forms* includes forms that can be used in the process of administering a lighting code based on the Pattern Code. *Appendix B: Example Applications of Section 4* summarizes how the shielding and lumens per acre standards of Section 4 apply to residential and commercial land uses in the various Lighting Zones. *Appendix C: Example Lighting Codes* includes brief descriptions and links to several real in-place lighting codes. Some have been written using this Handbook, or an earlier version; some have used other guides. These examples illustrate on-the-ground solutions to outdoor lighting problems in communities with differing size, location, history, composition, and goals.

3 How to Use the Handbook and USA Pattern Lighting Code

The IDA Lighting Code Handbook does not intend to offer a single solution appropriate for all communities or situations. It offers instead a comprehensive guide describing issues relevant to the control of the obtrusive aspects of outdoor lighting, and a list of effective regulatory approaches to mitigate these aspects. The Handbook is intended for use by any community of any size or locale in the USA seeking to produce a new or update an existing lighting code. It can also be a valuable guide for communities outside the USA, though IDA intends to supplement this Handbook with pattern codes and discussions more directly applicable to other countries as time and resources permit.

To begin the process of getting a lighting code for your community, you must first seek to establish a consensus that there is a problem and that something needs to be done (see also *What Makes a Lighting Code Effective*). Educate yourself about the issues, using this Handbook and the materials on the *IDA website*. Especially valuable are the IDA Information Sheets *IS #6: Advice on Working with Community Leaders, Officials and Others*, and IS #96: How to Get an Outdoor Lighting Ordinance. Meet with others of like mind, perhaps members of a local astronomy club, staff and users of local natural parks or areas, members of local environmental groups, civic groups, lighting engineers and designers. Meet also, early on, with the planning staff and the city council or other governing board of the community, tell them what you see as the problems, and seek their input on what they see as the problems. Give talks to local groups about the issues.

When enough people are concerned about the state of outdoor lighting, then a group can be formed to investigate solutions. Members should include yourselves, members of the planning staff, perhaps council members, lighting designers, sign manufacturers, electrical or lighting contractors. Membership should be broad, but the committee must also keep clear what the problems are and not let the committee steer away from effective answers to the problems.

As a beginning point, your committee and community must define the problems it wants addressed, and rank them where appropriate in order of priority. Is energy conservation a principle concern? Sky brightness? Is there a concern in the community about overlighting, or perhaps underlighting, or both? Is there a significant senior population who is likely to be more sensitive to glare than younger citizens? How sensitive is the community to the aesthetic appearance of the community at night? In which situations or locations does the community place a high priority on the preservation of starry skies, and in which on the illumination of the built environment such as buildings and landscaping?

Collect information to begin considering for your lighting code - beginning with lighting levels and practices in your community, any local lighting codes, and also examples of other lighting codes, particularly for your state or for communities of similar size from within your state if any are available (see the *IDA website* for many links to lighting codes and other resources.)

Any code prescribing something as complex and diverse as lighting practices will naturally be somewhat complicated. Complicated codes can be difficult codes - difficult to understand and difficult to apply, demanding considerable and perhaps unexpected resources of community planning departments. Good lighting codes recognize these facts, and seek approaches to the issues that are as simple to understand and apply as is possible while maintaining effectiveness.

Before modifications are attempted to form your code from the information in this Handbook, the USA Pattern Code, and other codes you may be using as guides, the information and codes must be understood. Then modifications appropriate to the local situation, attitudes and laws must be devised that will produce a lighting code that defines what your community wants and expects of its lighting. The perspective of the planners that will implement the code is vital, and they must be involved in this process, the earlier the better. At all times, be sure you understand the implications of the approaches chosen, both technically in terms of lighting

specifications and practically in terms of applicability, practicality, enforceability, and cost.
The implementation of a lighting code will require administrative procedures and forms. The forms contained in *Appendix A* should be modified to suit the code you have written and the style of implementation favored by your planning department. In most cases this will mean much shorter and simpler forms than included in this appendix, since these forms address a variety of situations that are possible in codes but unlikely to occur in a single lighting code.
Finally, you must stay involved with lighting issues in your community. You must regularly re-examine lighting practices in your community and the effectiveness of the code, and modify it or its implementation to improve effectiveness and address the inevitable problems that will arise. Refer back often to this Handbook on the *IDA website*, as it will be regularly updated as new or better solutions are found. If you find a solution that you feel might be better than the approach offered in the Handbook, or simply different and suited to a specific situation in your community, the IDA is interested in your information to help in keeping the Handbook as up-to-date and useful as possible.

4 Topics in Outdoor Lighting and Lighting Codes

4.01 Why Is Lighting Used?

Outdoor lighting is used for a variety of purposes in our modern society. For work or recreation, it enables people to see essential detail in order that they may undertake their activities at night. It can facilitate and enhance the safety and security of persons or property, for example through lighting on roads and pathways. It may be used to emphasize features of architectural or historical significance, and to light parks and gardens. It is used for advertising or display to promote products or services, or to call attention to commercial premises by means of area lighting or signs.
Sometimes, too often, lighting can be found that appears to have no use. It may be that whatever use or problem it was originally installed to address is no longer relevant or remembered, but it seems sometimes that there was never much thought given to the light. Any lighting should be carefully considered in terms of needs and community standards (see *IDA IS #138: Lighting Design Check List*).
The different uses to which lighting is put impose different requirements on the kinds and amounts of light needed, and give rise to differing potential adverse impacts. Because of this, lighting codes often distinguish three general types of lighting uses, and apply somewhat different standards for each.
Most lighting is used for **general illumination**, to provide simple visibility in areas used by pedestrians (walkways), pedestrians and vehicles (parking lots) or vehicles alone (roadways) at night. The lighting is used to allow the relatively simple tasks of navigation, avoiding hazards such as people, curbs or other vehicles, and locating vehicles.
Similar kinds of lighting and lighting code standards are applicable for **security lighting**. The relation of lighting to security is complex and uncertain, and one must be certain what is meant by "security." In the context of "security lighting," the word

is often used in the sense (as defined for example by the *Illuminating Engineering Society of North America - IESNA*; see also *IDA Information Sheet #47*) that the lighting provides a feeling of comfort or freedom from worry for the people using the area (it is important to note that IESNA recommended practices for security lighting do **not** purport to provide personal safety or protection from property crimes). The provision of security in the more important sense - freedom from danger - is problematic. Some studies of the relation of lighting to safety or the prevention of crimes show that lighting can help reduce accident or crime rates, but other studies show no relation or even that safety and security are decreased (see for example *IDA Information Sheet #51: Lighting and Crime*; *IDA Information Sheet #63: U.S. Department of Justice Study of Street Lighting and Crime*). The U.S. Department of Justice has concluded that there is no statistically significant evidence that street lighting impacts the level of crime, but that there is a strong indication that increased lighting decreases the fear of crime. This could even lead to the possibility that some low-quality lighting may make people more secure in the sense of feeling safer, but less safe in fact if they then behave in a less guarded manner.

Lighting used for both "security" and "general illumination" is addressed with similar standards, and is termed "*Class 2*" in this Handbook, defined as

All outdoor lighting used for, but not limited to, illumination for walkways, roadways, equipment yards, parking lots and outdoor security where GENERAL ILLUMINATION for safety or security of the grounds is the primary concern.

In some applications of outdoor lighting, it is considered essential not only to see the locations and nature of objects, but also the "true" **color** of those objects ("true" is generally defined in reference to the appearance under daylight conditions). Such uses might include signage, outdoor sales areas (automobile display lots, for example), outdoor dining areas, and service areas where detailed work is done on vehicles or other equipment at night. Here some kinds of light quite appropriate for general illumination may not provide adequate color perception, and the standards applied to such lighting in lighting codes may be different. The need for such lighting must be carefully weighed against the potential disadvantages such sources may have in terms of efficiency (see *What Types of Lamps Are Used in Outdoor Lighting?*). This kind of "white" lighting is termed "*Class 1*" lighting, and is defined as

All outdoor lighting used for, but not limited to, outdoor sales or eating areas, assembly or repair areas, advertising and other signs, recreational facilities and other similar applications where COLOR RENDITION IS IMPORTANT to preserve the effectiveness of the activity.

Finally, there is a large variety of minor uses for lighting where the principle purpose is decorative - building faade lighting, roof lighting, landscape lighting, *etc.* These uses for lighting, though certainly legitimate, are often viewed by communities as less important to the general public and may have limitations imposed accordingly. Further, it is increasingly recognized that building faade and roof lighting is often used as an advertising vehicle, effectively converting entire

buildings into advertising signage that takes advantage of a loophole in sign size limitations that are imposed in many communities.
These uses are grouped together under "*Class 3*" lighting, defined as

Any outdoor lighting used for DECORATIVE effects including, but not limited to, architectural illumination, flag and monument lighting, and illumination of trees, bushes, etc.

4.02 What is an Outdoor Lighting Code?
An outdoor lighting code is a legal document that establishes permitted and prohibited lighting practices, with an emphasis on limiting obtrusive aspects of lighting more than an emphasis on good lighting practices *per se*. Most lighting codes are concerned primarily with limiting the wide-reaching effects of stray light that causes glare, light trespass, sky glow, and limits the ability of persons to use property in ways that do not want or need lighting. Lighting codes are often included as a chapter of the zoning or land-use code, though zoning codes may severely restrict enforcement options. The standards of a lighting code are applied to new construction of all kinds in much the same way as a building code, electrical code, or plumbing code, and consideration should be given to enacting the lighting code using a similar legal structure to these. Lighting codes often require some previously installed lighting to be brought into compliance immediately or at some future date.
Lighting codes may be enacted at different governmental levels -- from state to county or township and city and even development project or neighborhood. State-level codes usually address only very general issues, though they may nonetheless serve a valuable role, enabling the adoption of more comprehensive codes at local levels. State-level codes also generally address lighting built with state funding, such as state highways or for state-owned facilities that are often legally exempt from local codes. They can also establish a basic code for areas of the state that do not yet have or may never have more comprehensive codes. At the development or subdivision level, lighting codes or restrictions can be included in design standards or Conditions, Covenants, and Restrictions (CC&Rs) to be applied only to the homes or developments within the subdivision. Such codes are often the most effective vehicle to address specific residential lighting issues such as shielding of low-output lighting that are often exempted in higher-level lighting codes for practical reasons.

4.03 Why Must Outdoor Lighting Be Regulated?
Though there are many needs for lighting in our built environments, obtrusive aspects of lighting often extend well beyond the boundaries of the area in which the lighting is installed and intended for use. These obtrusive aspects, such as glare, trespass, energy waste, and sky glow, can have serious consequences for the public health, safety, and welfare, but they can also be effectively controlled or eliminated with carefully considered attention to design, installation, and use.
Careless lighting practices can have serious negative impacts on public safety. Glare and excessive contrast caused by poorly shielded luminaires and overlighting compromise everyone's ability to see, and as eyes age they become particularly

susceptible to these disabling effects. It is commonly known that many elder citizens are reluctant to drive at night, but it is not so widely known that a large portion of the problem originates with poor lighting practices.
Further, some perfectly legitimate purposes for lighting have potential incompatibilities. As an example, the advertising effects of illumination that appears brighter or "cheerier" than the competition is a well entrenched aspect of business lore. The resultant competition for "visibility" and advertising is leading in many communities to upward "ratcheting" of lighting levels and extreme examples of overlighting and glare. It is well known what happens to a community that has no limits on the size of signage, and it should not be a surprise what happens when there is no limit on the amount of lighting. Though lighting may sometimes be effective in attracting customers, overlighting interferes with visibility on adjacent roadways, the goals of energy and resource conservation, and the preservation of the dark night sky. Balancing of these competing interests requires a carefully considered lighting code.
Other civil or federal regulations may have impacts on some aspects of outdoor lighting. Sign codes often address issues of size, lighting, colors and other design or composition details that may affect the light output of the sign lighting. The Federal Energy Code (Code of Federal Regulations, Title 10, Vol. 3) establishes energy conservation standards for the design of new commercial and multi-family high rise residential buildings, suggested for voluntary compliance at non-federal facilites but required for federal commercial and multi-family high rise residential buildings. It describes many issues related to quality lighting, but the primary focus is on the energy used.

4.04 What Makes a Lighting Code Effective?

The goal of good-lighting and dark-sky advocates is not a lighting code. The goal is the actual, real-life elimination of the adverse effects from outdoor lighting, such as light trespass, glare, energy waste, and sky glow. A good lighting code is a vital step toward these goals, but actually achieving them requires not only a lighting code, but also effective implementation and enforcement of the code on an ongoing basis. After adoption, the code must lead to quality lighting practices in the real world or it does not accomplish anything.
The actual adoption of a good lighting code for your community takes you through the first steps, but other steps must be accomplished if the overall goal is to be realized.

- **1. Define the Problem**

In most communities, even before you can hope to draft a lighting code, an awareness of the issues and of the characteristics of quality lighting must be built. This process starts first with any group that is especially motivated or sensitive to the issues, including persons sensitive to the aesthetic character of dark skies and/or the many values of quality lighting.
Through efforts at education this initial group then broadens the community's awareness, in general and especially of the legislative bodies (councils or county supervisors, for examples). Through this process a broad consensus will develop both that there is a problem and that there are effective solutions.

- **2. Draft and Enact a Lighting Code**

Only then can the process begin to draft a code appropriate for the community, and to take this code through the process of community review, enactment, and implementation.

If careful consideration is not given in these first steps to the practical issues of enforcement, adoption of a good lighting code will not achieve the goal of quality lighting and dark skies. To have a code that will be effective requires not only careful consideration of the implications of the way the code standards are written and compliance evaluated, it also requires that awareness and interest of the community in the issues is maintained. Breakdown on these factors has been the downfall of many otherwise technically correct lighting codes.

- **3. Enforcement and Monitoring**
- **4. Stay Involved!**

Practicality of implementation, application and enforcement are emphasized again and again in this Handbook. Definitions must be clear and understandable; rules must not only be technically correct and effective, they must also be understandable and easily interpretable and enforceable; forms for implementation and administration must be clear and understandable to lighting users, lighting designers, and planning staff. Achieving these complex and interrelated goals is challenging, but they must be successfully meshed if the community is to see real improvements.

4.05 Administrative Impacts of an Outdoor Lighting Code

Implementation and enforcement of a lighting code will have impacts on planning and code enforcement staff. In addition to the time required to review materials related to lighting, and follow-up on-site to verify compliance, the staff will need to develop some familiarity with lighting terms such as lumens, and how to reliably evaluate the shielding characteristic of luminaires. Further, enforcement of any code includes not only the assurance that plans and construction conform to the standards of the code when the building or lighting permit is issued and when the project is completed, but also monitoring of continuing compliance after the project is completed.

Initial on-site verification of complex installations can be minimized by requiring that large projects be certified by a registered engineer as conforming to submitted plans, after construction is complete (as in Section 7.6 of the *USA Pattern Lighting Code*).

One approach to implement the code can revolve around filling out the *Permanent and Temporary Lighting Application, Existing Lighting Inventory and Lumen Output Calculation Sheet*, or a modified version of this form. This form is filled out by the applicant, but staff will need to be familiar with initial lumen outputs of the variety of lamp types to be sure mistakes are not made. To verify initial lamp outputs, reference can be made to any manufacturer's lamp catalog (available from Sylvania or GE, for example) or the *IDA Information Sheet 4: Operating Data and the Economics of Different Lamps*. There may be slight differences in initial luminous

outputs for lamps from different manufacturers, or lamps with slightly different specifications. The values submitted should be vetted for obvious errors. Initial outputs are the values required for this form - staff must assure that other output values are not entered, such as "mean," "minimum," "effective," or "maintained" values.

For every lamp and luminaire combination proposed for a project, staff must review the information submitted (under Section 7.1.B in the *USA Pattern Code*) to be sure the shielding characteristic claimed by the applicant on the *Lighting Application* is justified. Unshielded luminaires will hardly need investigation, and there should be relatively few used under a lighting code. Luminaires claimed as shielded must be checked more carefully, but this will almost always require no more than a picture of the luminaire (see *Note 9.17: How to recognize fully shielded fixtures*).

Monitoring of lighting after the initial construction is completed is always difficult in practice, but also vital to the ultimate success of light pollution control. With a good foundation of education about lighting issues (see *What Makes a Lighting Code Effective*), there should not be many examples of such violations, but the treatment of those that do occur will determine whether they become a serious problem in the community, or fade away as the lighting community becomes accustomed to the code and the benefits of good lighting for everyone. If violations develop due to user ignorance, or due to outright "bootlegging," enforcement is difficult and time-consuming. The available planning and enforcement staff is usually not large enough to maintain any comprehensive surveillance, especially at night, and enforcement is usually on a "complaint" basis. A local IDA Section or outdoor lighting advisory group (see *Ongoing Education in Outdoor Lighting*) can be valuable here. On-going education, especially in the business and lighting communities, about the value of good lighting and the reasons for the code are valuable here also, but no community should expect that monitoring and ongoing enforcement will not require time and resources.

It is reasonable to consider even establishing a true "lighting permit" with associated fees, much as is done with building, electrical, and plumbing permits. Possible fee structures could be a fixed value for all permits, or based on numbers of luminaires and/or total lumen output of the project.

4.06 Why Are There Different Standards for Different Areas?

Different areas, with different developed and natural conditions, have differing levels of appropriate light usage, and different sensitivities to the various obtrusive aspects of outdoor light usage. Because of this, five Lighting Zones are defined in this Handbook, and lighting standards appropriate to those Zones are established. The Zones are based on the Environmental Zones defined by the *Commission Internationale de l'clairage (CIE)*, and also used by the IESNA, which are describe as follows:

Zone E1:

Areas with intrinsically dark landscapes. Examples are national parks, areas of outstanding natural beauty, areas surrounding major astronomical observatories (but outside Zone E1A - see below), or residential areas where inhabitants have expressed a strong desire that all light trespass be strictly limited.

Zone E2:
Areas of low ambient brightness. These are suburban and rural residential areas.
Zone E3:
Areas of medium ambient brightness. These will generally be urban residential areas.
Zone E4:
Areas of high ambient brightness. Normally these are urban areas that have both residential and commercial use and experience high levels of nighttime activity.
To this list of Zones based on those defined by the CIE, this Handbook adds a fifth Lighting Zone:
Zone E1A:
Dark-Sky Preserves. These are areas close to major active astronomical research facilities, and within and near dark-sky preserves or parks that have identified the preservation of the darkest nighttime environment as a priority. Here the preservation of a naturally dark landscape and the darkest sky is of utmost importance. Further, the spectral characteristics of the lighting used may be important, with a strong preference for low-pressure sodium (LPS) lighting near the astronomical facilities.
In a lighting code, these Lighting Zones may be tied closely to land-use zoning categories Some codes have established a strict one-to-one correspondence in this regard, where every occurence of a particular land-use zoning category (like heavy commercial or single-family detached residential) has the same lighting standards. Other communities may apply this concept somewhat differently, where Lighting Zones are defined in relation to proximity to some particular resource, like an observatory or a park, and apply the same lighting standards to all land-use zoning categories equally. A third possibility is a combination of these two approaches, where for example a commercial zoning in a rural area or near an observatory may be one Lighting Zone, whereas the same commercial zoning in an urban surrounding would be in a different Lighting Zone.
In general, the approach envisioned in this Handbook would establish Lighting Zones as an overlay to land-uses, following the definitions described above. Under this approach, a rural area overall might be considered Lighting Zone E1 or E2; a suburban or urban area might be Lighting Zone E3 or E4. Then, a parcel zoned for commercial use in the rural area might be permitted 25,000 or 50,000 lumens per net acre, while a parcel with the same zoning in the urban area might be permitted 100,000 or 200,000 lumens per net acre.

4.07 Should a Lighting Code Specify Lighting Levels?

Nighttime overlighting is increasingly becoming a serious issue. An egregious example in recent years is service station canopy and convenience store lighting, where illuminances of 1000 lux (100 footcandles) or more are increasingly being seen. Other applications are also seeing uncontrolled upward ratcheting of lighting levels in many communities, driven by competitive pressures and perhaps by perceived liability risks.
A principle in good lighting design maintains that the brightest areas in a person's field of vision should not exceed ten times the brightness of the average level to

which the eye is adapted. If roadways are to be taken as the reference level, illuminated at 3 to 16 lux (0.3-1.6 footcandles), then this common-sense rule is being exceeded in many cases by great margins. This is a serious problem, leading to compromised visibility and safety, particularly for the ageing eye. To effectively address many of the issues of light pollution, overlighting must be addressed.

A natural inclination is to turn to the lighting profession itself, and require, as a part of a lighting code, lighting levels as recommended by, for example, the Illuminating Engineering Society of North America (IESNA). Though this is a natural approach, used in some lighting codes to varying degrees, there are several practical problems with this approach.

First, the recommended practices of the IESNA are often specified as **minimum** average illuminances (particularly for parking lot lighting), meaning that the average level should be as specified or greater. More importantly, they are also not intended to be applied in a recipe approach, an approach inherent in a legal document such as a lighting code. The recommendations are offered as a beginning point for lighting professionals, who are expected to turn their expertise and training on the problem at hand to determine what other factors may influence the needed lighting. Lighting levels both above and below the recommended levels are professionally justifiable for some tasks and locales.

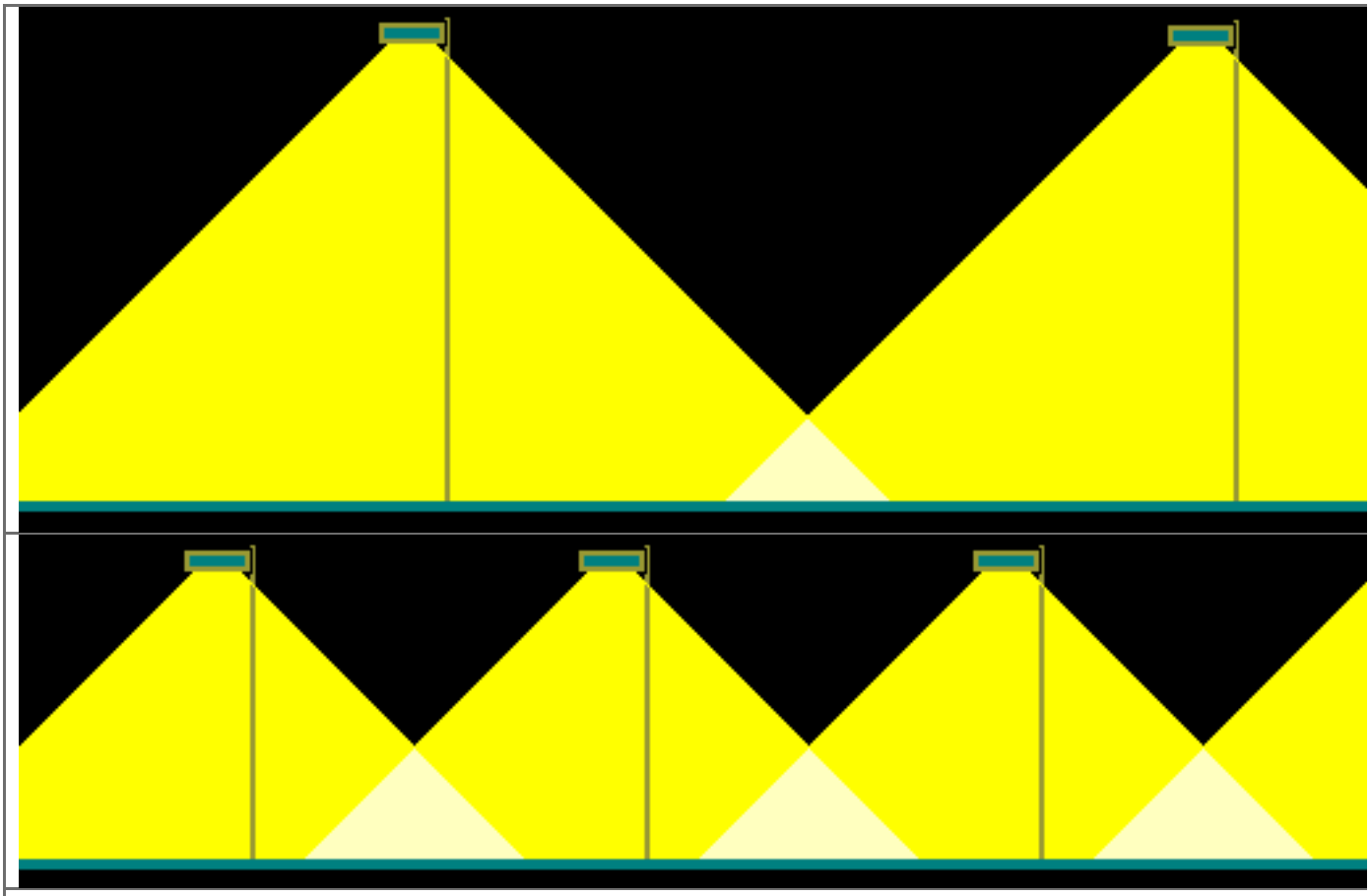
Second, lighting levels, when listed simply as an average illuminance (the most common number seen), are difficult to apply as a code limit. In practice, determining average illuminance requires expertise and time; it is not as simple, as is often imagined, as "going out with a meter and checking." Measuring an average illuminance requires nighttime work, in areas often with automobile traffic, laying out a regular grid of many points and taking illuminance measures at these points with a calibrated and carefully leveled meter with care taken to avoid any influence of shadows or reflections. Average illuminances commonly specified in professional practice are also "maintained" averages, which means that the illuminance is to be met when the light loss factors (*LLF*) appropriate for the lamps, luminaires and planned maintenance routines are applied. This means that the "maintained average" illuminance, such as appears in the recommended practices of the IESNA, is not actually measurable on the pavement in any simple way, and additional issues concerning appropriate maintenance factors will have to be considered in the code.

After-construction determination of compliance with any rule is a risky course, risking discovery of non-compliance after the money has been spent, the design finished, and the lighting literally set in concrete. To avoid these problems a code may consider defining compliance as occurring at design stage - but this approach then requires a professional design for every lighting permit application - an expensive requirement for small projects, and substantial training for staff to allow them to competently evaluate whether the designs offered are correctly done and without error.

Finally, lighting codes are interpreted, implemented, and enforced by persons that generally have limited expertise in the technical aspects of lighting design. The cost and training implications of extensive illuminance specification (or any technical specification) in a lighting code are severe. Either the planning departments must

obtain and maintain this expertise, or the costs must be imposed on the development community, including every small business that puts up a light.
This Handbook and the *USA Pattern Lighting Code* contained within it have emphasized a different approach, taking a direction that avoids wherever possible technical lighting specifications such as average or maximum illuminance, as valuable as these are to lighting professionals in the design process. The control of the majority of overlighting problems can be addressed effectively by an overall cap on the amount of light permitted, scaled to the area to be developed - lumens per acre caps. The amount of light included in a plan, measured in lumens, is practical and simple to verify from a simple list of lamps, and requires no special lighting expertise. It also leaves the maximum flexibility for the lighting designer, to work within an overall "lumen budget" to creatively achieve the goals presented by clients. As long as the lumen amounts permitted provide reasonable amounts of light for the designer to work with, professional quality designs can achieve the goals and solve the problems, if any, of each lighting situation by trading off amounts of decorative and general illumination, areas to be illuminated, illumination levels and uniformities, types of luminaire optical design, and other factors to achieve quality lighting without the code telling them permitted illuminance levels for each situation. (See *Note 9.07: Discussion of lumens per net acre caps*.) IDA believes that creativity in lighting design is enhanced rather than suppressed by this approach.
The tendency to upward ratcheting of lighting levels is viewed by many as a simple advertising ploy, though in public fora it is always justified with arguments about safety and security. The goal of the lighting code should be to stop overlighting, but implemented in a practical manner that allows design flexibility to assure that lighting is always ample for true safety and security.
Despite the effectiveness and practicality of lumens per acre caps for most general lighting uses, some special uses such as sports fields and display lots, because of the large amounts of light used and the potential for large obtrusive impacts should professional design standards be neglected, justify the fiscal impacts of technical specification and professional design. To avoid imposing large training or expertise requirements on planning department staff, these technical design details can be certified by a registered engineer hired by the builder. For the limited and generally large project types subject to this requirement, the relative cost implications are small, but are vital to assure the quality of the final lighting job.

4.08 Should a Lighting Code Limit Pole Heights?
Some communities have specified limits on the heights of lighting poles, either through a lighting code or otherwise in development design standards. There can be two intentions here, but the results of such restrictions may not be what is intended. If the intention is to limit the daytime visual impact of tall light poles against landscape views, then shorter poles may help, but lighting uniformity goals of the designer may offset the gains from shorter poles by causing an increase in the number of poles. More poles also are likely to cost more money to install and operate.



Pole height restrictions may cause more poles to maintain uniformity

If the intention is to limit the nightime visual impact of lights, in particular the spread of light from high luminaires into surrounding areas (light trespass), results may be much less than hoped. Again, since most area lighting has certain target uniformity levels, shorter poles will mean that more must be used, which may increase the visual impact at night as well as in the daytime. While these poles will be shorter, a community must carefully evaluate whether the trade-off of more poles might compromise the original intent to reduce visual clutter.

Pole height restrictions may cause more glare with higher angle candlepower distributions

Unfortunately, in attempts to reduce costs, some designers will avoid increasing the number of poles by using luminaires that have greater high-angle luminance, that is,

luminaires that throw more light to the side. These luminaires would achieve the illuminance and uniformity specifications sought with fewer poles, but will do so at the cost of increased glare. This will lead to increased light trespass, just the opposite of what the goal may have been in restricting pole heights. Visibility is likely to be compromised as well.

In general, it is not recommended that a lighting code limit pole heights. With good designs using fully shielded luminaires, poles with standard heights (up to about 11 meters or 35 feet) are in most situations minimally obtrusive. If there is trouble in your community due to unusual circumstances or practice with the use of unusually tall poles (over about 14 meters or 45 feet), then pole height restrictions may be considered to address the problem, though it is not recommended to restrict heights to much below about 8 meters (25 feet).

4.09 Roadway Lighting

Roadway lighting is a special case of area lighting. Since there are rarely advertising or competitive pressures involved in roadway lighting design, it is often approached in lighting codes differently than other outdoor lighting or even left out of the lighting code altogether. The issues driving lighting types and standards for roadways are dominated by considerations of safety, costs (capital, energy and maintenance), and to some degree aesthetics. Generally, the community itself will provide roadway lighting, or contract the design, installation and operation of the lighting through the local electrical utility company. If developers of new projects are required to install roadway lighting, the community will likely specify details of how the lighting is to be done and assume ownership and operation after construction. Such specifications commonly include hardware, pole heights (and sometimes colors), pole spacings and locations relative to the roadway, and illumination levels.

Many communities have engineering standards in need of updating, however, and most communities will have at least some old, obsolete and glarey streetlights. The first step in improving roadway lighting is to determine who specifies, installs and maintains the lighting: the local community, a power utility, or a state or local highway department. Once this is ascertained, the responsible agency should be encouraged to update any out-of-date standards. The current recommended practices for roadway lighting promulgated by the IESNA (in ANSI/IESNA RP-8-00) now include strong recommendations that all roadway luminaires be fully shielded. Though the illumination levels recommended may be considered by many smaller communities to be too generous, the levels are quite reasonable and provide for good visibility without any tendency to over-illumination in the sense commonly seen in commercial installations.

Any technical specifications for roadway lighting standards should be devised or at least reviewed by a licensed engineer who specializes in this field, or preferably has professional lighting design credentials.

It is for these reasons that roadway lighting is usually addressed through engineering standards. The engineers who devise these standards are aware or should be aware of the professional practices concerning roadway lighting. If the recommended practices of the profession are followed when determining the

roadway lighting standards for a community, there should be no need for further oversight in the more generally applicable lighting code. In many ways the lighting code is an attempt to bring the remaining lighting in a community, sometimes designed by competent professionals but often not, up to a level of quality commensurate with the state of modern roadway lighting design. (See also *Note 9.01: Roadway lighting standards*.)

4.10 What Types of Lamps Are Used in Outdoor Lighting?

There are many types of lamps used in outdoor lighting, a much greater variety than are familiar to most lighting users. Each type has applications where it is appropriate. Lighting designers must evaluate a variety of factors when choosing lamps, including available luminous outputs, output maintenance (how the lamp's output decreases with time), efficiency, capital costs, life cycle costs, color, size, lifetime, turn-on characteristics, environmental factors such as hazardous materials and effects on wildlife, and availability of fixtures. When decisions are made about what kinds of lamps to use in a project or to require in a lighting code, a consideration of all factors, both those advantageous and disadvantageous for any given type, must be made.

Below are descriptions of the principle lighting types used for outdoor area lighting and decoration. The less common or newer lighting technologies such as light-emitting diodes (LEDs), induction lamps, and others, are not discussed here, though they may occasionally be seen in large projects such as bridge lighting. For further information see also the IESNA Lighting Handbook, and many of the *IDA Information Sheets*, particularly *IS #52: Efficient Outdoor Lighting*. A summary of many of the factors related to the different lighting types discussed here appears *below*.

Incandescent

Incandescent Lamp Spectrum 700 -- 350 nm

Incandescent Lamp

Incandescent lamps are the lamps most familiar to homeowners; they are commonly used for the majority of residential lighting, both indoor and outdoor. Light is

produced by the passage of an electrical current through a tungsten wire in an evacuated or halogen-filled glass or silica envelope. Incandescent lamps are widely available in a huge variety of lamp styles of low to moderate luminous output (mostly below 2000 lumens). They are commonly used in applications where such low outputs are needed and where the lighting is often switched off and on. Some applications take advantage of the relatively high heat production of such lamps; more than 95% of the energy used by incandescent lamps goes into the production of heat. (It has been said that incandescent lamps are really heat sources that happen to produce a little light.) Advantages include low capital cost for lamps and luminaires, wide availability, wide variety of both lamp and fixture types, lack of a warm-up period, and lack of hazardous wastes. Disadvantages include short lifetimes (most less than a few thousand hours), low efficiency (about 8-20 lumens/watt) with resultant high per-lumen energy use and life cycle cost, attraction of insects, and high heat production.

Compact Fluorescent Lamp

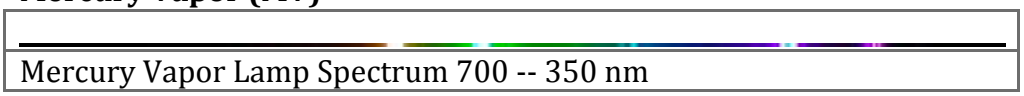
Fluorescent

Fluorescent Lamp Spectrum 700 -- 350 nm

Fluorescent lamps are also seen in residential lighting, and they predominate in indoor retail and office uses, and are occasionally seen in outdoor area lighting, usually in smaller or older installations. Light is produced predominantly by fluorescent powders coated on the inside of the lamp that are activated by ultra-violet radiation produced by an electrical arc through a low-pressure (about 2/1000th atmospheric pressure) mixture of gases including mercury vapor. A current-limiting device (ballast) is required to operate these lamps, but they can typically be easily and immediately switched on and off like incandescent lamps, and

they reach nearly full output almost immediately. Fluorescent lamps are also available in the so-called "compact" styles. These "PL" fluorescents can make highly efficient and cost-effective replacements for low-output residential lighting uses that are not too frequently cycled off and on. Outputs up to about 8000 lumens are available (about 2000 lm in "PL" styles). Advantages include low initial costs for lamps and fixtures compared with the lamp types below, low life cycle costs and high efficiency compared to incandescent (40-70 lumens/watt mean output), no warm-up period, good color rendition, and long lifetimes (10,000 - 20,000 hrs). Disadvantages include higher initial costs compared to incandescent lamps, large lamp size, low efficiency (compared to lamp types below) and poor output maintenance, attraction of insects, and potentially hazardous mercury waste.

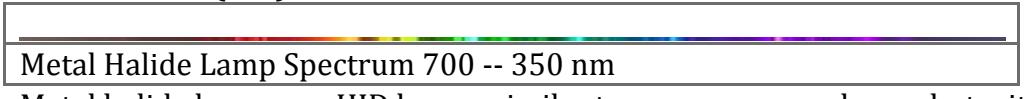
Mercury Vapor (MV)



Mercury Vapor Lamp Spectrum 700 -- 350 nm

Mercury vapor lamps (sometimes called high-pressure mercury, as distinguished from fluorescent) were the first widely used high-intensity discharge (*HID*) lamps. Light is produced by the passage of an electric arc through a small tube filled with mercury vapor at high pressure (2-4 atmospheres). A ballast is required to operate the lamp, and full output is not reached for several minutes after power is applied. Though highly efficient and long-lived compared to the incandescent lighting technology they displaced after the second World War, they have many disadvantages compared to other lighting sources available today, including low luminous efficiency, poor color rendition, and high ultra-violet output. Mercury vapor lamps have now been almost completely replaced in new applications by the more efficient metal halide and high-pressure sodium lamps. Many old fixtures remain, however, and they still remain available in the homeowner market, usually in notorious and poorly shielded "barnyard" or "dusk to dawn" fixtures. They were and are so widely used in these old poorly designed fixtures that to many mercury vapor has become almost synonymous with such poor lighting. One unusual characteristic of these lamps is that they seldom "burn out," instead fading to lower and lower outputs over years or even decades, though still consuming essentially the original amount of electrical power. Several lighting codes prohibit their use, though with mixed effectiveness. The technology is moribund, and not often specified for any extensive commercial or public outdoor lighting.

Metal Halide (MH)



Metal Halide Lamp Spectrum 700 -- 350 nm

Metal halide lamps are HID lamps, similar to mercury vapor lamps but with the addition of small amounts of various metallic halides, such as scandium, sodium, dysprosium, holmium and thulium iodide. Light is produced, as in the mercury vapor lamp, by the passage of an electrical arc through a small tube filled with mercury vapor and metal halides at 2-4 times atmospheric pressure. Again, a ballast is required, and full output is not reached for 2-10 minutes after power is applied.

The many different varieties of metal halide lamps give a wide variety of slightly different color characteristics, though generally they are white or blue-white sources. The technology is still evolving, and new types are appearing regularly. Besides a relatively steep fall-off in intensity with time (compared to high-pressure sodium; see below), many metal halide lamps also change their color as they age. Metal halide lamps are very commonly used in commercial outdoor lighting where white light with good color rendition is required or simply desired, such as car dealer display lots, sports lighting, and service station canopies. Advantages include a wide variety of moderate to high luminous output lamps (3500 - 170,000 lumens mean output), high efficiency compared to incandescent and mercury vapor (45 - 90 lumens/watt mean), and good color rendition. Disadvantages include lower efficiency and output maintenance compared to high- and low-pressure sodium, shorter lamp lifetime compared to high-pressure sodium, color changes, ultra-violet output if not adequately filtered, and potentially hazardous mercury waste.

High-Pressure Sodium Lamp

High-Pressure Sodium (HPS)

High-Pressure Sodium Lamp Spectrum 700 -- 350 nm

High-pressure sodium lamps are currently the most widely used HID lamps for roadway and parking lot lighting, though in some areas metal halide is becoming more popular. Light is produced by passing an electric arc through a small tube filled with sodium vapor at about 1/4 atmospheric pressure, and a ballast and warm-up of about 10 minutes are required. Advantages include a long lifetime, a wide variety of moderate to high luminous output lamps (2000 - 120,000 lumens mean output), high efficiency and good maintenance of luminous output compared

to all lamp types except low-pressure sodium, moderate color rendition compared to low-pressure sodium, and wide availability and moderate cost of lamps and luminaires. Disadvantages include poorer color rendition than metal halide, fluorescent and incandescent, poorer output maintenance and efficiency than low-pressure sodium, and potentially hazardous mercury waste.

Low-Pressure Sodium (LPS)

Low-Pressure Sodium Lamp Spectrum 700 -- 350 nm

Low-pressure sodium lamps are widely used in parts of Europe and elsewhere, and in some American cities, particularly those near active astronomical research facilities and those especially concerned about energy issues and municipal electric bills. Light is produced by the passage of an electrical arc through a tube filled with sodium vapor at about 6 millionths of atmospheric pressure. A ballast is required and 7-15 minutes are needed to reach full output. The light produced by LPS lamps is nearly monochromatic at a wavelength near 589 nanometers. Though the eye is very sensitive to this wavelength (leading to the high efficiency of LPS), the eye cannot distinguish colors when LPS light is the only source available. Low-pressure sodium lighting is favored where energy consumption and costs are a major concern and where color discrimination is either not needed or is supplied by other lighting. Advantages include the highest luminous efficiency and lowest energy use, low glare associated with the large lamps, good visibility and low scattering, minimal effects on insects and other wildlife, and lack of hazardous mercury wastes. Disadvantages include the lack of color rendition, shorter lamp lifetime and higher lamp replacement costs compared to HPS, and large lamp size in the higher output lamps.

Low-Pressure Sodium Lamp

A bigger disadvantage, not affecting the other lamp types, is the relation many lighting designers have with LPS lighting. For this reason LPS bears further discussion here, to address some of the issues any community will have to address if LPS lighting is considered.

Low-pressure sodium could profitably see more wide-spread use for what is called "Class 2" lighting, that is lighting situations in which the perception of color is not necessary for the lighting to be effective. Such a recommendation is made in this Handbook with particular emphasis for areas near astronomical observatories, but it can be extended to communities independent of the existence of nearby astronomical facilities. LPS lighting has many advantages: for a given amount of light, energy consumption and costs are low with LPS systems; when matched for maintained illumination levels, overall operating costs of LPS systems are lower or comparable to systems using HPS and other lamp types; LPS light generally has low glare and provides excellent visibility, especially to the aging eye and under poor atmospheric conditions like fog; the yellow color produced by LPS is highly visible at lighting levels used in outdoor lighting, but it is less efficient at producing skyglow because of the lower luminance of the sky (see *Lighting and the Eye*) and the decreased atmospheric scatter suffered by the yellow light; the yellow color of LPS light also interferes less with many living organisms, such as turtles and insects (see *IDA IS#29: Turtles and Outdoor Lighting in Florida* and *IS#109: Impact of Outdoor Lighting on Moths*); and finally, though this characteristic cannot be appreciated by the naked eye, LPS lighting pollutes only a limited portion of the visible spectrum, allowing other portions of the spectrum to remain relatively uncontaminated for astronomical research.

A large portion of outdoor lighting is actually Class 2 lighting, which has as its sole purpose the general illumination of an area to provide visibility for navigation of vehicles and pedestrians. Roadway lighting and most parking lot lighting is Class 2 lighting. On roadways, the perception of color is largely unnecessary, and where color perception is needed it is provided by light produced by the automobile headlights, which provide the lighting for roadway markings and roadside signage. The efficiency disadvantage that yellow light sources have when the eye is adapted to very low light levels (see *Lighting and the Eye*), of much current interest in lighting research, does not appear to be an issue at lighting levels used in roadway and parking lot installations.

Parking lot lighting is specifically provided to allow automobile drivers to see pedestrians and other hazards and to provide pedestrians visibility to navigate and avoid any hazards once they exit their automobiles and the ability to find their autos when they return. Under pure LPS lighting, there is almost no color discrimination, occasionally making for puzzled searching for a car of a particular color. In practice the hindrance is small, because we use other information to identify our cars such as make and model and whatever we left on the seat. The energy advantage of LPS in parking lot lighting is substantial, in general even larger than in roadway lighting, amounting to as much as a 50% reduction when compared to metal halide systems. It is recognized however that LPS continues to suffer a poor image within the lighting industry in many areas. Many designers will not willingly consider its use. This lack of support stems principally from the poor color rendition and the impression among some that LPS light provides for inferior visibility compared to broad-spectrum sources such as HPS and metal halide. There has also been considerable misinformation circulated concerning LPS lighting, and the damage done to its image has been substantial. More research is needed in some aspects of LPS lighting, such as lamp lifetimes, optimal operating conditions, and system operating costs. But the advantages of LPS are sufficiently well documented to justify the more widespread use of LPS lighting, particularly in these days of increasing energy consumption, increasing energy costs, and concerns for carbon dioxide production and global warming.

Recognizing this practical difficulty regarding the specification of LPS, the USA Pattern Lighting Code encourages LPS use, but does not require it, in applications where color rendition is not needed (Class 2 lighting) and in areas where astronomical observations are not an issue (though in general the USA Pattern Code is NOT a lighting code for any particular community - it must be modified and tailored to suit each community's concerns and goals as described in *How to Use the Handbook and USA Pattern Lighting Code*.) Where astronomical facilities may be affected, LPS lighting for Class 2 applications is required in the USA Pattern Lighting Code. Though this requirement is expressed here only for Lighting Zone E1A, the generalization of this standard to the other Lighting Zones should be seriously considered by any community seeking to minimize energy use for outdoor lighting and benefit from the other advantages of LPS described here.

"Neon"

"Neon" or "luminous tube" lighting is a term applied to a variety of small-diameter glass-tube sources, generally used for decorative purposes and signage. Light is produced by the passage of electrical current through the gas fill, producing light with a color or spectrum characteristic of the fill gas or gases and any phosphor coating within the tubing. Luminous outputs are not typically defined *per lamp*, but rather *per foot* or *per meter*, and depend principally on the fill gases and diameter/current rating, but also to some extent on the manufacturer and quality. Since luminous tube lighting is used for applications taking advantage of the color variety and shape flexibility inherent in the technology and not for area lighting, it is not meaningful to compare its advantages and disadvantages to the lighting sources above. But such lighting can account for large total outputs in some cases, particularly when used for architectural outlining, and it should not be overlooked in lighting codes.

Summary of Lamp Types

This table summarizes the most salient general differences in the lamp types for the most common sizes encountered in outdoor lighting, exclusive of sports lighting. The values given are approximate, and relative comparisons will depend on the details of the application.

LAMP TYPE COMPARISON -- SUMMARY

	Lamp Type			
Factor	**Incandescent**	**Fluorescent**	**Metal Halide**	**High-Pressure So**
Wattage	25-150	18-95	50-400	50-400
Output (lumens)	210-2700	1000-7500	1900-30000	3600-46000
Efficiency (lumens/watt)	8-18	55-79	38-75	72-115
Lumen Maintenance (%)	90 (85)	85 (80)	75 (65)	90 (70)
Lamp Life (hours)	750-2000	10000-20000	10000-20000	18000-24000
Energy Use	high	medium	medium	low
Color Rendition	good	good	good	moderate

- Wattage - Lamp wattages most commonly used in general outdoor lighting (not including sports lighting)
- Output - approximate mean luminous outputs of lamps most commonly used in outdoor lighting
- Efficiency - mean luminous efficiency for above lamp output range, taken at 50% of mean lifetime (does not include ballast losses)
- Lumen Maintenance - percent of initial lamp output at 50% of mean lamp lifetime and at end of mean lifetime (in parentheses)
- Lamp Life - approximate mean lifetime of indicated lamps
- Energy Cost - relative energy costs
- Color Rendition - relative ability of average observer to accurately perceive colors under lighting from indicated lamps only (* under pure LPS light, some discrimination of reds and oranges is possible, though they will appear as shades of brown. See also *Note 9.14: LPS/other lamp type mix for color rendition with LPS energy savings*.)

4.11 Lighting and the Eye

When evaluating the characteristics of lighting and lighting systems, it is easy to become lost in technical measures of lumens, lux, uniformities, mounting heights, candelas and watts. But the goal with lighting is to see (or to be seen), and we see with our eyes. All lighting must be gauged ultimately in terms of the visibility it produces in interaction with the human system of visual perception. An understanding of the characteristic of this complex system has been slow to develop, and is still deficient in many ways.

Of first importance when considering vision under most outdoor lighting situations is the importance of the eye's response to low light levels and large contrasts. Daylight presents the eye with illumination levels of about 100,000 lux (10,000 fc). Further, everything is brightly illuminated; the sky overhead is bright, and even shadowed areas are at about 30,000 lux. Indoor lighting is at much lower illumination levels (typically from 100-500 lux or 10-50 fc), but again contrasts are quite moderate since most areas that we frequent are fully illuminated.

But outdoors, at night, we operate in a much different lighting environment. Not only are illumination levels much lower (typically a few tens of lux to almost zero), but only limited areas are illuminated, leaving huge contrasts between lighted and unlighted areas. Further, the sky overhead is much darker, even in heavily light-polluted cities, leaving the illuminated areas and the light sources themselves to appear very bright in contrast with the generally dark environment.

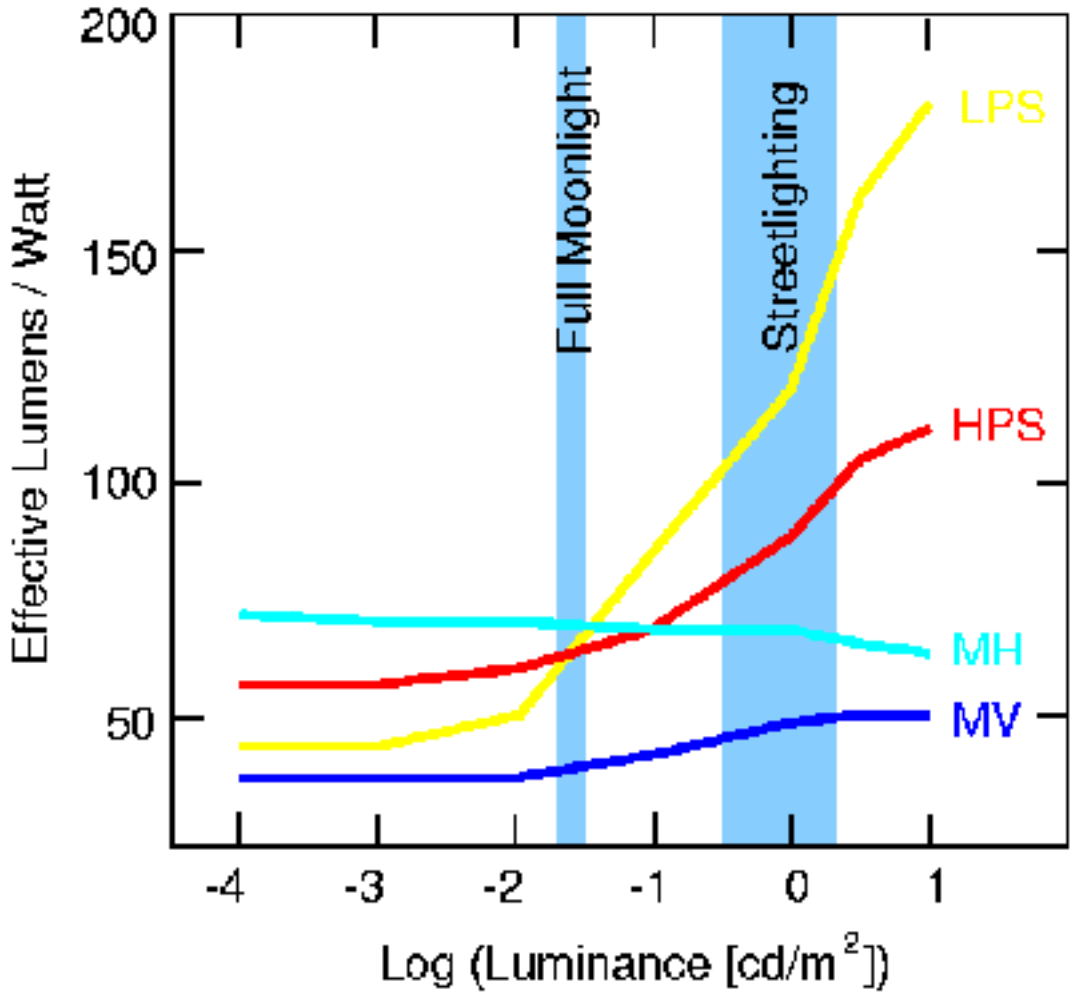
One aspect of human vision under low light levels has received much interest in recent years among lighting professionals. Everyone knows that you can see better at low lighting levels after your eyes become accustomed to the dark; who hasn't stumbled to a seat in a movie theater after arriving a bit late, only to navigate the same aisles with ease to get popcorn later on after your eyes adjust?

Less widely known is the fact that the eye's spectral sensitivity also shifts as dark adaptation progresses. Under daylight conditions the eye is sensitive to the spectral range from deep red (at about 700 nanometers (nm) or longer) to violet (at about 350 or 400 nm). The greatest sensitivity is in the middle of this range, at about 555 nm or yellow-green. But when the eye becomes fully dark-adapted the peak sensitivity shifts blueward to about 507 nanometers, in the blue-green portion of the spectrum. This effect, called the "Purkinje" shift, occurs because we use different retinal cells (using different photo-sensitive chemicals) to see under bright and dim lighting.

This shift in spectral sensitivity means that the relative efficiencies of different lighting sources (with different colors or spectral distributions) will also shift. To illustrate, consider low-pressure sodium lighting, with a nearly monochromatic spectral output near 589 nm. This wavelength falls very near the peak sensitivity of the eye's light-adapted response, and accounts for the high efficiency attributed to LPS. But under completely dark-adapted conditions, the peak sensitivity of the eye shifts toward the blue and lies further from the peak LPS emission, decreasing the efficiency of LPS.

These sensitivity shifts have been measured under laboratory conditions, with observers evaluating the visibility of visual stimuli presented under carefully controlled but artificial conditions. The effect of this shift on the performance of the

human visual system in real-life situations such as driving an automobile at night is much less understood. The light-adapted response of the eye, most sensitive to the yellow-green portion of the spectrum, is determined by cells in the retina called "cone" cells, after their shape. Cone cells pave the central portion of the retina - the "fovea" - the portion used when a person "looks at" something. The dark-adapted response, more sensitive to green or blue-green, comes from the other principle cell type, called "rods." Though the rods are more sensitive when light levels are very low, giving rise to the relative increase in efficiency of the bluer light sources such as metal halide, rods lie primarily in the peripheral portions of the retina, covering what is called "peripheral vision." There are no rods at all in the fovea. Whenever you read, whether a book or a roadway sign, you do it almost exclusively with the fovea and therefore with cone cells. When you look at other cars in the roadway, or pedestrians at the side, or for hazards in the roadway, you do it, at least principally, by looking directly at them and therefore by using the cones in your fovea.



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Uncertainty in the degree that peripheral and central vision are important to the various tasks required under outdoor lighting leads to uncertainty in the degree of

importance that should be ascribed to the efficiencies of lighting sources at low lighting levels and to peripheral vision.
The best current research, however, shows that under typical outdoor lighting levels, the visual system's performance, at least under laboratory conditions, is best characterized as lying closer to the light-adapted response than to the dark-adapted response (see graph above, as well as *IDA IS #136: Some Issues in Low Light Level Vision*, and references therein). Amateur astronomers will not be surprised at this, since they know that the eye is nowhere near dark-adapted after driving a car or walking around in an illuminated area such as a parking lot. More research needs to be done, but at present the indications are that yellow light sources such as LPS and HPS maintain most of their efficiency advantage over bluer sources such as metal halide and mercury vapor under conditions commonly encountered under typical outdoor artificial illumination.
Other important aspects of vision, increasingly being recognized by lighting researchers, are the changes that occur as we age. As the eye ages, the ability of the iris to open widely diminishes, the transparency and color of the lens and other transparent media within the eyeball change, and the speed with which we adapt to different light levels decreases. These changes mean generally that we require somewhat brighter lighting to see as well as younger persons, we become somewhat less sensitive to blue light, less able to adapt quickly to changes in light levels, and finally that we become particularly sensitive to glare, especially from bluer light sources. (See *IDA IS #156: The Aging Eye - Some Basic Information* for further information.) Ageing eyes especially benefit from the best quality, low-glare lighting that we all need.

5 Practical Issues and Problem Areas for Lighting Codes

Improvement of lighting quality in many areas can be effectively achieved through lighting codes, but many areas of lighting codes, including the USA Pattern Lighting Code offered here, suffer from difficulty and impracticality of enforcement. A few of those areas are discussed here. Partial solutions are described, but in general there limited solutions within the framework of a lighting code for many of these problems. Education is the best avenue for dealing with many of these (see *Ongoing Education in Outdoor Lighting*).

5.01 Swiveled Luminaires (Floodlights)

Floodlight with Swiveled Mounting

Luminaires with swiveled mounting hardware are easy to adjust inadvertently or intentionally, as they are installed or serviced. This can compromise shielding, and it may happen after the installation was examined and approved as complying with the lighting code. Further, such luminaires are not optically designed to be aimed straight down, as is necessary in most cases to obtain full shielding without added shields. Even add-on louvers or shields do not allow the luminaires to be aimed very high without the same problem. Unfortunately, these luminaires are often used for glare-prone lighting in an attempt to "light over there with a light over here." The user tries to avoid the expense of installing a proper support or pole where it is really needed, instead mounting the light on a building, pole or other structure located too far away from the area needing lighting to provide effective lighting.
To avoid this bad lighting practice and difficult enforcement problem, it can be feasible to simply prohibit the use of such swivel-mounted luminaires. This approach is not suggested here in the USA Pattern Lighting Code since it is then difficult to allow possible legitimate and correct uses of such luminaires, though these are rarely seen. Even prohibiting luminaires with obvious swivel mounts may not completely address the problem of poorly adjusted or mounted hardware, as many luminaires have adjustment capabilities that are not obvious in catalog photographs but could still lead to compromised shielding.

5.02 Sports Lighting

Lighting levels used for night sports are the highest commonly encountered in the nighttime environment. Recommended levels for social or recreational sports, including most municipal sports activities, range from 200 to 500 lux (20 to 50 footcandles); levels for professional play with large spectator attendance and television coverage can reach 3000 lux (300 footcandles). Controlling trespass and

glare with such lighting levels is an extreme technical challenge, requiring the utmost in quality luminaires and design.
Further, the lighting fixtures commonly used for sportsLighting can be huge sources of direct glare, not only to areas nearby and at considerable distances from the sports fields, but also to spectators and players actually using the fields. The brightest single sources of light visible in city nighttime landscape views are often these facilities. It is no surprise that such lighting is usually the single greatest source of complaint and neighborhood tension about lighting issues.

Unshielded Sports Lighting

Fully Shielded Sports Lighting (courtesy of Soft Lighting)

In the past, available fixtures, lighting designs, and the general level of the sports lighting art often left little choice for communities and designers seeking to minimize spill and glare in sports lighting. Even today, some manufacturers and designers will claim that spill and uplight cannot be reduced much below those obtained with these older designs and fixtures. Fortunately, several manufacturers have begun producing well shielded, even fully shielded luminaires suitable for sports lighting, particularly for the most commonly encountered levels of lighting. These designs provide major reductions in off-field spill, and can entirely eliminate direct uplight in all but the brightest lighting levels required for professional level sports. Further, many feel that these designs deliver substantially improved lighting quality on the field for the players.

Unfortunately, many facilities, particularly older ones, will continue to produce enormous amounts of light spill into adjacent areas, and both direct and reflected light into the sky. With quality designs using modern fixtures, these obtrusive effects can be considerably reduced, but the huge amounts of lighting required in some situations will always lead to some obtrusive impacts, even with the best design. Communities should be aware of the potential impacts. The location and alignment of new fields should be carefully considered. Technical specifications for sports lighting can be included in a lighting code that require fully shielded lighting where at all possible, and professional design and post-installation certification to assure that the standards are followed.

5.03 Wallpacks

A common problem source is wallpacks, wall-mounted luminaires with optical elements (reflectors and/or refractors) that usually direct a large portion of their light at angles near the horizontal. They are unfortunately commonly used in inappropriate ways, often in attempts to minimize hardware expenses as described above under swiveled luminaires, giving rise to much glare and poor lighting. The typical plain unshielded wallpack is easily recognizable and, if its output is above the threshold for full shielding requirements, can be denied approval. Trouble may however arise if a user offers to install an "add-on" shield which many manufacturers offer for their products.

Unshielded Wallpack	Wallpack with Internal Shield (but still not fully shielded).

These add-on shields may be claimed to provide "shielding" or "cutoff," but rarely if ever provide true full shielding according to the definition of no uplight used in the Pattern Lighting Code (this is an example of the confusion regarding these terms: see *Note 9.16: Shielding and cutoff terminology*). The planning officials must be aware that such luminaires are almost never fully shielded, even after adding shields, and either deny approval or require complete photometric information to verify the complete elimination of uplight. Since for such low-cost fixtures adequate photometric information is often not available, or if available is often unreliable, the best approach is to deny approval for such wallpacks except where they would be permitted as unshielded fixtures.

Shielded Wall-mounted Luminaire

Fully shielded wall-mountable luminaires are available from many manufacturers, with typical "shoebox" or can-shaped designs. These can provide good alternatives for many wallpack applications, though no luminaire will adequately solve the problem of getting useful light at great distances from the luminaire - "light over there with a light over here." For quality lighting, all luminaires must be placed reasonably near to where the light is needed.

5.04 Residential Lighting

Residential Luminaires

The effectiveness and enforcement of residential lighting restrictions is always problematic. First, the majority, even the vast majority, of lighting fixtures easily available on the homeowner market are inherently unshielded or swiveled and rarely used pointed straight down. Second, the details of residential lighting are often not reviewed by building departments, and even if they are the often large numbers of homes being built and the many details involved in inspections will mean that the shielding details of fixtures are often overlooked. Review and approval of lighting plans is typically done (as recommended in the USA Pattern Code) before building permits are issued and construction is started, but residential

lighting fixtures are often chosen or changed at nearly the end of construction. An even greater problem is that residential lighting is commonly changed or supplemented after construction is completed without any official review or approval process.

The low individual outputs of such lights and the low overall amounts used per home or acre mean that the impacts are lower in some respects than for commercial lighting - skyglow for example - though the impacts may be greater in other respects - light trespass in dark residential or rural environments, for example. A balance must be struck here between these impacts and the practical issues of enforcement. Though a lighting code should have carefully considered standards for residential lighting, the most effective way to address most residential lighting is by education (see *Ongoing Education in Outdoor Lighting*) and through homeowners' associations where available (see also *What Is an Outdoor Lighting Code?*).

A productive way to improve lighting used in residential areas, after suitable standards are written into the local lighting code, is to find which local retailers carry shielded products (and encourage more to do so), and to make this information available to homeowners in your community. Locally owned businesses are particularly well able to respond to this kind of approach. This information can be made available through the community planning department and distributed with building permits.

5.05 Laser and Search Lights

Sweeping laser or searchlight beams, projected high into the sky and visible for many miles, are used to attract attention to commercial activities or community events. The utility of such practices for attracting customers is questionable, since persons located at a distance from the lighting cannot generally tell where such light beams are originating. But the wide-reaching effects are not in question. Such practices can affect the appearance of the nighttime environment for thousands or even millions of persons, effectively turning the entire night sky into an advertising medium. IDA discourages this use of the common nightscape, and the USA Pattern Code reflects this.

5.06 Decorative Lighting

Decorative lighting of building exteriors, fountains, landscaping, bridges, statuary and other man-made and occasionally natural features is common, especially in large cities on large landmark structures. Holiday decorations, typically using low-output incandescent lamps, are widespread during the Christmas season. Decorative lighting can also include illumination of translucent building faades or large panels with internal light sources, such as is commonly seen on service station canopy edges. Many of the most common applications such as building floodlighting can be effectively accomplished using down-directed and fully shielded luminaires, but others are very difficult to light in this fashion and will inevitably lead to substantial proportions of light emanating into the sky. Internally illuminated decorations are inherently unshielded, and direct at least 50% of the emitted light directly into the sky.

To a limited degree, and when done well, decorative lighting can be attractive and effectively showcase distinctive architecture or community features. The illumination of building exteriors is however more often used as an advertising vehicle, effectively converting entire buildings into signs that are not regulated by the local sign codes. Common practice for building floodlighting uses up-directed luminaires that project a large proportion of their light directly into the sky. This approach should be strongly discouraged, and the USA Pattern Code makes extensive lighting of this type difficult by applying strict limits on the amount of unshielded lighting allowed. Luminaires mounted at the top of the wall or roof to be illuminated and directed downward are effective and will minimize uplight.

Up-Directed Flag Lighting

Down-Directed Flag Lighting

5.07 Flag Lighting

Flag lighting is almost always up-directed, and driven by the traditional requirement that any flag flying at night must be illuminated. Though it may be appropriate in some instances and in a limited way to light flags at night, it is clear that flags and flag lighting are also used for advertising. Though some shielded and down-directed options are available for flag lighting, IDA generally supports the old tradition of lowering flags at sunset.

5.08 Historical-Style Lighting

The appearance of old fashioned, "period," or historical luminaire styles is considered attractive in many communities, especially those trying to recapture the ambiance of the late 19th century in their downtown areas. Such lights are appearing even in relatively young communities that have had no historical use of such lighting. In the design of such historical district improvement projects, if lighting design is left to architects with little training in lighting and luminaire design, their training may tend to value the appearance of such fixtures in the daylight, and not their performance at night. In these types of luminaires especially there can be a big difference in these two qualities, where the most attractive or authentic-looking fixtures often perform the most poorly at night.

The luminaires are typically designed to hold a lamp within a glass (or plastic) enclosure, often with a globe-like glass cover or four flat panes in a metal housing, and fully visible straight from the side - there is no shielding for light rays projected near and even above the horizontal. Some of the globe styles have internal louvers designed to decrease glare, but these louvers are often insufficient, especially if the surrounding globe is designed to diffuse the light with a prismatic, milky or frosted material. Such unshielded luminaires can be effective and attractive if used purely for decorative purposes, with very low output lamps simulating the low output gas flames originally held by such fixtures. Bad lighting results however when an attempt is made to achieve modern illumination levels with such luminaires. To achieve even mininal illumination on the ground, the intensity projected at high angles becomes very high, severely compromising the effectiveness of the lighting due to the high glare.

"Antique" Fixture with Recessed Lamp

Day	Night

One effective way to use such styles is to use the typical unshielded luminaires with extremely low output lamps (no more than about 300 lumens each), and then to provide any required general illuminance on the ground by a completely separate and fully shielded modern area lighting system located well above the antique luminaires on separate poles at typical mounting heights of 7-10 meters (25-35 feet).

Also available now from a number of manufacturers are nearly fully-shielded but otherwise antique-style luminaires that contain the light source recessed within the top of the luminaire (the prismatic lenses available as an option for some of these designs should be avoided). Though the lamp is fully recessed into the upper housing in these designs, true full shielding is not achieved since the glass or plastic windows, even if quite smooth, will refract and scatter some light upward, particularly as they age and get dirty. Further, since such luminaires are generally mounted on quite short poles (3-4.5 meters or 10-15 feet), and since the pole itself generally will cast a substantial shadow on the ground around the pole, achieving good quality lighting with acceptable uniformity and glare is difficult with such designs. They should use lamps with about 5000 lumens or less output, and not be used as a sole light source where lighting quality is a priority.

6 Ongoing Education in Outdoor Lighting

Much can be accomplished through a process of general education in a community; many difficult enforcement problems cannot be effectively addressed in any other way. Such an education process is vital to the drafting and adoption of an outdoor lighting code.

But after the code is in place, its continued success depends on maintaining the involvement of the community. Understanding of lighting issues built during the process of drafting and adopting a lighting code must be continually refreshed, and new issues will arise as technology changes and lighting styles change to accommodate changes in fashions and technology. An effective way to address these concerns is through the formation of a local section of the IDA (see *IDA IS #8: Developing Local & Regional IDA Sections*) or a lighting advisory group. This group can meet regularly to discuss the lighting issues facing the community, to explore ways to improve community lighting, the effectiveness of the lighting codes, and of the efforts of the planning staffs to implement them. The members should be interested in and informed about the issues of quality lighting.

Such groups can help maintain the visibility of lighting issues in the community and serve as a resource to the community when questions arise about lighting. They can recognize good lighting installations in the community through good lighting awards; provide handout sheets to building departments for distribution to developers and new home builders; write letters to the newspaper editor and guest editorials describing the issues; give talks on the issues to the public and to retailers and electrical contractors; provide training for community development staff and inspectors; bring violations to the attention of enforcement staff. No one wants bad

lighting; the advisory group can help maintain awareness in the community about what constitutes good lighting.
See the *Example of an Outdoor Lighting Advisory Committee Proposal*.

7 USA Pattern Lighting Code

The USA Pattern Lighting Code below is intended only as a guide to writing a code suitable for your community. Issues and priorities will be to some extent different for every community, and the Pattern must be adapted to reflect your own community's concerns and desires. See *How to Use the Handbook and USA Pattern Lighting Code*.

Contents

Section 1. Purpose and Intent.
It is the intent of this Code to define practical and effective measures by which the obtrusive aspects of excessive and/or careless outdoor light usage can be minimized, while preserving safety, security, and the nighttime use and enjoyment of property. These measures will curtail the degradation of the nighttime visual environment by encouraging lighting practices that direct appropriate amounts of light where and when it is needed, increasing the use of energy-efficient sources, and decreasing the wastage of light and glare resulting from overlighting and poorly shielded or inappropriately directed lighting fixtures.

Section 2. Conformance with Applicable Codes.
All outdoor illuminating devices shall be installed in conformance with the provisions of this Code, the Building Code, the Electrical Code, and the Sign Code of the jurisdiction as applicable and under appropriate permit and inspection.

Section 3. Applicability.
3.1 New Uses, Buildings and Major Additions or Modifications. For all proposed new land uses, developments, buildings, and structures that require a permit, all outdoor

lighting fixtures shall meet the requirements of this Code. All building additions or modifications of twenty-five (25) percent or more in terms of additional dwelling units, gross floor area, or parking spaces, either with a single addition or with cumulative additions subsequent to the effective date of this provision, shall invoke the requirements of this Code for the entire property, including previously installed and any new outdoor lighting. Cumulative modification or replacement of outdoor lighting constituting twenty-five (25) percent or more of the permitted lumens for the parcel, no matter the actual amount of lighting already on a non-conforming site, shall constitute a major addition for purposes of this section.

3.2 Minor Additions. Additions or modifications of less than twenty-five (25) percent to existing uses, as defined in Section 3.1 above, and that require a permit, shall require the submission of a complete inventory and site plan detailing all existing and any proposed new outdoor lighting. Any new lighting on the site shall meet the requirements of this Code with regard to shielding and lamp type; the total outdoor light output after the modifications are complete shall not exceed that on the site before the modification, or that permitted by this Code, whichever is larger.

3.3 Resumption of Use after Abandonment. If a property or use with non-conforming lighting is abandoned as defined in Section 16.41, then all outdoor lighting shall be reviewed and brought into compliance with this Code before the use is resumed.

3.4 Public Roadways. Lighting for public roadways is exempt from the provisions of this Code.

Note 9.01: Roadway lighting standards

Section 4. <u>Shielding and Total Outdoor Light Output Standards.</u>

4.1 Shielding Standards. All nonexempt outdoor lighting fixtures shall have shielding as shown in Table 4.1.

Use Codes:

A = all types of fixtures allowed; shielding not required but highly recommended, except that any spot or flood-light must be aimed no higher than 45 degrees above straight down

F = only fully shielded fixtures allowed

X = not allowed

Table 4.1 LAMP TYPE AND SHIELDING STANDARDS

	LIGHTING ZONE				
USE CLASS AND LAMP TYPE	**E4**	**E3**	**E2**	**E1**	**E1A**
Class 1 lighting (Color Rendition):					
Initial output greater than or equal to 2000 lumens	F	F	F	F	F
Initial output below 2000 lumens (2)	A(1)	A(1)	A(1)	F	F
Class 2 lighting (General Illumination):					
Initial output greater than or equal to 2000 lumens	F	F	F	F	F
Initial output below 2000 lumens (2)	A(1)	A(1)	A(1)	F	F
Class 3 lighting (Decorative)(3):					

Initial output greater than or equal to 2000 lumens	F	F	X	X	X
Initial output below 2000 lumens (2)	A(1)	A(1)	F	F	F
Residential lighting (all Classes)(4):					
Initial output greater than or equal to 2000 lumens	F	F	F	F	F
Initial output below 2000 lumens (2)	A(1)	A(1)	A(5)	A(5)	F

Notes to Table 4.1

1. Flood or spot lamps must be aimed no higher than 45 degrees above straight down (half-way between straight down and straight to the side) when the source is visible from any off-site residential property or public roadway.
2. Exception: seasonal decorations using typical unshielded low-wattage incandescent lamps shall be permitted in all lighting zones from Thanksgiving thru 15 January.
3. All Class 3 lighting shall be extinguished between 11:00pm (or when the business closes, whichever is later) and sunrise.
4. Residential refers to all residential land-use zoning, including all densities and types of housing such as single-family detached and duplexes. Multiple-family residential uses must use standards above for Class 1, 2 and 3 lighting.
5. Any lamp installed on a residential property must be shielded such that the lamp itself is not directly visible from any other residential property.

Note 9.02: Origin of 45 degree limitation for spotlights and floodlights
Note 9.03: Discussion of 2000 lm shielding split
Note 9.04: Examples of lamps with 2000 lm and less
Note 9.05: Alternative section 4.1 with LPS requirement
Note 9.06: Shielded porchlights

4.2. Total Outdoor Light Output Standards. Total outdoor light output (see definition 16.30) shall not exceed the limits in Table 4.2. Seasonal decorations, permitted between Thanksgiving and 15 January, are not counted toward these limits; lighting used for external illumination of signs is counted, while lighting used for internal illumination of signs is not counted. (The values in this table are upper limits and not design goals; design goals should be the lowest levels that meet the requirements of the task.)

LUMEN CAPS - INITIAL LAMP LUMENS PER NET ACRE
Table 4.2 MAXIMUM TOTAL OUTDOOR LIGHT OUTPUT STANDARDS

	LIGHTING ZONE				
	E4	**E3**	**E2**	**E1**	**E1A**
Commercial and Industrial zoning (1)					
total (fully shielded + unshielded)	200000	100000	50000	25000	12500
unshielded only	10000	10000	4000	2000	1000
Residential zoning (2,3)					
total (fully shielded + unshielded)	20000	10000	10000	10000	5000

unshielded only	5000	5000	1000	1000	0

Notes to Table 4.2

1. This refers to all land-use zoning classifications for multiple family, commercial and industrial uses.
2. This refers to all residential land-use zoning classifications, including all densities and types of housing such as single-family detached and duplexes.
3. In Lighting Zones E4-E1, each residential single-family detached home or duplex is allowed up to 5,500 total lumens (2,300 lumens in Zone E1A), or the amount indicated in this Table based on the parcel's acreage, whichever is larger. Each is also allowed a maximum of 5,500 lumens (zero lumens in Lighting Zone E1A) of unshielded ("A") lighting, provided Table 4.1 allows the lamp's type with "A" shielding. All residential spot or flood lamps permitted are to be aimed no higher than 45 degrees above straight down (half-way between straight down and straight to the side).

Note 9.02: Origin of 45 degree limitation for spotlights and floodlights
Note 9.07: Discussion of lumens per net acre caps
Note 9.08: Origin of 5500 lumen unshielded cap
Note 9.09: Alternative section 4.2 with LPS requirement

4.3 Effective Shielding Standard. All light fixtures that are required to be shielded shall be installed and maintained in such a manner that the shielding is effective as described in the definition in Section 16.13 for fully shielded fixtures.

4.4 Light Trespass Standard. Beyond the shielding requirements of Section 4.1, all light fixtures shall be located, aimed or shielded so as to minimize stray light trespassing across property boundaries. Particularly, any lamp installed on a residential property and visible from any other residential property must be shielded such that it is not directly visible from that property.

4.5 Multi-Class Lighting Standard. Multi-Class lighting must conform to the shielding and timing restrictions, if any, that apply to the most restrictive included Class.

Appendix B: Example applications of Section 4

Section 5. <u>Outdoor Advertising Signs.</u>

5.1 Externally Illuminated Sign Standards. External illumination for signs shall conform to all provisions of this Code. In particular, such lighting shall be treated as Class 1 lighting and shall conform to the lamp source, shielding restrictions and lumen caps of Section 4. All upward-directed sign lighting is prohibited.

Note 9.10: Discussion of internally illuminated sign colors
Note 9.11: Off-site sign illumination

5.2 Internally Illuminated Sign and Neon Sign Standards.

A. Outdoor internally-illuminated advertising signs must either be constructed with an opaque background and translucent text and symbols, or with a colored (not white, off-white, light gray, cream or yellow) background and generally LIGHTER text and symbols. Lamps used for internal illumination of such signs shall not be counted toward the lumen caps in Section 4.2.

B. Neon signs shall be treated as internally illuminated signs for the purposes of this Code, and shall not have their luminous outputs counted toward the lumen caps in

Section 4.2. Neon lighting extending beyond the area considered to be the sign area (as defined in the Sign Code of this jurisdiction) shall conform to all provisions of this Code. In particular, such lighting shall be treated as Class 3 (decorative) lighting and shall conform to the lumen caps of Section 4.
C. Other internally-illuminated panels or decorations not considered to be signage according to the sign code of this jurisdiction (such as illuminated canopy margins or building faces), shall be considered decorative (Class 3) lighting, and shall be subject to the standards applicable for such lighting, including but not limited to the lamp source, shielding standards and lumens per acre caps of Section 4.
Note 9.12: Sign styles with smaller light pollution impacts
5.3 Curfews. Illumination for all advertising signs, both externally and internally illuminated, shall be turned off at the curfew times listed in Table 5.3 or when the business closes, whichever is later. Signs subject to curfews are required to have functioning and properly adjusted automatic shut-off timers. Light background (white, off-white, light gray, cream or yellow) internally illuminated signs, installed legally before enactment of this code [enter date], may continue to be used and illuminated but must conform to the curfews as indicated.

Table 5.3 ILLUMINATED SIGN CURFEWS

	LIGHTING ZONE				
Sign Type and Land Use Zone(1)	**E4**	**E3**	**E2**	**E1**	**E1A**
Commercial and Industrial zoning					
Opaque Background	12am	12am	11pm	11pm	N/A
Colored Background	12am	12am	11pm	N/A	N/A
Light Background	10pm	10pm	9pm	N/A	N/A
All residential zoning					
Opaque Background	11pm	11pm	10pm	9pm	N/A
Colored Background	11pm	11pm	10pm	9pm	N/A
Light Background	8pm	8pm	8pm	8pm	N/A

Note to Table 5.3

1. Land Use Zoning refers to the predominant use of land within 300 meters (or 1000 feet) of the parcel on which the sign is located.
2. N/A means that such signs are not permitted.

Section 6: <u>Special Uses.</u>
6.1 Recreational Facilities.
A. Lighting for outdoor athletic fields, courts or tracks in Lighting Zones E1, E2, E3, and E4, shall be considered Class 1 (Color Rendition), and shall be exempt from the lumens per acre limits of Section 4.2. In Lighting Zone E1A athletic field lighting is not allowed.

B. Shielding: In Lighting Zones E1, E2, E3 and E4, fully shielded lighting is required for fields designed for Class III or IV levels of play (typically amateur or municipal league, elementary to high school, training, recreational or social levels; cf. IESNA Lighting Handbook and IESNA RP-6 Sports and Recreational Area Lighting). Facilities designed for Class I and II levels of play (typically college, semi-professional, professional or national levels) shall utilize luminaires with minimal uplight consistent with the illumination constraints of the design. Where fully shielded fixtures are not utilized, acceptable luminaires shall include those which:
1. Are provided with internal and/or external glare control louvers and installed so as to minimize uplight and offsite light trespass, and;
2. Are installed and maintained with aiming angles that permit no greater than five percent (5%) of the light emitted by each fixture to project above the horizontal.
C. Illuminance: All lighting installations shall be designed to achieve no greater than the minimal illuminance levels for the activity as recommended by the Illuminating Engineering Society of North America (IESNA).
D. Off-site spill: The installation shall also limit off-site spill (off the parcel containing the sports facility) to the maximum extent possible consistent with the illumination constraints of the design. For Class III and IV levels, a design goal of 5 lux (0.5 fc) at any location on any non-residential property, and 1 lux (0.1 fc) at any location on any residential property, as measurable from any orientation of the measuring device, shall be sought. For Class I and II levels, a design goal of 7.5 lux (0.75 fc) at any location on any non-residential property, and 1.5 lux (0.15 fc) at any location on any residential property, as measurable from any orientation of the measuring device, shall be sought.
E. Certification: Every such lighting system design and installation shall be certified by a registered engineer as conforming to all applicable restrictions of this Code.
F. Curfew: All events shall be scheduled so as to complete all activity before the curfew listed in Table 6.1. Illumination of the playing field, court or track shall be permitted after the curfew only to conclude a scheduled event that was unable to conclude before the curfew due to unusual circumstances. Athletic field lighting in excess of lumens per acre limits of Section 4.1 is not permitted in Lighting Zone E1A.
Table 6.1 SPORTS FACILITY AND DISPLAY LOT LIGHTING CURFEWS

LIGHTING ZONE				
E4	**E3**	**E2**	**E1**	**E1A**
12am	11pm	11pm	10pm	N/A

6.2 Outdoor Display Lots.
A. Lighting for display lots shall be considered Class 1 (Color Rendition), and shall be exempt from the lumens per acre limits of Section 4.2.
B. Shielding: All display lot lighting shall utilize fully shielded luminaires that are installed in a fashion that maintains the fully shielded characteristics.
C. Illuminance: The display lot shall be designed to achieve no greater than the minimal illuminance levels for the activity as recommended by the Illuminating Engineering Society of North America (IESNA).

D. Off-site spill: The display lot shall limit off-site spill (off the parcel containing the display lot) to a maximum of 5 lux (0.5 fc) at any location on any non-residential property, and 0.5 lux (0.05 fc) at any location on any residential property, as measurable from any orientation of the measuring device.
E. Certification: Every display lot lighting system design and installation shall be certified by a registered engineer as conforming to all applicable restrictions of this Code.
F. Curfew: Display lot lighting exceeding the lumens per acre cap of Section 4.2 shall be turned off at the curfew listed in Section 6.1 or within thirty minutes after closing of the business, whichever is later. Lighting in the display lot after this time shall be considered Class 2 lighting, and shall conform to all restrictions of this Code applicable for this Class, including the lumens per acre caps in Section 4.2.
Note 9.13: Lumen cap exemption for display lots
6.3 Service Station Canopies.
A. Lighting for service station canopies shall be considered Class 2 lighting (General Illumination).
B. Shielding: All luminaires mounted on or recessed into the lower surface of service station canopies shall be fully shielded and utilize flat lenses.
C. Total Under-Canopy Output: The total light output used for illuminating service station canopies, defined as the sum of all under-canopy initial bare-lamp outputs in lumens, shall not exceed 430 lumens per square meter (forty lumens per square foot) of canopy in Lighting Zones E3 and E4, and shall not exceed 215 lumens per square meter (twenty lumens per square foot) in Lighting Zones E1A, E1 and E2. All lighting mounted under the canopy, including but not limited to luminaires mounted on the lower surface or recessed into the lower surface of the canopy and any lighting within signage or illuminated panels over the pumps, is to be included toward the total at full initial lumen output.
C. The lumen output of lamps mounted on or within the lower surface of a canopy is included toward the lumen caps in Section 4.2 according to the method defined in Section 16.30. Other lighting located under a canopy but not mounted on or within the lower surface is included toward the lumen caps in Section 4.2 at full initial output.
Note 9.14: LPS/other lamp type mix for color rendition with LPS energy savings
Note 9.15: Further information on canopy lighting
6.4 Other Lighting on Parcels with Special Uses. All lighting not directly associated with the special use areas above shall conform to the lighting standards described in this Code, including but not limited to the lamp type and shielding requirements of Section 4.1 and the lumens per acre limits of Section 4.2. The net acreage for the determination of compliance with Section 4.2 shall not include the area of the athletic field or outdoor display lot, as defined in Section 16.26; the area of any service station canopy **shall** be included in the net acreage.

Section 7. <u>Submission of Plans and Evidence of Compliance with Code, Subdivision Plats.</u>
7.1 Submission Contents. The applicant for any permit required by any provision of the laws of this jurisdiction in connection with proposed work involving outdoor

lighting fixtures shall submit (as part of the application for permit) evidence that the proposed work will comply with this Code. Even should no other such permit be required, the installation or modification (except for routine servicing and same-type lamp replacement) of any exterior lighting shall require submission of the information described below. The submission shall contain but shall not necessarily be limited to the following, all or part of which may be part or in addition to the information required elsewhere in the laws of this jurisdiction upon application for the required permit:

A. plans indicating the location on the premises of all lighting fixtures, both proposed and any already existing on the site;

B. description of all lighting fixtures, both proposed and existing. The description may include, but is not limited to, catalog cuts and illustrations by manufacturers (including sections where required); lamp types, wattages and initial lumen outputs;

C. photometric data, such as that furnished by manufacturers, or similar showing the angle of cut off of light emissions.

7.2 Additional Submission. The above required plans, descriptions and data shall be sufficiently complete to enable the designated official to readily determine whether compliance with the requirements of this Code will be secured. If such plans, descriptions and data cannot enable this ready determination, the applicant shall additionally submit as evidence of compliance to enable such determination such certified reports of tests as will do so provided that these tests shall have been performed and certified by a recognized testing laboratory.

7.3 Subdivision Plats. If any subdivision proposes to have installed street or other common or public area outdoor lighting, submission of the information as described in Section 7.1 shall be required for all such lighting.

7.4 Lamp or Fixture Substitution. Should any outdoor light fixture or the type of light source therein be changed after the permit has been issued, a change request must be submitted to the designated official for approval, together with adequate information to assure compliance with this Code, which must be received prior to substitution.

7.5 Plan Approval. If the designated official determines that the proposed lighting does not comply with this Code, the permit shall not be issued or the plan approved.

7.6 Certification of Installation. For all projects where the total initial output of the proposed lighting equals or exceeds 100,000 lamp lumens, certification that the lighting, as installed, conforms to the approved plans shall be provided by a certified engineer before the certificate of occupancy is issued. Until this certification is submitted, approval for use of a Certificate of Occupancy shall not be issued for the project.

Section 8. <u>Approved Materials and Methods of Construction or Installation/Operation.</u>

8.1 Approval of Alternatives. The provisions of this Code are not intended to prevent the use of any design, material, or method of installation or operation not specifically prescribed by this Code, provided any such alternate has been approved

by the designated official. The designated official may approve any such proposed alternate providing he/she finds that it:
A. provides at least approximate equivalence to that applicable specific requirements of this Code
B. is otherwise satisfactory and complies with the intent of this Code.

Section 9. Prohibitions.
9.1 Sale of Non-Conforming Fixtures and Lamps. The installation, sale, offering for sale, lease or purchase of any outdoor lighting fixture or lamp the use of which is not allowed by this Code is prohibited.
9.2 Laser Source Light. The use of laser source light or any similar high intensity light for outdoor advertising or entertainment, when projected above the horizontal, is prohibited.
9.3 Searchlights. The operation of searchlights for advertising purposes is prohibited.
9.4 Outdoor Advertising Off-Site Signs. Illumination of outdoor advertising off-site signs is prohibited in Lighting Zones E2, E1 and E1A.

Section 10. Temporary Exemption.
10.1 Request; Renewal; Information Required. Any person may submit, on a form prepared by the jurisdiction, to the designated official, a temporary exemption request. The request shall contain the following information:
A. specific Code exemption(s) requested;
C. duration of requested exemption(s);
E. proposed location on premises of the proposed light fixture(s);
B. purpose of proposed lighting;
D. information for each luminaire and lamp combination as required in section 7.1;
F. previous temporary exemptions, if any, and addresses of premises thereunder;
G. such other data and information as may be required by the designated official.
10.2 Approval; Duration. The designated official shall have five (5) business days from the date of submission of the request for temporary exemption to act, in writing, on the request. If approved, the exemption shall be valid for not more than thirty (30) days from the date of issuance of the approval. The approval shall be renewable upon further written request, at the discretion of the designated official, for a maximum of one (1) additional thirty (30) day period. The designated official is not authorized to grant more than one (1) temporary permit and one (1) renewal for a thirty (30) day period for the same property within one (1) calendar year.
10.3 Disapproval; Appeal. If the request for temporary exemption or its extension is disapproved, the person making the request will have the appeal rights provided in Section 12.

Section 11. Other Exemptions.
11.1 Nonconformance
A. Bottom-mounted or unshielded outdoor advertising sign lighting shall not be used beginning five years after enactment of this Code.

B. All other outdoor light fixtures lawfully installed prior to and operable on the effective date of this Code are exempt from all requirements of this Code. There shall be no change in use or lamp type, or any replacement (except for same-type and same-output lamp replacement) or structural alteration made, without conforming to all applicable requirements of this Code. Further, if the property is abandoned, or if there is a change in use of the property, the provisions of this Code will apply when the abandonment ceases or the new use commences.

11.2 State and Federal Facilities. Compliance with the intent of this Code at all State and Federal facilities is encouraged.

11.3 Emergency Lighting. Emergency lighting, used by police, firefighting, or medical personnel, or at their direction, is exempt from all requirements of this code for as long as the emergency exists.

11.4 Swimming Pool and Fountain Lighting. Underwater lighting used for the illumination of swimming pools and fountains is exempt from the lamp type and shielding standards of Section 4.1, though it must conform to all other provisions of this code.

Section 12. Appeals.

Any person substantially aggrieved by any decision of the designated official made in administration of the Code has the right and responsibilities of appeal to the Advisory/Appeals Board of this jurisdiction.

Section 13. Law Governing Conflicts.

Where any provision of federal, state, county, township or city statutes, codes, or laws conflicts with any provision of this Code, the most restrictive shall govern unless otherwise regulated by law.

Section 14. Violation and Penalty.

It shall be a civil infraction for any person to violate any of the provisions of this Code. Each and every day or night during which the violation continues shall constitute a separate offense. A fine shall be imposed of not less than fifty dollars nor more than seven hundred dollars for any individual or not less than 100 nor more than ten thousand dollars for any corporation, association, or other legal entity for each offense. The imposition of a fine under this Code shall not be suspended.

Section 15. Severability.

If any of the provisions of this Code or the application thereof is held invalid, such invalidity shall not affect other provisions or applications of this Code which can be given effect, and to this end, the provisions of this Code are declared to be severable.

Section 16. Definitions.

As used in this Code, unless the context clearly indicates otherwise, certain words and phrases shall mean the following:

16.1 *Candela*. Unit of luminous intensity; one lumen per steradian. [This definition is not used in the USA Pattern Code.]

16.2 Class 1 Lighting. All outdoor lighting used for, but not limited to, outdoor sales or eating areas, assembly or repair areas, advertising and other signs, recreational facilities and other similar applications where COLOR RENDITION IS IMPORTANT to preserve the effectiveness of the activity. Designation of lighting as Class 1 requires a finding by the Planning Director of the essential nature of color rendition for the application. Recognized Class 1 uses are: outdoor eating and retail food or beverage service areas; outdoor maintenance areas; display lots; assembly areas such as concert or theater amphitheaters.
16.3 Class 2 Lighting. All outdoor lighting used for, but not limited to, illumination for walkways, roadways, equipment yards, parking lots and outdoor security where GENERAL ILLUMINATION for safety or security of the grounds is the primary concern.
16.4 Class 3 Lighting. Any outdoor lighting used for DECORATIVE effects including, but not limited to, architectural illumination, flag and monument lighting, and illumination of trees, bushes, etc.
16.5 Development Project. Any residential, commercial, industrial or mixed use subdivision plan or development plan which is submitted to the City for approval.
16.6 Direct Illumination. Illumination resulting from light emitted directly from a lamp or luminaire, not light diffused through translucent signs or reflected from other surfaces such as the ground or building faces.
16.7 Directly Visible. Allowing a direct line-of-sight to the light source or lamp.
16.8 Display Lot or Area. Outdoor areas where active nighttime sales activity occurs AND where accurate color perception of merchandise by customers is required. To qualify as a display lot, one of the following specific uses must occur: automobile sales, boat sales, tractor sales, building supply sales, gardening or nursery sales, assembly lots, swap meets. Uses not on this list must be approved as display lot uses by the Planning Director.
16.9 Flood Lamp. A specific form of lamp designed to direct its output in a specific direction (a beam) with a reflector formed from the glass envelope of the lamp itself, and with a diffusing glass envelope: Such lamps are so designated by the manufacturers and are typically used in residential outdoor area lighting.
16.10 Flood Light. A form of lighting fixture designed to direct the output of a contained lamp in a more-or-less specific direction, utilizing reflecting or reflacting elements located external to the lamp. [This definition is not used in the USA Pattern Code.]
16.11 Footcandle. One lumen per square foot. Unit of illuminance. It is the luminous flux per unit area in the Imperial system. One footcandle equals approximately 10 (10.8) lux.
16.12 Full Cutoff Light Fixture. A luminaire light distribution where no light is emitted above the horizontal, and where the intensity at 80 degrees from nadir is no greater than 100 candela per 1000 lamp lumens. [This definition is not used in the USA Pattern Code.]
16.13 Fully Shielded Light Fixture. A lighting fixture constructed in such a manner that all light emitted by the fixture, either directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the luminaire, is projected below the horizontal as determined by photometric test or certified by the

manufacturer. Any structural part of the light fixture providing this shielding must be permanently affixed.
Note 9.16: Shielding and cutoff terminology
Note 9.17: How to recognize fully shielded fixtures
Note 9.18: Fully shielded lights and aiming of adjustable luminaires
16.14 Glare. The sensation produced by a bright source within the visual field that is sufficiently brighter than the level to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility; blinding light. The magnitude of glare depends on such factors as the size, position, brightness of the source, and on the brightness level to which the eyes are adapted. [This definition is not used in the USA Pattern Code.]
16.15 Illuminance. The amount of light falling onto a unit area of surface (luminous flux per unit area) - measured in lumens per square meter (lux) or lumens per square foot (footcandles).
16.16 Installed. The attachment, or assembly fixed in place, whether or not connected to a power source, of any outdoor light fixture.
16.17 Light pollution. Any adverse effect of manmade light. [This definition is not used in the USA Pattern Code.]
16.18 Light Trespass. Light falling where it is not wanted or needed, typically across property boundaries.
16.19 Lighting Zones. The five lighting zones are defined on the Lighting Zone Map, by this reference made a part of this Code. A parcel located in more than one of the Lighting Zones described under Section 16.19.A-E shall be considered to be only in the more restrictive Lighting Zone. Guidelines used to guide the delineation of the lighting zones are:
16.19.A Lighting Zone E4. Areas of high ambient lighting levels. This Zone generally includes urban areas with primary land uses for commercial, business and industrial activity, including highway commercial and downtown districts.
16.19.B Lighting Zone E3. Areas of medium ambient lighting levels. This Zone generally includes suburban residential areas, though neighborhood commercial or industrial parcels largely surrounded by suburban residential uses will often be included.
16.19.C Lighting Zone E2. Areas of low ambient lighting levels. This Zone generally includes rural residential and agricultural areas, but may also include small outlying neighborhood commercial and industrial areas surrounded by rural residential areas.
16.19.D Lighting Zone E1. Areas with intrinsically dark landscapes. This Zone includes all areas within fifty (50) kilometers (31 miles) of astronomical observatories and within ten (10) kilometers (6 miles) of local or national park boundaries, as well as the parks themselves. In these areas the preservation of a naturally-dark environment, both in the sky and in the visible landscape, is considered of paramount concern. This Zone may also include rural areas, including rural residential areas, that have identified preservation of natural darkness as a high priority or other areas where the preservation of a naturally dark landscape is of utmost priority.

16.19.E Lighting Zone E1A. Areas within twenty (20) kilometers (12 miles) of astronomical observatories. In these areas both the preservation of a naturally-dark sky and the emphasis on low-pressure sodium lighting is considered of paramount concern.
Note 9.19: Defining lighting zones: definitions from other codes
16.20 Lumen. Unit of luminous flux; used to measure the amount of light emitted by lamps.
16.21 Luminaire. The complete lighting assembly (including the lamp, housing, reflectors, lenses and shields), less the support assembly (pole or mounting bracket); a light fixture. For purposes of determining total light output from a luminaire or light fixture (see Table 4.1), lighting assemblies which include multiple unshielded or partially shielded lamps on a single pole or standard shall be considered as a single unit.
16.22 Luminous tube. A glass tube filled with a gas or gas mixture (including neon, argon, mercury or other gasses), usually of small diameter (10-15 millimeter), caused to emit light by the passage of an electric current, and commonly bent into various forms for use as decoration or signs. A "neon" tube. Does not include common fluorescent tubes.
16.23 Lux. One lumen per square meter. Unit of illuminance. It is the luminous flux per unit area in the metric system. One lux equals approximately 0.1 (0.093) footcandles.
16.24 Multi-Class Lighting. Any outdoor lighting used for more than one purpose, such as security and decoration, such that its use falls under the definition of two or more Classes as defined for Class 1, 2 and 3 Lighting.
16.25 Neon tube. See Luminous Tube.
16.26 Net Acreage. The remaining area after deleting all portions for proposed and existing streets within a development parcel or subdivision. For parcels including those special uses listed in Section 6 that are exempted from the lumens per acre caps of Section 4.2 (recreational facilities and outdoor display lots), the area devoted to the special use shall also be excluded from the net acreage.
Note 9.20: Sub-parcel developments
16.27 Obtrusive Light. Same as Light Pollution. [This definition is not used in the USA Pattern Code.]
16.28 Opaque. Opaque means that a material does not transmit light from an internal illumination source. Applied to sign backgrounds, means that the area surrounding any letters or symbols on the sign either is not lighted from within, or allows no light from an internal source to shine though it.
16.29 Outdoor light fixture. An outdoor illuminating device, outdoor lighting or reflective surface, luminous tube, lamp or similar device, permanently installed or portable, used for illumination, decoration, or advertisement. Such devices shall include, but are not limited to lights used for:
A. parking lot lighting;
B. roadway lighting;
C. buildings and structures;
D. recreational areas;
E. landscape lighting;

F. billboards and other signs (advertising or other);
G. product display area lighting;
H. building or structure decoration;
I. building overhangs and open canopies.
16.30 Outdoor Light Output, Total. The initial total amount of light, measured in lumens, from all lamps used in outdoor light fixtures. Includes all lights and luminous tubing used for Class 1, Class 2, Class 3 and multi-Class lighting, and lights used for external illumination of signs, but does not include lights used to illuminate internally illuminated signs or luminous tubing used in neon signs. For lamp types that vary in their output as they age (such as high pressure sodium, fluorescent and metal halide), the initial lamp output, as defined by the manufacturer, is the value to be considered. For determining compliance with Section 4.2 [Total Outdoor Light Output] of this Code, the light emitted from lamps in outdoor light fixtures is to be included in the total output as follows:
A. outdoor light fixtures installed on poles (such as parking lot luminaires) and light fixtures installed on the sides of buildings or other structures, when not shielded from above by the structure itself as defined in parts B, C and D below, are to be included in the total outdoor light output by simply adding the initial lumen outputs of the lamps;
B. outdoor light fixtures installed under canopies, buildings (including parking garage decks), overhangs or roof eaves where all parts of the lamp or luminaire are located at least five (5) feet but less than ten (10) feet from the nearest edge of the canopy or overhang are to be included in the total outdoor light output as though they produced only one-quarter (0.25) of the lamp's rated initial lumen output;
C. outdoor light fixtures installed under canopies, buildings (including parking garage decks), overhangs or roof eaves where all parts of the lamp or luminaire are located at least ten (10) feet but less than thirty (30) feet from the nearest edge of the canopy or overhang are to be included in the total outdoor light output as though they produced only one-tenth (0.10) of the lamp's rated initial lumen output.
D. outdoor light fixtures installed under canopies, buildings (including parking garage decks), overhangs or roof eaves where all parts of the lamp or luminaire are located thirty (30) or more feet from the nearest edge of the canopy or overhang are not to be included in the total outdoor light output. Such lamps must however conform to the lamp source and shielding requirements of Section 4.
Note 9.15: Further information on canopy lighting
16.31 Outdoor Recreation Facility. An area designed for active recreation, whether publicly or privately owned, including, but not limited to, baseball diamonds, soccer and football fields, golf courses, tennis courts, and swimming pools.
16.32 Person. any individual, tenant, lessee, owner, or any commercial entity including but not limited to firm, business, partnership, joint venture, or corporation.
16.33 Searchlight. A lighting assembly designed to direct the output of a contained lamp in a specific tightly focussed direction (a beam) with a reflector located external to the lamp, and with a swivelled or gimballed mount to allow the assembly to be easily redirected. Such lights are used commonly to sweep the sky for advertisement purposes.

16.34 Sign, Externally Illuminated. A sign illuminated by light sources from the outside.
16.35 Sign, Internally Illuminated. A sign illuminated by light sources enclosed entirely within the sign cabinet and not directly visible from outside the sign.
16.36 Sign, Neon. A sign including luminous gas-filled tubes formed into text, symbols or decorative elements and directly visible from outside the sign cabinet.
16.37 Sky Glow. The brightening of the night sky that results from the scattering of artificial visible radiation from the constituents of the atmosphere. [This definition is not used in the USA Pattern Code.]
16.38 Spot Lamp. A specific form of lamp designed to direct its output in a specific direction (a beam) with a reflector formed from the glass envelope of the lamp itself, and with a clear or nearly clear glass envelope: Such lamps are so designated by the manufacturers, and typically used in residential outdoor area lighting.
16.39 Spot Light. A lighting assembly designed to direct the output of a contained lamp in a specific tightly focussed direction (a beam) with a reflector located external to the lamp. [This definition is not used in the USA Pattern Code.]
16.40 Temporary Lighting. Lighting which does not conform to the provisions of this Code and which will not be used for more than one thirty (30) day period within a calendar year, with one thirty (30) day extension. Temporary lighting is intended for uses which by their nature are of limited duration; for example holiday decorations, civic events, or construction projects.
16.41 Use, Abandonment of. The relinquishment of a property, or the cessation of a use or activity by the owner or tenant for a period of six months, excluding temporary or short term interruptions for the purpose of remodeling, maintaining, or otherwise improving or rearranging a facility. A use shall be deemed abandoned when such use is suspended as evidenced by the cessation of activities or conditions which constitute the principle use of the property.

8 Pattern Code Section Overviews

Section 1 Overview: Purpose and Intent

This section sets out the purpose of the lighting code, briefly sketching the problems that are to be addressed. In some jurisdictions, this section has been used as an introduction to the general issues of light pollution. If there are explanations desired for the specific approaches or details within the code, they may be worked in to this section. Other codes keep such explanatory text to a minimum. A clear explanation of the purpose and intent can serve as a guide when unusual or unanticipated situations arise that may not be explicitly addressed in the code.
Go to Section 1

Section 2 Overview: Conformance with Applicable Codes
A standard section stating that the lighting code shall be applied in conjunction with other relevant codes within the jurisdiction.
Go to Section 2

Section 3 Overview: Applicability
This is an important section, defining what lighting the code will apply to. Issues of ownership (private, public, commercial, governmental), output, use, and grandfathering can all affect whether and how the lighting is addressed by the lighting code. All codes will apply to lighting installed after the effective date of the code, but many exempt public roadway lighting, some exempt fixtures containing lamps below a certain output level, and the approach to lighting in place before the code is adopted differs considerably from jurisdiction to jurisdiction.
An exemption for public roadway lighting, as shown here, is a practical issue related to the detailed specifications often used for such lighting. These are usually addressed by engineering standards (see *Roadway Lighting* and *Note 9.01: Roadway Lighting Standards*). It is not intended to imply that roadway lighting should not be held to high modern standards of quality lighting design.
Codes that exempt low-output fixtures seek to simplify the application of the code by avoiding restrictions and evaluation of such fixtures, which are regarded by some as having minimal obtrusive impacts even if they are poorly utilized. Such low-output fixtures are however a principle source of trouble and complaint in darker surroundings such as residential areas and particularly rural areas. Further, such an exemption in practice has often led to a tendency to use more poorly-designed and obtrusive low-output fixtures to avoid regulation, when the job would have been much better realized with higher output, higher quality fixtures. The USA Pattern Lighting Code recommends that all lights are addressed; some restrictions are relaxed for lower outputs, but they are not entirely excluded from consideration.
Regarding existing lighting, approaches vary from requiring immediate conformance of all lighting, including previous installations, to never requiring conformance of previous installations. The available options here will be constrained by many factors, including the state constitution, case law and precedent, political will, and community desires. If in-place lighting is given any different treatment, then the code is defining so-called "grandfather" rules for such lighting. During the period that such special rules apply, such lighting is said to be "grandfathered." Commonly, codes eventually require conformance of all lighting, usually after a period of time of from a few to ten years (a so-called sunset clause). Permanent grandfathering of old lighting installations will cause ongoing enforcement problems. In principle all old lighting will eventually be changed, because the fixture breaks, the site is re-developed or just redesigned. But in practice what often happens is that such lighting will be replaced piece-meal, and no permit is taken for the replacement or upgrade, and therefore no review is done and the replacement will often be as bad as the old lighting. Further, lighting will often be simply added to sites with grandfathered lighting. Though replacing or adding

lighting without approval is not allowed the way most codes are written, in practice someone must first notice. But even if someone notices that the lighting has been changed or supplemented, on a grandfathered site there may exist no documentation of the previous lighting, and the situation can degenerate to one person's or group's word against another. Such situations are economically and politically costly and should be avoided if possible by including a sunset clause in the code. If after ten years (for example) all old lighting must be brought into compliance, then there is no question - if the light is non-compliant, it is a violation; no-one has to prove when it was installed. The costs of bringing lighting into compliance will in many cases be offset by decreased operational costs associated with higher-quality modern lighting, and by the improved quality of the lighting.
The USA Pattern Lighting Code takes a conservative approach, requiring all old lighting to be brought into compliance only if the site or the lighting is significantly modified, or if the site resumes use after an extended period of unuse - abandonment in the parlance of the code. This approach originates in Arizona lighting codes, which are severely constrained by state law and precedent in their ability to impose sunsets. Because of this, the problems described above remain a serious issue for these codes. If sunsets are feasible in your jurisdiction, they are to be strongly recommended. But the extreme approach of requiring immediate compliance, even if legally possible, is not recommended. Generally a period of from five to ten years has been found practical in many areas.
Finally, some codes have been applied only to public or commercial lighting, exempting private (residential) and sometimes governmental lighting. Though residential standards have practical difficulty in application and enforcement (see *Residential Lighting*), lighting codes should address this lighting also, since it can have large obtrusive impacts in residential areas. Exempting lighting at governmental installations sends entirely the wrong message, and is strongly discouraged. Though governmental agencies of higher rank than the level at which the lighting code is enacted are not legally constrained by the code, publicly owned facilities, especially those owned by the community, should lead the way in conforming to their own codes, and demonstrate the advantages of quality lighting for all lighting users.
Go to Section 3

Section 4 Overview: Shielding and Total Outdoor Light Output Standards
This is the principle section defining lighting standards. Spend considerable time here to make sure the meaning and implications of the standards are understood. Outdoor lighting is tremendously diverse, with thousands of users with thousands of purposes and ideas. Be careful not to focus so strongly on one type of lighting that the code becomes impractical or impossible for other types. Persons have lots of ideas of how to light and what lighting is for - be careful in defining standards that you do not constrict their ability to do what they want any more than is justified by the wider community impacts of the practices.

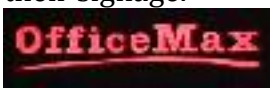
Though much of the lighting in a community is used for the relatively simple applications of roadway and parking lot lighting, providing reasonable standards for the remaining lighting can be the source of lots of code text and exceptions. Exceptions require skillful crafting, of they can create immense problems and "loopholes" where poor lighting practices are inadvertently allowed, or even encouraged, along with the intended exception.
Go to Section 4

Section 5 Overview: Outdoor Advertising Signs
Most civil regulations affecting signage will be contained in a Sign Code, and coordination of lighting aspects of signage addressed in the Outdoor Lighting Code with the Sign Code is essential. It is a good idea to include a reference within the sign code to this section of the lighting code, and *vice versa*.
But lighting of signs is an important lighting issue. After area lighting, commercial sign lighting is one of the largest sources of light in commercial districts. The uplight, glare, and aesthetic impacts of signage depend very strongly on the design of the sign and its lighting.

The USA Pattern Lighting Code includes requirements that all exterior lighting for signage be down-directed, with shielding and lamp type standards the same as for any other lighting. Some billboard manufacturers or operators may claim that such lighting cannot be done or is impractical, but many jurisdictions have been successful in requiring such lighting. Some jurisdictions (Flagstaff and Coconino County, as well as the state of Vermont) either prohibit lighting of such "off-site" signs (off the site of the advertised business), or prohibit such signs altogether. The USA Pattern Lighting Code includes a prohibition against lighting of off-site signs in some areas (Section 9.4).
Internally illuminated signs are by their nature unshielded light sources; in communities with good shielding practice, the light emanations from such signs are a major remaining source of direct uplight. Styles of signage with decreased background luminance can greatly reduce overall sign lighting outputs at the same time that they improve legibility and advertising effectiveness.

White-background signs or signs with yellow or other bright backgrounds, with darker text, produce the greatest amount of light. Further, such signs are often sources of glare and visual clutter in commercial districts and especially in rural areas, while their effectiveness at transmitting information is often very poor, particularly to the aging eye.

Colored backgrounds with lighter text and symbols often convey information more effectively and attractively, at the same time that overall light output is reduced to typically one-half or one-fourth of a white-background sign of the same size. Even the common "reader panels" (as here located below) with changeable text can be fitted internally with colored films to reduce the output by substantial amounts without compromising the visibility of the text. Moveable letters constructed with clear letters on black or colored tiles are also available, and are used by several national motel chains seeking better legibility and a higher-quality appearance to their signage.



Most efficient of all are signs with opaque backgrounds (or no backgrounds) - these signs can have extremely good legibility but produce often less than one-tenth the light output of the white background sign of equivalent size.
Go to Section 5

Section 6 Overview: Special Uses

These are relatively uncommon, mostly high-intensity lighting uses with large potential obtrusive impacts that justify special treatment. The USA Pattern Code requires professional design for some, which can have large cost implications. The temptation to include such technical and specific restrictions in the lighting code for many uses should be resisted, since such a path can lead to inflexibility and the jurisdiction trying to specify, understand and enforce designs and specifications that professional lighting designers take years to learn.

High-intensity lighting systems, such as those used for many sports activities, can have tremendous impacts on nearby properties, and even on properties up to considerable distances if the design is poor. The requirements for high levels of illumination, combined with the large areas to be illuminated and the large setback distances necessary to keep the lighting poles away from the field, together combine

to make it extremely challenging for designers to keep lighting and glare levels in the surrounding areas under good control.
For these reasons, good community land-use planning attempts to avoid the juxtaposition of such uses with uses that are adversely affected by this spill light, principally residential uses. Glare into nearby roadways can be a significant public safety hazard and must also be carefully considered. Even with such planning, trespass and glare can be very obtrusive, even hazardous, unless the utmost care and skill is utilized in the selection of luminaires and the design.
The USA Pattern Lighting Code requires that some Special Uses (athletic fields and display lots) be designed and certified after construction by a registered engineer. This approach avoids the necessity of having planning staff trained to evaluate such technical lighting designs. Though such a requirement has significant cost implications, the budgets for such projects are already usually large, and the relative impact of the professional design is therefore relatively small. Service station canopy lighting is an exception, which is addressed though lumens per square foot caps similar to the lumens per acre caps of Section 4.2, an approach easily handled by planners untrained in lighting design.
Codes that attempt to restrict pole heights can give unexpected negative results, in sports lighting or in any area lighting (see *Should a lighting code limit pole heights?*). The use of short poles can in some cases be accommodated by increasing the number of poles, though this will increase the cost. But overly restricting the height, especially in sports lighting, in an attempt to decrease the obtrusiveness of the poles against the landscape, or even in an attempt to reduce the spread of the light into neighboring areas, can in fact cause the lighting to be more obtrusive by forcing the designer to aim the lights closer to the horizon in an attempt to adequately illuminate areas located far from the poles.
Go to Section 6

Section 7 Overview: Submission of Plans and Evidence of Compliance with Code, Subdivision Plats
Here is the functional heart of the lighting code - the information required must be both relatively easy to come by, simple to understand for planning staff, and sufficient to assure compliance with the standards of the lighting code. There is a delicate balance between these aspects. Forms to collect the information required are included in the *Appendix A: Administrative Forms.*
Go to Section 7

Section 8 Overview: Approved Materials and Methods of Construction or Installation/Operation
This section provides a method for addressing any lighting designs or developments that have not been addressed in the code. As written in the USA Pattern Code, it provides a no-cost approach for innovations that otherwise would have to be

addressed through the jurisdiction's variance procedures. It is not often used in most codes.
Care must be exercised in deciding who will make the decision in these cases. As written here, the local planning official is suggested as most appropriate, since an official employed by the community is charged with overseeing the community's interests in evaluating the proposal. If there is a need for technical evaluation beyond the expertise of the designated official, outside advice can be solicited from the local lighting advisory group (see *Ongoing education in outdoor lighting*), or from a professional lighting designer hired for the occasion. Some codes have allowed lighting designers employed by the lighting permit applicant to determine the appropriateness of the suggested design or hardware. Though such persons may be well trained in the arts of lighting design, since they are employed by interested parties (i.e. the developer), they may not have the best interests of the community foremost on their agenda. Such conflicts or potential conflicts of interest should be avoided if possible.
Go to Section 8

Section 9 Overview: Prohibitions
Beyond the lighting standards detailed in the code, it is useful to address some specific areas that may arise. As a practical concern, to improve compliance especially in situations where permits are not taken or required, the sale of non-conforming fixtures is prohibited. This kind of wording has proved useful in informing retailers about lighting issues and making sure that they offer only fixtures that conform to the community's standards for outdoor lighting.
Go to Section 9

Section 10 Overview: Temporary Exemption
Some users of temporary lighting cannot reasonably work within the constraints of the lighting code. Examples are nighttime highway construction crews and carnivals. This section provides an avenue to address the issues that can be addressed (highway crews can exercise care in the direction they aim the floodlights, for example), and a way of limiting the time-span for such lighting.
Go to Section 10

Section 11 Overview: Other Exemptions
Section 11.1 specifies the grandfather rules for previously installed non-conforming lights. See also Section 3, which describes how the standards apply to new lighting and the conditions under which lighting is considered to be new.
Section 11.2 concerns the issue of eminent domain - state and federal bodies are not legally constrained by local codes, and they of course know this. In many areas

though such organizations will cooperate with the local planning bodies, submitting building plans for example as a courtesy for review. This subsection simply states that such a process is encouraged for lighting as well. The effective way to make sure it happens, though, is to have your representatives (city council, county supervisor, etc.) make contact with the local representatives of any state or federal operations, inform them of the issues and the code, and gain their personal assurance that they will cooperate with the community. This contact will need renewal on an intermittent basis.
Some municipalities exempt themselves from compliance with lighting codes. It is hard to avoid the impression that the municipality holds itself above the rest of the community when such things are done, and also such a practice sends entirely the wrong message that good lighting is not for everyone. Such exemptions are to be strongly discouraged. In fact, communities should strongly consider programs to bring all publicly owned lighting into conformance with the lighting code, as a leading example for the entire community and an example of the benefits quality lighting can bring.
Go to Section 11

Section 12 Overview: Appeals
This is a standard legal section, and should be modified to conform to the text used in your jurisdiction.
Go to Section 12

Section 13 Overview: Law Governing Conflicts
This is another standard legal section.
Go to Section 13

Section 14 Overview: Violation and Penalty
This is the stick, but it should rarely be pursued to the point of fines. Education is the key. Bad lighting is bad for everyone, good lighting is good for everyone.
But you still need the stick.
Go to Section 14

Section 15 Overview: Severability
A standard legal section.
Go to Section 15

Section 16 Overview: Definitions

Definitions in a lighting code are the vocabulary of effective lighting control and to some extent quality lighting. They must be approached with an understanding of who must understand and use them.

Quality lighting is a complex and evolving subject, practiced by professionals with extensive training in aspects of electrical, photometric and visual science, technology and application. Lighting codes are not intended to replace this training or the extensive professional manuals used by such designers, but instead are primarily intended for use and implementation by planning departments at city and county level.

Lighting codes must be understandable by lighting professionals, however, and they must use terms, if simpler than those used by professionals, at least consistent with them. For those interested in more technical information and definitions, the *IESNA* Lighting Handbook is a valuable resource, as are the Recommended Practices produced by the specialist committees of the IESNA. Another source of definitions is the *IDA IS#9 Glossary of Basic Terms and Definitions*.

Where at all possible, reliance on technical definitions should be avoided in a lighting code. Though a technical definition may be more precise, precision does not help if the person using the definition does not have the training or practical background to understand and apply it. The persons who must understand and use the lighting code are planners, developers, small business owners, homeowners, engineers, and everyday citizens. Only a few of these persons have the training to understand definitions like these:

Full Cutoff Light Fixture. A light fixture with a light distribution where no candela occur at or above an angle of 90 degrees above nadir. Additionally, the candela per 1000 lamp lumens does not numerically exceed 100 (10%) at a vertical angle 80 degrees above nadir. This applies to all lateral angles around the luminaire.

Lumen. The luminous flux emitted within a unit solid angle (one steradian) by a point source having uniform luminous intensity of one candela.

Most don't. There are ways around this kind of problem in almost all cases. For example, the USA Pattern Lighting Code has these definitions:

Fully Shielded Light Fixture. A light fixture constructed in such a manner that all light emitted by the fixture, either directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the luminaire, is projected below the horizontal.

Lumen. Unit of luminous flux; used to measure the amount of light emitted by lamps.

Almost nothing is lost, but now almost all users will be able to understand the definitions.

Much care has gone into many of the definitions in the Pattern Lighting Code, from the long experience gained with the application of real lighting codes. Be careful if you modify any - the implications and interpretations of other users must be a fully appreciated.

The definition section in the USA Pattern Code includes a number of definitions that are not used in the Pattern Code itself, as well as some words that are used in their standard dictionary sense though they may be relatively uncommon. They are included here for completeness, but may not be needed in a working lighting code.
Go to Section 16

9 Notes

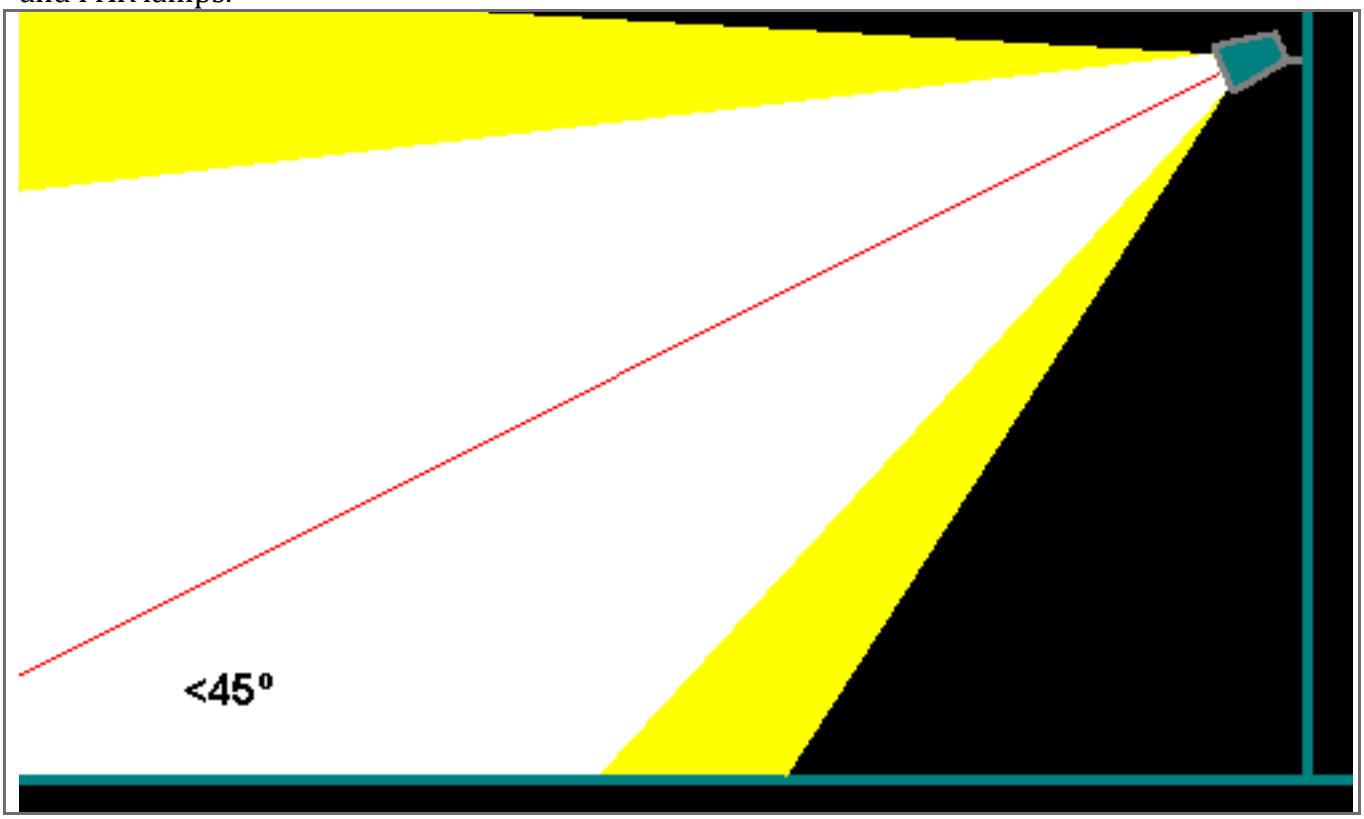
9.01: Roadway Lighting Standards

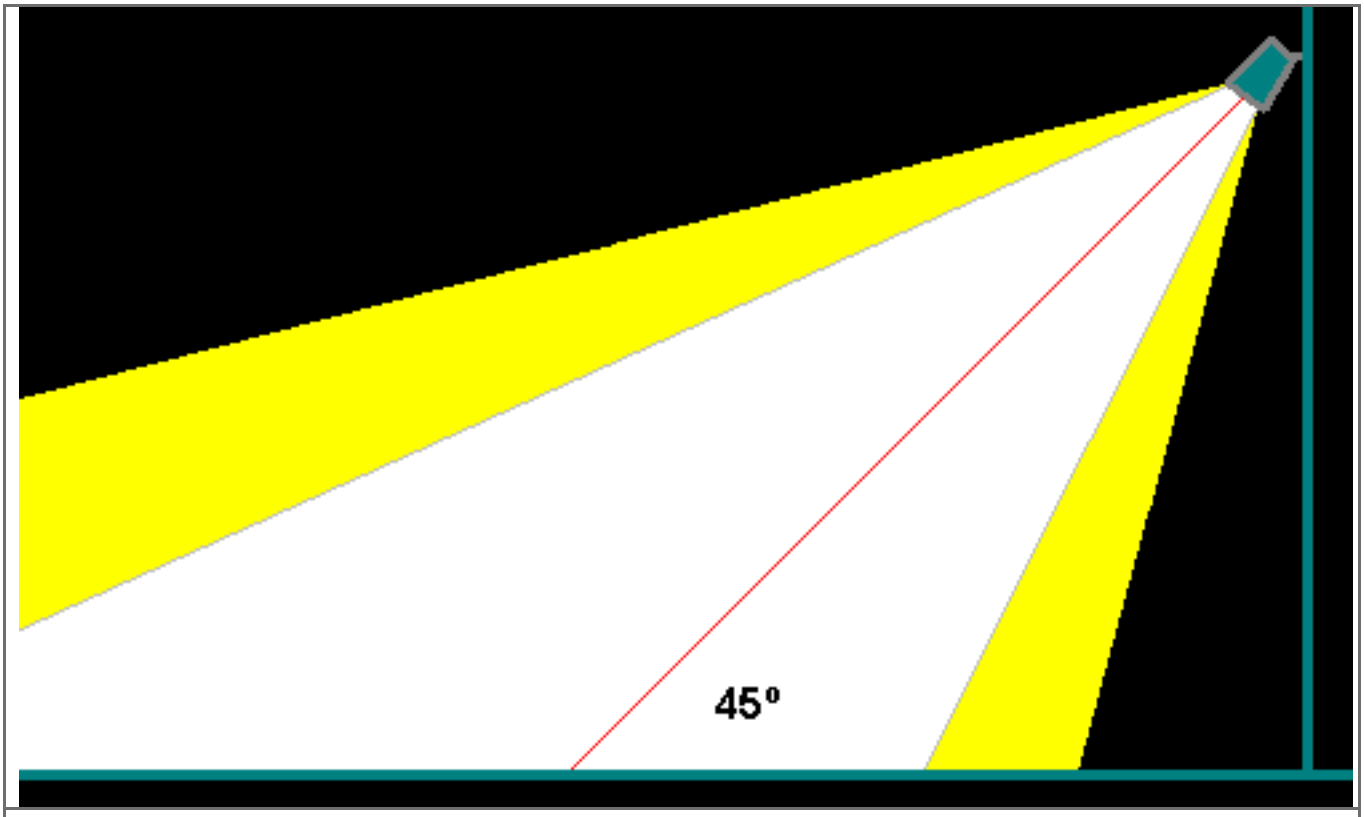
In most communities, roadway lighting is specified by engineering standards (see also *Roadway Lighting*). Such standards may include technical requirements such as average illuminance and uniformity, specific luminaires, mounting heights, pole spacing and location relative to roadsides, curbs or sidewalks, overhangs, lamp types and wattages, even paint or finish colors. The exemption in Section 3 is not intended to imply that roadway lighting need not be of good quality and conform to the goals of the lighting code, but the most appropriate vehicle to address such lighting is often engineering standards. If your community does not have such standards, then the exemption of Section 3.4 should be deleted and an alternative such as below included instead. If it does have relevant engineering standards, then you must work with the engineering department to assure that the standards are consistent with good modern roadway lighting practice and the lighting code (and stay that way!). Roadway lighting should be fully shielded. The use of the most efficient source (LPS) should also be considered. Fixtures with minimal across-road and "house side" waste should be specified, especially in residential areas, and these will depend on details of the roadway geometry and width. If illumination levels are part of the standards, minimum levels consistent with safety and utility should be specified; many communities do not specify any roadway lighting in residential areas, or require it only at potential conflict areas such as intersections, crosswalks, or sharp curves.
It is not unreasonable to include roadway lighting in the lighting code - but it will probably not be sufficient. And if the engineering standards are well written, having roadway lighting included in the general lighting code may be redundant. If you decide that it is desireable to include roadway lighting in the general code nonetheless, and assuming there are engineering standards as well to assure good design for this critical lighting, an alternative Section 3.4 could read:
3.4 Lighting for public roadways is exempt from the provisions of Section 4.2 of this Code, but must conform to all other applicable restrictions in this Code. Such lighting is to be considered Class 2 lighting, and must in all cases use fully shielded fixtures.

If there are no roadway lighting engineering standards in your community, it may be appropriate to create an additional special use under Section 6, and include a detailed set of standards there.

9.02: Origin of 45 Degree Limitation for Spotlights and Floodlights

The figure of 45 degrees is not based on any specific intensity distribution for such lamps, and there is such a tremendous variety of manufacturers and designs for these kinds of lights that a specific figure is difficult to justify based on such distribution patterns. But a 45-degree downward aim will ameliorate the glare from such lights, and it is simple to apply and verify as it is half-way between straight down and straight to the side. As written in the USA Pattern Code, if the output of a lamp is above 2000 lumens, it must be fully shielded; the 45-degree specification will apply to only lower-output lamps, including up to 100 watt incandescent R, ER and PAR lamps.





A 45-degree down-tilt will control the worst glare from floodlights. The illustrated pattern is 40/60 degrees full width at 50%/10% of peak candlepower, a typical PAR-38 floodlight pattern.

9.03: Discussion of 2000 lm Shielding Split

Relaxing shielding standards for low-output lamps increases flexibility for such lamps and fixtures. This may be particularly helpful for residential lighting, where well-shielded fixtures are hard to find and the obtrusive impacts may be considered minimal in many situations. But glare from unshielded lights, particularly in rural areas, can be quite obtrusive, and moving this split to a higher lumen level should only be done after careful consideration. In some communities or some Lighting Zones, consideration may be given to moving the split to 1000 lumens (see *Note 9.06: Shielded porchlights*).

The 2000 lm figure is consistent with the lamp types listed under *Note 9.04: Examples of lamps with 2000 lm and less*. Examples of other figures in use are 2950 lm (found under Class 3 lighting in the Tucson/Pima County/Marana Lighting Code) which is comparable with the output of a 150 watt incandescent lamp, and 4050 lm (in the *Flagstaff Code*), which allows up to a 200 watt incandescent or 50 watt metal halide or high-pressure sodium. This latter figure is probably too high, especially in residential settings, and either of the lower figures or similar is recommended.

An unfortunate and unintended side-effect of this shielding split in lighting codes is that some users may attempt to use lots of low-output poorly shielded lights instead

of fewer high-output shielded lights, perhaps in an attempt at minimizing initial hardware costs or because of a desire to use a particular luminaire with poor optical control because of it's aesthetic appearance. The worst consequences of this tendency (excessive glare and uplight) are mitigated by setting the lumen value of the split no higher than 2000 or 3000 lm, and by having a strict cap on the unshielded lumens per net acre (Section 4.2). But those applying the code should be encouraged to attach real meaning to the definition of "A" in Table 4.1: "all types of fixtures allowed; shielding not required but **highly recommended**..." should mean that unshielded lights, even of low output, should be allowed only if shielded lighting is not practical or feasible. The goal for all general lighting (Class 2) should be 100% fully shielded.

9.04: Examples of Lamps with 2000 lm and Less

The acceptability and shielding restrictions applicable to a particular lamp are decided by its initial lumen output, not wattage; check manufacturer's specifications. Examples of lamp types of 2000 lumens and below are

- 100 Watt Standard Incandescent
- 15 Watt Cool White Fluorescent
- 15 Watt Compact Fluorescent
- 18 Watt Low Pressure Sodium

9.05: Alternative Section 4.1 with LPS Requirement

The use of LPS is encouraged for general illumination (Class 2 lighting) in all Lighting Zones. Certainly, this approach should be used, at least for Lighting Zone E1A as shown here, if there is a major astronomical facility. Extending the requirement to all zones should be considered by any community, whether or not there are astronomical facilities nearby. The benefits of LPS extend beyond the usual arguments made for astronomy (see the discussion of LPS lighting under *What Types of Lamps Are Used in Outdoor Lighting?*).
Replacing Section 4.1 and 4.2 (see *Note 9.09: Alternative section 4.2 with LPS requirement*) in the USA Pattern Lighting Code with the alternative sections would have the effect of establishing an LPS requirement in Zone E1A.
Alternative text for Section 4.1 might read:
4.1 All nonexempt outdoor lighting fixtures shall have shielding as shown in Table 4.1.
Use Codes:
A = all types of fixtures allowed; shielding not required but highly recommended, except that any spot or flood-light must be aimed no higher than 45 degrees above straight down
F = only fully shielded fixtures allowed

X = not allowed

Table 4.1 LAMP TYPE AND SHIELDING STANDARDS

	LIGHTING ZONE				
USE CLASS AND LAMP TYPE	**E4**	**E3**	**E2**	**E1**	**E1A**
Class 1 lighting (Color Rendition):					
LPS greater than or equal to 2000 lumens	F	F	F	F	F
Others greater than or equal to 2000 lumens	F	F	F	F	F
All types below 2000 lumens (2)	A(1)	A(1)	A(1)	F	F
Class 2 lighting (General Illumination):					
LPS greater than or equal to 2000 lumens	F	F	F	F	F
Others greater than or equal to 2000 lumens	F	F	F	F	X
All types below 2000 lumens (2)	A(1)	A(1)	A(1)	F	F
Class 3 lighting (Decorative)(3):					
LPS greater than or equal to 2000 lumens	F	F	X	X	X
Others greater than or equal to 2000 lumens	F	F	X	X	X
All types below 2000 lumens (2)	A(1)	A(1)	F	F	F
Residential lighting (all classes)(4):					
All lamp types greater than or equal to 2000 lumens	F	F	F	F	F
All types below 2000 lumens (2)	A(1)	A(1)	A(5)	A(5)	F

Notes to Table 4.1

1. Flood or spot lamps must be aimed no higher than 45 degrees above straight down (half-way between straight down and straight to the side) when the source is visible from any off-site residential property or public roadway.
2. Exception: seasonal decorations using typical unshielded low-wattage incandescent lamps shall be permitted in all lighting zones from Thanksgiving thru 15 January.
3. All Class 3 lighting shall be extinguished between 11:00pm (or when the business closes, whichever is later) and sunrise.
4. Residential refers to all residential land-use zoning, including all densities and types of housing such as single-family detached and duplexes. Multiple-family residential uses must use standards above for Class 1, 2 and 3 lighting.
5. Any lamp installed on a residential property must be shielded such that the lamp itself is not directly visible from any other residential property.

9.06: Shielded Porchlights

Fully shielded porchlights are hard to find, but available (see *Residential Lighting*). By far most products available on the homeowner market are unshielded, and

designed mostly for daytime (and showroom) appearance. Many well-known retailers carry only unshielded lights.
The standard described under Note 5 to Table 4.1 is stricter than Note 1, and is suggested to be applied on residential property only in the darker mostly rural and residential Lighting Zones (E2, E1 and E1A). These areas are the most sensitive to the glare of unshielded lights. Some alternative approaches would be to have this strict requirement in only the darkest Lighting Zone(s) (for example E1 and E1A), or to modify it to read: "Any lamp over 1000 initial lumens, installed on a residential property, must be shielded such that the lamp itself is not directly visible from any other residential property." The 1000 lumen cutoff would permit unshielded incandescent lamps 60 watts and under (typical of many porchlights), but require 100 watt or higher lamps to be fully shielded (or really just not directly visible from off the property).

9.07: Discussion of Lumens per Net Acre Caps

The approach of limiting lumens per acre is used in large part because of its simplicity of calculation and application, and *to avoid* the wide use of technical specifications and the concomitant imposition of technical training and design complications on planning departments. The limits described in this Handbook intentionally do not specify lighting levels for various uses (see *Should a Lighting Code Specify Lighting Levels?*); the choices of lighting levels and the design details used to meet those goals are left to the expertise of the lighting designer. Establishing a "lumen budget" through lumens per acre caps encourages efficiency and creativity in lighting design.
But a brief discussion of the general implications of these caps for illumination levels is helpful to provide perspective for these unfamiliar limits and their general impacts on lighting levels.
Analyses of recommended lighting practices and many examples of commercial development show that the lumens per acre limits of Table 4.2 for Lighting Zones E4 and E3 (200,000 and 100,000 lumens per net acre) allow sufficient lumens for efficient and safe lighting of outdoor areas with scant impacts on typical lighting designs and practices even in large cities with higher-intensity lighting. The limits for Lighting Zone E2 (50,000 lumens per net acre) may require some adjustments to typical designs to concentrate light, but allow illuminances consistent with recommended practices for low-activity levels (considered by many to be appropriate community-wide for smaller cities and rural areas) with efficient lighting design. The limits for Lighting Zones E1 and E1A are lower than typically used by commercial activities with even low activity levels, and are to large degree incompatible with commercial development without considerable increases in the proportion of land area left unlighted on developed parcels.
An estimate of the average lighting levels with these lumen per acre caps for large area lighting (such as parking lots) can be obtained from the following considerations, starting with per acre raw output lumen totals:

25,000 or 50,000 or 100,000 or 200,000 lumens
If the entire acre (43,560 s.f.) needed illumination, this amount of raw initial lamp lumen output would give these average initial illuminances, assuming a Coefficient of Utilization (CU) of 0.45. (The CU describes how much of the light emitted by the lamp that escapes the fixture and is directed onto the area of interest - in this case, 45%, a figure typical for parking lots of about one acre.)

3 or 6 or 11 or 22 lux
(0.3 or 0.5 or 1.0 or 2.1 footcandles)
Since each parcel is allowed to use the entire *net acreage* to determine the lumen allowance, and since some of the property will not require outdoor illumination (e.g. the building footprint and landscaping), the average values in the lighted areas will be higher than these figures. Light Loss Factors (*LLF*) will dim metal halide lighting to as low as about 55% of the initial values (*LLD*=0.65, *LDD*=0.85) and 62% for high-pressure sodium (LLD=0.73, LDD=0.85), whereas low-pressure sodium will suffer a depreciation of 10% or less (LLD=1.00, LDD> 0.90).
These average illuminances for 50,000 lumens per acre and above compare favorably with IESNA recommendations for roadways, pedestrian areas and parking facilities (assuming average:minimum uniformity ratios somewhat better than the recommended maximum), though public roadway areas and illumination systems are not included in the lumen caps or net acreage as defined in the USA Pattern Lighting Code. At 50,000 lumens per acre, the illumination levels are comparable with IESNA recommended practice for low activity level general parking facilities (see IESNA RP-33) if average to minimum uniformity is 2.5:1 or better.
Codes with lumen per acre caps presently in place include the *Flagstaff* and Coconino County codes, with caps at 25,000, 50,000 and a maximum 100,000 lm/acre; the Cottonwood (Arizona) lighting ordinance with a cap of 100,000 lm/acre in all areas, and the Tucson/Pima County code with caps of 12,500 lm/acre to 300,000 lm/acre, depending on area and lighting type.

9.08: Origin of 5500 Lumen Minimum / Unshielded Cap.

Single-family detached home residential parcels are commonly as small as 1/5 or 1/6 acre, or even smaller. Rural properties are commonly an acre or larger. For larger properties, it is appropriate to scale the lighting allowance with area, since many large parcels will have auxiliary structures such as barns, shops or other outbuildings. But per acre lumen caps appropriate for larger rural properties will give unreasonably small allowances for small suburban or urban lots; conversely, per acre caps appropriate for small lots would give huge allowances for larger properties. The approach in the USA Pattern Lighting Code is to apply per acre caps appropriate for larger properties, and establish minimum values that allow adequate lighting for smaller properties. The minimum is based on the following list of lamps, which might be considered typical for outdoor residential lighting:

2 60W INC porchlight 2 X 855 lm = 1710 lm (Std A incandescent) 6 50W INC floodlights 6 X 590 lm = 3540 lm (GE Std Halogen PAR-38) -------
5250 lm
The limit at 5500 lm rounds out this figure and allows for other manufacturer's lamps. Other values are reasonable, and should be used if the community feels another lamp inventory is more appropriate. Though there may be some concern in allowing such apparently large amounts of lighting for residential uses, remember that most residential lighting is off most of the time. If 5500 lm were to be on all the time, it might be considered obtrusive (but remember the shielding standards in Table 4.1 notes 1 and 5, Table 4.2 note 3, and Section 4.4), but effective ways to address these rare instances, that are not overly restrictive for the majority of users who leave most lights off most of the time, have not been addressed.
So, the minimum amount of lighting allowed for a residential parcel, no matter how small, is 5,500 lumens. Residences will be permitted more than this minimum if the per acre cap is larger. At the lumens per acre caps of Section 4.2, the allowed lumen budget will exceed the minimum 5,500 lumens for parcels of 0.28, 0.55 or 1.1 acre (in Lighting Zones E4, E3-E1, and E1A, respectively).
It is difficult, though not impossible, to find quality shielded luminaires for low-output residential lighting (see the discussions under *Residential Lighting* and *Note 9.06: Shielded porchlights*). The major light pollution impact of such lighting is usually light trespass, and this problem is addressed by requiring all lamps over 2000 lm to be fully-shielded and any flood- or spotlights under 2000 lm to be directed downward 45 degrees when visible from any neighboring property. In the darkest Lighting Zones (E2 and E1), there is the further restriction that all lighting, no matter the output, must not be directly visible from other residential properties (Note 5 to Table 4.1), and in Zone E1A all lighting must be fully shielded. Some communities do require that all lamps used in residential lighting must be fully shielded (as here in Lighting Zone E1A), no matter how low the output; these restrictions can imposed through CC&Rs (Conditions, Covenants and Restrictions) and enforced by the local homeowners' association.

9.09: Alternative Section 4.2 with LPS Requirement

Replacing Sections 4.1 (see *Note 9.05: Alternative section 4.1 with LPS requirement*) and 4.2 in the USA Pattern Lighting Code with the alternative sections would have the effect of establishing an LPS requirement. As implemented here with the 90%/10% LPS/non-LPS split, even Class 1 lighting can often be effectively accomplished under this approach (remember, sports facilities, which could not effectively use this LPS mixture in most situations, are exempt from these caps). The non-LPS caps are set at one-tenth of the overall lumen caps for Lighting Zone E1A. This limit comes from arguments about color perception discussed under *Note 9.14: LPS/other lamp type mix for color rendition with LPS energy savings.*
It is not suggested to have non-LPS caps in residential areas. This is principally because the overall light usage in residential areas is low, LPS is not available in low

outputs usually used in residential lighting (minimum is about 1800 lumens), and there is little selection and availability of luminaires for residential application. Alternative text for section 4.2 might read:
4.2. Total Outdoor Light Output Standards. Total outdoor light output shall not exceed the limits in Table 4.2. Seasonal decorations, permitted between Thanksgiving and 15 January, are not counted toward these limits; lighting used for external illumination of signs is counted, while lighting used for internal illumination of signs is not counted. (The values in this table are upper limits and not design goals; design goals should be the lowest levels that meet the requirements of the task.)

LUMEN CAPS - INITIAL LAMP LUMENS PER NET ACRE
Table 4.2 MAXIMUM TOTAL OUTDOOR LIGHT OUTPUT STANDARDS

	LIGHTING ZONE				
	E4	**E3**	**E2**	**E1**	**E1A**
Commercial and Industrial zoning (1)					
total (shielded + unshielded, LPS + non-LPS)	200000	100000	50000	25000	12500
unshielded only	10000	10000	4000	2000	1000
non-LPS	20000	10000	5000	2500	1250
Residential zoning (2,3)					
total (shielded + unshielded, LPS + non-LPS)	20000	10000	10000	10000	5000
unshielded only	5000	5000	1000	1000	0

9.10: Discussion of Internally Illuminated Sign Colors

Codes which simply prohibit signs with "white backgrounds" have encountered trouble with designers asking if a very slight tint of yellow, cream or other nearly-white color will be allowed. The intention is to encourage the approach where the information on the sign (text and logos) is the more brightly illuminated portion, which leads to better legibility and effectiveness with decreased light outputs. Standards for colored backgrounds that are not "white, off-white, cream or yellow" should encourage this understanding further.

9.11: Off-site Sign Illumination

These signs include typical highway billboards. Some jurisdictions prohibit, in all areas, the lighting of signs that are not located on the same parcel as the advertised business; others prohibit off-site signs entirely (Coconino County, Arizona, and Vermont are examples).

To prohibit lighting of off-site signs, alternative text for section 5 might read
5.1 Externally Illuminated Sign Standards. External illumination for on-site signs (signs located on the same parcel as the business they are advertising or providing information for) shall conform to all provisions of this Code. In particular, such lighting shall be treated as Class 1 lighting and shall conform to the lamp source, shielding restrictions and lumen caps of Section 4.
5.2 Illumination of Off-Site Signs. Illumination of off-site advertising signs (signs located on a different parcel than the business they are advertising or providing information for) is prohibited in all lighting zones.
[Renumber subsequent sections]
An further alternative 5.2 might allow such sign lighting only in the brighter urban districts:
5.2 Illumination of off-site advertising signs is prohibited in Lighting zones E1A, E1 and E2. External illumination for such signs in Lighting Zones E3 and E4 shall be included toward any applicable limits in Table 4.2 for the parcel on which they are actually located.

9.12: Sign Styles with Smaller Light Pollution Impacts

On average, colored-background signs have from 25% to 50% the total light output of white- or light-background signs; opaque background signs have outputs from 5% to 50% of a white-background sign (see the discussion under *Section 5 Overview*).
Though the USA Pattern Lighting Code takes a middle approach (prohibiting only light-background signs), requiring sign styles with lower outputs should be considered, either community-wide or in the darker lighting zones (E2 through E1A). Opaque-background signs not only produce the least light pollution (usually by a wide margin), they are also usually the most legible and therefore most effective for conveying information. Another approach is to require low-output styles (for example opaque background) for signs advertising businesses that are open all night (such as motels, hotels, service stations, etc) or after a particular time of night (such as midnight).
A subsection implementing this latter approach might read:
5.x Internally illuminated signs on after midnight shall be designed with opaque backgrounds and translucent letters and symbols. No colored-background or white-background internally illuminated signs are to be illuminated after midnight. Lighting used inside internally illuminated sign cabinets is not included toward any applicable lumen caps, since the actual amount of light that escapes the sign is variable over a tremendous range (from a percent or less of the lamp lumens to 50% or more, if white-background styles are considered). To fairly include the actual outputs with such variation would require an difficult and complex evaluation of the sign materials and details of the sign construction. Further, since the lamps used inside signs are not visible without opening the sign cabinet, verifying their outputs by planners on site inspection would be very difficult. A simpler and still effective

approach is to require lower output styles (such as colored or opaque backgrounds) and limitations on sign numbers and sizes specified in the local sign code.

9.13: Lumen Cap Exemption For Display Lots

Display lots are exempted from the lumen caps, since the illumination goals for such lots may be difficult to accommodate under the caps.
But at 100,000 lumens per acre and above, lighting for display lots could reach the lower IESNA recommended average illuminance (50 lux or 5 footcandles) relatively easily for substantial portions (20-30% or more) of a parcel, and therefore an exemption may not be necessary if such proportions are judged sufficient. The feasibility of this approach for a given community must be judged on the feasibility of limiting the proportion of a parcel illuminated as a display lot - some car dealerships, for example, illuminate virtually the entire parcel as a display lot, while others brightly illuminate only the front "display" row adjacent to the parcel frontage.
At lower lumens per acre caps the design implications of removing the lumen cap exemption are more severe, meaning that proportionately smaller portions of a parcel could reach the IESNA recommended illuminance or that lower illuminances could be used. Lower illuminances are certainly adequate for safety and visibility of displayed items.

9.14: LPS/Other Lamp Type Mix for Color Rendition with LPS Energy Savings

Though service station canopy lighting could be principally LPS (color perception is not regarded as necessary to pump gasoline), very good color rendition can be obtained with a small amount of broad-spectrum lighting such as fluorescent. Studies have shown (see Boynton and Purl, Lighting Research and Technology, 21:23, 1989) that as little as 10% white light added to LPS light permits nearly normal color perception. This is supported by experience in the Tucson and Flagstaff areas, where LPS lighting is extensively used, and where some luminaires combining both LPS and fluorescent lamps have been used, even at an automobile dealership.
In fact, for most service stations and especially service station / convenience store combinations, white light from auxiliary lighting under the canopy (for example pump banners) or spill light from the store front would usually provide enough white light for quite adequate color perception. Otherwise, if spill light from other sources is insufficient, a few (fully shielded) fluorescent fixtures can be added to the canopy to provide good color perception. If a typical canopy of 55 x 55 feet uses 120,000 lumens total, a 90/10 mix would be obtained by using eight 90-watt LPS lamps (13,500 lumens each) and four 39-watt F48T12/CW cool-white fluorescent lamps (3000 initial lumens each).

Such a mixed-light system would retain most of the energy advantage of LPS, and provide good color perception too. A pure metal halide system producing 120,000 maintained lumens, would require about 2.4 kW; a pure LPS system could provide the same maintained lumen level for about 1.1 kW. A 90% LPS / 10% fluorescent system would use about 1.4 kW. The mixed system uses just over half the energy the pure metal halide system needs. Over one year this would amount to about 2,000 kWh or about $150 in electrical cost savings alone (assuming half night operation). Where is the disadvantage?

9.15: Further Information on Canopy Lighting

Service station canopies are the most conspicuous and common type of canopy, but other canopies are seen for example covering the entrance area and adjacent driveway at hotel or motel entrances. Since these canopies are generally not such a large proportion of a parcel's net acreage as is seen for service stations, they will generally fit easily under the overall lumens per net acre caps of Section 4.1, especially considering the "canopy factors" described in Section 16.30.
Two IDA information sheets discuss issues related to service station canopy lighting:
IDA Information Sheet 150: Uplight Impacts of Canopy Lighting, describes how the position of a fully shielded luminaire under a canopy affects how much light gets into the sky after reflection off the ground. This information lies behind the canopy factors used in the definition of Total Outdoor Light Output (USA Pattern Code Section 16.30).
IDA Information Sheet 151: A Solution to Canopy Overlighting describes lumens per square foot caps for canopies that limit under-canopy illuminances to 5 and 10 footcandles maintained, values recommended by the IESNA. This information lies behind the canopy *lumens per square foot* caps in the USA Pattern Code, Section 6.3.C.
Note that the acreages devoted to special uses that are exempted from the lumens per acre caps of Section 4.2 (athletic fields and display lots) are **not** included in a parcel's net acreage; acreages for non-exempt special uses (service station canopies) **are** included in the net acreage. This is a practical issue of both the intensity required (for athletic fields) and the proportion of the parcel usually covered by the special use, since athletic fields and display lots are often a large portion of the parcel, while service station canopies are not.
Other codes have approached "canopy factors" in a simplified fashion, for example counting all under-canopy lighting at 50% toward lumen caps (Cottonwood, Arizona), regardless of distance from the canopy edge. This is another effective approach.

9.16: Shielding and Cutoff Terminology

There is much confusion surrounding terms used to describe the way luminaires restrict the light emanating from the lamps contained within. Good lighting advocates must learn the minimal set of definitions and endeavor to be careful in usage of the terms.

There are two terms used to describe luminaires or lamps that have no shielding, allowing light to shine unrestricted in all directions: **unshielded** and **noncutoff**. Neither term specifies the intensity distribution in any further detail. Post-top globes, with more than 50% uplight, barnyard or "dusk-to-dawn" lights with perhaps 30% uplight, most porchlights, many drop-refractor "cobrahead" streetlight luminaires - all are unshielded or noncutoff. Some have a greater uplight fraction than others.

The next case of interest, where there is some but not complete restriction of upward emanations, has three terms and three separate definitions, one using the word "shielded" and two using "cutoff":

Partially Shielded: shielded in such a manner that more than zero but less than ten percent of the light emitted directly from the lamp or indirectly from any part of the fixture is projected above the horizontal.

Semicutoff: Intensity at 80 degrees from nadir does not exceed 200 candela per 1000 lamp lumens, nor at 90 degrees from nadir does intensity exceed 50 candela per 1000 lamp lumens.

Cutoff: intensity at 80 degrees from nadir does not exceed 100 candela per 1000 lamp lumens, nor at 90 degrees from nadir does intensity exceed 25 candela per 1000 lamp lumens.

This is where lighting codes and the professional lighting specifications diverge: lighting professionals have reason to address in detail how the light intensity is distributed as it exits the luminaire. But for the principal purposes of uplight elimination we are concerned with in lighting codes, we are much less so. Further, lighting professionals have the training to understand and use the "candela per 1000 lamp lumens" specifications. Most persons administering light codes do not.

Moving on to the case where uplight is completely eliminated, we have the following terms:

Fully Shielded: constructed in such a manner that all light emitted by the fixture, either directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the luminaire, is projected below the horizontal.

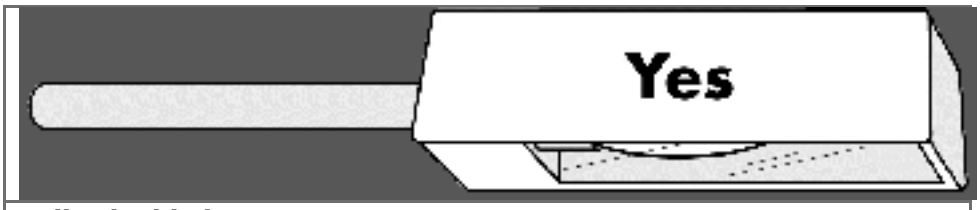
Full Cutoff: A luminaire light distribution where no candlepower occurs at or above an angle of 90 degrees from nadir. Additionally, the candela per 1000 lamp lumens does not numerically exceed 100 at a vertical angle of 80 degrees above nadir. This applies to all lateral angles around the luminaire.

The candlepower per 1000 lamp lumen restrictions at specific angles are important metrics for directly addressing issues of glare. But since the terms require both detailed photometric information and technical expertise to evaluate, in the venue of lighting codes and their implementation using them will make the code difficult to implement and enforce.

This Handbook recommends that lighting codes use the term fully shielded as defined above and in Section 16. Simple elimination of uplight, conforming to the

definition of fully shielded but no further, has been found to give quite good results, certainly for uplight elimination, but even in the reduction of glare. Though the term is somewhat less restrictive than full cutoff, it has practical advantages. You can almost always tell if a luminaire is fully shielded, just by looking at the luminaire as it is installed or at a picture of how it is meant to be installed. This is a great advantage for the administration of a lighting code. You cannot tell by looking if a luminaire is semicutoff, cutoff, or full cutoff. For this you must obtain, and be able to evaluate, reliable technical photometric specifications.
Be careful how you use words to describe shielding. "Shield" is a commonly used term in English, and in common speech and even in luminaire manufacturers' literature anything that blocks any of the light coming from the lamp can be called a shield. But in lighting codes we mean something much more specific when we use the term "fully shielded." So be careful to always say "fully shielded" when you mean that there is no uplight. Not "shielded", not "cutoff", not even "full cutoff". These all have either less-specific or more specific meanings, and using them carelessly only leads to more confusion.

9.17: How to Recognize Fully Shielded Fixtures



Fully Shielded Luminaire

Fully shielded fixtures are technically or photometrically defined as lights that emit *no light above the horizontal direction*, but in practice such fixtures are usually easily recognizable from catalog drawings or pictures without requiring or interpreting photometric specifications. Such fixtures almost always have a *flat, horizontally oriented* lens and *opaque* (usually metal) sides. They are often described as "shoebox" luminaires if the luminaire has a predominantly rectangular form, but they come in many shapes and sizes. There is nothing mysterious about a shielded luminaire - if you can see the lamp or any optical part (a reflector, prismatic lens or even a clear non-prismatic lens) from the side of the luminaire (or any angle above), it is almost certainly not fully shielded. Beware of some fixtures that either have reflecting surfaces or lenses (clear or prismatic) located below the lamp and visible from the side or above, and fixtures that can be mounted such that the shielding is ineffective (see *Swiveled Luminaires (Floodlights)*). Also beware of claims for shielding based on the appearance of the word "shield", "shielded", "cutoff" or similar in the description if the luminaire does not also look obviously fully shielded as described here or as in figures illustrated in *IDA Information Sheet 143*.

The use of the "fully shielded" standard in lighting codes is strongly recommended for the very reason that it is almost always verifiable simply from an examination of an illustration or the luminaire itself.
Rarely, photometric information may be necessary, especially if a catalog illustration is not available or if the illustration looks questionable. Interpretation of technical photometric data is complicated and requires some training. There are also often problems with the completeness and accuracy of photometric data, and recognizing when this might be the case with submitted information is also difficult.
Consultation with a lighting advisory group may be helpful (see *Ongoing Education in Outdoor Lighting*), or other outside technical expertise may be used. The difficulty, time and possible expense involved for such evaluations is one of the principle reasons lighting codes should be written to avoid technical specification if at all possible (for further discussions of this issue see *Note 9.16: Shielding and cutoff terminology* and *Should a Lighting Code Specify Lighting Levels?*).
See also *Note 9.18: Fully shielded lights and aiming of adjustable luminaires*.

9.18: Fully Shielded Lights and Aiming of Adjustable Luminaires

Aimable luminaires - though we specify particular designs as shielded, it is clear that such lights must be properly aimed to maintain the shielding characteristics. Even the best fully-shielded design, if aimed sideways, will become a terrible glare source and a terrible light. Thus there is emphasis in the pattern code on "installed and maintained such that the shielding is effective". Both elements - a fully shielded design and proper aiming - are essential.
See also *Practical Issues and Problem Areas for Lighting Codes*.

9.19: Defining Lighting Zones: Definitions From Other Codes

Lighting Zones define areas where general conditions related to lighting uses are sufficiently different to merit some differences in lighting standards in the lighting code (see *Why Are There Different Standards for Different Areas?*). The most common differentiation made is urban areas versus sub-urban residential and rural areas. The main differences in the USA Pattern Code that depend on Lighting Zone are shielding standards (generally stricter in darker Lighting Zones) and lumens per acre caps (lower for any given land-use type in darker Lighting Zones); see *Section 4* in the Pattern Code.
The locations and boundaries for Lighting Zones must be defined on a case-by-case basis for each community. Factors to consider will include acceptable levels of glare and trespass, practical land-use considerations such as current land-use zoning or long-term community development or growth plans, land ownership, sensitive areas such as parks or observatories, even amounts of forest or other vegetation that might shield lights otherwise visible over longer distances.

Lighting codes using lighting zones or areas are in effect in Tucson and Flagstaff, Arizona, as well as in Pima and Coconino County, Arizona. Astronomical observatories are only one of the reasons for these zones: in Coconino County lighting zone restrictions originally devised for the areas near the local observatories have been extended to both a developed area near Grand Canyon (Tusayan) and to a dark-sky preserve in a remote area near the Navajo Reservation.
From the *Tucson Code* (1986):
"Area A" means the circular area, thirty-five miles in radius, the center of which is the center of the Kitt Peak National Observatory; the circular area, twenty-five miles in radius, the center of which is the center of Mount Hopkins Observatory; while the boundary lines for Area A around Mt. Lemmon are defined as: The Pinal County line on the north, along the center line of the Santa Cruz River, to the center line of the Rillito Creek, to the center line of Tanque Verde Creek with the junction to the northern border of the Saguaro National Monument, then along that border until it ends on the east side and bends east to the County line.
"Area B" means all area outside Area A and outside the territorial limits of every Indian reservation lying wholly or partially within Pima County.
From the *Flagstaff Code* (1989):
Zone I is in two parts centered at the observatories located on Anderson Mesa (Lowell Observatory) and west of Flagstaff (Naval Observatory); the outer boundary of Zone I is set at approximately two and one-half (2.5) miles from these observatories. Zone II extends from the outer boundary of Zone I to approximately seven miles from the observatories. Zone III is all remaining property within the City limits.
The Coconino County Lighting Code is similar to the Flagstaff Code, except that there have been several ammendments to extend stricter standards to areas not associated with the local observatories. Zone II standards (with 50,000 lumens per net acre) have been extended to a large rural residential development located considerably outside of the original Zone II based on a 7 mile distance from an observatory; Zone III standards were extended to Tusayan, Arizona, and a complete set of Zone I/II/III with the same dimensions as in the Flagstaff Code have been added at Roden Crater, an unusual "interactive environmental sculpture" by the artist James Turrell, located about 35 miles northeast of Flagstaff.

9.20: Sub-Parcel Developments

Occasionally, a development project will propose to use only a portion of a legal parcel, leaving the remaing area undeveloped or available for future development. With the definition for Net Acreage included in the USA Pattern Code, such a project may lead to a lumen budget, if based on the entire parcel, that is unreasonably large. In areas where this definition for Net Acreage has been used, this potential problem has rarely arisen. The few times a single parcel has accomodated more than one development, either the different projects were considered and approved at nearly the same time, allowing the lumen budget to be distributed among the projects, or

the planning staff has held the projects administratively to a portion of the lumen budget equal to the portion of the parcel developed.
If it is felt necessary to accomodate such developments within the definition, an alternative definition might read:
Net acreage. The remaining area after deleting all portions for proposed and existing public roadways within a development parcel or subdivision. For parcels including those special uses listed in Section 6 that are exempted from the lumens per acre caps of Section 4.2 (recreational facilities and outdoor display lots), the area devoted to the special use shall also be excluded from the net acreage. For development proposals utilizing less than a full legal parcel, the net acreage includes all area included in the footprint of all structures and site modifications or improvements, such as but not limited to setbacks or buffer areas, parking lots, access drives, landscaping, and sidewalks, plus any applicable setbacks that would apply to further potential developments on the remaining parcel, and after deleting all portions for proposed and existing public roadways.

10 Definitions of Lighting Terms

CU
Coefficient of Utilization. A factor (between 0.0 and 1.0) that describes the fraction of the total lamp lumens that strike the area to be illuminated (the "work plane"). For a roadway, the work plane is the traveled roadway surface and perhaps the shoulder, but not the areas beyond the sides of the road or the median, if present.

HID
High Intensity Discharge (Lamp). An electric discharge lamp in which the light producing arc is stabilized by the arc tube wall temperature, and the arc tube has a bulb wall loading in excess of three watts per square centimeter. HID lamps include mercury vapor, metal halide, and high-pressure sodium.

LLF
Light Loss Factor. Factor (between 0.0 and 1.0) describing light output of a luminaire after losses due to dirt accumulation and lamp lumen depreciation, relative to the output when the lamp and luminaire are new. LLF = *LDD* x *LLD*

LDD
Luminaire Dirt Depreciation. Factor (between 0.0 and 1.0) used to describe how much light produced by the lamp is not lost to dirt accumulation and other changes in the optical characteristics of the luminaire, relative to the value when the

luminaire is new. Depends on the quality of the luminaire, materials used, maintenance, environment.

LLD
Lamp Lumen Depreciation. Factor (between 0.0 and 1.0) used to describe how the lamp output changes with time compared to the initial output. Depends principally on lamp type.

11 References

The IDA Lighting Code Handbook and USA Pattern Lighting Code rely heavily on four lighting codes as principle sources: the 1994 Revised Tucson and Pima County (AZ) Outdoor Lighting Control Ordinances (see *IDA Information Sheet 91*) and the 1999 Revised Flagstaff (AZ) Outdoor Lighting Ordinance (see *IDA Information Sheet 94*) with its Coconino county counterpart in Chapter 17 of the Coconino County Zoning Ordinance. These codes are both presently in their fourth revisions, the Tucson Code having been first adopted in 1973, and updated in 1986 and 1994 with another revision recently completed during the writing of version 1.1 of this Handbook. The Flagstaff Code was first adopted in 1973, and also has been updated in 1989, 1991 and 1999, while the Coconino County Lighting Ordinance was first adopted also in 1973, and updated in 1989 and 1998. These codes have a track record to help establish what does and does not work, and have pioneered most of the approaches to lighting control detailed here. They have served as *de facto* pattern lighting codes for many years. Any community should carefully review these codes, as they show examples of approaches, some more strict, some less strict, than the *USA Pattern Lighting Code* in this Handbook.

Further extensive reference has been made of the professional lighting literature and technical specifications. The Illuminating Engineering Society of North America (*IESNA*; see *IDA Information Sheet 47*) is a professional society of lighting users, designers and manufacturers whose purpose is to establish scientific lighting recommendations and to disseminate this information to all interested parties. It's recommendations are promulgated through the IESNA Lighting Handbook, now in its 10th edition (1999), and in IESNA Recommended Practices (RP). The IESNA RP-33-99 *Recommended Practice for Lighting for Exterior Environments (see IDA Information Sheet 152),* published in 1999, contains extensive discussions on the issues related to outdoor lighting and control of its obtrusive aspects, as well as a professional lighting designer's perspective on essential characteristics of outdoor lighting codes.

The work of the International Commission on Illumination (*Commission Internationale de l'clairage or CIE*; see also *IDA Information Sheet 48*) serves as background for much of lighting and visual science. The CIE is an international body devoted to cooperation and exchange of information among its member countries on all matters relating to the science and art of lighting. The CIE has promulgated

concepts and knowledge essential to lighting and visual science, including the CIE photopic and scotopic sensitivity curves which characterize the spectral sensitivity of the human eye under light- and dark-adapted conditions. An especially useful concept developed by the CIE, extended here in the USA Pattern Lighting Code as Lighting Zones, is the concept of *Environmental Zones.* These zones are used to provide a context for different lighting situations, and are used in the USA Pattern Lighting Code to define differing levels of control to minimize obtrusive aspects of lighting.
Finally, the International Dark-Sky Association (IDA) (and the information concerning a wide variety of lighting issues contained on the IDA website *www.darksky.org/ida*) is behind much of the light pollution control and education effort in the past ten years. IDA is a non-profit, membership-based organization whose goal is to stop the adverse environmental impact of light pollution through education about the value and effectiveness of quality nighttime lighting and about the solutions to the problems. The efforts of this organization and its members have had a tremendous effect, among communities and professional lighting workers alike, on the perception of the aesthetics of the night and the awareness of how lighting practices can enhance or detract from our nighttime environment and activities.

12 Example of an Outdoor Lighting Advisory Committee Proposal

The following proposal was made to the Flagstaff city council and Coconino County Board of Supervisors in 1999. It led to the formation of the Flagstaff and Coconino County Regional Advisory Committee on Outdoor Lighting.

Proposal
For
A Regional Advisory Committee on Outdoor Lighting
(an ad hoc citizens committee of the City of Flagstaff and Coconino County)
What: An advisory committee on outdoor lighting practices and problems, jointly appointed by the City of Flagstaff and Coconino County, comprising approximately 10-15 members including at least two residents of the City of Flagstaff and two residents of Coconino County, plus representation of government entities, commercial interests, citizens, and the professional astronomical community.
Need: Outdoor lighting defines the nature of the nighttime environment in terms of public safety, aesthetics, and the visibility of natural dark skies. Flagstaff, Arizona first enacted lighting controls more than forty years ago, and ten years ago the City of Flagstaff and Coconino County enacted nearly identical updates to outdoor lighting ordinances in order to:

- Minimize light pollution, glare, and light trespass

- Conserve energy while maintaining nighttime safety, utility, security and productivity
- Curtail the degradation of the nighttime visual environment

As a result of these ordinances, our nighttime outdoor environment presents a more congenial face to visitors and citizens than most municipalities can claim. Flagstaff and Coconino County are regarded as having excellent lighting codes. Preserving the darkness of the region's dark skies is listed in Flagstaff s 2020 vision statement as a component of protecting the environment.

Recently, the national press has begun to publicize the disappearance of natural dark skies from most of the nation's municipalities, the enormous energy and dollar costs of wasteful inefficient lighting, and the benefits of improved outdoor lighting. Having begun to address some of these issues long ago, Flagstaff and Coconino County have set a national example in promoting improved outdoor lighting and are in a good position to maintain a leadership position.

For example, full shielding of fixtures minimizes trespass and glare, mandated high efficiency light sources reduce energy waste, and area-lighting restrictions control tendencies toward excessive illumination levels. All of these efforts are fully consistent with internationally recognized recommendations by professional illumination engineers (e.g., IESNA -- The Illuminating Engineering Society of North America).

Despite great progress towards a nighttime outdoor environment free of the most egregious sources of glare and light pollution, there remains a need for:

- Better public awareness of light pollution and its remedies,
- Information about which kinds of lighting fixtures are the best and which kinds to avoid,
- A means of communication between commercial interests, citizens, and government about lighting issues,
- A shared base of technical information about good lighting,
- Progress towards the timely remediation of outstanding light pollution problems,
- An inventory of unresolved outdoor lighting problems and issues,
- A local action plan for implementation of the state-mandated timetable for the elimination of obsolete mercury vapor lighting,
- Promotion of Flagstaff and Coconino County as visitor-friendly region with clear, dark skies.

Tasks: While we envision that tasks will evolve over time to address the needs listed above, there are three general areas where a citizen effort may be profitably employed.

- **Awareness** - to educate the general public and commercial and institutional entities about the problem of light pollution.
- **Information** - to accumulate an organized body of information about lighting practice and technology and to make that information widely available.

- **Action** - to provide a cadre of citizen manpower available to educate, advise, and represent the citizens of Flagstaff and Coconino County on matters related to improved outdoor lighting practices.

Benefits:

- A safe, friendly, natural nighttime environment
- Freedom from glare and trespass
- Appropriately illuminated residential roadways and properties
- A congenial interface between residential and commercial areas
- More effective and efficient commercial lighting
- Avoidance of costly "brighter is better" competition
- Reduced energy consumption

Appendix A: Administrative Forms

Permanent and Temporary Lighting Application, Existing Lighting Inventory and Lumen Output Calculation Sheet

PLANNING DIVISION CITY OF ANYTOWN
PERMANENT AND TEMPORARY LIGHTING PERMIT APPLICATION
EXISTING LIGHTING INVENTORY AND LUMEN OUTPUT CALCULATION SHEET _____
==========
Lighting Permit Check List [ ] Complete this form [ ] Attach manufacturer's catalog cuts (pictures) and specifications (lumen output) for each type of proposed fixture and lamp. [ ] Attach two copies of a site plan showing all proposed and existing outdoor lighting, with all fixtures labeled by type as indicated in the table below under "Plan Key (ID)." [ ] Attach Neon Tube Lighting Lumen Output Calculation Sheet if any neon or luminous tube lighting other than permitted signage is proposed. [ ] Attach Special Use and Roadway Lighting Design and Construction Certification Form if any lighting for outdoor recreational facilities, outdoor display lots or public roadways are proposed. [ ] A $XX non-refundable fee is required. INCOMPLETE APPLICATION SUBMITTALS WILL NOT BE PROCESSED
==========
APPLICANT'S NAME: _____
BUSINESS NAME: _____ PROJECT NAME: _____ CONTACT PERSON: _____ PHONE: _____ PROJECT LOCATION: _____ ASSESSOR'S PARCEL NO.: _____ DATE SUBMITTED: _____ TYPE OF LIGHTING PERMIT:
Permanent [ ] Temporary [ ]

==========
Office Use Only Lighting Permit No: _____ Staff Review: _____ Date: _____ Application Fee Received (date): _____ Receipt No: _____ Action: Approved _____ Conditional Approval _____ Denied _____ Comments/Conditions:
==========
As a reference source, please refer to the Outdoor Lighting Code of this Jurisdiction. CLASS(ES) OF ILLUMINATION PROPOSED (NEW LIGHTING ONLY): Yes No Class 1 Color Rendition ___ ___ Class 2 General Illumination ___ ___ Class 3 Decorative ___ ___ MultiClass ___ ___ SITE ACREAGE: Gross acreage of entire site _____ Acres for Public Right-of-Way - _____ Acres for Special Uses (See Section 6) - _____ Net Acreage of Site _____ LUMEN OUTPUT PERMITTED Project Lighting Zone: Lumen Output Permitted total unshielded Non-LPS Zone E1A: 12,500 lumens x _____ net acres = _____ 1,000 lumens x _____ net acres = _____ 1,250 lumens x _____ net acres = _____ Zone E1: 25,000 lumens x _____ net acres = _____ 2,000 lumens x _____ net acres = _____ 25,000 lumens x _____ net acres = _____ Zone E2: 50,000 lumens x _____ net acres = _____ 4,000 lumens x _____ net acres = _____ 50,000 lumens x _____ net acres = _____ Zone E3: 100,000 lumens x _____ net acres = _____ 10,000 lumens x _____ net acres = _____ 100,000 lumens x _____ net acres = _____ Zone E4: 200,000 lumens x _____ net acres = _____ 10,000 lumens x _____ net acres = _____ 200,000 lumens x _____ net acres = _____ SIGN LIGHTING Yes No Sign Lighting Proposed ___ ___ If yes, indicate type: internal (closed cabinet) [ ] external neon [ ] external flood* [ ] * Note: lamps used for external floodlighting of signs are subject to all restrictions applicable to Class 1 outdoor lighting. Refer to the Lighting Code. In particular, the outputs of the lamps are included toward any applicable lumen output caps. Outputs of internal illumination and neon tube sources in signs are not included toward lumen output caps (see Section 5.3 of the Lighting Code). LIGHTING INVENTORY List the information below for each lamp and luminaire combination to be used for outdoor illumination, including any existing lighting already installed on the site. Do not include streetlights for public right-of-way, athletic field lighting, or display lot lighting: if your project has such uses you must fill out the Special Use and Roadway Lighting Design and Construction Certification Form. If your project includes any non-sign neon or luminous tube lighting, you must fill out the Neon Tube Lighting Lumen Output Calculation Sheet and enter the total output figures for such lighting on this form below. Table Key: Cl: Enter lighting Class: refer to Section 16 of the Lighting Code Watts Each: Enter lamp wattage Lamp Type: Use the following abbreviations for lamp types: LPS low-pressure sodium HPS high-pressure sodium MH metal halide FL fluorescent IN incandescent (including quartz-halogen) Shield: Use the following abbreviations for shielding: F for fully shielded P for partially shielded A for unshielded N/E: Enter "N" for proposed new lighting, and "E"

for existing lighting R/P: Enter "R" for existing lighting that will be removed, and "P" for existing lighting that will be preserved. Lumens Each: Enter initial lumen output of each lamp type List all new or proposed lighting first, then any existing lighting. Include any lighting proposed for external floodlighting of signs. Attach photometric data sheet or manufacture's product description sheet for all F and P lamp/luminaire combinations, both new and existing, showing photometric description to verify upward light control characteristics. If such data are not available for existing fixtures that will be retained, include photographs of the fixtures showing sufficient detail to determine the shielding characteristics. Cl No. Watts Lamp Mfg's Model Plan Key Shield N/E R/P Lumens Lumens Units Each Type & Catalog No. (ID) Each Total

._____.

|__|_____|_____|_____|_____|_____|_____|___|___|_____|_____|

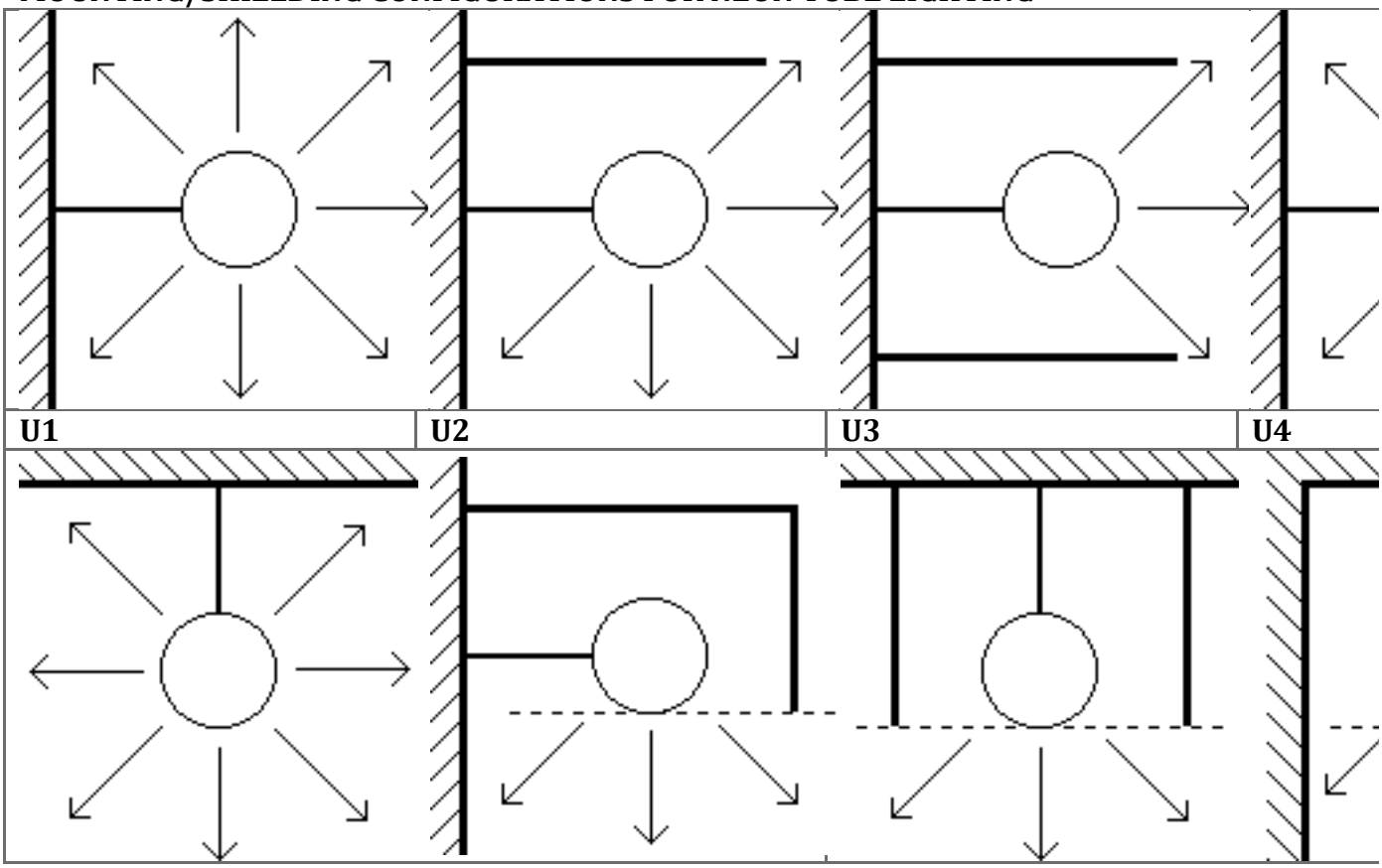
Lumen total existing lighting 1)_____ Lumen total new shielded neon 2)_____ Lumen total new unshielded neon 3)_____ Lumen total new and preserved fully shielded (incl line 2)
4)_____ Lumen total new and preserved partially and unshielded (incl line 3)
5)_____ Lumen total new and preserved all types and shielding (lines 4+5)
6)_____ Project Manager: _____ Approval Date: _____

Neon Tube Lighting Lumen Output Calculation Sheet

PLANNING DIVISION CITY OF ANYTOWN
NEON TUBE LIGHTING LUMEN OUTPUT CALCULATION SHEET
_____ Neon tube lighting varies in its luminous output, depending on fill gases, filtration, phosphor composition, tube diameter and quality. A typical output for good quality tubes is about 300 lumens per linear foot; you may

calculate the luminous output of your proposed neon tube lighting using this figure. If your lighting produces an output below 300 lumens per foot, you may use the actual figure for your tubing provided you supply documentation of the output from the manufacturer or from a photometric testing laboratory. NOTE: decorative neon tube lighting must in general be fully shielded, i.e. the installation must provide shielding that prevents ANY light from the tube from projecting above the horizontal. See the illustrations on the back of this form for an indication of some shielded and unshielded configurations. (Some unshielded lighting is permitted, the amount depending on the Lighting Zone and Land-use Zoning: see the Lighting Code Section 4.2) Indicate for each proposed color of neon tube lighting the following information. Use 300 lm/ft unless a different figure is documented. Shielding types are F (fully shielded) and U (unshielded); also indicate which figure on the back of this form applies to each installation. Color Linear Feet lm/ft Total Lumens Shielding Figure =========
========== ===== ========== ========= _____ _____ X ____ = _____ _____ _____ _____ X ____ = _____ _____ _____ _____ X ____ = _____ _____ _____ _____ X ____ = _____ _____ _____ _____ X ____ = _____ _____
Total Fully Shielded = _____ Total Unshielded = _____

MOUNTING/SHIELDING CONFIGURATIONS FOR NEON TUBE LIGHTING



U5	F1*	F2*	F3*

* Shield in fully shielded configurations (F1 through F3) must extend to level of bottom of neon tube or lower (indicated by dashed line) **at all locations**. Neon tubes running at an angle to the horizontal, such as along the inclined roofline over a gable, will **not** be fully shielded with shields that extend only below the directly adjacent tubing.

Special Use and Roadway Lighting Design and Construction Certification Form

NOTE: Roadway lighting specifications are approached in various ways in various communities. Some communities specify particular average illuminance and uniformity values according to IESNA or AASHTO (American Association of State Highway Transportation Officials) recommendations, or their own values. Some communities have no specific illumination standards but instead have lamp type, pole height and pole spacing standards. The details of the form suggested below will vary accordingly.

PLANNING DIVISION CITY OF ANYTOWN
SPECIAL LIGHTING USE PUBLIC ROADWAY LIGHTING DESIGN AND CONSTRUCTION CERTIFICATION FORM _____
PROJECT: _____ LOCATION: _____ DESIGN CERTIFICATION DATE: _____ CONSTRUCTION CERTIFICATION DATE: _____ TYPE OF LIGHTING USE: Sports Field [ ] Display Lot [ ] Roadway [ ] This form must be completed and signed by a registered engineer, both to certify the design and after construction to certify that construction conforms to the certified design. Attach the following to the completed form for design submittal: 1. For sports or display lot lighting, an illumination plot showing the field or display lot layout, the location of all luminaires used to illuminate the field or display lot, and the maintained illuminance values in the recommended IESNA grid pattern or on a 5' x 5' grid pattern if none is specified by the IESNA. 2. For public roadway lighting, a representative roadway section and lighting calculation showing that the proposed lighting meets required City roadway lighting standards. 2. Manufacturer's catalog cut sheets for each luminaire type proposed. As a reference source, please refer to the Outdoor Lighting Code of this Jurisdiction. Based on the IESNA Recommended Practice or on lighting standards supplied by the City, enter the following: If Sports Lighting, Sport and Class _____ Recommended average maintained illuminance _____ IESNA RP Reference and Date (if applicable) _____ Based on the actual design, enter the following: Designed average maintained illuminance _____ LIGHTING INVENTORY FOR SPECIAL USE AREA AND PUBLIC ROADWAY LIGHTING No. Watts Lamp Mfg's Model Lighting Plan Shielding Lumens Lumens Units Each Type & Catalog No. Key (ID) (F,P or A) Each Total .____.

____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____	This signature certifies that the lighting system described herein conforms to all applicable conditions and restrictions of the ANYTOWN Outdoor Lighting Code. Name _____ Signed _____ Date _____ This signature certifies that the lighting system was build according to the specifications as certified above. Name _____ Signed _____ Date _____ Project Manager: _____ Approval Date: _____

Temporary Lighting Exemption Application Form

PLANNING DIVISION CITY OF ANYTOWN
TEMPORARY LIGHTING EXEMPTION APPLICATION FORM
_____ PROJECT:
_____ LOCATION:
_____ APPLICATION DATE:
_____ Specific exemption requested (Code Section): _____ Duration of exemption (start D/M/Y - end D/M/Y): _____ Purpose of lighting: _____
Reason lighting can not be installed or operated in conformance with the Outdoor Lighting Code: _____
_____
_____ Previous exemptions at this site (Application Date): _____
_____ Previous exemptions to this user (Application Date): _____
_____ Attach a plan diagram showing the proposed location(s) for the proposed lighting. LIGHTING INVENTORY FOR REQUESTED EXEMPTION No. Watts Lamp Mfg's Model Lighting Plan Shielding Lumens Lumens Units Each Type & Catalog No. Key (ID) (F,P or A) Each Total .
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____
____	_____	____	_____	_____	_____	_____	_____	Exemption Status: Approved [ ] Denied [ ] Date: _____ Extension Requested (D/M/Y): _____ Extension Status: Approved [ ] Denied [ ] Date: _____ Designated Official: _____ Date: _____

Appendix B: Example Applications of Section 4.
The shielding standards and lumen caps of Tables 4.1 and 4.2 in the USA Pattern Code are summarized here as they apply for the various land uses in the five lighting zones. The notes to the tables and other subsections of Section 4 affect details of the lighting use, some of which are not shown here.o
Most communities will have only a few of the Lighting Zones included in the USA Patern Code, greatly simplifying the possibilities summarized more completely here.

1. Residential single-home and duplex properties (per parcel)
    - Zone E1A:
        - All lamp types, all outputs must be fully shielded
        - Maximum Lumens:
            - 5,000 lm/AC or 2,300 lm (whichever is greater), all outputs all types
    - Zone E1:
        - All lamps 2000 lm or greater must be fully shielded
        - Any unshielded lights must be less than 2000 lm each and must not be directly visible from any other residential property
        - Maximum Lumens:
            - 10,000 lm/AC or 5,500 lm (whichever is greater), all lights, including up to
                - 1,000 lm/AC or 5,500 lm (whichever is greater), unshielded
    - Zone E2:
        - All lamps 2000 lm or greater must be fully shielded
        - Any unshielded lights must be less than 2000 lm each and must not be directly visible from any other residential property
        - Maximum Lumens:
            - 10,000 lm/AC or 5,500 lm (whichever is greater), all lights, including up to
                - 1,000 lm/AC or 5,500 lm (whichever is greater), unshielded
    - Zone E3:
        - All lamps 2000 lm or greater must be fully shielded
        - Any unshielded lights must be less than 2000 lm each; any flood or spot lamps must be aimed no higher than 45 degrees from straight down
        - Maximum Lumens:
            - 10,000 lm/AC or 5,500 lm (whichever is greater), all lights, including up to
                - 5,000 lm/AC or 5,500 lm (whichever is greater), unshielded
    - Zone E4:

        - All lamps 2000 lm or greater must be fully shielded
        - Any unshielded lights must be less than 2000 lm each; any flood or spot lamps must be aimed no higher than 45 degrees from straight down.
        - Maximum Lumens:
            - 20,000 lm/AC or 5,500 lm (whichever is greater), all lights, including up to
                - 5,000 lm/AC or 5,500 lm (whichever is greater), unshielded

2. Multiple Family, Commercial and Industrial (per parcel)
    - Zone E1A:
        - Class 1: all types and outputs permitted, fully shielded
        - Class 2: all types and outputs permitted, fully shielded
        - Class 3: all types under 2000 lm permitted, fully shielded
        - Maximum Lumens:
            - 12,500 lm/AC, all lights, including up to
                - 1000 lm/AC unshielded lights
    - Zone E1:
        - Class 1: all types and outputs permitted, fully shielded
        - Class 2: all types and outputs permitted, fully shielded
        - Class 3: all types under 2000 lm permitted, fully shielded
        - Maximum Lumens:
            - 25,000 lm/AC, all lights, including up to
                - 2,000 lm/AC, unshielded lights
    - Zone E2:
        - Class 1: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Class 2: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Class 3: all types under 2000 lm permitted, fully shielded
        - Maximum Lumens:
            - 50,000 lm/AC, all lights, including up to
                - 4,000 lm/AC, unshielded lights
    - Zone E3:
        - Class 1: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Class 2: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down

        - Class 3: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Maximum Lumens:
            - 100,000 lm/AC, all lights, including up to
                - 10,000 lm/AC, unshielded lights
    - Zone E4:
        - Class 1: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Class 2: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Class 3: all types and outputs permitted; over 2000 lm must be fully shielded, under 2000 lm no shielding restriction except all spot and flood lamps must be aimed no higher than 45 degrees from straight down
        - Maximum Lumens:
            - 200,000 lm/AC, all lights, including up to
                - 10,000 lm/AC, unshielded lights

Appendix C: Example Lighting Codes

The general approach and details of lighting codes will be affected by varying community interests and values, by the legal structures imposed or chosen, by the size of the town or city of interest, and by the characteristics of the urban and natural landscape within and surrounding the community. As a guide to the real-world solutions to these factors, example lighting codes provide valuable insight when new codes are considered and drafted.

Below are links to four lighting codes chosen to illustrate recent and comprehensive solutions to lighting codes in different sized communities in the USA. Many other codes are available, and can be consulted (see the excellent list of lighting regulations and other related resources on the IDA's Outdoor Lighting Regulations Page web page).

The *Revised Tucson/Pima County Outdoor Lighting Control Ordinance* has been extensively revised as the Tucson/Pima County/Marana Outdoor Lighting Code (the revision is not yet available on the web), and was adopted in Pima County, Arizona, in March 2000. This new lighting code reflects the majority of the approaches described in this Handbook. Tucson is a large metropolitan area (2000 population just under 800,000) in the arid American Southwest, with extensive commercial districts, continuously illuminated interstate freeways, and residential districts spreading into the surrounding areas of Pima County. The premier astronomical

observatories at Kitt Peak, Mount Hopkins and Mount Lemmon are are supported by low-pressure sodium standards and strict limits on the amounts of lighting allowed nearby. In all areas the code has strict shielding standards. Lighting amounts are limited through lumens per acre caps that range from very low to quite high levels (12,500 lm/AC to 300,000 lm/AC), reflecting standards applied for areas from those extremly near the observatories and to the high lighting levels attendant with established urban commercial districts.
The *Revised Flagstaff Arizona Outdoor Lighting Ordinance* is an actively maintained and updated code for a town of about 60,000 residents (2000). Flagstaff also has astronomical facilities located nearby (Lowell Observatory and the U.S. Naval Observatory, located 13 and 8 km (8 and 5 miles) from the town). Further, Lowell observatory was founded nearly at the same time as the town itself, and there is a continuing interrelation between the astronomical community and the community as a whole which helps to maintain a widely based support for dark skies. As a small city that is very supportive of a small-town atmosphere, dark skies and an astronomical heritage, stricter lumens per acre caps (25,000, 50,000 and 100,000 lm/AC max) have been implemented city-wide. Low-pressure sodium is required by the code for most Class 2 lighting, and in the last ten years it has become employed very extensively and it is very well supported by the community. Internally illuminated signs may not utilize light-colored backgrounds, and new billboards have been prohibited for more than fifteen years. Though there are many over-lit service station canopies, due to extensive canopy renovations in the mid 1990s, such lighting for future canopies is now strictly limited to amounts consistent with maintained illuminaices of 50 and 100 lux (5 and 10 footcandles), as recommended in the *USA Pattern Code*. After more than ten years' experience at the level of 50,000 and 100,000 lm/ac the community continues to support these limits vigorously.
As an example of a code recently developed for a smaller town, the Cottonwood, Arizona (2000 population about 9,000) *lighting code* (adopted 1999) has simpler approaches to some issues. There is only a single lumens per acre cap, or one lighting zone, for the entire community (at 100,000 lumens per acre); canopy lumen calculations include all under-canopy lamps, regardless of position, at 50% of initial output. The low-output split in the shielding standards table is at 2050 lumens.

Revision History of the IDA Outdoor Lighting Code Handbook
Below is a brief summary of changes made to the Handbook at each revision. Full digit or tenth-digit updates only are included; minor revisions (indicated as hundredth-digit) include changes to format or HTML bug fixes only, and do not modify the content.

- Ver. 1.0 : 28 April 2000
- Ver. 1.1 : 23 December 2000
    - Roadway Lighting: Revised

- What Types of Lamps Are Used in Outdoor Lighting? Added spectra; LPS subsection: added skyglow and biological system benefits; added links to IS 29 & IS 109
- Practical Issues and Problem Areas for Lighting Codes. Residential Lighting: Added images and paragraph concerning local retailers and shielded lighting. Flag Lighting: added images of fully shielded flag lighting.
- Ongoing Education in Outdoor Lighting. Added references to IDA sections.
- Pattern Code:
  - Added table of contents
  - Added summary phrase to all section and subsections
  - Section 7.1: Add lamp wattage and initial lumen output
  - Definitions:
    - Modified: Outdoor Light Output, Total; Outdoor Light Fixture; Luminaire; Glare
    - Added: Spot Light; Flood Light; Searchlight; Luminous Tube; Neon Tube; Illuminance; Candela
- Notes:
  - Implement new browser invocation for Notes
  - Metric Caps: Deleted
  - Roadway Lighting Standards: Revised
  - Off-site Signs and Illumination: Revised.
  - Defining Lighting Zones: Definitions from Other Codes: Revised
  - Example Applications of Section 4: Moved to Appendix
  - Alternative Section 4.1 with LPS Requirement: Added
  - Porchlights: Added.
  - Sub-Parcel Developments: Added
- Updated all references to new Tucson/Pima County/Marana LC
- Extensive minor format and wording changes and additions, all sections of HB
- Added HB editor contact information
- Added Revision History
- Minor Revisions:
  - Ver. 1.11 : 30 January 2001
  - Ver. 1.12 : 26 October 2001
  - Ver. 1.13 : 27 January 2002
    - Corrected outdoor illuminances section 4.11
  - Ver. 1.14 : 24 September 2002
    - Corrected lux/fc conversion factor errors Pattern Code Section 16

Comments

Comments on this document are welcome and encouraged. Anyone using this Handbook to write or update an outdoor lighting code may find errors, deficiencies,

or new and more effective solutions to some of the many problems of light pollution. This is an evolving document, and your experience and input can help improve it. Please send your comments to the Handbook Editor.

This handbook was written by the IDA Model Outdoor Lighting Code Committee (C. Luginbuhl (chair), D. Crawford, D. Davis, P. Ianna, L. Leetzow, C. Monrad, D. Oesper, A. Upgren, C. Walker, J. Walker) with additional input and consultation from N. Clanton, T. McGowan, M. Mutmansky, and C. Barron. Revisions have benefited from the input of many participants at IDA workshops on this Handbook and from users, and the Committee expresses appreciation for the many helpful and insightful comments received from these many sources, too many to list here. This document will continue to be revised as the science and art of outdoor lighting and lighting regulation progresses, and as any errors are discovered. Any errors are strictly the responsibility of the IDA.

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