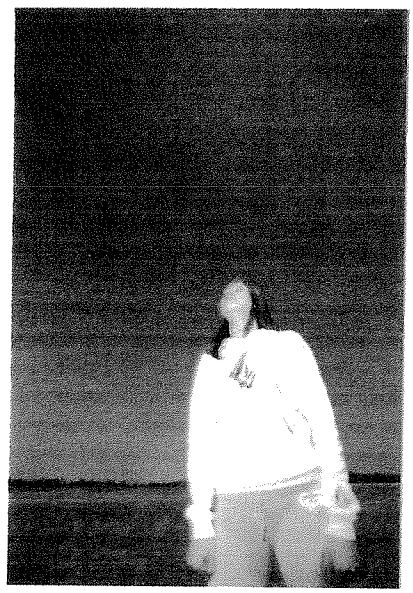
Twinkle, Twinkle, Little Star



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Canada Wide 2005- British Columbia

Background

"**Light pollution is light that does not contribute to safety or utility.**" This is the formal definition of light pollution.

Light pollution is wasted light. It is light that sprays where it is not wanted, such as up into to night sky or needlessly into peoples' eyes. It is caused by badly designed or placed streetlights, billboard lights and outdoor lighting.

An increasing amount of people are not longer able to enjoy the beautiful night skies that people for generations have been able to take pleasure in. Light pollution is as important as air and noise pollution but not as well known.

By increasing awareness of this issue, we can save our beautiful, starry skies for future generations.

Purpose

The purpose of my science fair project was to educate myself and others on the issue of light pollution. I wanted to become more familiar with the "good" and "bad" outdoor lighting fixtures that people are using both for residentially and commercially.

I planned to observe the design of outdoor lighting and discover how this affects the efficiency and effectiveness of the job which the lighting was intended to do.

I wanted do a rough estimate of a star count to see how many star are visible in each of the four areas Tobermory, Lion's Head, Wiarton and Owen Sound to see if the light pollution diminished the amount of stars I was able to see.

I also wanted to study how astronomy is affected by light pollution in my community and the three surrounding communities and to see if the population of a city is directly connected to the amount of light pollution that city emits.

I was interested to find which lens yields a higher amount of light pollution, the old drop lens, high pressure sodium or the new retrofit, flat lens high pressure sodium that I see in my town.

I will research a plan to help neighbours construct a light shield to reduce unwanted light, as well as where to place an outdoor fixture (height and distance from property line).

I was interested as well to discover how light pollution affects the environment for humans and animals.

Hypothesis

I believe that outdoor light fixture will not do the appropriate job that they are intended to do. I think this because the streetlights outside my house shines very brightly, making it difficult to sleep. I also noticed the lighting in many areas is extremely bright and glary.

I think the Owen Sound will have less visible stars than both Tobermory and Lion's Head. I think that Wiarton will have limited stars visible as well. I think this because Owen Sound and Wiarton have a larger population compared to both Tobermory and Lion's Head.

I believe that the amount of light pollution will be directly related to the population of a given city, the higher the population, the vaster the sky glow will be.

I also think that I will find that the new retrofit, flat lens streetlight will cause less light pollution than the old sag lens streetlights. I think this because I can tell without any light measuring equipment that the retrofit lights are less invasive at night.

I feel I will be able to find a plan to help construct an inexpensive light shield and a formula to determine where to properly place a residential light so not to intrude on neighbours.

My hypothesis is that light pollution will be devastating to animals and humans. I think this because I've heard of many cases when birds are found dead at the bottom of brightly lit buildings. I know that when the streetlight shines into my bedroom at night, I can't get enough sleep so I don't feel productive the next day.

Procedure

First I went onto the internet and found information about the different types of outdoor lighting (streetlights, billboard lighting, storefront lighting, etc) and information regarding how light pollution affects humans and animals.

I purchased a copy of ***SkyNews***, ***night sky***, and ***Astronomy*** (all March/April 2005) for references for the seasonal star chart and general information.

I conducted 6 experiments:

Experiment #1: The study of "good" and "bad" outdoor lighting

1. Decide which four towns to conduct this experiment upon. Find distance of each town from home base (Tobermory).
2. Travel around Tobermory photographing streetlight, billboard lights, and globe lights in both the daylight and night.
3. Travel 50 kilometers to Lion's Head, 77 kilometers to Wiarton, and 110 kilometers to Owen Sound. Photographing different outdoor light fixtures and billboards in daylight and waiting until the sun goes down and taking photos of same lights after dark.
4. Take digital camera to Wal-Mart and have pictures developed.
5. Classify pictures, pairing up the day and night photos of lights and billboards. Match the photos taken with the examples of excellent, fair, and bad lighting from the internet and brochures.

Experiment #2: Star count of the four chosen towns

1. Make a star box for counting the stars in the towns. Use a piece of card stock for the frame. Cut a square 20 cm by 20 cm, then measure 3 cm all the way around and cut out the middle leaving a 3cm border. Cut a piece of string 40 cm long and tape one end of the string to the corner of the frame.
2. Decide on an evening using a *twilight table.* The evening should be when the sun is low enough below the Western

Horizon that twilight doesn't interfere. This is after a time called "Astronomical Twilight" (when the sun is 18 degrees below the western horizon.) Do the count before moonrise, specifically 1 hour and 12 minutes prior to moon rise, so any "moon astronomical twilight" doesn't reduce the star count. Count needs to be done within 2 1/2 hours due to the errors associated with the Earth's rotation.

3. Use a star chart to determine where the star constellations are. Start with Polaris, as it is in a location in the sky that will not vary much with the time it takes to travel to all four towns. Tape the string that is attached to the star box to shoulder and hold frame in front so the string is fully extended.
4. Look through the frame at Ursa Minor with Polaris in the center of the star box. Count the stars visible in the box and record. Move to the end of the bowl (closest to Polaris in the Big Dipper). Move to the bowl of Ursa Minor and next count the stars in the handle of Ursa Major. Finally put your star box on Corona Borealis and count the stars.
5. Repeat this for all four towns in a location of similar elevation. Find the average of all samples for each town and multiply by 40 to find an estimate of stars visible in the night sky. 40 is the amount of star boxes it would take to cover the entire sky.
6. Compile results determining how much light pollution each town has and the estimate of stars each town has visible to them.

Experiment #3: Observe Sky Glow in each of the four towns

1. Contact a photographer (Ethan Melag) to help take photographs of Tobermory, Lion's Head, Wiarton and Owen Sound's sky glow.
2. Research population of the four towns.
3. Locate a map showing the four towns.
4. Travel to a location 1 kilometer from the main town and photograph pictures of night sky.

5. Use Walker's Law to determine the sky glow for each town. The formula for Walker's Law $I = 0.01Pd^{-2.5}$ where I = increase in sky glow level above the natural background and P is the population of the city and d is the distance to the centre of the city in km.

Experiment #4: Which lens design yields a larger amount of light pollution.

1. Take photograph of both old dropped lens high pressure sodium lights and the new retrofit flat lens high pressure sodium light.
2. Record the wattage of the lights. Newer retrofit lamps have a yellow sticker on the fixture stating wattage (eg, 10=100 or 15=150). Older lights have the wattage on the lamp.
3. Take a reading with a light intensity (lux) meter of all the samples of lights. Begin with the first reading directly under the lamp. Next, take a reading at 0 degrees, 45, 90, 135, and 180 degrees. Record all results. This is measured in Electron Volts (eV).
4. Lux is the measurement of light intensity. Electron Volts can be converted using this formula:

   Lux=2.5x10eV

   Where eV represents the energy value of the street lamps found from the light intensity meter.
5. The value of other light that would occur naturally is 1.1 lux. Subtract this from Lux to get the Final lux.
6. Follow this procedure for all the samples and record results.

Experiment # 5: Making a shield.

1. Measure the outside diameter of the light housing where the plastic lens attaches.
2. To find the circumference around that diameter use the following formula: **D** = diameter

   R = radius = D/2

   C = circumference

$\pi = 3.1416$

3. The formula to find circumference is **$C = 2\pi R$.**
4. Add 1or 2 inches or 2.5 to 5 centimeters to this number before you cut.
5. Cut the flashing the predetermined measurement (the extra allows for overlap).
6. Connect two hose clamps together and secure around the housing unit.
7. Attach to the light by placing the shield between the light and the clamps.
8. Total cost of this is less than $10.00 and now all the light remains on the property.

Experiment # 6: Suggestions for proper outdoor fixture placement.

1. Use the formula H = 3ft + D/3 or
   metric (H= .91m + D/3)

   H = Height of fixture

   D = Distance to fixture from the property line,

   to determine fixture placement and height.

Results

Experiment #1

Location	Kind of Light	Type of Lamp	Glare Scale 1-5	Mounted	Good or Bad
Owen Sound Staples	Sag lens	HPS	4	Own pole	Bad
Owen Sound Grey Motors	Spotlight	MVL	3	Own pole	Fair
Owen Sound Street light	White globe	MVL	4	Own pole	Bad
Owen Sound Home Depot 1	Wall mounted flood lights	MVL	1	On side of building	Good
Owen Sound Home Depot 2	Cluster Reflector	MVL	4	Own pole in a group	Bad
Wiarton Post Office	Globe light	MVL	5	Own pole	Bad
Wiarton Tim Hortons 1	Typical wall pack	MVL	4	Mounted on side of building	Bad
Wiarton Tim Hortons 2	Shoe box with a sag lens	MVL	5	Post top	Bad
Wiarton Street lights	Drop lens Cobra Head	HPS	5	Cobra Head Post	Bad
Wiarton Rankin River Trading Co.	Full cut off (down)	HPS	1	Board attached to sign on building	Excellent
Lion's Head B.P.D.S. 1	Typical Wall Pack	HPS	4	Mounted on side of building	Bad
Lion's Head B.P.D.S. 2	Post top with top shield	MVL	1	Own Pole with shield on top	Fair

Tobermory Maple Golf Crescent	Drop lens Cobra Head	HPS	5	Mounted to hydro pole	Bad
Tobermory Ferry Dock Parking Lot1	Spotlight	MVL	5	Mounted on pole in pairs	Bad
Tobermory Ferry Dock Parking Lot 2	Globe light	MVL	5	Own pole on a horizontal pole	Bad
Owen Sound Billboard	Spotlight illuminating from below	MVL	4	Mounted to bottom of billboard	Bad
Tobermory Billboard	No light used. Reflective lettering	none	0	0	Excellent

Definitions

Kind of light

Sag light- A portion of the light goes uselessly sideways and upward, creating a glare, adding to light trespass and sky glow.

Spotlight- Light is not directed completely on the target spilling light sideways. Also referred to as a "prison yard" look and should not be used.

White globe- They look good in daytime but are very wasteful at night, because most of the light goes sideways and up into the sky because they are open on the top.

Wall mounted flood lights- They direct light just to the desired place on the wall. They have a top and side shield controlling the escaping light.

Cluster reflectors- A group of lights that scatter light both horizontally and downward. They contribute to light pollution.

Typical wall pack- These lights produce enormous glare and uplight.

Shoebox with sag light- Light is a shoebox shape (usually throwing light forward) but with a sag light it sprays light in all directions.

Drop lens cobra head- Designed for a wide road coverage but it still emits glary sidelight that dazzles motorists or sleepers.

Full cutoff (down)- This light directs light ONLY to the desired location, and not to the side or upwards. It has a large brim which controls light pollution.

Post top with light shield- If the post is too tall the light cannot be directed to the ground and will mostly shine wastefully elsewhere. The top shield controls the light from shinning upwards, however most light shines sideways and is not directed down.

Spotlight illuminating for below- These lights are for lighting up billboards or storefronts. They lose light skyward, wasting energy and adding to sky glow.

Reflective lettering-Although not a light, this is the most effective way to light up a billboard without causing sky glow and saving energy.

Types of lamp

HPS-High pressure sodium lamps are pinkish or amber in colour. Its main usage is outdoors, for street lighting, and other such applications. It is generally more energy efficient than metal halide and is a good choice when true colour is not critical. It is very common.

MVL- Mercury vapour lamps are commonly used for a number of outdoor applications, such as "security lighting" as well as indoor for some applications. It has a long life. Light is produced when an electric current passes through the mercury vapour.

Glare

Glare-Estimate the amount of glare on a scale of 1 to 5, when 1 is "no glare at all" and 5 is "very glary".

Mounted

Mounted- This describes what and how a light is attached. It may be on a pole of its own or attached to another pole.

Good or Bad

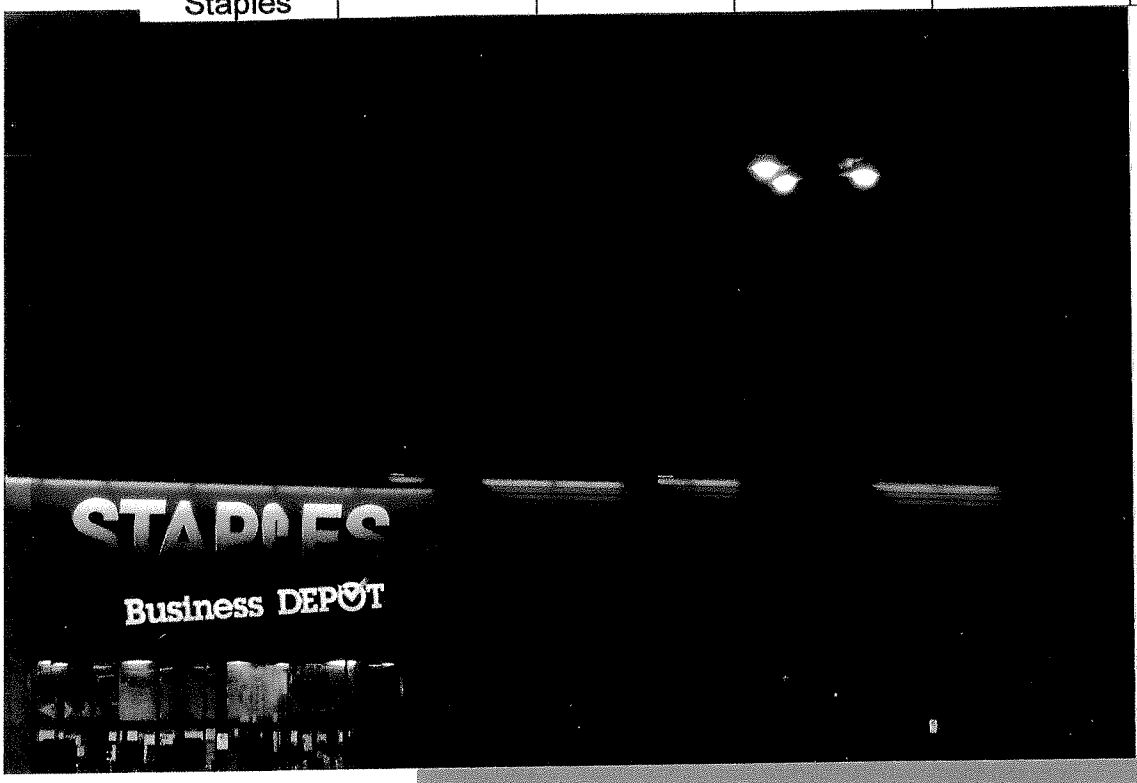
Fair- This indicates that the light is not too glary and does not contribute to light pollution too much.

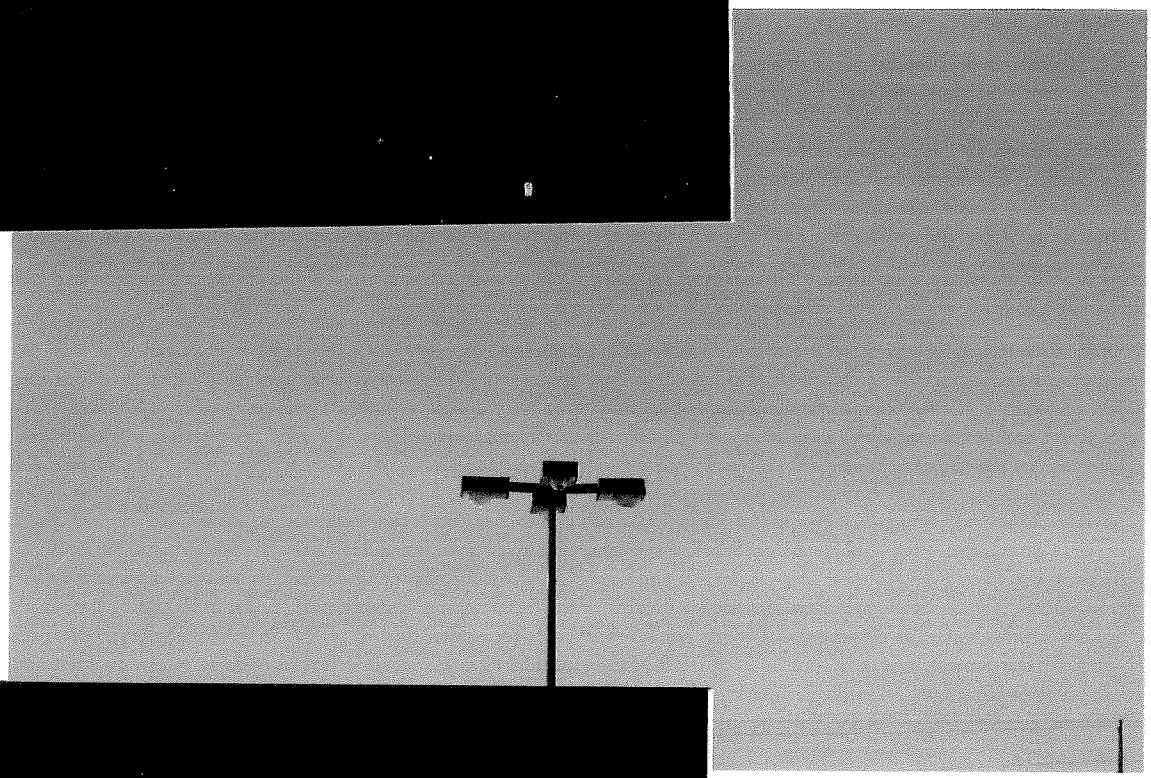
Good- This indicates that the light is not doing a large amount of damage to the environment and that a large number of stars can still be observed.

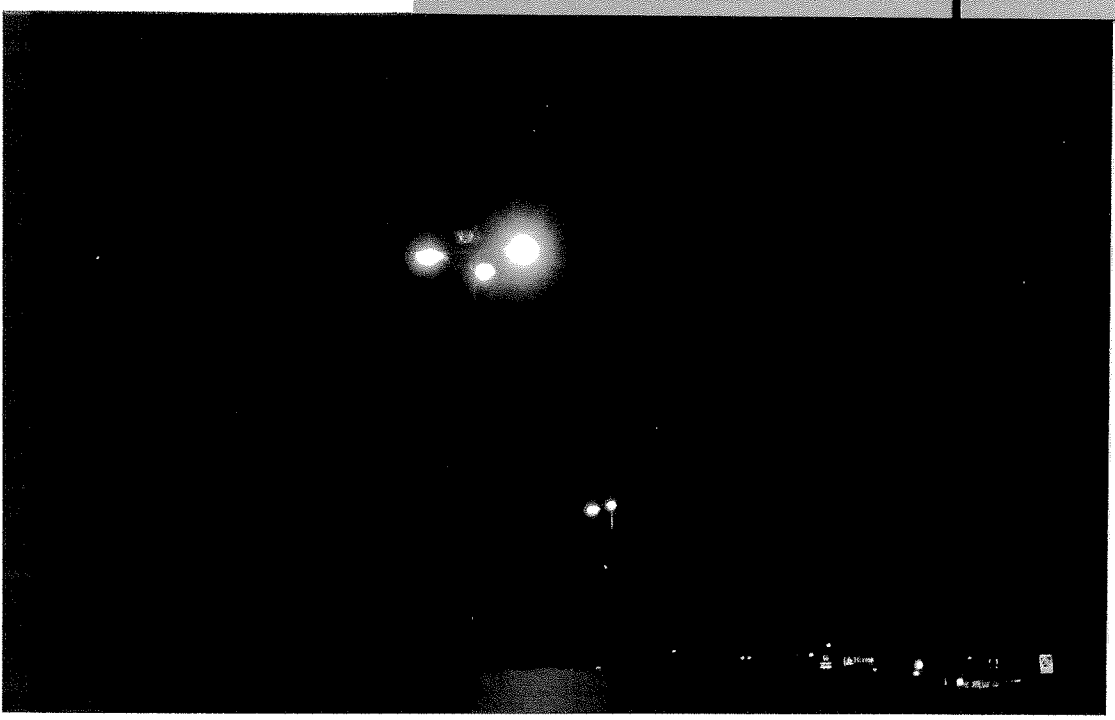
Excellent- Excellent would be used when the lighting was not interfering at all or very little with someone enjoying the dark sky or sleep or does not affect the animal kingdom.

Bad- These lights cause bad light pollution and damage to the environment as well as humans and animals.

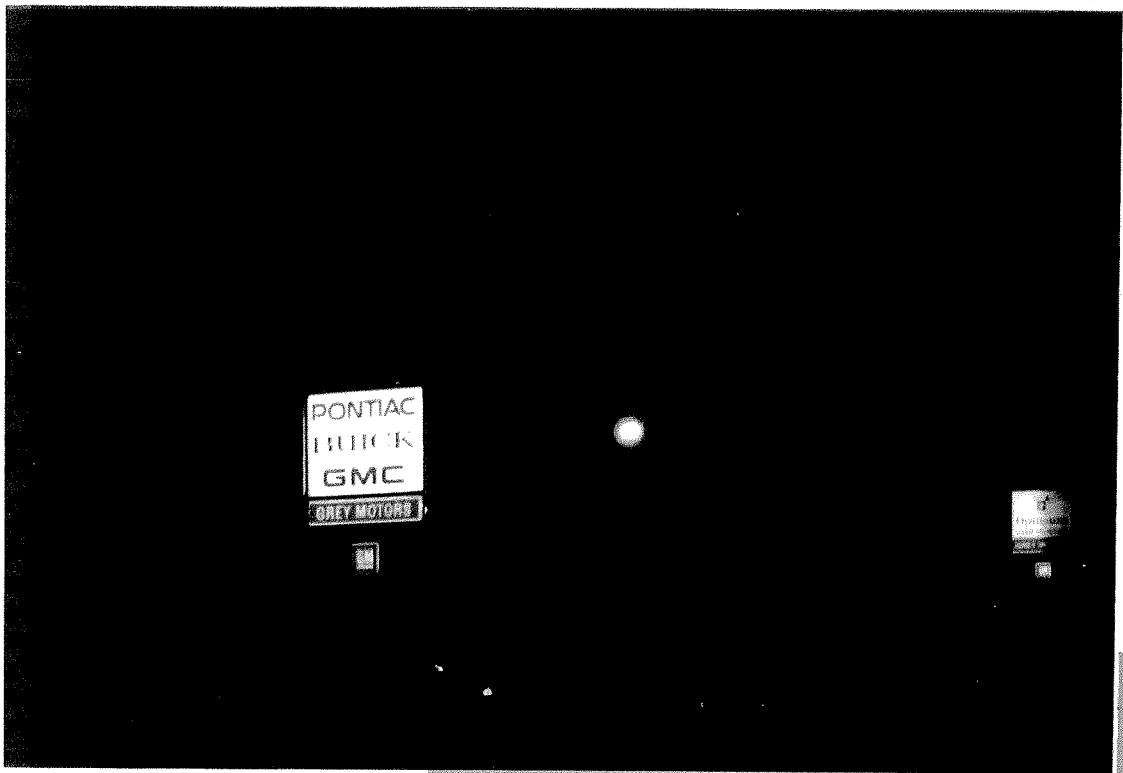
Owen Sound Staples	Sag lens	HPS			

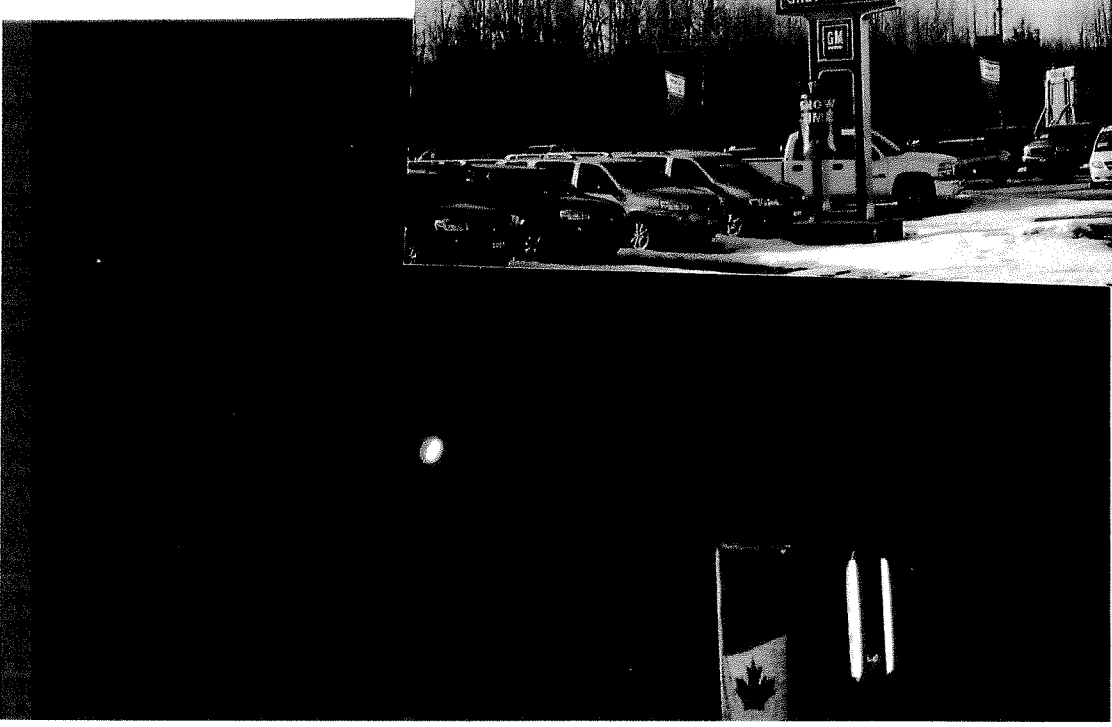




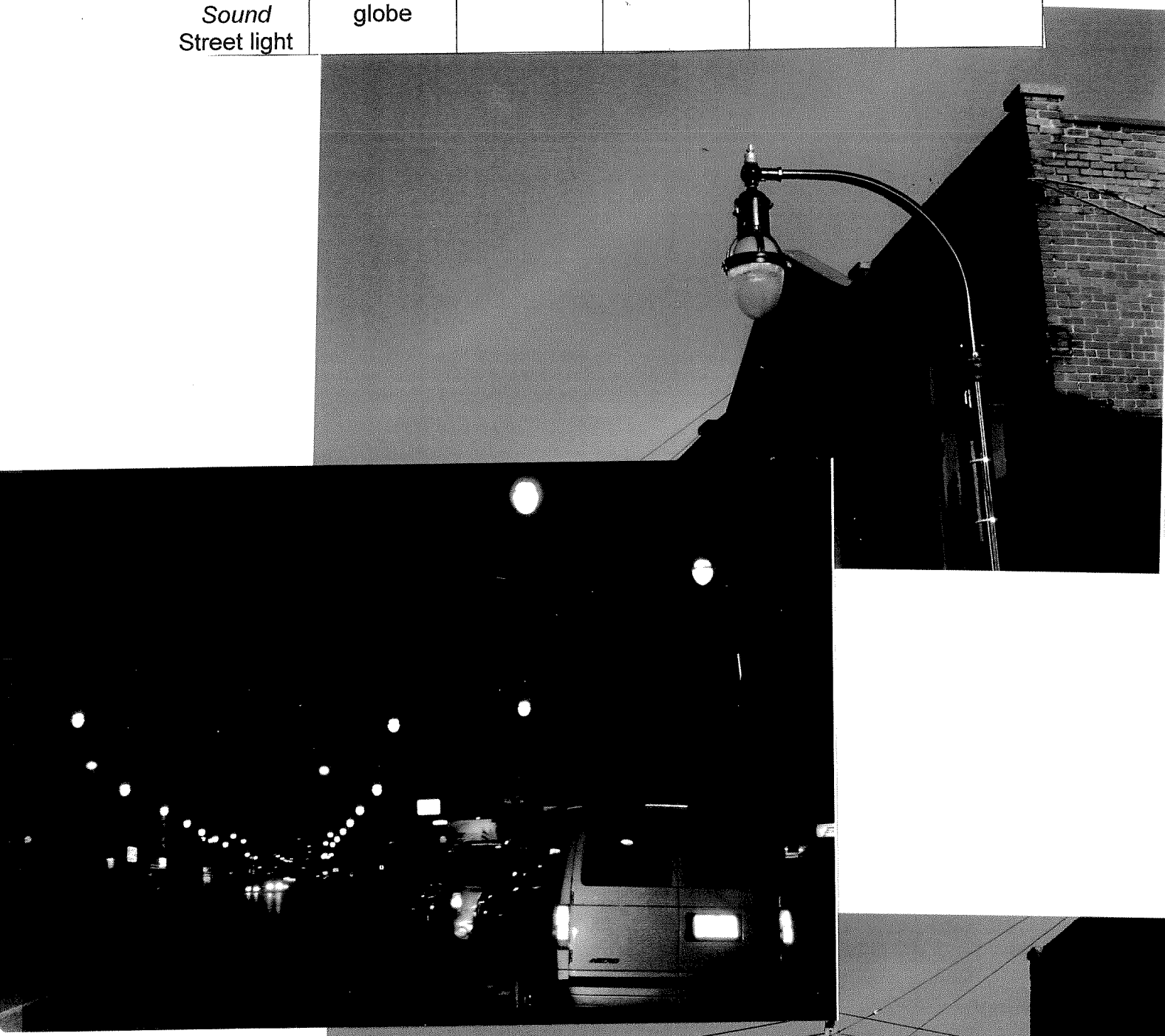


Owen Sound Grey Motors	Spotlight	MVL	3	Own pole	Fair





Owen Sound Street light	White globe	MVL	4	Own pole	Bad



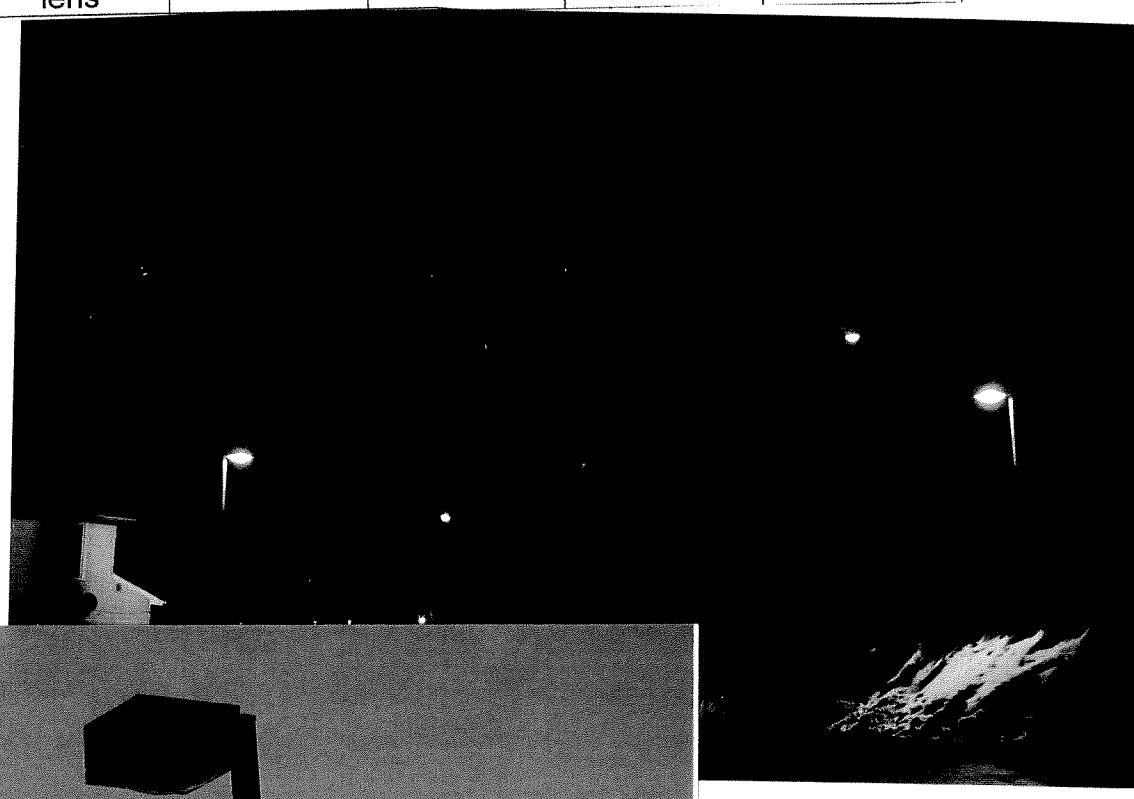
Owen Sound Home Depot 1	Wall mounted flood lights	MVL	1	On side of building	Good

Owen Sound Home Depot 2	Cluster Reflector	MVL	4	Own pole in a group	Bad

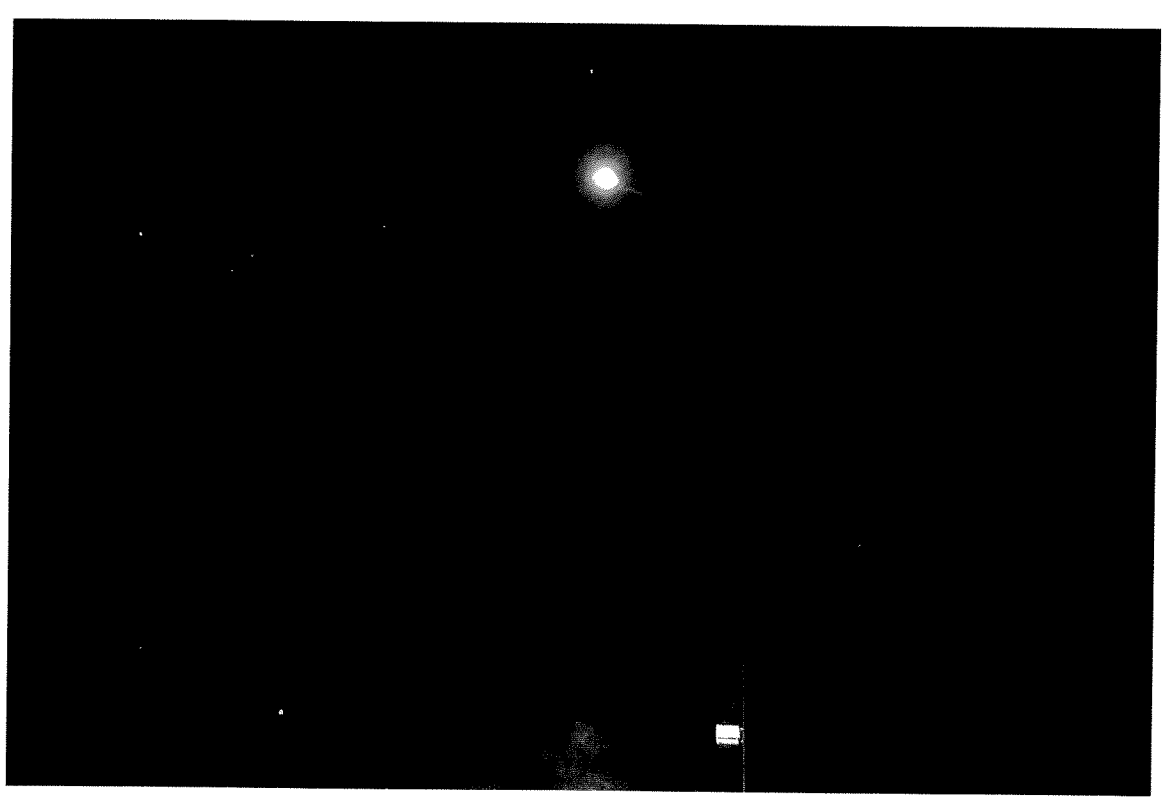
Wiarton Post Office	Globe light	MVL	5	Own pole	Bad

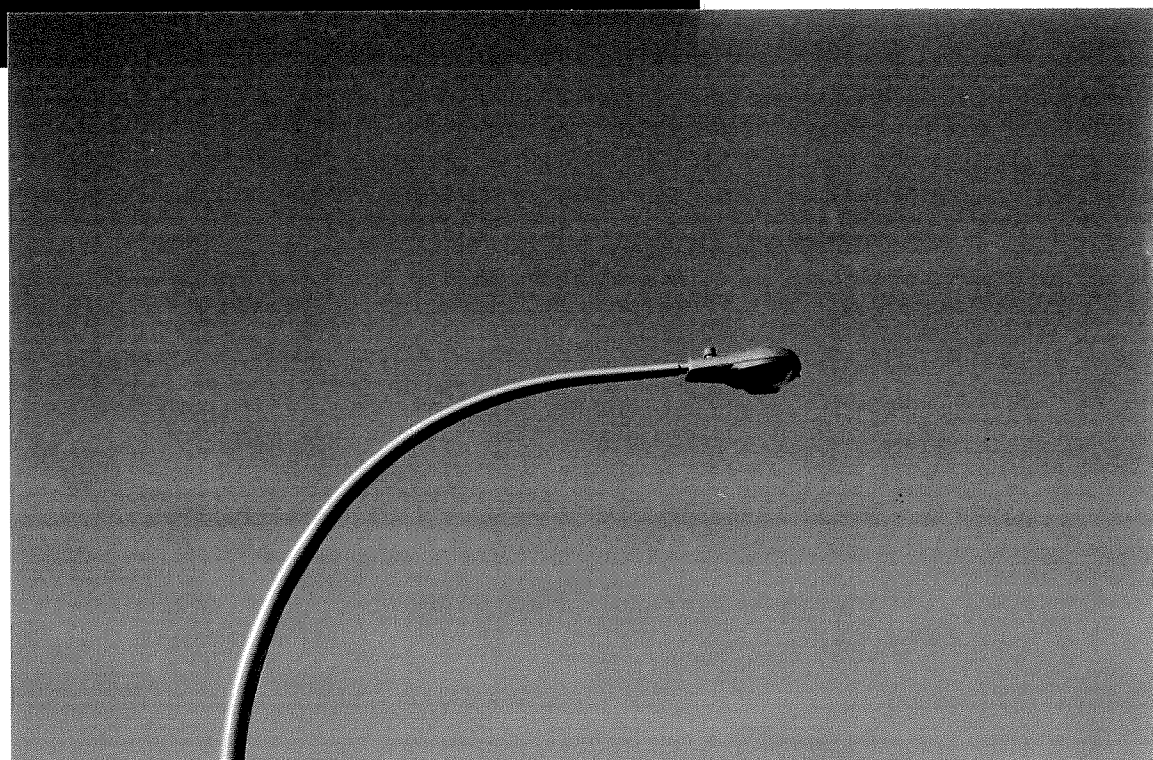
Wiarton Tim Hortons 1	Typical wall pack	MVL	4	Mounted on side of building	Bad

Wiarton Tim Hortons 2	Shoe box with a sag lens	MVL	5	Post top	Bad

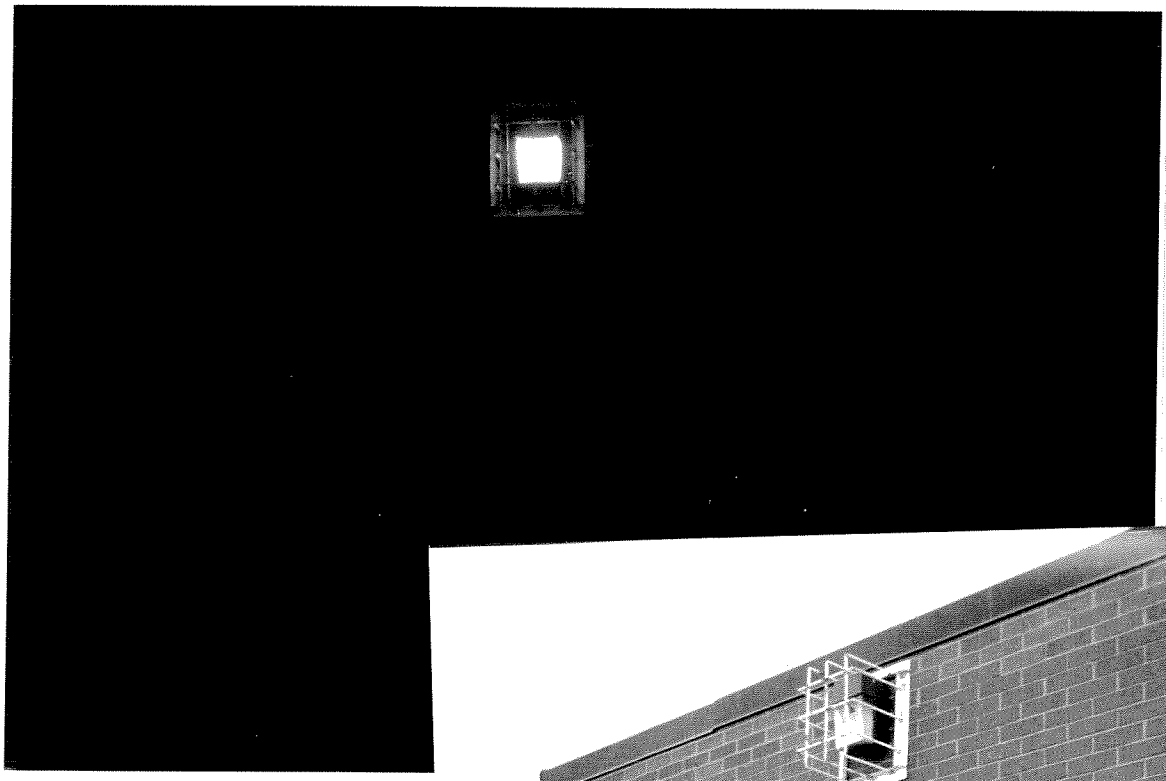


Wiarton Street lights	Drop lens Cobra Head	HPS	5	Cobra Head Post	Bad





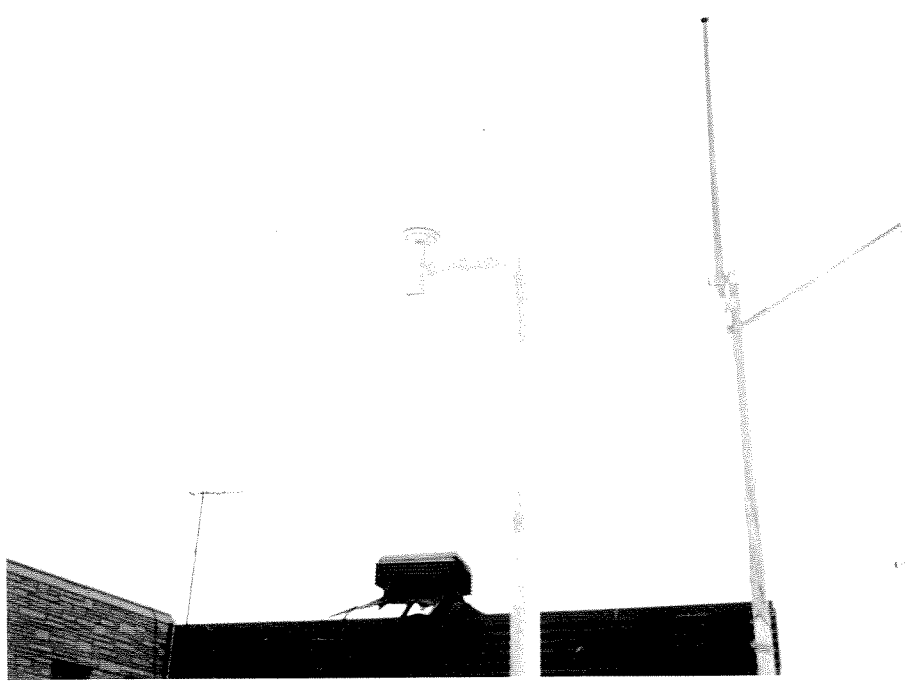
Lion's Head B.P.D.S. 1	Typical Wall Pack	HPS	4	Mounted on side of building	Bad



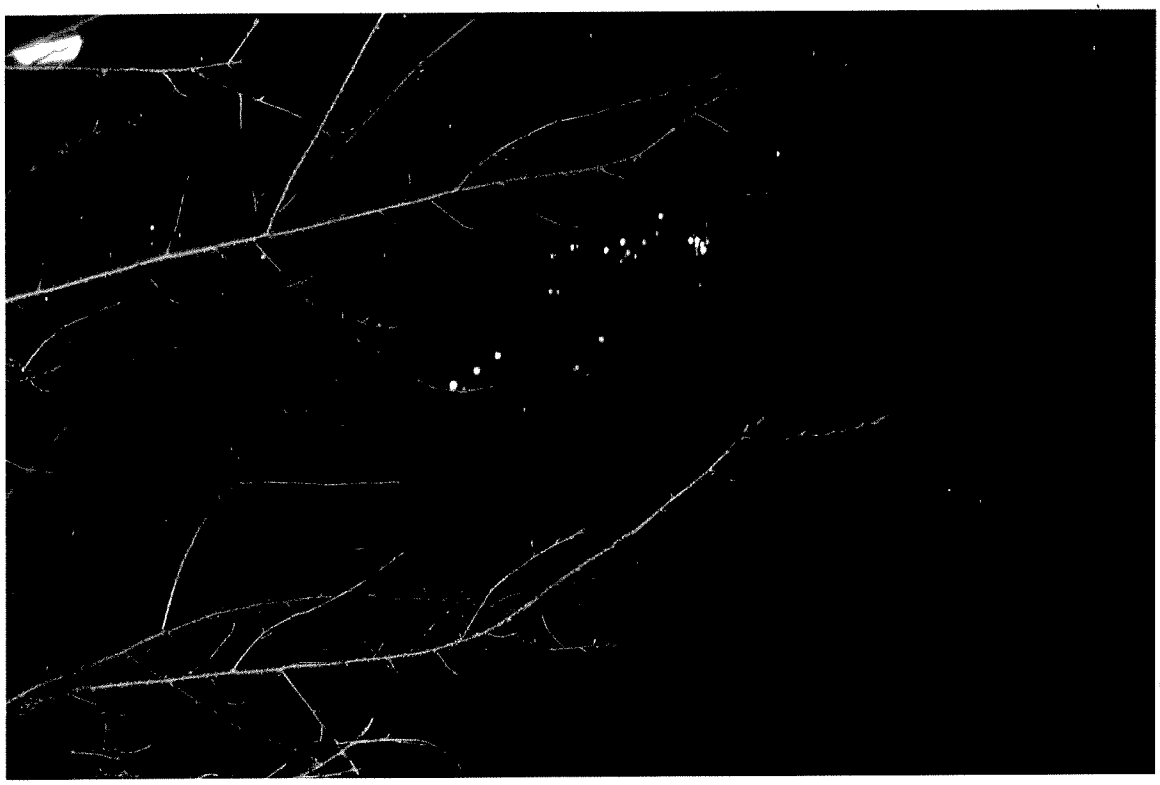
Lion's Head B.P.D.S. 2	Post top with top shield	MVL	1	Own Pole with shield on top	Fair

Tobermory Ferry Dock Parking Lot1	Spotlight	MVL	5	Mounted on pole in pairs	Bad

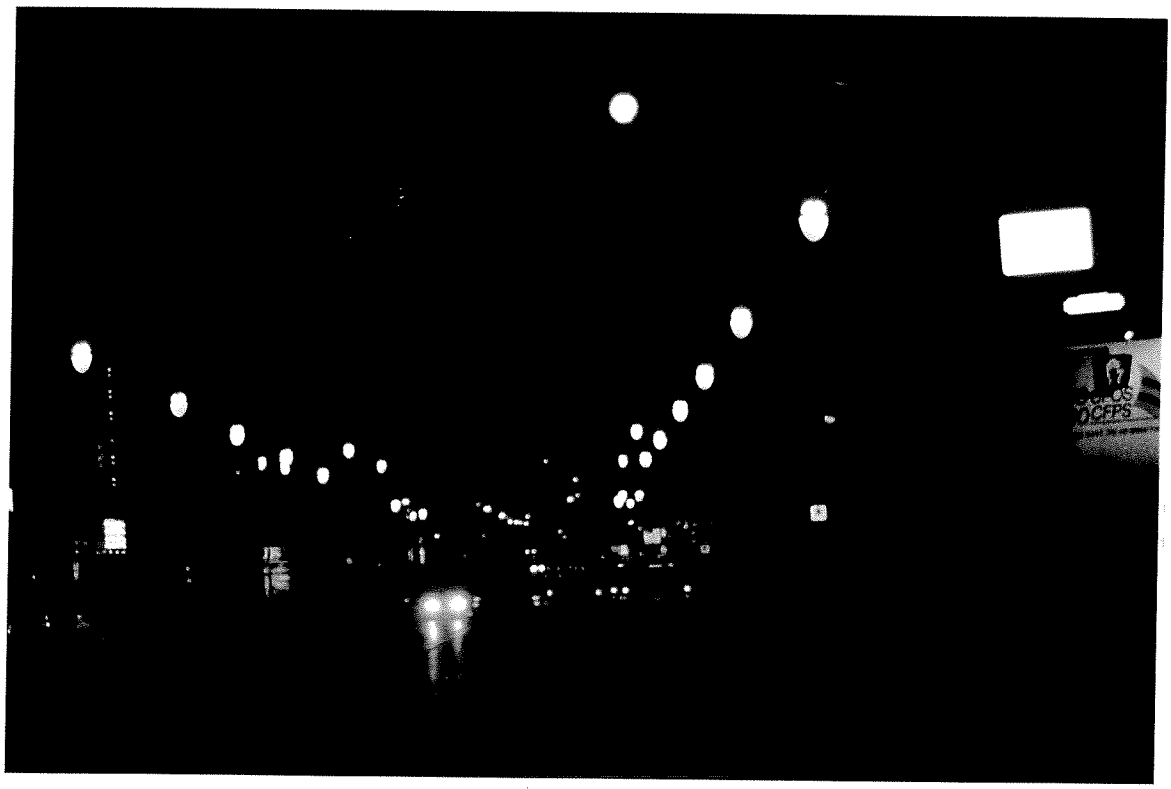
Tobermory Ferry Dock Parking Lot 2	Globe light	MVL	5	Own pole on a horizontal pole	Bad



View From Hillcrest Public School



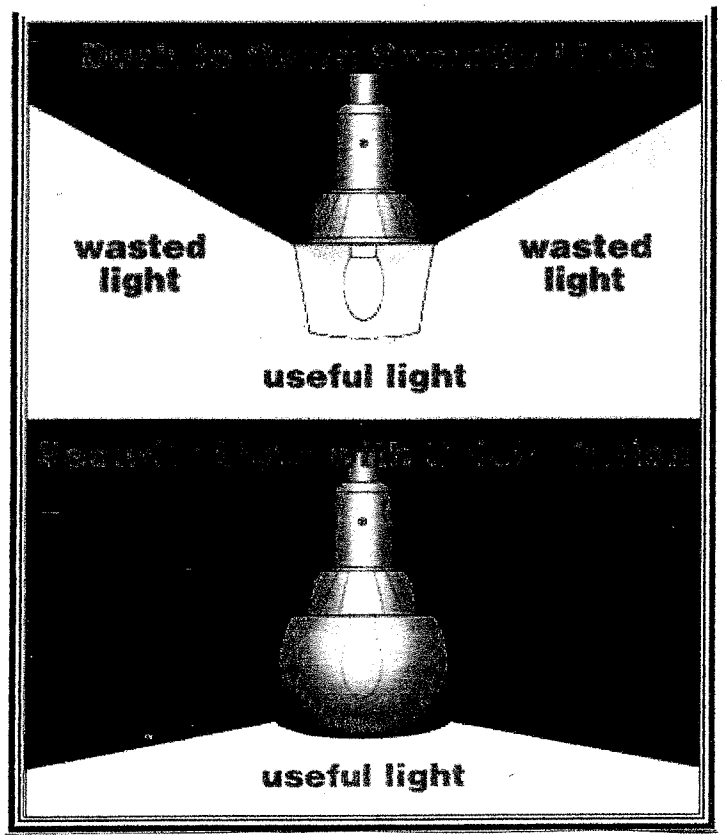
Downtown Owen Sound, Ontario



Wal-Mart
Huntsville, Ontario
January 2004

February 2004

Example of Good and Bad Lighting



As a security light, this dusk-to-dawn fixture leaves much to be desired. It has a great deal of glare, blinding observers. The light output is harsh, and there are strong shadows. With the glare and shadows, it is most difficult to see, and it is easy for any criminal to hide. They don't mind this kind of light at all. The only "plus" factor is the feeling of security that the light generates in the unaware. Real security is lacking. Glare and brightness don't insure security. What to use instead, for a real security light? Three suggestions:

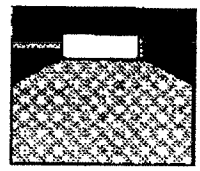
a. Use a low wattage (18, or 35, or 55 watt) low pressure sodium fixture, as a wall pack or with other mounting. There is lots of light, little or no glare (especially with a full cutoff or sharp cutoff fixture), and no sharp or deep shadows. One is not blinded, one can see. Visibility is the goal. These fixtures offer excellent visibility.

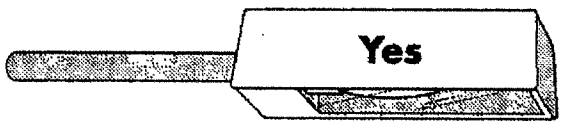
b. Use an infra-red sensor spotlight fixture. The spotlights only come on when the sensor senses movement. Any intruder will be scared off by the sudden turn-on of the spots. You are alerted. Energy use is minimal. What could be better? This type of fixture is a great security lighting system: effective, cost effective, quality lighting.

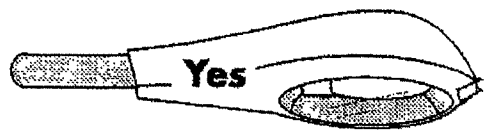
c. Use one or more low-wattage compact fluorescent lamps in well-shielded fixtures. The light level is adequate, and you save a great deal of energy.

Figure 1

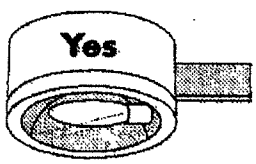
What is a True Full Cutoff Outdoor Lighting Fixture?

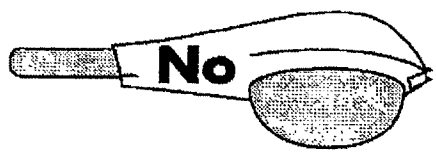




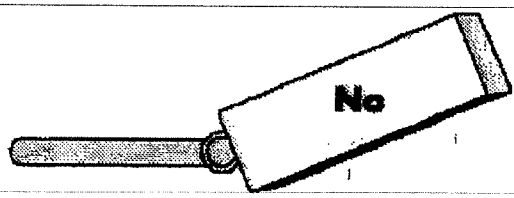


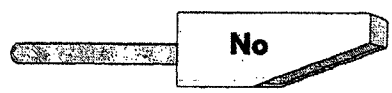
Flat glass lens, eliminates or minimizes direct glare, no upward throw of light. The housing for these fixtures are available in many styles.

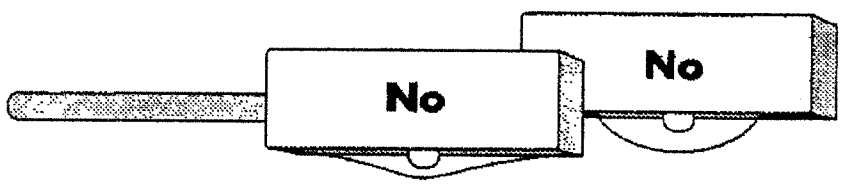




Same fixture as above mounted incorrectly – defeating the horizontal mounting design. The fixture now produces direct glare, and can also produce uplight at steeper mounting angles.







Known as just "Cutoff" Center "drop" or "sag" lens with or without exposed bulb, produces direct glare.

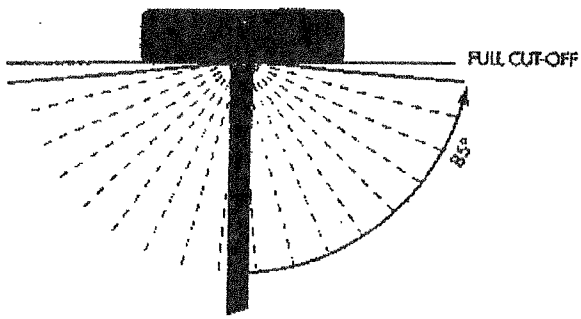


FIGURE 2

85° Full Cut-Off Fixture

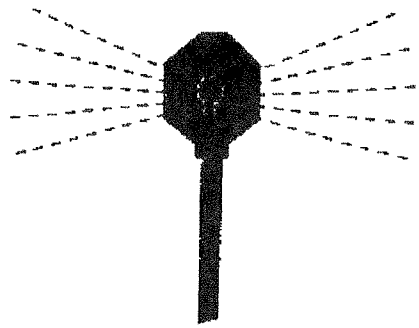


FIGURE 3

Partially Shielded
(translucent siding - bulb not visible)

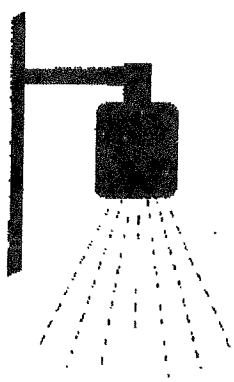


FIGURE 4

Shielded

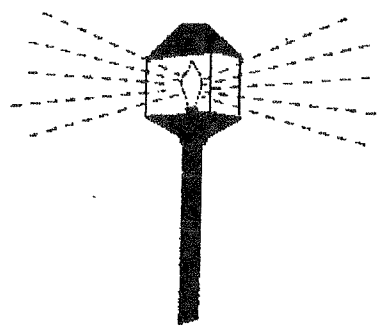


FIGURE 5

Unshielded with Opaque Top
(less than 375 lumens)

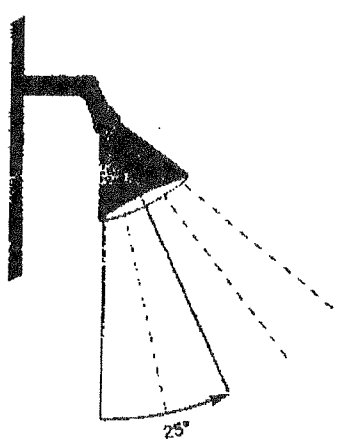


FIGURE 6

Angle of Flood Light
with External Shielding

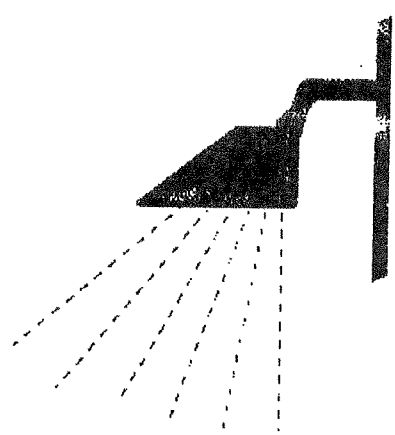


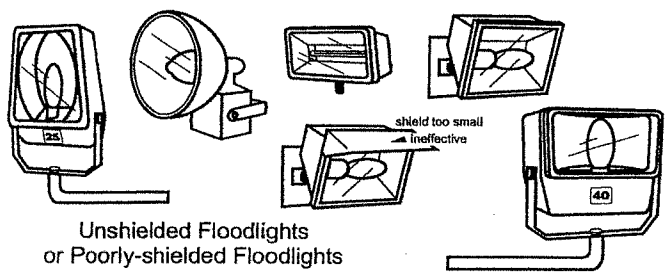
FIGURE 7

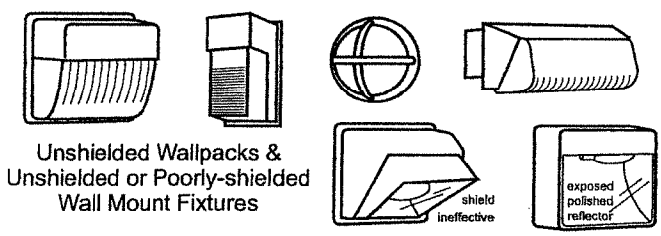
Directional Flood Light

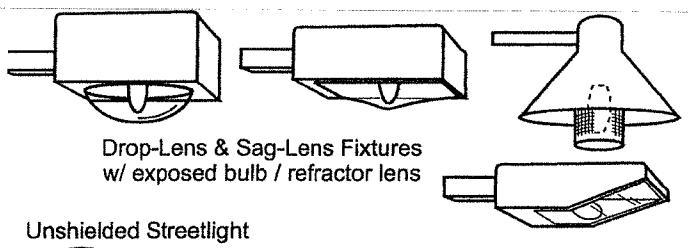
Examples of Acceptable / Unacceptable Lighting Fixtures

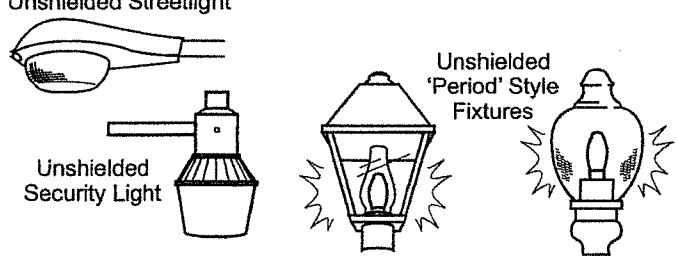
Unacceptable / Discouraged

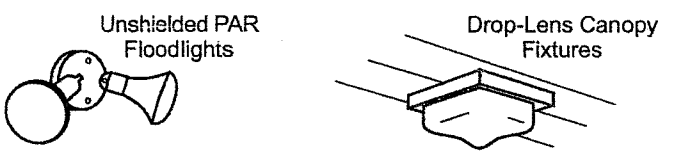
Fixtures that produce glare and light trespass





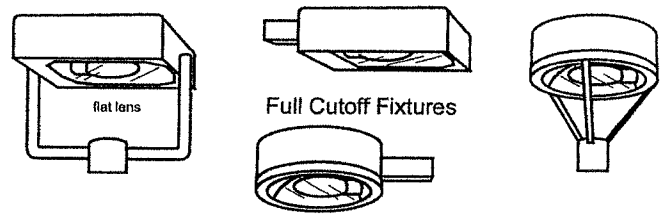


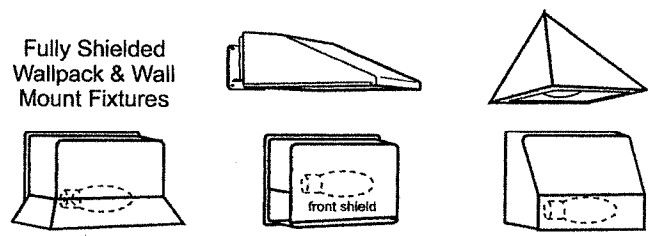


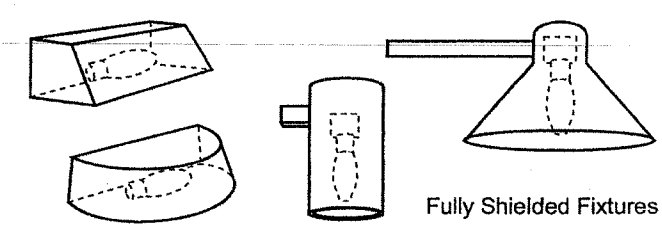


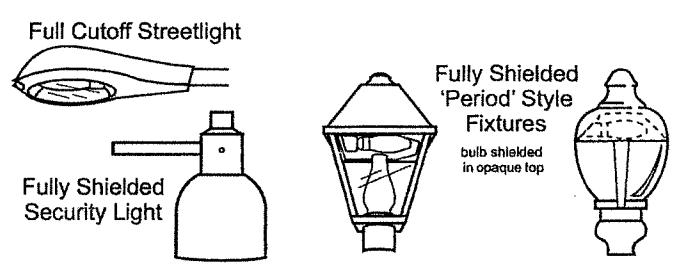
Acceptable

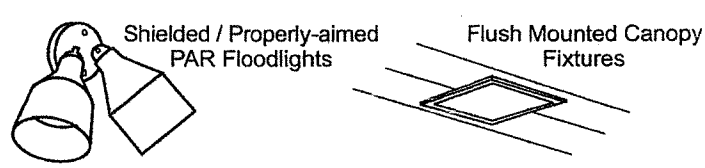
Fixtures that shield the light source to minimize glare and light trespass and to facilitate better vision at night











BC 10/02

Good Neighbor OUTDOOR LIGHTING

PRESENTED BY THE NEW ENGLAND LIGHT POLLUTION ADVISORY GROUP (NELPAG) AND SKY PUBLISHING CORP.

What is good lighting?

Good outdoor lights improve visibility, safety, and a sense of security, while minimizing energy use, operating costs, and ugly, dazzling glare.

Why should we be concerned?

Many outdoor lights are poorly designed or improperly aimed. Such lights are costly, wasteful, and distractingly glary. They harm the nighttime environment and neighbors' property values.

Glare Here's the basic rule of thumb: If you can see the bright bulb from a distance, it's a bad light. With a good light, you see lit ground instead of the dazzling bulb. "Glare" is light that beams directly from a bulb into your eye. It hampers the vision of pedestrians, cyclists, and drivers.

Light Trespass Poor outdoor lighting shines onto neighbors' properties and into bedroom windows, reducing privacy, hindering sleep, and giving the area an unattractive, trashy look.

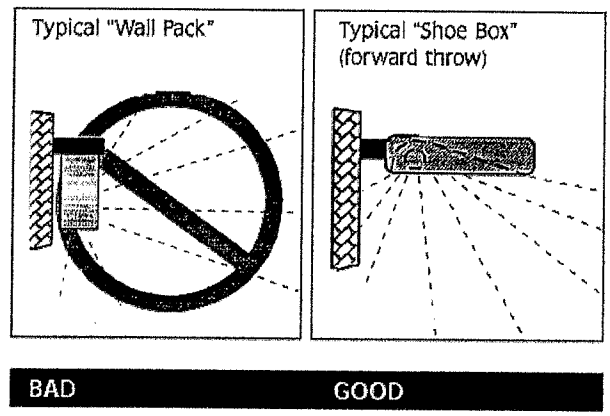
Energy Waste Many outdoor lights waste energy by spilling much of their light where it is not needed, such as up into the sky. This waste results in high operating costs. We waste over a billion dollars a year in the United States needlessly lighting the night sky.

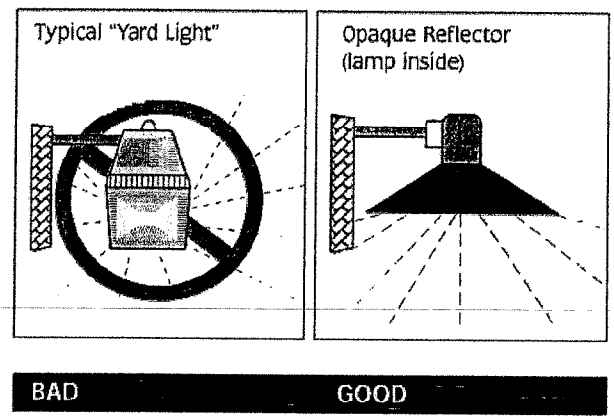
Sky Glow Rays that beam uselessly above the horizon create murky skyglow – the "light pollution" that washes out our view of the stars.

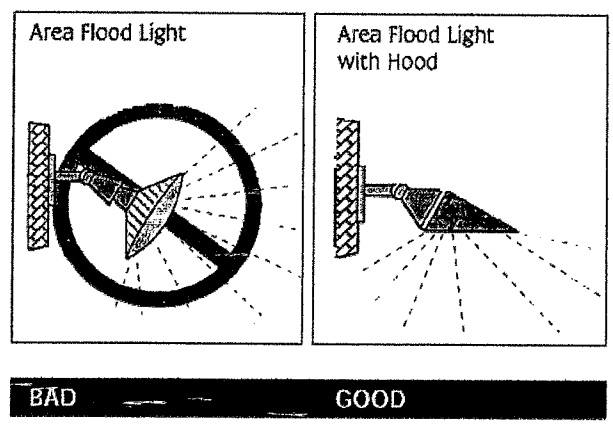
How do I switch to good lighting?

1 Provide only enough light for the task at hand; don't over-light, and don't spill light off your property. Specifying enough light for a job is sometimes hard to do on paper. Remember that a full Moon can make an area quite bright. Some lighting systems illuminate areas 100 times more brightly than the

Some Good and Bad Light Fixtures







full Moon! More importantly, by choosing properly shielded lights, you can meet your needs without bothering neighbors or polluting the sky.

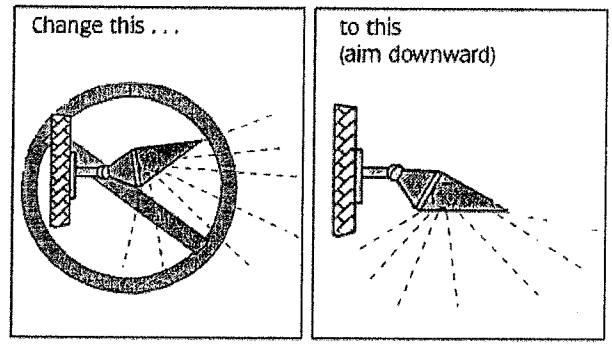
2. Aim lights down. Choose "full-cutoff shielded" fixtures that keep light from going uselessly up or sideways. Such fixtures produce minimum glare. They create a pleasant-looking environment. They increase safety because you see illuminated people, cars, and terrain, not dazzling bulbs.
3. Install fixtures carefully to maximize their effectiveness on the targeted area and minimize their impact elsewhere. Proper aiming of fixtures is crucial. Most are aimed too high. Try to install them at night, when you can see where all the rays actually go.

   Properly aimed and shielded lights may cost more initially, but they save you far more in the long run. They can illuminate your target with a low-wattage bulb just as brightly as a wasteful light does with a high-wattage bulb.
4. Choose energy-efficient low-pressure sodium (LPS) or high-pressure sodium (HPS) lamps wherever yellowish light will do the job. Use less efficient white lights only where ideal color rendition is important.
5. Where feasible, put lights on timers to turn them off each night after they are no longer needed. Put home security lights on a motion-detector switch, which turns them on only when someone enters the area; this provides a great deterrent effect!

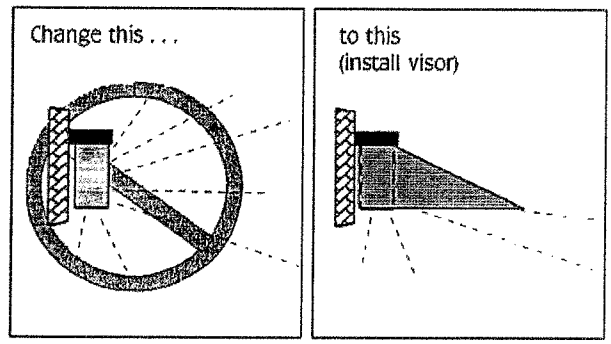
Replace bad lights with good lights.

You'll save energy and money. You'll be a good neighbor. And you'll help preserve our view of the stars.

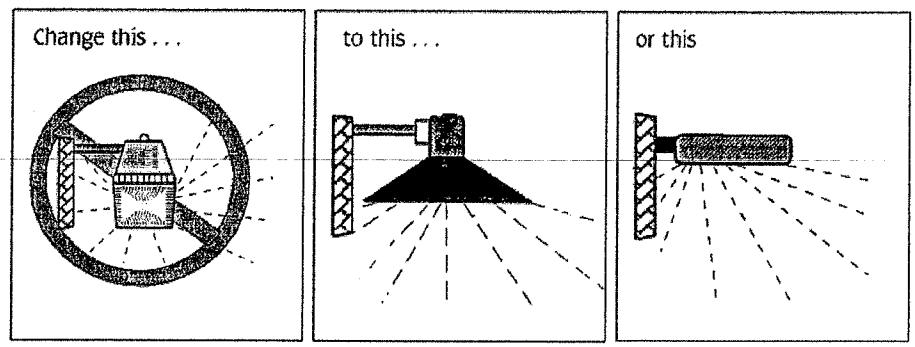
What You Can Do To Modify Existing Fixtures



FLOOD LIGHT



WALL PACK



YARD LIGHT OPAQUE REFLECTOR SHOE BOX

Presented by the
New England Light Pollution Advisory Group (NELPAG)
(http://cfa-www.harvard.edu/cfa/ps/nelpag.html) and
Sky Publishing Corp. (http://www.skypub.com/).
NELPAG and Sky Publishing Corp. support the
International Dark-Sky Association (IDA) (http://www.darksky.org/).
We urge all individuals and groups interested in the problems of light pollution and obtrusive lighting to support the IDA and subscribe to its newsletter. IDA membership costs $30 per year; send your check to IDA, 3225 N. First Avenue, Tucson, AZ 85719, U.S.A.

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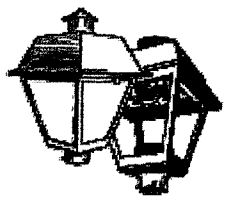
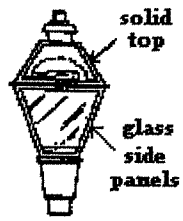
Examples of Good and Bad Lighting Fixtures



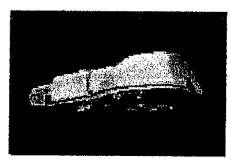
GOOD Even post-top ornamental fixtures, like this Salem Cutoff from GE Lighting, can be cutoff with clear panels and lamp/reflector located above.



GOOD The Yorktown, another ornamental from Emery Fixtures, also has clear panels and bulb located above for maximum glare and spill light control.

BAD Non-cutoff fixtures like this "acorn" ornamental cause light pollution.

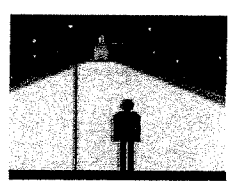
GOOD Flat-lens cobra head fixtures, like this American Electric Series 125 Roadway Cutoff luminaire, provide excellent roadway lighting with greatly reduced glare and no uplight.



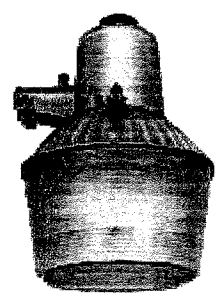
GOOD This new generation of flat-lens cobra head fixture from American Electric, call the DuraStar 2000, provides superior lighting uniformity at standard mounting heights and spacings.

BAD The ubiquitous drop-lens cobra head luminaire produces a level of glare and uplight that is both unacceptable and unnecessary.

GOOD Many existing dusk-to-dawn security lights and residential streetlights can be retrofitted with the Hubbell Skycap.

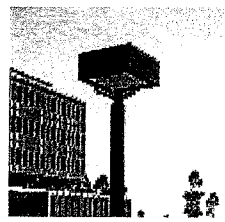


GOOD The Hubbell Skycap turns any standard Barn Light into a full-cutoff light with wide area coverage.



BAD Barn Light style fixtures are very inefficient, sending about 20% of the light upward and another 20% horizontally outward, creating glare.

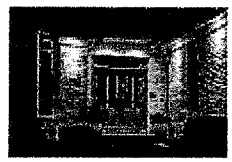
GOOD Flat-lens shoebox fixtures come in many forms; square, rectangular, circular, etc. All control the light with internal reflectors. Glare and light trespass are minimized; no uplight is produced.



GOOD Post-top flat-lens shoebox fixtures like this one provide good area illumination without light pollution.

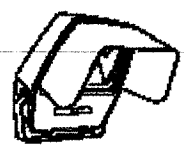
BAD (sometimes) The telltale sag lens gives this luminaire away as a possible problem. If the lens is clear and very shallow, and the bulb wattage is not too high, this type of light can cover a wider area without too much glare or uplight, but beware!

GOOD Full-cutoff wall packs such as this mcPhilben 101 Wall Sconce make excellent entryway and building perimeter lights, and there is enough forward throw that adequate lighting is provided for near-building parking.

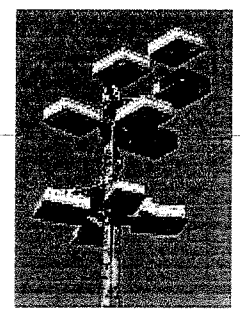


GOOD Recessed canister lights built into the eaves or canopy of a house, garage, or other building is the first choice for lighting building exteriors.

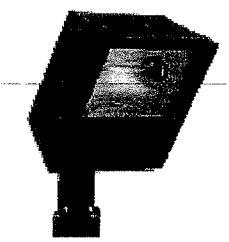
BAD Wall packs like this should never be used. They produce enormous glare and uplight.



GOOD If floodlights must be used, they should always have top and side shielding, and be pointed at least 45 ° below the horizontal.



GOOD Even sports lighting can be done well, if one uses cutoff light fixtures such as these from Soft Lighting Systems.



BAD Unshielded floodlights provide a trashy "prison yard" look and should not be used.

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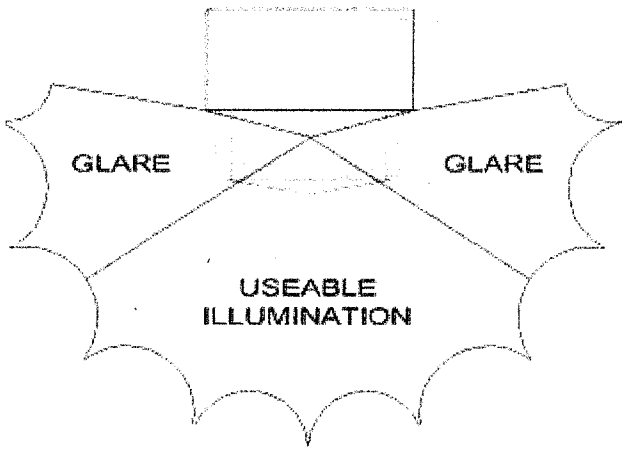
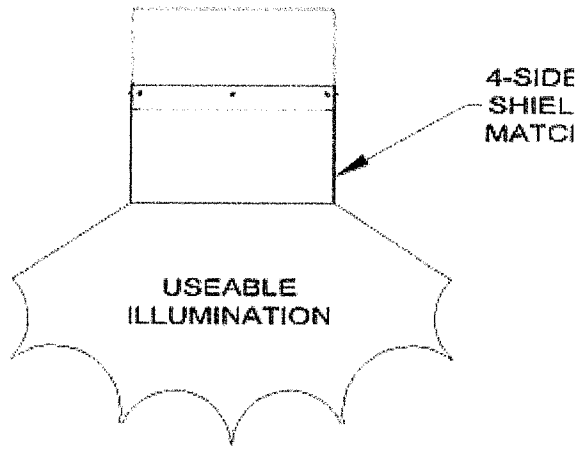
Shielding Petroleum Retailer Canopy Ligh

UNSHIELDED



SHINES GLARING LIGHT EVERYWHERE
CREATES LIGHT TRESPASS
REDUCES PUBLIC SAFETY
GLARE REDUCES VISION

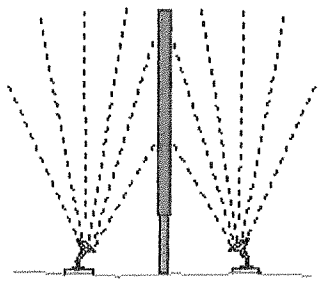
SHIELDED



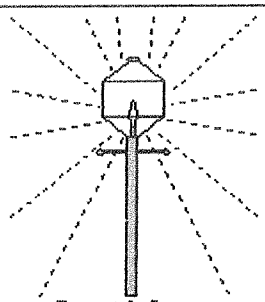
SHINES LIGHT ONLY WHERE NEEDED
CONTROLS LIGHT TRESPASS
IMPROVES PUBLIC SAFETY
REDUCES VISIBLE GLARE
INEXPENSIVE REMEDY

EXAMPLES OF SOME COMMON LIGHTING FIXTURES

POOR

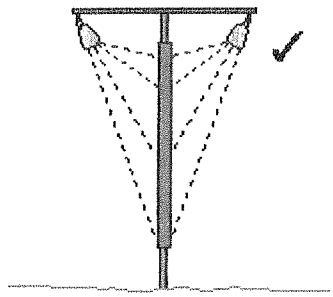


Ground-mounted
Billboard Floodlights

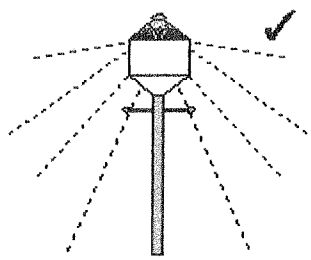


Post-style Lamp
(more than 1,800 lumens)

GOOD

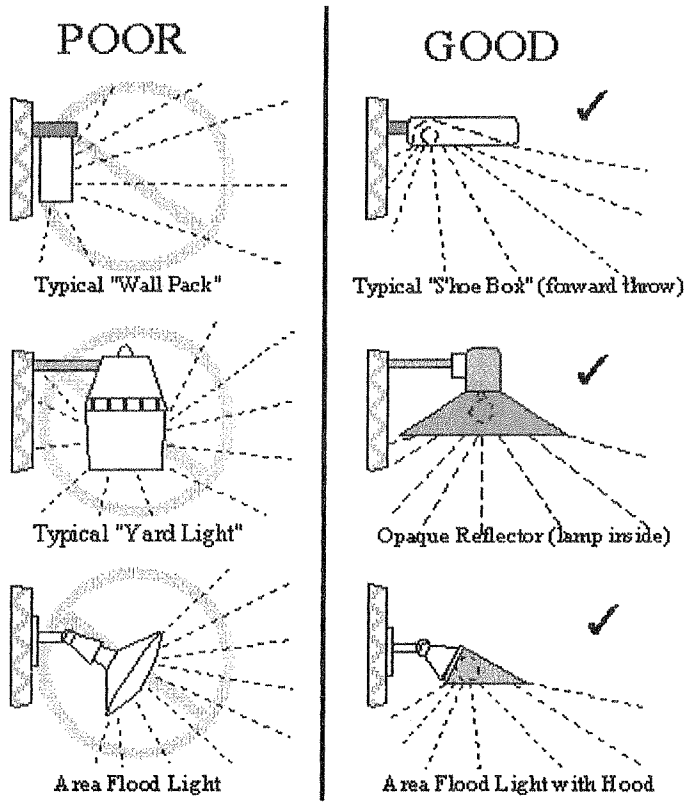


Top-mounted
Billboard Floodlights
(carefully focused onto billboard)



Post-style Lamp
(lamp set in opaque top)

EXAMPLES OF SOME COMMON LIGHTING FIXTURES



Glossary of Light Pollution-Related Terms

full cutoff

Describes a light fixture designed to emit no light at or above the horizontal (90 degrees). Such lights are desirable for their efficiency and lack of glare.

glare

Glare is light that draws attention to the light source itself, rather than what the fixture should be illuminating. The points of light seen in city- and streetscapes are the result of glare. Fully shielded lights produce no glare. Glare is known to have serious effects on the vision of motorists at night.

high-pressure sodium

This light source uses slightly more electricity than low-pressure sodium, but less than metal-halide or mercury-vapor. It has a yellow color like LPS, but unlike LPS, the light fades some with age.

light trespass

Light which shines into neighboring properties or is of an undesirable or obtrusive nature. Floodlights and yard lights which spill over into neighbor's yards and windows are common examples of light trespass.

low-pressure sodium

The most energy-efficient and least pollutive light source. It emits all of its light into a narrow range of wavelengths, which can be filtered out easily by astronomers. LPS produces a deep yellow light which does not render colors well, but has excellent visibility and is well-suited to security and utility lighting. Fixtures using LPS do not suffer from fading over the years. In commercial situations where a truer color is desired, such as car lots, metal-halide light can be interspersed with LPS to restore colors.

mercury-vapor

This light source is one of the least energy-efficient and its use is highly discouraged. It emits a portion of its light at wavelengths which are useless for illumination purposes, but which interfere with astronomy and are difficult to filter out. Mercury vapor's blue-green light is subject to severe dimming with age.

metal halide

A light source similar to mercury-vapor, but with a whiter color.

uplight

Artificial light that is cast upward toward the sky or into the horizontal plane. Obviously, uplight is a major cause of energy waste and light pollution.

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NSP
Hyde Observatory

Light Pollution Fact Sheet

Our goal is to encourage quality lighting! We are NOT against night lighting. The 100 inch diameter telescope at Mt. Wilson Observatory, which overlooks the Los Angelas basin, is only 11% as effective as when it was built. This telescope is severely limited in its research capabilities because of light pollution. 1 billion dollars ($1,000,000,000) is wasted each year in the United States by lighting up the sky. This wasted light serves no purpose for safety, security or utility.....it is simply wasted energy! We want to start NOW to preserve as best as we can the sky above Holmes Park and Hyde Observatory.

Components of light pollution include:

1. Light trespass - Spill light coming from another property.
2. Glare - From seeing the bright filament of an unshielded light, troublesome and dangerous.
3. Clutter - Excessive grouping of lights, causes confusion as well.
4. Energy waste - Costing us over One Billion Dollars a year in the U.S.A. alone.
5. Urban sky glow - Domes of light over cities. Blocks out faint objects such as the Milky Way, Nebula and distant galaxies. Only a few bright stars can be seen from the city.

SOME TYPES OF LAMPS:

Low Pressure Sodium (LPS) fixture produces a yellow tint.
High Pressure Sodium (HPS) fixture produces a pink tint.
Mercury Vapor fixture produces a blue/white tint.
Incandescent light (bulbs) produces a yellow/white tint.

The first three types are a gas discharge source. The light is produced when the electric current passes through a container of gas, causing the energized gas to give off characteristic bands of color.

In an incandescent source a thin wire is heated to a high temperature by an electric current. This filament begins to glow and gives off light of many colors. A large amount of energy is given off as heat making the incandescent source not as efficient as the discharge source.

55 watt LPS = 100 watt HPS = 175 watt Mercury Vapor = 400 watt incandescent

For less energy a 55 watt LPS fixture can produce the same amount of lumens (light output) as the 100 watt HPS, the 175 watt Mercury Vapor and the 400 watt incandescent.

For more information, see the IDA page "Good Lighting Fixtures and Where to Get Them."

LIGHT TRESPASS:

Light from an unshielded fixture that is suppose to be illuminating the ground is also casting light upward. This is wasted light and wasted money. Some fixtures spill light onto other properties. This can be prevented by taking care in the placement and alignment of the light.

GLARE:

Generally speaking, if you can see a lights filament or source from a reasonable distance then the light is not well shielded.

The glare from an unshieded fixture can compromise visibility and increases the chance for accidents. Bright glare can also produce high contrast shadows. These shadows actually become cooridors of darkness that can become hiding places for potential criminals.

CLUTTER:

Excessive glare can make driving difficult and light clutter can cause distraction. For safety reasons every effort should be made to establish quality lighting on and near heavily traveled roads. Billboards and outdoor signs are designed to attract our attention. Often these are lit up with bright flashing lights. These light sources add considerably to the overall light pollution.

ENERGY WASTE:

A night time aerial view of a city reveals how much energy we waste by using unshielded lights. Any direct light sources that can be seen from above are contributing to a waste of energy and the precious resources that produce that energy.

Lincoln is fortunate to have some of the lowest electrical rates in the country. Summer rates are 6.5 cents per kilowatt-hour and winter rates are 5 cents. A national average is 8 cents. By reducing the amount of upward (wasted) light we can help to extend our overall energy pool. Since Lincoln is growing rapidly, this makes good economic sense.

URBAN SKY GLOW:

This is the bane of astronomers world-wide. The combined output of all the lights in a city cause the sky to be washed out. Faint deep sky objects such as galaxies and nebula become impossible to see.

Sky glow is rapidly becoming worse. We must start now to encourage quality lighting. Reducing the upward shining light will help eliminate these light domes. Our children need to be able to see the stars. They are the ones with the eager questions and imaginations that will shape our future!

SOME EASY SOLUTIONS:

1. Use the right amount of light, not overkill.
2. Shield the light so that is goes down, not up or sideways.

3. Use light timer controls whenever possible.
4. Use LPS fixtures whenever possible because it is the most energy efficient and because its light can be filtered out with telescope filters.
5. Avoid using round globe lights unless they are properly shielded.
6. Be aware of quality lighting. Let people know when you see some good and attractive lighting arrangements.
7. Educate other people about the adverse effects of inappropriate lighting.

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Light Pollution Abatement Site

Calgary Centre

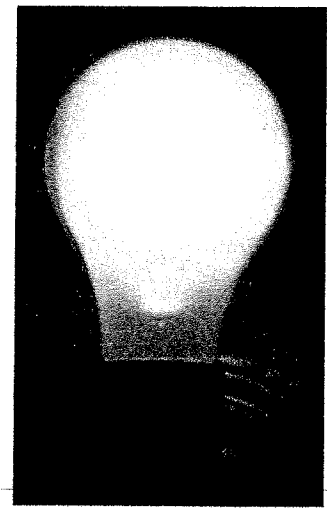
Royal Astronomical Society of Canada

DEFINITIONS

TYPES OF LIGHT "BULBS" OR LAMPS

See also the Light and Greenhouse Gases section of this website for more detailed look at different types of lighting and their efficiencies.

Incandescent - is Thomas A. Edison's light bulb, except the carbon filament has been replaced by tungsten wire. This is your ordinary light bulb, like the one in your refrigerator. Light is emitted by the filament when it is heated to a high temperature by electric current. About half of the energy is used to produce infrared light, or heat, so this is not a very efficient light source. As a point source, shielding incandescent light bulbs to prevent glare is easy, but for some reason, shielding is not often done by manufacturers.

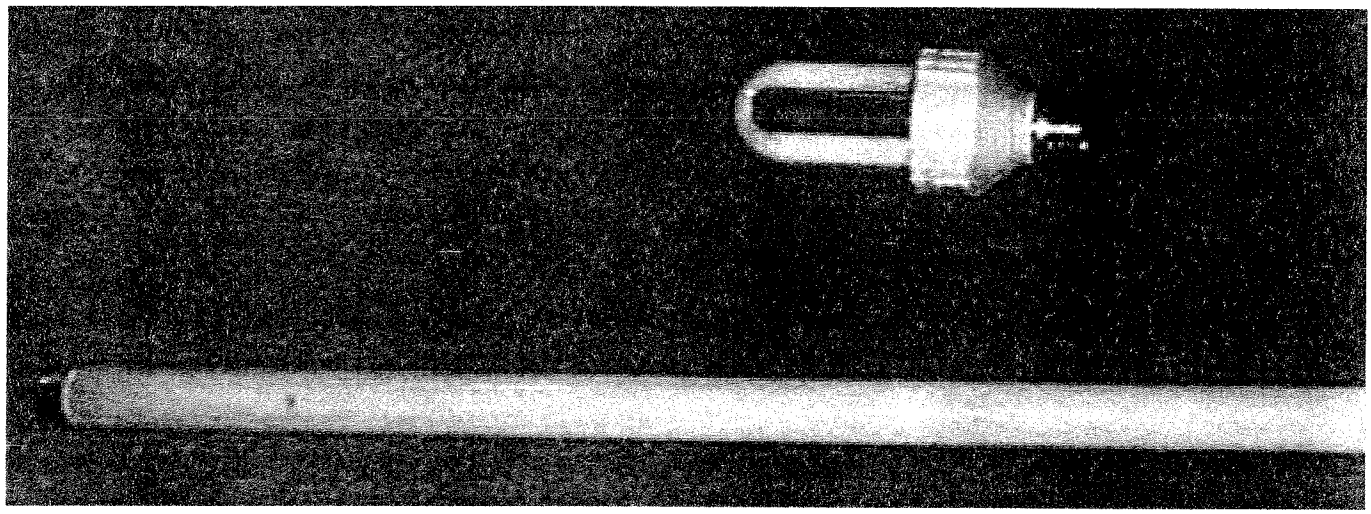


An incandescent light bulb.

Mercury Vapour - the familiar bluish white light of these old streetlights rendered many colours a sort of unfamiliar bluish purple hue. Because much of the light emitted is in the ultraviolet part of the spectrum, these lamps are not efficient at turning electricity into visible light. Being a point source, it is possible to design light fixtures that prevent glare, but most of these light bulbs were used in drop-lens semi-cutoff light fixtures (see below). It pays for itself to replace these lights with efficient High-Pressure Sodium bulbs.

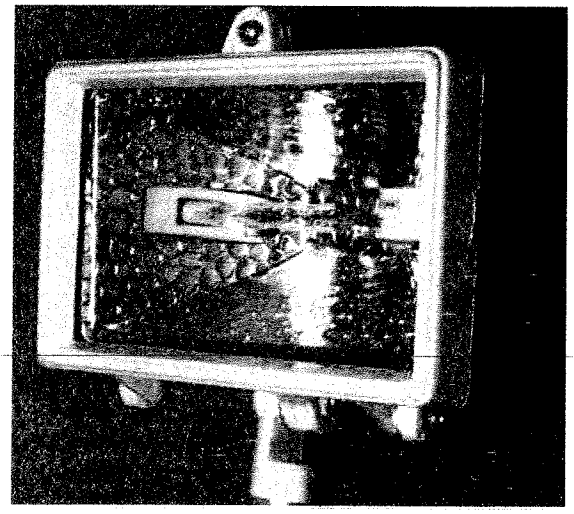
Fluorescent - common in stores and many businesses where their energy efficiency makes them a better choice than incandescent. Mercury vapour in the tubes gives off ultraviolet light, which is converted by powdered materials coating the inside of the tube into visible light through fluorescence (hah!, and you thought they just gave these lights a weird name. It's because of the weird process that occurs in them!). Now-a-days, manufacturers have created different coatings that fluoresce in different colours, so no longer must you suffer from ghoulish green skin tones. Fluorescent lamps are quite efficient - most of the initial radiation is ultraviolet with a minimum of infrared (heat) and as long as the coatings are intact, most (but not all) of the ultraviolet light is converted into visible light (another efficient process). So-called black lights are simply fluorescent tubes without the fluorescent material - they emit straight ultraviolet.

Because fluorescent lamps are much more efficient than incandescent lamps, it is tempting to think that they can be left on all the time without worrying about wasting electricity. This is the wrong attitude. Wasted energy is still wasted energy and the issue is that poorly installed fluorescent lamps can create just as much glare and other visibility problems as the incandescent lamps they replace. Outside of commercial use, it is a very rare situation indeed that requires a light on for extended periods.



Common fluorescent tube designs. The upper lamp is designed to directly replace incandescent bulbs, while the lower is the more familiar straight tube design.

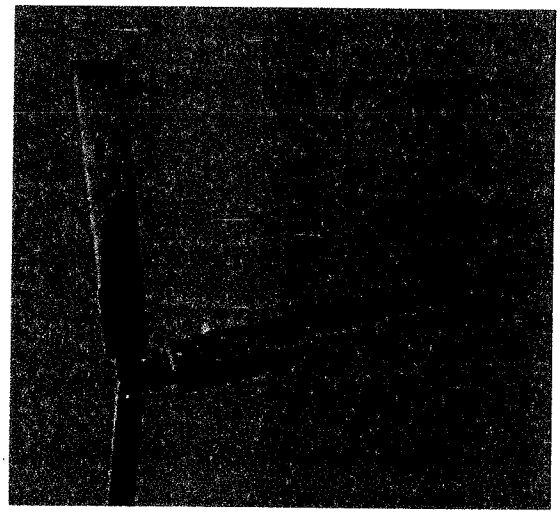
Halogen - relatively efficient pure white light makes it a good choice for outdoor lighting where correct colour rendition is important. As a point source, they are easily shielded and focussed to produce a shaped beam pattern and for this reason are the prime choice for most automobile's headlights, replacing the older incandescent light bulbs used prior to the 1980's. They do get hot, indicating some inefficiencies in creating visible light from electricity; in fact, there are halogen heating elements for stoves. Modern indoor halogen "torchiere" light fixtures are required to have a metal safety grating on them because too many drapery fires were started by the hot bulbs.



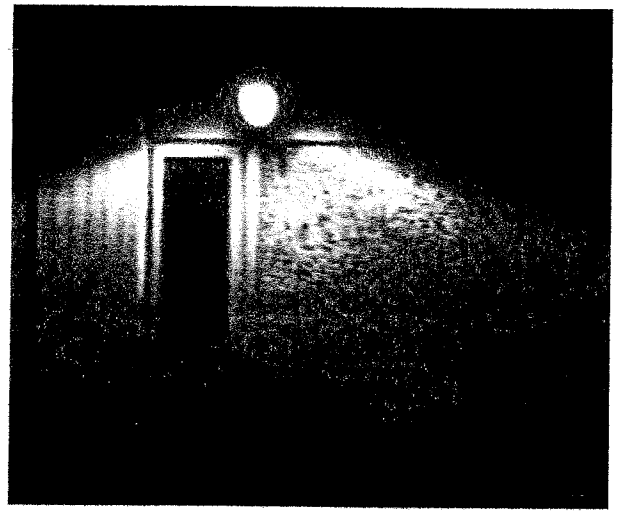
An example of a halogen outdoor lamp sold as a security light.

Metal Halide - the new kid on the block. A very bright bluish white light commonly seen coming from the headlights of newer expensive imported automobiles. Metal halide is an energy efficient point source lamp.

Low-Pressure Sodium (LPS) - a discharge lamp where the light is produced by radiation from sodium vapour at a relatively low partial pressure. LPS is a "tube source", making it somewhat difficult, but not impossible, to shield it to prevent glare. It is monochromatic light, roughly orange yellow in colour. Because all of the emitted energy is in the visible part of the spectrum, this is a very efficient lamp. However, everything looks various shades of orange yellow; there is no colour rendition. Under a Low-Pressure Sodium lamp, a green car can look the same as a blue one, or a red one.

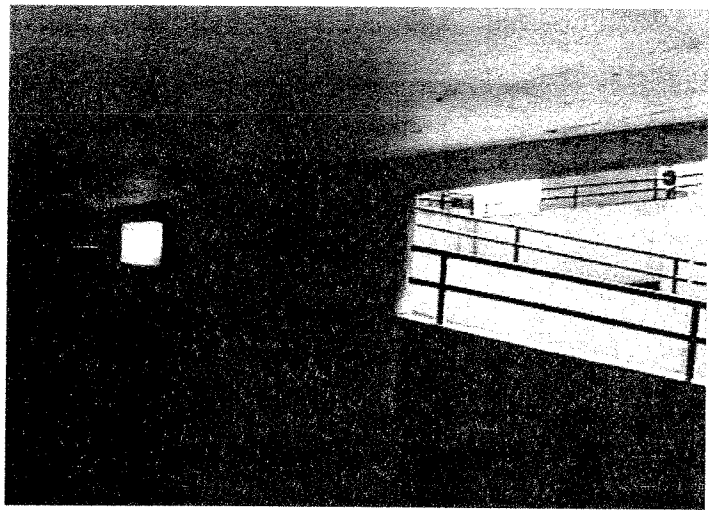


Low pressure sodium light fixtures at the Calgary Science Centre. Note that the tubes' elongated shape must be accommodated.



The characteristic golden yellow colour of low pressure sodium. This fixture is shielded to put most of the light onto the ground.

High-Pressure Sodium (HPS) - lamp where radiation is produced from sodium vapour at relatively high partial pressures. HPS is essentially a "point source", meaning it can be shielded and focussed efficiently if the manufacturer wishes to. Not as energy-efficient as the Low-Pressure Sodium tube, the HPS lamp's distinctive pinkish-orange colour has just enough blue tones in it to allow you to correctly guess the colour of any car you see at night.



High pressure sodium wall-mounted lamp. Note the colour difference between the HPS light and the background sunlight.

LIGHT FIXTURE TERMINOLOGY

Fixture - the assembly that holds the lamp in a lighting system. It includes the elements designed to give light output control, such as a reflector (mirror) or refractor (lens), the ballast, housing, and the attachment parts.

Luminaire - a fixture with its lamp.

Light Standard - the pole to which the fixture is attached.

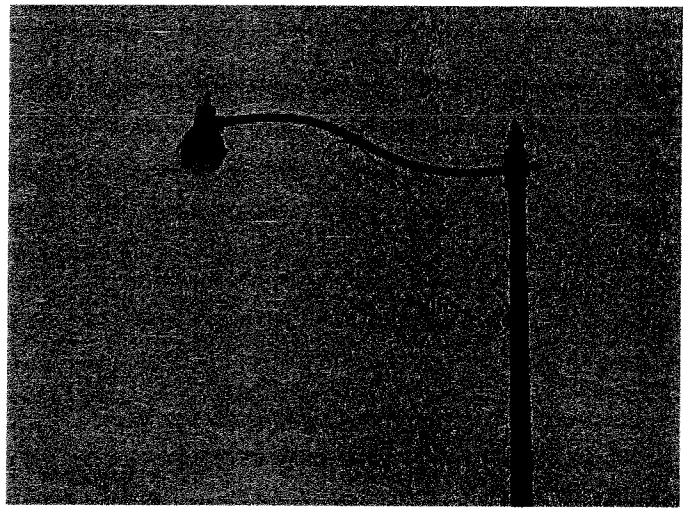
Cut off angle, of a luminaire - the angle, measured up from the nadir (i.e. straight down), between the vertical axis and the first line of sight at which the bare source (the bulb or lamp) is not visible.

Full-cutoff fixture - a fixture that allows no emission above a horizontal plane through the fixture.

Sharp Cut-off - the optical design that restricts the distribution of light from the fixture. These restrictions include:

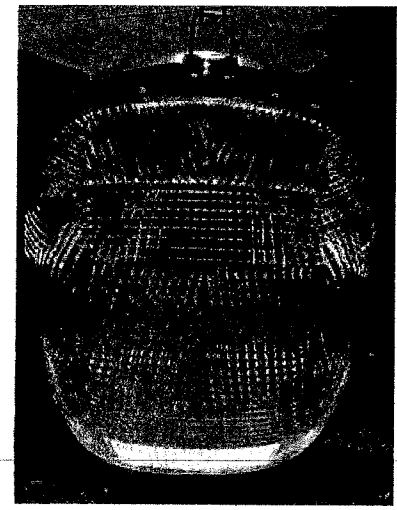
- no light is emitted above a horizontal plane passing through the bottom of the fixture
- less than 10% of the emitted light shines within 10 degrees below the horizontal plane passing through the bottom of the fixture

Semi-cutoff fixture - a fixture that provides some cutoff, but less than a full-cutoff fixture. The light source in a semi cut-off luminaire can be seen directly when viewed from the side. Most of the light is placed on the ground, but much is at such low angles that it contributes more to glare than to visibility. Such fixtures are used to cheaply throw light a long ways from the light standard, allowing fewer light fixtures per street. However, good engineering principles commonly indicate that additional full cut-off light fixtures should be used instead. The overly large distance sometimes seen between semi cut-off light fixtures on Calgary streets can lead to problematic situations when retrofitted with full cut-off fixtures when the compromises and shortcuts of the initial streetlight installation become obvious.



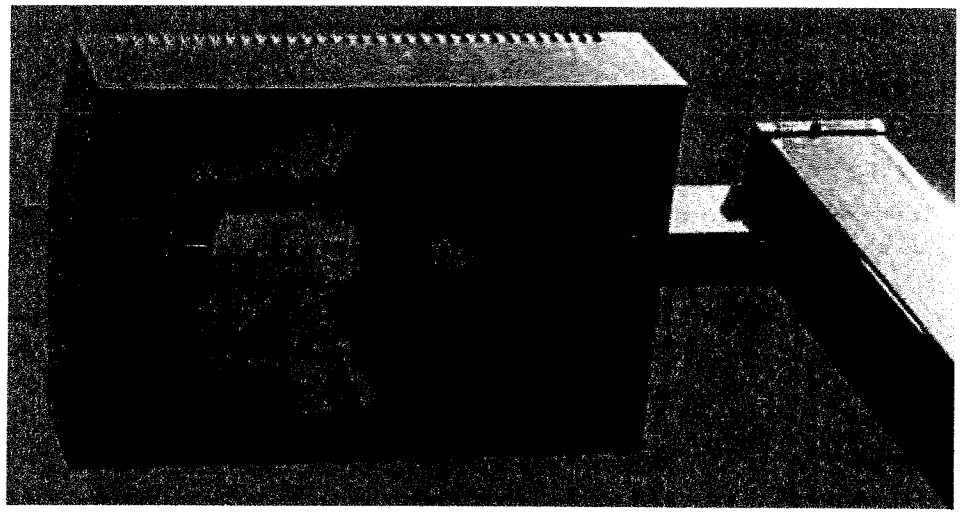
This modern light fixture designed to resemble an old time light is a semi-cutoff light fixture.

Lens or Refractor: - controlling light output by means of refraction (lens). More common in older light fixtures, but still used in some good modern designs.



This photograph shows the dispersion of light caused by the sets of angled ribs on both sides of this glass refractor from a semi cut-off light fixture.

Mirror or Reflector - controlling light output by means of reflection (mirror). More and more common in newer designs.

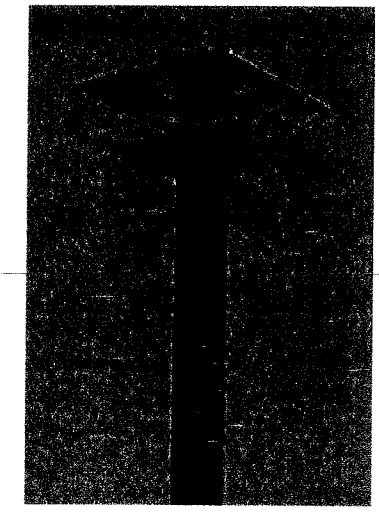


Note the system of angles in the metal reflector of this shoe-box full cut-off light fixture. These separate segments of the metal mirror are used to shape the light beam pattern.

TYPES OF STREETLIGHT FIXTURES

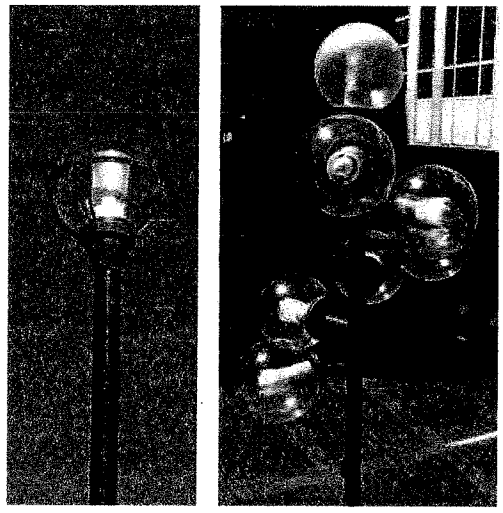
Luminaire - the complete lighting unit, including the lamp, the fixture, and other parts.

Post Top Fixture - any of a number of decorative lighting units where the lamp is directly on top of the vertical post that supports it. Typically, these fixtures have a poor distribution of light beneath the lamp and create glare by shining light sideways. Common examples of post top lights are globe, acorn-style and lantern-style fixtures.

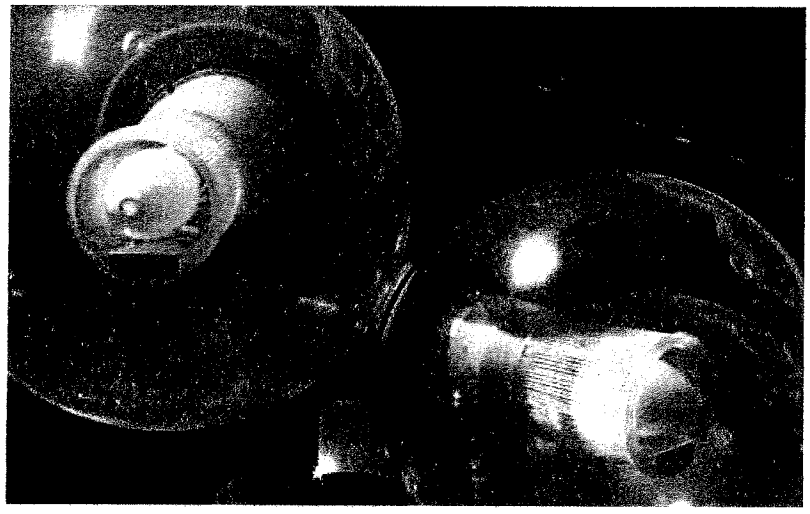


Unusual post-top fixture where the lamp at the top of the metal post shines upward and the light is redirected to the ground by a convex mirror held in place by the transparent box. The light distribution on the ground is low-glare, but since some light bypasses the mirror completely, there is a strong component of uplight, and a brighter bulb than necessary must be used to maintain light levels on the ground.

Globe-Style Light Fixture - a post-top light with a "modern" rounded glass ball enclosing the lamp. Can be fitted with internal louvres or shielded bulbs to reduce glare, but this is commonly not done, so globes are usually glary light fixtures.

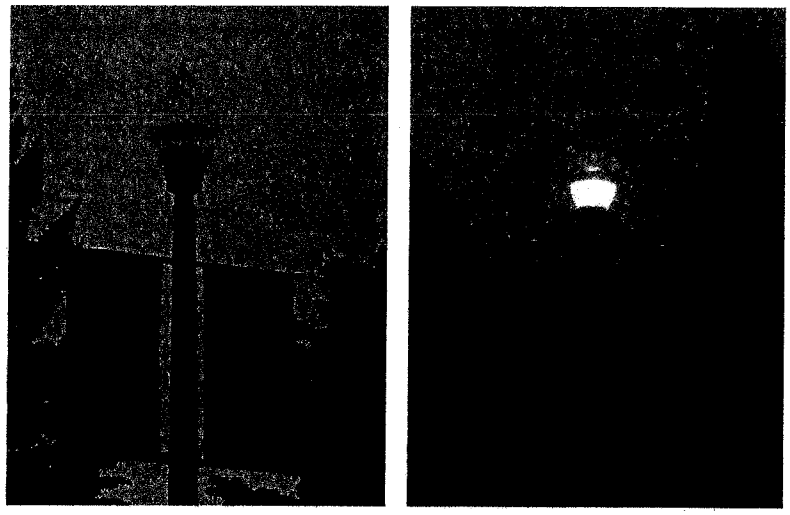


Globe-style light fixtures in Calgary. Apart from minor details, these are identical fixtures. Note that the one on the right is not only a post-top design, there are additional lights arrayed along the side of the post.



Close-up of globe-style light fixture showing the small metal shields used to direct the light. In this case, the shields are installed up-side-down, directing the light upwards, away from the street! This increases the contrast between the bright streetlight and the poorly-illuminated street and sidewalk, creating a hazardous situation.

Acorn-Style Light Fixture - a post-top streetlight design with a decorative glass globe that resembles an acorn. These glary light fixtures were initially used with low-output incandescent light bulbs in the first half of the 1900s. Modern examples are typically used with very bright high-pressure sodium or halogen light bulbs and generally render much more glare than other light fixtures.

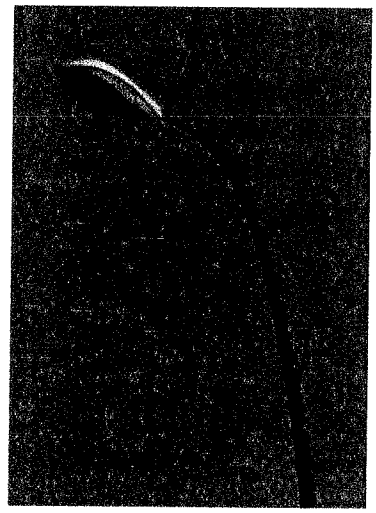


Acorn-style light fixtures. Such lamp posts evoke simpler times with good reason; they are outdated designs ill suited to modern high output lamps and city-dwellers' 24-hour day.

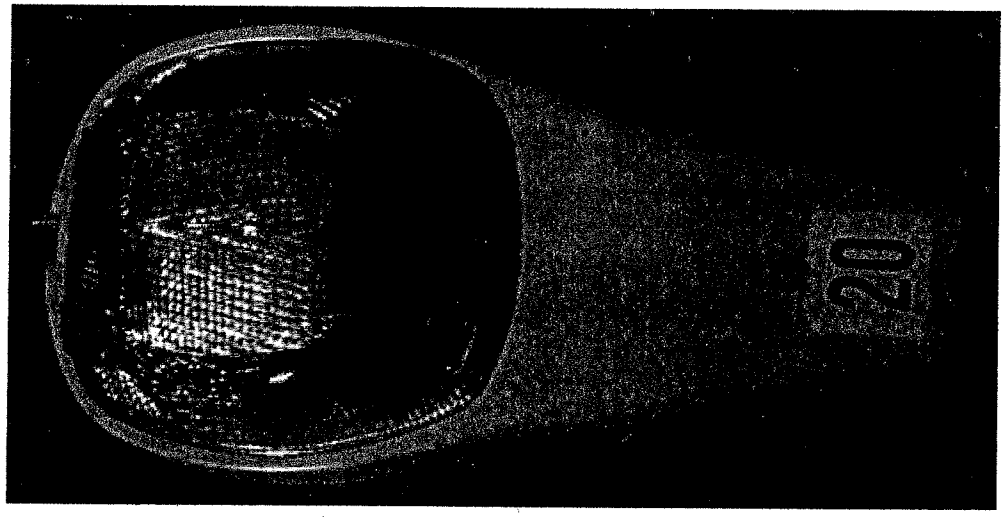
Lantern-Style Light Fixture - a post-top streetlight or home or yard light designed to resemble an old-time kerosene lantern. Usually used in areas to promote a historic look or charm. While attractive in the daytime, lantern-style luminaires are typically one of the worst designs for nighttime lighting due to their glary nature. Shielded bulbs or internal louvres help immensely.

Lantern-style house light, lantern-style yard light and lantern style streetlight.

Cobrahead Light Fixture - an informal term for the curved-arm oblong-headed fixtures that are mainstay of roadway lighting in Calgary. These are semi cut-off light fixtures in that the refractor distributes most of the light onto the ground, but a significant fraction shines sideways (creating glare) and some shines upwards, never hitting the ground (and thereby causing sky glow).

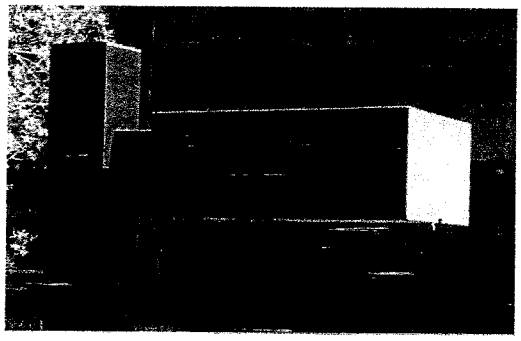


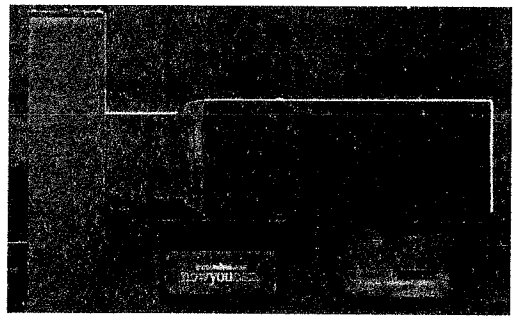
Cobrahead light fixture that characterises much of suburban Calgary. Note the bulbous refractor that resembles a glass salad bowl.



Closeup of part of cobrahead fixture showing the glass refractor. The '20' denotes that this fixture carried a 200W lamp.

Shoe-Box Light Fixture - an informal term for a rectangular full-cutoff light fixture with a flat glass lens. All of these fixtures are low-glare full cut-off designs.





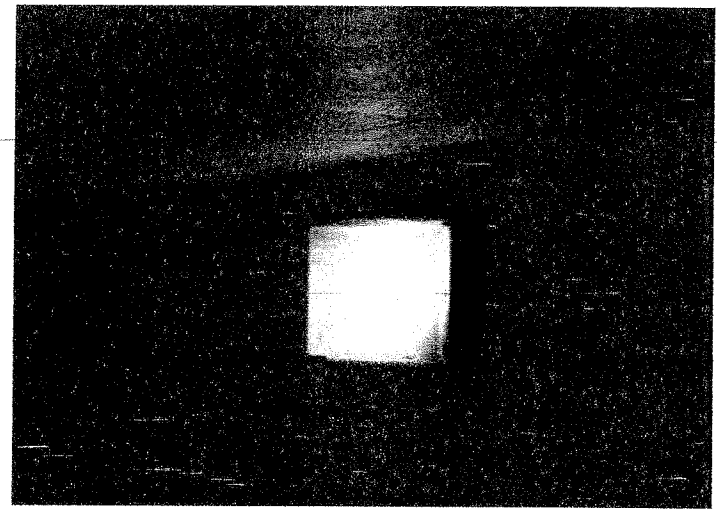
Shoe-box light fixtures are manufactured by a number of companies. All have a similar compact rectangular shape, a flat glass plate instead of a shaped lens or refractor, and a mirror system inside to shape the beam pattern.

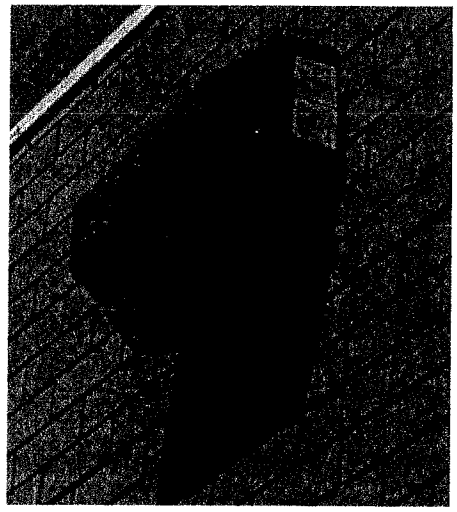
OTHER TYPES OF NIGHTTIME LIGHTING

Security Lighting - this is a broad term used to cover off a number of light fixture types and purposes whose overall stated goal is to improve security and reduce crime. A number of studies now question the effectiveness of light as an inhibitor of crime; lighting with nobody around to view the criminals means that the criminals don't need to remember to bring a flashlight if it is night. Studies show that most home break-ins occur during the day - when people are away at work. Proper lighting can enhance surveillance, but it is unlikely to scare criminals away. Much more information is available in our Light and Crime section of this website.

Task Lighting - this term has been introduced to describe certain types of indoor lighting. Adding lights with a specific job or purpose in mind usually means that the correct light fixture is chosen. For instance, under-cabinet light in kitchens using relatively efficient halogen spotlights or fluorescent tube fixtures means that bright, glare-free lighting is available for food preparation without resorting to overly-bright ceiling fixtures which may just cast shadows under the cabinet overhangs anyway. A proper desk light is another instance of using the task lighting philosophy: think of the job you want done, then find the right light fixture to do it. Outdoors, where the stakes (personal safety, traffic safety) are higher, this type of thinking is needed too.

Wallpack - a light fixture that mounts on the wall and shines light outward and sideways. These are the most commonly used "security light" on commercial premises. Most of these lamps produce a lot of glare because of the mistaken belief that proper outdoor lighting can be achieved by throwing light "over there" from "over here". Wallpacks are commonly a "band-aid" solution, when putting in a light fixture on a pole is thought to be too expensive or too much work.





Three wallpack light fixtures. Note how they are designed to allow light to shine outwards and sideways along the building.

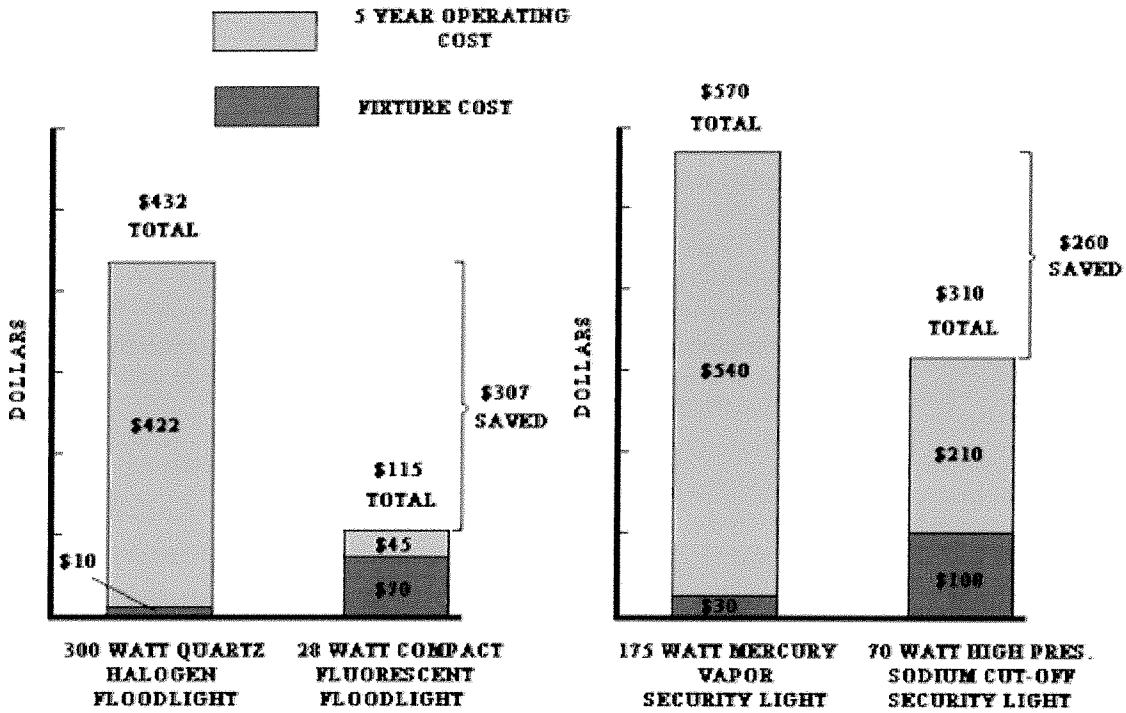
Motion Sensor Lights - use an infrared detector to turns lights on. Used as part of a system to reduce the potential for crime, motion sensor lights are used for two purposes, to draw attention to activity in a normally dark area, and to illuminate the area to allow surveillance by potential witnesses. Motion sensor lights do not fool criminals into thinking that someone just turned on the light - criminals see these lights in the stores, too, so they know what's going on. In better fixtures, the detector can be aimed so that only movement in the selected area causes the lights to illuminate; this reduces false alarms. Some motion sensor lights resemble lantern fixtures. While better than regular lantern fixtures which must remain on all the time, compared to other designs, lantern-style motion detector lights typically produce a lot of glare unless fitted with a special light bulb that is itself shielded to reduce stray light. Look for motion sensor lights with metal shields for the bulbs and fit them with 25 to 60 watt bulbs. Unshielded two-bulb fixtures are typically sold with 75 W or brighter flood lamps. Too much light, like these lamps or halogen fixtures typically produce, only means that nearby unlit areas appear much darker by contrast. Lower wattage regular light bulbs in these fixtures spray glare everywhere and are not a good solution. Unshielded two-bulb fixtures fitted with director bulbs can put light where it is needed without creating glare. See additional discussion in Light and Crime section of this website.

Flood Lights - light bulbs or fixtures designed to direct light evenly over a large area.

Spot Lights - light bulbs (such as director bulbs) or fixtures designed to concentrate light on a specific object. Some manufacturers produce director bulbs with a specific beam divergence (60 degrees, for example), that allows good matching of light source to needs.

Accent Lights - decorative lights used to draw attention to particular features of objects as diverse as plants, trees, or fountains, or buildings. Such lights may be aimed as to accentuate shadows on a textured wall or simply to highlight a particular object at night. It is key to remember that such decorative lights can impact safety and security if they mask steps or ledges or if the light's glare means that a neighbour or homeowner cannot see properly, reducing their ability to keep the property under surveillance for the purposes of reducing crime.

Marker Lights - commonly used on radio transmission towers or along airport runways. Also seen at some shopping malls (Chinook Mall) or on home driveways or sidewalks (low-voltage lighting). Lights should be low brightness and low glare. Many garden lights are too glary to be properly used for this purpose.


5 YEAR OPERATING COST
FIXTURE COST
DOLLARS
$432 TOTAL
$422
$10
$307 SAVED
$115 TOTAL
$45
$70
300 WATT QUARTZ HALOGEN FLOODLIGHT
28 WATT COMPACT FLUORESCENT FLOODLIGHT
SIGN LIGHT
DOLLARS
$570 TOTAL
$540
$30
$260 SAVED
$310 TOTAL
$210
$100
175 WATT MERCURY VAPOR SECURITY LIGHT
70 WATT HIGH PRES. SODIUM CUT-OFF SECURITY LIGHT
AREA LIGHT

Results

Experiment # 2

Star Count

(Should be between 1500 and 2500)

Tobermory

Sample # 1 10 stars
Sample # 2 26 stars
Sample # 3 25 stars
Sample # 4 29 stars
Sample # 5 32 stars

24.4 (average) x 40 = 976 stars in the night sky.

Lion's Head

Sample # 1 14 stars
Sample # 2 24 stars
Sample # 3 31 stars
Sample # 4 30 stars
Sample # 5 28 stars

25.4 (average) x 40 = 1016 stars in the night sky.

Wiarton

Sample # 1 11 stars
Sample # 2 10 stars
Sample # 3 22 stars
Sample # 4 19 stars
Sample # 5 24 stars

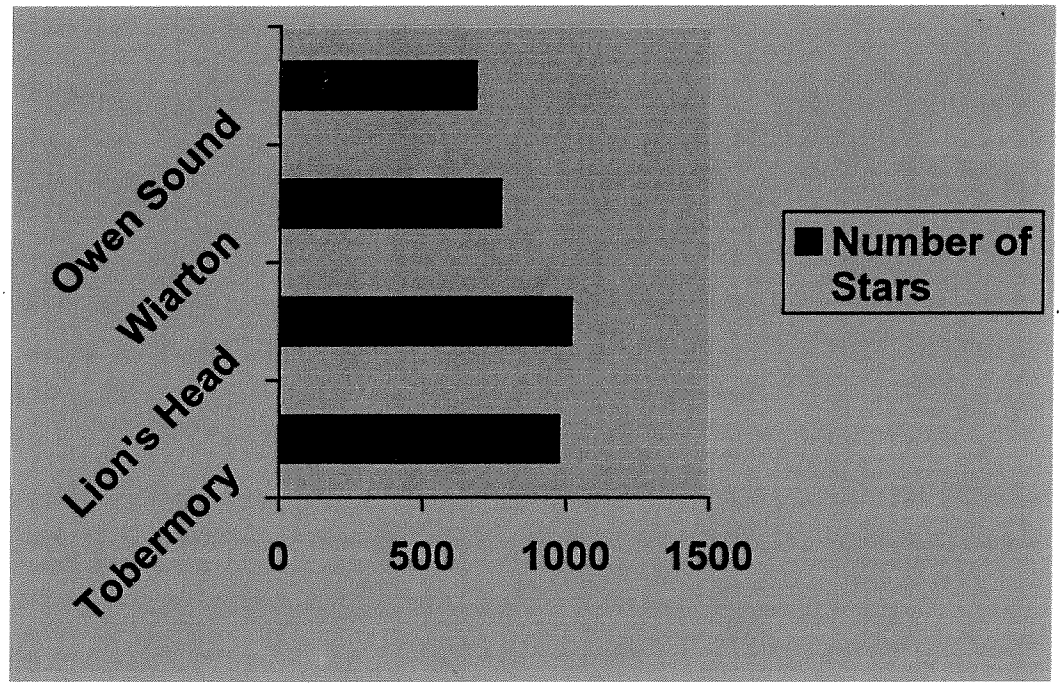
19.2 (average) x 40 = 768 stars in the night sky.

Owen Sound

Sample # 1 11 stars
Sample # 2 19 stars
Sample # 3 20 stars
Sample # 4 20 stars
Sample # 5 15 stars

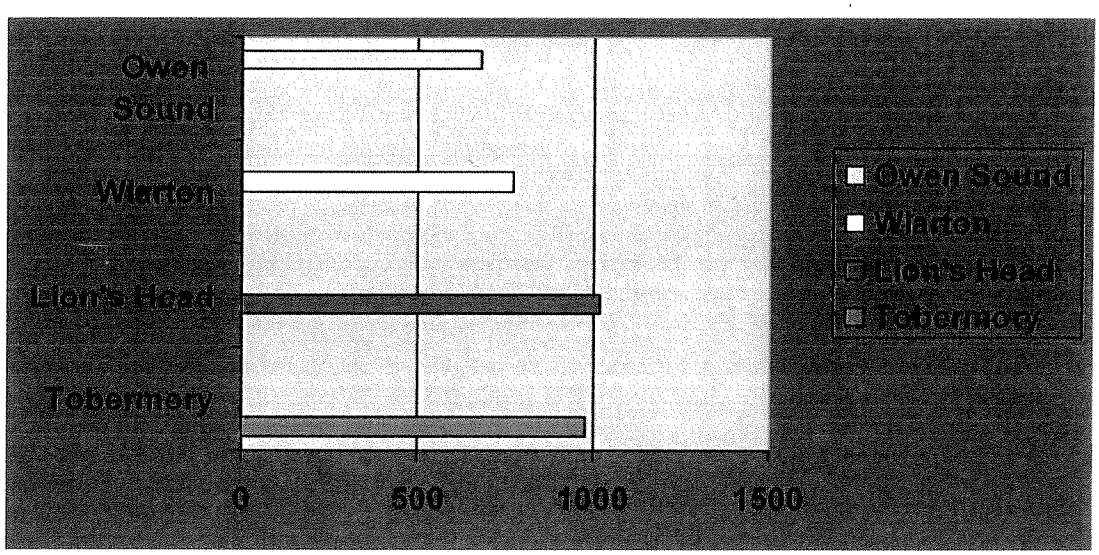
17 (average) x 40 = 680 stars in the night sky.

*****STAR COUNT*****



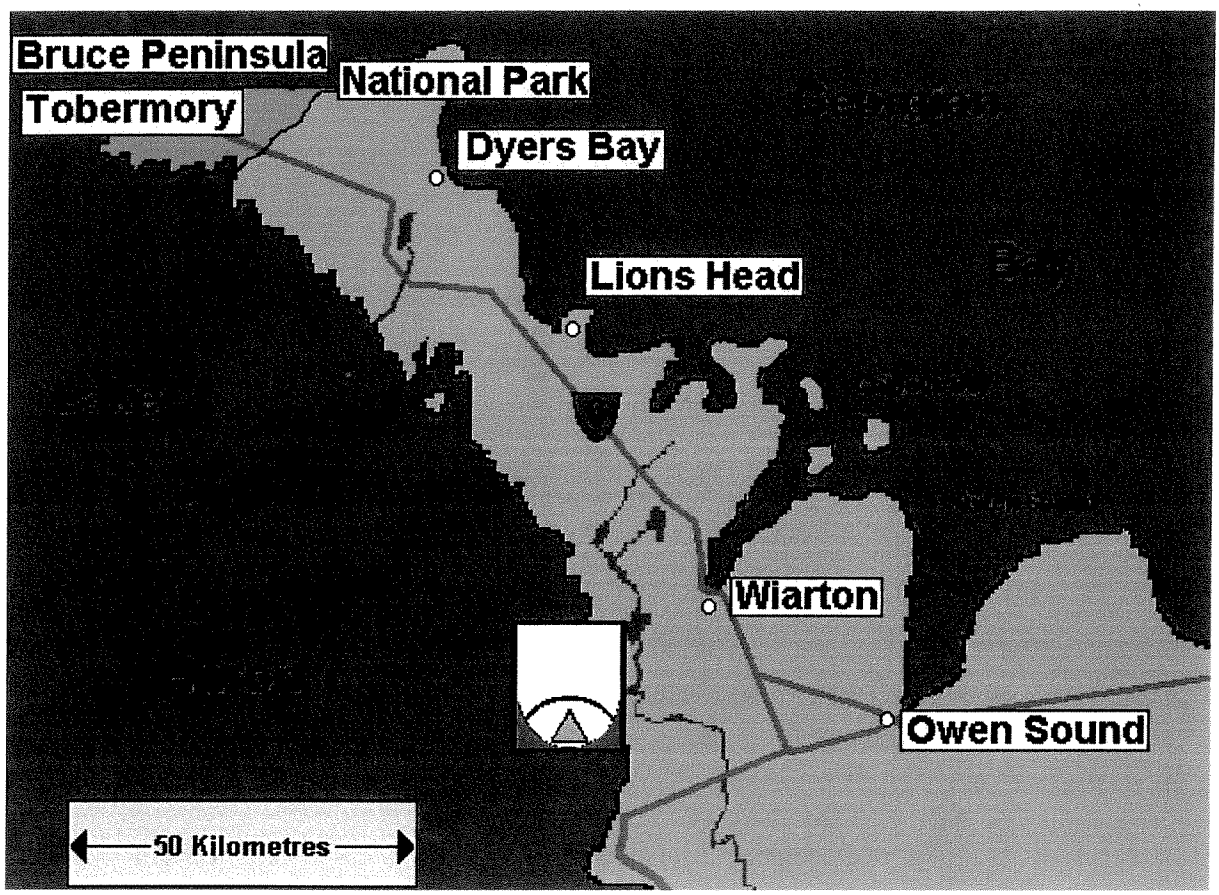
* When I counted the stars I tried to be as consistent as possible with the location and elevation. I found the place I felt was the very light polluted and did my count there.
Tobermory (Highway 6) - Under streetlights.
Lion's Head (Main Street) - Under streetlights.
Wiarton (Highway 6, Top of the Hill) - Under streetlights.
Owen Sound (Wal-Mart Parking Lot) - Under streetlights.

Town	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average	Total (Average x 40)
Tobermory	10	26	25	29	32	24.4	976
Lion's Head	14	24	31	30	28	25.4	1016
Wiarton	11	10	22	19	24	19.2	768
Owen Sound	11	19	20	20	15	17	680



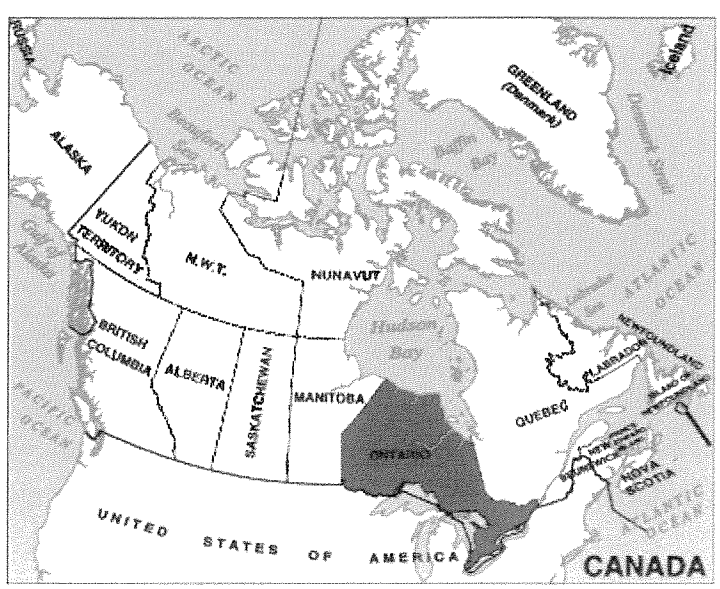
Results

Experiment #3



The population of the four towns surveyed is as follows:
Tobermory - 1 000
Lion's Head - 600
Wiarton - 2 000
Owen Sound - 22 000

Map of Ontario containing the four towns photographed



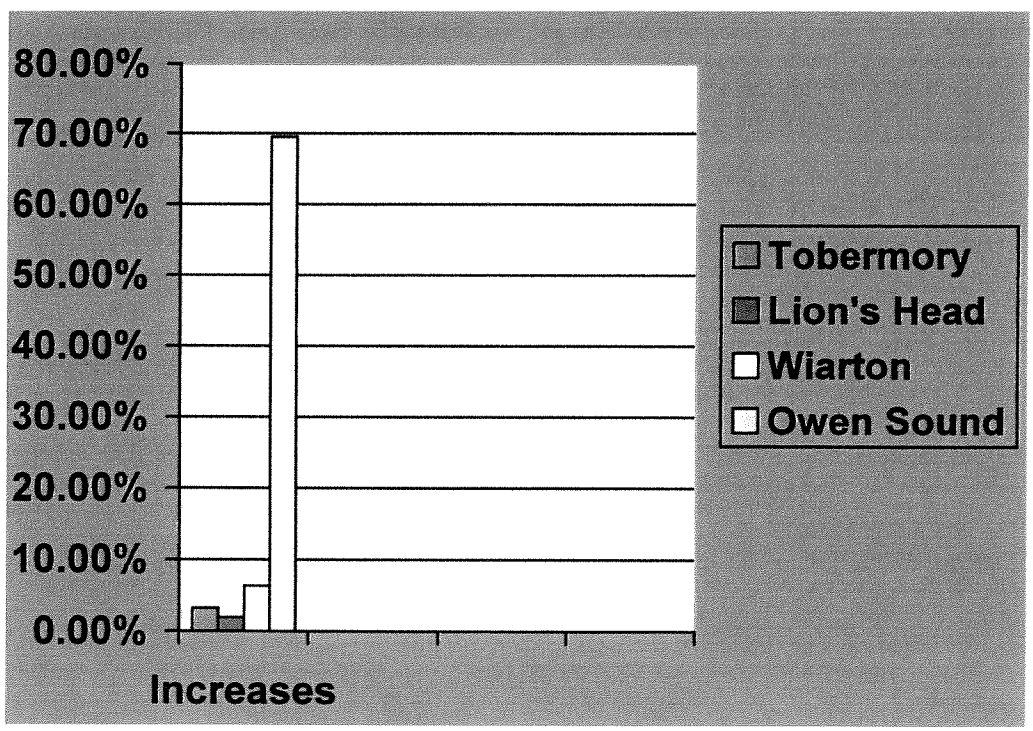
Map of Canada showing the four towns photographed

Walker's Law

$I = 0.01Pd^{-2.5}$

Where I is the increase of sky glow above the natural background
and P is the population of the city
and d is the distance to the centre of the city in kilometers

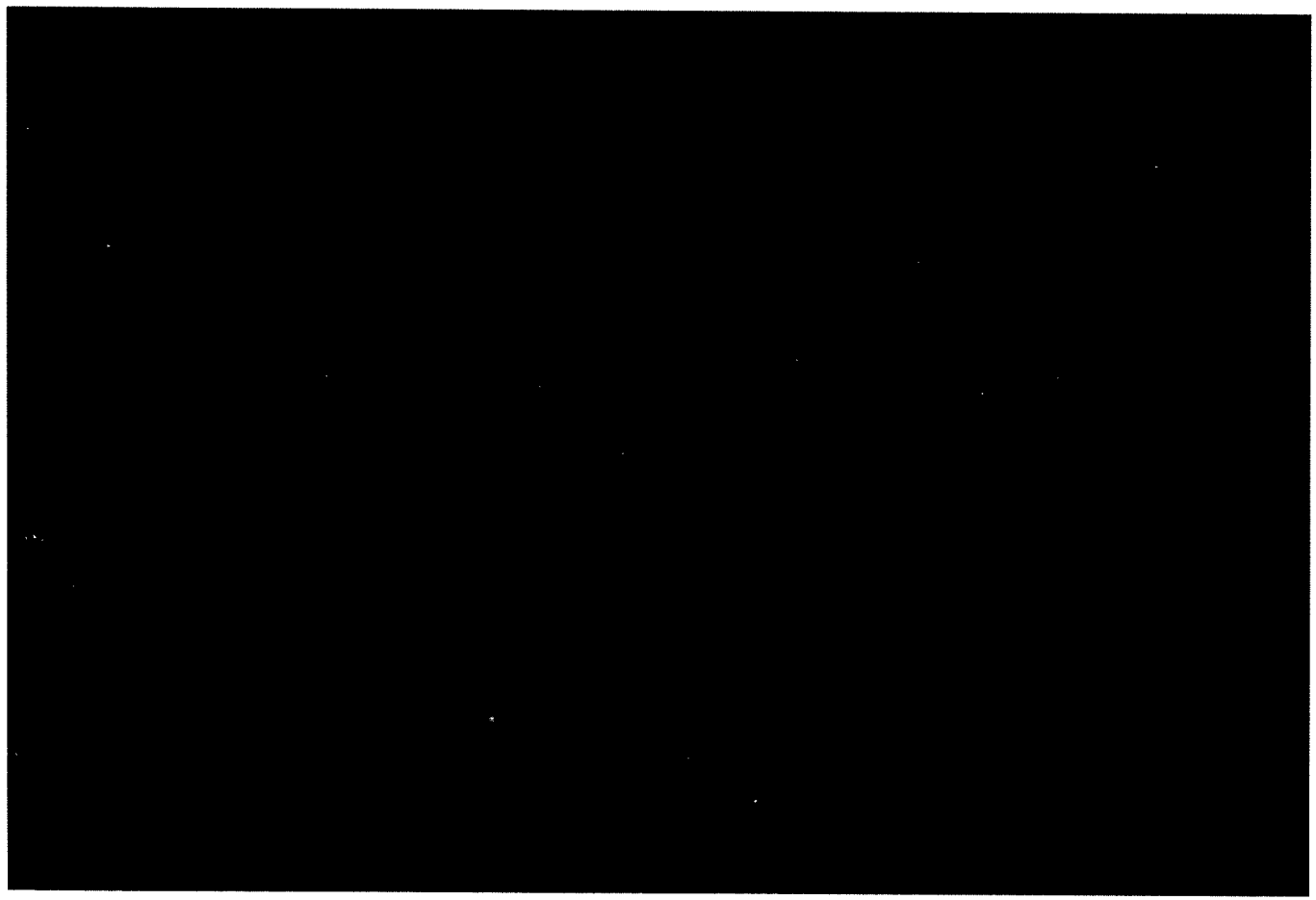
Place	Population **(p)**	Distance from Center **(d)** Standard km	Increase in Sky Glow **(I)** 45 degrees up
Tobermory	1 000	10 km	3.2 %
Lion's Head	600	10 km	1.9 %
Wiarton	2 000	10 km	6.3 %
Owen Sound	22 000	10 km	69.5 %



Tobermory, Ontario

Population – 1 000

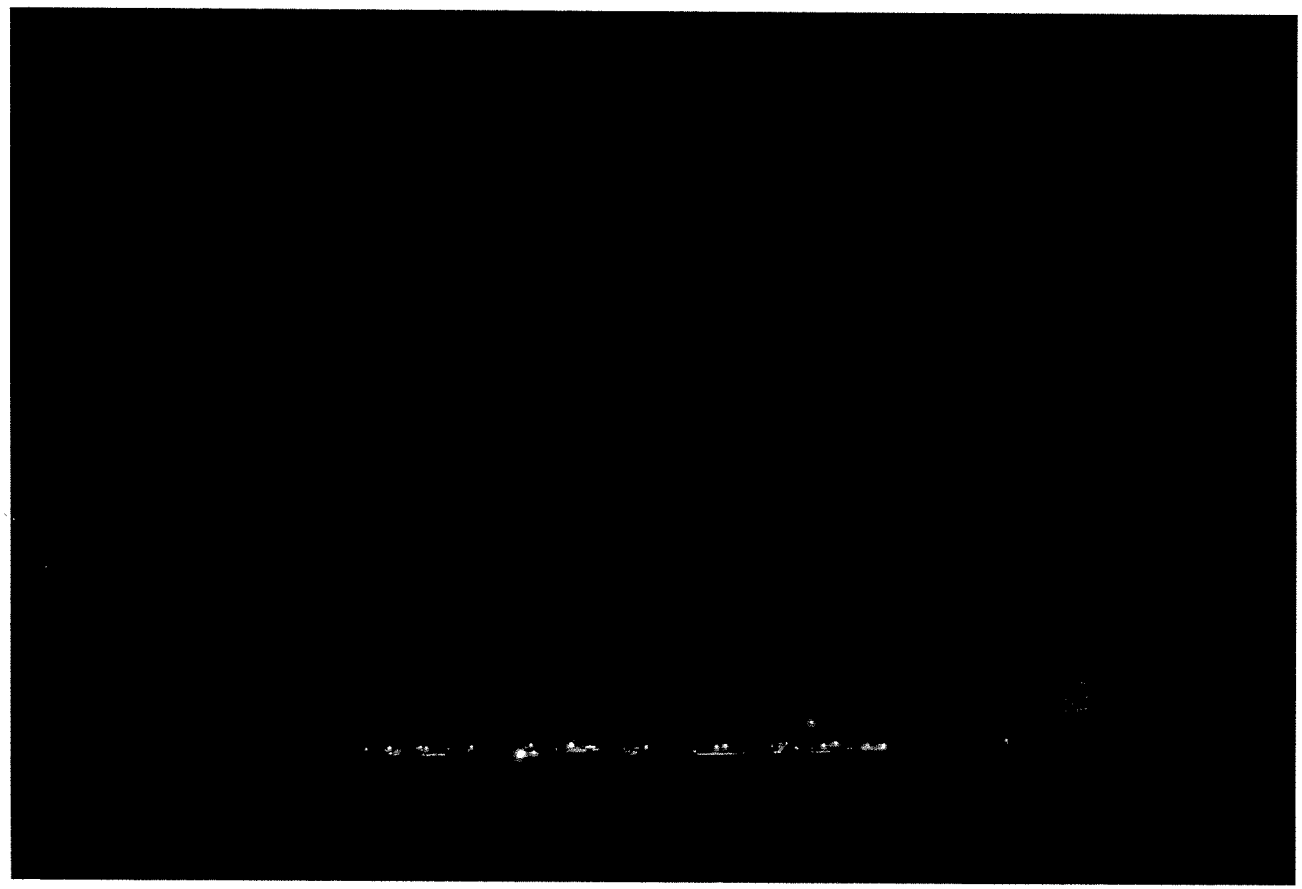
Sky glow at 10 km – 3.2 %



Lion's Head, Ontario

Population – 600

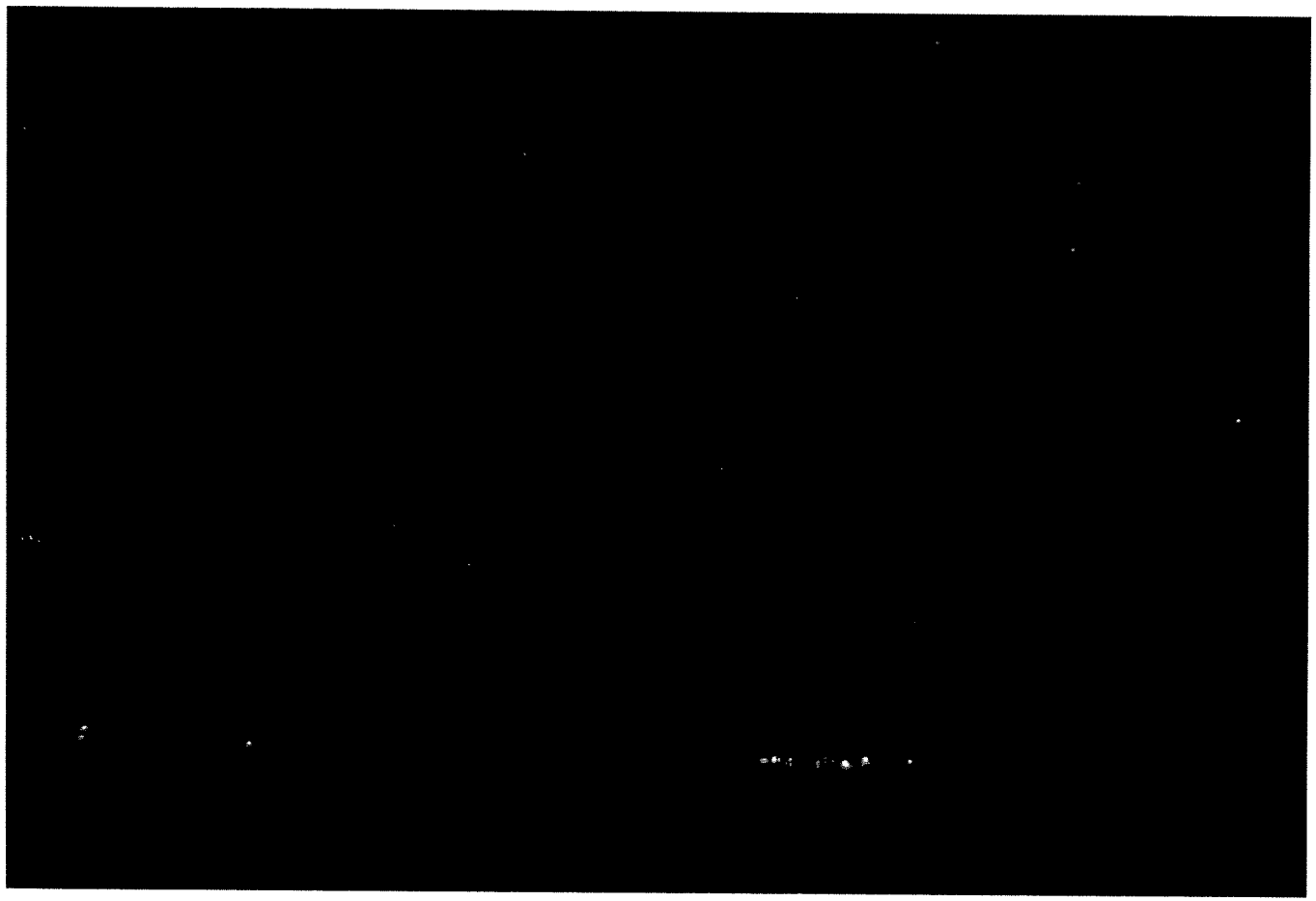
Sky glow at 10 km – 1.9 %



Wiarton, Ontario

Population – 2 000

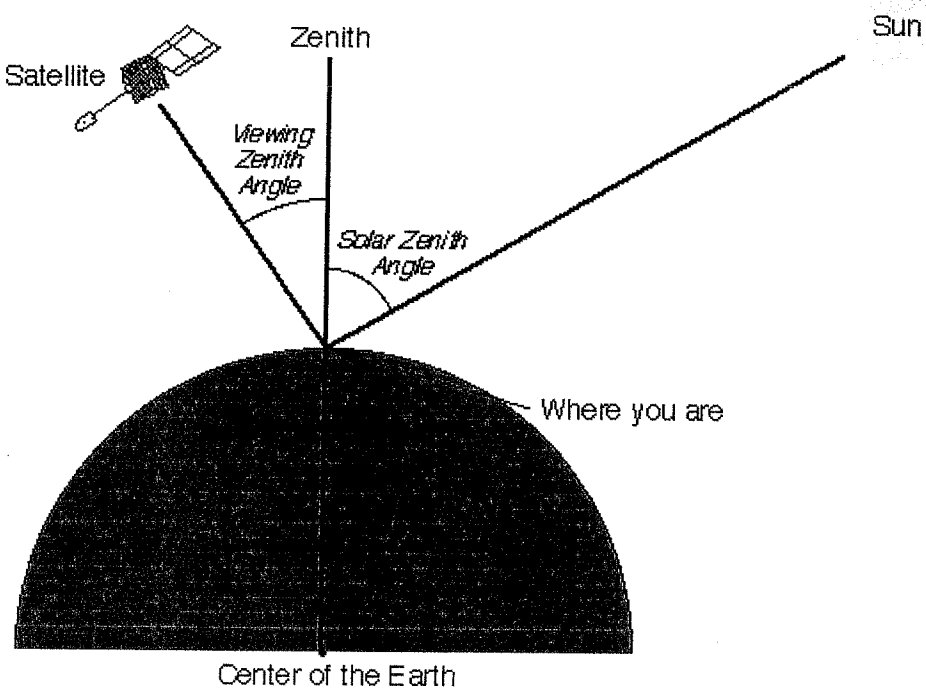
Sky glow at 10 km – 6.3 %



Owen Sound, Ontario

Population – 22 000

Sky glow at 10 km – 69.5%


Satellite
Zenith
Sun
Viewing Zenith Angle
Solar Zenith Angle
Where you are
Center of the Earth

- URBAN SKY GLOW

Urban sky glow is the result of stray light being scattered in the atmosphere brightening the natural sky background level. This effect is extremely detrimental to astronomers as well as annoying to many people in the general public. It is sometimes difficult to comprehend the effect of sky glow and the sensitivity of astronomical instruments. Human eyes can barely discern a star of the 6th magnitude which is about 15 million times brighter than a 24th magnitude star that astronomers observe. A candle flame (luminous intensity of approximately one candela) observed at a distance of about one kilometer is as bright as a 1st magnitude star and easily seen by the naked eye. This candle is about 1.5 billion times brighter than the limits of astronomical instruments.

Street lighting has been blamed for up to 50% of the urban sky glow due to 95% of the light directed down toward the pavement being reflected upward at reflectance rates ranging from 6% for asphalt to 25% for concrete (Ref 1). Urban sky glow has been reported to be increasing around 30% annually in some American cities (Ref 5).

An empirical formula has been developed in California by Merle Walker known as Walker's Law (Ref. 5) which is used to estimate the sky glow at an observing site, looking at a zenith angle of 45 degrees toward an urban source r kilometers away.

$I = 0.01 \times P \times r^{-2.5}$

where:

I = the increase in sky glow level above the ambient background

P = the population of the urban center

r = distance in kilometers from the urban center

For a city with a population of 300,000 (Greater Victoria) and an observing site 25 km away (Sannich Observatory):

$I = 0.01 \times 300{,}000 \times 25^{-2.5} = 0.96$

The increase in sky brightness, at a 45 degree angle, over the natural background is approximately 96%, half of which may be caused by roadway lighting.

Another source of sky glow, possibly of greater consequence (although studies to date are scarce), is the direct luminance from the luminaires above the horizontal plane. Many of the poor non-cutoff luminaires emit up to 10% of their light above the vertical angle of 90 degrees, with up to 30% of their light above a vertical angle of 80 degrees. Full-cutoff luminaires on the other hand emit no light above 90 degrees and considerably reduce the contribution to sky glow.

Other problems related to sky glow comes from the radiation outside the visual spectrum emitted by roadway luminaires. The traffic engineering profession has been mostly concerned with visible light, however astronomers observe the sky in many wavelengths. Some "full spectrum" lights, such as mercury vapor, emit a lot of ultraviolet radiation. High pressure sodium lights emit more of a monochromatic light and low pressure sodium lights emit essentially only monochromatic light, which can be easily filtered out by astronomical equipment.

Although urban sky glow has been difficult to quantify, some jurisdictions, particularly those around observatories such as Tucson, Arizona, have enacted ordinances requiring the use of full-cutoff luminaires and glare shields for roadway lighting.

Some of the more minor aspects of light pollution involve confusion, clutter, energy waste, and general annoyance.

About Ethan...

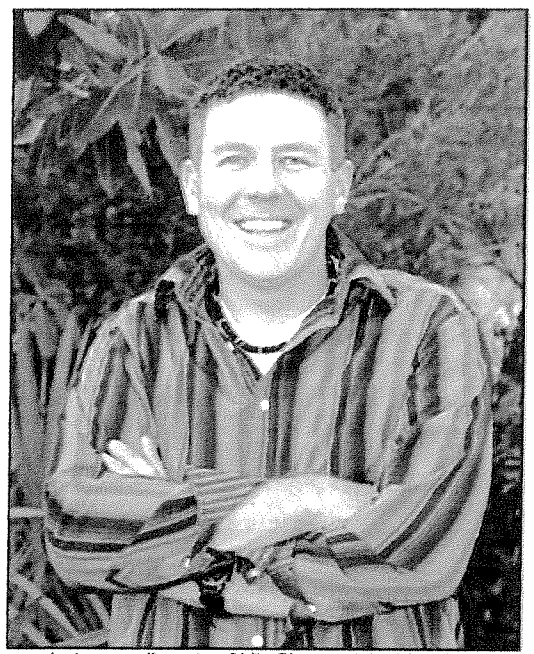


photo compliments of Lily Shuster (aka Mom!)

Ethan Meleg is a professional naturalist and photographer, specializing in birds and landscapes. His dramatic images convey the awe-inspiring beauty and diversity of the natural world.

Ethan grew up near world-famous birding location Point Pelee National Park - the place that inspired his passion for nature. He's been leading bird and nature tours for over a decade and is a member of the champion Kowa 'Canadian' Birding Team. In addition, Ethan is primary author of 'A Guide to Exploring Pelee Island Wildlife'.

Ethan is a self-taught photographer. His photos have been published all over the world in books, calendars, brochures, magazines and corporate ads. Credits include: Ranger Rick books, Forbes Magazine, Canadian Geographic, Wyman Calendars, Birder's World, Birding, Birdwatch, Wildbird, Living Bird Quarterly, Birder's Journal, National Wildlife, Nature Canada, ON Nature, Canoe & Kayak and many more. At only 31 years of age, Ethan is already established as one of Canada's leading nature photographers.

Ethan lives by the shore of Georgian Bay, in the spectacular rugged setting of Ontario's Bruce Peninsula. His great passion in life is exploring the natural world with his camera, whether on distant travels or in his own backyard.

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Environment Canada Environnement Canada

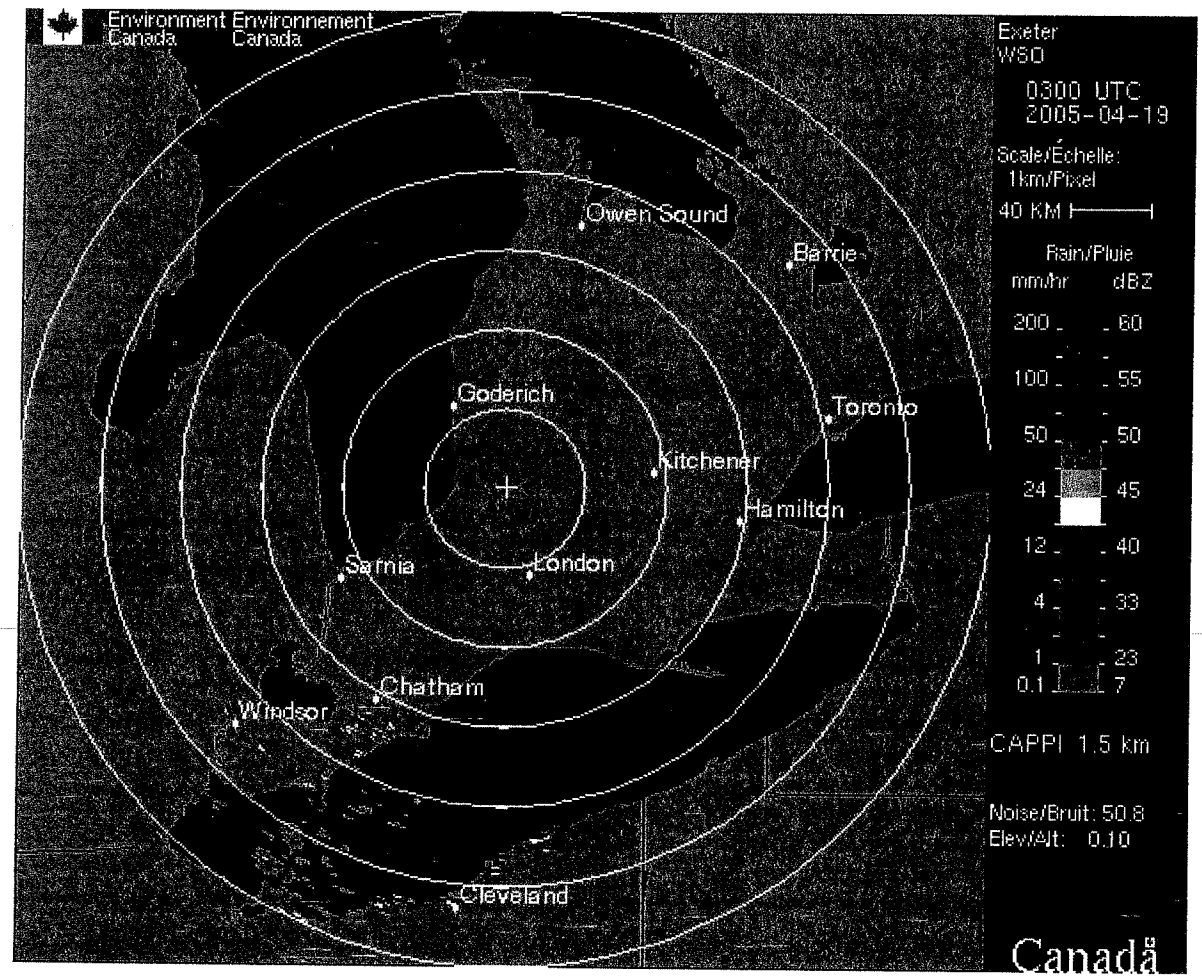
Canadian Weather Radar

Common Interpretation Errors

Click the "Play" button to activate the controls

Speed:

Image Date: 11:00 PM EDT 18-04-05



N/O = Non-operational

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Environment Canada | Environnement Canada

Tobermory

Currently

Observed at: Cyprus Lake
18 April 2005 10:00 PM EDT

Temperature	8 °C
Humidity	91 %
Dewpoint	7 °C
Wind	SSE 9 km/h

Yesterday

Max Temp.	19.6 °C
Min Temp.	0.7 °C
Precip Total	0.0 mm

Regional Normals

Max Temp.	12 °C
Min Temp.	1 °C

Record Values

Today

Sunrise	6:35
Sunset	20:17
Moonrise	15:13
Moonset	4:54

5 Day Forecast from Environment Canada

Monday night

Low 7 °C

Cloudy periods

Tuesday

High 23 °C

Sunny with cloudy periods

Wednesday

High 14 °C
Low 9 °C

Showers

Thursday

High 9 °C
Low -1 °C

A mix of sun and cloud

Friday

High 11 °C
Low 0 °C

A mix of sun and cloud

These icons are a summary. See complete text below

Text Forecast from Environment Canada

Tobermory: Issued 3.30 PM EDT Monday 18 April 2005

Tonight	A few clouds. Fog patches overnight. Low 7.
Tuesday	Sunny with cloudy periods. Wind becoming southwest 30 km/h gusting to 50 in the afternoon. High 23. UV index 6 or high.
Wednesday	Showers. Low 9. High 14.
Thursday	A mix of sun and cloud. Low minus 1. High plus 9.
Friday	A mix of sun and cloud. Low zero. High 11.

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Important Notices and Disclaimers

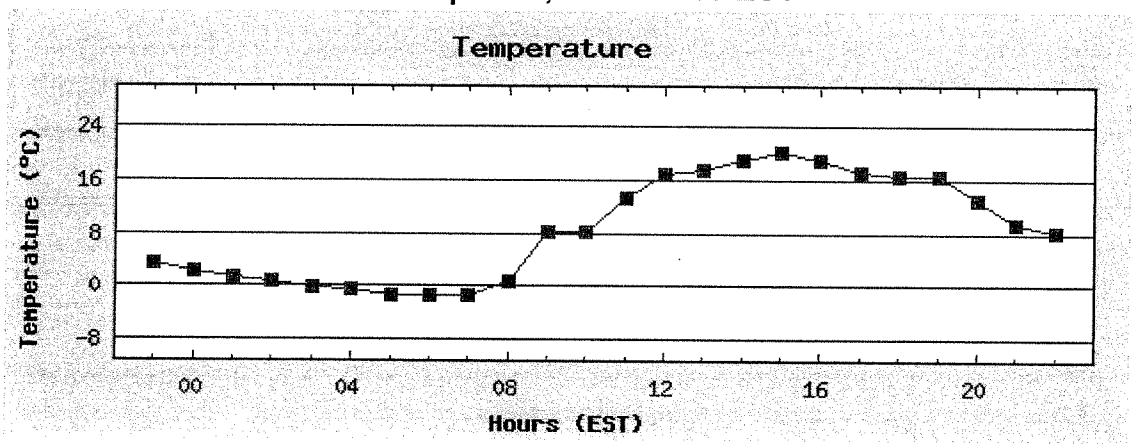
Created : 2002-12-31
Modified : 2004-07-13
Reviewed : 2002-12-31
Url of this page : http://weatheroffice.ec.gc.ca/city/pages/on-157_metric_e.html

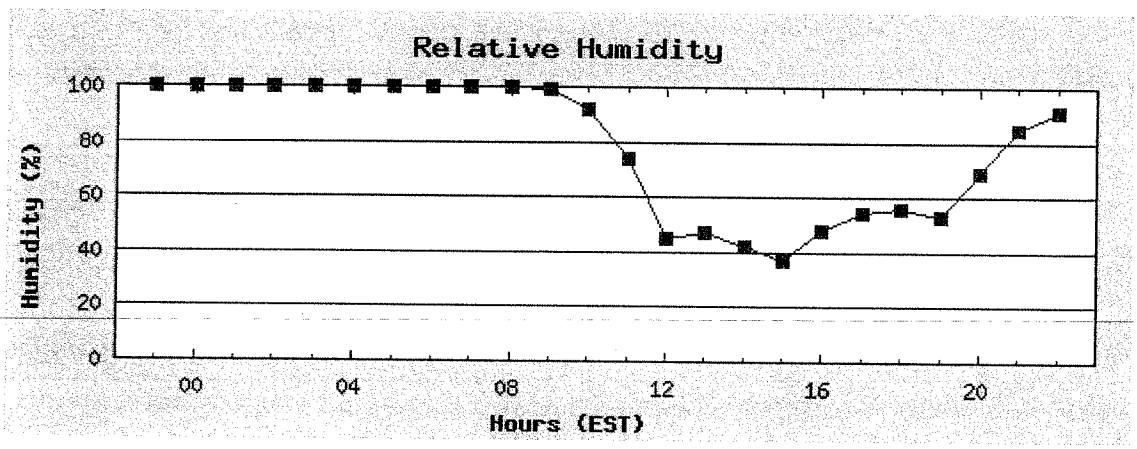
Environment Canada Environnement Canada

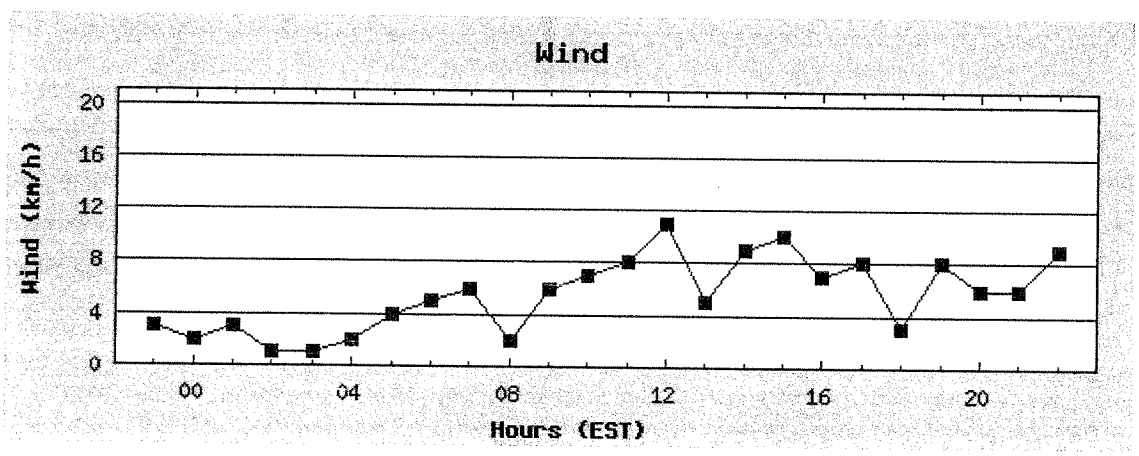
Cyprus Lake
Past 24 Hour Trends Graph

Imperial Units **Tabular Format**

Local time: April 18, 2005 22:00 EST







Pressure

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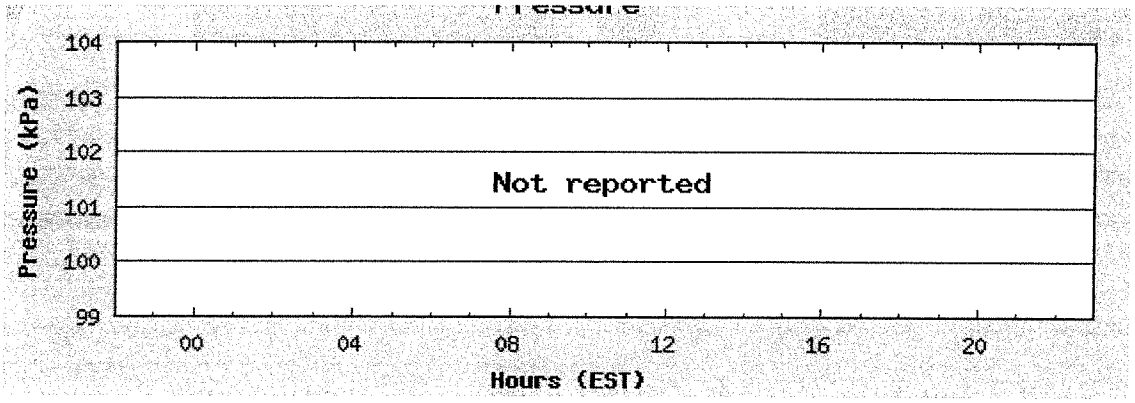

** Breaks in the graphs denote periods for which no observations are reported.

[Graphics Off] [Format for Print]

Important Notices and Disclaimers

Created : 2002-12-31
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Reviewed : 2002-12-31
Url of this page : http://weatheroffice.ec.gc.ca/forecast/trends_graph_e.html?xcy&unit=m

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Environment Canada's World Wide Web Site.

Canada

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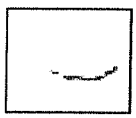
Environment Canada | Environnement Canada

Wiarton

Currently

Observed at: Wiarton Airport
18 April 2005 10:00 PM EDT



Mainly Clear

Temperature	**8 °C**
Pressure/ Tendency	**101.8 kPa ↓**
Visibility	**24 km**
Humidity	**79 %**
Dewpoint	**5 °C**
Wind	**ESE 8 km/h**

Yesterday

Max Temp.	**18.0 °C**
Min Temp.	**3.6 °C**
Precip Total	**0.0 mm**

Regional Normals

Max Temp.	**12 °C**
Min Temp.	**1 °C**

Record Values

Today

Sunrise	**6:34**
Sunset	**20:14**
Moonrise	**15:12**
Moonset	**4:50**

5 Day Forecast from Environment Canada

Monday night
Low 7 °C
Cloudy periods

Tuesday
High 23 °C
Sunny with cloudy periods

Wednesday
High 14 °C
Low 9 °C
Showers

Thursday
High 9 °C
Low -1 °C
A mix of sun and cloud

Friday
High 11 °C
Low 0 °C
A mix of sun and cloud

These icons are a summary. See complete text below

Text Forecast from Environment Canada

Wiarton: Issued 3.30 PM EDT Monday 18 April 2005

Tonight	A few clouds. Fog patches overnight. Low 7.
Tuesday	Sunny with cloudy periods. Wind becoming southwest 30 km/h gusting to 50 in the afternoon. High 23. UV index 6 or high.
Wednesday	Showers. Low 9. High 14.
Thursday	A mix of sun and cloud. Low minus 1. High plus 9.
Friday	A mix of sun and cloud. Low zero. High 11.

[Graphics off] [Format for Print]

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Reviewed : 2002-12-31
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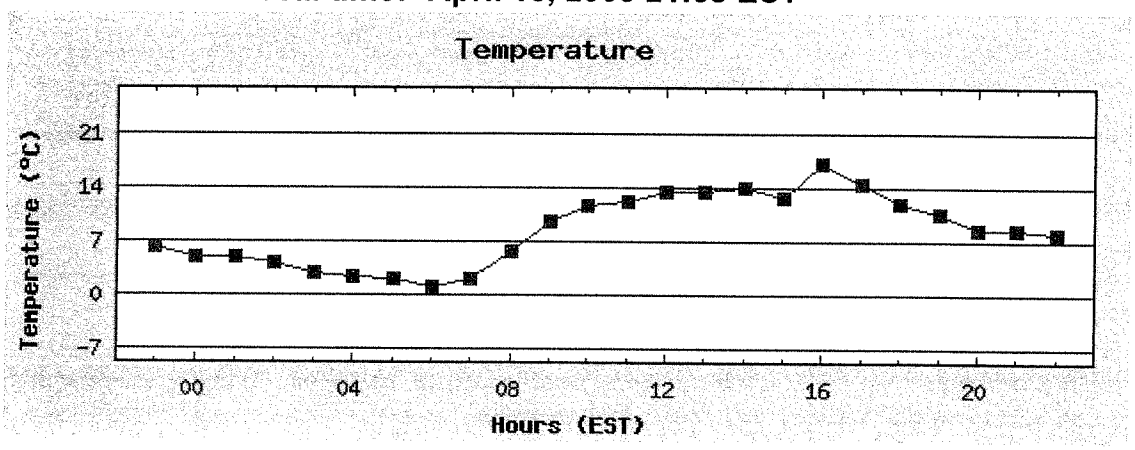
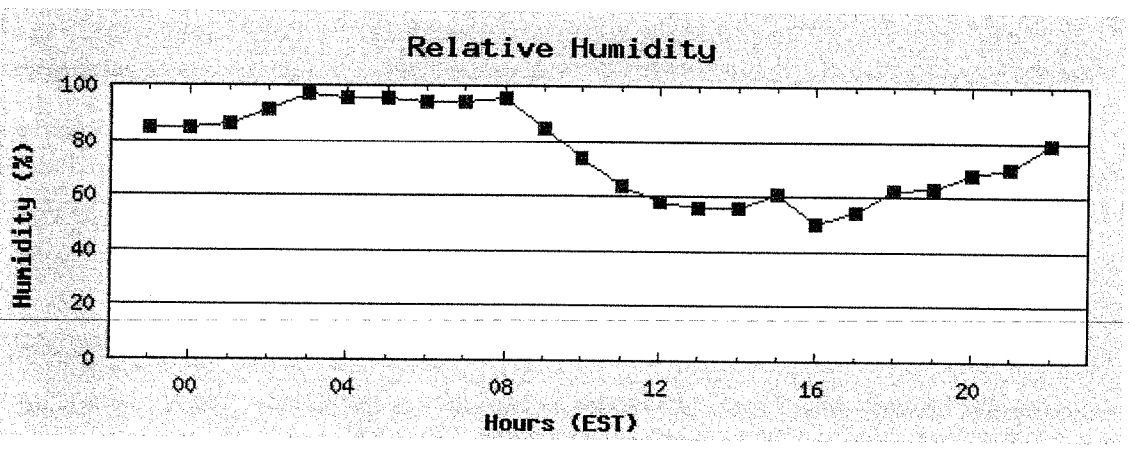
Environment Canada Environnement Canada

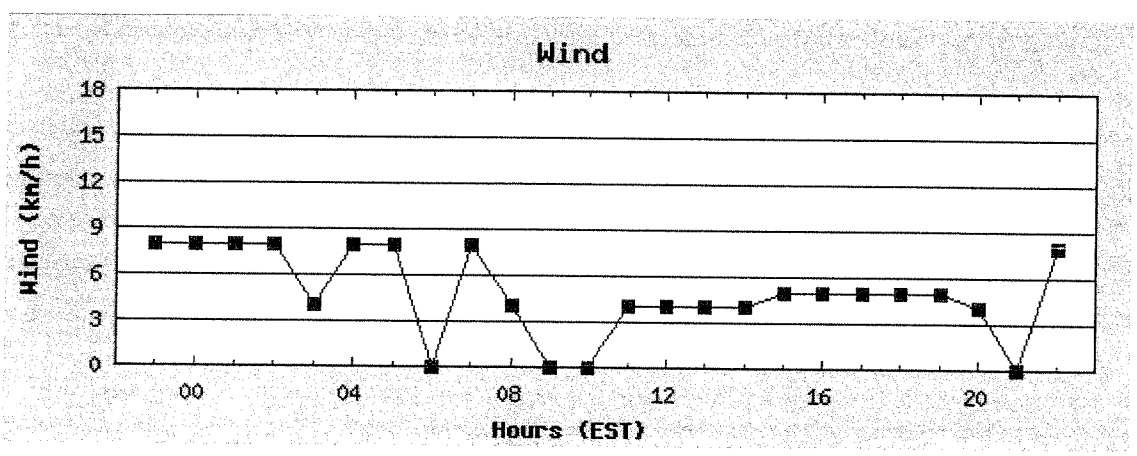
Wiarton Airport
Past 24 Hour Trends Graph

Imperial Units **Tabular Format**

Local time: April 18, 2005 21:58 EST







Pressure

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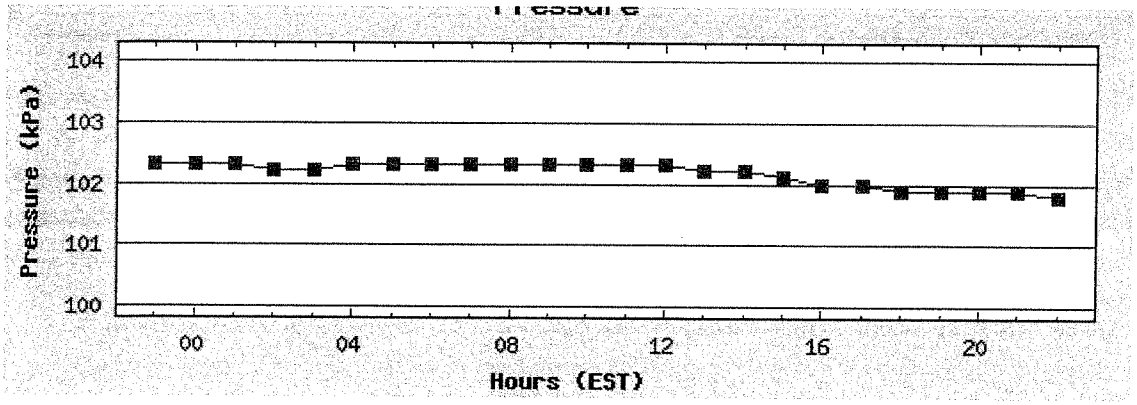

** Breaks in the graphs denote periods for which no observations are reported.

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Modified : 2004-07-13
Reviewed : 2002-12-31
Url of this page : http://weatheroffice.ec.gc.ca/forecast/trends_graph_e.html?yvv&unit=m

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Environment Canada's World Wide Web Site.

Canada

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&w&bPage

Environment Canada | Environnement Canada

Owen Sound

Currently

Observed at: Wiarton Airport
18 April 2005 10:00 PM EDT

Mainly Clear

Temperature	8 °C
Pressure/ Tendency	101.8 kPa ↓
Visibility	24 km
Humidity	79 %
Dewpoint	5 °C
Wind	ESE 8 km/h

Yesterday

Max Temp.	18.0 °C
Min Temp.	3.6 °C
Precip Total	0.0 mm

Regional Normals

Max Temp.	12 °C
Min Temp.	1 °C

Record Values

Today

Sunrise	6:33
Sunset	20:13
Moonrise	15:11
Moonset	4:49

5 Day Forecast from Environment Canada

Monday night	Tuesday	Wednesday
Low 7 °C	High 23 °C	High 14 °C Low 9 °C
		
Cloudy periods	**Sunny with cloudy periods**	**Showers**

Thursday	Friday
High 9 °C Low -1 °C	High 11 °C Low 0 °C
	
A mix of sun and cloud	**A mix of sun and cloud**

These icons are a summary. See complete text below

Text Forecast from Environment Canada

Owen Sound: Issued 3.30 PM EDT Monday 18 April 2005

Tonight	A few clouds. Fog patches overnight. Low 7.
Tuesday	Sunny with cloudy periods. Wind becoming southwest 30 km/h gusting to 50 in the afternoon. High 23. UV index 6 or high.
Wednesday	Showers. Low 9. High 14.
Thursday	A mix of sun and cloud. Low minus 1. High plus 9.
Friday	A mix of sun and cloud. Low zero. High 11.

[Graphics off] [Format for Print]

Created : 2002-12-31
Modified : 2004-07-13
Reviewed : 2002-12-31
Url of this page : http://weatheroffice.ec.gc.ca/city/pages/on-7_metric_e.html

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danshel

From: quetican [quetican@amtelecom.net]
Sent: Wednesday, April 27, 2005 10:06 PM
To: danshel
Subject: Re: Thanks and another question

Hi Shelby,
You are right about the meaning of zenith .. it is simply the point directly above an observer's head ! ...and a zenith angle of 45 degrees is a line of 45 degrees measured from the zenith along a line of sight toward the town or city whose light pollution you are measuring.
Keep up the good work. In little more than two weeks you will be headed to Vancouver ... you will have a ball !
Doug Cunningham

From: "danshel" <danshel@amtelecom.net>
To: "'quetican'" <quetican@amtelecom.net>
Subject: Thanks and another question
Date: Tue, Apr 26, 2005, 11:32 PM

Hello Mr. Cunningham,

Thanks so much for your help with the sky glow. It really helped. I have another question. Tonight at the Science Fair meeting, Mr. Lacey (one of the organizers) said I need to really understand what zenith means. I have been online searching and what I see is Zenith is the point straight up from the observer head. Walkers Law said a zenith angle of 45 degrees. Does this mean not straight up but sort of half way down towards the horizon? Thank you for everything.

Shelby

Northern Bruce Peninsula
Doug Cunningham,
quetican@amtelecom.net

Ontario, Canada: The Municipality of Northern Bruce Peninsula unanimously passed a Dark Sky Proclamation without a single negative response from ratepayers! Local amateur astronomer Doug Cunningham and the Bruce Peninsula Environment Group were primarily responsible for raising awareness and support for the proclamation. Although the proclamation is not a bylaw, it is a major step toward improving the lighting designs used around the two major Ports and Harbours in one of Ontario's premier tourist destinations. The Northern Bruce Peninsula Council has indicated that approval for any major developments on the peninsula will include a provision for Dark Sky Compliant Lighting.

Feature Story by April Cunningham

The Dark Skies of the Bruce Peninsula

Click on the pictures below for a larger image

The Quetican Observatory, privately owned by Doug Cunningham

Doug Cunningham

To experience the rugged and tranquil beauty on the Bruce Penins through the daytime is one thing, but when the night falls, astronon and star gazers alike look up to the heavens and see the Peninsul 'dark skies' emerge.

With a much smaller population than many other Great Lake regio there are fewer lights to contribute to the growing problem of light pollution, and when the clouds are few, the Bruce Peninsula provic some of the best star-gazing in Southern Ontario.

Guy Nason, president of the Toronto branch of the Royal Astronomical Society, knows of the Bruce Peninsula's clear skies. "Several years ago, a friend of mine had a cottage at Red Bay whi we used for astronomical observing," he says. "Sky conditions ther were very good."

He pointed out that if someone is far enough from Owen Sound to avoid its light pollution, the skies above the Bruce Peninsula would the best for stargazing in the entire Great Lakes Region.

Because of the 'lake effect' from the surrounding Georgian Bay an Lake Huron, the Bruce Peninsula's skies may be dark, but thick clc prevents Peninsula astronomers from observing some evenings fr late November until early in February

"I would say that within a 100 kilometre radius of Wiarton, we have highest concentration of amateur observatories in Canada," says Doug Cunningham, a retired science teacher from Bruce Peninsul District School. The area seems to attract many professional and amateur astronomers like himself.

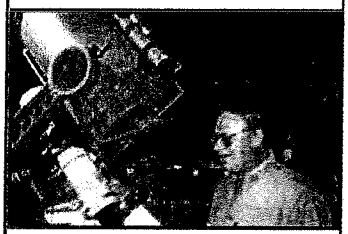
At his home on the cliffs of Lion's Head he has a private, four-year 'Quetican Observatory' where he enjoys the dark skies of the Bruc Peninsula.

Cunningham believes that astronomy is indeed a science, but it's a in a sense, an art. "An amateur astronomer sees with his eye, but l also sees with his mind. When they're seeing with their eyes their minds are engaged and they want to know more about the stars they're observing," he says.

And then the 'addiction' begins.

Cunningham's love for astronomy began when he was 22. He and

Doug Cunningham looking into the telescope



Doug Cunningham looking into the telescope

wife Paula were motorbiking to their cottage at West Cove one nigl when it struck him. "I was quite amazed by the Milky Way and I wanted to learn more about the star clouds I saw," he said. Later th weekend he picked up a book in a variety store, "The New Handbc of the Heavens", that explained a lot of the aspects of space he wa curious about. But the extent of what there is to know is endless ar he was tempted to learn more. "From then on, I was hooked. I bou my first telescope that fall."

The distinctive rings and cosmic beauty of Saturn, Cunningham's fi breathtaking observation, helped him decide what to name his observatory. "'Quetican', translated from Ojibway means 'spirit of beautiful places,'" he says.

So now, several years later, Cunningham is enjoying his first year retirement, mainly focused on this hobby of astronomy at what bett place but the Bruce Peninsula. This summer he and his wife Paula made a trip to Zambia, Africa to witness a total solar eclipse that h said was nothing short of astounding. He has also been to Mexico see an eclipse and even took two of his eager students along with him.

He has developed a fondness for our area over the years. "What makes this place so special is its natural history, the Niagara Escarpment, the fact that we have the best sea kayaking south of Lake Superior and we have the darkest skies in Ontario," says Cunningham. "The skies in Cypress Lake at Bruce Peninsula Natic Park are 50 times darker than the skies in Hamilton."

He also feels a particular responsibility, as an amateur astronomer the Bruce, to do his part to keep the skies here unpolluted by light.

This past April, Cunningham presented some ideas to the municipa of Northern Bruce Peninsula. "Even though we live in an area whe there's very little light pollution," he says, "the lighting practices we employ are the same practices that have caused the light pollution the south. There's so few of us up here, it's not a problem yet."

He recommended that when people are lighting their properties, th keep the light only on their property. When the municipality is insta new lights, he advised them to use full cut-off lighting that stops the light from going places not intended to be lit. These lights should u high pressure or low pressure sodium and not the traditional mercu

"We can do this intelligently, more efficiently with less expense anc still preserve the night sky," Cunningham says.

Cunningham is not the only person concerned with maintaining the dark skies. The International Dark Skies Association has centres ir

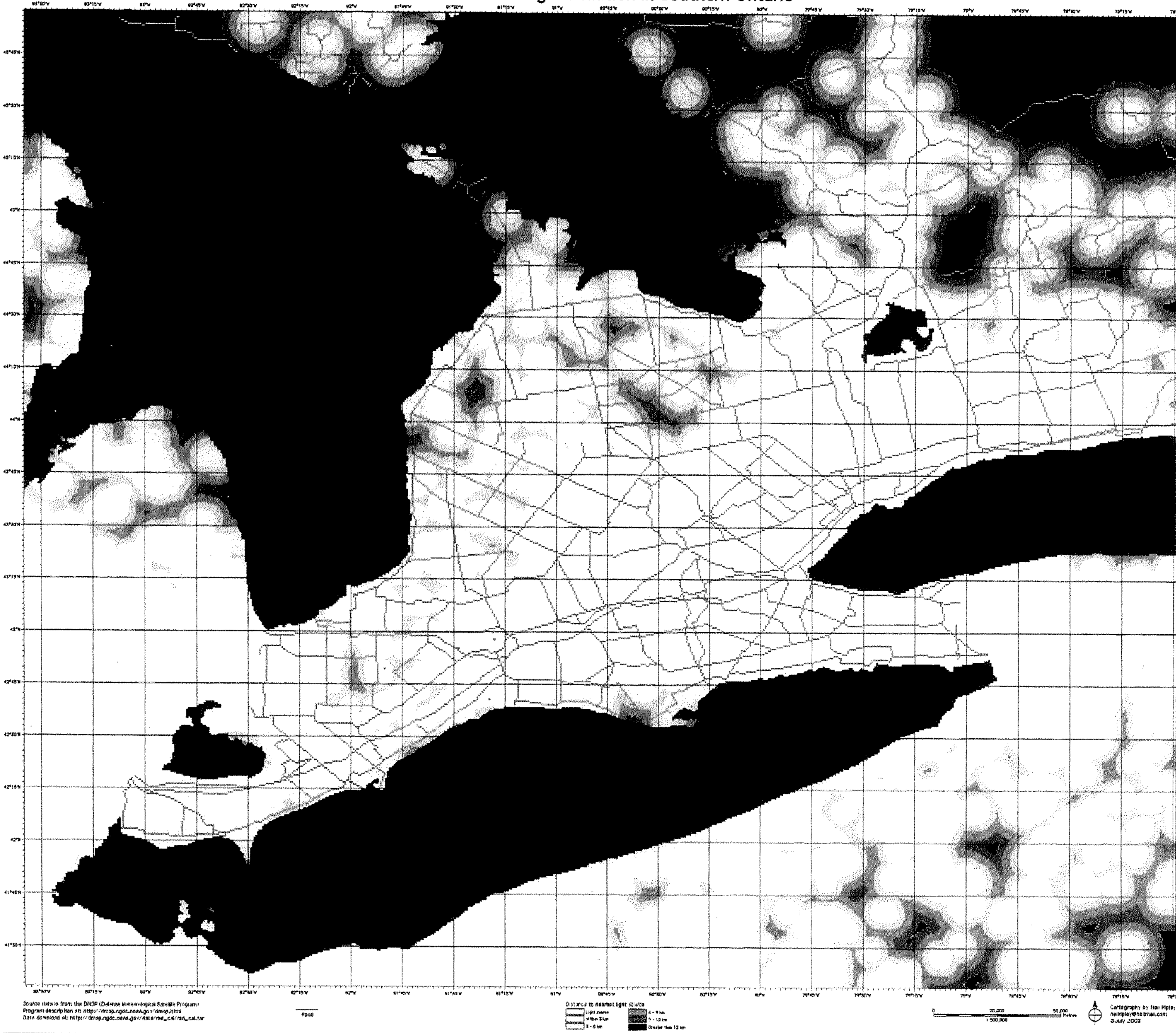
countries and has over 10,000 members world-wide. Their mission
to spread the word about the Dark Skies Concept and gradually m
more skies free of light pollution.

Back to Feature Stories

Shelby. You have a fine project!
Glad to see you do such excellent work
on an important topic!
Have fun at the CWSF - you join
a long line of Bruce Peninsula School
students attending this great event!
Make lots of friends!

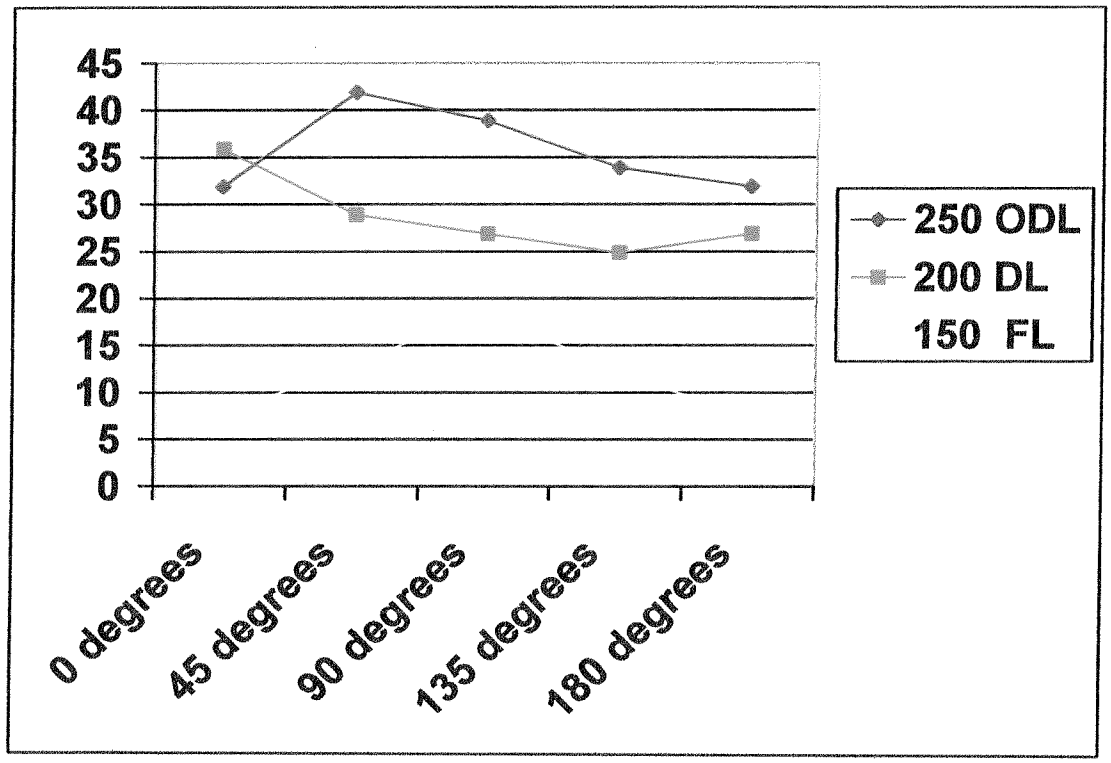
Mr Cunningham

Distance from Light Pollution in Southern Ontario



Experiment # 4

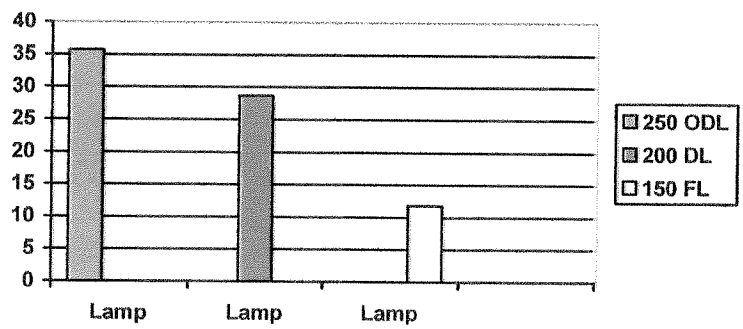
Comparison of three streetlights



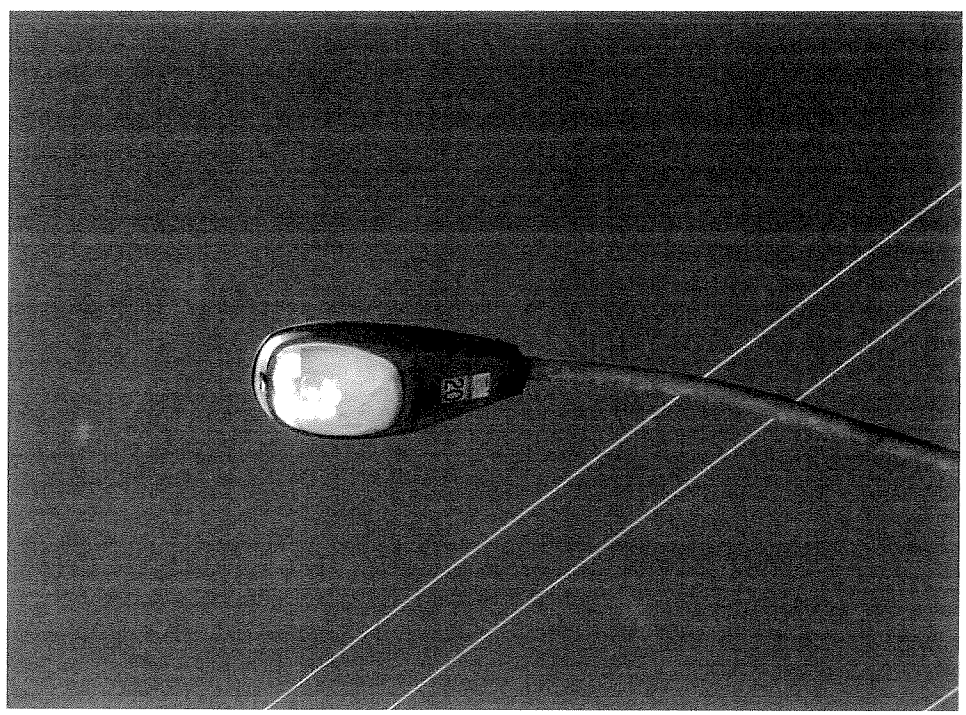
ODL – old drop lens (250 Watt) streetlight
DL – drop lens (200 Watt) streetlight
FL – new retrofit flat lens (150 Watt)

These results indicate that the new retrofit streetlight does a much better job of lighting a designated area. The light under and around the retrofit light, measures lower on the light intensity meter.

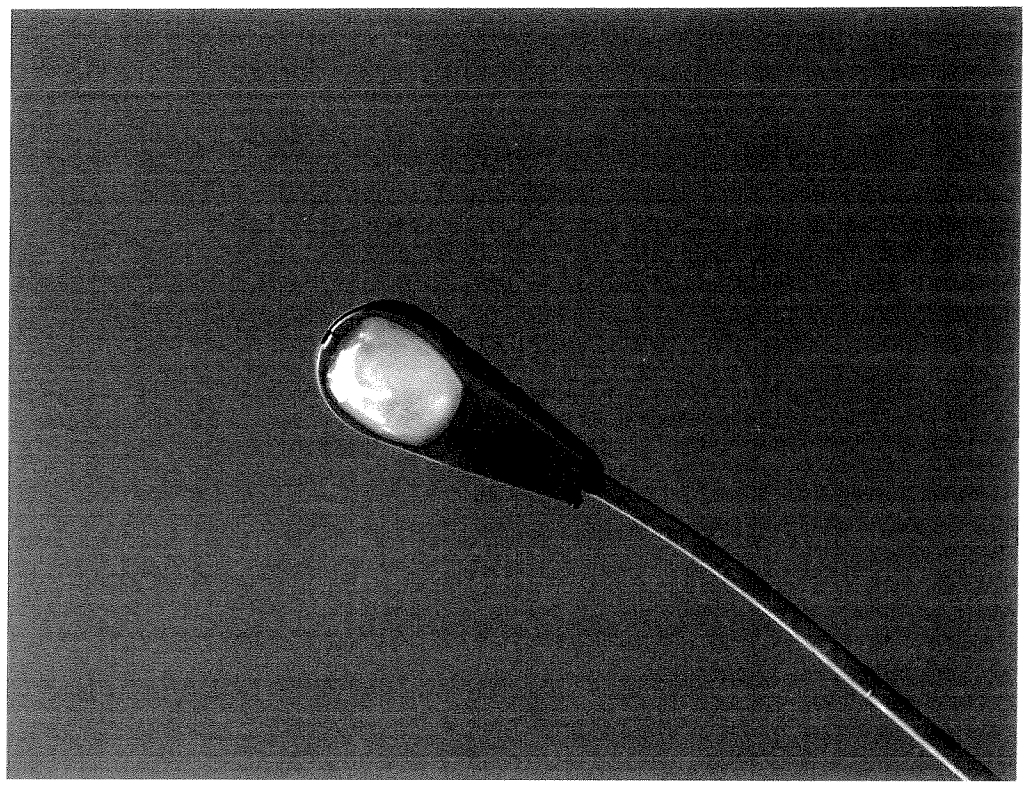
Comparison of three streetlights



150 Watt new retro flat lens.



200 Watt drop lens.



250 Watt old drop lens.

lux [lx] The lux is used to measure the illuminance

The lux is used to measure how brightly lit an area is, that is how much light it receives. One lux means that the area of one square meter receives the luminous flux of one lumen. One lux is therefore defined as one lumen per square meter (1 lx = 1 lm / m^2).

The lumen takes the sensitivity of the human eye into account, lux and lumen are therefore a true measure of how much light a human sees.

Lux does not measure how bright a surface or an object appears – it just measures how much light is received by the surface or the object. If a white sheet of paper and a black sheet of paper receive the same amount of light, the white sheet will appear brighter, because it reflects more light. The measure for brightness, which takes this property of objects to reflect or to absorb light into account, is candela per square meter (cd / m^2).

Lux is frequently used in laws and standards that define the minimum brightness for certain places like offices, schools, etc. Factors like the ability to see (naturally, humans cannot see in the dark), the ability to see colours, and even concentration depends on the illuminance or brightness of a room or workspace.

Studies have shown that by increasing the illuminance from 90 to 500 lux, the memory of humans improves by 16 %, logical thinking by 9 % and the speed and accuracy of manual calculations by 5 %.

The name and the unit have been in use since 1889.
Adopted by the 9th CGPM in 1948.

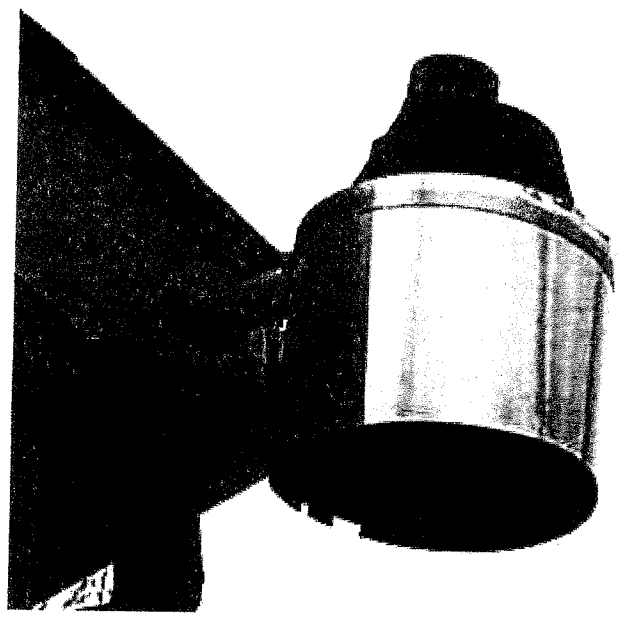
Reference points for lux (most commonly used as lux)

Moon light on a clear night outside	0.1 lx
Dimly lit hallway	20 lx
Room, no reading required	300 lx
Illuminance required in an office	500 lx
Well lit workspace	1 000 lx
Illuminance required in a clockmaker's workshop	1 500 lx
Cloudy day outside	10 000 lx
Sunny day outside	100 000 lx

Back to top of document. — Back to tables of metric units. — Back to metre.info homepage.

Results

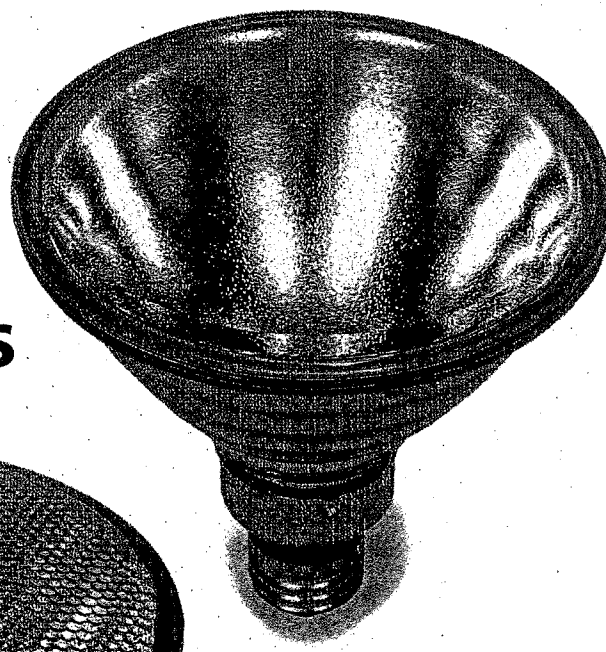
Experiment #5

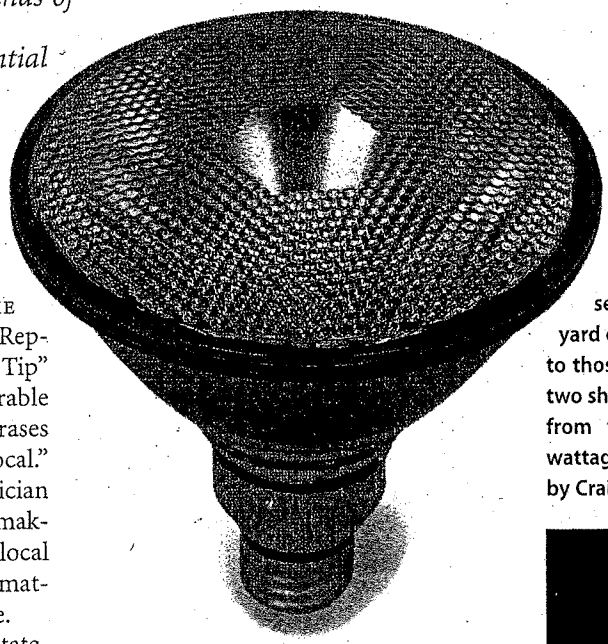


Light Shield constructed of flashing and hose clamps. Total cost of this shield is less than $10.00.

Home Lighting for Amateur Astronomers

You don't have to search to the ends of the Earth to find exterior residential lighting that's dark-sky friendly. | **By Dennis di Cicco and J. Kelly Beatty**





Today's homeowners have many options for outdoor light fixtures. In our search for ones that are friendly to backyard observers we found that, when it comes to those fitted with floodlights similiar to the two shown here, there is little difference apart from the greater light output of higher-wattage lights. *Sky & Telescope* photographs by Craig Michael Utter and Dennis di Cicco.

THE LATE SPEAKER OF THE United States House of Representatives Thomas P. "Tip" O'Neill provided a memorable entry for the lexicon of modern phrases when he opined, "All politics is local." The legendary Massachusetts politician was reflecting on the tendency of lawmakers to be most influenced by their local constituency even when voting on matters of national or global importance.

With a bit of paraphrasing, his statement applies equally well to light pollution. As amateur astronomers we are concerned with the "big picture" issues of light pollution and how they affect the public's awareness and appreciation of the night sky. But when it comes to backyard observing, our concerns lie much closer to home. All annoying light pollution is local.

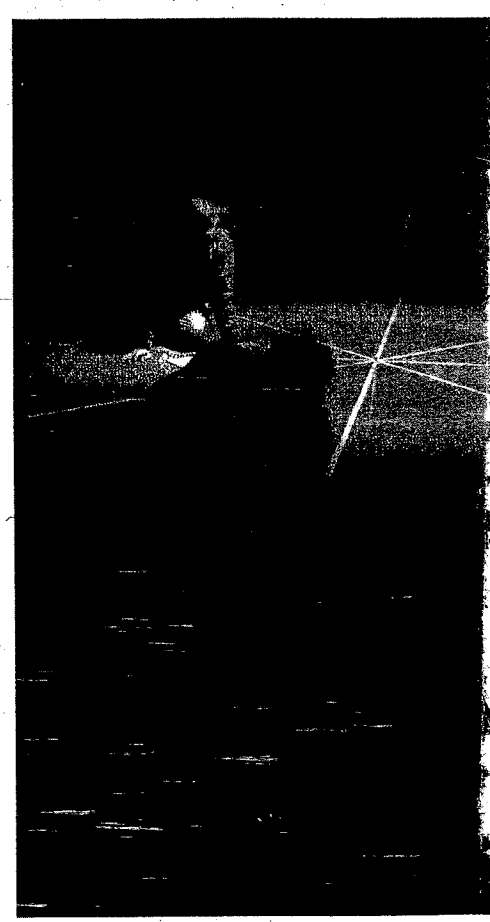
Here's a case in point. We both live on the outskirts of metropolitan Boston. While the city's rampant light pollution affects our entire sky, for me (di Cicco) it is worse toward the east in the direction of the city. But my sky is almost as bright to the south because of a cluster of back-to-back shopping centers straddling a mile or so of roadway only a fifth as far away as downtown Boston. When I'm at the eyepiece of a telescope, however, the lights that really annoy me are those illuminating porches and yards of nearby houses. Indeed, I occasionally suspend my observing when any of these with a direct line of sight are turned on as neighborhood dogs go out to answer nature's final call of the night.

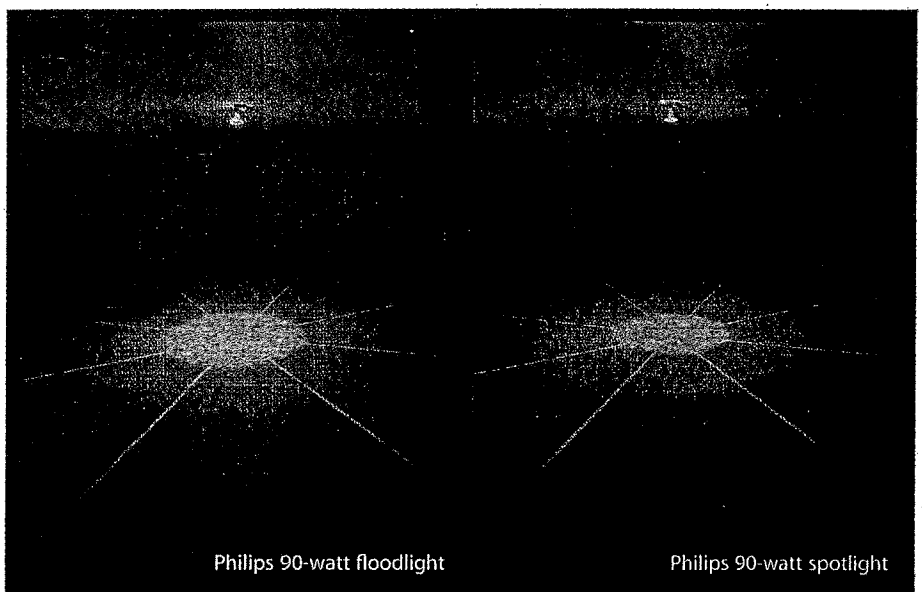
As explained in the article beginning on page 40, there are many approaches that today's homeowners can take to providing safe and effective residential lighting. We tested some of the most commonly chosen options as well as a few that seem particularly "astronomy friendly." Some of the things we discovered surprised us.

All Lights Are Not Created Equal

When it comes to lighting yards and driveways, it's probably a safe bet that the outdoor floodlight fixture is king. These typically hold one or two unshielded bulbs in sockets that can be swiveled to adjust the aim of the lights. Considering their popularity, it's not surprising that store shelves are stocked with bulbs for these fixtures from a variety of manufacturers.

Apart from the obvious differences in wattage and brightness output, some of





Philips 90-watt floodlight Philips 90-watt spotlight

While the illumination pattern falling on the ground appears different (and that really is the spotlight on the right!), the 90-watt flood- and spotlights manufactured by Philips have a similar brightness level at the outer edge of their respective light cones. Neither one offers a significant advantage over the other for controlling light spill away from the beam's centerline.

these bulbs are called floodlights, while others are listed as spotlights. Any thoughts we had that the two terms were simply used interchangeably were dismissed when we found a pair of 90-watt halogen bulbs manufactured by Philips, one labeled "spot," the other "flood." Outwardly the only difference between them is the textured surface on the inside of the bulb's face. We assumed that the spotlight would have a tighter beam and thus be of interest to people trying to control the outward spill from these lights.

While our tests did reveal that the spotlight has a slightly more concentrated *overall* illumination pattern, the cone of light emerging from the bulb, measured at diameters of equal brightness, is only 12 percent smaller than that of the floodlight. More surprising is that at the center of the beam, the spotlight is actually 40 percent dimmer. Unless these bulbs are mounted side by side, however, it's unlikely that a homeowner will visually note much difference between them, especially when it comes to preventing light spill at large radii from the center of the beam.

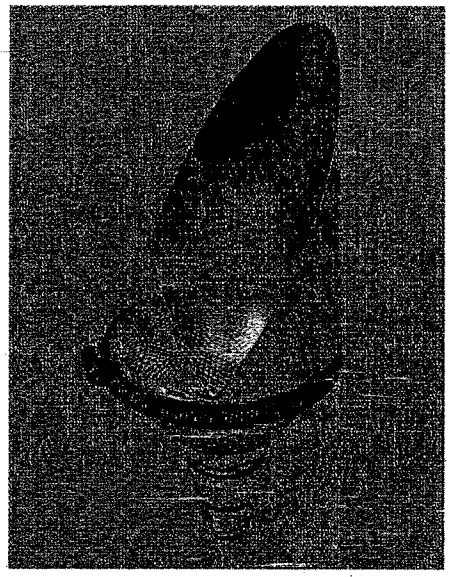
Although some of the bulbs we tested projected interesting rings and spikes of light on the ground, the most noteworthy trend involved the level of illumination at increasing distances from the center of the beam. As common sense suggests, the greater an incandescent bulb's wattage, the greater its light output, and the broader its cone of illumination at a given level of brightness. In our test setup we measured the diameter of each bulb's cone of light at a fixed progression of intensities out to a minimum of 0.5 foot-candle. At this level of brightness, which is sufficient to illuminate a yard area adequately in most situations, a 50-watt Sylvania halogen floodlight 7 feet (2.1 meters) above the ground produced a cone of light subtending a 104° angle; a 100-watt General Electric floodlight, 116°; and a 150-watt Westinghouse floodlight, 126°.

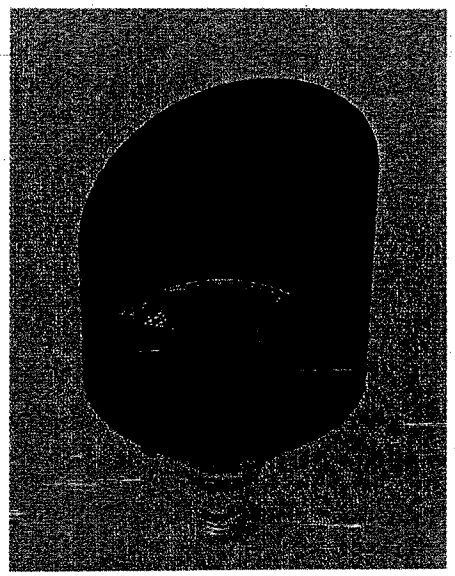
Shields

As mentioned above, while the illumination coming from a nearby light fixture is of concern to backyard observers, a direct line of sight to the face of an offending bulb can be far more annoying. In such cases a simple shield can dramatically improve the situation for the observer without significantly affecting the performance of a floodlight for the homeowner. We tried the two shields shown below.

When correctly oriented, both are very effective at restricting a direct line of sight to a floodlight's front surface, especially when the observer is at a large angle to the beam's centerline. This is often the case for lights in neighboring yards. Cliff Haas's simple sheet-metal shield provided a substantial reduction in the light spreading outward from one side of a floodlight, and this asymmetric pattern gives some control to the homeowner illuminating an area close to the fixture. The clip-on shield created by Susan Harder offered a more uniform reduction of the floodlight's angular coverage. At the 0.5-foot-candle level, it reduced the light cone from the General Electric 100-watt halogen floodlight from 116° to roughly 70°.

It's not unusual to find porches, especially on older homes, illuminated by conventional incandescent bulbs fitted to simple, nonrecessed ceiling sockets. Unlike floodlights, the illumination from these bulbs is not aimed in a particular direction, and as such, any direct line of

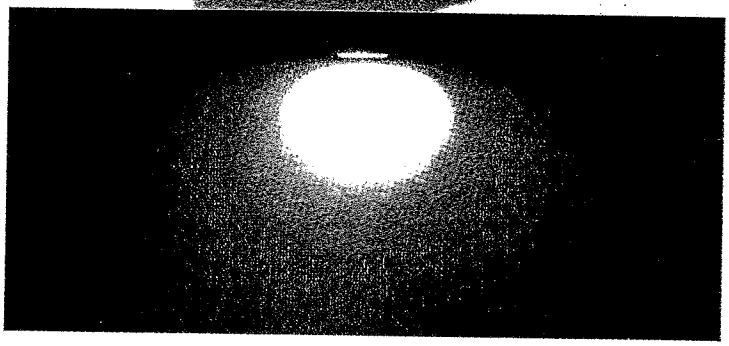




The best way we found to control light spill from floodlights is with a shield such as the ones seen here by Cliff Haas *(left)* and Susan Harder *(right)*. More information about shields, as well as contact information for Haas and Harder, is available at http://members.aol.com/ctstarwchr/shielding.htm.

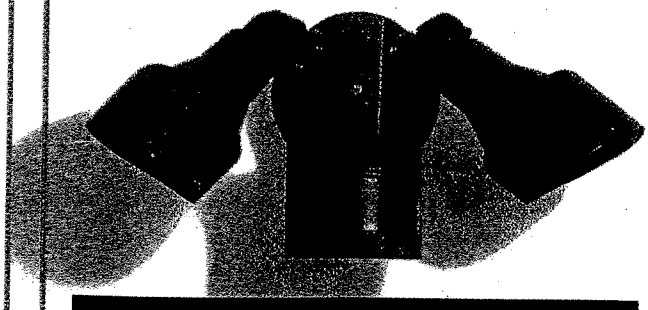
Regent RSM100

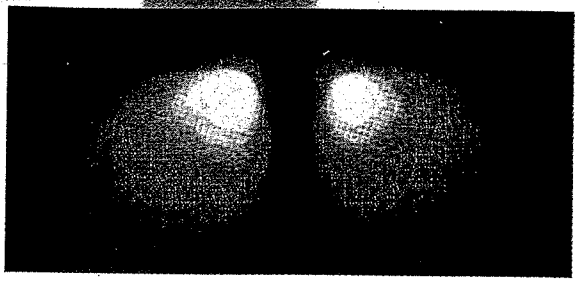
When you need a lot of light on the ground, the Regent RSM100 mercury-vapor light does the job with a full cutoff fixture.



Heath Zenith SL-5597

In addition to the motion-activated dual-brightness features in other Heath Zenith lights we tested, this halogen floodlight can be preset to automatically turn off three or six hours after dusk.





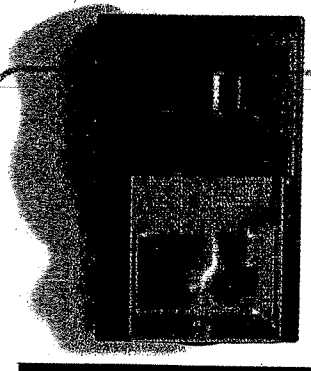
We found that it still offered substantial illumination when fitted with its proper 100-watt lamp. One disadvantage of any fixtures using mercury- or sodium-vapor lamps is that they require several minutes after being turned on before providing usable levels of illumination — they are not suited to applications where light is needed "instantly" or for short intervals.

Heath Zenith makes a large assortment of outdoor lighting fixtures. Two that caught our eye feature halogen bulbs and dual-brightness levels controlled by a motion sensor. The **Heath Zenith SL-5630** is a wall-mounted unit with a single bulb recessed under a shield that offers a decent amount of vertical cutoff. We removed a small angled reflector from inside the housing (see the accompanying photograph for details). Removing this reflector is easy, since you have to temporarily remove it in the process of installing the light. This reduced much of the stray light emitted to the fixture's sides. In fact, were it not for ribbing molded into the transparent plastic cover, this unit would keep almost all of its light directed toward levels at or below that of the fixture.

The unit is equipped with an electric eye for dusk-to-dawn operation. A few minutes after being turned on, this unit automatically dims but will instantly return to full brightness when the motion detector is triggered. Unlike motion-sensor lights that are either on or off, this one provides accent illumination in the "quiet" mode, which is desirable in many applications such as around doorways and walkways.

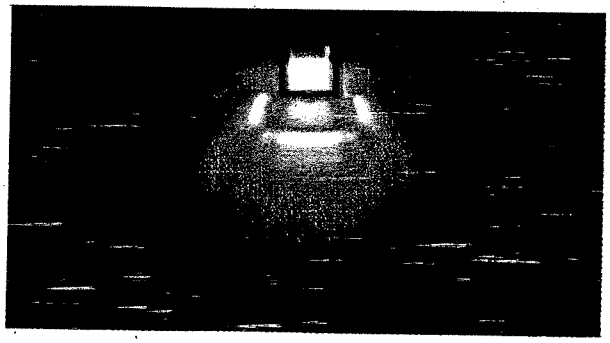
The **Heath Zenith SL-5597** looks more like a conventional twin-bulb floodlight. It too offers the motion-activated Dual Brite feature. Furthermore, the light will automatically turn on at dusk and off after either preset intervals of three or six hours or when dawn arrives. There is manual override of the automatic features, controlled by toggling the light switch (usually inside a house) that powers the unit. Both lamp heads on this fixture have adjustable shields that are effective at reducing the angle with a direct line of sight to the bulb.

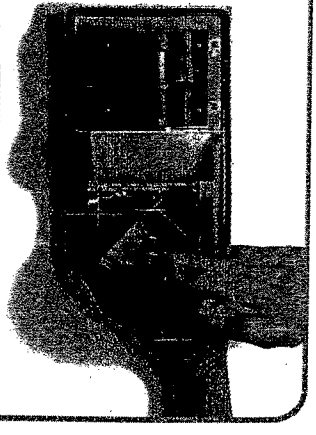
While few of today's lighting fixtures have been designed with astronomy in mind, the conscientious homeowner can find lighting solutions that are more than adequate and, at the same time, friendly to any neighborhood skywatchers.



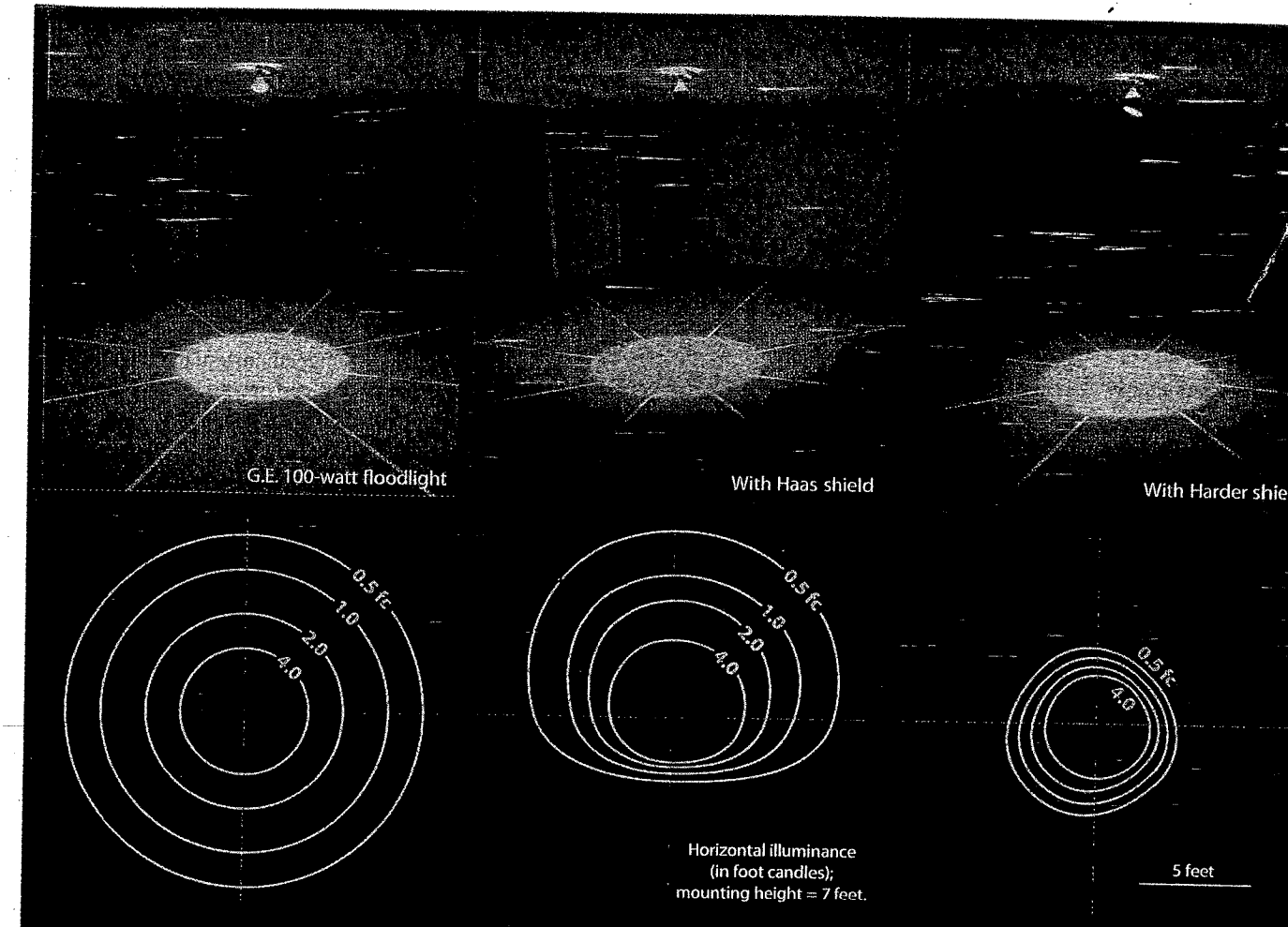
Heath Zenith SL-5630

This wall-mount fixture by Heath Zenith provides low-level "accent" illumination for doorways and walkways but automatically switches to full brightness when its motion detector is triggered. An electric eye provides dusk-to-dawn operation. We found that removing the unit's small pyramid-shaped reflector *(lower right)* greatly improved the effectiveness of the fixture's vertical cutoff.





DENNIS DI CICCO *and* KELLY BEATTY *joined the editorial staff of* Sky & Telescope *within weeks of each other as Saturn was crossing from Orion into Gemini. They're looking forward to that happening again next year.*



The effectiveness of the Haas and Harder shields is revealed in tests made with a General Electric 100-watt floodlight.

sight to these bulbs is vexing to observers. In such cases a do-it-yourselfer can often fabricate an effective shield — but important safety issues involving heat must be considered.

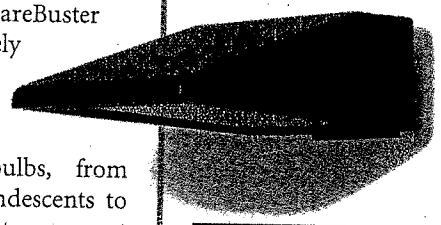
For example, we made a seemingly simple shield by removing the top and bottom from a 1-pound coffee can and fitting it around a standard 100-watt incandescent bulb mounted in the temporary ceiling fixture used for our tests. Within minutes there was enough heat buildup to melt a plastic fitting that had remained unscathed during hours of previous tests. Furthermore, insidious heat buildup behind a lighting fixture can be even more dangerous, damaging electrical wiring and creating a potential fire hazard. Any shield near an incandescent bulb needs to have provisions for ventilation and heat dissipation.

Commercial Fixtures

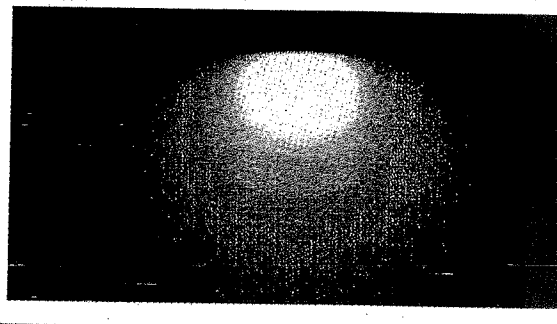
Of the many outdoor lighting fixtures that we encountered while working on this review, several seemed worthy of a closer look. Topping the list is the **GlareBuster,** since it alone is touted as an astronomy-friendly lighting fixture. Inside the box we found an instruction sheet that offers a mini-lesson on light pollution as well as information promoting the International Dark-Sky Association. The GlareBuster is an extremely effective full-cutoff fixture that accepts a variety of bulbs, from standard incandescents to energy-efficient compact fluorescents.

Another fixture that provides full-cutoff lighting is the **Regent RSM100** (mercury-vapor) fixture. This unit can put a lot of light on the ground while suppressing direct lighting at all angles above the fixture. The one we tested is a dusk-to-dawn model controlled by "electric eye." Be alert: ours came with 175-watt mercury-vapor bulb by mistake, a lamp that will prove too strong for virtually any homeowner applicatio

GlareBuster



The only light fixture marked as friendly to astronomy the full-cutoff GlareBuster sc by Lighting by Branford (co tact information is on page 4 which accepts a variety light sources.

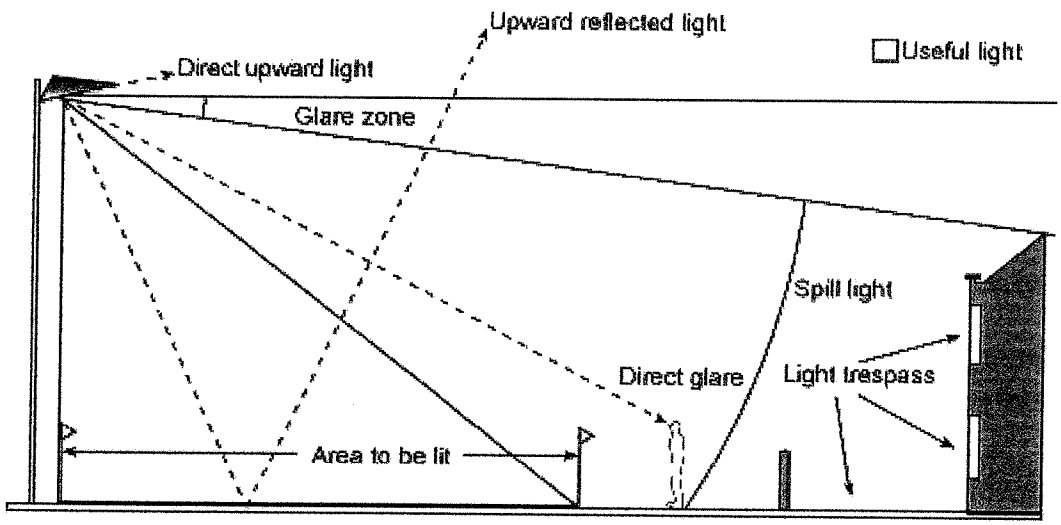


Results

Experiment #6

Below is an example of proper outdoor light placement;

Example of useful light and light pollution from a typical pole-mounted outdoor light fixture.

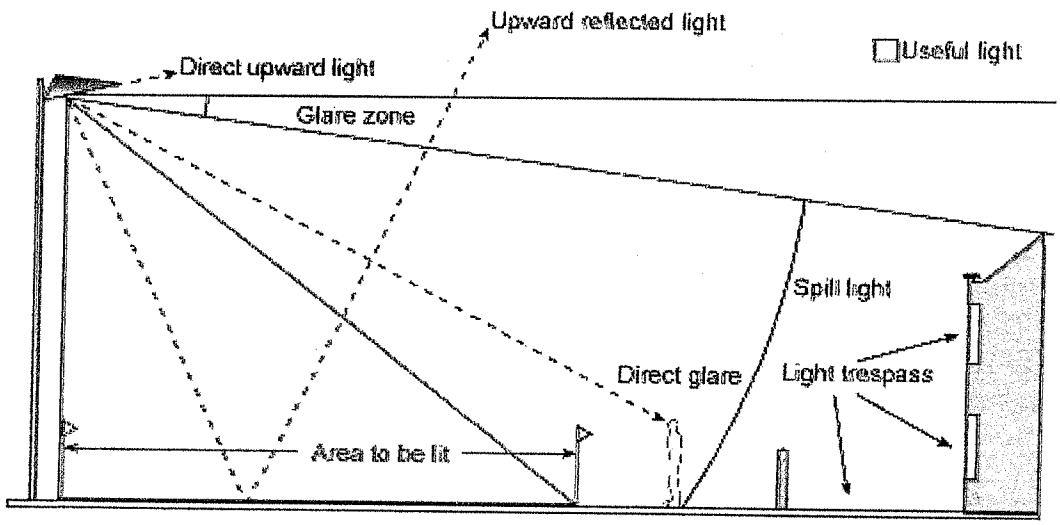


Light pollution is often caused by the way light is emitted from lighting equipment. Choosing proper equipment and carefully mounting and aiming it can make a significant difference.

Using the formula, H= .91m + D/3, we can determine the proper placement for an outdoor lighting fixture, that can stop light from being directed where it is not wanted or needed.

Below is an example of proper outdoor light placement;

Example of useful light and light pollution from a typical pole-mounted outdoor light fixture.

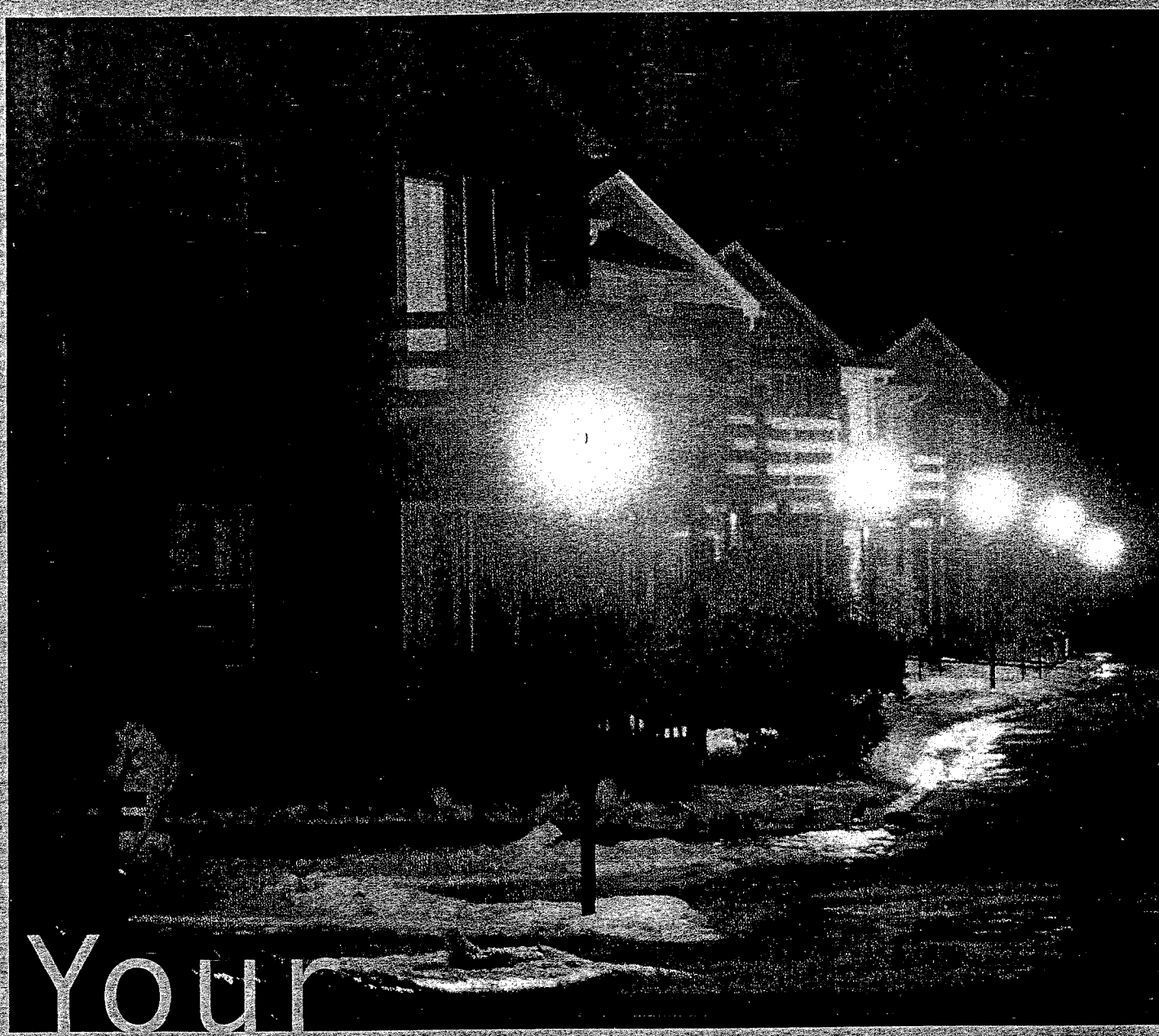


Light pollution is often caused by the way light is emitted from lighting equipment. Choosing proper equipment and carefully mounting and aiming it can make a significant difference.

Using the formula, H= .91m + D/3, we can determine the proper placement for an outdoor lighting fixture, that can stop light from being directed where it is not wanted or needed.

MOUNTING HEIGHT/LAMP OUTPUT RECOMMENDATIONS

MOUNTING HEIGHT (FEET)	MAX LUMENS
6	1,000
8	600 to 1,600
10	1,000 to 2,000
12	1,600 to 2,400
16	2,400 to 6,000
20	4,000 to 8,000
24	6,000 to 9,000
28	8,000 to 12,000
32	9,000 to 24,000
36	12,000 to 28,000
40	16,000 to 32,000



Your Home Lighting Guide

Do these harsh, glaring lights look like those in your neighborhood or, worse, the ones in *your* front yard? As detailed in this article, the battle against light pollution begins at home.

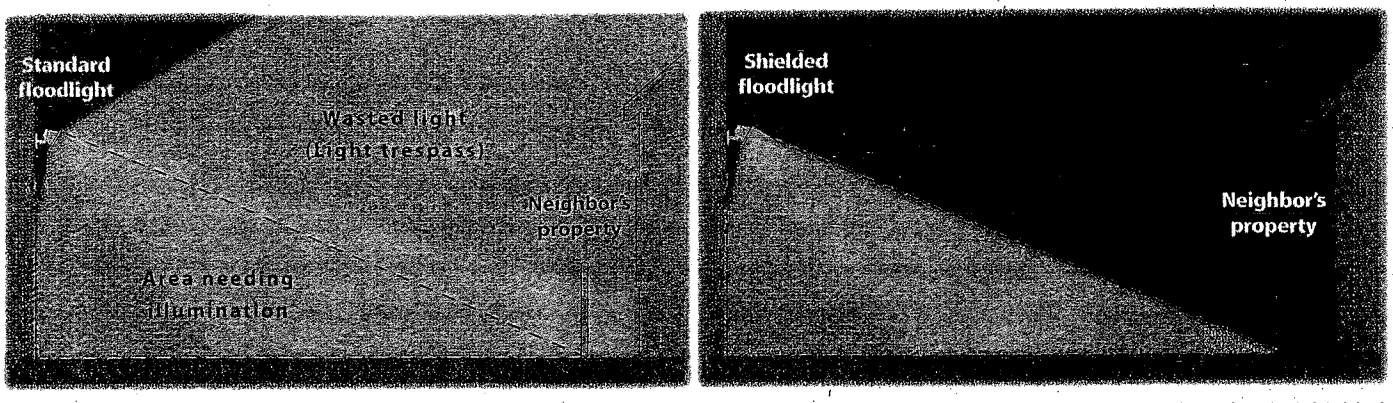
How to light your home safely, save energy, and decrease light pollution at the same time.

By Rachel Thessin and David L. Crawford

WE ASTRONOMERS ARE ENGAGED IN A LONG, DIFFICULT effort to fight light pollution and regain our dark, starry skies. But do we practice what we preach? Take a look outside your home. Do your fixtures shine light into your neighbor's window and toward the sky, or do they send all their light onto the ground? Can you see the bare bulbs from a distance, or are they shielded? Do you illuminate your house when no one is awake to admire it?

Reducing the glare from your home's exterior lighting is a common-sense courtesy to your neighbors, who, like you, have every right to a dark bedroom at night. But it is in your best civic interest as well, to promote a safe, pleasant nighttime environment. Many jurisdictions are passing laws that prohibit light trespass, rays that shine from one property onto another. What's more, "dark-sky-friendly" practices will reduce your electricity bill. How? By ensuring that all your fixtures direct their light onto the ground, instead of spraying it up and all around, you can achieve the desired level of illumination with lower-wattage bulbs. Each watt saved means more money in your pocket.

Home lights waste even more energy (and money) when they shine unneeded throughout the night. Let's look at converting a 200-watt security light from continuous dusk-to-dawn operation to having it on only when triggered by a motion sensor. Shining all night, it will be turned on about 4,100 hours over the course of a year and use 820 kilowatt-hours of



SOURCE: INTERNATIONAL DARK-SKY

A poorly directed, overly bright light *(left)* can spill light far from its intended target — onto your neighbor's house or up into the sky. Shielded lights *(right)*, especially those with "full-cutoff" designs, minimize glare and make your neighborhood safer and easier on the eyes at night.

electricity, costing you $82 (at $0.10 per kilowatt-hour) in the process. However, the same light, activated by a motion sensor a few times each night, will shine for no more than about a half hour during darkness and use less than $4 in electricity annually. These remarkable savings recover the $20 cost of a standard motion sensor in the first three months.

Beyond this needless expense, however, poor lighting may actually increase the chance of crime against your home and family. In its *Recommended Practice Guideline 33* (issued in 1999), the Illuminating Engineering Society of North America states: "Too often people associate more light or brighter light with safer surrounds. It can be easily demonstrated that too much light, or poorly directed light, causes a loss of visibility." When you look toward a glaring, poorly shielded fixture, the pupils of your eyes constrict in response to the bright light — despite being in otherwise dark surroundings. As even novice skywatchers know, your eyes then require several minutes to readapt before they can again see properly in the dark. Such glare can temporarily incapacitate your vision, making it uncomfortable (if not impossible) to view anything near its bright source. Worse, overly bright lights cast harsh shadows in which intruders can hide from view.

A shielded fixture with a lower-wattage bulb, on the other hand, disrupts your dark adaptation less and allows you to see more of everything around you. Arranging your home's lights for evenly distributed illumination will minimize harsh shadows. And, of course, your eyes will adapt to the dark faster as you leave the proximity of your house.

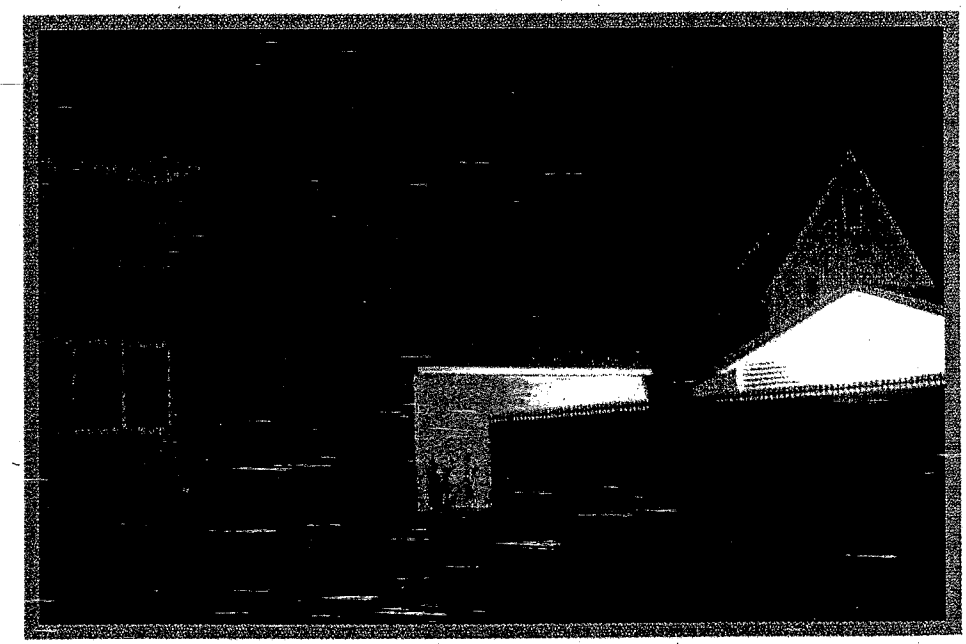
Let's face it: for most homeowners, an outdoor-lighting "makeover" is long overdue. With this in mind, we researched more than 20 manufacturers of residential lighting, talked to lighting contractors, and visited major U.S. retailers to create a consumer guide to purchasing dark-sky-friendly light fixtures.

Preliminary Considerations

Before heading to the hardware store, consider what you are trying to illuminate and why. Is your lighting for security, increased visibility, or aesthetics? Do you really need to cover your entire yard, or just specific areas next to your house? The intended use of the light affects how bright it needs to be. Usually low-wattage fixtures suffice for an entryway or for decorative illumination, while something stronger might be warranted to light up a patio or parking area. As explained in "Bulb Basics" on the facing page, some sources create light more efficiently — or have longer lifetimes — than others.

The intended purpose also determines how long a fixture should remain on each night. For example, you may have decorative lighting to accent your home's exterior or landscaping. If so, consider installing a timer so it operates only while members of your household are awake.

With few exceptions, no security light needs to be on from dusk to dawn. Unless you're in the habit of looking out your bedroom window all night long, such continuous operation merely provides the means for a criminal to survey your home's exterior from afar or, worse, to show where to break in. If you're concerned about safety, choose a motion-sensing fixture, because by turning on it alerts you and your neighbors that someone (or some*thing*) is moving around outside. Most



J. KELLY BEATTY

A classic case of light trespass. Strong, harsh light from poorly designed fixtures is streaming onto three neighboring buildings.

Bulb Basics

Some light bulbs are more efficient than others, and each renders color slightly differently. For example, compact-fluorescent bulbs emit near-white light, have long lifetimes, and are very energy efficient, whereas everyday incandescent (tungsten-filament) bulbs create a warm cast, burn out much more frequently, and use lots of electricity for the amount of light they produce. When choosing a bulb, first determine how much light you need for your application, then find the most appropriate bulb for that need. Look for the lumen rating — not just the wattage — on the packaging. Bear in mind that some types, like incandescent and mercury-vapor bulbs, may have low initial cost but use a great deal of electricity. In fact, as the table below shows, in dusk-to-dawn applications a two-bulb outdoor lighting fixture can cost more than $100 per year to operate!

Bulb type	Watts	Mean lumens	Lifetime (years) dusk-to-dawn	Lifetime (years) motion-sensor[2]	Power cost (1 year)[3] (d-to-d)	Power cost (1 year)[3] (m-s)	Power cost (5 years)[3] (d-to-d)	Power cost (5 years)[3] (m-s)
Incandescent, flood	150	2,000	0.5	0.1	$68.50	$2.74	$342.50	$13.70
Mercury vapor	100	3,230	5	3	55.35	2.85	276.75	14.25
Quartz halogen	90	1,400	0.5	0.1	41.00	1.85	205.00	9.25
Incandescent (frosted)	100	1,690	0.2	5	41.00	1.85	205.00	9.25
Incandescent (frosted)	90	2,540	0.5	0.1	37.60	1.70	188.00	8.50
High-pressure sodium	50	3,600	6	3	27.40	1.40	135.50	7.00
Compact fluorescent	20	1,200	7.5	5	11.00	0.55	55.00	2.75

[1] Based on an average use of 11.25 hours per day (4,100 hours per year). [2] Based on six 5-minute cycles per night. [3] Based on actual wattage used by fixture and electricity costing $0.10 per kilowatt-hour. [4] Initial lumen output is 4,100; output decreases significantly over time. [5] Long warm-up time precludes use in motion-sensor applications.

models have manual override switches to keep them turned on (or off) continuously.

Ideally, everyone would choose to install full-cutoff fixtures, which emit no light above horizontal. Let's be realistic, however. Most homeowners are unlikely to put up poles in the middle of their yards just so they can illuminate the surrounding areas with full-cutoff lighting. Instead, you're going to attach a fixture to the side of your house, then point it to shine the light outward. So if illuminating your entire yard is important, at least try to minimize the damage: aim the fixture and use glare shields to fine-tune exactly where the light shines, and place it high on your house so that it can be aimed down as much as possible and still illuminate the yard. Attach the light to a motion sensor, and always use the lowest light output that you need.

Sometimes the offending light isn't yours but a neighbor's. Obviously, such situations need to be approached diplomatically. Offering a little guided tour of the night sky through your telescope can be used to bring up the subject, or you can always take a more direct — but friendly — approach. (Don't forget to emphasize the possible cost savings.) If your neighbor agrees that some modification is in order, you could try to shield the existing light. Unfortunately, shields are almost never available for residential outdoor lighting — you will probably need to fashion one yourself (see page 47). If it's worth it to you to have glare-free nights, just consider buying your neighbor a new fixture!

Roaming the Aisles

Three categories of exterior lighting await you at your neighborhood home-improvement store: "security," decorative, and path. Unfortunately, many outdoor-lighting offerings control their output poorly and waste energy needlessly, so learn to discern the good from the bad by asking questions and examining various fixtures carefully. But if you must choose from among the "lesser of evils" that you find at local retailers, here are some basic guidelines:

- Ask for "glare-free" or "neighbor-friendly" lights — many retailers and manufacturers were confused when we mentioned "dark-sky-friendly" or "full-cutoff" fixtures.
- Look for fixtures that direct the light where you want it — down, toward the ground. These will have an opaque cover that hides the bulb itself from view to the side, or they may have glare shields.
- Buy lights with motion sensors, if possible, or buy one that allows you to attach a motion sensor yourself.
- Be wary of a fixture that merely *claims* to be dark-sky friendly. Determine for yourself whether it will create glare, or is simply too bright for your intended purpose. (Note that "Energy Star" fixtures contain energy-efficient bulbs, but they still may shine much of their light toward the sky.)
- Remember that fixtures are frequently marked with the highest-wattage bulb that they accept — but choose instead the lowest wattage that you need.

You may have some luck finding a dark-sky-friendly security or area light, as a few good ones have been introduced recently. In any case, look for the lowest-wattage floodlights possible (as mentioned earlier, an excessively strong source can do more harm than good), and if you have to angle the floodlight slightly upward, attach a shield so that the light goes only where needed.

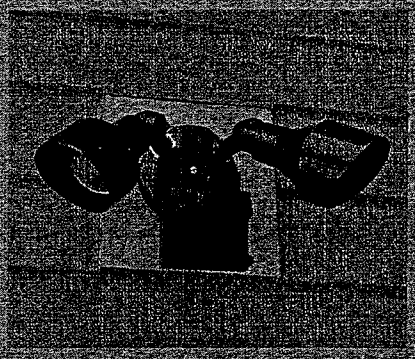
If you're determined to have a light stay on all night, consider dual-brightness fixtures with motion sensors; these shine at partial brightness until activated by someone walking by, at which point they temporarily switch to full intensity. Expect to spend $35 to $50 for a good area light and $10 to $90 for a motion sensor with

floodlights attached. You can also buy motion sensors alone ($10 to $60) that can be screwed or wired into your existing fixtures.

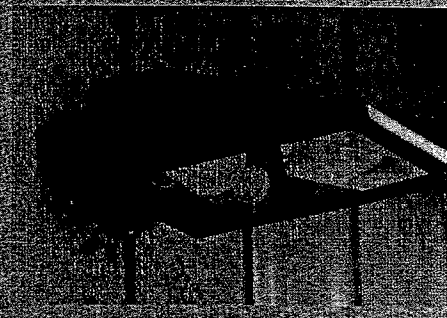
Good decorative fixtures are much harder to come by. Designed to look nice in daylight, almost all have glass sides that expose the glaring bulb to direct view and spill light in all directions at night. So if you must have these outside your home, base your purchase on performance, rather than good looks alone, and use low-output bulbs. Hampton Bay (Heath Zenith), Regent, and Surveillance brands all offer $30-to-$50 decorative fixtures equipped with motion sensors, or you can attach a sensor to your existing light.

Recommended Fixtures

As you might expect, visits to retail stores across the U.S. turned up a wide variety of outdoor-lighting offerings. The largest retail chains — Home Depot, Lowe's, Wal-Mart, and Sears Hardware (Orchard Supply Hardware in California) — tend to carry well-established product lines, though the items in any product that their manufacturers offer; Lowe's even has catalogs in the aisle for your perusal. Sears Hardware maintains a "buy list" from which you can order. You can also head online to search for fixtures that are truly dark-sky friendly.



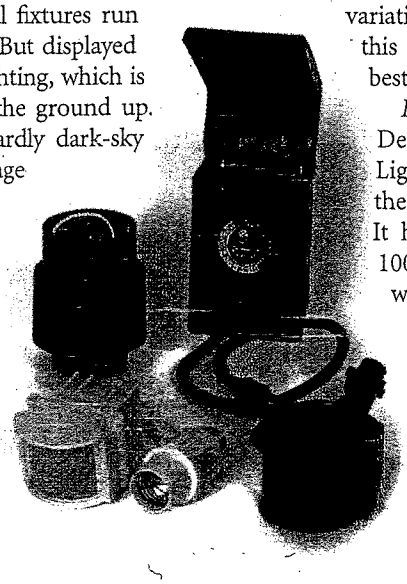
This residential security fixture, model SL-5597 by Heath Zenith, is one of the few to offer shielded bulbs. It also features motion-sensor activation and dual-brightness illumination.



The GlareBuster is a full-cutoff lighting fixture developed by amateur astronomer Bob Crelin and two associates. It is designed for easy installation and accepts a variety of incandescent, halogen, and compact fluorescent bulbs.

Path lighting is least problematic from the dark-sky standpoint. Closely spaced and low to the ground, these lights use low-output bulbs and tend to be well shielded. Individual fixtures run from $6 to $70, and many are solar powered. But displayed along with these you'll often find landscape lighting, which is used to illuminate trees and buildings from the ground up. They send most of their light skyward — hardly dark-sky friendly — though many models use low-wattage bulbs. If you use landscaping lighting, whenever possible place the fixtures well above ground level (look for tree mounts) so that the light shines down, and place the lights on a timer so that they are on only when people are around to admire them.

You may not find a specific fixture on the store's shelves. However, both Lowe's and Home Depot allow you to special order stock vary from region to region. In most cases the ones described below are only examples; there exist many acceptable variations on these themes. (Beginning on page 50, this issue's *S&T* Test Report explores a few of the best ones in more detail.)



Floodlights and area lights. The Heath Zenith Decorative Halogen Motion Sensing Security Light (SL-5597; $40 at Home Depot) is one of the few shielded motion-sensor lights we found. It has a 240° detection zone, adjustable 15- to 100-foot range, manual override, and 10-year warranty. Thanks to its innovative "Dual Brite"

If you want to keep your existing fixture, consider wiring it to a motion sensor or timer. These inexpensive accessories can save you hundreds of dollars in electricity costs.

feature, you can choose to have the light turn on at dusk at a low level. It will momentarily brighten whenever someone walks by, triggered by a motion sensor. Then, three or six hours later (once everyone is in bed), its motion-sensing electronics revert to all-or-nothing operation.

Online option: RAB sells the Stealth Sensor with two floods for $90 on eLights.com. Shields cost $8 each.

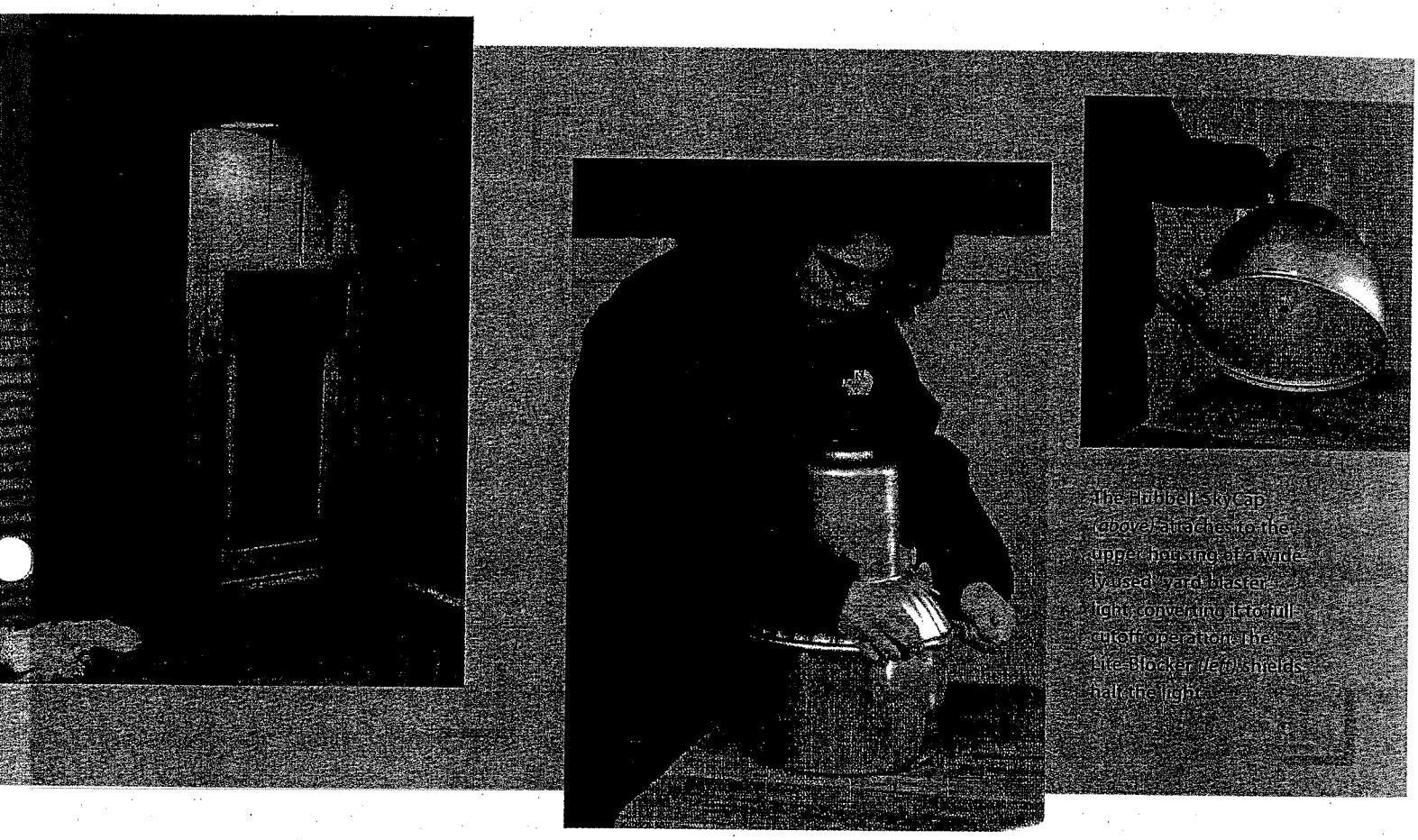
Many motion sensors can be purchased separately to install with an existing fixture. One example is the Regent 180° Motion Sensor (MS180; $20 at Lowe's). It has a broad detection zone, a range of up to 70 feet, manual override, and 5-year warranty. Regent also makes a 240°, 10-year-warranty version for $25; RAB sells sensors with a few more features on eLights.com for $39 to $60; Heath Zenith makes a line of motion-sensing adapters for both flood and decorative fixtures.

If motion-sensor lighting won't work in your situation, try using a timer. Unfortunately, there are few outdoor timers from which to choose. (In fact, some models we saw had been on the shelf so long, their batteries had corroded.) The Intermatic Heavy-Duty 24-Hour Outdoor Timer (HB31R; $18 at Home Depot) permits two on-off cycles per day and comes with an override switch.

Other options: Outdoor Lighting Associates sells DPN Photocontrol for $50. This creative alternative to dusk-to-dawn lighting will keep your lights turned on for exactly half the night.

A recent entry in the home-lighting market is the GlareBuster (GB-1000, about $60), manufactured by Lighting by Branford. Light-pollution activist Bob Crelin teamed with his longtime friend, lighting engineer Perry Maresca, and Peter D'Engenis to create a true full-cutoff fixture that homeowners can easily install themselves. The GlareBuster accepts various standard bulbs, comes with an adapter for mounting on siding (eave mount available), and can be outfitted with a motion sensor. Unfortunately, the GlareBuster is not yet available in any retail chain, though it is available through a growing number of independent dealers.

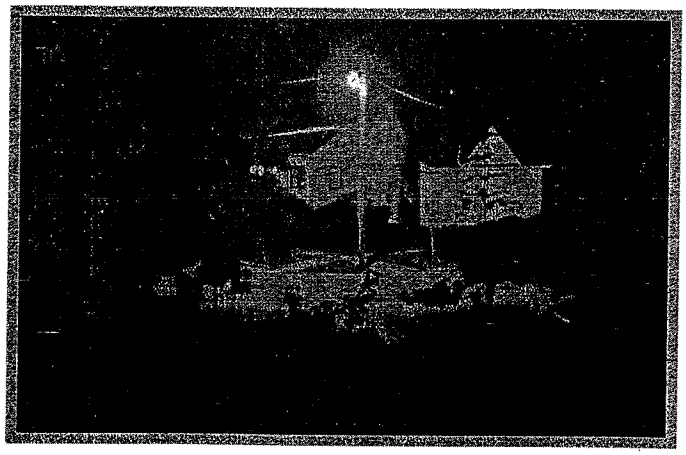
Other options: Regent makes two area lights with full-cutoff designs. The sleek RSM100 ($35 at Lowe's) comes with a 100-watt mercury-vapor bulb, while the dome-shaped LP175 ($49 at some Lowe's stores) has a 175-watt mercury-vapor bulb. However, these high-output bulbs will be too strong for many homeowner applications.

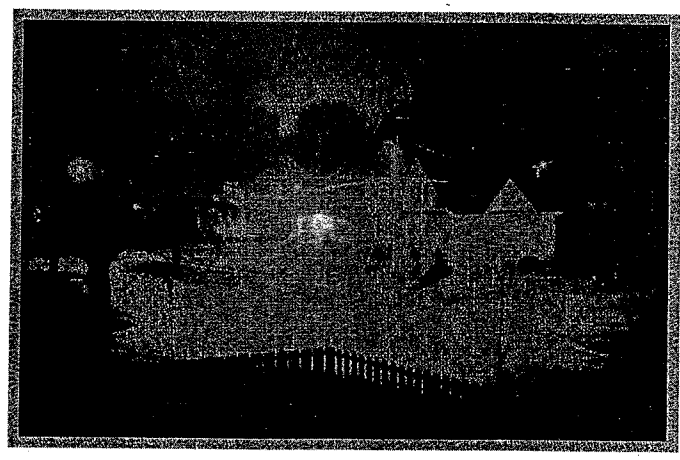


The Hubbell SkyCap (*above*) attaches to the upper housing of a widely used yard blaster light, converting it to full-cutoff operation. The Lite-Blocker (*left*) shields half the light.

Shields. If replacing your existing fixture (or your neighbor's) is not an option, it may be possible to buy or make a shield for it. One common light, sold by many retailers, is a dusk-to-dawn fixture in a quasi-cylindrical enclosure with a mercury-vapor bulb of 100 to 175 watts. These are legendary for the amount of glare and waste they produce — one manufacturer even calls its model the "Yard Blaster." If you have one of these, or must endure one installed by your neighbor, help is now available.

Since 1994 Hubbell Lighting has produced a hemispherical shield known as the SkyCap (NPU-BI). This all-metal attachment turns this style of security light into a full-cutoff fixture. Unfortunately, Hubbell sells its products almost exclusively through commercial distributors. But a version of the SkyCap is available (NH1204; $35 plus $10 shipping) from Outdoor





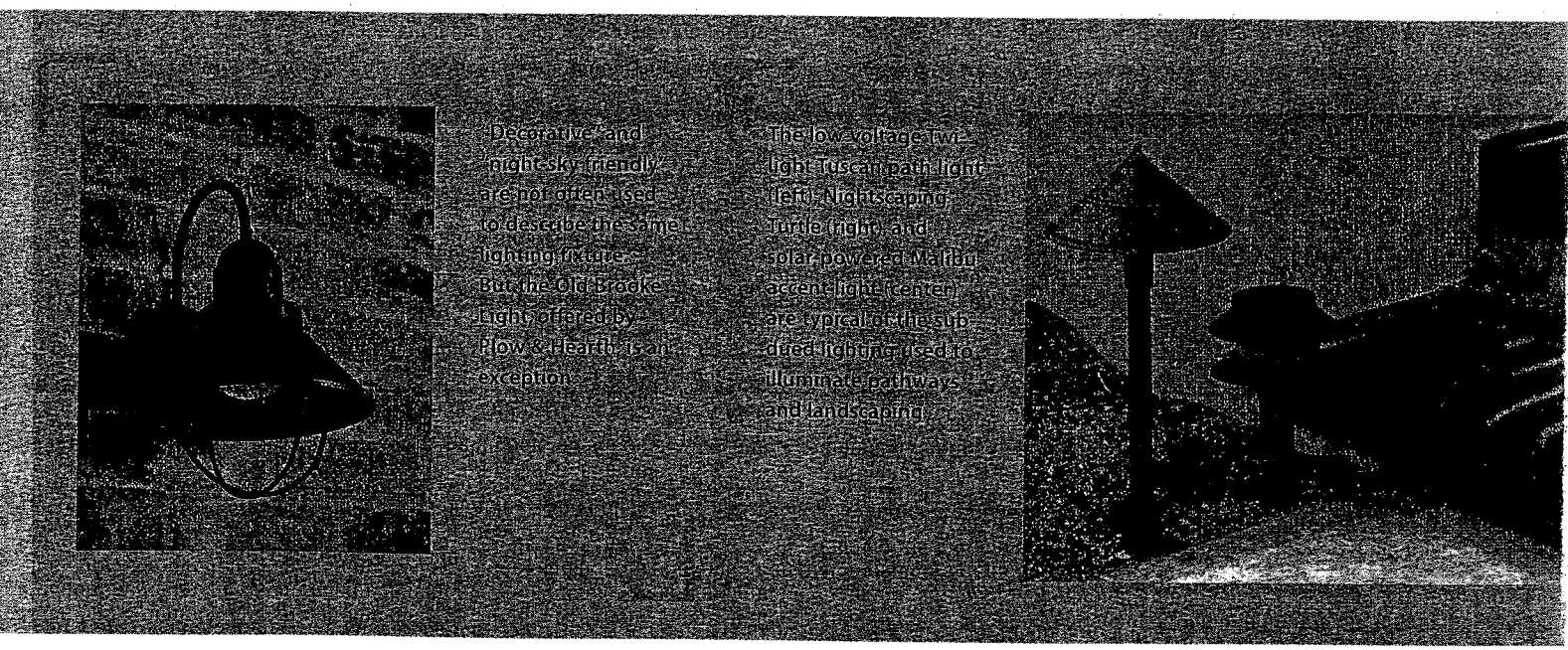
DAVID OESPER (OUTDOOR LIGHTING ASSOCIATES)

The addition of a Hubbell SkyCap to an existing mercury-vapor fixture can dramatically reduce the amount of glare and light trespass.

Lighting Associates. David Oesper, OLA's owner, has added a centering ring to ease installation, provide proper alignment, and make it more durable in adverse weather. Hubbell also incorporates the SkyCap in its series of complete Nite-to-Lite fixtures (NPU; $120 from Outdoor Lighting Associates).

Decorative exterior lighting. After despairing that no decorative full-cutoff lights were available in major retail stores, we found one that comes close. The Heath Zenith Security Wall Light (SL-5630; $50 at Home Depot) uses a combination of shielding, internal reflectors, and Fresnel lensing to control the efficient LED emits only a few lumens, throwing a soft glow onto its immediate surroundings. The installation is easy (just plug in the batteries and stick it in the ground), though you may have concerns about the durability of these plastic fixtures.

Another product is the Twilight Low Voltage Tuscan Path Light (TTG-104; $17 at Lowe's). The Tuscan is a full-cutoff, low-voltage fixture that connects to your house for electricity (as do most path-lighting systems). Such low-voltage applications are safer than household current; also, they are not regulated by local building codes and do not require a special un-



Decorative and night-sky friendly are not often used to describe the same lighting fixture. But the Old Brooke Light, offered by Plow & Hearth, is an exception.

The low-voltage Twilight Tuscan path light (left), Nightscaping Turtle (right), and solar-powered Malibu accent light (center) are typical of the subdued lighting used to illuminate pathways and landscaping.

output from its 100-watt halogen bulb. A few other good fixtures were found through online searches. Plow & Hearth offers the Old Brooke Light ($30 to $100) in three sizes, which allows for placement from next to your front door to above the garage. The same company also sells a full-cutoff Country Lamp ($125 to $200). Restoration Hardware sells the full-cutoff Galvanized Barn Light ($75).

Path and landscape lighting. One commonly available offering is the Malibu Solar-Powered Accent Light (LZ1D; $10 at Home Depot, Lowe's, Wal-Mart, and Sears Hardware). Its energy-

derground conduit. But you do have to purchase a transformer ($33 and up) separately.

Nightscaping sells and installs products through professionals that use minimal lighting to achieve your desired effect. We were impressed by the Deckliter, a little unit that hides under your eaves and illuminates a deck or patio as would the full Moon, and the versatile Turtle, which can sit on the ground as a path light or be a full-cutoff sconce on the side of your house. However, these quality fixtures come at a price: basic multiple-unit installations run from $1,500 to $5,000.

A Less-Bright Future?

Residential outdoor lighting has far to go. We would all like to see retail shelves stocked with full-cutoff, energy-efficient lighting fixtures. But this change must come on all fronts — from manufacturers, retailers, and consumers alike.

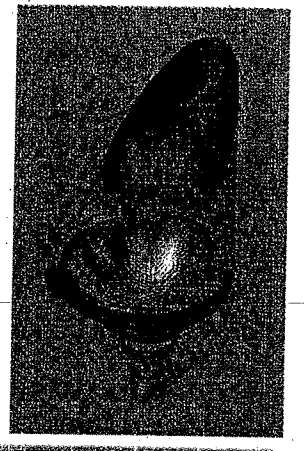
Sadly, some manufacturers still have little appreciation for the many benefits of dark-sky-friendly fixtures. When contacted by *Sky & Telescope* about "full-cutoff" or "glare-free" lighting, many company representatives had no idea what we were referring to — some even believed that we wanted their potent dusk-to-dawn lights. Home lighting, it seems, is rarely designed to the exacting photometric specifications that are the standard for commercial lighting; most residential fixtures just hold a bulb.

There are exceptions, of course. The Regent brand (now owned by Cooper Lighting) now includes a few "neighbor-friendly" and "dark-sky lighting" products. Heath Zenith was the most helpful manufacturer in tracking down which dark-sky options they did offer. And resourceful amateur astronomers like Bob Crelin and David Oesper have come forward to fill an obvious need.

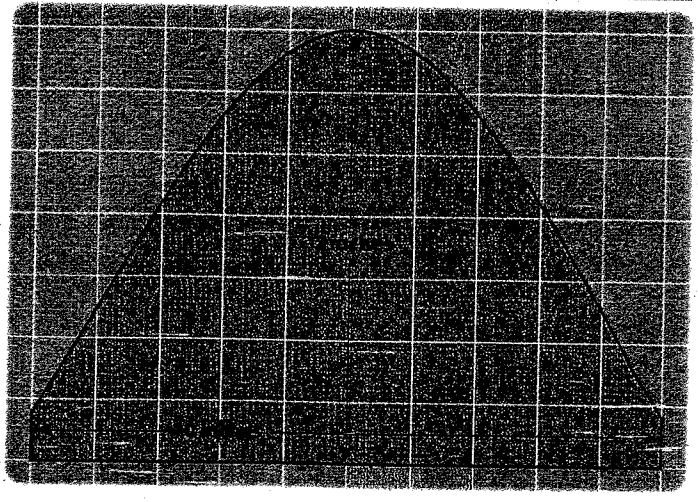
The key with retailers, it seems, is to make your preferences known. On the floor of one Home Depot store, a sales associate noted that frequent demands for a certain product can convince the regional buyer to purchase and stock the requested items. Retailers *are* willing to change, and residential lighting will improve if consumers *insist* on low-glare lights. Only then will both the retailers and the manufacturers respond.

Fortunately, the consumer-lighting industry is beginning to get the message. "We're trying to focus more attention on dark-sky issues," notes Rebecca Rainer, a marketing manager at Cooper Lighting who works on new-product development. (Cooper's Regent and Lumark lines are sold extensively at major home-improvement stores.) She says retailers are now pushing for a product line that includes full-cutoff fixtures — especially in areas of the U.S. where light pollution has become a topic of discussion and legislation. According to Blake Aldridge, marketing manager for DESA International's Heath Zenith products, motion-sensor fixtures now dominate the sales of security lighting for homeowner use. "It's a more intelligent choice," Aldridge says.

But reversing the tide will be a slow process. Consumers are still drawn to the lowest cost, which all too often translates into strong, glary lights with little or no shielding. Now that compact-fluorescent bulbs are gaining widespread acceptance as an energy-efficient alternative to incandescent sources, they are beginning to see use in outdoor fixtures. Unfortunately, these bulbs do not handle rough weather or cold temperatures well. Rainer says that a new lighting product, once approved, can take anywhere from one to two years to design, produce, and distribute. That said, both Cooper and Heath Zenith plan to introduce new low-glare fixtures for homes this year. Watch for them at a store near you!



Cliff Haas, a Connecticut light-pollution activist, has devised an economical way to shield standard "PAR" floodlights. First cut a sheet of aluminum flashing to the shape shown in the template below (one square equals 1 inch), then attach it to the bulb's raised outer lip using a large hose clamp.



RACHEL THESSIN *(rthessin@caltech.edu) never imagined she would learn so much about the lighting industry while serving as an editorial intern at* Sky & Telescope. DAVID L. CRAWFORD *(crawford@darksky.org), a former professional astronomer, founded the International Dark-Sky Association in 1988.*

Further Information

Manufacturers

Heath Zenith (www.desa.com/Heath/index.shtml)
Malibu/Intermatic (www.intermatic.com)
Nightscaping (www.nightscaping.com)
RAB (www.rabweb.com)
Regent (www.regentlighting.com)

Retailers (asterisks denote online-only sources)

eLights* (www.elights.com)
Home Depot (www.homedepot.com)
Lighting by Branford (www.theglarebuster.com)
Louie Lighting* (www.louielighting.com)
Lowe's (www.lowes.com)
Orchard Supply Hardware (www.osh.com)
Outdoor Lighting Associates* (members.aol.com/outdoorltg/ola.html)
Plow & Hearth* (www.plowhearth.com)
Restoration Hardware (www.restorationhardware.com)
Sears Hardware (www.sears.com)
Wal-Mart (www.walmart.com)

Online sources for lighting help

International Dark-Sky Association (www.darksky.org/ida/fixtures/res.html), which wants details of any good lighting fixtures or situations you encounter.

Light Pollution Awareness Website (members.aol.com/ctstarwchr/).

"Mr. Cutoff" Lighting Tree (www.skykeepers.org/examtre2.htm), which describes how to convert dusk-to-dawn fixtures.

Good-Neighbor Outdoor Lighting (SkyandTelescope.com/resources/darksky/article_85_1.asp), a two-page guide prepared by *Sky & Telescope* and the New England Light-Pollution Advisory Group.

Dissecting Light Pollution

By Arthur R. Upgren

Every astronomer knows the artificial skyglow that hangs over populated areas, washing out almost everyone's view of the universe to a greater or lesser degree. In the last two generations, light pollution has spread from a problem in cities to a major astronomical disruption almost everywhere.

But some aspects of light pollution are not widely appreciated by amateur astronomers. Knowledge is power; here are facts that may help you avoid some of the problem and combat the rest more effectively.

Glare versus skyglow. The most annoying and destructive problem is light that beams directly into your eye from a bright bulb. This is called *glare;* it comes from fixtures that are poorly designed or improperly aimed, in other words most of those currently in use. When glare crosses property lines and creates a nuisance, it's called "light trespass." Glare is often the easiest problem to avoid -- by setting up your telescope in a shadowy corner, erecting a tarpaulin to shade the telescope, or negotiating with your neighbors or local government to have the offending light turned off or replaced with a modern one of better design.

Skyglow is what the term "light pollution" properly denotes. One way to measure it is to compare it to the night sky's natural background light. The sky does have a certain minimum surface brightness even in the most pristine, unspoiled environment. This natural skyglow has four sources: faint airglow in the upper atmosphere (a permanent, low-grade aurora), sunlight reflected off interplanetary dust (zodiacal light), starlight scattered in the atmosphere, and background light from faint, unresolved stars and galaxies. Airglow peaks around the maximum of the 11-year sunspot cycle; the other sources vary with the hour of night and the seasons. But their combined average is well known.

A typical suburban sky today is about 5 to 10 times brighter at the zenith than the natural sky. In city centers the zenith may be 25 or 50 times brighter than the natural background.

Full-cutoff shielding in light fixtures is the essential remedy for both glare and skyglow. A lamp should send all its light more or less down where the light is intended to be used, not upward or sideways. "Full cutoff" is usually taken to mean that no light rays from the fixture go above the horizon, and that at least 90 percent of the light is blocked in the near-sideways range from 0° to 20° below the horizontal plane.

Light that shines in this near-sideways range contributes nothing to most lighting needs. It is merely a dazzling annoyance in the eyes of people nearby and dissipates uselessly into the distance. Light spilling upward, of course, is wasted totally. Tremendous above-the-horizon waste is tolerated because it goes unseen; people who install lights don't normally check them at night from high in the air! The electricity cost of this wasted light has been put at $1 billion to $2 billion annually in the United States.

Near-horizontal light is especially destructive. A light ray aimed straight up is usually not the worst kind. It escapes into space quickly, passing through what astronomers call one "air mass." A ray aimed 10° above the horizon, on the other hand, passes through 5.6 times as much atmosphere -- 5.6 air masses -- polluting all the way. A ray that skims the horizon pollutes up to 10 air masses, though not much of the light is left by the time it goes through the last few of them.

The situation is comparable to atmospheric extinction of starlight arriving in the opposite direction. When a light ray travels straight up through clear air from sea level, only 20 to 30 percent of it is absorbed or scattered by the atmosphere. The rest escapes harmlessly into space. When the same ray is aimed 5° above the horizon, about 90 percent of it is absorbed or scattered. Thus it causes three or four times as much pollution, when all the damage is summed up over an area many miles across. (That, anyway, is the situation in clear air. Aerosols can complicate the picture.)

Add the fact that most lights provide *some* blockage at high angles, and it becomes clear that most of the light-pollution war will be won or lost in the narrow battleground just a little way above the horizon. At least this is true at sites fairly far from the offending lights -- the semirural areas that seem to have suffered the worst degradation in the last 20 years. Right inside a city, rays at higher angles (and reflected from the ground) are the primary problem.

Some skyglow is surprisingly local. You can often see more stars 15 miles from a big city than a quarter mile from even one bad rural shopping center.

I've made extensive sky-brightness measurements of the zenith at two sites in Middletown, Connecticut: at the Van Vleck Observatory on the Wesleyan University campus, and at my home two miles away in wooded, semirural suburbia. The campus had, until recently, a night sky more than 20 times brighter than the natural sky background. The sky over my house is only four to five times brighter than the natural level. The change in two miles was remarkable -- from a nearly invisible Milky Way to views of the Sagittarius and Scutum starclouds on good nights.

In 1994 the university agreed to replace most of its walkway lights within a block of the observatory with properly shielded fixtures. The sky brightness at the zenith dropped by almost half -- a dramatic improvement of 0.6 or 0.7 magnitude.

Such observations point up the importance of dealing with local lights. You don't have to convert an entire city to see results. Hartford, Connecticut, a metropolitan area of a million people, is only 15 miles north of the Wesleyan campus. Its lights obtrude only marginally. Those of New York City about 90 miles southwest interfere not at all.

Another example appears on the light-pollution map of the Washington, D.C., region made by the Northern Virginia Astronomy Club and published in the June 1996 *Sky & Telescope*, page 82. The club members found surprising holes of relatively dark sky in a region around Washington that looks solid white in nighttime spacecraft photographs.

Watch the color of the daytime sky, especially near the horizon. The bluer the sky, the darker the night will probably be. Whiteness in a daytime sky is due to sunlight scattered by tiny particles. They do just as good a job of scattering artificial light at night. A deep blue sky in the afternoon should mean a transparent sky after dark.

Dry air is another good sign. Even if the upper atmosphere is fairly free of haze, high humidity is liable to bring haze (or fog) lower down. Watch for forecasts of low humidity.

Air pollution matters. The white haze in a blue sky consists of microscopic water droplets that have condensed on tiny solid particles, primarily sulfate dust from distant factories and power plants. These particles are the precursors of acid rain. Sulfur emissions in the United States peaked in 1970 and have since been reduced by about 30 percent. Whether these reductions will continue or backslide is an open question. But the Clean Air Act of 1970 has meant darker skies in the 1990s than we otherwise would have had.

A windy cold front sweeping through a city can clear out local pollution, leaving the night marvelously dark. The windiest city and suburban nights are often the darkest. A passing rainstorm or blizzard can also leave an unusually dark night in its wake.

A case based on money, energy, and good-looking surroundings will get you farther than one based only on astronomy when appealing for light-pollution control. Light sent into the sky wastes money. It adds to noxious power-plant emissions, dependence on foreign oil, and all the other problems created by energy profligacy. It creates an annoying, garish nighttime environment. Those are the points that will carry the most influence with the public and elected officials.

Full-cutoff fixtures that illuminate the ground efficiently with a smaller bulb can save electricity so fast that the cost of retrofitting is typically recovered in three years. After that the savings are free and clear. The city of San Diego, for example, is now saving about $3 million a year in this manner.

Full-cutoff lighting looks more pleasant. By reducing glare it improves nighttime visibility, so that motorists, for instance, can see pedestrians and objects more clearly. Many full-cutoff fixtures are becoming available in various styles. The best ones rely entirely on reflection above the bulb rather than refraction by a plastic cover hanging below it. They provide not only less waste and glare but smoother, more uniform illumination. When people see what well-designed lighting looks like at night, they want it for their own area.

When light pollution is reduced, everybody wins. This conceptual breakthrough was what led David Crawford of Kitt Peak National Observatory and his amateur colleague Tim Hunter to found the International Dark Sky Association (IDA) in 1988. Kitt Peak's successful efforts against light pollution from neighboring Tucson, Arizona, convinced Crawford and Hunter that astronomers have common cause with everyone else. Before then, most astronomers had assumed that "good lighting" was exactly what they didn't want, and that they faced a hopeless battle against the rest of the world.

Join the IDA. The IDA produces useful fact sheets and educational materials (including sources for good lighting fixtures), lobbies the lighting industry, and has worked for state, local, and international light-pollution control initiatives. As of February 2002 it was supported by 8,803 dues-paying members, nearly five times as many as just six years ago. "I can assure you that we in the IDA office are working under intense overload all the time," writes Crawford. "We get over a hundred emails a day, most with requests for help, plus mail and phone requests and ordinary mail." Dues from members are essential to pay for staff to handle this work and carry out the IDA's numerous programs.

Supporting the IDA financially is the most effective thing you can do to turn the light-pollution tide. Basic membership starts at $30 a year; the address is 3225 N. First Ave., Tucson, AZ 85719, U.S.A. The IDA maintains a Web site, which includes its fact sheets and newsletters, at www.darksky.org. Every amateur astronomer should be eager to help.

Art Upgren is an astronomer at Wesleyan and Yale Universities and a charter member of the IDA. He has long been active in night-sky brightness research.

Related Articles:

- Astronomers and Light Pollution
- Good Neighbor Outdoor Lighting

1. How does light pollution affect people?

A: In three main ways:

Health & Quality of Life: Recent landmark studies by University of Connecticut epidemiologist Dr. Richard Stevens have discovered that bright lights at night can nearly double the risk of cancer by disrupting the hormonal and immune systems of the body. These disruptions also cause insomnia, depression, and other physical and mental diseases.

See:
http://abcnews.go.com/sections/living/DailyNews/darkness_wnt010517.html
http://www.fhcrc.org/news/science/2001/10/16/graveyard_cancer.html
http://www.bcaction.org/Pages/SearchablePages/2000Newsletters/Newsletter061A.html

Safety, Security and Crime: These are the problems nighttime outdoor lights are advertised to eliminate. Unfortunately, many lights today like Acorn streetlights, unshielded forward-firing Floodlights, Drop-Lens Roadlights and Dusk-to-Dawn Yardlights waste 30-60% of their light, sending blinding glare into people's eyes and polluting the night sky. Because this type of lighting doesn't enhance visibility, safety and security are not increased but rather are in many cases decreased.

According to the U.S. Department of Justice Report to Congress on the effectiveness of lighting, http://home.att.net/~icole/crime_ref_guide.html "We can have very little confidence that improved lighting prevents crime, particularly since we do not know if offenders use lighting to their advantage. In the absence of better theories about when and where lighting can be effective, and rigorous evaluations of plausible lighting interventions, we cannot make any scientific assertions regarding the effectiveness of lighting. In short, the effectiveness of lighting is unknown."

In closing, after decades of aggressive lighting programs, the results speak for themselves! Crime rates in America are higher today than in any previous time in recorded history. Security is diligently sought for but never achieved. Personal safety is at an all-time low.

All this with an annual pricetag of more than $20,000,000,000 worldwide!

Uncontrolled Outdoor Lighting, like crime, never pays!

Astronomy:

Personal: This is the part of light pollution that you are probably most familiar with. After all, a dome of skyglow over cities and the resulting lack of stars have become far too familiar of a sight for most Americans.

In spite of the record low prices and wide selection of powerful Astronomical telescopes, starting at $150 from dealers like www.telescope.com, light pollution is fast blocking our view of the night sky and ending personal Astronomy as we know it.

We need to take action today to save the Universe! We can change the world, one light at a time! See http://www.darksky.org/

Professional: The pace of Astronomical discoveries today is truly remarkable, especially with space telescopes like the Hubble, Chandra, WMAP, and Mars Rover missions!

But the workhorses of Astronomy, Ground-Based Observatories, which direct the space telescopes towards targets of interest, are under fire from light pollution. Although lighting regulations have been enacted to protect several observatories, we need to guarantee that every observatory is protected!

2. How does light pollution affect animals?

A. Although light pollution affects all animals negatively, some species are killed by the millions worldwide, like birds and sea turtles.

See:
http://news.nationalgeographic.com/news/2003/04/0417_030417_tvlightpollution.html

3. How does the affect of light pollution differ in the city rather than rural and suburban areas?

A. Light Pollution becomes much more intense, to the point where only the brightest stars can be seen and the night sky glows brightly. Nearby light pollution sources can also blind the observer, resulting in a sky that appears black but is completely devoid of stars. This destruction of dark-adaptation can be even worse than skyglow itself.

4. In what way can light pollution be prevented?

A. With the combination of two technologies; Smart Lighting & Full Impact Lighting:

Full-Impact Lighting: Lighting that aims all of its light toward the ground where its needed, not into the night sky where its wasted. None of the bulb should be visible at night when you're standing at the same level as the fixture. Most of these fixture can be identified by their flat, horizontal lenses. Examples: Flat-Lens Roadway Lighting, Flat-Lens Parking Lot Lighting, the Hubble SkyCap and the residential Glarebuster.

Smart Lighting: Using high-tech motion sensors and timers to provide true safety, security and savings. Motion sensor lighting works like a security system, turning on only when an intruder is in the yard, scaring them away and alerting you by a sudden blast of light. Both timers and motion-sensors save lots of energy and save you lots of money on your power bill!
Best example: Heath-Zenith SL-5597 Full-Impact Motion-Sensor Floodlight
$30.00 at Home Depot

SKY & TELESCOPE
SkyandTelescope.com

Jennifer Barlow: Dark-sky Devotee

By Monica Bobra

High-school sophomore Jennifer Barlow shows off her first telescope – a gift that has fueled her passion for astronomy and for preserving dark night skies. *Courtesy Elizabeth Barlow.*

When someone on an Internet message board suggested that a night be set aside each year to dim outdoor lights so that people could enjoy the heavens, a high-school student from Midlothian, Virginia, decided to take action. Passionate about astronomy and strong-willed, 15-year-old Jennifer Barlow parlayed her idea into a widespread movement to have everyone "step back for a moment and realize the wonder that our universe holds." While maintaining her busy high-school schedule, she single-handedly coordinated the effort and set up a Web site to spread the word.

More than a year later, Barlow's hard work has paid off: her National Dark Sky Week, first observed throughout the United States on April 1–8, 2003, has been endorsed by the American Astronomical Society, Astronomical League, International Dark-Sky Association, and *Sky & Telescope.*

S&T: *What's the number-one reason people should participate in NDSW?*

Barlow: To be reconnected with the night sky. Most of us have forgotten the legacy of the night sky as it seems to fade away behind the blanket of light pollution. The universe is an important part of our history that should not be forgotten.

S&T: *How are you encouraging your community to participate in NDSW? Are you having any difficulties?*

Barlow: I've distributed fliers in my neighborhood and encouraged almost everyone that I meet to turn out their lights to preserve our night skies. The major difficulty that I have is lack of participation by people who do not seem to recognize light pollution as a problem. In order for this to work, we need more participation.

S&T: *Have you encountered any opposition?*

Barlow: I've encountered a few people who think that NDSW is a waste of time. Some say, "Aren't other things more important?" A great many of them are, but I think there is little recognition for light pollution. We have laws passed for the contamination of our water and air. What about our starry skies?

S&T: *Do you feel people are educated on the light-pollution issue?*

Barlow: Some people see that light pollution is a problem, but others do not know anything about it. I've noticed that some people are 100 percent for NDSW – but, again, some have never heard of it or

don't want to participate.

S&T: *Have you talked to local politicians about your idea?*

Barlow: Not yet, but I plan to do so for the years following.

S&T: *How did you begin collaborating with the International Dark-Sky Association?*

Barlow: In the summer of 2002 I sent an e-mail to the IDA asking for their support. I got a reply from Robert Gent, who wanted to help me with my efforts.

S&T: *What's the coolest deep-sky object light-polluted cities are missing out on?*

Barlow: The first and foremost greatest thing to me that cannot be seen under light-polluted skies is the Sagittarius Arm of our Milky Way galaxy. The Pleiades and the Orion Nebula are also among the most beautiful features of the universe.

S&T: *Do you have bigger and bolder plans for next year?*

Barlow: I haven't thought too much about next year's NDSW yet, but definitely over the next few years, I would like to see National Dark Sky Week become International Dark Sky Week. It would be even better to get the whole world involved!

S&T: *Have any interesting people contacted you?*

Barlow: I have been contacted by people from radio shows, magazines, newspapers, and astronomical societies. It's been wonderful getting to hear from all of them.

S&T: *You've gone from a small-town schoolgirl to a national news figure. What's that like?*

Barlow: Being recognized hasn't made me any different — just a little busier! I'm still a normal teenager, worrying about tomorrow's algebra test! Again, it has been good to be able to spread the wonder of the skies in their full beauty — without light pollution.

National Dark-Sky Week

National Dark-Sky Week 2005 occurs from April 8-16

What is NDSW?

- A week during which everyone turns out outdoor lighting to temporarily reduce light pollution
- An event that promotes better lighting and the study of the universe

How do I participate?

- Most importantly, turn off the lights!
- Spread the word about National Dark-Sky Week. The only way that there can be success is if people are aware and participate
- Go to a safe, dark area with a group of people to observe the beauty of the night sky. Carry a red-tinted flashlight with you to maintain your night vision

Safety note: Do not turn out any lights that are necessary for safety purposes, i.e., busy walkways and parking lots

For more information, contact **Jennifer Barlow**, the founder of National Dark-Sky Week at ndsw@comcast.net

danshel

From: Jennifer Barlow [astronomer107@comcast.net]
Sent: Sunday, April 03, 2005 10:17 PM
To: danshel
Subject: Re: RE: dark sky

ıelby,
ɔngratulations on winning the science fair!! I attached the NDSW flier if you want to distribute them around your wn and at the next science fair. Thank you so much for your help and good luck at the regional science fair!

ear Skies,
nnifer

----- Original Message -----
From: danshel
To: 'Jennifer Barlow'
Sent: Sunday, April 03, 2005 9:45 PM
Subject: [Norton AntiSpam] RE: dark sky

Thanks so much for your email. I actually won at our school level and now I go on to the regional science fair. I would love anything you could send me. Are you planning another dark sky? I read you had one a few years ıgo. My next science fair is on Wednesday, April 6.

ɔhelby

---

rom: Jennifer Barlow [mailto:astronomer107@comcast.net]
ent: Friday, April 01, 2005 11:38 PM
o: danshel
ubject: Re: dark sky

i Shelby!
n sorry that I didn't get this until after the science fair; I've been away for a week in Florida. I think it was a reat idea to do light pollution for a science fair because so many people are unaware of the harmful effects of ght pollution. Do you still want fliers? Let me know! Keep your interest in science and keep looking up!

lear (and dark) skies,
ennifer

----- Original Message -----
From: danshel
To: Astronomer107@comcast.net
Sent: Saturday, March 26, 2005 10:57 AM
Subject: [Norton AntiSpam] dark sky

Hello Jennifer,
My name is Shelby Mielhausen and I am in grade 8. I am doing my science fair project on light pollution and saw you name and read about the work you have done. Congratulations on your hard work.. So far I have taken pictures of our little town and 2 larger surrounding towns lighting. I took them both at night and during the day(of light fixtures, street lights, billboards etc) and plan to demonstrate the light pollution and which ights are less invasive. I real that you could send me a flier attactment so maybe I could hand out the fliers at he fair or If you could help I would make my own. Anyway the bad news is science fair is Tuesday, so if you ɔould reply quickly I would apprieciate it. Thanks so much. Even if you receive the email to late I would still ove to hear from you and maybe help anyway.

Thank you,

Shelby Mielhausen danshel@amtelecom.com

Outdoor Lighting Code Handbook

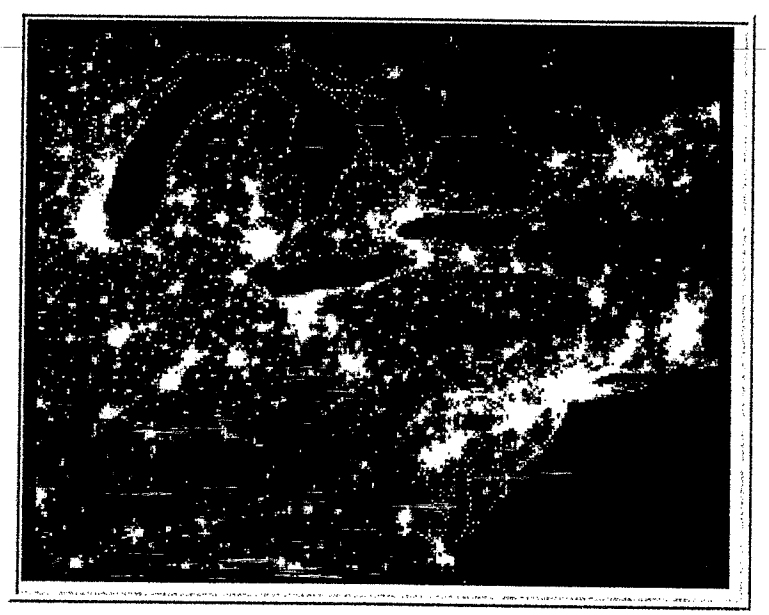
Version 1.11
December 2000 / January 2001

International Dark-Sky Association
3225 N. First Ave., Tucson, AZ 85719 U.S.A.
E-mail: ida@darksky.org
WWW: http://www.darksky.org

ostract

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

ONTENTS

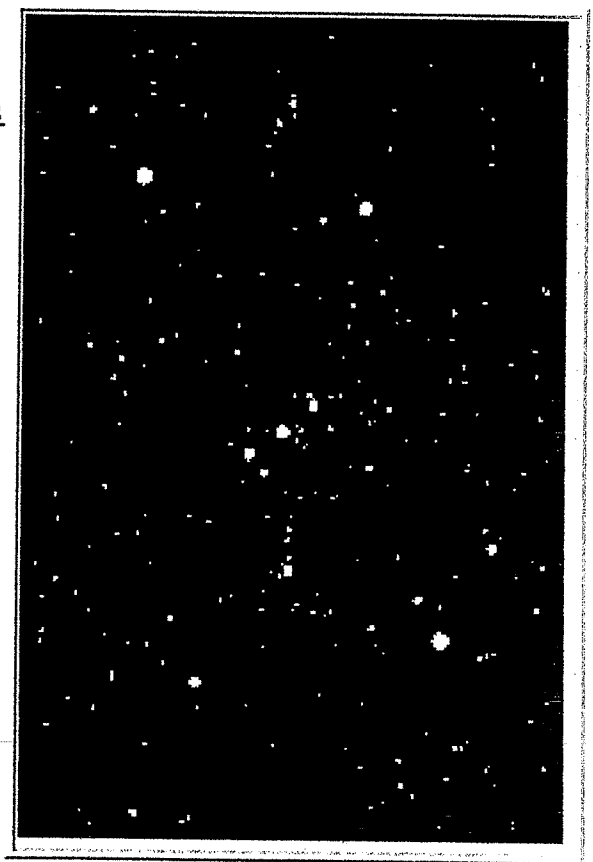


troduction

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

need not happen.

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



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

poor lighting practice is rampant. Careless and excessive use of hting in our outdoor environments causes extensive damage to the thetics of the night, at the same time that it compromises safety and ity, the very uses for which it is usually installed. Bad lighting hurts ryone. It starts a cascade of negative consequences - beginning with loss of our views of the heavens, continuing through falling levels of ty and utility, irritation of neighbors and wildlife, disturbance of the thms of day and night that are vital to many natural systems, damage to the aesthetic appearance of our mmunities, wasted monetary and natural resources used to produce wasted light, and increased air pollution and oon dioxide levels from wasted fossil fuels. There is nothing good that comes from bad lighting.

st bad lighting can be blamed on the fact that the user is unaware of the issues of visibility and utility, how they are anced by good lighting and compromised by bad. Much is known about how lighting affects our ability to see, to afe, and to use the nighttime environment. Much remains to be learned. Though the science of lighting has made nendous strides in the understanding of quality lighting and visual perception, our communities will not benefit n this knowledge until we raise our awareness and expectations, and demand both quality lighting and dark skies.

ghting code is the vehicle for a community to express its expectation for quality lighting and dark skies. If it is well ten, implemented and enforced, the amount of improvement that can be achieved for most communities is nothing t of phenomenal, both in reduction of sky glow and improvement in visibility on the ground. Effective shielding ards, as recommended in this Handbook, will reduce the amount of light escaping into the sky by fifty percent or compared to typical unregulated lighting practice. In the majority of cases, these shielding standards will also ually eliminate glare. In applications where overlighting has become a common practice, such as in service station opy and much convenience store lighting, the overall lighting limits recommended in the USA Pattern Lighting

de, expressed as lumens per acre caps, will reduce unnecessary lighting, glare and stray light by even greater portions. And, unlike other forms of pollution, the elimination of light pollution in all its forms actually saves ney. Quality lighting costs less than bad lighting, in the long term and even usually in the short term. Everyone wins lighting is done right.

e IDA Lighting Code Handbook is a response to the many requests for information on lighting codes and assistance composing lighting codes from the increasing numbers of communities interested in addressing these issues in tdoor lighting. Many issues related to outdoor lighting use and the means of decreasing obtrusive side effects of its through effective regulation are discussed. The Handbook is not a guide to other related issues or subjects such as icient energy use, lighting system construction, design standards in general, or interior lighting. It is intended as an to communities that are recognizing the value and beauty of dark skies and the effectiveness of quality outdoor hting, that are seeking to take control of their outdoor lighting, to "take back the night" that is being lost necessarily to careless and excessive use of outdoor lighting.

tructure of the Handbook

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

xt is the *USA Pattern Lighting Code* , a generic code embodying the principles of light pollution control described he Handbook. All section titles within the Pattern Code are linked to *Section Overviews* , where general issues ted to the section are described.

n each section are links to *Notes* that follow the USA Pattern Lighting Code, each addressing specific issues ted to the code text, such as alternative versions, issues that should be considered if the text is modified, and mples of codes that use similar text or from which the pattern text has been borrowed. Different communities will e different goals and priorities, and alternatives may be offered where a different emphasis or approach can be en. Sometimes the implications of alternative approaches or modifications may not be obvious, and the notes will cribe some of these. Examples are used to show what has worked, where, and why.

such links are indicated by the usual hyperlink color and underline convention using *this color* (if not yet ited") and *this color* (if already "visited"), and also by *italics,* so that they may be evident in black and white dcopies.

lowing the *Notes* are short sections covering a few technical *definitions* used in the Handbook but not included ne Pattern Code Definitions - if you come across a term you don't understand in the Handbook, check for it here in *Section 16* ; a brief description of the primary reference sources and organizations serving as background for Handbook; and an example *Lighting Advisory Committee Proposal* .

t are Appendices. *Appendix A: Administrative Forms* includes forms that can be used in the process of inistering a lighting code based on the Pattern Code. *Appendix B: Example Applications of Section 4* marizes how the shielding and lumens per acre standards of Section 4 apply to residential and commercial land s in the various Lighting Zones. *Appendix C: Example Lighting Codes* includes brief descriptions and links to eral real in-place lighting codes. Some have been written using this Handbook, or an earlier version; some have l other guides. These examples illustrate on-the-ground solutions to outdoor lighting problems in communities with ering size, location, history, composition, and goals.

w to Use the Handbook and USA Pattern Lighting Code

IDA Lighting Code Handbook does not intend to offer a single solution appropriate for all communities or

ıations. It offers instead a comprehensive guide describing issues relevant to the control of the obtrusive aspects of door lighting, and a list of effective regulatory approaches to mitigate these aspects. The Handbook is intended for by any community of any size or locale in the USA seeking to produce a new or update an existing lighting code. It lso be a valuable guide for communities outside the USA, though IDA intends to supplement this Handbook with h codes and discussions more directly applicable to other countries as time and resources permit.

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

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

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

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

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

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

implementation of a lighting code will require administrative procedures and forms. The forms contained in *endix A* should be modified to suit the code you have written and the style of implementation favored by your ning department. In most cases this will mean much shorter and simpler forms than included in this appendix, e these forms address a variety of situations that are possible in codes but unlikely to occur in a single lighting e.

lly, you must stay involved with lighting issues in your community. You must regularly re-examine lighting ces in your community and the effectiveness of the code, and modify it or its implementation to improve ctiveness and address the inevitable problems that will arise. Refer back often to this Handbook on the *IDA site* , as it will be regularly updated as new or better solutions are found. If you find a solution that you feel might

better than the approach offered in the Handbook, or simply different and suited to a specific situation in your mmunity, the IDA is interested in your information to help in keeping the Handbook as up-to-date and useful as ssible.

pics in Outdoor Lighting and Lighting Codes

hy Is Lighting Used?

tdoor lighting is used for a variety of purposes in our modern society. For work or recreation, it enables people to essential detail in order that they may undertake their activities at night. It can facilitate and enhance the safety and urity of persons or property, for example through lighting on roads and pathways. It may be used to emphasize tures of architectural or historical significance, and to light parks and gardens. It is used for advertising or display to mote products or services, or to call attention to commercial premises by means of area lighting or signs.

metimes, too often, lighting can be found that appears to have no use. It may be that whatever use or problem it was ginally installed to address is no longer relevant or remembered, but it seems sometimes that there was never much ught given to the light. Any lighting should be carefully considered in terms of needs and community standards (see *A IS #138: Lighting Design Check List*).

e different uses to which lighting is put impose different requirements on the kinds and amounts of light needed, and e rise to differing potential adverse impacts. Because of this, lighting codes often distinguish three general types of ting uses, and apply somewhat different standards for each.

st lighting is used for **general illumination**, to provide simple visibility in areas used by pedestrians (walkways), estrians and vehicles (parking lots) or vehicles alone (roadways) at night. The lighting is used to allow the relatively ple tasks of navigation, avoiding hazards such as people, curbs or other vehicles, and locating vehicles.

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

nting used for both "security" and "general illumination" is addressed with similar standards, and is termed "*Class* 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.

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

tdoor 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.

ally, there is a large variety of minor uses for lighting where the principle purpose is decorative - building façade ting, roof lighting, landscape lighting, *etc.* These uses for lighting, though certainly legitimate, are often viewed communities as less important to the general public and may have limitations imposed accordingly. Further, it is reasingly recognized that building façade and roof lighting is often used as an advertising vehicle, effectively verting entire buildings into advertising signage that takes advantage of a loophole in sign size limitations that are posed in many communities.

ese 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.

hat is an Outdoor Lighting Code?

outdoor lighting code is a legal document that establishes permitted and prohibited lighting practices, with an phasis on limiting obtrusive aspects of lighting more than an emphasis on good lighting practices *per se* . Most ting codes are concerned primarily with limiting the wide-reaching effects of stray light that causes glare, light pass, sky glow, and limits the ability of persons to use property in ways that do not want or need lighting. Lighting es are often included as a chapter of the zoning or land-use code, though zoning codes may severely restrict orcement options. The standards of a lighting code are applied to new construction of all kinds in much the same as a building code, electrical code, or plumbing code, and consideration should be given to enacting the lighting e using a similar legal structure to these. Lighting codes often require some previously installed lighting to be ght into compliance immediately or at some future date.

hting codes may be enacted at different governmental levels -- from state to county or township and city and even elopment project or neighborhood. State-level codes usually address only very general issues, though they may etheless serve a valuable role, enabling the adoption of more comprehensive codes at local levels. State-level codes generally address lighting built with state funding, such as state highways or for state-owned facilities that are n legally exempt from local codes. They can also establish a basic code for areas of the state that do not yet have or never have more comprehensive codes. At the development or subdivision level, lighting codes or restrictions can ncluded in design standards or Conditions, Covenants, and Restrictions (CC&Rs) to be applied only to the homes evelopments within the subdivision. Such codes are often the most effective vehicle to address specific residential ting issues such as shielding of low-output lighting that are often exempted in higher-level lighting codes for tical reasons.

y Must Outdoor Lighting Be Regulated?

ugh there are many needs for lighting in our built environments, obtrusive aspects of lighting often extend well ond the boundaries of the area in which the lighting is installed and intended for use. These obtrusive aspects, such lare, trespass, energy waste, and sky glow, can have serious consequences for the public health, safety, and fare, but they can also be effectively controlled or eliminated with carefully considered attention to design, allation, and use.

less lighting practices can have serious negative impacts on public safety. Glare and excessive contrast caused by ly shielded luminaires and overlighting compromise everyone's ability to see, and as eyes age they become cularly susceptible to these disabling effects. It is commonly known that many elder citizens are reluctant to drive ght, but it is not so widely known that a large portion of the problem originates with poor lighting practices.

r, some perfectly legitimate purposes for lighting have potential incompatibilities. As an example, the advertising ts of illumination that appears brighter or "cheerier" than the competition is a well entrenched aspect of business The resultant competition for "visibility" and advertising is leading in many communities to upward "ratcheting"

lighting levels and extreme examples of overlighting and glare. It is well known what happens to a community that s no limits on the size of signage, and it should not be a surprise what happens when there is no limit on the amount lighting. Though lighting may sometimes be effective in attracting customers, overlighting interferes with visibility djacent roadways, the goals of energy and resource conservation, and the preservation of the dark night sky. cing of these competing interests requires a carefully considered lighting code.

her civil or federal regulations may have impacts on some aspects of outdoor lighting. Sign codes often address ues of size, lighting, colors and other design or composition details that may affect the light output of the sign hting. The Federal Energy Code (Code of Federal Regulations, Title 10, Vol. 3) establishes energy conservation ndards for the design of new commercial and multi-family high rise residential buildings, suggested for voluntary mpliance at non-federal facilites but required for federal commercial and multi-family high rise residential buildings. describes many issues related to quality lighting, but the primary focus is on the energy used.

hat Makes a Lighting Code Effective?

e goal of good-lighting and dark-sky advocates is not a lighting code. The goal is the actual, real-life elimination of adverse effects from outdoor lighting, such as light trespass, glare, energy waste, and sky glow. A good lighting de is a vital step toward these goals, but actually achieving them requires not only a lighting code, but also effective plementation and enforcement of the code on an ongoing basis. After adoption, the code must lead to quality lighting ctices in the real world or it does not accomplish anything.

e actual adoption of a good lighting code for your community takes you through the first steps, but other steps must accomplished if the overall goal is to be realized.

- **1. Define the Problem**

most communities, even before you can hope to draft a lighting code, an awareness of the issues and of the racteristics of quality lighting must be built. This process starts first with any group that is especially motivated or sitive to the issues, including persons sensitive to the aesthetic character of dark skies and/or the many values of y lighting.

rough efforts at education this initial group then broadens the community's awareness, in general and especially of legislative bodies (councils or county supervisors, for examples). Through this process a broad consensus will elop both that there is a problem and that there are effective solutions.

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

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

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

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

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

inistrative Impacts of an Outdoor Lighting Code

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

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

ne approach to implement the code can revolve around filling out the *Permanent and Temporary Lighting plication, Existing Lighting Inventory and Lumen Output Calculation Sheet* , or a modified version of this form. is form is filled out by the applicant, but staff will need to be familiar with initial lumen outputs of the variety of mp types to be sure mistakes are not made. To verify initial lamp outputs, reference can be made to any nufacturer's lamp catalog (available from Sylvania or GE, for example) or the *IDA Information Sheet 4: erating Data and the Economics of Different Lamps* . There may be slight differences in initial luminous outputs lamps from different manufacturers, or lamps with slightly different specifications. The values submitted should be ted for obvious errors. Initial outputs are the values required for this form - staff must assure that other output ues are not entered, such as "mean," "minimum," "effective," or "maintained" values.

r every lamp and luminaire combination proposed for a project, staff must review the information submitted (under ction 7.1.B in the *USA Pattern Code*) to be sure the shielding characteristic claimed by the applicant on the *hting Application* is justified. Unshielded luminaires will hardly need investigation, and there should be relatively y used under a lighting code. Luminaires claimed as shielded must be checked more carefully, but this will almost ays require no more than a picture of the luminaire (see *Note 17: How to recognize fully shielded fixtures*).

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

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

hy Are There Different Standards for Different Areas?

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

e 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.

e E2:

Areas of low ambient brightness. These are suburban and rural residential areas.

ne E3:

Areas of medium ambient brightness. These will generally be urban residential areas.

ne 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.

this list of Zones based on those defined by the CIE, this Handbook adds a fifth Lighting Zone:

ne 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.

a lighting code, these Lighting Zones may be tied closely to land-use zoning categories Some codes have established rict one-to-one correspondence in this regard, where every occurence of a particular land-use zoning category (like vy commercial or single-family detached residential) has the same lighting standards. Other communities may apply concept somewhat differently, where Lighting Zones are defined in relation to proximity to some particular ource, like an observatory or a park, and apply the same lighting standards to all land-use zoning categories equally. hird possibility is a combination of these two approaches, where for example a commercial zoning in a rural area or r an observatory may be one Lighting Zone, whereas the same commercial zoning in an urban surrounding would n a different Lighting Zone.

general, the approach envisioned in this Handbook would establish Lighting Zones as an overlay to land-uses, owing the definitions described above. Under this approach, a rural area overall might be considered Lighting Zone or E2; a suburban or urban area might be Lighting Zone E3 or E4. Then, a parcel zoned for commercial use in the l area might be permitted 25,000 or 50,000 lumens per net acre, while a parcel with the same zoning in the urban ight be permitted 100,000 or 200,000 lumens per net acre.

ould a Lighting Code Specify Lighting Levels?

httime overlighting is increasingly becoming a serious issue. An egregious example in recent years is service station opy and convenience store lighting, where illuminances of 1000 lux (100 footcandles) or more are increasingly g seen. Other applications are also seeing uncontrolled upward ratcheting of lighting levels in many communities, en by competitive pressures and perhaps by perceived liability risks.

rinciple in good lighting design maintains that the brightest areas in a person's field of vision should not exceed ten es the brightness of the average level to which the eye is adapted. If roadways are to be taken as the reference level, minated at 3 to 16 lux (0.3-1.6 footcandles), then this common-sense rule is being exceeded in many cases by great gins. This is a serious problem, leading to compromised visibility and safety, particularly for the ageing eye. To ctively address many of the issues of light pollution, overlighting must be addressed.

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

t, the recommended practices of the IESNA are often specified as **minimum** average illuminances (particularly for ing lot lighting), meaning that the average level should be as specified or greater. More importantly, they are also intended to be applied in a recipe approach, an approach inherent in a legal document such as a lighting code. The mmendations are offered as a beginning point for lighting professionals, who are expected to turn their expertise training on the problem at hand to determine what other factors may influence the needed lighting. Lighting levels bove and below the recommended levels are professionally justifiable for some tasks and locales.

nd, lighting levels, when listed simply as an average illuminance (the most common number seen), are difficult to

ly as a code limit. In practice, determining average illuminance requires expertise and time; it is not as simple, as is en imagined, as "going out with a meter and checking." Measuring an average illuminance requires nighttime work, areas often with automobile traffic, laying out a regular grid of many points and taking illuminance measures at these nts with a calibrated and carefully leveled meter with care taken to avoid any influence of shadows or reflections. ge illuminances commonly specified in professional practice are also "maintained" averages, which means that illuminance is to be met when the light loss factors (*LLF*) appropriate for the lamps, luminaires and planned intenance routines are applied. This means that the "maintained average" illuminance, such as appears in the ommended practices of the IESNA, is not actually measurable on the pavement in any simple way, and additional ues concerning appropriate maintenance factors will have to be considered in the code. After-construction ermination of compliance with any rule is a risky course, risking discovery of non-compliance after the money has en spent, the design finished, and the lighting literally set in concrete. To avoid these problems a code may consider ining compliance as occurring at design stage - but this approach then requires a professional design for every iting permit application - an expensive requirement for small projects, and substantial training for staff to allow them competently evaluate whether the designs offered are correctly done and without error.

ally, lighting codes are interpreted, implemented, and enforced by persons that generally have limited expertise in technical aspects of lighting design. The cost and training implications of extensive illuminance specification (or any nical specification) in a lighting code are severe. Either the planning departments must obtain and maintain this ertise, or the costs must be imposed on the development community, including every small business that puts up a t.

s Handbook and the *USA Pattern Lighting Code* contained within it have emphasized a different approach, taking rection that avoids wherever possible technical lighting specifications such as average or maximum illuminance, as uable as these are to lighting professionals in the design process. The control of the majority of overlighting blems can be addressed effectively by an overall cap on the amount of light permitted, scaled to the area to be eloped - lumens per acre caps. The amount of light included in a plan, measured in lumens, is practical and simple erify from a simple list of lamps, and requires no special lighting expertise. It also leaves the maximum flexibility the lighting designer, to work within an overall "lumen budget" to creatively achieve the goals presented by clients. long as the lumen amounts permitted provide reasonable amounts of light for the designer to work with, sional quality designs can achieve the goals and solve the problems, if any, of each lighting situation by trading amounts of decorative and general illumination, areas to be illuminated, illumination levels and uniformities, types uminaire optical design, and other factors to achieve quality lighting without the code telling them permitted minance levels for each situation. (See *Note 7: Discussion of lumens per net acre caps* .) IDA believes that tivity in lighting design is enhanced rather than suppressed by this approach.

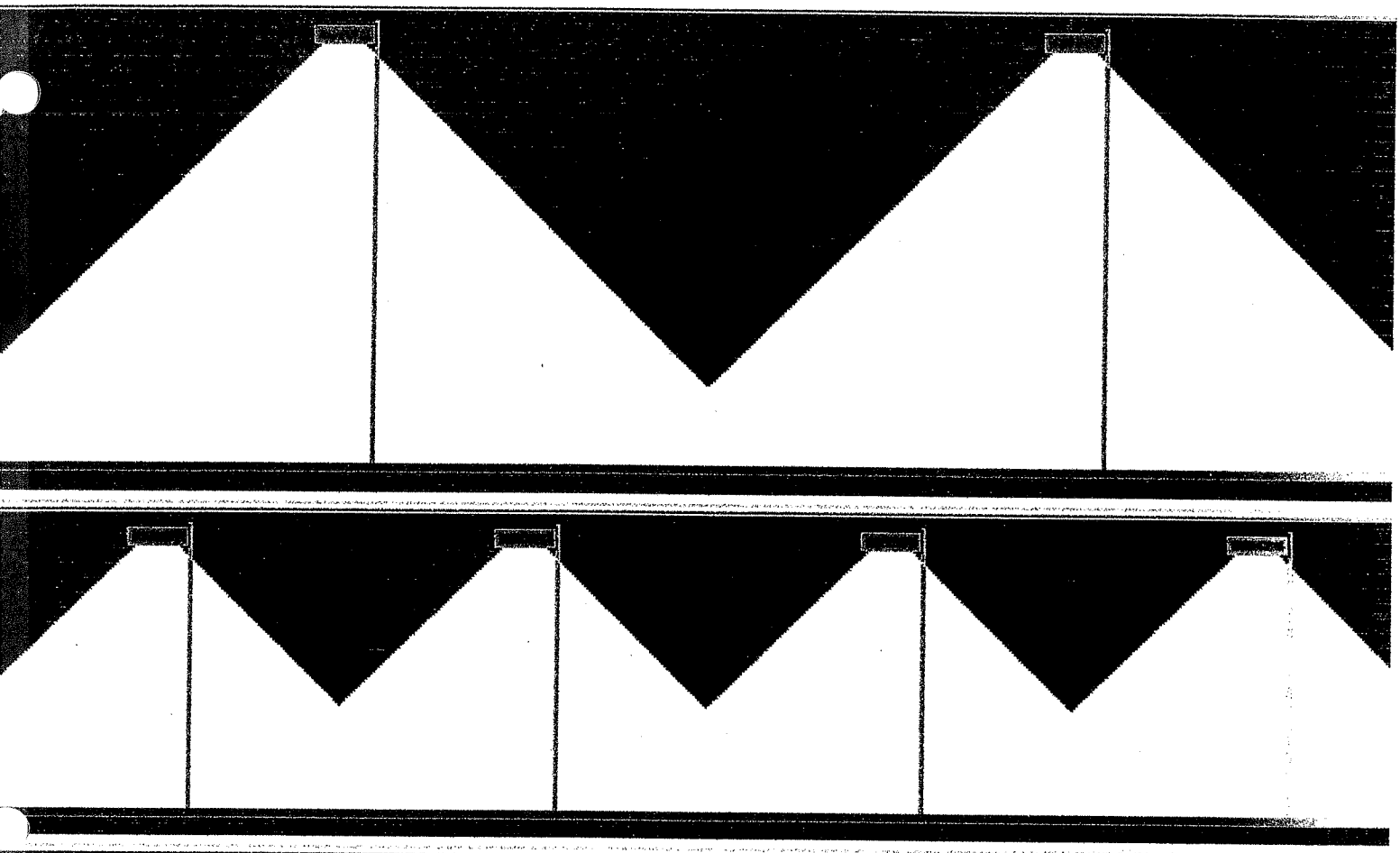
tendency to upward ratcheting of lighting levels is viewed by many as a simple advertising ploy, though in public it is always justified with arguments about safety and security. The goal of the lighting code should be to stop rlighting, but implemented in a practical manner that allows design flexibility to assure that lighting is always ample true safety and security.

pite the effectiveness and practicality of lumens per acre caps for most general lighting uses, some special uses such ports fields and display lots, because of the large amounts of light used and the potential for large obtrusive impacts uld professional design standards be neglected, justify the fiscal impacts of technical specification and professional gn. To avoid imposing large training or expertise requirements on planning department staff, these technical design ils can be certified by a registered engineer hired by the builder. For the limited and generally large project types ect to this requirement, the relative cost implications are small, but are vital to assure the quality of the final lighting

ould a Lighting Code Limit Pole Heights?

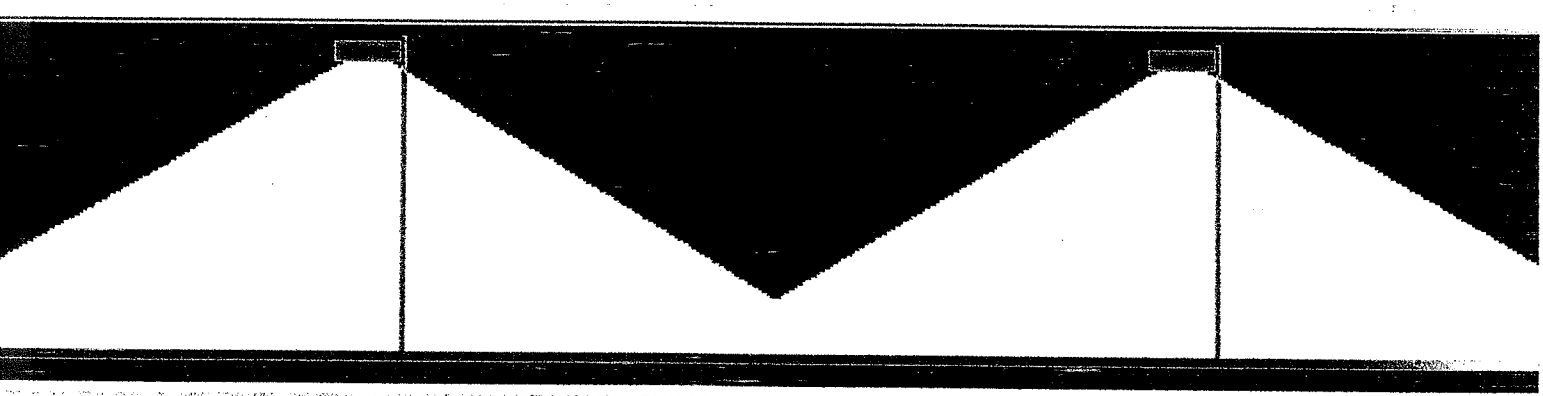
ne communities have specified limits on the heights of lighting poles, either through a lighting code or otherwise in elopment design standards. There can be two intentions here, but the results of such restrictions may not be what is nded.

intention is to limit the daytime visual impact of tall light poles against landscape views, then shorter poles may ; but lighting uniformity goals of the designer may offset the gains from shorter poles by causing an increase in the ber 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

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



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

rtunately, in attempts to reduce costs, some designers will avoid increasing the number of poles by using aires that have greater high-angle luminance, that is, luminaires that throw more light to the side. These naires would achieve the illuminance and uniformity specifications sought with fewer poles, but will do so at the of increased glare. This will lead to increased light trespass, just the opposite of what the goal may have been in

tricting pole heights. Visibility is likely to be compromised as well.

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

adway Lighting

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

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

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

for these reasons that roadway lighting is usually addressed through engineering standards. The engineers who se these standards are aware or should be aware of the professional practices concerning roadway lighting. If the ommended practices of the profession are followed when determining the roadway lighting standards for a mmunity, there should be no need for further oversight in the more generally applicable lighting code. In many ways lighting code is an attempt to bring the remaining lighting in a community, sometimes designed by competent essionals but often not, up to a level of quality commensurate with the state of modern roadway lighting design. also *Note 1: Roadway lighting standards* .)

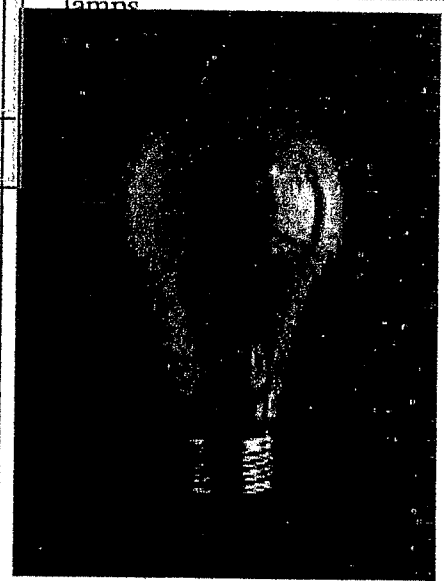
at Types of Lamps Are Used in Outdoor Lighting?

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

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

ndescent

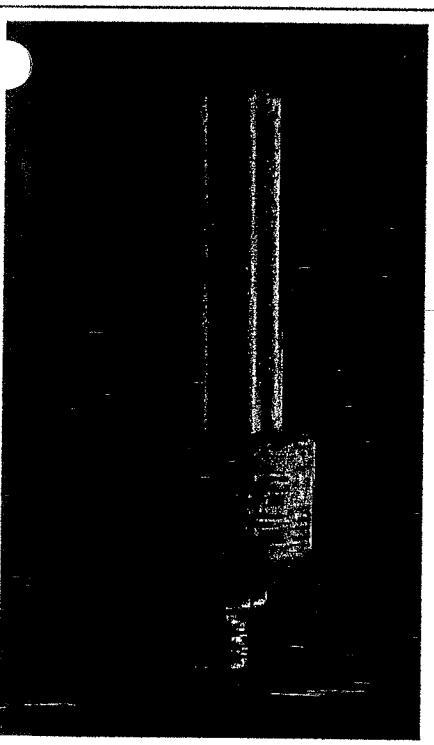
Incandescent lamps



8-20 lumens watt^{-1}

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

Fluorescent



40-70 lumens watt^{-1}

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
npared to lamp types below) and poor output maintenance, attraction of insects, and potentially hazardous mercury
te.

lercury Vapor (MV) HID- high intensity discharge

54 lumens per watt

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

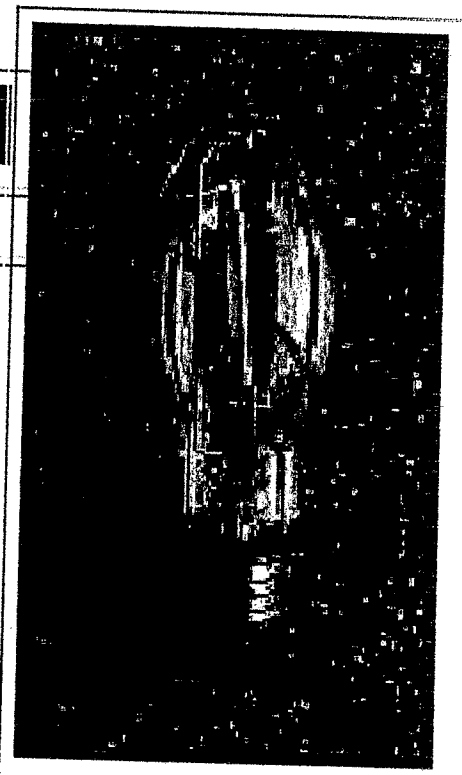
tal Halide (MH)

45-90 lumens watt^{-1}

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 or lamp, by the passage of an electrical arc through a small tube filled with mercury vapor and metal halides at 2-4 s atmospheric pressure. Again, a ballast is required, and full output is not reached for 2-10 minutes after power is ied. The many different varieties of metal halide lamps give a wide variety of slightly different color characteristics, gh generally they are white or blue-white sources. The technology is still evolving, and new types are appearing larly. Besides a relatively steep fall-off in intensity with time (compared to high-pressure sodium; see below), / metal halide lamps also change their color as they age. Metal halide lamps are very commonly used in commercial oor lighting where white light with good color rendition is required or simply desired, such as car dealer display sports lighting, and service station canopies. Advantages include a wide variety of moderate to high luminous ut lamps (3500 - 170,000 lumens mean output), high efficiency compared to incandescent and mercury vapor (45 - mens/watt mean), and good color rendition. Disadvantages include lower efficiency and output maintenance pared to high- and low-pressure sodium, shorter lamp lifetime compared to high-pressure sodium, color changes, violet output if not adequately filtered, and potentially hazardous mercury waste.

igh-Pressure Sodium (HPS)

125 lumens watt^{-1}



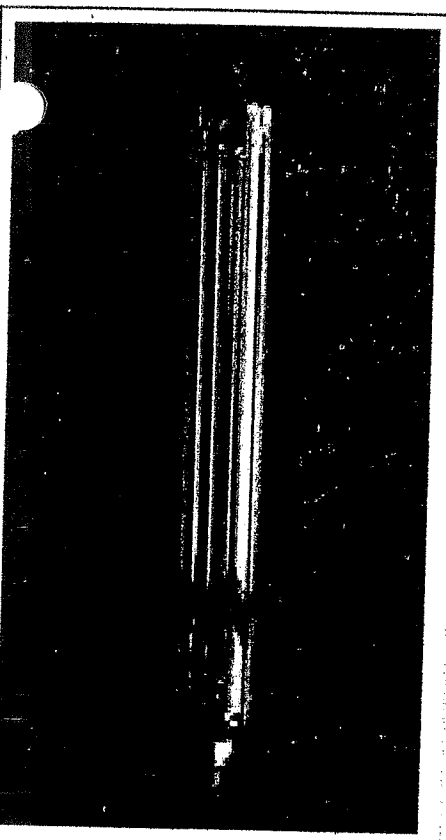
D lamps for roadway and parking lot lighting, though in some areas metal ide is becoming more popular. Light is produced by passing an electric through a small tube filled with sodium vapor at about 1/4 atmospheric ssure, and a ballast and warm-up of about 10 minutes are required. vantages include a long lifetime, a wide variety of moderate to high inous output lamps (2000 - 120,000 lumens mean output), high ciency and good maintenance of luminous output compared to all lamp es except low-pressure sodium, moderate color rendition compared to -pressure sodium, and wide availability and moderate cost of lamps and inaires. Disadvantages include poorer color rendition than metal halide, rescent and incandescent, poorer output maintenance and efficiency than -pressure sodium, and potentially hazardous mercury waste.

w-Pressure Sodium (LPS)

183 lumens watt^{-1}

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

erned about energy issues and municipal electric bills. Light is produced by the passage of an electrical arc through e filled with sodium vapor at about 6 millionths of atmospheric pressure. A ballast is required and 7-15 minutes eeded to reach full output. The light produced by LPS lamps is nearly monochromatic at a wavelength near 589 meters. Though the eye is very sensitive to this wavelength (leading to the high efficiency of LPS), the eye cannot nguish colors when LPS light is the only source available. Low-pressure sodium lighting is favored where energy mption and costs are a major concern and where color discrimination is either not needed or is supplied by other ng. Advantages include the highest luminous efficiency and lowest energy use, low glare associated with the large s, good visibility and low scattering, minimal effects on insects and other wildlife, and lack of hazardous mercury es. Disadvantages include the lack of color rendition, shorter lamp lifetime and higher lamp replacement costs pared to HPS, and large lamp size in the higher output lamps.



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 ghting is Class 2 lighting. On roadways, the perception of color is largely unnecessary, and where color eption is needed it is provided by light produced by the automobile headlights, which provide the lighting for way markings and roadside signage. The efficiency disadvantage that yellow light sources have when the eye is ted to very low light levels (see *Lighting and the Eye*), of much current interest in lighting research, does not ar to be an issue at lighting levels used in roadway and parking lot installations.

ng lot lighting is specifically provided to allow automobile drivers to see pedestrians and other hazards and to de pedestrians visibility to navigate and avoid any hazards once they exit their automobiles and the ability to find autos when they return. Under pure LPS lighting, there is almost no color discrimination, occasionally making for ed searching for a car of a particular color. In practice the hindrance is small, because we use other information to fy our cars such as make and model and whatever we left on the seat. The energy advantage of LPS in parking lot ng is substantial, in general even larger than in roadway lighting, amounting to as much as a 50% reduction when ared to metal halide systems.

ecognized however that LPS continues to suffer a poor image within the lighting industry in many areas. Many ners will not willingly consider its use. This lack of support stems principally from the poor color rendition and pression among some that LPS light provides for inferior visibility compared to broad-spectrum sources such as nd metal halide. There has also been considerable misinformation circulated concerning LPS lighting, and the ge done to its image has been substantial. More research is needed in some aspects of LPS lighting, such as lamp nes, optimal operating conditions, and system operating costs. But the advantages of LPS are sufficiently well nented to justify the more widespread use of LPS lighting, particularly in these days of increasing energy mption, increasing energy costs, and concerns for carbon dioxide production and global warming.

nizing this practical difficulty regarding the specification of LPS, the USA Pattern Lighting Code encourages se, but does not require it, in applications where color rendition is not needed (Class 2 lighting) and in areas astronomical observations are not an issue (though in general the USA Pattern Code is NOT a lighting code for

y particular community - it must be modified and tailored to suit each community's concerns and goals as described *How to Use the Handbook and USA Pattern Lighting Code* .) Where astronomical facilities may be affected, LPS hting for Class 2 applications is required in the USA Pattern Lighting Code. Though this requirement is expressed nly for Lighting Zone E1A, the generalization of this standard to the other Lighting Zones should be seriously lered by any community seeking to minimize energy use for outdoor lighting and benefit from the other vantages of LPS described here.

leon"

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

mmary of Lamp Types

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

LAMP TYPE COMPARISON -- SUMMARY

	Lamp Type				
Factor	**Incandescent**	**Fluorescent**	**Metal Halide**	**High-Pressure Sodium**	**Low-Pressure Sodium**
ttage	25-150	18-95	50-400	50-400	18-180
tput (lumens)	210-2700	1000-7500	1900-30000	3600-46000	1800-33000
iciency mens/watt)	8-18	55-79	38-75	72-115	100-183
nen intenance	90 (85)	85 (80)	75 (65)	90 (70)	100 (100)
mp Life urs)	750-2000	10000-20000	10000-20000	18000-24000	16000
rgy Use	high	medium	medium	low	lowest
or Rendition	good	good	good	moderate	none*

- 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 14: LPS/other lamp type mix for color rendition with LPS energy savings* .)

ghting and the Eye

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

irst importance when considering vision under most outdoor lighting situations is the importance of the eye's onse to low light levels and large contrasts. Daylight presents the eye with illumination levels of about 10,000 lux 0 fc). Further, everything is brightly illuminated; the sky overhead is bright, and even shadowed areas are at about) lux. Indoor lighting is at much lower illumination levels (typically from 100-500 lux or 10-50 fc), but again rasts are quite moderate since most areas that we frequent are fully illuminated.

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

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

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

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

sensitivity shifts have been measured under laboratory conditions, with observers evaluating the visibility of stimuli presented under carefully controlled but artificial conditions. The effect of this shift on the performance human visual system in real-life situations such as driving an automobile at night is much less understood. The dapted response of the eye, most sensitive to the yellow-green portion of the spectrum, is determined by cells in na called "cone" cells, after their shape. Cone cells pave the central portion of the retina - the "fovea" - the used when a person "looks at" something. The dark-adapted response, more sensitive to green or blue-green, from the other principle cell type, called "rods." Though the rods are more sensitive when light levels are very ving rise to the relative increase in efficiency of the bluer light sources such as metal halide, rods lie primarily in ipheral portions of the retina, covering what is called "peripheral vision." There are no rods at all in the fovea.

et regularly to discuss the lighting issues facing the community, to explore ways to improve community lighting, the ectiveness of the lighting codes, and of the efforts of the planning staffs to implement them. The members should be erested in and informed about the issues of quality lighting.

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

the *Example of an Outdoor Lighting Advisory Committee Proposal* .

SA Pattern Lighting Code

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

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tents

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tion 1. Purpose and Intent.

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

tion 2. Conformance with Applicable Codes.

utdoor illuminating devices shall be installed in conformance with the provisions of this Code, the Building Code, lectrical Code, and the Sign Code of the jurisdiction as applicable and under appropriate permit and inspection.

tion 3. Applicability.

ew Uses, Buildings and Major Additions or Modifications. For all proposed new land uses, developments, ngs, and structures that require a permit, all outdoor lighting fixtures shall meet the requirements of this Code. All ng additions or modifications of twenty-five (25) percent or more in terms of additional dwelling units, gross area, or parking spaces, either with a single addition or with cumulative additions subsequent to the effective date s provision, shall invoke the requirements of this Code for the entire property, including previously installed and ew outdoor lighting. Cumulative modification or replacement of outdoor lighting constituting twenty-five (25) nt or more of the permitted lumens for the parcel, no matter the actual amount of lighting already on a onforming site, shall constitute a major addition for purposes of this section.

inor Additions. Additions or modifications of less than twenty-five (25) percent to existing uses, as defined in n 3.1 above, and that require a permit, shall require the submission of a complete inventory and site plan ng all existing and any proposed new outdoor lighting. Any new lighting on the site shall meet the requirements Code with regard to shielding and lamp type; the total outdoor light output after the modifications are complete ot exceed that on the site before the modification, or that permitted by this Code, whichever is larger.

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

esumed.

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

): Roadway lighting standards

ction 4. Shielding and Total Outdoor Light Output Standards.

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

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

to Table 4.1

. 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.
. 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.

te 2: Origin of 45 degree limitation for spotlights and floodlights

te 3: Discussion of 2000 lm shielding split

te 4: Examples of lamps with 2000 lm and less

te 5: Alternative section 4.1 with LPS requirement

te 6: Shielded porchlights

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

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

	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

s 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).

e 2: Origin of 45 degree limitation for spotlights and floodlights

): Discussion of lumens per net acre caps

e 8: Origin of 5500 lumen unshielded cap

e 9: Alternative section 4.2 with LPS requirement

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

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

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

endix B: Example applications of Section 4

ction 5. Outdoor Advertising Signs.

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

0: Discussion of internally illuminated sign colors

11: Off-site sign illumination

nternally 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.

12: Sign styles with smaller light pollution impacts

urfews. Illumination for all advertising signs, both externally and internally illuminated, shall be turned off at the w times listed in Table 5.3 or when the business closes, whichever is later. Signs subject to curfews are required ve functioning and properly adjusted automatic shut-off timers. Light background (white, off-white, light gray, or yellow) internally illuminated signs, installed legally before enactment of this code [enter date], may continue 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

e 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.

tion 6: Special Uses.

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

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.

e 13: Lumen cap exemption for display lots

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.

te 14: LPS/other lamp type mix for color rendition with LPS energy savings

te 15: Further information on canopy lighting

ther Lighting on Parcels with Special Uses. All lighting not directly associated with the special use areas above ll conform to the lighting standards described in this Code, including but not limited to the lamp type and shielding uirements of Section 4.1 and the lumens per acre limits of Section 4.2. The net acreage for the determination of npliance with Section 4.2 shall not include the area of the athletic field or outdoor display lot, as defined in Section 26; the area of any service station canopy **shall** be included in the net acreage.

ction 7. Submission of Plans and Evidence of Compliance with Code, Subdivision ats.

Submission Contents. The applicant for any permit required by any provision of the laws of this jurisdiction in nection with proposed work involving outdoor lighting fixtures shall submit (as part of the application for permit) dence that the proposed work will comply with this Code. Even should no other such permit be required, the allation or modification (except for routine servicing and same-type lamp replacement) of any exterior lighting shall uire submission of the information described below. The submission shall contain but shall not necessarily be ited to the following, all or part of which may be part or in addition to the information required elsewhere in the s 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.

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

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

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

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

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

tion 8. Approved Materials and Methods of Construction or tallation/Operation.

proval of Alternatives. The provisions of this Code are not intended to prevent the use of any design, material, ethod of installation or operation not specifically prescribed by this Code, provided any such alternate has been oved by the designated official. The designated official may approve any such proposed alternate providing he/she

ds 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.

ction 9. Prohibitions.

Sale of Non-Conforming Fixtures and Lamps. The installation, sale, offering for sale, lease or purchase of any tdoor lighting fixture or lamp the use of which is not allowed by this Code is prohibited.

Laser Source Light. The use of laser source light or any similar high intensity light for outdoor advertising or ertainment, when projected above the horizontal, is prohibited.

Searchlights. The operation of searchlights for advertising purposes is prohibited.

Outdoor Advertising Off-Site Signs. Illumination of outdoor advertising off-site signs is prohibited in Lighting nes E2, E1 and E1A.

ction 10. Temporary Exemption.

1 Request; Renewal; Information Required. Any person may submit, on a form prepared by the jurisdiction, to the ignated 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.

2 Approval; Duration. The designated official shall have five (5) business days from the date of submission of the uest for temporary exemption to act, in writing, on the request. If approved, the exemption shall be valid for not e than thirty (30) days from the date of issuance of the approval. The approval shall be renewable upon further tten request, at the discretion of the designated official, for a maximum of one (1) additional thirty (30) day period. designated official is not authorized to grant more than one (1) temporary permit and one (1) renewal for a thirty day period for the same property within one (1) calendar year.

3 Disapproval; Appeal. If the request for temporary exemption or its extension is disapproved, the person making request will have the appeal rights provided in Section 12.

tion 11. Other Exemptions.

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.

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

Emergency Lighting. Emergency lighting, used by police, firefighting, or medical personnel, or at their direction,

exempt from all requirements of this code for as long as the emergency exists.

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

ction 12. Appeals.

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

ction 13. Law Governing Conflicts.

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

ction 14. Violation and Penalty.

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

ction 15. Severability.

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

ction 16. Definitions.

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

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

2 Class 1 Lighting. All outdoor lighting used for, but not limited to, outdoor sales or eating areas, assembly or air areas, advertising and other signs, recreational facilities and other similar applications where COLOR NDITION IS IMPORTANT to preserve the effectiveness of the activity. Designation of lighting as Class 1 requires nding by the Planning Director of the essential nature of color rendition for the application. Recognized Class 1 uses outdoor eating and retail food or beverage service areas; outdoor maintenance areas; display lots; assembly areas n as concert or theater amphitheaters.

3 Class 2 Lighting. All outdoor lighting used for, but not limited to, illumination for walkways, roadways, ipment yards, parking lots and outdoor security where GENERAL ILLUMINATION for safety or security of the unds is the primary concern.

4 Class 3 Lighting. Any outdoor lighting used for DECORATIVE effects including, but not limited to, architectural mination, flag and monument lighting, and illumination of trees, bushes, etc.

5 Development Project. Any residential, commercial, industrial or mixed use subdivision plan or development plan is submitted to the City for approval.

6 Direct Illumination. Illumination resulting from light emitted directly from a lamp or luminaire, not light diffused

ough translucent signs or reflected from other surfaces such as the ground or building faces.

7 Directly Visible. Allowing a direct line-of-sight to the light source or lamp.

Display Lot or Area. Outdoor areas where active nighttime sales activity occurs AND where accurate color ception of merchandise by customers is required. To qualify as a display lot, one of the following specific uses st occur: automobile sales, boat sales, tractor sales, building supply sales, gardening or nursery sales, assembly , swap meets. Uses not on this list must be approved as display lot uses by the Planning Director.

9 Flood Lamp. A specific form of lamp designed to direct its output in a specific direction (a beam) with a reflector med from the glass envelope of the lamp itself, and with a diffusing glass envelope: Such lamps are so designated the manufacturers and are typically used in residential outdoor area lighting.

10 Flood Light. A form of lighting fixture designed to direct the output of a contained lamp in a more-or-less cific direction, utilizing reflecting or reflacting elements located external to the lamp. [This definition is not used in USA Pattern Code.]

11 Footcandle. One lumen per square foot. Unit of illuminance. It is the luminous flux per unit area in the Imperial tem. One footcandle equals approximately 0.1 (0.093) lux.

12 Full Cutoff Light Fixture. A luminaire light distribution where no light is emitted above the horizontal, and ere the intensity at 80 degrees from nadir is no greater than 100 candela per 1000 lamp lumens. [This definition is used in the USA Pattern Code.]

13 Fully Shielded Light Fixture. A lighting fixture constructed in such a manner that all light emitted by the fixture, er directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the inaire, is projected below the horizontal as determined by photometric test or certified by the manufacturer. Any ctural part of the light fixture providing this shielding must be permanently affixed.

16: Shielding and cutoff terminology

e 17: How to recognize fully shielded fixtures

e 18: Fully shielded lights and aiming of adjustable luminaires

4 Glare. The sensation produced by a bright source within the visual field that is sufficiently brighter than the level hich the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility; blinding t. The magnitude of glare depends on such factors as the size, position, brightness of the source, and on the htness level to which the eyes are adapted. [This definition is not used in the USA Pattern Code.]

5 Illuminance. The amount of light falling onto a unit area of surface (luminous flux per unit area) - measured in ens per square meter (lux) or lumens per square foot (footcandles).

6 Installed. The attachment, or assembly fixed in place, whether or not connected to a power source, of any oor light fixture.

7 Light pollution. Any adverse effect of manmade light. [This definition is not used in the USA Pattern Code.]

8 Light Trespass. Light falling where it is not wanted or needed, typically across property boundaries.

9 Lighting Zones. The five lighting zones are defined on the Lighting Zone Map, by this reference made a part of Code. A parcel located in more than one of the Lighting Zones described under Section 16.19.A-E shall be idered to be only in the more restrictive Lighting Zone. Guidelines used to guide the delineation of the lighting s 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.

e 19: Defining lighting zones: definitions from other codes

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

21 Luminaire. The complete lighting assembly (including the lamp, housing, reflectors, lenses and shields), less the port assembly (pole or mounting bracket); a light fixture. For purposes of determining total light output from a inaire or light fixture (see Table 4.1), lighting assemblies which include multiple unshielded or partially shielded ps on a single pole or standard shall be considered as a single unit.

22 Luminous tube. A glass tube filled with a gas or gas mixture (including neon, argon, mercury or other gasses), lly of small diameter (10-15 millimeter), caused to emit light by the passage of an electric current, and commonly into various forms for use as decoration or signs. A "neon" tube. Does not include common fluorescent tubes.

23 Lux. One lumen per square meter. Unit of illuminance. It is the luminous flux per unit area in the metric system. lux equals approximately 10 (10.8) footcandles.

24 Multi-Class Lighting. Any outdoor lighting used for more than one purpose, such as security and decoration, that its use falls under the definition of two or more Classes as defined for Class 1, 2 and 3 Lighting.

25 Neon tube. See Luminous Tube.

26 Net Acreage. The remaining area after deleting all portions for proposed and existing streets within a lopment parcel or subdivision. For parcels including those special uses listed in Section 6 that are exempted from umens per acre caps of Section 4.2 (recreational facilities and outdoor display lots), the area devoted to the special hall also be excluded from the net acreage.

20: Sub-parcel developments

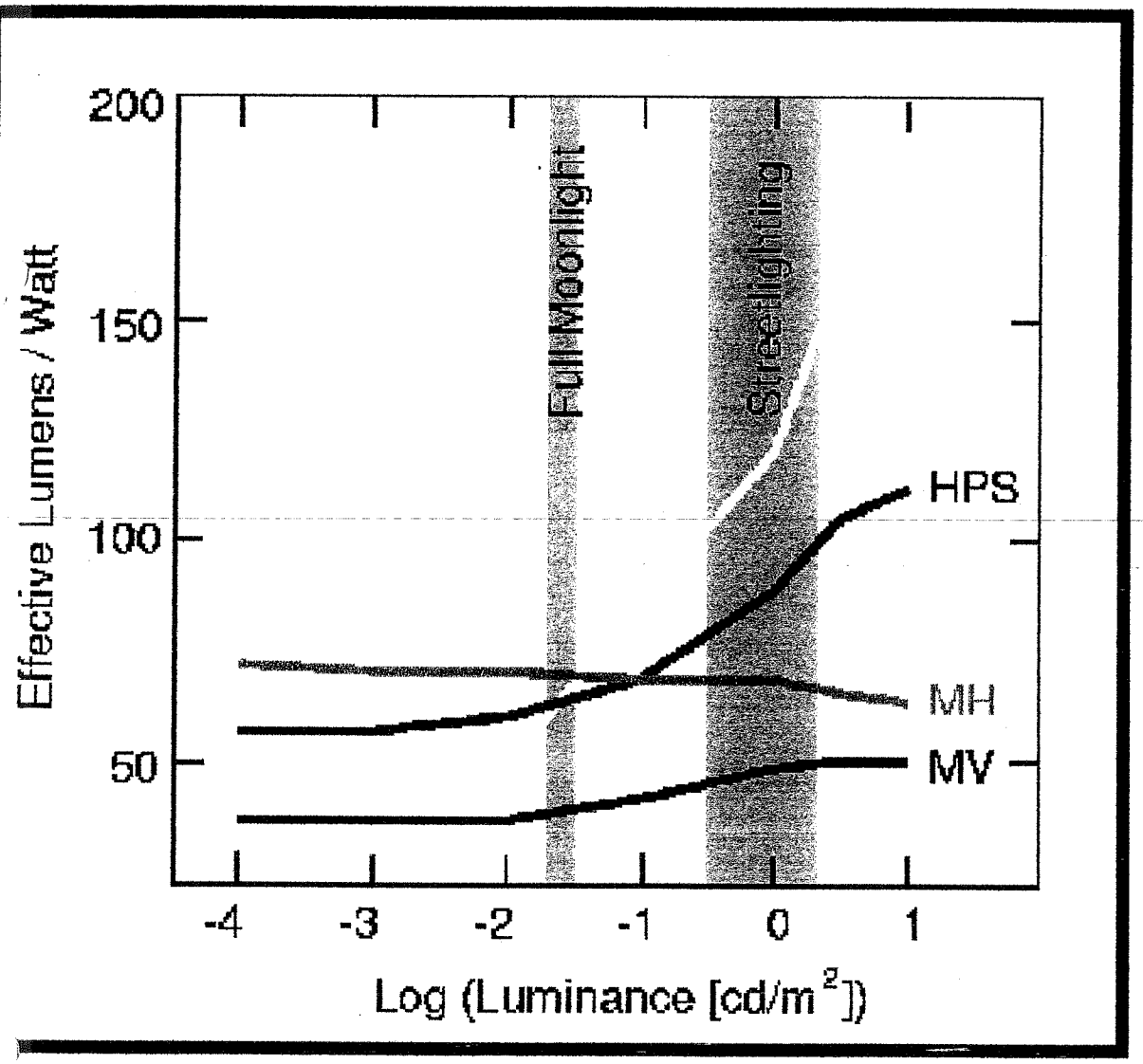
27 Obtrusive Light. Same as Light Pollution. [This definition is not used in the USA Pattern Code.]

28 Opaque. Opaque means that a material does not transmit light from an internal illumination source. Applied to backgrounds, means that the area surrounding any letters or symbols on the sign either is not lighted from within, ows no light from an internal source to shine though it.

29 Outdoor light fixture. An outdoor illuminating device, outdoor lighting or reflective surface, luminous tube, or similar device, permanently installed or portable, used for illumination, decoration, or advertisement. Such es shall include, but are not limited to lights used for:

A. parking lot lighting;
B. roadway lighting;

ıenever you read, whether a book or a roadway sign, you do it almost exclusively with the fovea and therefore with ıe cells. When you look at other cars in the roadway, or pedestrians at the side, or for hazards in the roadway, you it, at least principally, by looking directly at them and therefore by using the cones in your fovea.



Effective Lumens per Watt Efficiencies of Light Sources at Different Lighting Levels

The efficiencies of different lighting types as the adaptation level of the eye changes.

Note that the conventional ranking (LPS > HPS > MH > MV) holds for all luminance levels relevant for streetlighting. It is not until illumination becomes as low as or lower than full moonlight (about 1/10 of the lowest levels encountered in roadways or parking lots) that metal halide begins to exceed LPS and HPS efficiency. Key: LPS = low-pressure sodium; HPS = high-pressure sodium; MH = metal halide; MV = mercury vapor. (Adapted from Adrian, W., 1999, "The Influence of the Spectral Power Distribution for

Equal Visual Performance in Roadway Lighting Levels", in Proceedings: Vision at Low Light Levels, EPRI, Palo Alto, CA, pg. 85) (Click on graph for larger version)

certainty in the degree that peripheral and central vision are important to the various tasks required under outdoor hting leads to uncertainty in the degree of importance that should be ascribed to the efficiencies of lighting sources at lighting levels and to peripheral vision.

e best current research, however, shows that under typical outdoor lighting levels, the visual system's performance, east under laboratory conditions, is best characterized as lying closer to the light-adapted response than to the k-adapted response (see graph above, as well as *IDA IS #136: Some Issues in Low Light Level Vision* , and erences therein). Amateur astronomers will not be surprised at this, since they know that the eye is nowhere near k-adapted after driving a car or walking around in an illuminated area such as a parking lot. More research needs to done, but at present the indications are that yellow light sources such as LPS and HPS maintain most of their ciency advantage over bluer sources such as metal halide and mercury vapor under conditions commonly ountered under typical outdoor artificial illumination.

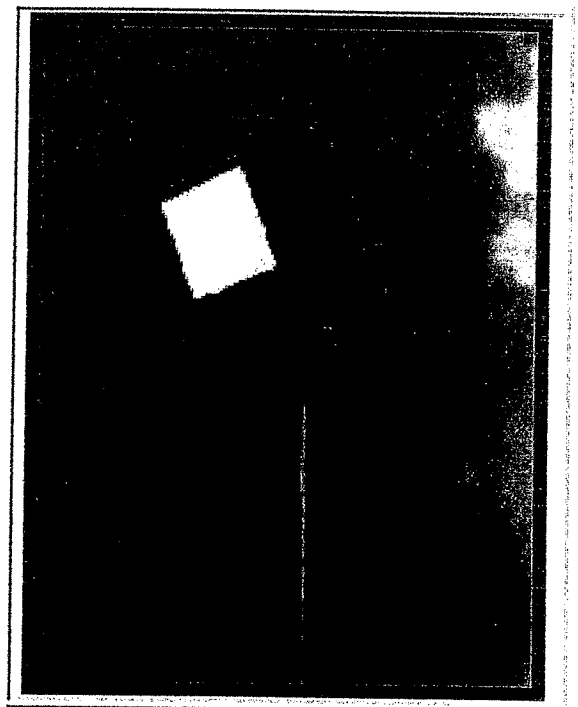
er important aspects of vision, increasingly being recognized by lighting researchers, are the changes that occur as e. As the eye ages, the ability of the iris to open widely diminishes, the transparency and color of the lens and transparent media within the eyeball change, and the speed with which we adapt to different light levels reases. These changes mean generally that we require somewhat brighter lighting to see as well as younger persons, become somewhat less sensitive to blue light, less able to adapt quickly to changes in light levels, and finally that become particularly sensitive to glare, especially from bluer light sources. (See *IDA IS #156: The Aging Eye - ne Basic Information* for further information.) Ageing eyes especially benefit from the best quality, low-glare ting that we all need.

ractical Issues and Problem Areas for Lighting Codes

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

iveled Luminaires (Floodlights)

minaires with swiveled mounting hardware are easy to adjust dvertently or intentionally, as they are installed or serviced. This compromise shielding, and it may happen after the installation xamined and approved as complying with the lighting code. ,er, such luminaires are not optically designed to be aimed ught down, as is necessary in most cases to obtain full shielding hout added shields. Even add-on louvers or shields do not allow luminaires to be aimed very high without the same problem. fortunately, these luminaires are often used for glare-prone ting in an attempt to "light over there with a light over here." The r tries to avoid the expense of installing a proper support or pole ere it is really needed, instead mounting the light on a building, e or other structure located too far away from the area needing ting to provide effective lighting.



Floodlight with Swiveled Mounting

avoid this bad lighting practice and difficult enforcement problem, an be feasible to simply prohibit the use of such swivel-mounted inaires. This approach is not suggested here in the USA Pattern hting Code since it is then difficult to allow possible legitimate and rect uses of such luminaires, though these are rarely seen. Even nibiting luminaires with obvious swivel mounts may not npletely address the problem of poorly adjusted or mounted dware, as many luminaires have adjustment capabilities that are obvious in catalog photographs but could still lead to promised shielding.

orts Lighting

ing levels used for night sports are the highest commonly encountered in the nighttime environment. mended levels for social or recreational sports, including most municipal sports activities, range from 200 to lux (20 to 50 footcandles); levels for professional play with large spectator attendance and television coverage can h 3000 lux (300 footcandles). Controlling trespass and glare with such lighting levels is an extreme technical lenge, requiring the utmost in quality luminaires and design.

her, the lighting fixtures commonly used for sportsLighting can be huge sources of direct glare, not only to areas by and at considerable distances from the sports fields, but also to spectators and players actually using the fields. brightest single sources of light visible in city nighttime landscape views are often these facilities. It is no surprise such lighting is usually the single greatest source of complaint and neighborhood tension about lighting issues.

the past,
ailable fixtures,
hting designs,
e general
of the sports
nting art often
little choice for
nmunities and
igners seeking
minimize spill
l glare in sports
nting. Even
ay, some
nufacturers and
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m that spill and
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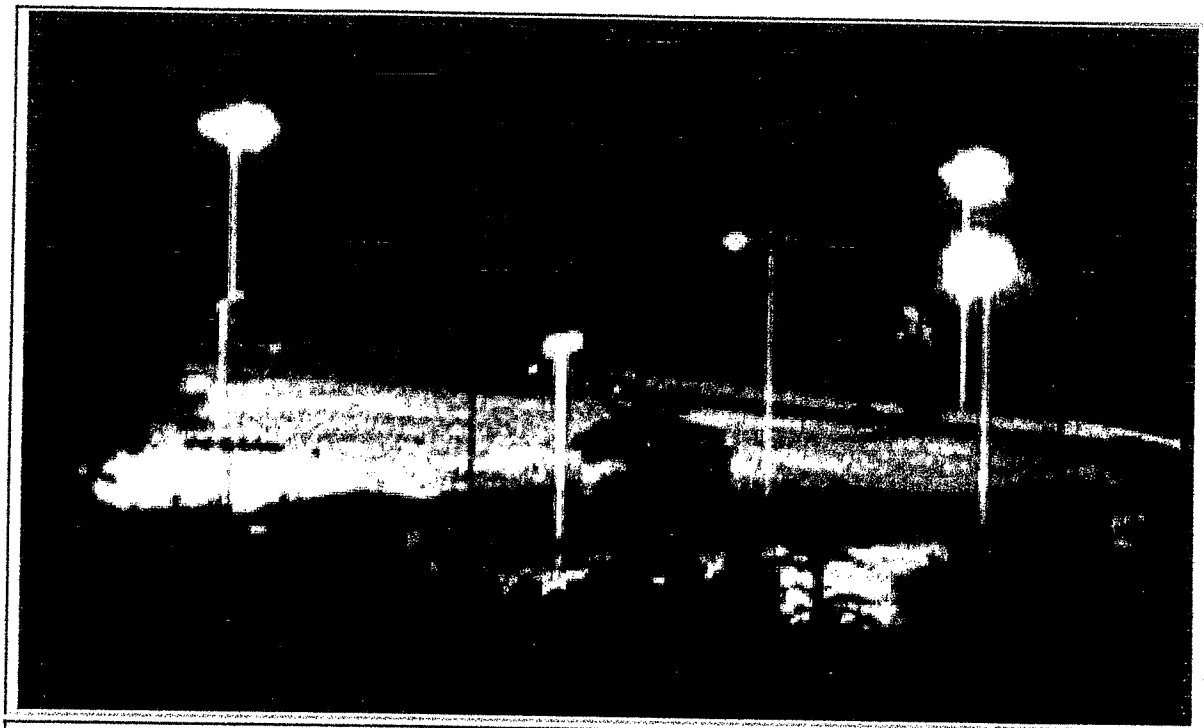
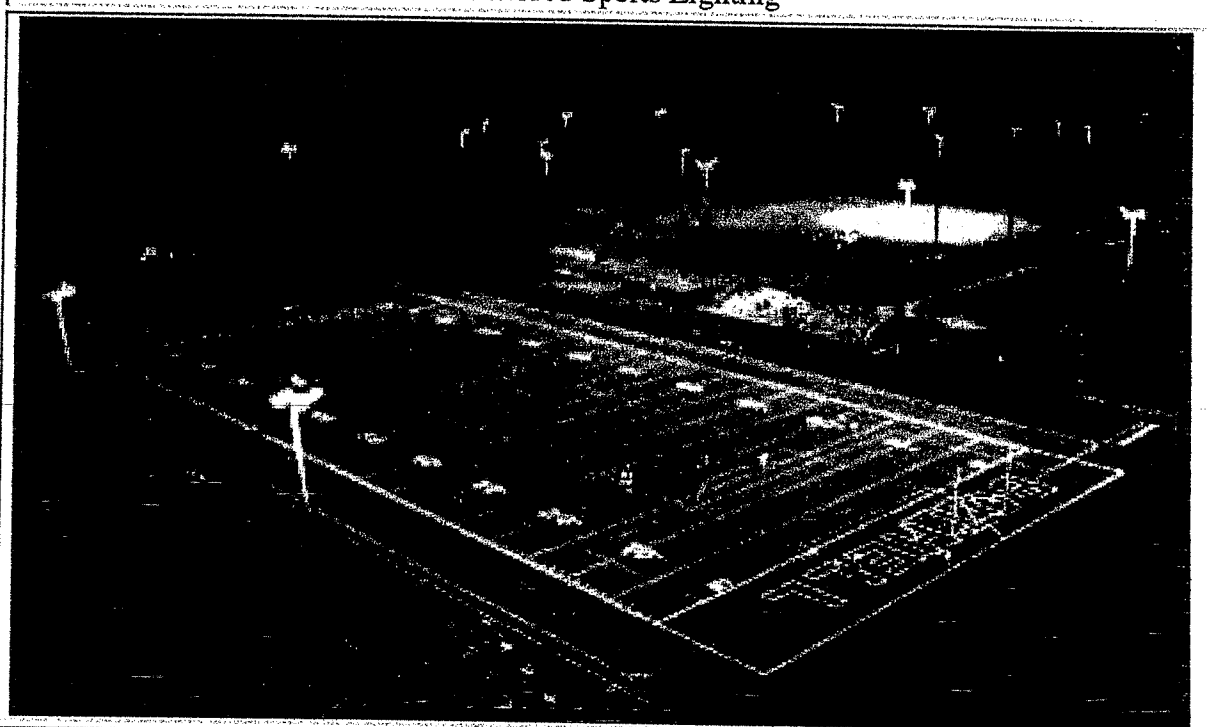


Unshielded Sports Lighting



Fully Shielded Sports Lighting (courtesy of Soft® Lighting)

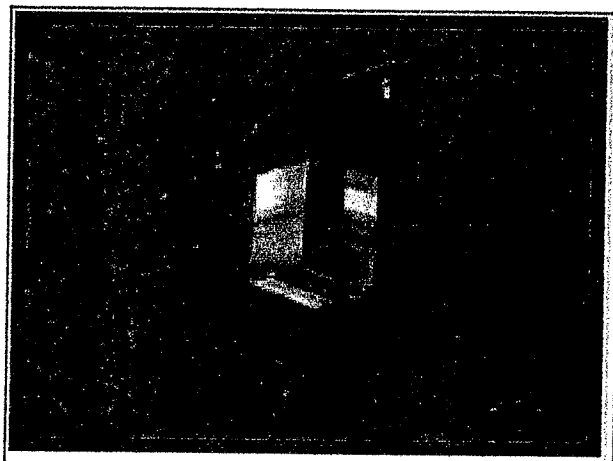
tantially improved lighting quality on the field for the players.

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

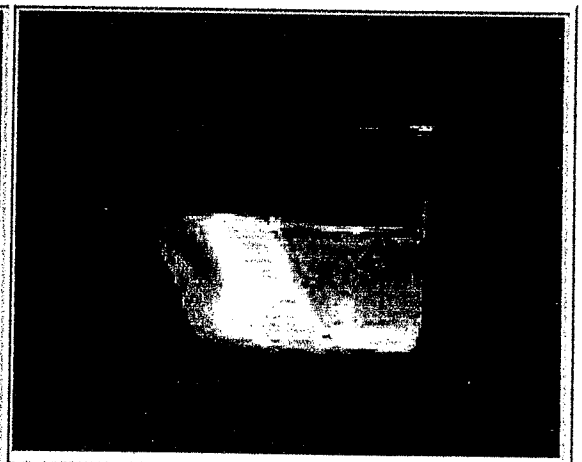
st-installation certification to assure that the standards are followed.

allpacks

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

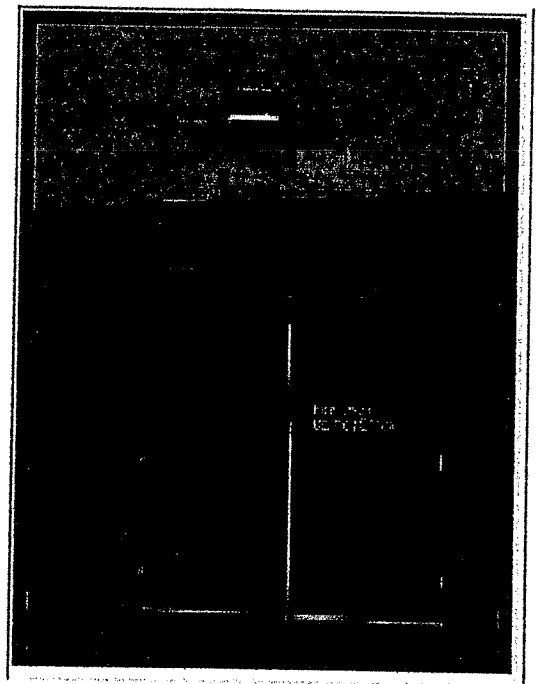


Unshielded Wallpack



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

e add-on shields may be claimed to provide "shielding" or "cutoff," but rarely if ever provide true full shielding rding to the definition of no uplight used in the Pattern Lighting Code (this is an example of the confusion rding these terms: see *Note 16: Shielding and cutoff terminology*). The planning officials must be aware that luminaires are almost never fully shielded, even after adding shields, and either deny approval or require complete ometric information to verify the complete elimination of uplight. Since for such low-cost fixtures adequate ometric information is often not available, or if available is often unreliable, the best approach is to deny approval uch wallpacks except where they would be permitted as unshielded fixtures.



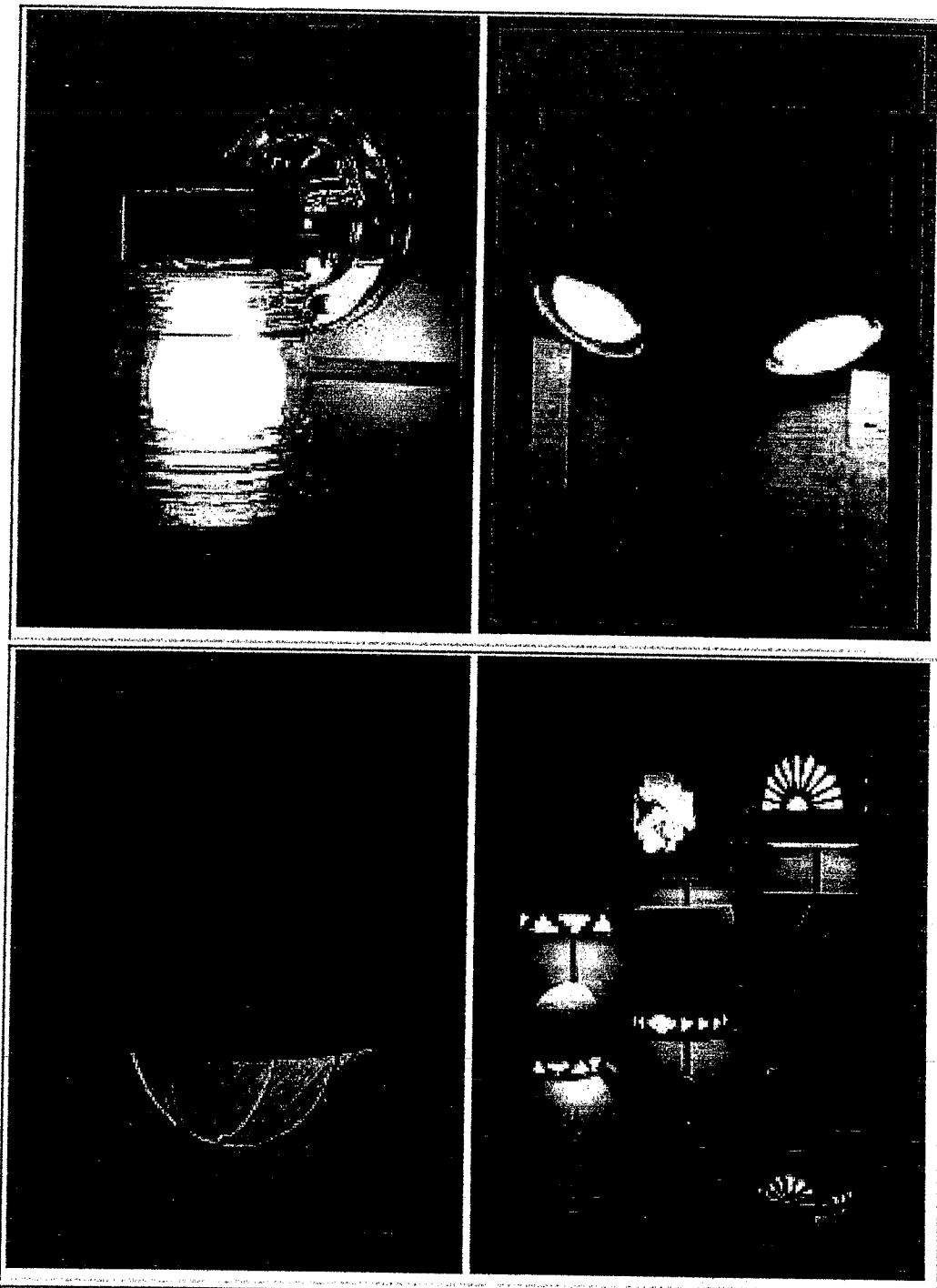
Shielded Wall-mounted Luminaire

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

dential Lighting

e effectiveness and
orcement of residential
hting restrictions is always
matic. First, the majority,
he vast majority, of
ting fixtures easily available
the homeowner market are
erently unshielded or
veled and rarely used
nted straight down. Second,
details of residential lighting
often not reviewed by
lding departments, and even
ey are the often large
nbers of homes being built
the many details involved in
ections will mean that the
lding details of fixtures are
n overlooked. Review and
roval of lighting plans is
cally done (as recommended
he USA Pattern Code) before
ding permits are issued and
struction is started, but
dential lighting fixtures are
n chosen or changed at
ly the end of construction.
even greater problem is that
dential lighting is commonly
ed or supplemented after
struction is completed
out any official review or
roval process.

low individual outputs of
lights and the low overall
unts used per home or acre
n that the impacts are lower
me respects than for
mercial lighting - skyglow
xample - though the
cts may be greater in other
ects - light trespass in dark
dential or rural
ronments, for example. A
nce must be struck here
een these impacts and the
ical issues of enforcement.



Residential Luminaires

gh a lighting code should have carefully considered standards for residential lighting, the most effective way to
ess most residential lighting is by education (see *Ongoing Education in Outdoor Lighting*) and through
eowners' associations where available (see also *What Is an Outdoor Lighting Code?*).

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

d distributed with building permits.

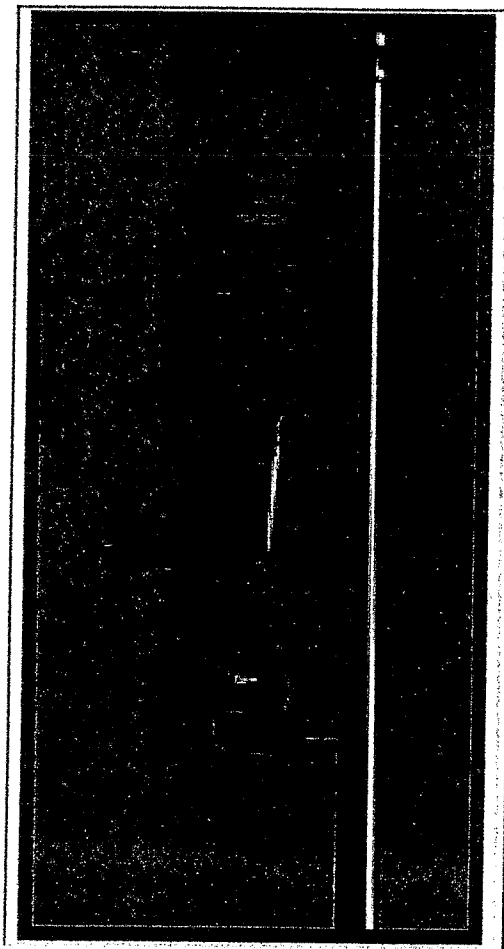
aser and Search Lights

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

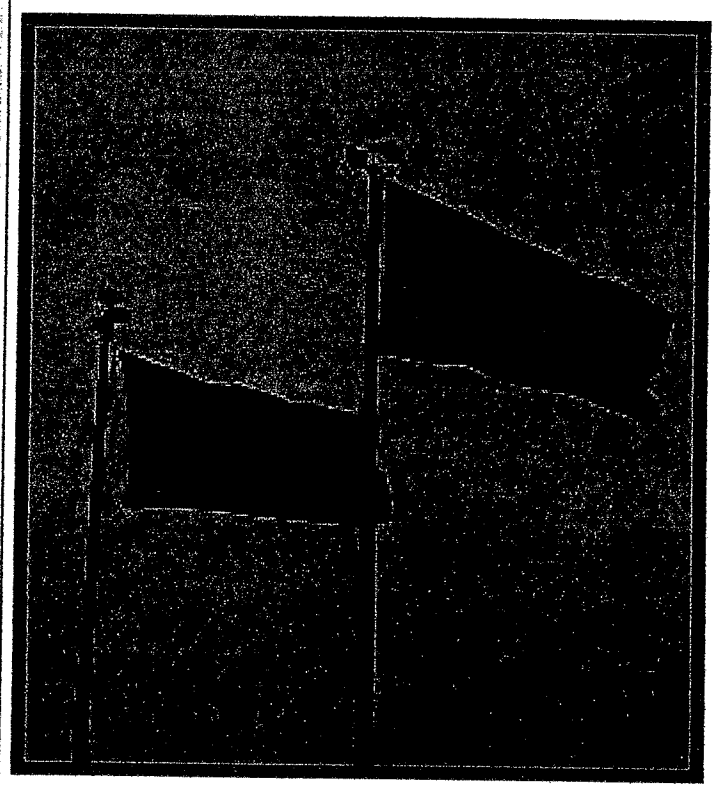
ecorative Lighting

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

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



Up-Directed Flag Lighting



Down-Directed Flag Lighting

g Lighting

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

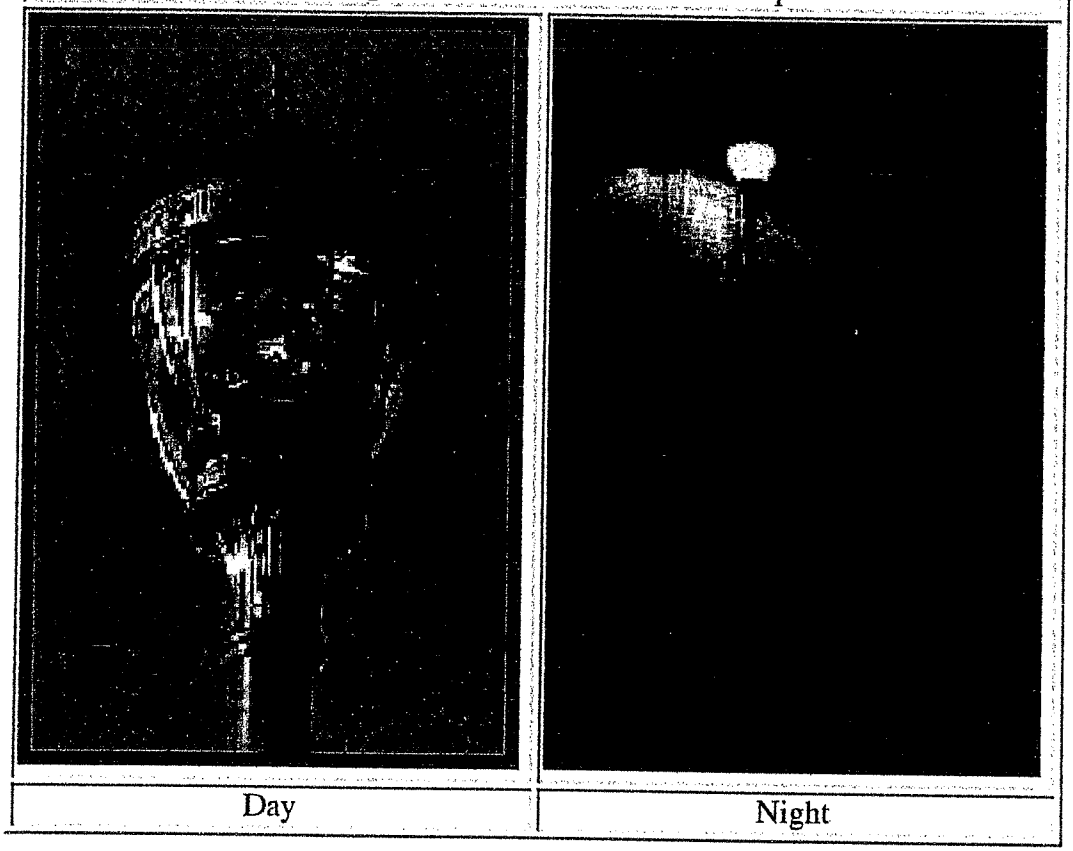
torical-Style Lighting

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

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

mpromising the effectiveness of the lighting due to the high glare.

"Antique" Fixture with Recessed Lamp



Day | Night

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

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

going Education in Outdoor Lighting

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

fter the code is in place, its continued success depends on maintaining the involvement of the community. rstanding of lighting issues built during the process of drafting and adopting a lighting code must be continually ed, and new issues will arise as technology changes and lighting styles change to accommodate changes in s and technology. An effective way to address these concerns is through the formation of a local section of the (see *IDA IS #8: Developing Local & Regional IDA Sections*) or a lighting advisory group. This group can

Results

After researching how light pollution affects humans, I discovered, last year researcher at the University of Pennsylvania released a study that found, children younger than 2 who slept with a night-light on were more likely to develop nearsightedness during childhood and teenage years. Obviously a night-light or light pollution from outdoors would do the same damage.

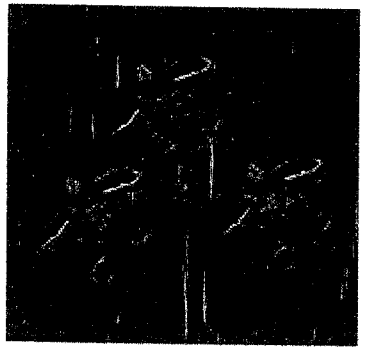
Exposure to bright light at night can disrupt the internal clocks. It can upset cycles such as behavioral rhythms, daily changes in blood and urine chemistry, and the production of melatonin, a hormone which is involved in the wake/sleep cycle.

In short term, the disruption of sleep can produce grogginess, depression and impaired thinking. It is better for your health to sleep in a darkened room.

Light pollution not only affects humans it has a large affect on many animals. Migrating birds rely on constellations to guide them during their twice yearly migration. But scientist says that when they fly near urban areas, the bright lights short-circuit their steering sense. Numerous reports have documented birds flying off course, toward lights on buildings, towers, lighthouses and even boats. Birds are attracted to light. Often birds will die of exhaustion because they keep flying around not knowing where they are going.

Other animals are threatened by light pollution too. At least five sea-turtle species found in Florida rely on an instinctive attraction to light to guide them to water. But lights on the beach or near the beach can confuse the turtles and cause them to head in the wrong direction. Scientists have seen them cross parking lots, streets and yards, transfixed on streetlights. Disoriented turtles usually die from exhaustion, dehydration or are eaten. Many are also squashed by cars.

Nocturnal animals are confused by the lights as well. Often they are not sure when it is night.



2213 Avenue B Bradenton Beach, Florida 34217

Anna Maria Island Turtle Watch

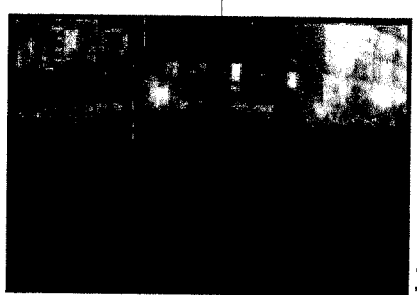
Office: (941)778-5638 Emergencies: (941)232-1405

Home
Guided Tours
Etiquette
Featured Volunteer
Surrounding Lights
Newspaper Articles
Adopt A Hatchling / Nest
Links

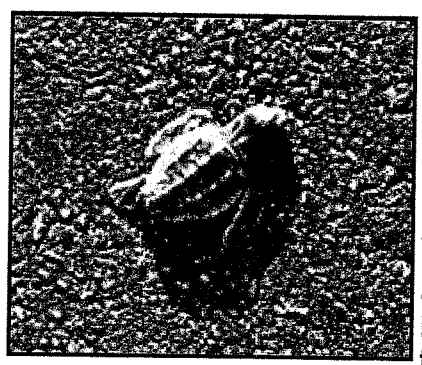
The Issue of Lights

Check out some OTHER HAZARDS

Each year we work toward improving light problems that affect sea turtles. The good news is the three cities are making big strides toward changing out streetlights with new fixtures that hopefully will keep the streets lit without shining on the beaches. Even though we have had one disorientation due to condo lighting, many people have made the effort to change or shield lights.



In an effort to help this threatened species survive, all local coastal governments have adopted and enforce Sea Turtle Conservation Codes. Compliance with these regulations has resulted in thousands of



On a natural beach, the lighter seaward horizon guides the hatchlings to the water. Artificial lights,however, confuse the hatchlings and they wander

successful sea turtle hatchlings safely reaching our Gulf waters. Manatee County alone contains over 11 miles of beach habitat suitable for seaturtle nesting.

inland. Lost and disoriented, they soon die from dehydration, heat exhaustion or they are crushed on nearby streets.

Sea turtles are protected under the US Endangered Species Act (ESA) as well as the Florida Statutes. Violations defined by ESA include harassing a nesting female, taking hatchlings or disturbing a nest.

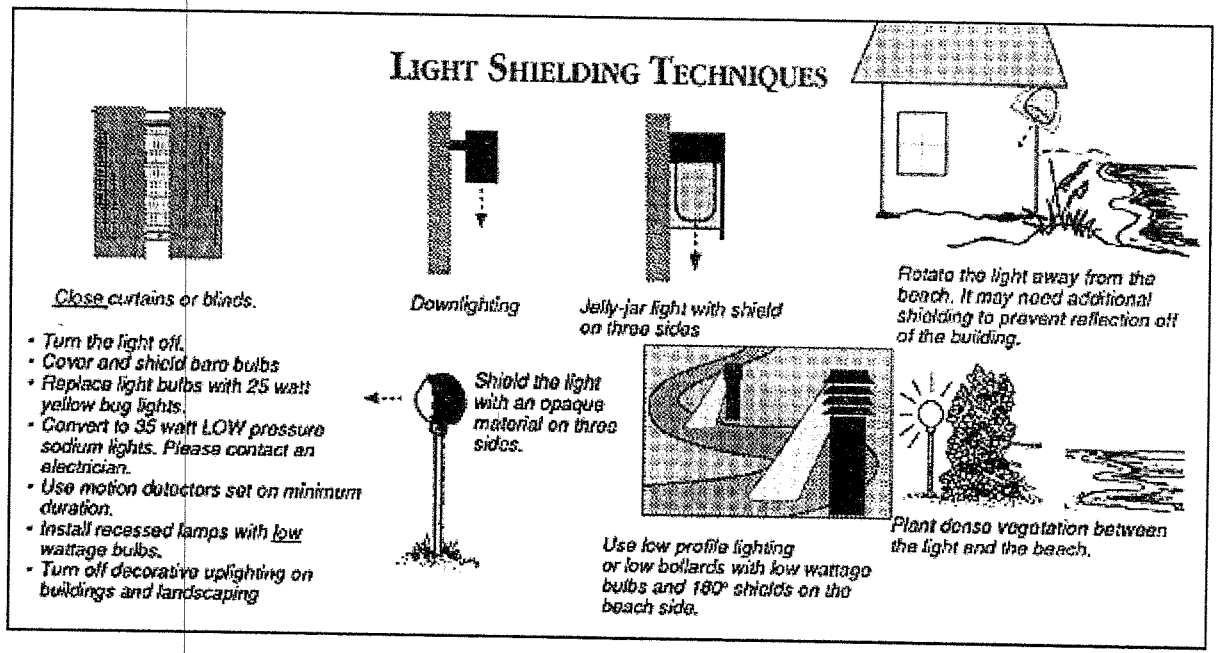
HOW YOU CAN HELP

May 1 through October 31 of each year, beach residents must shield all lights that can be seen from the beach from ***9pm to 7am***. Light can travel great distances so shielding is important to reduce visible light along the beach.

Lights may not directly or indirectly illuminate the beach. Even *reflected* light can disorient sea turtles Interior lights can also illuminate the beach. Please close curtains or blinds after 9pm.

Lights visible from the beach alters the critical nocturnal behavior of sea turtles .. . how female sea turtles choose their nesting sites, how they return to the sea after nesting and how the newly emerged hatchlings find their way to the ocean.

Motorized vehicles and open fires are not allowed on the beach during the sea turtle nesting season.

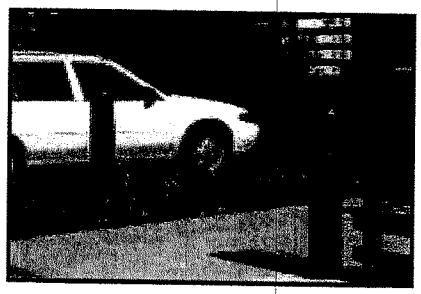


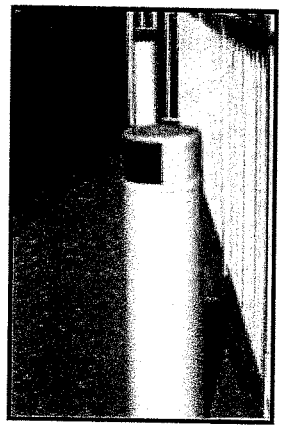
The following photographs are examples of good lighting fixtures suitable for use near sea turtle nesting beaches.

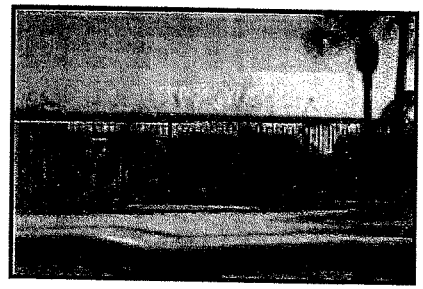
bollards (low profile lights) along a sidewalk

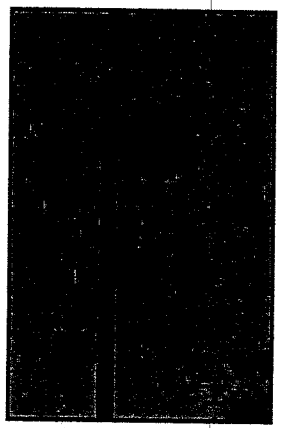
shielded lighting with dune vegetation between the lights and beach

shielded lighting with dune vegetation between the lights and beach

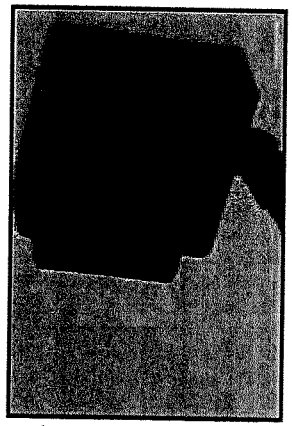




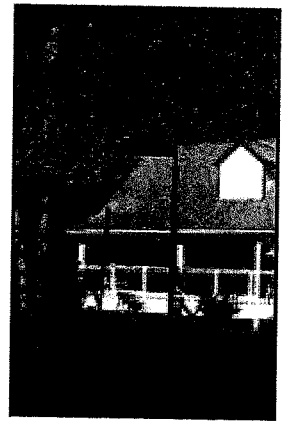




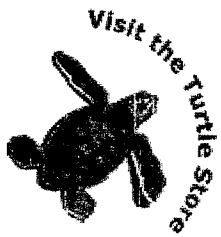
downlight on 12 foot pole in parking lot

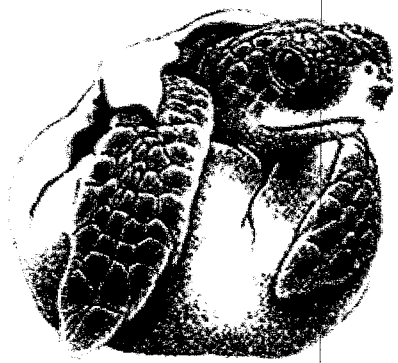


downlight with shield and baffle

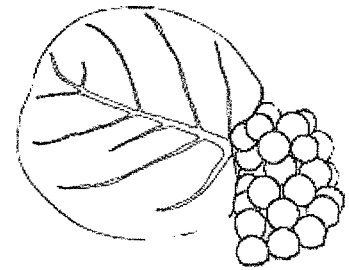


downlight





Sea Grape Trimming and Sea Turtles



What are sea grapes and how do I know if I have them?

Sea Grape, Coccoloba uvifera is a remarkable native, salttolerant species of plant found along many of Florida's beaches. Plants may appear as low spreading bushes or tall continuous hedges along the sand dunes. This plant can be identified by its thick circular leaves 8" to 10" in diameter and its grape-like clusters of fruit. This fruit is consumed by a number of native birds and mammals, while the protective canopy provides habitat for animals including songbirds, lizards, gopher tortoise and beach mice.

In addition to providing habitat, sea grape helps to stabilize sand dunes and to protect upland structures from storm-induced erosion. In fact, this plant has been deemed important enough to protect under Florida Statute.

Does Florida really have sea turtles?

How can trimming my sea grapes affect sea turtles?

In a word, light. Artificial lighting trespassing onto sea turtle nesting beaches affects sea turtles in two ways. First, artificial lighting deters adult females from emerging from the surf to nest. Two studies conducted in Florida clearly demonstrated dramatic reductions in nesting attempts by loggerhead turtles where artificial lighting was introduced. This included effects by lighted piers and roadways close to beaches. (Raymond, 1984b and Mattison et al.,1993)

Secondly, hatchling turtles find their way to the ocean by orienting toward the brightest horizon. On a natural beach, this is the horizon over the ocean while the dune silhouette behind them keeps them from heading the wrong direction. Hatchling turtles are highly sensitive to even minute quantities of this short wavelength or white light and will orient toward the brightest direction.

Yes. In fact, with its miles of warm sandy beaches, Florida is the single most important state for sea turtle nesting. Nesting season occurs from May 1st to October 31st throughout most of the state. From Brevard County to Broward County along the Atlantic coast, the nesting season extends from March 1st through October 31st.

Sea turtles are large air-breathing reptiles with paddle-shaped foreflippers and a number of adaptations that make them perfectly suited for a life at sea. These amazing animals once roamed the world's oceans in the millions with a suprising diversity of species. Today, only seven species remain worldwide. Five of these, the leatherback, green, loggerhead, Kemp's ridley and hawksbill, can be found in Florida's coastal waters. The first three regularly nest on Florida beaches. Sadly, all five species are listed as threatened or endangered.

It has only been in the last few centuries that demand for sea turtle meat, eggs, shell, leather and oil drastically reduced their numbers. Additional declines have continued from drowning in shrimp trawls, captures on long-lines, pollution and non degradable debris in the ocean. One of the most devastating impacts to marine turtles has come from artificial light pollution onto nesting beaches.

Although they may live their entire life at sea, marine turtles must leave the relative safety of the ocean to nest. Usually, under cover of

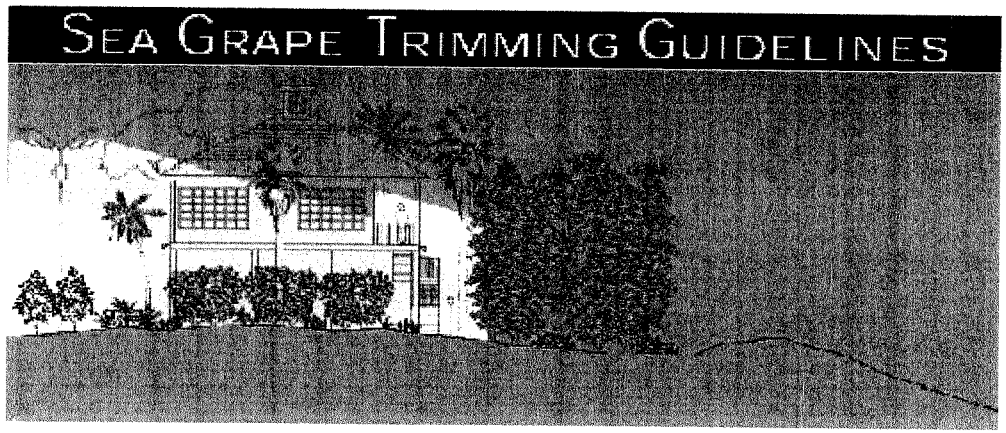
We don't often think of light as pollution. Yet when artificial light is introduced into this critical nesting habitat, the effects can be disastrous. Between 20,000 to 30,000 hatchlings disorient to artificial lights each year. Hatchlings that orient towards a streetlight, condominium light or residential porchlight usually die from exhaustion, dehydration, predation or moredirect causes such as being run over by cars. Any steps to minimize this light trespass and direct the light only where it is needed help to protect sea turtles and restore nesting beaches.

Throughout the state, stands of sea grape act as a natural vegetative barrier blocking artificial light from nesting beaches and minimizing upland glow. Trimming or removal of this vegetative barrier can increase illumination levels on the beach and deter nesting or disorient hatchlings. This is considered interference with the normal nesting behavior of threatened and endangered species and can expose the property owner to potential fines or imprisonment under the Endangered Species Act (1973) and Florida Statutes 161 and 370.12. The following pages illustates the best ways to minimize potential light trespass.

darkness, females will drag their bodies from the ocean across the beach where she will dig a nest and deposit roughly 100 leathery eggs in the warm sand. After about 60 days of incubation, the eggs will hatch and the hatchlings will make their way as a group to the sea. For loggerhead turtles, it may be 15 to 20 years before one of these hatchlings returns to her natal beach to nest for the first time.

Sea Grape Trimming Guidelines

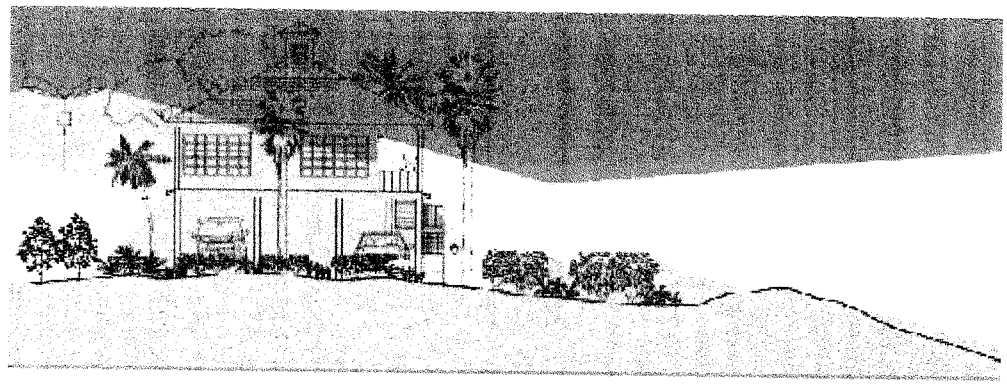
BEFORE
Sea Grape
Trimming



This diagram depicts a beach house with several styles of exterior lighting. These lights are shielded from the beach by a large stand of sea grape, Coccoloba uvifera. The homeowner would like to trim this stand of

sea grape to improve the view from the balcony but is concerned about light trespass onto a sea turtle nesting beach and potential liability should these lights cause the disorientation and deaths of protected sea turtles.

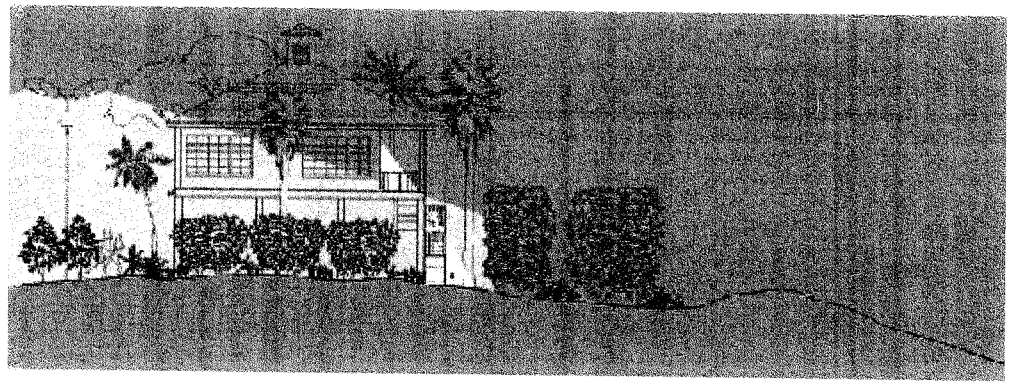
BAD
Sea Grape
Trimming



Here, the homeowner has over trimmed the sea grape stand. Although the homeowner now has a better view of the ocean, light pollution now shines onto the nesting beach disrupting normal sea turtle nesting behavior. Of particular concern are the poor light fixtures, car headlights and now the streetlight is also visible from the beach. This unpermitted trimming damages the sea grape stand, disrupts sea turtle nesting and exposes the homeowner to potential legal action including substantial fines.

APPROPRIATE
Sea Grape

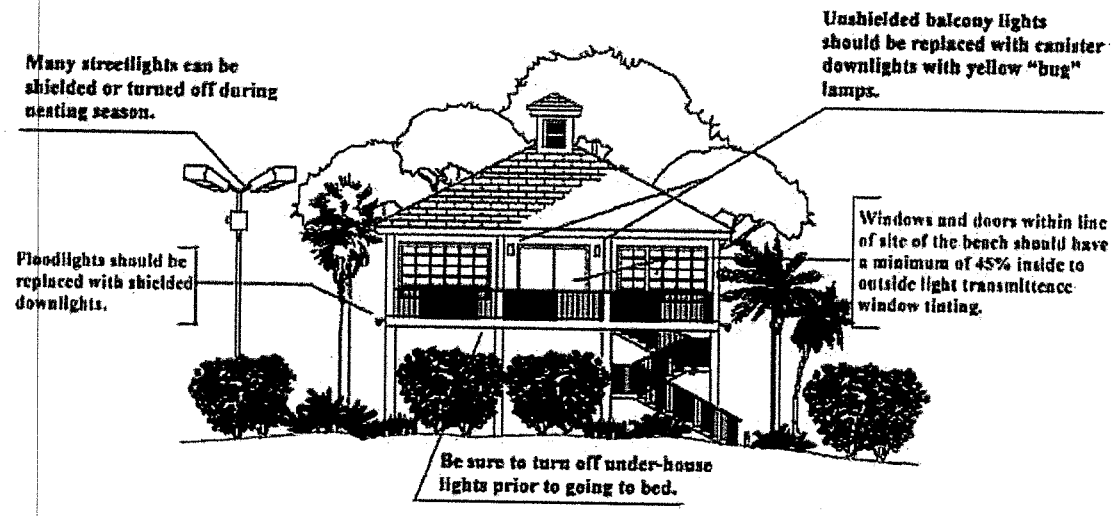
Trimming



The trimmed seagrape stand now allows a view of the ocean from the balcony. Realizing this would make the balcony light visible from the beach, the homeowner has replaced the jelly-jar light to a well shielded canister downlight equipped with a 25watt yellow bug bulb. The homeowner has also replaced the floodlight on the beachside of the house with another canister downlight and bollard fixture with downcast horizontal louvers to illuminate the stairs for safety. Even after trimming, the homeowner has actually reduced illumination visible to the nesting beach.

A Typical
Beach

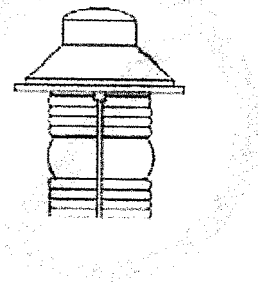
House As Seen From the Ocean



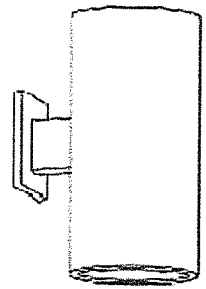
Replace Poorly Shielded Lights Prior to Trimming Vegetation

This diagram depicts a typical beach house with several styles of exterior light fixtures. These fixtures are inappropriate for use near sea turtle nesting beaches and should be replaced with shielded, downward directed lights. When correcting problem light fixtures, don't forget about your interior lights. Windows within line of site of the beach should be tinted with 45% inside to outside light transmittence film. Try to make it a habit to keep your window blinds closed at night during sea turtle nesting season (May 1st through October 31st) through most of the state and (March 1st through October 31st) from Brevard through Broward County on the Atlantic coast.

Replace Floodlights and Unshielded Fixtures with Walkway and Path Lighting

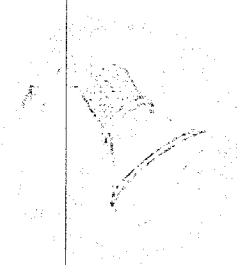


"Jelly-Jar" Balcony Lights

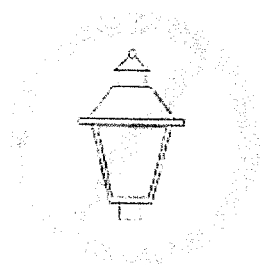


Canister Downlights

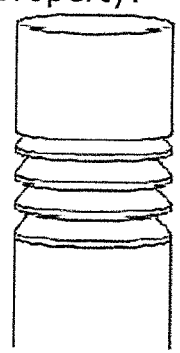
Inexpensive unshielded balcony lights like the one shown above are visible up and down nesting beaches and cause problems for sea turtles every summer. It is not uncommon to see these poorly designed $3 and $4 fixtures on homes costing between $250,000 and $500,000. The best light fixture for beachfront property is the canister downlight using a 25watt to 40watt yellow bug lamp. Excellent for human safety, minimum glare, almost no light trespass occurs to the neighbor's property.



Floodlights



Carriage Lamps



Bollard Fixture

These unshielded exterior lights are poorly suited for use near sea turtle nesting beaches. These light fixtures contribute to light trespass onto

neighbor's property as well as the beach. This bollard fixture is equipped with horizontal downcast louvers. This is an excellent fixture for illuminating pathways and landscaping. Specified with long wavelength "yellow" lamps, these lights reduce glare and actually improve night vision.

Example Lighting Fixtures

These fixtures are meant to show typical acceptable/unacceptable lighting fixtures in respect to lighting for structures along Florida's coast to protect Sea Turtle Nesting.

For guidance please contact
Florida Fish and Wildlife Conservation Commission
Division of Wildlife - Bureau of Protected Species Managment
520 South Meridian Street DOW-EPS Tallahasse, FL 32399-1600
(850) 922-4330 Fax (850)921-6988

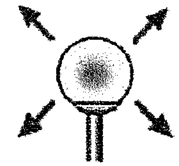
ACCEPTABLE

Only With Proper Bulb(s)

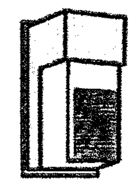
UNACCEPTABLE

Low Profile Bollards with Louvers

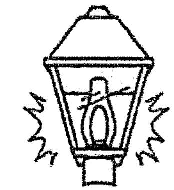
WALKWAY/PATH LIGHTING



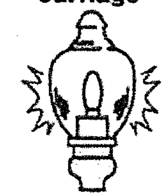
Globe Fixture



Wallpack

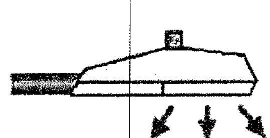


Unshielded Carriage



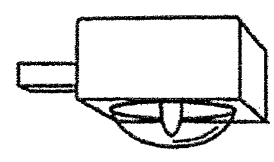
Acorn Fixture

STREET/PARKING LIGHTING



Full Cutoff Streetlight

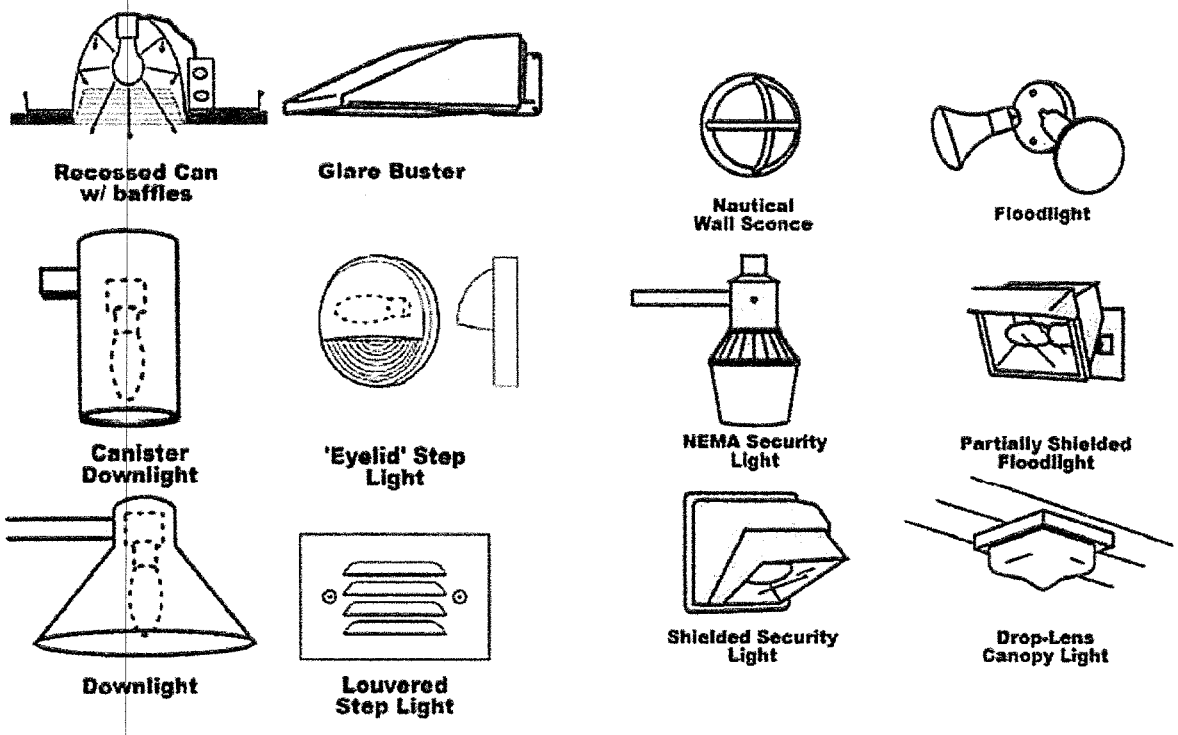
Fully Shieded NEMA Light



Drop-Lens/Sag-Lens w/ exposed bulb

Unshielded Streetlight

ARCHITECTURAL LIGHTING



Bulbs for all fixtures should be of the Yellow "Bug" Light variety incandescent or compact fluorescent.

Excerpts from the FDEP - Chapter 62B-34, General Permits for Activities Seaward of the
Coastal Construction Control Line

62B-34.070 General Permit for a Single Family Dwelling and Associated Minor Structures or

Activities

(4) Turtle Protection Requirements. All work authorized by this General Permit shall
meet the following turtle protection requirements:

(a) All windows and glass doors on the seaward and shore-perpendicular sides of any
new dwellings or additions shall be tinted to transmittance value (light transmission
from inside to outside) of 45% or less through the use of tinted glass or window film
or screens.

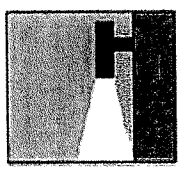
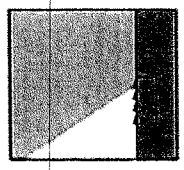
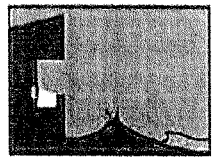
(b) The following types of lighting are authorized under the General Permit. Any departure or deviation from these lighting requirements shall constitute a violation of
the General Permit.

1. Balcony, deck and entranceway lights shall be of approved canister down-light fixtures or louvered wall lights that adhere to the following standard:

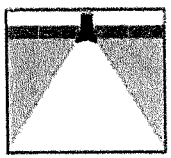
a. Canister down-light fixtures shall be equipped with black baffles or grates, shall have the light source recessed so that it is not visible from the beach, shall be used with one 40 watt, or less incandescent yellow "bug" bulb, and shall be limited to no more than one fixture per egress.

b. Louvered wall lights shall be mounted 12 inches or less above the adjacent floor or deck, shall be equipped with louvers that completely hide the light source, shall be used with one 40 watt, or less, incandescent yellow "bug"

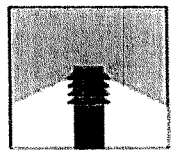
bulb, and shall be limited to no more than one fixture per egress.

2. Underhouse lights for unenclosed or partially enclosed parking and building access areas shall be canister fixtures, either mounted on piles or recessed into the ceiling. The fixtures shall be equipped with black baffles, shall have the light source recessed so that it is not visible from the beach, shall be used with one 40 watt, or less, incandescent yellow "bug" bulb, and shall be limited to no more than one fixture per 100 square feet of parking or building access area.



3. Landscaping and pathway lights shall be mushroom type fixtures, shall extend no
more than 12 inches above the ground, shall be used with incandescent bulbs of 25 watts or less, or with fluorescent bulbs of 7 watts or less, shall extend no farther seaward than the house, and shall be limited to one fixture per 8 feet of path length or 1 fixture per 100 square feet of ground area.



(c) No lights shall be permitted on dune walkovers or elevated walkovers to the beach.

(d) No additional lighting shall be authorized.

(e) No temporary lighting of the construction area is authorized at any time during the

marine turtle-nesting season (May 1-Oct 31 all counties except Brevard, Indian River, St. Lucie, Martin, Palm Beach and Broward counties March 1-Oct31)
Disclaimer: The information on this handout is provisional. For matters affecting legal rights, please
refer to the printed version of the appropriate official publication.

Info and Pictures coutesy of Turtle Time, Inc. at 941-481-5566

Conclusion

I conclude that lighting does not very often do the job it is intended to do. I noticed that very few light fixtures are dark sky friendly and often even if the lights were dark sky friendly, stores and businesses would leave lights on inside their stores (Home Depot, Staples and Wiarton Post Office), causing sky glow and wasting energy and money. Therefore, my hypothesis was correct.

As I predicted, you could see the least amount of stars in Owen Sound and Wiarton than you could see in Tobermory and Lion's Head. Out of a possible 1500 - 2500 stars that most people should be able to see in an unpolluted area, in Owen Sound I saw 680, in Wiarton I saw 768, in Tobermory I was able to see 976 and Lion's Head I saw the most with 1016 stars in the sky.

After photographing the sky glow in the four towns, at 10 kilometers from the center of each of the four towns, Owen Sound had the greatest sky glow of the four, with Wiarton being the second greatest and Tobermory with more sky glow than Lion's Head. This confirms that indeed my hypothesis was correct, the greater the population the greater the sky glow.

After conducting my light meter readings, I was able to confirm my hypothesis. The new retrofit flat lens streetlights are wasting less light than the old sag lens streetlights.

I was able to successfully construct a light shield that can reduce light pollution at a very low cost of less than $10.00. Also to every neighbours satisfaction I was able to find a formula to use as a guideline as to where to place a backyard lighting fixture.

I also discovered through my research that not many people know what light pollution is or how extremely important dark skies are to everyone's wellbeing as well as the animals. It is said that people would not want their children growing up never seeing the trees or water; well if the dark skies are taken away they may grow up never seeing the stars.

Acknowledgements –

Tammie and Marshall Mielhausen- Proof-reading, construction of board

Danielle Mielhausen – Proof-reading, helped with computer programs

Linda Watson – Lent me her digital camera

Steven Liverance – Painted backboard

Ethan Melag (photographer) – Assisting me in photography

Bibliography -

Web Sites

www.brucepeninsula.org

www.darksky.org

www.rasc.ca

www.roselandobservatory.com

www.sciencenetlinks.com

www.skyandtelescope.com

www.skynewsmagazine.org

www.yosemite.org

Books -

Berger, Melvin (2000) Scholastic Science Dictionary. New York, NY: Scholastic Inc.

Gupta, Rajiv. (2005) Observer's Handbook . Toronto. ON: University of Toronto Press

Howell, Rodgers, Henderson (2001) Earth and Space. London, England: Usborne Publishing Ltd.

Magazines –

MacRobert, Alan. (March/April 2005). April's Evening Sky. nightsky 18

Kelly, Roen. (April 2005). All Sky Map. Astronomy 49

Dyer, Alan. (March/April 2005) March/April 2005 Star Chart SkyNews 20

Crawford, D., & Thessin , R. (April 2002) Your Home Lighting Guide Sky & Telescope

Interviews –

Darryl Robins – Civil Engineer

Date: April 7, 2005

Place: Miller Lake, Ontario

Jennifer Barlow-Founder of National Dark-Sky week

Date: April 1, 2005

Place: through emails

Mr. Doug Cunningham – Retired Science Teacher & Astronomer

Date: April 15, 2005

Place: Lion's Head, Ontario @ Quetican Observatory

Spencer Tackaberry – Student at B.P.D.S.

Date: April 20, 2005

Place: Lion's Head, Ontario @ B.P.D.S.

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Date July 8, 2005 *Signature* Shelby Mielhausen

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Address 38 Maple Golf Cres.

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