Dark Skies Rangers Program

School Outdoor Lighting Audit

INTRODUCTION TO LIGHTING

Thank you for your interest in the Dark Skies Rangers and International Dark-Sky Association (IDA) Education programs. Our mission is "to preserve and protect the nighttime environment and our heritage of dark skies through environmentally responsible lighting." Our goals are to raise awareness of light pollution, its causes and its solutions to the general public. IDA does this by working with lighting designers and manufacturers to produce light fixtures that produce no light above the 90 degree angle (fully shielded), and then IDA's volunteers work with governments to require this type of outdoor lighting for all applications.

Dark Skies Rangers and IDA education programs are designed to continue and advance this mission by providing curriculum to children and adults about the causes and solutions to light pollution. This program is designed to provide a teaching tool for high school students and adults who would like to learn more about quality outdoor lighting.

The challenge of this project is to take a complex subject and make it understandable to the general public. We hope that those who complete this program will observe outdoor lighting with more understanding and informed questions.

Scope of the Project: The main teaching tool is a Power Point presentation that will be the reference material needed to complete the following 4 activities. The activities will be of increasing complexity as the student/audience progresses with them.

Activities:

Activity 1 – Vocabulary – There is a glossary, a fill in the blank quiz, and an answer key.

Activity 2 – Energy Lighting Audit – For students the audit would involve auditing their school campus. For adults the audit could be an audit of the outdoor lights in their neighborhood (i.e. park, streets, school). This audit will include calculating energy consumption of the lights in the area.

Activity 3-Measurements/Observations from the Audit – Choose 2 different types of lamps/fixtures from the audit. For each of these lamps complete at least 2 measurements/observations. For instance you will observe if a light is fully shielded or not, and you measure the power density of a luminaire.

Activity 4- Produce a revised master plan – This could include the entire campus, part of the campus, your neighborhood, or one aspect of the neighborhood. Students (individual or teams) will present their revised lighting plan to the class and give explanations for changes, or keeping the status quo for all fixtures in a given area. Part of this revised lighting plan will include re-calculating the energy consumption of the lights as explained in Activity 2. Did you save money for your school? For adults in a community then can use this revised lighting scheme when they present to a planning & zoning meeting of their city government.

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Goals:

Provide students/general public with tools and information they need to effectively monitor energy use within their campus or neighborhood.

Identify ways to save money by using energy wisely

Understand that the information that they learn may be used to help improve the environment

Encourage municipalities, schools, and businesses to consider managing or retrofitting their buildings so that energy is used as efficiently and wisely as possible.

Learning Objectives:

Define terms associated with an energy audit

Identify the components to include in an outdoor energy/lighting audit

Prepare and conduct an outdoor energy/lighting audit

Analyze data from the school/neighborhood outdoor energy/lighting audit

Write recommendation/improvement options for more efficient lighting.

Calculate the savings realized by using more efficient lighting.

Write out observations and measurements about current outdoor lighting

Develop and present an action plan to school/city officials about the results of the lighting audit, measurements, and options using power point, photos, worksheets, and designs.

Arizona Science Standards: (This activity utilizes the following Standards but is not limited to them.)

Grades 9 –12

- **S1,C2,PO4**. Conduct a scientific investigation that is based on a research design.
- **S1,C2.PO5.** Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and
- computers.
- **S1,C3,PO6**. Use descriptive statistics to analyze data, including: mean, frequency, range. (MHS-S2C1-10)
- **S1,C4,PO1**-For a specific investigation, choose an appropriate method for communicating the results.
- **S1,C4,PO3**. Communicate results clearly and logically.
- **S2,C1,PO3.** Analyze how specific changes in science have affected society.
- **S2,C2,PO3.** Distinguish between pure and applied science.
- **S3,C1,PO5.** Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity.
- **S3,C2,PO3.** Support a position on a science or technology issue.

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Equipment Needed:

- Graph Paper
- Pencils
- Long tape measure
- Lighting workbook (below)
- Camera
- Illuminance Meter - optional (Minolta T-10, $300 approximately) **OPTIONAL**
- Lighting catalogue (internet access required) **OPTIONAL**
- Calculator

Teaching Options:

- Instructors have the option of making this a team project, or an individual project depending on the size of the class or the campus.
- Instructors have the option of assigning certain measurements based on the availability of resources, i.e. cameras, lighting meters, access to facilities management, internet access.
- The Power Point can be shown by itself, or with any combination of activities.
- Instructors have the discretion of giving the vocabulary quiz before or after the other activities are completed. Or it can be before the activities and then again after the activities to see how much has been retained.
- Instructors have the option of printing off the notes pages to the power point and providing them to the students during the activities.
- Instructors can contact lighting designers or lighting engineers in their area to volunteer their time as consultants for the students on the project. For adults working to improve their neighborhood, this would also be a helpful option.
- Instructors can make their own assumption about the total lighting area to be measured i.e. the entire parking lot, or one section, the entire sports area or one field. Be consistent.

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Activity 1 Vocabulary

You will find a vocabulary sheet, a quiz, and an answer key.

Instructors: You have the following options for the quiz:

Give it directly after the power point presentation

Give it after the last activity has been completed

Have it be an "open book" project that the students complete while they are completing the activities.

Give the quiz after the power point and then again after the last activity to see the difference in the retention.

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Glossary of Lighting Terminology

For the Instructor: Following are general lighting terms and their definition.

- High School Students-These terms can be used in conjunction with English classes. A quiz has been designed to determine if they have retained the definitions.
- Adults –Being familiar with the language of lighting will be useful when working on outdoor lighting ordinances. The best way for an ordinance to be enforceable is to use industry language so there is no misunderstanding of terms.

Adapt: the Process by which the human visual system adjusts to light levels. Complete adaptation takes considerable time, especially when changing from a light to a dark environment.

Annual operating cost: the cost per year of electricity and maintenance of a lighting system, including replacement parts and associated labor.

ANSI: American National Standards Institute. ANSI coordinates and approves the processes for developing voluntary national standards, including those related to the lighting industry.

Area lighting: lighting provided to illuminate open areas uniformly.

Beam spread: the width, expressed in degrees, of a light beam from a reflector lamp. The edge of the beam is typically defined as the point at which the luminous intensity is 50% as great as at the center of the beam.

Bollard: a low post-shaped luminaire, typically 3 to 4 ft in height, used to light pathways, walkways, and perimeters.

Candlepower: a measure of luminous intensity of a light source in a specific direction measured in candelas. See luminous intensity

Contrast: the luminance of an object related to its immediate background.

Control: a device or system that turns lamps on and off, or dims them. Controls include switches, dimmers; timing devices motion detectors, photo sensors, and central control systems.

Current: a rate of flow of electricity, measured in amperes.

Cutoff luminaire: an outdoor luminaire having light distribution characteristics designed to reduce luminous intensity at angles above 65 degrees from vertical. Cutoff luminaires generally provide well-defined patterns.

Efficacy (of a light source): The ratio of light output from a lamp to the electric power it consumes (lamp output divided by input power). Efficacy is expressed in lumens per watt (LPW).

Efficiency (of a luminaire): the ratio of luminous flux (lumens) of a luminaire to the luminous flux of the lamp(s) alone. Luminous efficiency is a dimensionless measure, expressing the percentage of initial lamp lumens that exit the luminaire.

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Energy: the product of power (watts) and time (hours). Energy used for lighting can be saved by reducing the power required or the time lighting is used, or both.

Fixture: see luminaire.

Fluorescent lamp: a lamp containing mercury under low pressure, relative to high intensity discharge lamps. The mercury is ionized by an electric arc, producing ultraviolet energy which, in turn, causes a phosphor coating inside the lamp to fluoresce.

Footcandle (fc): unit of illuminance, equal to one lumen per square foot. One footcandle equal s 10.76 lux (lx).

Glare: excessive brightness from a source of light in the line of sight, usually horizontal. Luminaires with poor optical control can be sources of direct glare.

High intensity discharge lamp (HID): an electric lamp that produces light directly from an arc discharge under high pressure. Metal halide, high pressure sodium, and mercury vapor are types of HID lamps.

Illumination: the distribution of light on a horizontal surface. Illumination is measured in footcandles. For conversion purposes, 1 footcandle (fc) is equal to 10.76 lux (lx).

Incandescent lamp: a lamp producing visible radiant energy by electrical heating of a filament.

Kilowatt-hour (kWh): measure of electrical energy use; the product of power, as measured in kilowatts, and time, as measured in hours. For example, one kilowatt used for one hour equals on kilowatt-hour (kWh).

Lamp: a lighting industry term for an electric light bulb, tube, or other lighting device.

Light distribution: the spread of light that is produced by a lamp or a luminaire; also the overall pattern of light on a surface.

Light output: luminous flux, measured in lumens. The lumen rating of a lamp is measure of its total overall light output. See also lumen.

Light pollution: adverse effects, including glare, light trespass, and sky glow, of unwanted light in the atmosphere, typically produced by the upward components of outdoor lighting systems at night. Wasted light.

Light trespass: extraneous light on adjacent property, typically produced by stray light from outdoor lighting systems. Light trespass includes glare from direct viewing, as well as unwanted “spill light.”

Lumen: the unit of luminous flux. The lumen is the rate of flow of light, and is used to express the overall light output of a lam

Luminaire: a complete lighting unit consisting of a lamp or lamps, together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to a power supply.

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Luminance: the photometric quantity most closely associated with the perception of brightness. It is the luminous intensity emitted or reflected in a particular direction per unit area of reflective surface, measured in candelas per square feet or square meters.

Luminous flux: the rate of the flow of light, measured in lumens. The overall light output of a lamp.

Lux: the Systeme Internationale d"Unite (SI) unit of illuminance equal to 1 lumen per square meter. One lux equals 0.0929 foot candles.

Mercury vapor lamp: an HID light source in which radiation from mercury vapor produces visible light, which is characterized by a bluish-white color.

Metal halide lamp: an HID light source in which radiation from a mixture of metallic vapors produces visible light, characterized by a white color.

Photosensor: a device that converts light to electrical current. Photo-sensors switch lights on or off, based on the amount of incident light.

Power density: a measure of electrical power per unit area, measured in watts per square foot or square meter. Many building codes prescribe maximum power density values for various areas of use in an effort to promote the use of energy-efficient product.

Reflector lamps: a class of lamps that have reflecting material integrated into the lamp. Types include common reflector (R), parabolic aluminized reflector (PAR), and multi-faceted reflector (MR) lamps.

Sky glow: a result of scattered light in the atmosphere above urban areas. Sky glow is exasperated by the presence of water vapor, particulate (air) pollution, clouds, or rain.

Uniformity: in outdoor lighting, a measure indicating how evenly light is distributed across a surface. Typically the measure is expressed as a ratio of one value to another, such as average to minimum, or maximum to minimum. Using ratios, perfect uniformity would be 1:1.

Voltage: the difference in electrical potential that causes current flow in a circuit.

Watt: unit of real electric power; the rate at which electric energy is used.

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Vocabulary Test

Overall light output is measured in _____.

The ratio of luminous flux (lumens) of a luminaire to the luminous flux of the lamp(s) alone is called _____.

Cities and school must budget for the_____ _____ _____, which are the sum total expenses for using and repairing the lighting system.

Any lighting device in the industry is referred to as a _____.

The _____ _____ _____ _____ is the organization that coordinates and approves the processes for developing voluntary national standards, including those related to the lighting industry.

_____ _____is the lighting provided to illuminate open areas uniformly.

This low post-shaped luminaire, called a_____ usually lights pathways, walkways, & perimeters.

Luminous intensity is also referred to as_____.

Businesses and municipalities can reduce energy costs by installing _____ devices that turn lamps on and off, or dims them.

It can take up to 20 minutes for your eyes to _____to the dark after they have been in a brightly lit area at night.

In order to reduce light pollution and overall sky glow, all luminaries should be specified as a full_____ _____.

The overall pattern or spread of light on a surface is referred to as _____ _____.

Watts times hours of operation equals the _____ used by a luminaire.

Compact _____ _____ use a small amount of mercury to produce ultraviolet energy.

One _____ equals 10.76 lux.

Metal halide, high pressure sodium, and mercury vapor are types of _____ _____ _____ lamps.

_____is best described as the light that reflects off of a horizontal surface.

Thomas Edison invented the first successful _____ _____ _____ that heated a filament with electricity.

Blinding light that shines usually horizontally is known as _____.

_____ is a term used to express lumens per watt of a light source.

The luminous flux of a fixture, also called overall_____ _____, is measured in lumens.

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Too much wasted, artificial light at night that produces glare, trespasses beyond its intended destination, or it contributes to sky glow is called _____ _____.

A neighbor's light spilling into your bedroom window is a good example of _____ _____.

The perfect ratio indicating _____, which shows how evenly light is distributed, is 1:1.

A lighting fixture is called a _____ by the lighting industry and refers to the complete lighting unit.

_____ _____ _____are an example of an HID light source that uses mercury.

A type of control device, a _____ , switches lights on or off, based on the amount of surrounding light.

This orange haze known as _____ _____ is a result of scattered light in the atmosphere above urban areas.

The rate at which electricity is used is measured in units called _____.

When someone is talking about the perception of brightness of a source of light they are talking about its _____.

A HID light source in which Radiation from a mixture of metallic vapors produces a white color light is a _____ _____ _____.

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Vocabulary Test Answer Key

Overall light output is measured in _lumens_____.

The ratio of luminous flux (lumens) of a luminaire to the luminous flux of the lamp(s) alone is called efficiency_____.

Cities and school must budget for the_annual_____operating_____costs_____, which are the sum total expenses for using and repairing the lighting system.

Any lighting device in the industry is referred to as a lamp_____.

The __American National Standards Institute__ is the organization that coordinates and approves the processes for developing voluntary national standards, including those related to the lighting industry.

Area Lighting__is the lighting provided to illuminate open areas uniformly.

This low post-shaped luminaire, called a bollard usually lights pathways, walkways, & perimeters.

Luminous intensity is also referred to as_candlepower___.

Businesses and municipalities can reduce energy costs by installing _control__ devices that turn lamps on and off, or dims them.

It can take up to 20 minutes for your eyes to _adapt___to the dark after they have been in a brightly lit area at night.

In order to reduce light pollution and overall sky glow, all luminaries should be specified as a full cutoff luminaire_.

The overall pattern or spread of light on a surface is referred to as _light distribution___.

Watts times hours of operation equals the _energy__ used by a luminaire.

Compact fluorescent lamp use a small amount of mercury to produce ultraviolet energy.

One _footcandle___ equals 10.76 lux.

Metal halide, high pressure sodium, and mercury vapor are types of _high__intensity discharge_lamps._

Illumination__is best described as the distribution of light on a horizontal surface.

Thomas Edison invented the first successful _incandescent lamp__ that heated a filament with electricity.

Blinding light that shines, usually horizontally, is known as _glare_.

_Efficacy____ is a term used to express lumens per watt of a light source.

The luminous flux of a fixture, also called overall light output_, is measured in lumens.

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Too much wasted, artificial light at night that produces glare, trespasses beyond its intended destination, or it contributes to sky glow is called __light pollution__.

A neighbor's light spilling into your bedroom window is a good example of _light trespass_.

The perfect ratio indicating _uniformity___, which shows how evenly light is distributed, is 1:1.

A lighting fixture is called a __luminaire_ by the lighting industry and refers to the complete lighting unit.

_Mercury Vapor Lamp___is an example of an HID light source that uses mercury.

A type of control device, a _photo-sensor_____ , switches lights on or off, based on the amount of surrounding light.

Many building codes prescribe maximum _power density values for various areas of use in an effort to promote the use of energy-efficient product.

This orange haze known as _sky glow_ is a result of scattered light in the atmosphere above urban areas.

The rate at which electricity is used is measured in units called _watts___.

When someone is talking about the perception of brightness of a source of light they are talking about its _luminance_____.

A HID light source in which radiation from a mixture of metallic vapors produces a white color light is a _Metal Halide Lamp___.

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Activity 2: Energy Lighting Audit

Your instructor will place you into groups of three or four. Each group picks a different building at your school to use in the lighting audit. Make sure the building has more than a half dozen lights on the exterior.

- ✓ Measure the dimensions of the building and sketch it to scale on a piece of graph paper. Be sure to write the length and width on the sketch.
- ✓ On your schematic of the building, draw the location of the lights and where you think the light will fall (e.g., on the ground). You can figure out where the light will fall by looking at the shielding (if any) and where the light is pointed.
- ✓ Take a picture of the fixture, close enough to identify it later.
- ✓ Identify the kind of shielding. Match it to one of the pictures in the package. Identify the shape of the lamp.
- ✓ Come back at night as a group and confirm where the light falls for each fixture. Describe whether the area being illuminated is too much or too little for the task. Describe if the light falls where needed or beyond where it is needed, or if it is blocked by vegetation or another structure. Also, describe if there are overly bright or dark patches that hinder your ability to see what is around you.
- ✓ Record the color of the lamp (i.e. yellow orange-ish, greenish-white, bluish white, etc.)
- ✓ For every light that you see, record the watts and lamp type by interviewing the facilities staff. Ask about whether the lights are on timers or on light sensors (dust to dawn) or motion sensors. If the lights are on timers, then ask the staff what the approximate hours of operation are.
- ✓ Determine the *annual operating costs* of the lights in your audit. (This is for all of the building lights on average.)

Example: For the purposes of illustrating how such a schedule might work take a hypothetical school week where the lights are on from 7 p.m. to 7 a.m., Monday through Friday. During school sessions, the lights are on 12 hours a day for five days a week totaling 60 hours a week.

If your school has 10 weeks off during the summer, a 2 week winter break, a week off for spring break, and a week off for holidays, this would amount to 15 weeks a year. The calculated "on times" for most of the lights in this case would be as follows:

$$(O \times I) + (F \times N) = Y$$

- O = the number of hours that the outdoor lights are on when school is in session
- I = the number of weeks the school is in session
- F = the number of hours the outdoor lights are on when school is not in session
- N =the number of weeks that the school is not in session

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Audit Worksheet

For every fixture with a particular lamp that has a particular wattage, calculate:

_____	X _____	x _____	=	_____
# of lamps	wattage	estimated hours of use In a year		energy (Wh) used in a year

Add together the energy used in a year for all the different laps of different wattages

Divide this yearly energy usage in watt-hours by 1000 to change the units to kilowatt-hours. You have determined how many kilowatt-hours or how much energy has been consumed by the outdoor light on your campus.

Find out from the district main office what the dollars per kilowatt-hour is for the school. This number or ratio can be found on the monthly bill.

Do the math to determine roughly the current annual cost of operating the outdoor light around your building:

_____	X	_____	= dollars spent on outdoor lights
# of kilowatt-hours Calculated		dollars per kilowatt-hour	

The amount of carbon dioxide greenhouse gas generated during electricity production ranges from 1.4 lbs. to 2.8 lbs. per kilowatt-hour, depending on whether or not the electricity is produced from coal, nuclear power or hydropower. Estimate the amount of greenhouse gas created when the electricity is made to power the outdoor lights around your building;

_____	X 2 =	_____
# of kilowatt-hours Calculated		amount greenhouse gas to power the outdoor lights

Congratulations! You have data that will help determine whether the lighting around your school building can be made more energy and cost effective.

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Activity 3: Measurement of Audited Lights

The purpose of this section is to have you become more aware of the fixtures in the audit and make observations and measurements about how effective they are in performing the function for which they were installed. It is hoped that the student will become more aware of the science and design elements of quality outdoor lighting. It will also provide more in-depth analysis of the energy audit. And provide the student with more information to make recommendations. Choose two different types of lamps/fixtures from the audit. For each lamp prepare at least 2 of the following measurements.

- ✓ Determine pole height
- ✓ Determine power density
- ✓ Determine light output in lumens
- ✓ Determine illuminance levels in footcandles
- ✓ Various observations about the luminaires i.e. how are they controlled, are they full cut-off, etc.

Choose your two types of luminaires

Write a description of the luminaires:

Type of mount – wall, pole, ceiling, other
Color of lamp – white, orange, green,
What is its location/purpose - parking lot, walkway, intersection, park/green area, over a door?
What task is it lighting for – driving, walking, reading, facial recognition, security camera

Luminaire #1 - _____

_____

_____

_____

_____

Luminaire #2 - _____

_____

_____

_____

_____

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Observation/Measurement Worksheet

Observations:

Can you see any light/glare showing above the 90 degree angle? Feature these with photos if possible?
#1
#2

Can you determine if the light is full cut-off or not?
#1
#2

Is there a sag lens or a diffuser beneath the lamp?
#1
#2

Is the lamp on a circuit (meaning a zone/area goes on and off together), or it is controlled individually? What are the controls; i.e. dusk to dawn, clock, photo cell, or motion activated? (You may need facilities management to access this information)
#1
#2

Can you make any inferences about the controls? Lights are on too much, too little, just right?
#1
#2

From the audit are there any glaring/bad lighting examples? Feature these with photos if possible.

_____

Can you make any inferences about the general lighting scheme from the energy audit? Good, bad, glaring, not enough coverage, too much coverage, old technology, new technology?

_____

_____

_____

_____

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Measurements

Determine the light output (in lumens) of a particular luminaire. Internet access required. No instrumentation required.

Luminaire #1 – Description as shown above.

_____
_____
_____
_____

Determine the manufacturer's type and the light source used in the luminaire. If you know the owner of the light source (school, business, and professional offices) you may have to ask the building maintenance staff for assistance.

Download the manufacturer's specification sheet from the manufacturer's Web site and check the rated lumen output of the lamp from the lamp manufacturer's Web site or catalog. This will be referred to as the photometric file of the fixtures.

The lumen output of the luminaire will be the rated lamp lumens multiplied by the luminaire efficiency (measured in %); so there is only one calculation to do:

Luminaire lumens = rated lamp lumens x luminaire efficiency.

For Extra Credit – Estimate how much light from the luminaire goes into the sky?

Luminaire #2 - Description as shown above.

_____
_____
_____
_____

Determine the manufacturer's type and the light source used in the luminaire. If you know the owner of the light source (school, business, and professional offices) you may have to ask the building maintenance staff for assistance.

Download the manufacturer's specification sheet from the manufacturer's Web site and check the rated lumen output of the lamp from the lamp manufacturer's Web site or catalog. This will be referred to as the photometric file of the fixtures.

The lumen output of the luminaire will be the rated lamp lumens multiplied by the luminaire efficiency (measured in %); so there is only one calculation to do:

Luminaire lumens = rated lamp lumens x luminaire efficiency.

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Power Density

Unit Power Density (W/sq.ft.) = Total System Input Wattage (W) ÷ Total Area (Square Feet)

Luminaire #1 – Campus Location _____
Type of lamp _____
Function/Task _____
Equation _____
Observations _____

Luminaire #2 - Campus Location _____
Type of lamp _____
Function/Task _____
Equation _____
Observations _____

NOTE: You may make your own assumptions about the total area you are working with. For example you can measure the entire parking lot, or a courtyard, or an outside walkway. Whatever assumptions you use, note them and be consistent with the measurements.

Pole Mounting Height

Luminaires on poles can provide illumination in every direction at distances of two to two and half times the mounting height from the pole. Thus, luminaires on a single pole can serve an area of about four times the mounting height - squared. For example, a 50-ft pole can cover about 40,000 sq ft and a 150-ft pole about 369,000 sq ft.

Look at other lights that might be in the area but are not necessarily on campus (street lights, city parking lot lights, businesses and their parking lots).

Luminaire #1

Pole Height _____
(pole height) x 4 = lighted area from pole
Observations:
What is the task of this light? _____
Can you complete the task using the current light source? _____
If not, describe the situation. _____
_____
Is there overlap from other light sources in the lighted area, such as nearby street lights, a shopping center, businesses, or parking lots? _____
_____
_____

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Luminaire #2

Pole Height _____

(pole height) x 4 = lighted area from pole

Observations:

What is the task of this light? _____

Can you complete the task using the current light source? _____

If not, describe the situation. _____

_____

Is there overlap from other light sources in the lighted area, such as nearby street lightings, a shopping center, businesses or parking lots? _____

_____

Instrumentation Required

Determine the illumination level (footcandles) that the luminaire provides on the pavement/walkway at various distances from the luminaire (2, 5, 10, 20, 30 fee for example). The purpose of this exercise is to figure out how the light output of the lamp and luminaire (measured in lumens) distributes the light and directs it onto the pavement so it provides illumination (lumen/sq. foot or lumens/ sq. meter).

You will need an illuminance meter for this exercise and the measurements will clearly need to be completed at night. The typical measurements for a street light or post-top luminaire would range from 5 footcandles down to 0.1 footcandles. Illuminance meters are calibrated to read footcandles, lux or both.

For calculation purposes:

One footcandle of illumination = 1 lumen/square foot

In metric terms: One lux of illumination = 1 lumen/square meter

The meter readings are taken by placing eh meter on the ground at various distances from the luminaire and recording the reading. The meter is measuring “horizontal illuminance” when you do this which means the illuminance on the (horizontal) pavement surface.

Observation after measurement – How much light is this luminaire providing compared to moonlight?

Luminaire #1

Luminaire #2

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School Outdoor Lighting Audit

Activity 4: Design New Lighting Plan & Audit

Produce a revised lighting scheme for your school campus or neighborhood.

- ✓ Design a visual master plan for your campus:
- ✓ What are your goals for the plan
- ✓ Please show a diagram on graph paper of your new lighting plan.
- ✓ Take into account these areas (you are welcome to make your own assumptions, just be consistent) and address each area in your final presentation.
    - How will it be used? A lot, a little? Ball Park? Walk/Cycling path? Restrooms? Nearby parking lot? Sculpture? Fountain?
    - What are the hours of use?
    - What safety precautions are in place?
    - Has glare been reduced or eliminated?
    - What types of luminaires are you recommending and why?
    - What is around your park/campus? Residential, open space, businesses, mixed use?

Using the material you have learned determine:

- ✓ If all the lights in the audit are now necessary. If not, why not?
- ✓ What task/purpose is a lamp used for. Is the current light adequate to perform this task. List reasons either way.
- ✓ Is there a money saving alternative? Give reasons why and why not.

Re-calculate the energy consumption of the lights for the revised plan using the equations from the audit in the second activity. Have you saved money? What is the pay off time of any new equipment that was recommended to be purchased (purchase cost – energy savings costs over time = energy saved over time).