DARK SKY ASSESSMENT GUIDE

WHAT IS LIGHT POLLUTION?
Light pollution is “the inappropriate or excessive use of artificial light,” and consists of four main factors:

1. Glare: Excessive brightness that causes visual discomfort
2. Sky glow: Brightening of the night sky over inhabited areas
3. Light trespass: Light falling where it is not intended or needed
4. Clutter: Bright, confusing and excessive groupings of light sources

Light pollution caused by the inappropriate or inefficient use of outdoor lighting is costly, and effects people, wildlife, and outdoor environments—most noticeably, it limits our view of the starry night sky.

HOW DO I USE THIS WORKSHEET & GUIDE?
The initial groundwork for a dark sky designation is establishing the current status. This worksheet guides users through several evaluation methods which could be used for a general assessment of dark sky-friendly lighting. While not all of the included methods are required for a quality assessment, it is recommended that those conducting the assessment use as many methods as appropriate to gain a broader perspective. In addition, the various methods may be adapted for public education and engagement on dark sky issues.

After completing your assessment, you will know the current state of lighting in your community or area and will have identified key areas for improvement.

For help with this guide, contact Utah’s Community Development Office: (801) 468-0133, info@ruralplanning.org or the Colorado Plateau Dark Sky Cooperative: darkskycooperative@gmail.com

PREPARING FOR YOUR DARK SKY ASSESSMENT

1. Define your purpose
   - Who requested the assessment? Who is sponsoring or supporting it?
   - What is the goal of your assessment?
   - How will you use information gathered during the assessment?
   - Will it be the only assessment or will there be more?

2. Identify who should be involved
   - List and invite key stakeholders (leaders, active citizens, business owners, etc).
   - What do they need to know to support your project and engage in the assessment?
   - Who might help you engage with necessary stakeholders and supporters?

3. Design and prepare for the assessment
   - Prepare a map of town (can use Google maps, a hand drawn map, or existing city maps).
   - Organize where the assessment will begin and end. It may help to divide into different areas, separating commercial districts, residential sectors, or government districts for the purposes of the assessment.
   - Walk the route beforehand—are there safety concerns or other considerations that should be acknowledged before conducting an assessment?
   - Select areas during the day to take illustrative photos—most SLR cameras can take a good night photo.
   - You should try to carry out your assessment on a clear night, with little or no cloud cover. Don’t do the assessment when the moon is in the sky.

4. Get the word out
   - If not initiated or conducted by the town, notify the town when your assessment will be performed.
   - Notify and remind stakeholders.
   - Notify the public (fliers, posters, Facebook, etc.); assessments can be helpful and fun for community education (e.g. Our Town Nights, Community Night Connections, etc.).
   - Gather maps and other assessment materials.

NOTES

REMEMBER TO TAKE...
- This guide
- Printed map of assessment area
- Pencils / pens / colored markers
- Clipboards
- Measuring tape
- DSLR camera & tripod
- Orange vests / visible clothing / reflective gear
- Comfortable walking shoes
- A friend—work in groups for safety
DARK SKY ASSESSMENT GUIDE

TABLE OF CONTENTS

3 DARK SKY LIGHTING BASICS
- Lighting shielding ........................................... 3
- Appropriate lighting levels ................................ 3
- Lighting color .................................................. 4
- Essential takeaways .......................................... 4
- Acceptable lighting types ................................... 5

6 CONDUCTING A FORMAL AUDIT
- Basic audit guidelines ....................................... 6
- Lighting inventory equipment ............................... 6
- Lighting inventory template #1 .............................. 7
- Lighting inventory template overview .................. 8-11
- Lighting inventory template #2 ............................ 12
- Taking a sky quality survey ................................. 13

14 DIFFERENT ASSESSMENT TOOLS
- Mobile apps and resources ................................. 14
- Who can I contact for help? ................................. 14
- Lighting issue concerns and land use .................. 15
- Public engagement & education ......................... 15
- Marking a map .................................................. 16
- Taking night photos ......................................... 16
- Calculate the savings ........................................ 17
- SWOT analysis ................................................. 18

19 AFTER YOUR ASSESSMENT
- Debrief after the assessment .............................. 19
- Form a local dark skies group ............................. 19
- Pursue Dark Sky Place Certification .................. 19
- Plan action ..................................................... 19

20 ADDITIONAL RESOURCES
- General resources ........................................... 20
- Recreation Lighting ......................................... 20
- Flag Lighting .................................................. 20
- Illumination standards ..................................... 20

GENERAL LIGHTING TERMS

- CLUTTER: Bright, confusing and excessive groupings of light sources.
- COLOR SPECTRUM: Refers to the portion of the electromagnetic spectrum that is visible to the human eye.
- CORRELATED COLOR TEMPERATURE (CCT): Specifies the color appearance of light emitted by a lamp.
- DARK SKY: Denoting or located in a place where the darkness of the night sky is relatively free of interference from artificial light.
- DSLR CAMERA: “Digital single-lens reflex” or DSLR cameras are versatile cameras with changeable lenses that produce high-quality photos.
- FIXTURE: The assembly that holds the lamp in the lighting system and includes elements such as a reflector (mirror) or refractor (lens), the ballast, housing, and the attachment parts.
- FOOTCANDLE (fc): Illuminance produced on a surface that is everywhere one foot from a uniform point source of light of one candle and equal to one lumen per square foot.
- FULLY SHIELDED: A fixture that allows no emission above a horizontal plane passing through the lowest light-emitting or light-reflecting part of the fixture.
- GLARE: Excessive brightness that causes visual discomfort.
- KELVIN: A measurement unit for light’s “warmness” or “coolness.”
- KW (Kilowatt): A measure equal to 1,000 watts of electrical power.
- kWh (Kilowatt Hour): A measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.
- LAMP: A device for giving light which can consist of an electric bulb with its holder and shade or cover, or one burning liquid fuel and consisting of a wick or mantle and a glass shade.
- LIGHT TRESPASS: Light falling where it is not intended or needed.
- LUMEN: A measurement unit for the brightness from a light source.
- LUMINAIRE: A complete lighting unit that usually includes the fixture, ballasts, and lamps.
- LUX: One lumen per square meter. Unit of illuminance.
- REFLECTION: Light redirected back into the sky off of surfaces that are being illuminated.
- SKYGLOW: Brightening of the night sky over inhabited areas.
- WATT: The standard unit of power in the International System of Units (SI).
DARK SKY ASSESSMENT GUIDE

DARK SKY LIGHTING BASICS: THE “THREE-LEGGED STOOL”
We need lighting for safety at night. However, many city lights are undirected and waste energy while causing light pollution. Proper lighting begins with proper lighting design standards which form a proverbial “three-legged stool”. The legs of the stool are:

1. Shielding
2. Appropriate lighting levels
3. Lighting color

These three basic design principles form the basis for good lighting design, and when applied correctly, will reduce light pollution.

1. LIGHTING SHIELDING

OUTDOOR LIGHTING SHOULD BE “FULLY SHIELDED,” meaning no light above a 90-degree angle. The goal of fully shielded light fixtures is to prevent:

- Light trespass is light falling where it is not wanted or needed. Light trespass can create problems for neighboring and distant properties.
- Glare is intense and blinding light that can cause discomfort and temporary blindness.
- Skyglow reduces our ability to view celestial objects due to scattered light from sources on the ground.

The more light is directed towards the intended subject, the better. Fully shielded lighting can be purchased or retrofitted.

2. APPROPRIATE LIGHTING LEVELS

Outdoor lighting can easily become excessive or “cluttered.” Appropriate lighting levels mean practically managing the amount of outdoor lighting in terms of duration and illuminated area. Ordinances that support appropriate lighting levels will specify the acceptable amount of lumens within an area (such as lumens per acre). Many municipalities use illumination guidelines established by the Illuminating Engineering Society (IES) to set lighting levels in their ordinances. In addition, municipalities will remove lights no longer in use or needed. Note that International Dark Sky Association (IDA) standards are more strict than IES standards.

- Lumens are a measurement unit of the brightness from a light source.
- Clutter is excessive groupings of light sources that create a bright and confusing environment.
- Reflection off of what is being illuminated causes light to be redirected back into the sky, contributing to sky glow.

Timers, motion sensors, dimmer switches, and turning lights off when not in use can help improve lighting levels.

Generally, use lighting where it’s needed, when it’s needed, and only as bright as needed.
3. LIGHTING COLOR

The color of the light is important as well. Cool, blue spectrum lights brighten the night sky more than amber colored light and researchers are beginning to connect blue light spectrum to negative health effects in people and greater problems for wildlife. IDA recommends using long-wavelength lighting with a color temperature of < 3000 Kelvin.

- **Kelvin** refers to a temperature scale used to measure light's warmness or coolness.
- **Color Spectrum** refers to the portion of the electromagnetic spectrum that is visible to the human eye.

**ESSENTIAL TAKEAWAYS**

- **LIGHT ONLY WHAT YOU NEED**: Use fully shielded fixtures. Shine lights down, not up. Direct lighting at desired areas. Be strategic with lighting and only use it where needed.
- **LIGHT ONLY WHEN YOU NEED**: Install timers, motion sensors, and dimmer switches, and turn off lights when not in use.
- **LIGHT ONLY HOW MUCH YOU NEED**: Use the right amount of light. Save electricity by using the lowest adequate wattage bulbs. Too much light is wasteful, impairs vision, and can be costly.
- **LIGHT ONLY HOW YOU NEED**: Use long-wavelength lights with a red or yellow tint to minimize negative health effects. Use warmer colored bulbs, like yellow or amber instead of white. Avoid bluish light, which is known to have a variety of negative effects.

ADAPTED FROM THE INTERNATIONAL DARK-SKY ASSOCIATION, DARKSKY.ORG
ACCEPTABLE LIGHTING TYPES

The images below illustrate various acceptable lighting forms. For more information, visit [http://www.darksky.org/fsa/fsa-products/](http://www.darksky.org/fsa/fsa-products/).

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**Unacceptable / Discouraged**
Fixtures that produce glare and light trespass

- Unshielded Floodlights
- Unshielded Wallpacks & Unshielded Wall Mount Fixtures
- Drop-Lens & Sag-Lens Fixtures w/ exposed bulb / refractor lens
- Unshielded Streetlight
- Unshielded Security Light
- Unshielded PAR Floodlights
- Drop-Lens Canopy Fixtures

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

- Full Cutoff Fixtures
- Fully Shielded Wallpack & Wall Mount Fixtures
- Fully Shielded Fixtures
- Full Cutoff Streetlight
- Fully Shielded "Period" Style Fixtures
- Fully Shielded Security Light
- Shielded / Properly-aimed PAR Floodlights
- Flush Mounted Canopy Fixtures

ILLUSTRATIONS BY BOB CRELIN®. RENDERED FOR THE TOWN OF SOUTHAMPTON, NY. COURTESY OF INTERNATIONAL DARK-SKY ASSOCIATION.
CONDUCTING A FORMAL LIGHTING AUDIT

The IDA requires formally designated Dark Sky Communities (DSC) to adopt a quality and comprehensive lighting code which includes a commitment to a brightness measurement program. The brightness measurement program can be maintained either by the community or by another public or private organization. The measurement program is meant to monitor success in reducing light pollution. A formal lighting audit should be performed to establish a baseline for monitoring success.

A formal audit may require outside help from organizations such as a university, research center, IDA chapter, astronomy club, or other qualified entities since determining the electrical, physical, and operational characteristics of lighting can be difficult or technical. The process for lighting audits vary depending on the organization; however, the Federal Department of Energy (DOE) recommends several basic guidelines.

BASIC LIGHTING AUDIT GUIDELINES

THE FOLLOWING ITEMS ARE RECOMMENDED FOR CONSIDERATION:

- The age, condition, quality, and location of existing light fixtures.
- Model and manufacturer of lighting system to obtain existing photometrics (perceived brightness).
- Lamp wattage and ballast type (if appropriate).
- Take note of the environment, is there the possibility of particulate, moisture, or dirt buildup in or around the lighting fixture?
- Take note of what kinds of activities, or uses are being performed in the space. Are there any special visual requirements?
- Observe how the lighting system is controlled and how often it is used.
- Note the perceived color of the lighting, e.g. blue, white, or amber light.
- Measure the physical layout of the existing lighting system and take note of height and spacing.
- If possible, use an illuminance meter to measure light intensity. Readings should be taken on the ground and at even intervals to create a “grid” of measurements.

A lighting audit provides benchmarks for determining the effectiveness of lighting improvements and energy savings.

USEFUL MEASUREMENT EQUIPMENT

<table>
<thead>
<tr>
<th>ON HAND</th>
<th>OPTIONAL EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAPE MEASURE</td>
<td>LIGHT METER</td>
</tr>
<tr>
<td>DSLR CAMERA</td>
<td>COLOR TEMPERATURE METER</td>
</tr>
<tr>
<td>SMART PHONE</td>
<td>SKY QUALITY METER</td>
</tr>
<tr>
<td>(see pg. 15)</td>
<td>LASER DISTANCE METER</td>
</tr>
</tbody>
</table>

OPTIONAL EQUIPMENT?

- **Light Meter** an instrument used to measure the intensity of light.
- **Color Temperature Meter** a device used to measure color temperature in degrees Kelvin.
- **Sky Quality Meter (SQM-L with lens)** an instrument used to measure the luminance of the night sky.
- **Laser Distance Meter** a portable device designed to measure distance from the device to a remote target.

EQUIPMENT RENTAL

The Colorado Plateau Dark Sky Cooperative has some equipment available to rent for free! Contact darkskycooperative@gmail.com for more information.

Available:

- Sky Quality Meter (SQM) - 1 available
- Laser Distance Meter - 2 available
**EXAMPLE LIGHTING INVENTORY TEMPLATE #1**

<table>
<thead>
<tr>
<th>ID</th>
<th>LOCATION</th>
<th>FUNCTION</th>
<th>HAZARDS</th>
<th>NUMBER OF FIXTURES</th>
<th>LAMPS PER FIXTURE</th>
<th>FIXTURE TYPE</th>
<th>LAMP TYPE</th>
<th>COLOR TEMP (K)</th>
<th>LUMENS</th>
<th>SHIELDING STATE</th>
<th>OPERABLE?</th>
<th>ADAPTIVE CONTROLS?</th>
<th>LIGHT MANAGEMENT PLAN (LMP) COMPLIANT?</th>
<th>CLOSEUP</th>
<th>CONTEXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Restroom building at parking lot in Visitor Center</td>
<td>Egress</td>
<td>None</td>
<td>8</td>
<td>1</td>
<td>Can</td>
<td>Par 16 Amber Lamp, 3W</td>
<td>1800</td>
<td>120</td>
<td>Fully</td>
<td>Yes</td>
<td>None</td>
<td>Yes</td>
<td><img src="image1.png" alt="Closeup" /></td>
<td><img src="image2.png" alt="Context" /></td>
</tr>
<tr>
<td>2</td>
<td>Path near Visitor Center</td>
<td>Wayfinding</td>
<td>Uneven Surface</td>
<td>22</td>
<td>1</td>
<td>Post</td>
<td>8W Amber A-lamp, 4 yellow LED or CFL “bug lights”</td>
<td>&lt;2700</td>
<td>200</td>
<td>Partially</td>
<td>Yes</td>
<td>None</td>
<td>8 Yes / 14 No</td>
<td><img src="image3.png" alt="Closeup" /></td>
<td><img src="image4.png" alt="Context" /></td>
</tr>
<tr>
<td>3</td>
<td>Admin Building</td>
<td>Building approach</td>
<td>Steps</td>
<td>1</td>
<td>2</td>
<td>Spot</td>
<td>8W Par 60 Amber LED</td>
<td>1800</td>
<td>320</td>
<td>Eave</td>
<td>Yes, only one socket in use</td>
<td>Motion sensor, 4 min duration/ 15 sec. delay/ Programmed 10%-60%/10%</td>
<td>Yes</td>
<td><img src="image5.png" alt="Closeup" /></td>
<td><img src="image6.png" alt="Context" /></td>
</tr>
<tr>
<td>4</td>
<td>Lab Building</td>
<td>Egress</td>
<td>None</td>
<td>1</td>
<td>1</td>
<td>Jelly Jar</td>
<td>3W Par 16 Amber LED</td>
<td>1800</td>
<td>320</td>
<td>Unshielded</td>
<td>No</td>
<td>None</td>
<td>No</td>
<td><img src="image7.png" alt="Closeup" /></td>
<td><img src="image8.png" alt="Context" /></td>
</tr>
<tr>
<td>5</td>
<td>Staff Housing</td>
<td>Egress</td>
<td>Step</td>
<td>1</td>
<td>1</td>
<td>Wallpack</td>
<td>7W Amber LED</td>
<td>1800</td>
<td>280</td>
<td>Fully</td>
<td>Yes</td>
<td>None</td>
<td>Yes</td>
<td><img src="image9.png" alt="Closeup" /></td>
<td><img src="image10.png" alt="Context" /></td>
</tr>
</tbody>
</table>

**Notes:**
- Some data points can be captured during the day while other data points will require a nighttime visit.
- The template was adapted from the Anza-Borrego Desert State Park IDA Nomination with supplemental information from John Barentine, International Dark Sky Association Director of Conservation.
- The template can be adapted by parks, communities, and other entities performing a lighting inventory.

**Lighting Inventory Template:**

There are different ways to log lighting inventory information. One simple way is to record the information on a spreadsheet. The following example spreadsheet was adapted from the Anza-Borrego Desert State Park IDA Nomination with supplemental information from John Barentine, International Dark Sky Association Director of Conservation. Accompanying the template are descriptions of the content found in the columns of the sample Lighting Inventory worksheet below. The template can be adapted by parks, communities, and other entities performing a lighting inventory. Some data points can be captured during the day while other data points will require a nighttime visit.

A detailed description of each item and examples of fixture and lamp types follows.
**TEMPLATES OVERVIEW**

**FIXTURE ID:** Any unique identifier for the fixture or group of fixtures. This usually takes the form of some running number (e.g., 1, 2, 3, ...) but could include letters or other location-specific information. For example, a set of fixtures at a visitor center could be identified as VC1, VC2, ..., etc. Ideally the Fixture ID is sufficiently specific to identify individual fixtures among a group.

**LOCATION:** A short description of where the lighting is located; e.g., “Campground restrooms”, “Staff housing”, “Administration building”. If no location is otherwise available, give GPS coordinates (latitude/longitude).

**FUNCTION:** The nominal purpose of the lighting, whether or not such lighting is warranted according to the park’s LMP. “Function” should indicate why the lighting exists at the location. If the function is not evident, enter “Unknown”.

**HAZARDS:**
What safety hazard is the lighting intended to mitigate? If no hazards are evident, enter “None”. If hazards cannot be determined, enter “Unknown”.

**NUMBER OF FIXTURES:** If more than one identical fixture is present at a discrete location, group these together. For example, a restroom building might have several identical fixtures on its various sides.

**LAMPS PER FIXTURE:** The number of discrete lamps per individual fixture, regardless of the number of fixtures at a site. The total number of lamps at a site = number of fixtures × lamps per fixture.

**FIXTURE TYPE:** The variety of fixture, usually relating to its function. If the fixture type is not evident, enter “Unknown”.

**FUNCTION EXAMPLES:**
- Area (illuminates a large area of ground)
- Decorative (serves no safety or task performance purpose, but is installed for aesthetic reasons)
- Egress (as from a structure)
- Other
- Pathway (to prevent tripping or to point out a drop-off)
- Parking
- Roadway
- Safety (to point out specific safety hazards)
- Security (intended to discourage or prevent the incidence of property or violent crime; note that this is NOT a valid reason for lighting in an International Dark Sky Park/Reserve/Sanctuary)
- Sign
- Wayfinding (safe transit between points, marking, e.g., the edges of a trail)

**HAZARD EXAMPLES:**
- Curb
- Pathway
- Stairs (indicating multiple steps)
- Step (indicating a single step)
- Uneven surface
- Water
- Other

**HAZARDS:**
- Curb
- Pathway
- Stairs (indicating multiple steps)
- Step (indicating a single step)
- Uneven surface
- Water
- Other
**FIXTURE EXAMPLES:**
1. Barn
2. Bollard
3. Can
4. Ceiling
5. Emergency
6. Flood
7. Phone Booth
8. Pole
9. Spot
10. String
11. Vending Machine
12. Wallpack
13. Wall Sconce

**LAMP TYPE EXAMPLES:**

**LAMP TYPE:** If no lamp is present, enter “Empty Socket”. If the lamp type cannot be determined, enter “Unknown”.

1. Compact Fluorescent (“CFL”)
2. Incandescent
3. Halogen
4. Neon (or other gas-filled tube)
5. High-pressure Sodium (“HPS”)
MORE LAMP TYPE EXAMPLES:
6. Low-pressure Sodium (“LPS”)
7. Mercury Vapor
8. Metal Halide (“MH”)
9. LED (specify “amber”, “white” or other color)
10. Fluorescent Tube

SHIELDING STATE:
To what extent is the fixture shielded? Response should be one of the following states.

SHIELDING STATES:
- Fully (shielded in such a way that no light can be seen above a horizontal plane passing through the lowest light-emitting part of the fixture with respect to the illuminated surface)
- Partially (some shielding, usually of the fixture top, but not meeting the definition of ‘fully shielded’)
- Unshielded (shielding is not a part of the design, with light emitted or diffused from all surfaces other than the mounting point)
- Other (some other arrangement not captured by ‘fully shielded’, ‘partially shielded’, or ‘unshielded’)
- Unknown (unable to determine in the field)

OPERABLE?: Can the fixture be operated according to the manufacturer’s instructions? Response should be “Operable”, “Inoperable”, or “Unknown”. Lights are typically inoperable because they are fully disconnected from a power supply, and are thus considered LMP-compliant by nature. Note that a light with a broken switch or missing lamp is not considered “inoperable”.

ADAPTIVE CONTROLS:
Any electronic or mechanical device attached to a light intended to dynamically control the duration, intensity, spectrum, or area illuminated by the lighting.

ADAPTIVE CONTROL EXAMPLES:
- Automatic switch
- Motion sensor
- Timer

ADAPTIVE CONTROL INFORMATION

<table>
<thead>
<tr>
<th>LIGHT SOURCE</th>
<th>ADAPTIVE CONTROLS</th>
<th>COLOR TEMP (K)</th>
<th>BEFORE ADAPTIVE CONTROLS (2016)</th>
<th>AFTER ADAPTIVE CONTROLS (2017 - 2018)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED</td>
<td>Programmed 10%-60%-10%</td>
<td>3000 K, 1600 (60%)</td>
<td><img src="image1" alt="Before Adaptive Controls" /></td>
<td><img src="image2" alt="After Adaptive Controls" /></td>
</tr>
</tbody>
</table>
LMP COMPLIANT?:
Does the light meet all of the requirements of the park's Lighting Management Plan (if applicable)?

CLOSEUP PHOTO: An image of the light in place, taken sufficiently close to reveal some details about it.

CONTEXT PHOTO:
An image of the light in place, taken from further away to illustrate the function or other contextual information about it.

PHOTO EXAMPLES

NOTES
Below is another example of how to record and organize your lighting audit data. Specific technology or technical assistance may be required to capture each data point. No matter what method or structure you use, be consistent and well organized.

<table>
<thead>
<tr>
<th>DAYTIME VISIT</th>
<th>NIGHTTIME VISIT</th>
<th>MITIGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visit Date:</strong></td>
<td><strong>Visit Date:</strong></td>
<td><strong>Mitigation Required</strong></td>
</tr>
<tr>
<td><strong>Fixture Height (ft):</strong></td>
<td><strong>Fixture Height (ft):</strong></td>
<td><strong>Yes</strong></td>
</tr>
</tbody>
</table>
| **Fixture Lighting Purpose:**  
  - Area  
  - Entrance/Egress  
  - Pathway  
  - Parking  
  - Roadway  
  - Sign  
  - Stairway  
  - Other | **Correlated Color Temperature CCT:**                                        | **No**                                                                    |
| **Fixture Type:**  
  - Barn  
  - Bollard  
  - Ceiling Mount  
  - Dark Cowbell  
  - Flood  
  - Hanging Light  
  - Lamp Post  
  - Phone Booth  
  - Recessed  
  - Spotlight  
  - Tin Hat  
  - Tube  
  - Vending Machine  
  - Wall Pack  
  - Wall Sconce  
  - Other | **Illuminance:**                                                             | **Mitigation Date:**                                                       |
| **Number of Fixtures**                                                        | **Footcandle:**                                                               |                                                                            |
| **Lamps per Fixture:**                                                       |                                                                               |                                                                            |
| **Historic Fixture?**  
  - Yes  
  - No |                                                                               |                                                                            |
| **Fixture Power:**  
  - Solar  
  - Utility  
  - Other |                                                                               |                                                                            |
| **Fixture Adaptive Controls:**  
  - Motion Sensor  
  - None  
  - Photocell  
  - Switch  
  - Timer Switch  
  - Other |                                                                               |                                                                            |
| **Lamp Type:**  
  - CFL  
  - Empty Socket  
  - Fluorescent Tube  
  - Halogen  
  - HPS  
  - Incandescent  
  - Induction  
  - LED  
  - LPS  
  - Mercury Vapor  
  - Metal Halide  
  - Other |                                                                               |                                                                            |
| **Shielding:**  
  - Fully Shielded Eve  
  - Fully Shielded Fixture  
  - Fully Shielded Lamp Lens  
  - Partially Shielded Eve  
  - Partially Shielded Fixture  
  - Partially Shielded Lamp Lens  
  - Unshielded |                                                                               |                                                                            |

Adapted from Bryan Boulanger, Ohio Northern University Contact: b-boulanger@onu.edu
THINKING LONG TERM
A lighting inventory provides the foundational knowledge needed to improve lighting used at night. Before improvements are made, a sky brightness measurement program* should be established and maintained in order to monitor the evolution of light pollution in a community over time. *Note that evidence of a sky brightness monitoring program is a requirement for International Dark Sky Place Designation.

WHAT ARE YOU MONITORING?
You are monitoring sky brightness (or quality) over time.

HOW IS SKY QUALITY MEASURED?
There are a variety of ways to conduct a sky quality survey including:
1. A Sky Quality Meter (SQM-L) Survey
2. Bortle Scale Interpretation
3. Photographic Evidence

Below is a brief description of how to conduct a sky quality survey using a Sky Quality Meter. For more information and descriptions of other methods visit: http://darksky.org/our-work/conservation/idsp/become-a-dark-sky-place/sky-quality-survey/

TAKING A SKY QUALITY SURVEY
The Unihedorn Sky Quality Meter (SQM-L version with "lens") is a small battery powered device that is used to take scientific-quality measurements of sky brightness.

To use a Sky Quality Meter simply hold the device directly above your head so that the photometer is pointed toward the sky (at zenith) and click the start button. The screen will then display the sky brightness at the point you are standing. The higher the number, the darker the sky is.

Take 5-6 measurements per location per visit, discarding the first measurement (the first measurement will not be accurate). Choose several locations throughout your community that will represent the darkest and the brightest areas in order to achieve a comprehensive survey of the location.

We recommend collecting data over several nights spaced out by a week or two. This dilutes the effects of fog, dust, and other atmospheric conditions that can reduce accuracy.

Remember that you will need to return to these locations in the future as you continue to monitor sky quality over time.

BEST PRACTICES
1. Never take a measurement directly underneath a light source or anything that might block the clear sky.
2. Always take measurements under a clear, open, cloudless sky.
3. Always take measurements when the moon is below the horizon or when the moon is new.
4. Always take measurements under conditions of "astronomical darkness" meaning the sun is at least 18° below the local horizon.
5. The success of your sky brightness measurement program will depend on staying organized and consistent with your data.
6. Share your data with the Globe at Night citizen science project at globeatnight.org

DATA TO CAPTURE (WITH EXAMPLES)
- Location: Cemetery
- Latitude: 39.686
- Longitude: 110.846
- Altitude: 1,814m
- Time: 9:15pm
- Date: 5/20/19
- SQM measurements taken at zenith:
  1. 21.02 (record the first number but remember that it should be discarded later for accuracy)
  2. 20.95
  3. 20.95
  4. 20.96
  5. 20.95
  6. 20.97

CEMETERY
AVERAGE SQM RATING = 20.96
DIFFERENT ASSESSMENT TOOLS
There are a variety of ways to collect information for your dark sky assessment. The following pages describe different methods for collecting, documenting, and organizing information. While the DOE and IDA offer basic guidelines, each community is unique, and the methods used and data collected will depend on individual goals, capacity, and access to technology. Dark Sky Community status won’t be the goal for every community, but a formal audit will provide a baseline for limiting light pollution.

USE TECHNOLOGY
A wide variety of Iphone and Android apps can be used to take night sky brightness measurements. Other applications, such as COLLECTOR FOR ARCGIS can capture a comprehensive set of geographic data points.

For more precise measurements, the IDA recommends using a SKY QUALITY METER with lens (SQM-L) see page 13. Choose apps and resources that make sense for you and your community or contact a dark sky expert for help. Below is a list of basic apps to get you started:

MOBILE APPS AND RESOURCES

<table>
<thead>
<tr>
<th>DATA COLLECTION</th>
<th>SKYGLOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLLECTOR FOR ARCGIS</td>
<td>SKY QUALITY METER</td>
</tr>
<tr>
<td>Collector can capture geolocated measurements for:</td>
<td>DARK SKY METER APP (IOS)</td>
</tr>
<tr>
<td>□ Shielding</td>
<td>CITIES AT NIGHT PROJECT</td>
</tr>
<tr>
<td>□ Fixture height</td>
<td>GLOBE AT NIGHT PROJECT</td>
</tr>
<tr>
<td>□ Lamp type</td>
<td>MY SKY AT NIGHT PROJECT</td>
</tr>
<tr>
<td>□ Color temperature</td>
<td>LOSS OF THE NIGHT APP</td>
</tr>
<tr>
<td>□ Lumens (Lux)</td>
<td></td>
</tr>
<tr>
<td>□ Footcandles (fc)</td>
<td></td>
</tr>
</tbody>
</table>

WHO CAN I CONTACT IF I HAVE QUESTIONS?
The International Dark Sky Association (IDA)
(520) 293-3198
http://www.darksky.org

The Colorado Plateau Dark Sky Cooperative
(435) 213-7026
https://cpdarkskies.org/
darksycooperative@gmail.com

The Consortium for Dark Sky Studies
http://www.darkskystudies.org/
daniel.l.mendoza@gmail.com
valspal13@gmail.com

National Park Service Natural Sounds & Nights Skies Division
https://www.nps.gov/orgs/1050/index.htm
randy_stanley@nps.gov
DARK SKY ASSESSMENT GUIDE

LIGHTING ISSUE CONCERNS & LAND USE
Another tool for documenting light pollution sources is to mark the number of issues (e.g. poor shielding, blue/white lighting color, excessive lighting) observed in relation to land use. This can help identify focus areas and large-scale opportunities. Color in the number of issues related to the “three-legged stool” observed in the radial table below. Optional “issue-related” color coding is suggested below. The goal is to be able to compare the size of the “pie slices” after the assessment.

PUBLIC ENGAGEMENT & EDUCATION
Community engagement is an essential part of any kind of community-wide initiative. The support of local leaders, residents, and business owners can be gained from talking to people on an individual level and addressing their concerns. Make an effort to talk to neighbors and friends about light pollution and educate them on the benefits of improved lighting.

2 MINUTE SURVEYS...
Ask residents and business owners about their experience with light pollution. As you survey people educate them about basic light pollution concepts and issues. Why should they care?

QUICK QUESTIONS
Is preserving dark skies important to you?

Would you support simple changes to limit light pollution?

What concerns do you have?

EDUCATE
Briefly explain why light pollution is an issue.

Describe why preserving the night sky is important to you.

Discuss the “three-legged stool” and simple ways to mitigate light pollution.
**MARKING A MAP**

Marking lighting issues on a map can help identify and document spatial clusters and provide a reference for others.

An official zoning map, Google map, or other reference map of your community can be used to document sources of light pollution as well as examples of “dark-sky friendly” lighting.

Some areas may require a map that is “zoomed in on an area” such as on main street or a sports park. Your assessment may include just publicly owned lighting or all lighting including commercial, residential, and open space. The scale and amount of detail are up to the community.

Marked lighting issues should relate to the “three-legged stool” but should also be tailored to your community’s specific dark sky assessment goals.

**IDEAS FOR WHAT TO MARK**

- Unshielded lighting
- Glare/ intense brightness
- Unnecessary lighting
- Blue/ White Colored Light
- Good lighting

**TAKING NIGHT PHOTOS**

Documenting light pollution is an important way for educating the public on the actual situation and to support a case for improved lighting.

**UNSHIELDED**

**SHIELDED**

**NIGHT PHOTO GUIDELINES**

The following are helpful guides on settings for taking certain types of photos at night. Remember, always use a tripod. These settings should be adjustable on the manual mode for any DSLR camera.

- **DSLR** stands for “digital single-lens reflex.” DSLR cameras are versatile cameras with changeable lenses that produce high-quality photos.

<table>
<thead>
<tr>
<th>Photo Type</th>
<th>Shutter</th>
<th>Aperture</th>
<th>ISO</th>
<th>Flash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signs</td>
<td>1/50</td>
<td>F/2.8</td>
<td>100</td>
<td>N</td>
</tr>
<tr>
<td>City Scape</td>
<td>1/320</td>
<td>F/4.5</td>
<td>100</td>
<td>N</td>
</tr>
<tr>
<td>Bridges</td>
<td>15/1</td>
<td>F/5.6</td>
<td>100</td>
<td>N</td>
</tr>
<tr>
<td>Street</td>
<td>1/5</td>
<td>F/4</td>
<td>320</td>
<td>Y</td>
</tr>
<tr>
<td>Monuments</td>
<td>15</td>
<td>F/16</td>
<td>250</td>
<td>Y</td>
</tr>
<tr>
<td>Life</td>
<td>6</td>
<td>F/9</td>
<td>100</td>
<td>Y</td>
</tr>
<tr>
<td>The Milky Way</td>
<td>20+</td>
<td>F/2.8</td>
<td>1600</td>
<td>N</td>
</tr>
</tbody>
</table>
CALCULATE THE SAVINGS

Many communities are now realizing the benefits of controlling energy waste through better-quality and better-designed lighting. Calculating potential energy savings and payback for upgrade conversions is another way to understand how adopting dark sky policies and best practices can benefit your community. Use the following formula from the Federal Department of Energy’s Exterior Lighting Guidelines to calculate an estimation of lighting power and energy use. Compare your current lighting energy costs with estimated energy costs of an upgrade conversion. Calculating an energy use estimation for prospective lighting replacements is an effective way to illustrate cost savings.

<table>
<thead>
<tr>
<th>BACK TO THE BASICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>W</strong> (watt) the standard unit of power in the International System of Units (SI)</td>
</tr>
<tr>
<td>• <strong>Wh</strong> (watt hour) a unit of energy equal to the power of 1 watt operating for 1 hour</td>
</tr>
<tr>
<td>• <strong>kW</strong> (kilowatt) a measure of 1,000 watts of electrical power.</td>
</tr>
<tr>
<td>• <strong>kWh</strong> (kilowatt hour) a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.</td>
</tr>
<tr>
<td>• <strong>Luminaire</strong> a complete lighting unit that usually includes the fixture, ballasts, and lamps.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIGHTING POWER &amp; ENERGY USE ESTIMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. COMPUTE THE TOTAL POWER (kW) USED BY THE EXISTING SYSTEM</strong></td>
</tr>
<tr>
<td>EXISTING LAMP OR LUMINAIRE WATTAGE</td>
</tr>
<tr>
<td>W x lamps = W</td>
</tr>
<tr>
<td><strong>2. COMPUTE THE TOTAL ENERGY (kWh) CONSUMED ANNUALLY BY THE EXISTING SYSTEM.</strong></td>
</tr>
<tr>
<td>TOTAL POWER CONSUMED BY SYSTEM LUMINAIRE</td>
</tr>
<tr>
<td>W x hrs/day x days/wk x wks/yr = kWh/yr</td>
</tr>
<tr>
<td><strong>3. COMPUTE THE TOTAL ENERGY COST (DOLLARS) ANNUALLY FOR OPERATION OF THE EXISTING SYSTEM.</strong></td>
</tr>
<tr>
<td>TOTAL ENERGY CONSUMED</td>
</tr>
<tr>
<td>kWh/yr $/kWh = $/yr</td>
</tr>
</tbody>
</table>

IN A NUTSHELL...

ENERGY = POWER x TIME
**SWOT ANALYSIS**

A SWOT analysis is a strategic planning and brainstorming tool that encourages participants to assess and reflect on the *Strengths, Weaknesses, Opportunities, and Threats* of a place, situation, or goal. Use a SWOT analysis to assess the strengths, weaknesses, opportunities, and threats that are relative to your community’s goal to preserve and protect dark skies (see example content below).

**SWOT ANALYSIS SUBJECT:**  *Star City USA - becoming a dark sky destination*

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Shared values among community members</td>
<td>- Lack of cultural resources</td>
</tr>
<tr>
<td>- Tourist destination</td>
<td>- Limited funding</td>
</tr>
<tr>
<td>- Friendly</td>
<td>- Perception town is anti-business</td>
</tr>
<tr>
<td>- Small town values</td>
<td>- Lack of destination facility</td>
</tr>
<tr>
<td>- Low population</td>
<td>- Vacant store fronts</td>
</tr>
<tr>
<td>- Historical assets</td>
<td>- Lack of rental housing</td>
</tr>
<tr>
<td>- Close to outdoor recreation</td>
<td>- Codes are too flexible</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Public education</td>
<td>- Light pollution from nearby city</td>
</tr>
<tr>
<td>- Retrofitable lighting</td>
<td>- Attitudes towards change</td>
</tr>
<tr>
<td>- Room to grow</td>
<td>- Afraid to try new things</td>
</tr>
<tr>
<td>- Explore astro-tourism</td>
<td>- Youth leaving</td>
</tr>
<tr>
<td>- Attract new businesses and families</td>
<td>- High employee turnover</td>
</tr>
</tbody>
</table>
NOW WHAT? AFTER YOUR DARK SKY ASSESSMENT

What you do after your dark sky assessment is almost as important as the assessment itself. Depending on your specific goals, the following steps can lead to an organized and effective action plan.

1. Debrief after the assessment
   - Hold a post-assessment meeting with all assessors.
   - Compile information, recording comments and clarifying notes.
   - Brainstorm and record suggestions for changes and improvements. Develop ideas for projects that take advantage of opportunities, improve strengths, strengthen weaknesses, or mitigate threats.
   - Invite participants to be involved in your project and identify how they will be committed.
   - Thank everyone for their participation and outline next steps.

2. Form a local Dark Skies Group
   (adapted from Advice on Starting a Local Dark Skies Group, Ed Stewart, Dark Skies, Inc., of the Wet Mountain Valley)
   - Educate yourself on the various aspects of light pollution.
   - Develop a core working group to support the initiative.
   - Build awareness and education through local media and social media.
   - Personally contact business owners and managers on the benefits of proper outdoor lighting.
   - Provide a vendors list of dark sky friendly fixtures to contractors, hardware stores, and home improvement businesses.
   - Contact the local power company for potential incentives or discounts on amber LED fixtures.
   - Individually approach town leadership to get a feel for local support.
   - Take the long-range approach. This may be seen as a “tree hugger” issue, but is about protecting the rural environment and quality of life.
   - Stay positive and focus on benefits and advantages: reduced power consumption, cost savings, improved quality of life, and improved potential tourism.

3. Pursue International Dark Sky Places certification
   - Provide the compiled report to local leadership, with suggested actions.
   - Gauge the level of willingness of local leadership to take action.
   - Outline the current project prioritization for leaders and ask leaders for input.
   - Examine the potential to become a dark-sky certified community at http://www.darksky.org/idsp/become-a-dark-sky-place/.

4. Plan action
   - Create an implementation plan based on prioritized projects or actions.
   - Identify potential funding sources as needed, required partners, and any needed changes to town code.
   - Plan completion of small simple tasks first to build momentum for larger projects.
   - Build critical mass—get the word out! Notify and continually engage and invite stakeholders, land owners, business owners and general public.

NOTES

IDA DARK SKY COMMUNITY
An IDA Dark Sky Community (DSC) is a town, city, or municipality that has shown exceptional dedication to the preservation of the night sky through the implementation and enforcement of quality lighting codes, dark sky education, and citizen support of dark skies.

Communities apply to the IDA who will make a decision in an average of one-to-two years from the initial request.

Requirements that must be maintained:
- Quality comprehensive lighting code
- Community commitment to dark skies
- Broad support from community organizations
- Community commitment to education on dark skies
- Success in light pollution control
- A continuing sky brightness measurement program

For full instructions and information: http://www.darksky.org/idsp/become-a-dark-sky-place/
ADDITIONAL RESOURCES

GENERAL
International Dark Sky Association: http://www.darksky.org
Colorado Plateau Dark Sky Cooperative: https://cpdarkskies.org
The Consortium for Dark Sky Studies: http://darkskystudies.org
Dark Sky Lighting Ordinance Walkthrough: https://utah.maps.arcgis.com/apps/MapSeries/index.html?appid=1cb7caaa1aa543dea3c813ec9f1f7f93#
CPDSC Educational Video Series: https://vimeo.com/user95912242
Interactive light pollution mapping tool: https://www.lightpollutionmap.info
Building Energy Codes Program: https://www.energycodes.gov/comcheck
The new world atlas of artificial night sky brightness: http://advances.sciencemag.org/content/2/6/e1600377.full
How to carry out a dark sky survey: https://darkskydiary.wordpress.com/2010/12/18/how-to-carry-out-a-dark-sky-survey/

RECREATION LIGHTING
Nordic Valley Night Skiing: 6,639,390 lumens and about 54 acres of skiable terrain (ratio of about 3 lumens per square foot). 6500 Kelvin color temp.

FLAG LIGHTING
Canopy lighting a parking lot light: See IDA model ordinance regarding lumens per gas pump and lumens per parking stall: http://darksky.org/our-work/public-policy/mlo/

TOWER LIGHTING
Federal Aviation Administration: https://www.faa.gov/regulations_policies/faa_regulations/

ILLUMINATION STANDARDS
Illuminating Engineering Society (IES): https://www.ies.org/standards/

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