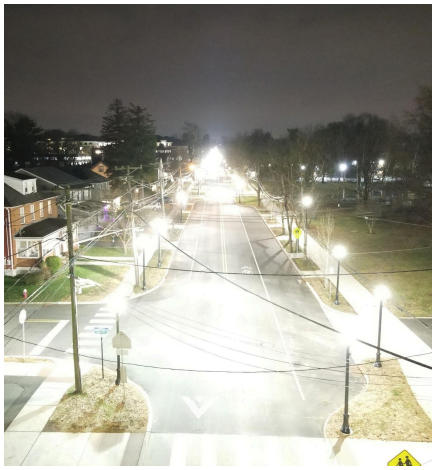
The Glaring Problem with Witherspoon's New Lights

Executive Summary

The recently installed GranVille LED Post-top Acorns lights on Witherspoon Street are **highly light-polluting fixtures, with an estimated 46% of the light wasted (glare + uplight), and are incompatible with any modern sustainability and environmental principles**, including Princeton's municipal code. The Witherspoon Street Improvement Project's lighting plan was based on the seriously outdated (12 year old) ANSI/IES RP-8-14 code, reflecting an early LED-transition framework not adequately addressing backlight, uplight and glare (BUG), or the impacts of blue-rich light, whereas more recent IES guidance and best practice emphasize full cutoff fixtures, reduced high-angle luminance, and warmer color temperatures—often 2700 K or lower—particularly in residential and historic contexts. The new lights are **blindingly harsh, causing a glare that poses a safety risk, as** recognized in recent lighting and vision studies. Their BUG rating (0 being best, 5 being worst) of 2-4-4 is grossly incompatible with modern sustainability and environmental practices, where U0 lighting is a solid standard, and backlight/glare is preferred at 0 or 1. The new lights are **predominantly blue (4000K), contrary to health recommendations from hundreds of peer-reviewed articles over the past two decades, which have linked long-term adverse health effects to such lighting**. Based on extensive photometric measurements, the new fixtures overlight the area multiple times, creating excessive contrast between Witherspoon and its side streets. The blinding of pedestrians as they turn onto Witherspoon and the disruption of night vision as they enter the side streets are again security concerns. Because of the lack of shielding, the buildings on both sides of Witherspoon are floodlit. The added glow from Witherspoon is now measurable as excess sky brightness at night from Princeton's golf course.

The new Granville GVD3 Holophane lights on Witherspoon, 2025 December.



Night view of Witherspoon, demonstrating the excessive, harsh, blue lighting and the spill of light (2025 December).

The fixture selection aims to preserve Princeton's historic character, but the Granville Holophane falls short in overall effect. The **new lights do not match Princeton's historic ambiance**, which was warm in color, modest in intensity, and directed downward to illuminate the roadway and sidewalk while leaving buildings, trees, and the night sky largely unlit. Most importantly, classic gas-lit fixtures were shielded on the top, and their color temperature was around 2000K, generating an atmosphere that felt intimate, calm, and cohesive. Their light output ranged from 100 to 500 lumens. By contrast, the new unshielded, high-intensity, cool (4000K) lighting conveys a stark, utilitarian character more typical of service or loading areas with an output of 5,500 lumens (10 to 50 times the brightness of historical lights). Details of the fixture are invisible at night, as they are too bright to see any of their features.

The new Witherspoon light, photographed from directly above by a levitating drone, demonstrates the spill in the night sky.

The new Witherspoon light from ~30 degrees above the horizon, demonstrating the enormous light spill to the sides and into the sky.

Obviously, the situation must be remedied on a short timescale. I suggest two ways forward.

As an immediate action item, before retrofitting, all light fixtures could be dimmed to 25% of their current brightness to avoid the ongoing damage to the environment and the ambiance. Alternatively, they can be turned off until the retrofitting is complete, returning the area's light levels to those present for many decades without these lights, which I measured at 0.2-0.4 FC on the sidewalks and 0.4-0.6 FC on the roadway, conforming to the lower value of Princeton's code based on IESNA standards (crosswalks were already all far in excess of 1 FC illuminance *without* the new lights, often at 2 to 4 FC).

RETROFIT OPTION 1. Replace all fixtures with PSEG's **Epic Medium fixture**, which is a decorative pendant-style outdoor luminaire designed for streets, parks, and urban spaces, and has a BUG rating of B1–U0–G1, i.e., full cutoff of uplight (U0). **It is an excellent light fixture with a wide range of modern, sustainable, safe, and healthy options, including warm color** temperatures of 2200K (amber) and 2700K, dimming options, and retrofit adapters. Later in this report, I provide a template letter to PSEG requesting this specific retrofit.

PSEG's EPIC Medium full-cutoff pendant-style outdoor fixture, which is fully dark-sky compliant.

A realistic simulation of Witherspoon street demonstrating the effect of the proposed retrofit from the current fixtures (left) to the **Epic Medium fixture, full cutoff, 2700K (right, simulated).** This proposed retrofit would achieve zero uplight, i.e., a BUG rating if U=0. The pendants could also be turned outward, toward the sidewalk. Illumination levels on the sidewalk would be perfectly consistent with Princeton's municipal code.

RETROFIT OPTION 2. The second, much less preferred option is r**etrofitting the existing GVD3-P20-40K-AS-3-N fixtures to be shielded, warmer, dimmer, and having better internal light distribution**. This can be achieved by replacing the internal LEDs from P20 to P10 (lower light output), adding the "lunar optics" (LU) feature, and changing the internal LEDs from 4000K

to 2700K. In addition, affixing the readily available "FC" full shield on top and adding "house shieldings" to reduce light trespass onto properties. i.e., retrofitting the luminaires to "GVD3-P10-27K-XXXXX-ZT-XX-GL3LU-BK-XX-XX-TBK-XX-FC". All these options are readily available from Granville and could have been specified in the original lighting plan. PSEG is reluctant to offer these subvariants. This retrofit would leave the existing lampposts and electrical distribution unaffected. Note that this retrofit option would still have significant uplight because the fixtures' geometry allows light to escape upward from the sides even with a full shielding cap on top. As with the Epic Medium, the light levels on Witherspoon would be consistent with the Princeton municipal code.

A full-cutoff retrofit with 2700 K and house-side shielding dramatically reduces glare and skyglow.

A realistic simulation demonstrating the effect of the proposed retrofit of Witherspoon Street, calculated from the relevant .ies engineering photometry files for each light fixture and rendered to the expected light output and illuminance. The current situation is shown on the left. The right side is the simulated rendering, based on the .ies files. Notice the decreased glare and the warm, inviting atmosphere.

Detailed calculations using the .ies photometry files for the relevant fixtures and subsequent simulations show that with the proposed retrofitting, the wasted light fraction (above 75°, i.e., glare, trespass, and uplight) would decrease from 46% to 21%, and the direct uplight component would decrease from 25% to 8%. The "**P10 + 2700 K + FC + LU + house-side shielding"** retrofit would result in a calmer roadway brightness, no visible uplight, and

significantly reduced glare. Measured photometry from the engineering files shows that a P10 Lunar optic with full cover reduces total high-angle light by nearly 40% compared to the current P20 configuration, while maintaining the same controlled angular distribution.

A realistic simulation demonstrating the effect of the proposed retrofit.

Retrofitting simulations

Below are several retrofit simulation results showing the visual effects of the proposed retrofits. These simulations use the IES photometric files and associated engineering data for the fixtures, when available. They are realistic approximations of the expected visual appearance.

A realistic simulation demonstrating the effect of the proposed retrofit from the current fixtures (left, photo taken in December 2025) to the **Epic Medium fixture, full cutoff, 2700K (right, simulated rendering).** This proposed retrofit would achieve zero uplight, i.e., a BUG rating if U=0. Notice the significant difference in light trespass: the houses remain dark, while the sidewalk is well lit.

A realistic simulation demonstrating the effect of the proposed retrofit from the current fixtures (left, photo taken in December 2025) to the **Epic Medium fixture, full cutoff, 2700K (simulated rendering using IES files).** This proposed retrofit would achieve zero uplight, i.e., a BUG rating if U=0. The area remains well-lit, with significantly improved visibility due to reduced glare.

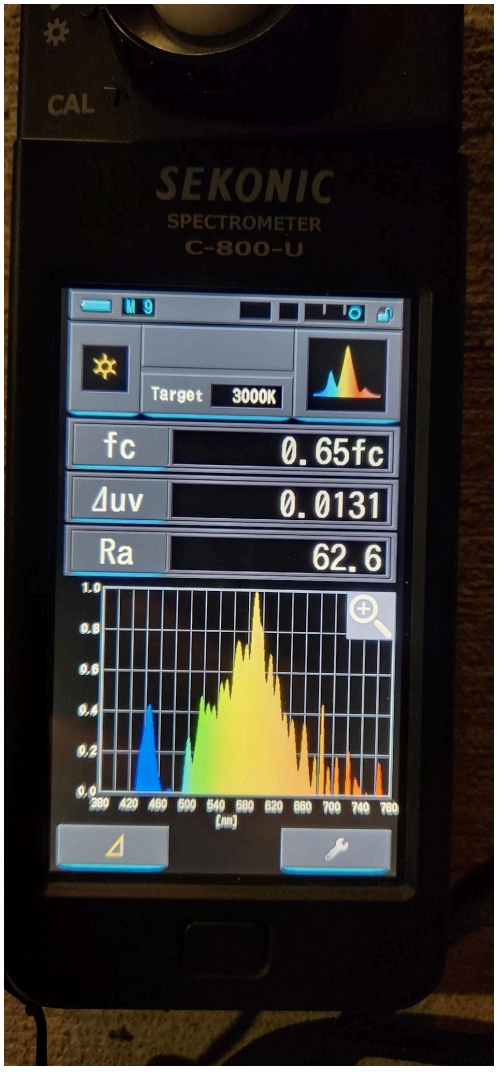
A realistic simulation demonstrating the effect of the proposed retrofit from the current GVD fixtures (left, photo taken in December 2025) to the GVD **P10 + 2700 K + FC + LU + house-side shielding (right, simulated)***, calculated from the relevant .ies engineering files and rendered to the expected light output and illuminance. Notice the decreased glare and the warm, inviting atmosphere.*

A realistic simulation demonstrating the effect of the proposed retrofit from the current fixtures (left, photo taken December 2025) to the **P10 + 2700 K + FC + LU + house-side shielding***, calculated from the relevant .ies engineering files and rendered to the expected light output and illuminance. Image taken from right above the fixture.*

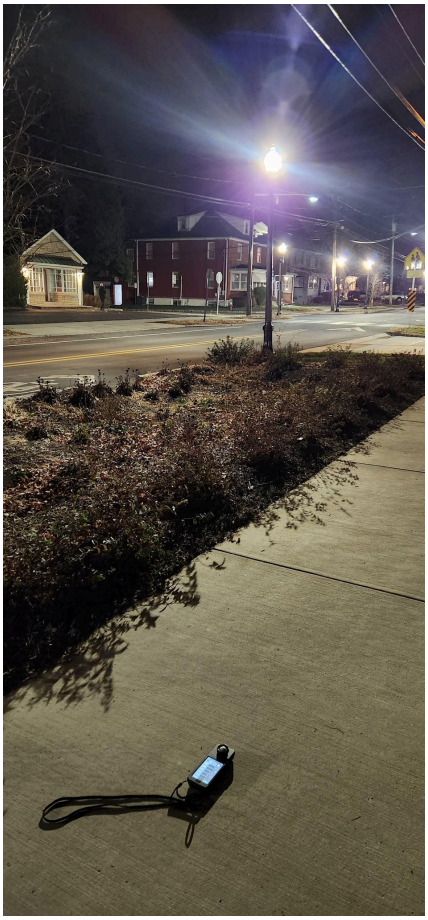
Measurements and Imagery

I conducted extensive photometry and photography on Witherspoon Street on seven nights in December 2025. Selected results are shown below. I used a wide range of instruments, including 4 photometers, including the highly advanced Sekonic C-800 spectrophotometer and the high-sensitivity Konica Minolta T-10A. I also used a color-temperature calibrated Canon 6D and a DJI Mavic Drone.

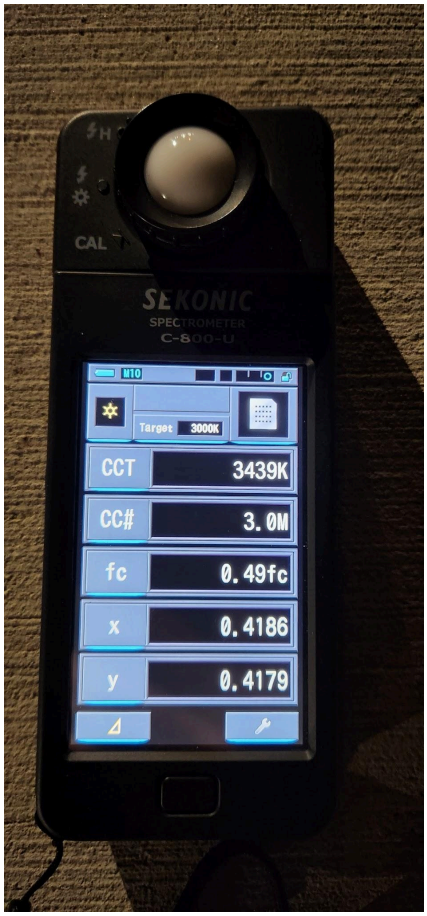
Spectrophotometric measurements on the sidewalk, moderately close to a light fixture.



The illuminance is 0.65FC, which is about 2-3x brighter than the IESNA recommendations for minimum sidewalk lighting. The overall spectrum is blue, with a significant, harmful spike at 430nm. (While we don't directly sense the spike, as it is overwhelmed by the less blue light, it is present, and is harmful for e.g. melatonin production, and also causes strong atmospheric scattering).



Spectrophotometric measurements on the sidewalk, at the darkest possible location, in between poles, and as far as possible from streetlights.



The illuminance is 0.5C, approximately 2x the IESNA recommendation for minimum sidewalk lighting.

Spectrophotometric measurements on the sidewalk, at the brightest possible location, with illumination coming from both sidewalk and streetlights.

The illuminance is 1.9FC, which is about 7-8x brighter than the IESNA recommendations for minimum sidewalk lighting.

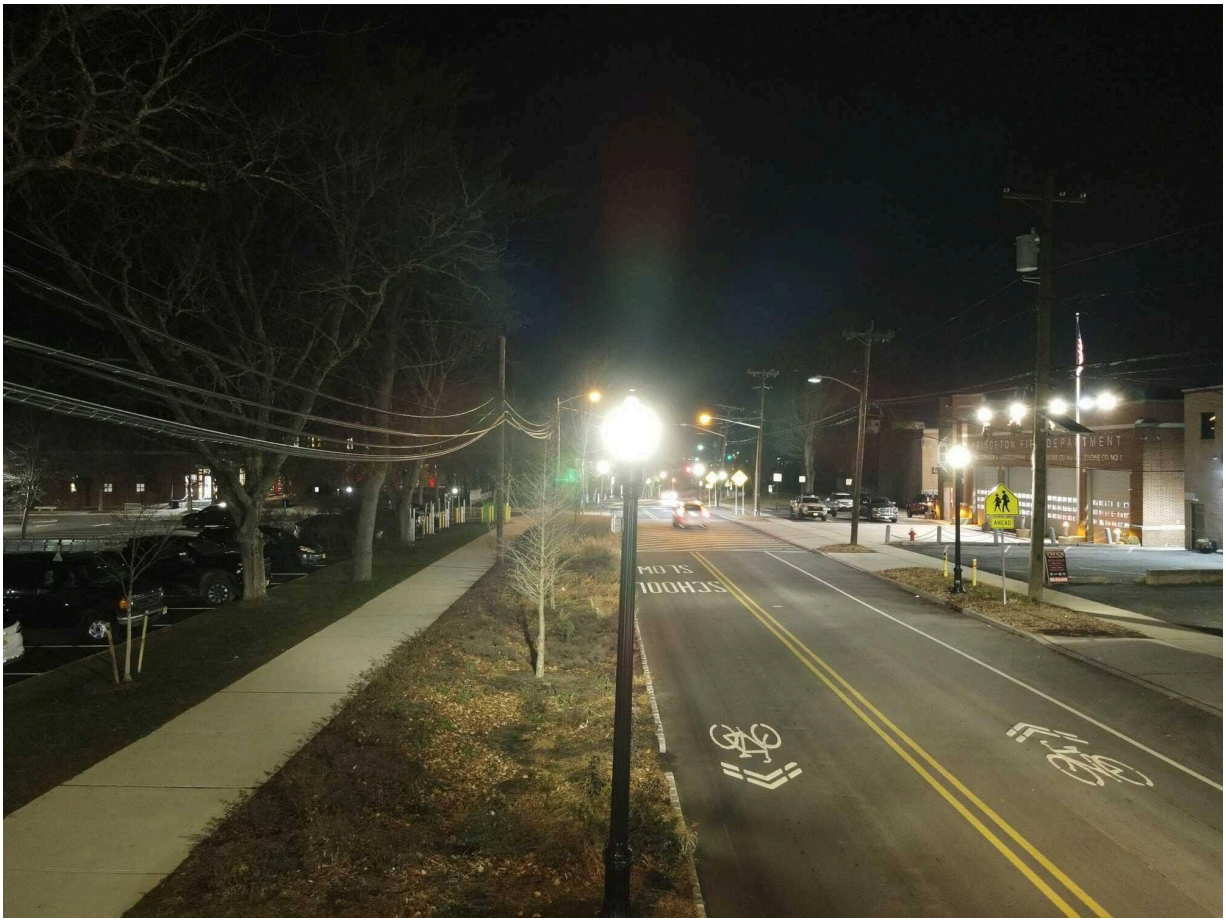


Photo taken horizontally, at the exact same height as the luminaire. Notice the excessive glare and light trespass. This is technically referred to as a 90-degree light-emission angle (0 is toward the nadir, 90 is horizontal, 180 is zenith).

Photo taken from +10 degrees above horizontal (100 degrees).

Photo taken from +30 degrees above horizontal (120 deg).

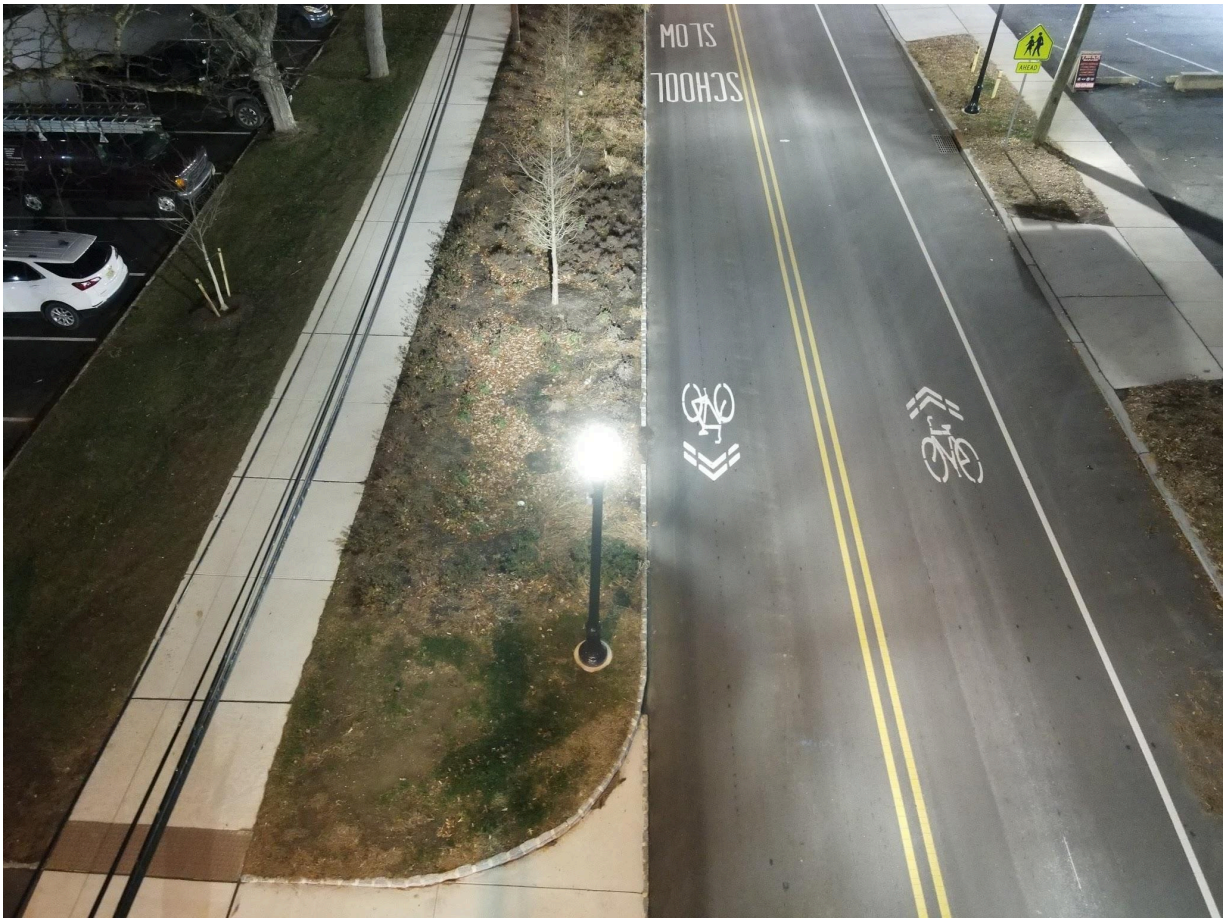


Photo taken from 45 degrees above horizontal (135 deg).

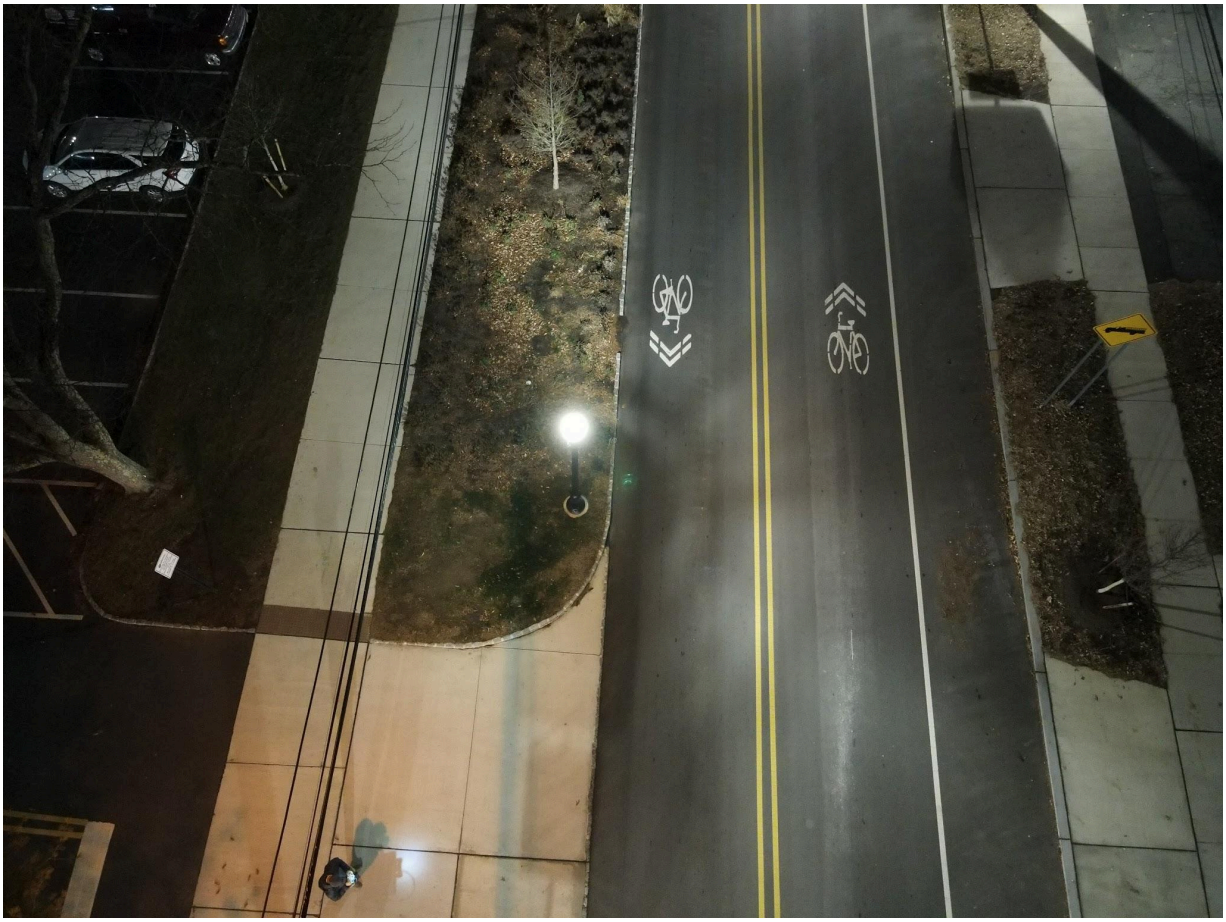
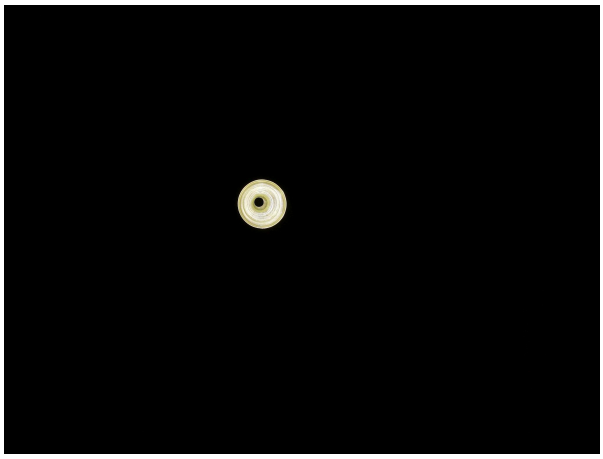


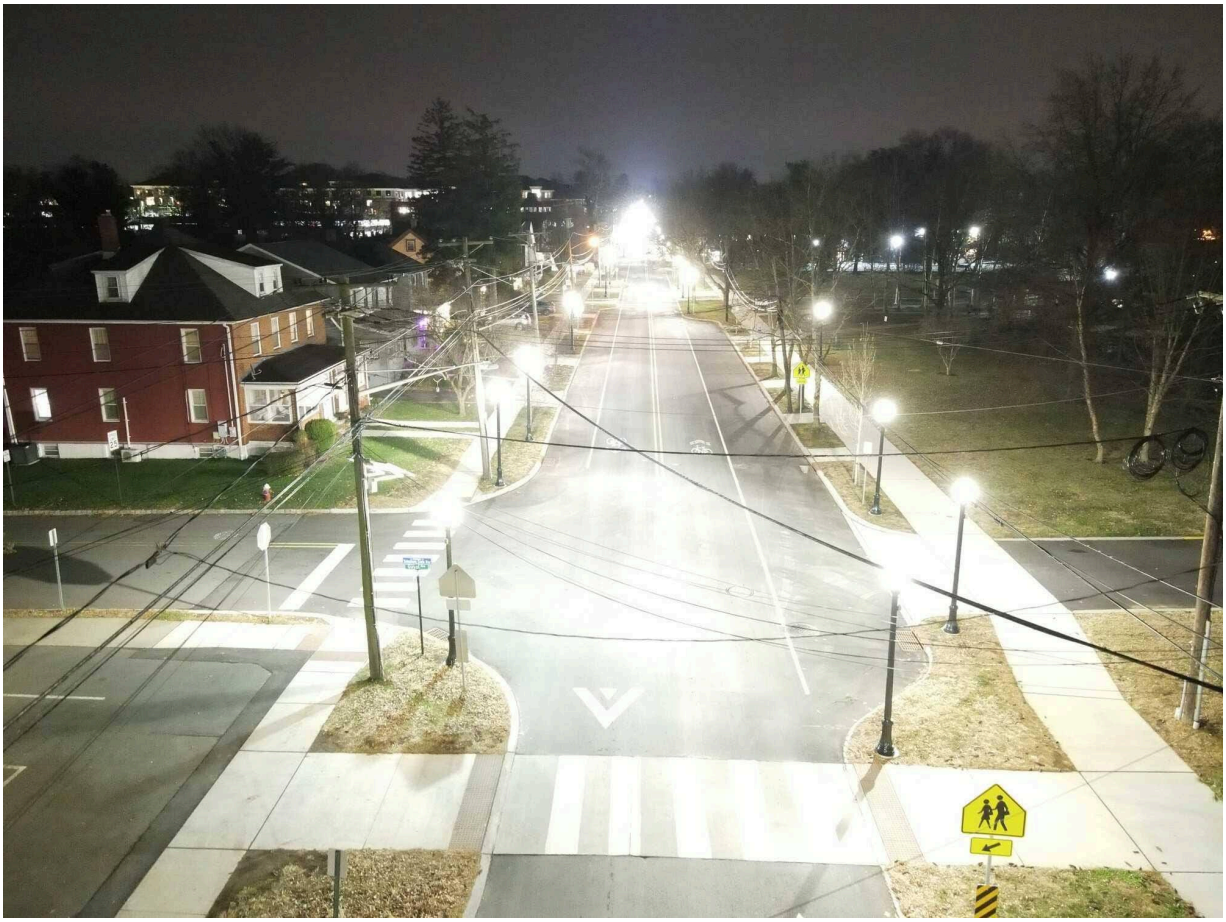
Photo taken from 60 degrees above horizontal (150°). Note that in order to achieve an accurate angle measurement, the drone was lifted up with fixed horizontal coordinates, thus the distance between the drone and the fixture was increasing, which leads to a dimmer appearance. Also, note that large patches of shaded rings under the fixture are due to poor design and the base's support, which shields the light from illuminating the ground.

Photo taken from 85 degrees above horizontal, i.e., almost overhead (175 °). Notice the huge light loss directly emitted in the sky.

Ultrashort exposure (1/1000th sec) photos to measure the light emission pattern of the fixture. This is the 135° view (45° above horizontal).



Ultrashort exposure (1/1000th sec) photos to measure the light emission pattern of the fixture. This is the 180 ° view, directly overhead.



Witherspoon Street from about 10m above ground. The image demonstrates overlighting and harsh lighting with a strong glare and an uplight component.

Witherspoon Street view showing everything: strong blue glare from the new fixtures; flathead halide cobrahead streetlights "overshadowed" by the new lights; one older sodium cobrahead with an orange color representing the ~2000K amber color. The glare dominates the view, reducing visibility of drivers before reaching the pedestrian crossing. This is a textbook example of more lights not improving the overall visibility.

Witherspoon Birch intersection. The light level on Witherspoon is conservatively estimated to be 20x that of Birch.

Turning into Birch Street, essentially pitch dark with eyes still blinded from the glare of Witherspoon.

The new lights floodlight residential properties up to roof level.

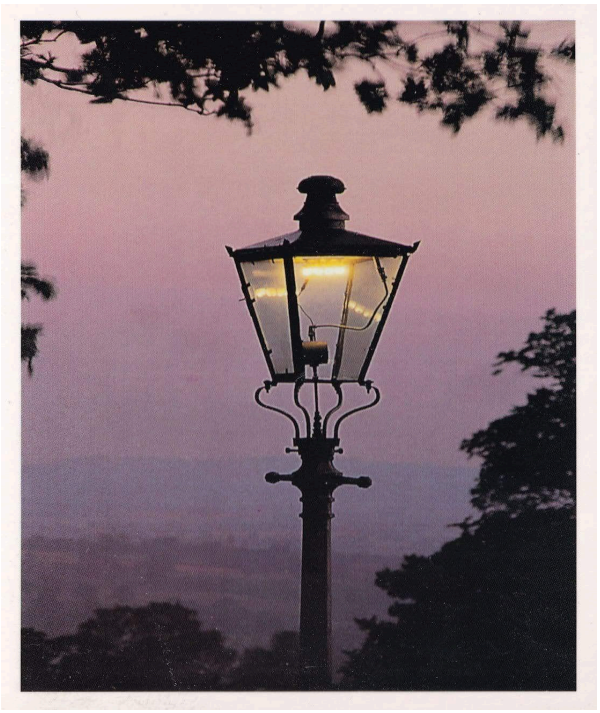
Properties on the Witherspoon are floodlit to the top.

Historical Lighting

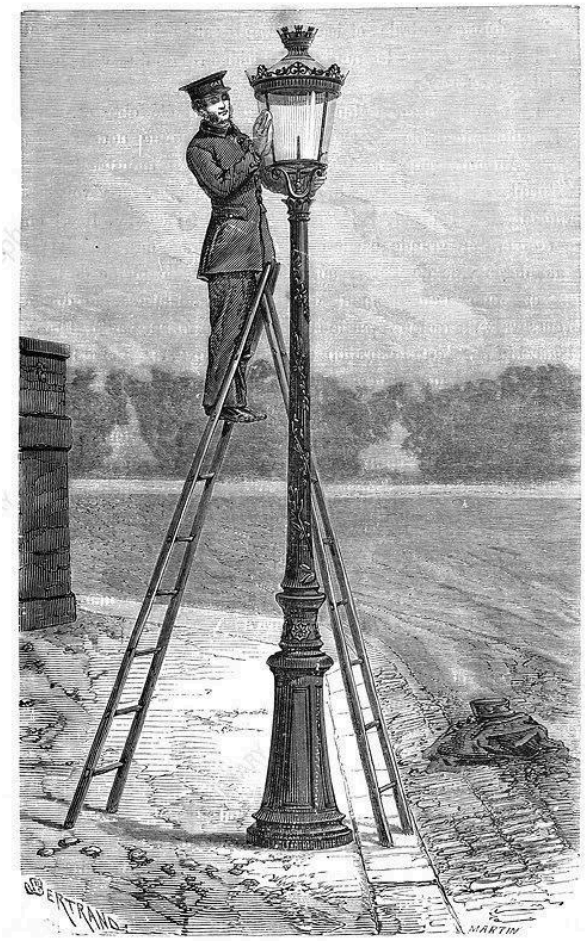
Historic street lighting in Princeton in the 19th and early 20th centuries relied on warm, low-intensity illumination intentionally shielded from above. Gas and early electric street lamps commonly incorporated opaque metal caps, crowns, or internal reflectors that prevented upward light escape, directing illumination downward toward the street and sidewalk. As a result, these fixtures produced no visible uplight and did not illuminate tree canopies, building façades, or the night sky. The nighttime environment was defined by localized pools of warm light and surrounding darkness, creating a calm, human-scaled streetscape that emphasized orientation and safety without glare or skyglow.

Historic gas street lamps were deliberately designed with opaque crowns to prevent upward light and direct illumination downward. As a side result, they preserved the darkness of the night sky.

Historical gas lights. Notice the cover on the top and the vertical "ribbons" supporting the shield.



Historical gas lights. Notice the shield on top.



Historical gas lights. Light was expensive because it burned gas, so most fixtures were fitted with a reflective top shield.

Historical gas lights. This version resembles the Penn-Globe fixtures used at Princeton University's campus.

The classic Paris "gas lamp" fixtures span a couple of generations:

- Early flat-flame gas lamps (mid-1800s Paris): about 10 candlepower per burner
- Welsbach (incandescent mantle) gas lamps (early-1900s): about 35–40 candlepower for the improved mantle type.

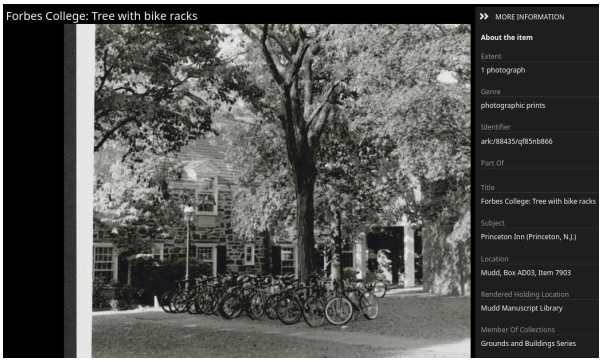
Converting these to lumens by multiplying the candlepower by 4π yields an **estimated brightness of 50 to 500 lumens for the historical gas lights**. I**n comparison, the current Witherspoon lights are 5,500 lumens (10–100x brighter) and are uncomfortably bright, making it hard to see** their features at night. Of course, standards have changed in the meantime, requiring a higher level of illumination, but the point is that the **current Witherspoon fixtures do not copy the classic appearance of old-style gas lights, neither in the daytime (missing top shield), nor in the nighttime (features are invisible due to glare).**

The proposed street-lighting retrofit restores the historic nighttime character of Princeton's streetscape. Historically, Princeton's public lighting was warm in color, modest in intensity, and directed downward to illuminate the roadway and sidewalk while leaving buildings, trees, and the night sky largely unlit. The existing lighting installation produces excessive brightness, glare, and uplight, all of which are incompatible with this historic character. The proposed retrofit—incorporating a 2700 K light source, reduced distribution, full-cutoff shielding extending to the fixture's widest rim, and house-side shielding—restores lighting behavior consistent with historic precedent while retaining the existing fixture form. The proposed retrofits will be context-sensitive, visually compatible with the historic district, and supportive of preservation objectives.

Below are examples of Princeton's classical lighting, demonstrating that all fixtures were shielded from the top and that many had supporting or decorative vertical "ribbons" on the sides.

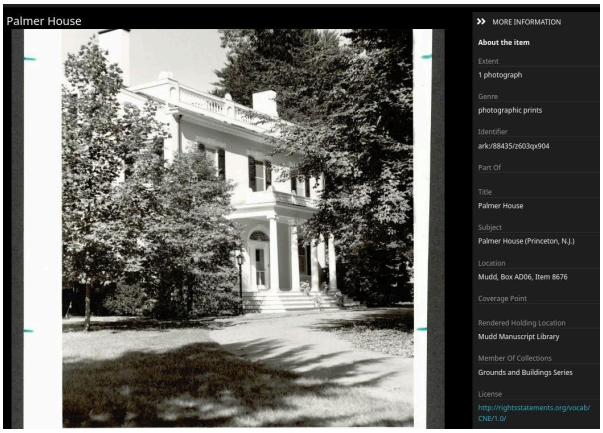
Princeton Chapel, maybe 1940. There were altogether 4-6 light fixtures around the Chapel.

Note the shielding on the top.



Forbes area, 1970s?

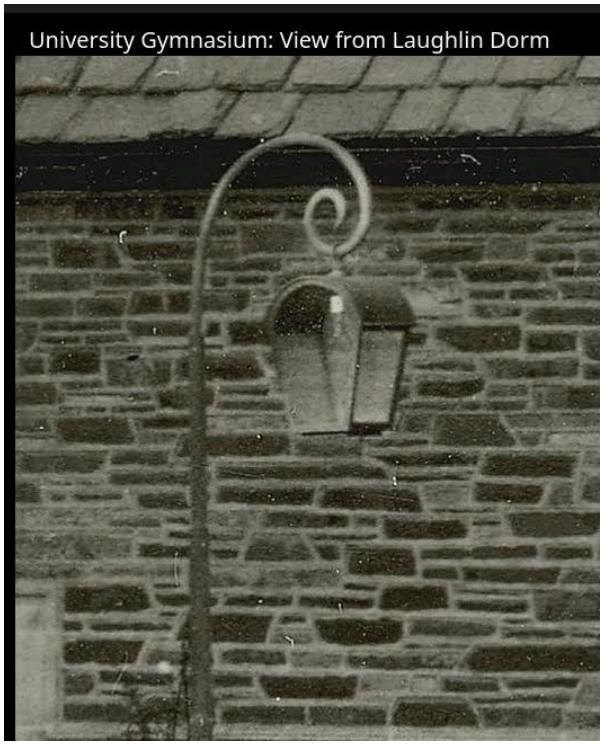
Classic Penn-Globe fixture with shield on top.



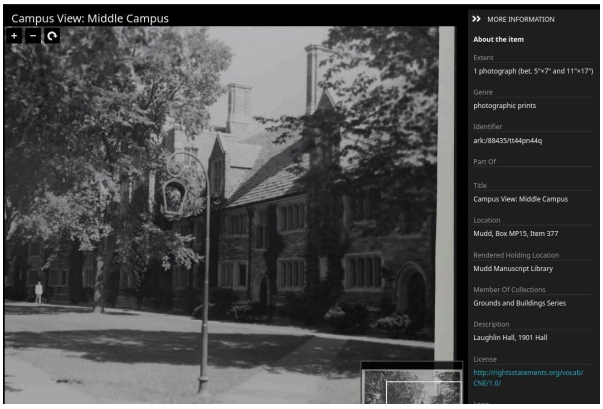
Palmer House, 1930s?

Top shield, side ribbons.

University Gymnasium, 1905



Notice the shield, ribbons, and asymmetric light distribution.



Laughlin Hall, 1901

Top shield, side ribbons for vertical support.

Glare

Executive summary: disability and discomfort glare steeply increase with a lack of shielding and blue color, and are also strongly age-dependent. The current GVD3 fixtures at Witherspoon match all these criteria and cause excessive glare for both pedestrians and drivers.

The **Illuminating Engineering Society** distinguishes:

- **Disability glare:**
  - Light scattered in the eye
  - Reduces contrast and visual acuity
  - Makes it harder to see *past* the light

- **Discomfort glare**

  - Sensation of brightness, annoyance, or harshness
  - Does not necessarily reduce acuity
  - Strongly affects pedestrian experience

Spectrum affects *both*, but disability glare is especially problematic. Light scattering in the eye (and atmosphere) follows approximately a λ^{-4} relationship, where λ is the wavelength of the light (classic Rayleigh scattering). Blue light (~450 nm) scatters much more than amber (~600 nm). The greater the scatter, the greater the veiling luminance and the higher the glare. The key point is that at equal lumen output, a 4000 K LED produces more disability glare than a 2700 K LED. Please see references below (Vos 2003, van den Berg 1995).

Discomfort glare—the sensation of harshness or visual annoyance—is also **spectrally dependent**. Studies show higher discomfort ratings for cooler (blue-rich) sources at the same illuminance. **4000 K light is consistently rated as more uncomfortable than 2700–3000 K light**, especially when the source itself is visible.

Blue light also scatters more in the atmosphere, increasing **skyglow** and the perceived brightness of haze or low clouds.

Altogether, Vision science and IES guidance show that blue-rich light scatters more strongly in the eye and atmosphere and is perceived as disproportionately brighter at night; consequently, a 4000 K luminaire produces substantially more disability and discomfort glare than a 2700 K luminaire at the same lumen output. **The estimated glare difference between 2700K and 4000K is a factor of 2, based on the references below.**

Age Dependence

As the eye ages, the crystalline lens and ocular media develop microscopic irregularities that **scatter light**. This scattered light produces **veiling luminance** across the retina, which is the primary mechanism behind **disability glare**. Straylight in a healthy eye increases by **~2-3×** between young adulthood and age 65–75. The increase is continuous; it is not limited to cataract patients (van den Berg 2007, Vos 2003). Because of increased scatter, the same luminaire causes significantly greater functional impairment for older observers: reduced contrast sensitivity, slower detection of pedestrians and obstacles, and longer recovery time after exposure to bright sources. This effect is strongest for: **high-angle light** (75–90°), **visible sources, blue-rich spectra (Owsley 2001, Elliott 2014).** In summary, vision science shows that intraocular light scatter increases substantially with age, causing older adults to experience significantly greater disability glare from the same lighting conditions, particularly from high-angle and blue-rich sources. This is why modern best practice emphasizes: cutoff optics, lower high-angle luminance, warmer spectra.

Princeton must recognize that glare affects residents unequally. Vision science shows that older adults and individuals with visual sensitivities experience significantly greater glare and contrast loss under the same lighting conditions due to age-related increases in light scatter within the

eye. **High-angle, blue-rich lighting therefore creates a disproportionate burden for seniors and others with reduced visual resilience, making nighttime walking and navigation less comfortable and potentially less safe.** By reducing high-angle light, limiting uplight, and specifying a warmer color temperature, the proposed lighting retrofit improves nighttime accessibility and comfort for a wider range of users, supporting an equitable and inclusive public realm consistent with Princeton's community values.

Princeton, NJ, Municipal Outdoor Lighting Code

Executive summary of the code, relevant to our case

Princeton's municipal lighting ordinance requires that outdoor street lighting be adequately shielded to prevent glare, uplight, and light trespass, with shielded fixtures defined as allowing no direct light emissions above 90 degrees for street lighting and strictly limiting high-angle output above 80 degrees. The ordinance expressly identifies glare, sky glow, and misdirected light as adverse impacts to be avoided and requires that lighting be designed, installed, and maintained to reduce unnecessary glare and prevent objectionable direct light emissions visible from adjacent properties. Illuminance levels must not exceed IES recommendations, which are treated as maximums rather than targets, and the ordinance explicitly discourages overlighting in favor of energy efficiency and contextual appropriateness. In residential and historic areas, lighting style, intensity, and distribution must be consistent with neighborhood character, with particular emphasis on shielding, limiting light trespass onto buildings and vegetation, and avoiding visually intrusive or industrial-appearing fixtures. **Taken together, these provisions favor fully shielded, low-uplight, low-glare street lighting with controlled lumen output and context-appropriate appearance, and provide a clear regulatory basis for modifying or retrofitting high-output or partially unshielded fixtures such as the GVD3 to reduce high-angle light, glare, and excessive brightness.**

Princeton's code

Highlighted are parts that are particularly relevant to our case.

§ B17A-365 Lighting and sound systems.
(a) The provisions of this section shall apply to all principal uses, secondary residence uses and accessory uses or activities permitted within R1, R2, R3 and R4 districts or located within 200 feet of the boundary line of any such R1, R2, R3 or R4 district, and to all nonconforming uses so located.

(b) Any outdoor lighting shall be **adequately shielded and directed away from the adjoining properties**.

(c) No public address system or loudspeaker devices shall emit noises which can be heard beyond the property lines.

(d) The permanent illumination of all or any part of a building, such as a façade, gable, roof, side wall or corner shall not be permitted, except as allowed by the board of adjustment as a decision upon a special question.

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§ B17A-365.1 Lighting.

(a) **Purpose.** Regulation of outdoor lighting including recreational and sports facility lighting is necessary to prevent the cause of unnecessary sky glow, to prevent light trespass and to reduce unnecessary glare caused by inappropriate or misaligned light fixtures and/or the inappropriate location of light poles. These standards are intended to promote energy efficiency, preserve and protect adjacent residential neighborhoods from unnecessary lighting impacts and discourage overlighting consistent with public safety.

(b) **Definitions.**

- **AUTOMATIC TIMING DEVICE:** A switching device, a part of which is a clock, set to the prevailing time (Eastern Standard Time or Daylight Saving Time), that will control the period of illuminating outdoor light fixtures and outdoor signs.

- **FOOT-CANDLE:** The measurement of light on a surface of one square foot in area on which there is uniformly distributed a light flux of one lumen.

- **GLARE:** The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility.

- **LIGHT TRESPASS:** Any form of artificial illumination emanating from a light fixture or illuminated sign on a property that penetrates across the property line or lines into another property.

- **MOTION SENSOR DEVICE:** A device that will sense motion electronically and switch on security lighting during the activity and for a brief duration thereafter.

- **OBJECTIONABLE DIRECT LIGHT EMISSIONS:** Direct light emissions visible above a height of five feet at the subject property line. A bulb, a reflective device, a refractive lens device, a globe, or diffuse panels, shall be considered a direct light emission source.

- **OUTDOOR LIGHT FIXTURE:** An electrically powered illuminating device containing a total light source of more than 1,800 initial lumens per fixture … permanently installed outdoors, including but not limited to devices used to illuminate any site, architectural

structure, or sign.

- **SHIELDED LIGHT FIXTURE:** A light fixture with cutoff optics that allows no direct light emissions above a vertical cutoff angle of 90° for street lighting and 80° for all other lighting, through the light fixture's lowest light-emitting part. Any structural part of the light fixture providing this cutoff angle must be permanently affixed.

(c) **Standards.**

(1) Only shielded light fixtures shall be used. Any fixture mounted above 10 feet shall have no more than 10% of its light distribution at a vertical angle of 80° above nadir and 2.5% at an angle of 90° above nadir.

(2) Where used for commercial, educational, or institutional purposes or for sports or recreational facilities, all light fixtures shall be equipped with automatic timing devices set to be turned off during non-operating hours or when not necessary for safety and security purposes.

(3) Light fixtures used to illuminate flags, statues or other objects mounted on a pole, pedestal or platform shall use a narrow column beam of light that will not extend beyond the maximum extension of the illuminated object.

(4) Other upward directed architectural, landscape or decorative direct light emissions shall have at least 90% of their total distribution pattern within the profile of the illuminated structure.

(5) Lighting for freestanding signs shall use shielded light fixtures or other device(s) to shield the light source.

(6) All outdoor lighting shall be metal halide, incandescent, light emitting diode (LED), induction or compact fluorescent unless otherwise approved by the board of jurisdiction.

(7) When not necessary for safety and security purposes all outdoor lighting during nonoperating hours of the business or use shall be turned off by 11:00 p.m. or limited to parking areas essential for night use. The use of motion-sensor devices is permissible in all parking lots or walking paths.

(8) All lighting shall be designed to prevent misdirected or excessive artificial light and to be energy efficient.

(9) All light fixtures shall be designed, installed and maintained to prevent **light trespass**.

(10) Illumination levels shall not exceed those recommended in the **IESNA Lighting Handbook**, 8th Edition, and IESNA publication RP 6-88, Sports Lighting.

(11) Except for lights located along public or private streets, the maximum height of freestanding lights shall not exceed the height of the principal building, or 14 feet, whichever is less in residential zones, historic districts or properties adjacent to residential zones or uses; in nonresidential zones where the light will not be seen from a residential use a height up to 20 feet is permitted.

(12) The style of the light and light standards (poles) shall be consistent with the architectural style of the principal building or surrounding area. Nonresidential uses constructed in residential areas shall maintain a residential character in the type and style of lighting installed. In historic districts the style of the light and light standards shall comply with the district requirements.

(13) Floodlight-type fixtures attached to buildings shall be prohibited unless other lighting is not

suitable for its intended use.
(15) All wiring shall be underground.

(d) **Illuminance Requirements (excerpt).**
(1) **Street lighting:** Average maintained illuminances shall not exceed IESNA recommended ranges and be consistent with safety standards. Lighting fixtures shall be chosen to blend into the existing character of the area. Examples:
• Arterial roadway nonresidential area: 1.2–1.7 fc
• Arterial roadway residential area: 0.6–0.9 fc
• Local roadway residential area: 0.4–0.3 fc
(2) **Open parking facilities:** Average and minimum foot-candle levels depend on level of activity (0.2–1.0 foot-candles).
(3) **Walkways:** Minimum average foot-candles (e.g., residential walkways: 0.2).
(4) **Light trespass:** At the property line, illumination from light fixtures shall not exceed 0.1 fc on residential property or 0.5 fc on nonresidential; outdoor fixtures must be directed so there will be **no objectionable direct light emissions**.

(e) **Site Plan Requirements.**
Plans for all lighting other than street lighting shall include:
(1) Description of outdoor lighting fixtures including component specifications such as lamps, reflectors, optics, angle of cutoff, supports, poles, color of lighting and include manufacturers' catalog cuts.
(2) Location and description of every outdoor light fixture and hours of operation.
(3) Photometric grid showing foot-candle readings.
(4) Other details including pole foundations.
Use of IES recommendations requires supporting documentation.

IESNA vs. ANSI/IES

As you may have noticed, Princeton's lighting code refers to the Illuminating Engineering Society of North America (IESNA) standards instead of ANSI/IES. In contrast with our code, the design of Witherspoon relies on an antique 2014 ANSI/IES code (ANSI-IES-RP-8-14).

This is deliberate. Relying on IESNA:

- Avoids frequent code amendments
- Automatically tracks evolving best practice
- Allows:
    - Lower CCT (e.g., ≤2700 K)
    - Improved glare control
    - Dark-sky-friendly designs
- Reduces the risk of being stuck with outdated assumptions.

In contrast, utilities prefer ANSI/IES, as it has:

- Fixed targets
- Predictable liability exposure
- Conservative lighting levels

Hence, continued reliance on **RP-8-14**, even though it is superseded.

Princeton's approach in its municipal code is **quite modern and intentional**. However, the design of Witherspoon's upgraded lights did not comply with Princeton's code; instead, it used the outdated ANSI/IES RP-8-14 (2014) standard, missing many features from the past ~12 years. ANSI/IES RP-8-14 (2014) was developed during the early transition to LED roadway lighting and is now widely regarded as outdated because it relies primarily on illuminance-based criteria and does not adequately address the high luminance, glare potential, and spectral impacts of modern LED sources. Subsequent IES guidance and industry practice have shifted decisively toward controlling luminaire luminance, high-angle light, and source visibility, recognizing that LED glare and disability glare can persist even when illuminance targets are met. **Newer frameworks place far greater emphasis on limiting uplight and sky brightness through full cutoff optics, quantifiable BUG (Backlight-Uplight-Glare) ratings, and reduced high-angle output, as well as on minimizing light trespass beyond the intended roadway.** In addition, post-2014 research has led to **broad adoption of warmer color** temperatures—typically 3000 K or lower, and often 2700 K in residential or historic contexts—to reduce glare, skyglow, and blue-light impacts. As a result, contemporary best practice has moved beyond RP-8-14 toward a more holistic, LED-specific, dark-sky-aligned approach that prioritizes visual comfort, environmental protection, and contextual appropriateness rather than maximizing brightness.

Princeton University Master Lighting Plan Excerpts

Princeton University recently adopted its 2025 Master Lighting Plan, and I was part of multi-year discussions with lighting engineers and other stakeholders to shape it. Here are some important points from the plan that are highly relevant for the entire municipality.

Princeton's campus was split into 3 lighting zones: LZ0 (highly protected, environmentally fragile area), LZ1 (moderate traffic), and LZ2 (higher pedestrian/vehicular traffic). More than half of the campus falls in LZ2. Even in LZ2, the BUG rating limitation for fixtures is at least B-U-G = 2-0-2 (i.e., zero uplight).

The following are selected direct quotes from the plan:

"The Princeton University Outdoor Lighting Masterplan establishes a comprehensive strategy for enhancing campus lighting with a focus on safety, ***light pollution mitigation, and environmental responsibility.*** *[...] Human-scale lighting fixtures,* ***warm color temperatures***

(2700K), and glare control features are prioritized *to create safe, comfortable, and inviting environments for students, faculty, staff, and visitors. The plan supports the University's goals by adopting energy-efficient LED technologies, smart lighting controls (motion sensors, time-based dimming), and systems that limit lighting to when and where it is needed.* ***In alignment with International Dark Sky Association principles, the plan minimizes light pollution through fully shielded luminaires, downward-directed light, and reduced uplight****—especially near sensitive ecological zones like Lake Carnegie and wooded perimeters."*

"The exterior lighting shall favor warm tones and shall complement Princeton's architectural identity. Fixtures shall be discreet, using low-profile forms and maintaining a consistent design. The fixtures shall preserve the visual integrity of the built and natural environment while meeting current standards for safety and efficiency."

"In line with Princeton's dedication to environmental stewardship, the ***exterior lighting design will emphasize the reduction of light pollution through the use of directional fixtures and shielded luminaires.*** *These strategies protect ecosystems, improve well-being, and preserve the night environment. Lighting near ecologically sensitive areas, such as Lake Carnegie, shall be designed to minimize environmental disruption. Shielded and downward-directed fixtures aim to reduce sky glow and glare in order to preserve natural habitats and maintain biodiversity."*

*"****One of the most widespread myths in lighting design is the belief that simply increasing brightness leads to better visibility. In reality, over-lighting an area can be counterproductive. High light levels can lead to the 'black hole effect,' where brightly lit zones cause adjacent areas to appear even darker by comparison****, making the surroundings feel more threatening or ambiguous. Over-illumination wastes energy and disrupts ecological conditions without necessarily improving functional visibility. Effective design requires targeted, appropriately scaled lighting that prioritizes visual clarity, not just brightness."* [Note added by GB: this is exactly the case for all the side streets of Witherspoon.]

*"The Princeton University Outdoor Lighting Masterplan adheres to standards established by the Illuminating Engineering Society of North America (IESNA), which define recommended light levels (measured in foot-candles or lux) for various types of outdoor environments." [*Note by GB: not ANSI/IES RP-8-14].

"To align with Princeton's sustainability initiatives and Dark Sky standards, the campus lighting should incorporate techniques to reduce light pollution and trespass. This includes well-shielded fixtures to reduce glare, restricting uplighting to limit contributions to sky glow, and controlling backlight to minimize light trespass."

*"****Warm-colored lighting, ideally with a color temperature of 2700 Kelvin (K) or lower,*** *can reduce the harmful effects of blue-rich light."*

A Sample Retrofit Request Letter for replacing the GVD3 fixtures with Epic Medium Fixtures

Dear PSE&G Outdoor Lighting Services Team,

The Municipality of Princeton is requesting a review and modification of the recently installed decorative street lighting along Witherspoon Street. Based on field observations and community feedback, the current fixtures are producing excessive glare, high-angle light, and unnecessary illumination of adjacent building façades and tree canopy, which is inconsistent with Princeton's municipal lighting ordinance, historic context, and adopted dark-sky and sustainability objectives.

To address these concerns while maintaining public safety and appropriate roadway illumination, Princeton proposes replacing the existing fixtures with **Epic Medium decorative luminaires**, configured to emphasize glare control, shielding, and context-sensitive illumination. Specifically, the Municipality requests that the Epic Medium fixtures be specified with a **fully shielded, full-cutoff optical configuration (U0)**, a **warm color temperature (2700 K)**, and a **reduced lumen package equivalent to a P10 output level**, or the closest available Epic Medium configuration that achieves comparable performance.

The Epic Medium fixture is well-suited to this application due to its precise optical control, minimal uplight, and discreet visual profile, all compatible with Princeton's historic streetscape. A fully shielded Epic Medium configuration would significantly reduce direct source visibility, high-angle glare, and sky glow, while still delivering uniform, functional illumination of the roadway and sidewalks. The warmer color temperature further improves visual comfort, reduces perceived glare—particularly for older pedestrians—and aligns with Princeton's environmental stewardship and dark-sky goals.

Princeton's municipal code requires outdoor street lighting to be adequately shielded, to prevent objectionable direct light emissions, to limit high-angle output, and to avoid overlighting. **Illuminance levels must not exceed IES recommendations, which are treated as maximums rather than targets, and lighting design must be consistent with the neighborhood character, particularly in residential and historic areas.** The proposed Epic Medium retrofit directly implements these requirements while preserving safety, energy efficiency, and maintainability.

We respectfully request that PSE&G and its lighting vendor review the feasibility, specifications, and cost implications of replacing the existing fixtures with the proposed Epic Medium

configuration, and confirm the availability of optical, lumen, and shielding options. Princeton is prepared to coordinate further on technical details, photometric documentation, and scheduling to ensure a smooth transition.

Thank you for your attention to this matter and for your continued collaboration in supporting lighting solutions that meet Princeton's safety, environmental, and community standards.

Sincerely,

[Name]
[Title]
Municipality of Princeton
[Department]
[Contact Information]

A Sample Retrofit Request Letter for patching the GVD3 fixtures[1]

Subject: Request for Retrofit of Installed Witherspoon Street Luminaires – Specification Modification for Glare and Light Pollution Mitigation

To:
Engineering and Lighting Services
PSEG
and
Holophane

From:
Princeton
Department of Public Works / Engineering

Date: [Insert date]

Purpose

[1] Note that as of writing, PSEG does not support the requested sub-specficiations of the GVD3 fixture, even though they would be readily available from the manufacturer.

The Municipality of Princeton requests a **retrofit of newly installed street lighting luminaires on Witherspoon Street** to address documented concerns regarding **excessive glare, perceived brightness, and light pollution**, while maintaining appropriate roadway and pedestrian safety.

Existing Installation

The currently installed luminaires are identified as:

- **Holophane GVD3-P20-40K-AS-3-N**
- Post-top LED luminaires
- 4000 K correlated color temperature
- P20 distribution
- BUG rating reported as **3-4-3**

Field observations and resident feedback indicate that the current configuration produces significant near-horizontal glare, uplight, and residential light trespass, which are inconsistent with Princeton's adopted outdoor lighting standards and community character objectives (https://ecode360.com/36815013#36815026).

Requested Retrofit Configuration

Princeton requests confirmation of the feasibility, cost, and implementation timeline for retrofitting the installed luminaires to the following **revised specification**:

1. **Light Distribution**
    - Replace the existing **P20** optical package with a **P10 distribution**, suitable for residential/local roadway contexts.
2. **Correlated Color Temperature**
    - Replace existing **4000 K** LED light engine with **2700 K** LED light engine to reduce blue-rich spectral content, glare perception, and skyglow.
3. **Uplight Control**
    - Install **FC (Full Cutoff / Full Cover)** optical configuration to eliminate direct uplight (target ULOR ≈ 0, BUG U0–U1).

4. **House-Side Shielding**
    - Install **house-side shielding** with a **minimum 120-degree arc** (e.g., GVDHSS120 or equivalent) oriented toward residential frontage to further reduce glare and light trespass.
5. **Electrical / Controls**

    - Retain existing drivers where compatible with the reduced wattage of the P10 / 2700 K configuration, or replace drivers as required to maintain UL listing and warranty.
    - Existing poles, wiring, and mounting to remain unchanged.

Requested Deliverables

Please provide:

- Confirmation that the above configuration is **approved and UL-listed** for retrofit on installed GVD3 luminaires
- Identification of required **retrofit components** (light engine, optics, refractor/top assembly, shields)
- **Updated photometry (.IES)** and resulting **BUG rating** for the revised configuration
- Estimated **energy consumption** and lumen output after retrofit
- **Cost estimate** per fixture (material and labor)
- Confirmation of **warranty and listing continuity**

Rationale

This retrofit aligns with:

- Princeton's outdoor lighting performance standards address **glare, shielding, and light trespass**
- IES best-practice guidance for **residential roadway lighting**
- Established municipal practice for post-installation correction of LED lighting that proves overly intense in residential contexts

The Municipality seeks to resolve these concerns **without full fixture replacement**, using approved manufacturer and utility retrofit pathways.

Conclusion

Princeton respectfully requests prompt technical confirmation and cost information so that an appropriate corrective action can be implemented efficiently and in coordination with PSEG and Holophane.

Comparison of Retrofitting Variants of GVD3

In the following, we compare different scenarios for retrofitting the current GVD3 fixtures using the LU (lunar optic) and FC (full shielding) options, while reducing light levels from P20 to P10. For the comparison, we kept the color temperature at 4000K.

PERFORMANCE DATA

Performance Package	Distribution	Input Watts	27K (2700K CCT, 70 CRI)					30K (3000K CCT, 70 CRI)					40K (4000K CCT, 70 CRI)				
			Lumens	LPW	B	U	G	Lumens	LPW	B	U	G	Lumens	LPW	B	U	G
P10	GL3	23	2,891	126	1	3	3	3,281	143	1	3	3	3,342	145	1	3	3
	GL5		2,890	126	2	3	2	3,281	143	2	3	2	3,341	145	2	3	2
	GL3LU		2,386	104	1	3	2	2,709	118	1	3	2	2,759	120	1	3	2
	GL5LU		2,397	104	2	3	1	2,720	118	2	3	1	2,771	120	2	3	1
P20	GL3	39	4,753	122	2	4	4	5,395	138	2	4	4	5,494	141	2	4	4
	GL5		4,752	122	3	4	3	5,394	138	3	4	3	5,494	141	3	4	3
	GL3LU		3,923	101	2	3	3	4,453	114	2	3	3	4,536	116	2	3	3
	GL5LU		3,940	101	3	3	2	4,472	115	3	3	2	4,555	117	3	3	2

GL3 P20 3000K and 4000K specs. The Witherspoon fixtures are the 4000K variant highlighted by red, emitting 5494 lumens, 46% of which is wasted. The yellow highlight indicates one possible retrofit, changing to P10, GL3LU, and applying a full shield (FC) (not shown in the table). The resulting waste (glare + uplight) would drop to 21% of the 2386 lumens, corresponding to 500 lumens, or 1/4th that of the current configuration.

An explanation of the first row of the table is enough to understand the other elements in the table. The current GL3 unshielded P20 fixtures emit 5432 lumens, from which 46% go above 75 degrees, i.e., glare, light trespass (75–90 deg), and direct uplight (90-180 deg). The table also shows that 37% goes above 80 degrees, and 25.4% is emitted above the horizon. This corresponds to 0.254 x 5432 = 1379 lumens uplight. Just the pure uplight component of one of these new lights is equivalent to the full output of 3 to 20 classic gas-lights from the early 20th century.

The second row changes the internal LEDs to LU, thereby decreasing glare and uplight, but they still remain significant.

The third row (GL3 RB FC) adds a shield on our existing fixture, but without a lunar optics.

The fourth row (GL3LU RB FC) combines the lunar optics with the full shield, reducing uplight to 8.3% (318 lumens). This is still very light-polluting, but already 4 times less than the current fixtures.

The fifth row (GL3LU RB FC P10) changes the internal LEDs to the P10 package, decreasing the light emission to 2400 lumens, and the uplight to 200 lumens, about 7x less than the current setting. Otherwise, the fixture geometry remains the same as GL3LU RB FC (4th row), only the light level is reduced.

This is basically the best option we can achieve by retrofitting the current luminaires, while sticking to the same product line. Note that with the other proposed retrofitting option of using the Epic Medium lights, the uplight portion in the table would be 0%.

Summary of High-Angle and Uplight Emission

GranVille LED Post-Top (GL3), 4000 K — Photometric Analysis

Configuration	Total Lumens	% > 75°	% > 80°	% > 90° (Uplight)
1 GL3 – Unshielded (P20)	≈ 5,432	**46.0 %**	**37.0 %**	**25.4 %**
2 GL3LU (Lunar optic, P20)	≈ 4,278	**21.8 %**	**15.6 %**	**9.5 %**
3 GL3 RB FC (P20)	≈ 4,093	**37.1 %**	**26.8 %**	**13.5 %**
4 GL3LU RB FC (P20)	≈ 3,841	**21.0 %**	**14.5 %**	**8.3 %**
5 GL3LU RB FC (P10)	≈ 2,423	**21.0 %**	**14.5 %**	**8.3 %**

Senate No. 1635 Bill of New Jersey

The current status of this bill (https://pub.njleg.state.nj.us/Bills/2026/S2000/1635_I1.PDF) is:

- Senate Bill 1610 was introduced and referred to the Senate Environment and Energy Committee on January 9, 2024.
- On February 10, 2025, I testified to the Senate Environment and Energy Committee.
    - The committee adopted amendments so that the bill language was identical to Assembly Bill 2196, which had passed unanimously on June 28, 2024.
    - The new amended version was referred to the Senate Budget and Appropriations Committee, which is required of all bills that spend money.
    - Unfortunately, the bill did not pass the Senate Budget and Appropriations Committee before the Senate term ended on January 13, 2026.
- Senators Andrew Zwicker and Raj Mukherji reintroduced the bill in the new session on January 13, 2026. The new bill number is Senate Bill 1635.
    - Note: The reintroduced bill includes our suggested amendments that were added to the previous version of the bill.
- Assemblywoman Mitchelle Drulis, the original sponsor of Assembly Bill 2196, has not reintroduced bills in the new session yet, but when she does, it is likely that there will be an identical Assembly version of Senate Bill 1635.

SENATE, No. 1635

STATE OF NEW JERSEY

222nd LEGISLATURE

PRE-FILED FOR INTRODUCTION IN THE 2026 SESSION

Sponsored by:
Senator ANDREW ZWICKER
District 16 (Hunterdon, Mercer, Middlesex and Somerset)
Senator RAJ MUKHERJI
District 32 (Hudson)

Co-Sponsored by:
Senator Johnson

SYNOPSIS

Requires outdoor lighting fixtures installed or replaced by, or on behalf of State, or at projects receiving State funds, to meet certain criteria.

CURRENT VERSION OF TEXT

Introduced Pending Technical Review by Legislative Counsel.

AN ACT concerning certain outdoor lighting fixtures and supplementing Title 52 of the Revised Statutes.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

1. As used in this act:

"Backlight, uplight, and glare rating," or "BUG rating" means a rating assigned to a luminaire, using criteria developed by the Illuminating Engineering Society, where the light emitted behind the desired direction of illumination ("backlight"), upward ("uplight"), and in a slant angle causing glare ("glare") from the luminaire are rated from 0 (desirable) to 5 (worst).

"Energy conservation" means the reduction of energy costs and resources by use of methods including, but not limited to, the use of light fixtures with the lowest feasible wattage or a photo-sensitive, motion detecting, or timer switch.

"Full cutoff fixture" means a luminaire whose luminous intensity in candelas at or above an angle of 90 degrees above nadir is zero and the luminous intensity, in candelas, at or above a vertical angle of 80 degrees above nadir does not numerically exceed two percent of the luminous flux of the lamp or lamps in the luminaire.

"Fully shielded luminaire" means a luminaire that allows no direct light emissions above a horizontal plane through the lowest light-emitting part of the luminaire.

"Glare" means direct light emitting from a luminaire that is significantly greater than luminance to which the eyes are adapted, and which causes reduced vision or momentary blindness.

"Illuminance" means the unit measure of light at a surface.

"Lamp" means the component of a luminaire that produces the specific form of radiant energy that is observed as light.

"Light trespass" means light emitted by a luminaire that shines beyond the boundaries of the property on which the luminaire is located.

"Lumen" means an international standard unit of luminous flux representing the quantity of visible light output.

"Luminaire" means the complete lighting unit fixture consisting of a lamp, or lamps and ballasts, together with the parts designed to distribute light, including, but not limited to, a reflector, lens, and diffuser, to position and protect the lamps, and to connect the lamps to the power supply.

"Luminous flux" means the measure of the perceived power of the light in lumens.

"Outdoor lighting fixture" means any type of fixed or movable lighting equipment that is designed or used for illumination outdoors. "Outdoor lighting fixture" shall not include lighting equipment that is required by law to be installed on motor vehicles, or lighting required for the safe operation of aircraft or installed at an aviation facility.

"Project" means the acquisition, construction, improvement, reconstruction, or repair of all or part of any building, facility, structure, or real property.

"State agency" means any of the principal departments in the Executive Branch of State Government, any division, board, bureau, office, commission, or other instrumentality created by a principal department, and any independent State authority, commission, instrumentality, or agency established by law.

2. a. Commencing on the effective date of this act, an outdoor lighting fixture installed or replaced by, or on behalf of, a State agency, or as part of a project that receives funds from a State agency, shall comply with the following specifications:

(1) the luminaire shall be a fully shielded luminaire, be equipped with a full cutoff fixture, emit no more than two percent of its total lumen output above 80 degrees from nadir, and have a BUG rating of U0;

(2) the outdoor lighting fixture shall emit only as much light as necessary for the intended purpose and shall not exceed the minimum illuminance level recommended for that purpose by the Illuminating Engineering Society of North America or the Federal Highway Administration;

(3) an outdoor lighting fixture used to illuminate sports fields shall be turned off when not in use;

(4) full consideration has been given to energy conservation, and reducing glare, minimizing light trespass and light pollution, and preserving the natural night environment and public health;

(5) the correlated color temperature of an outdoor lighting fixture shall be no more than 2,700 Kelvin, except that:

(a) a luminaire within direct line-of-sight to areas seaward of a frontal dune or within close proximity to a nature preserve shall emit no radiant energy with a wavelength of less than 560 nanometers;

(b) the maximum correlated color temperature for outdoor sports lighting shall be the lowest possible for the sport, class of play, and viewing audience, but shall not exceed 4,200 Kelvin; and

(c) luminaires used specifically for the decoration of facades or landscapes may have a correlated color temperature in excess of 2,700 Kelvin; and

(6) the outdoor lighting fixture shall use a motion sensor device that automatically turns on, dims, or turns off the light, as appropriate.

b. The provisions of subsection a. of this section shall not apply in the following circumstances:

(1) the outdoor lighting fixture is used on a temporary basis because emergency personnel require additional illumination for emergency procedures;

(2) the outdoor lighting fixture is used on a temporary basis for nighttime work;

(3) a compelling safety interest exists that cannot be addressed by another method; or

(4) the outdoor lighting fixture is located in a high-security area, as designated by the New Jersey Office of Homeland Security and Preparedness and the New Jersey State Police.

c. Notwithstanding the provisions of this section to the contrary, in the case of outdoor lighting fixtures installed along any roadway in the State, the Department of Transportation shall assess whether the purpose of the outdoor lighting fixture can be achieved by the installation of reflective road markers, lines, warning or informational signs, or other effective passive methods in lieu of the installation of outdoor lighting fixtures.

d. The Division of Property Management and Construction shall collaborate with the Board of Public Utilities to ensure uniformity in lighting specifications for State-owned buildings and any funding and rebates available to State-owned buildings under the State Facilities Initiative.

e. The State Treasurer shall provide guidance to every State agency concerning the requirements of this act.

3. Notwithstanding the provisions of any other law, or rule or regulation adopted pursuant thereto, to the contrary, the Director of the Division of Purchase and Property in the Department of the Treasury, the Director of the Division of Property Management and Construction in the Department of the Treasury, or any State agency having authority to contract for the purchase of goods or services, shall comply with the requirements of this act.

4. This act shall take effect on the first day of the third month next following the date of enactment.

STATEMENT

This bill would require outdoor lighting fixtures installed or replaced by, or on behalf of, a State agency, or at projects receiving public moneys from a State agency, to meet certain criteria in order to reduce light pollution.

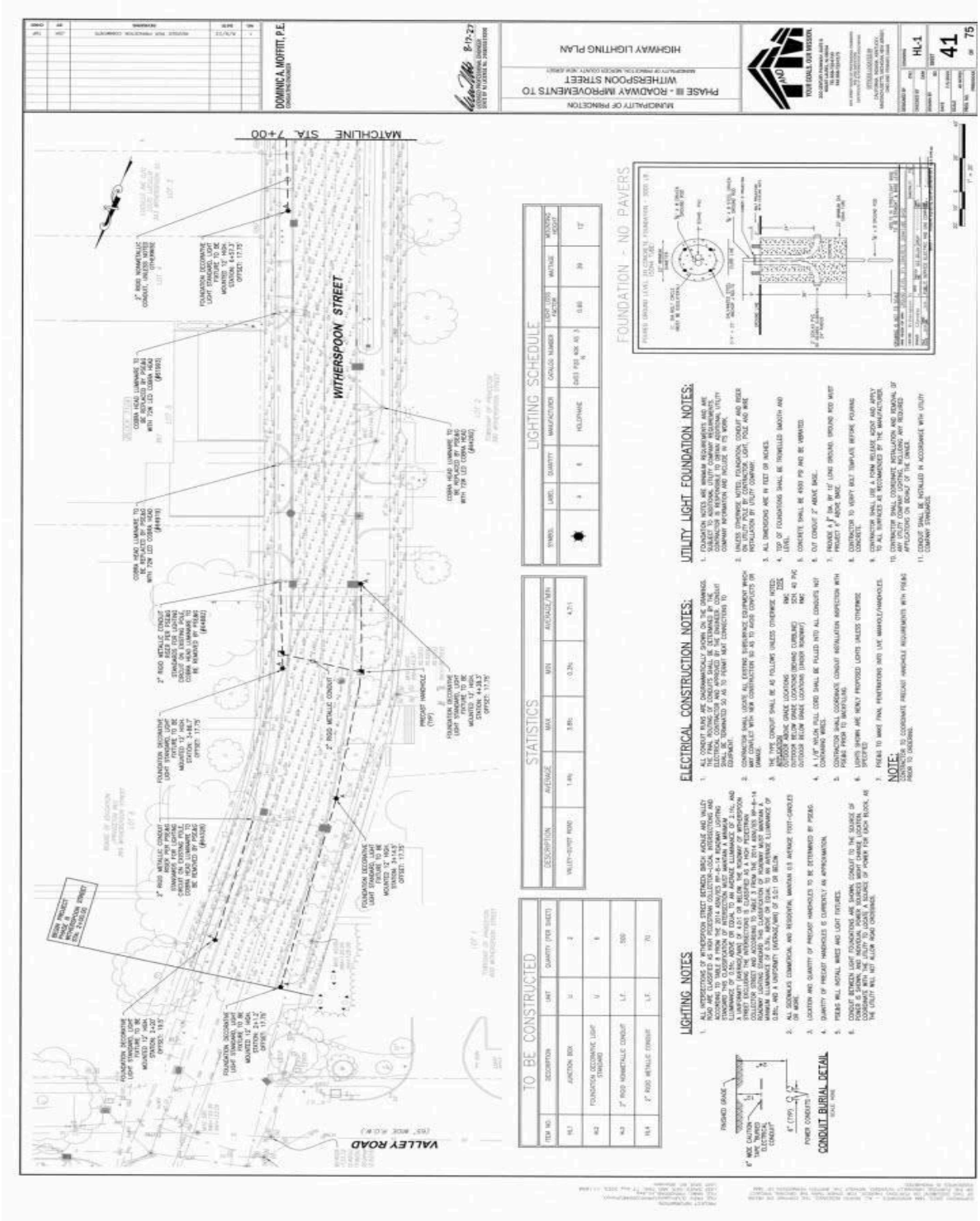
The bill would require outdoor lighting fixtures installed or replaced by, or on behalf of, a State agency, or as part of a project that receives funds from a State agency, to comply with the following: (1) the luminaire is a fully shielded luminaire and a full cutoff fixture with a backlight, uplight, and glare (BUG) rating of U0, as those terms are defined by the bill; (2) the outdoor lighting fixture emits only as much light as necessary for the intended purpose and does not exceed the minimum illuminance level recommended for that purpose by the Illuminating Engineering Society of North America or the Federal Highway Administration;

(3) an outdoor lighting fixture used to illuminate sports fields are turned off when not in use; (4) full consideration has been given to energy conservation, reducing glare, minimizing light trespass and light pollution, and preserving the natural night environment and public health; (5) the correlated color temperature of the outdoor lighting fixture is no more than 2,700 Kelvin, with certain exceptions; and (6) the outdoor lighting fixture has a motion sensor device that turns on, dims, and turns off the light as appropriate.

The bill would not apply if: the outdoor lighting fixture is used on a temporary basis because emergency personnel require additional illumination for emergency procedures; the outdoor lighting fixture is used on a temporary basis for nighttime work; a compelling safety interest exists that cannot be addressed by another method; or the outdoor lighting fixture is located in a high-security area.

In addition, in the case of outdoor lighting fixtures installed along roadways, the bill requires the Department of Transportation to assess whether the purpose of the outdoor lighting fixture can be achieved by the installation of reflective road markers, lines, warning or informational signs, or other effective passive methods in lieu of the installation of outdoor lighting fixtures. The provisions of the bill would take effect on the first day of the third month after the bill is enacted.

The Witherspoon Plan



Witherspoon Street Lighting plan.

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