Appendix A
Lighting Study

09/17/24

LIGHTING STUDY

Watchfire Signs has been manufacturing outdoor electric signs since 1932 and LED signs since 1996. Currently, we have more than 60,000 LED signs in operation worldwide.

History of Optical Measurements and Calculations

Outdoor signs using incandescent light bulbs commonly measured illuminance using meters that report brightness in foot-candles. This unit is the standard measurement partly because a light bulb is a source of light that illuminates equally in all directions. LED signs are measured with the same meter even though its light does not illuminate equally in all directions. LED signs are designed to be highly directional, which is an advantage. LEDs allow light to be directed toward an intended audience, rather than dispersed in a wider arc out from the face of the sign.

In the LED industry, luminance, or the intensity of visible light, is measured by nits, where one candela per square meter is equal to one nit. However, luminance meters are expensive, difficult to use in the field, and are not ideal for lighting studies commonly used for meeting local permitting requirements. As a result, LED signs are often evaluated using foot-candle measurements.

A foot-candle is the amount of light produced by a single candle when measured from one foot away. For reference, a 100-watt light bulb produces 137 foot-candles from 1 foot away, .0548 foot-candles from 50 feet away, and .0137 foot-candles from 100 feet away.

Watchfire Signs is Compliant with National Lighting Requirements

Watchfire Signs has adopted brightness standards endorsed by both the International Sign Association (ISA) and Outdoor Advertising Association of America (OAAA). These standards were the result of detailed analysis and recommendations for lighting control completed by Dr. Ian Lewin of Lighting Sciences Inc. The studies are based on accepted practices by the Illuminating Engineering Society of North America (IESNA) for evaluating and controlling “light trespass”. Watchfire Signs’ products meet the requirements set forth by both associations, based on these studies and recommendations, which results in lighting impact of no more than 0.3 foot-candles above existing ambient light levels. Total foot-candles are dependent on size and distance and can be adjusted as needed. Please see below for the site-specific lighting study and Exhibit A for details surrounding the OAAA lighting standards and practices.

Automatic Brightness Adjustment:

Watchfire’s billboard displays are set to have a maximum daytime brightness level of 7,500 nits and a maximum nighttime brightness level of 300 nits. All Watchfire signs automatically adjust brightness levels using a primary 100-step hardware photocell, with a software photocell backup. The hardware photocell will automatically adjust the sign’s brightness relative to changes in ambient light levels. If the software photocell is used, the sign will automatically adjust brightness based on the longitude and latitude location of the sign. The sign is appropriately dimmed or brightened based around daily sunrise and sunset. For both options, a sign operator can manually decrease the brightness from standard

settings, but for safety reasons and in conformance to industry codes, Watchfire cannot allow signs to operate brighter than standard settings.

Night Skies:

All Watchfire signs are designed with night skies in mind. To achieve the best image quality and power efficiency, we are interested in having light reach only the audience. We have implemented technology into our products that prevent them from being brightened in the field after installation and allow for downward adjustment when the impact is too great for a specific area or application. Watchfire has developed specially designed louver panels that not only protect the LEDs from damage but limit the vertical impact of the light output. This technology, coupled with the automated brightness adjustments, limits impact to vertical ambient lighting.

Title 24 Compliance:

Watchfire displays was the first in the industry to meet the requirements for UL Greenleaf certifications set forth by Title 24 of the California Code of Regulations. A copy of the Certificate of Conformance is available upon request.

Redundancy:

All Watchfire displays have intelligent control with Automated Diagnostics down to individual LED level. In the unlikely event that a lighting control fails, or a sign malfunction, the operator and Watchfire are immediately notified. If necessary, there are protocols in place to have the sign go dark along with hardware installed in each display to allow for remote power control.

Equipment used by Watchfire Signs to Measure Luminance
Foot-candles/Lux - Minolta Illuminance Meter T-10
Nits/candela/sq. m – Minolta Luminance Meter LS-100
Sign Calibration – Minolta CS-1000 Spectra radiometer

The proceeding study uses actual lab measurements made on modules using an illuminance meter. These measurements and extrapolations were then scaled up to the size of the sign and distance corrections were made using the inverse square law.

SIGN LIGHTING STUDY

Sign Details

Size: 14’ x 48’ 16mm Digital Billboard

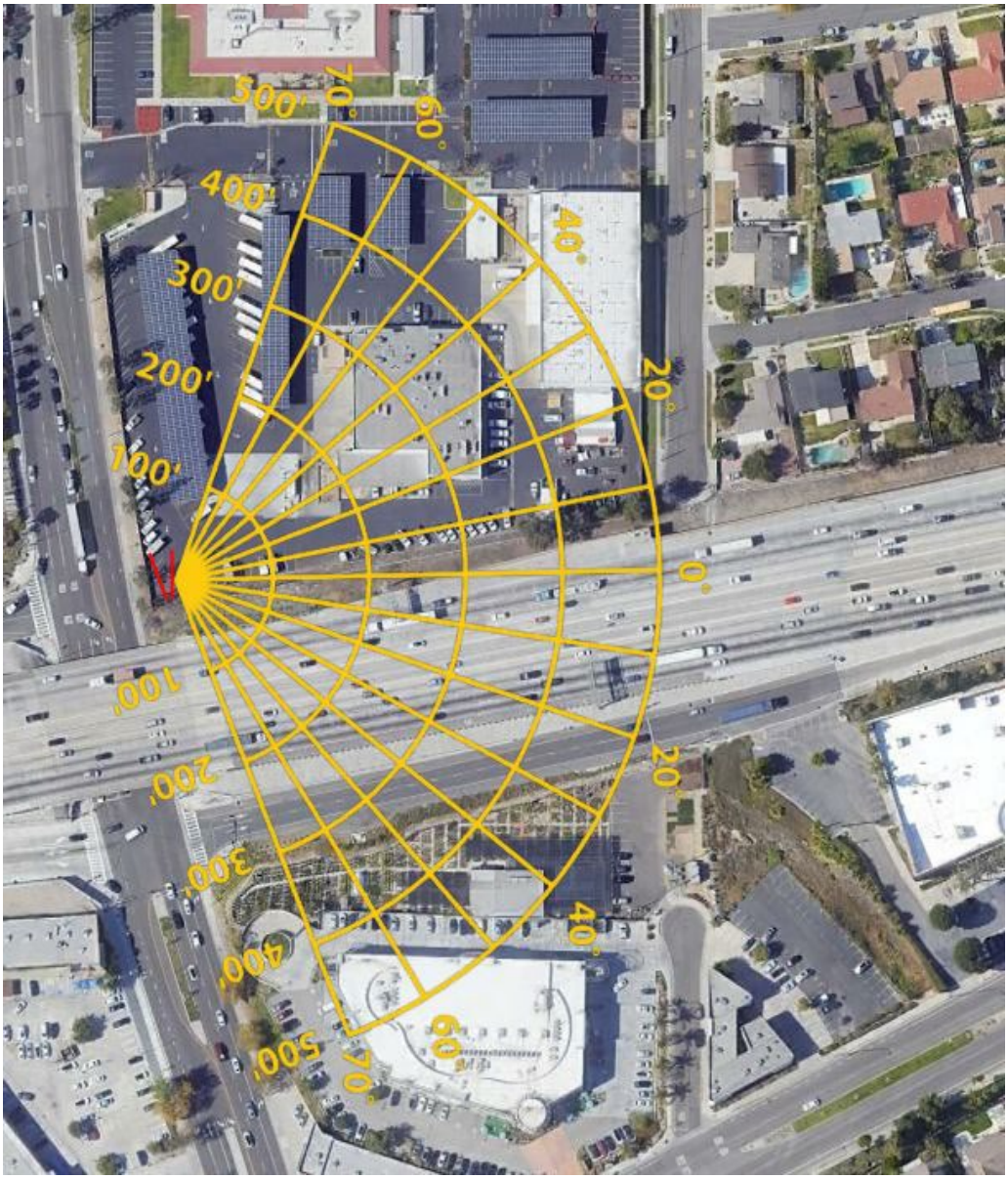
Location: 880 South Lemon Ave., Diamond Bar, CA

The table below represents a 14’ x 48’ LED sign, demonstrating the increase in illuminance from the sign during normal night operation. The values are within the standards of both the ISA and OAAA and indicate that the ambient light broadcast into the surrounding area has minimal effect.

Foot-candles at night under normal operation:

Display Area (ft) (H x W)	14	x	48		
Foot-candles at night under normal operation					
	Horizontal Viewing Angle				
Viewing Distance (ft)	**0°**	**20°**	**40°**	**60°**	**70°**
100	0.75	0.69	0.60	0.42	0.26
200	0.19	0.17	0.15	0.10	0.06
300	0.08	0.08	0.07	0.05	0.03
400	0.05	0.04	0.04	0.03	0.02
500	0.03	0.03	0.02	0.02	0.01

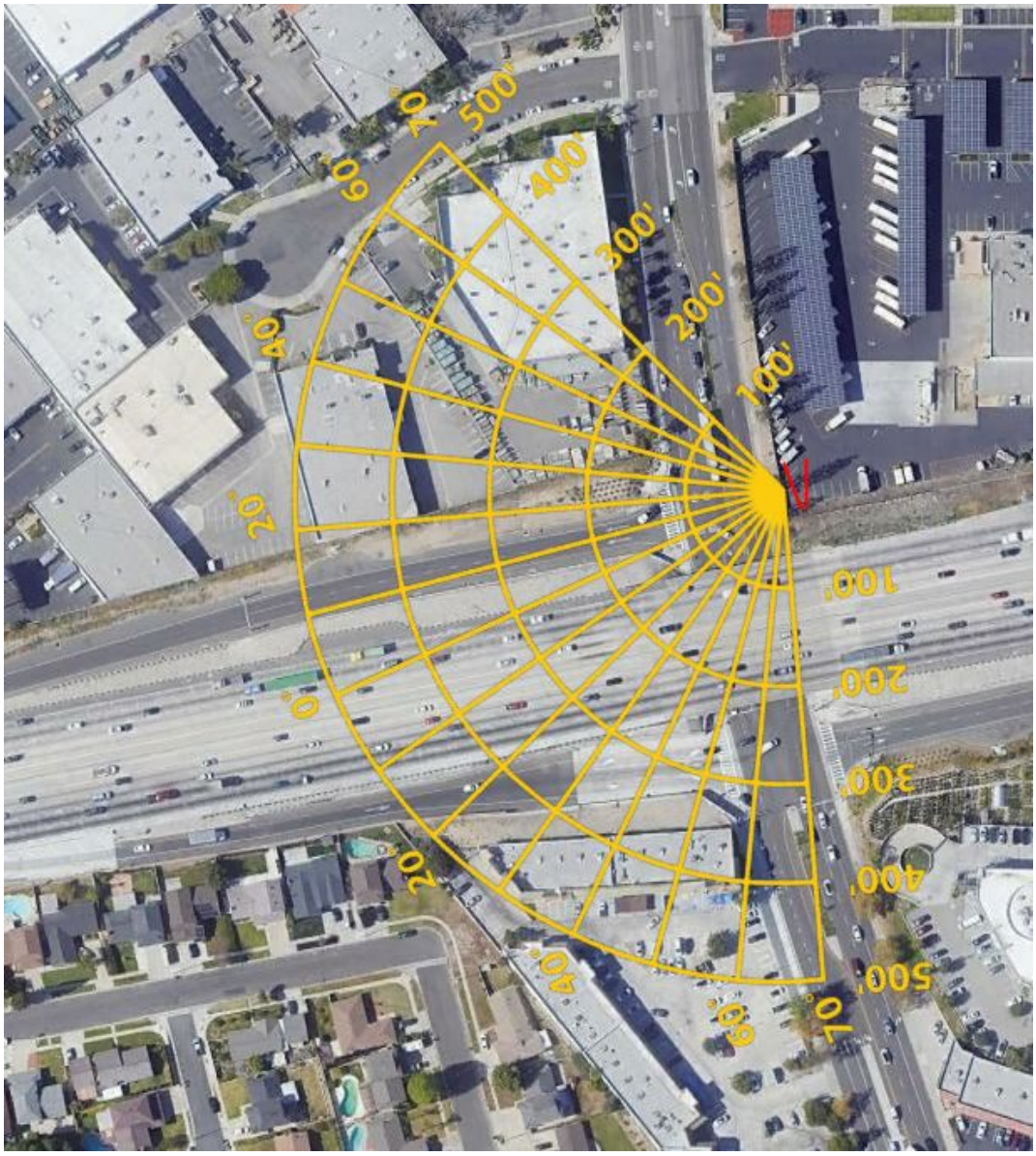
Example Broadcast of Light at Distances and Angles: East Face



Conclusion

Given the above comparisons and measurements, the area will see an almost undetectable difference in ambient light after installation of the digital led billboards. This display will operate within the regulations of the OAAA, the State of California and local ordinances.

Example Broadcast of Light at Distances and Angles: West Face



Conclusion

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Exhibit A: OAAA Lighting Standards

Brightness Criteria

A. OAAA Guidelines: The OAAA recommended brightness criteria for digital billboards is as follows:
   - Light produced by a digital billboard should not exceed 0.3 Footcandles over ambient light levels.
   - Measurement should be taken utilizing a Footcandle meter from the following distances perpendicular to the face of the digital billboard):
     - Posters: 150 feet
     - 10'6x36 Bulletins: 200 feet
     - 14x48 Bulletins: 250 feet
     - 20x60 Bulletins: 350 feet

     The measurement distances are based on the average minimum viewing distances for each type of billboard.
   - Digital billboards must have automatic dimming capability.

B. Basis for the Guidelines. These guidelines are based on recommendations by lighting expert Dr. Ian Lewin, Lighting Sciences Inc. (Scottsdale, AZ), in a March, 2008 report to the OAAA. Dr. Lewin developed brightness criteria to meet the following general guidelines:
   - Appropriately Legible Copy. Digital advertising copy is appropriately legible and not overly bright.
   - Simplicity. Provide a guideline that can be easily implemented and enforced. Measurement of the ambient light level of the sign on and off is conducted by a footcandle meter. If the difference in measurements is less than 0.3 footcandles, the digital billboard is in compliance.
   - Established Guidelines. The criteria are based on established scientific methodology and established industry standards from the Illuminating Engineering Society of North America (IESNA) publication TM- 11-00 “light trespass” theory which is an accepted standard in the lighting industry.
   - Flexibility. Ensure proper brightness levels in a variety of lighting environments.

C. Additional Issues/Clarification
   - Automatic Dimming Capability. A digital billboard must be able to automatically adjust as ambient light levels change. An automatic light sensing device (such as photocell or similar technology) should be utilized for adjusting the digital billboard’s brightness. Sunset-sunrise tables and manual methods of controlling brightness are not acceptable as a primary means of controlling brightness.
   - Brightness Measurement Methodology. The brightness standard requires the use of a Footcandle meter (also known as a “Lux meter”; ~$100-1000). A Footcandle meter measures the amount of light arriving at the meter (illuminance), as opposed to an absolute measurement of the amount of light emanating from a light source or light sources (luminance). A Footcandle is a measure of lumens (light rays) that fall on one square foot area; Lux is the metric equivalent of a Footcandle.
     In contrast, a Candela Meter / NIT Gun (~$3,000) measures the amount of light emanating from a specific light source (luminance). A NIT gun measures candelas (a measure of luminance or brightness) per meter squared (also known as “NITS”), which is a measure of the brightness emanating from a specific light source. It excludes ambient light (which may include light from many sources) from the measurement. Standard NIT levels and/or utilization of a NIT gun are not a part of the OAAA recommended brightness guideline.

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