WATERTOWN-CAMBRIDGE GREENWAY

LIGHTING STUDY

Introduction

The purpose of this lighting study is to review possible methods of lighting for a new portion of the Watertown-Cambridge Greenway path, while trying to minimize the effect of lighting on the surrounding environment. The City of Cambridge and Department of Conservation and Recreation are jointly pursuing the construction of this new section of path in Cambridge, and have agreed to review possible lighting options for inclusion in the present or future construction of the path.

The desire for lighting the path came up as part of the public process for the project, stemming from safety concerns and a desire to have the path useable at all times of the year for commuting and recreation. Given the relative isolation of users in sections of the path, there is a desire to create a lighting plan that offers flexible lighting for safety. This lighting could be timed to make the path useable during commuting hours at all times of the year, with lights that could be dimmed or turned off on a pre-determined schedule. Reducing light pollution and minimizing the effects on nearby animals and birds is an equally strong goal of the design, particularly as the path passes through a section of Fresh Pond Reservation.

This study will review the range of lighting that may be used on this type of pathway, and establish design criteria. The ecological consequences will be considered and methods for mitigation will be defined. Possible lighting design options will be reviewed and a design solution proposed, including parameters for creating a schedule when lights would be turned on and off, and dimmed to reduce impact on the environment. A lighting fixture recommendation and a layout of a proposed fixture are presented in the drawings that are included in this report.

Lighting Design for Walkways and Bikeways

To properly light a multi-use path that is separate from the street, a dedicated lighting system typically needs to be installed to provide sufficient light levels for safe and secure passage. For the Greenway, much of which is far from any other light sources, this is certainly the case.

The lighting should ideally serve these functions:

- Provide sufficient light levels so that the surface of the path can be seen clearly and any obstacles detected.
- Provide sufficient illumination on people's faces, so that approaching persons do not appear as dark silhouettes (which can be very disconcerting).
- If the surrounding area is dark, some light should be spread onto the ground on either side of the path, to push back the shadows for an improved sense of security.

The recommended light level criteria for this path are 5-lux average, 0.5-lux minimum, on the paved portion of the walkway. These are based on Illuminating Engineering Society (IES) recommendations, such as in IES RP-33-14 and IES DG-5, and were also used for Cambridge parks during the LED lighting conversion project. These levels are sufficient to give a sense of safety to those walking the path.

Ecological Impacts

Electric light at night may impact animals in many ways, such as affecting breeding behavior, predator avoidance, foraging behavior, and causing navigation errors, and biological clock disruption. Light can attract some animals and deter others. Different animal species have varying relative sensitivities to different wavelengths (“colors”) of light, but there is no one color that is universally bad or good.

Plants are highly sensitive to light, and it affects many plant processes. Some plant species are sensitive to photoperiodicity. This means that they need a daily cycle of light and dark. These species may be adversely affected by prolonged light. However, it is not generally clear whether or not electric light at night poses any significant consequences to plants in nature.

Unfortunately, there is no magical type of light that is “wildlife friendly”. The best we can say is that it is prudent to absolutely minimize light emitted into the natural landscape. Three primary techniques must be employed to mitigate any potential adverse ecological impacts of electric light at night. These are the same fundamental techniques used for general light pollution control, which is also important to abutters who may be concerned about light shining onto their property.

- Put the light only where it is needed, and not into areas where is not needed.
- Light only to the minimum levels absolutely required for the task.
- Turn off the lights when they are not needed.

Additionally, there is some indication that minimizing shorter wavelength (“blue”) light may generally reduce some possible adverse effects on animals. Ultra-violet wavelengths should be avoided, as they are known to attract insects and contribute nothing to human vision.

For more information on the topic of minimizing ecological impacts of lighting, please see the following references:

https://islandpress.org/book/ecological-consequences-of-artificial-night-lighting
Ecological Consequences of Artificial Night Lighting
Catherine Rich and Travis Longcore, 2005

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3546378/
Reducing the ecological consequences of nighttime light pollution: options and developments
The Journal of Applied Ecology, 2012

http://www.techstreet.com/standards/ies-rp-33-14?product_id=1888389
IES RP-33-14 Lighting for Exterior Environments
Illuminating Engineering Society, 2014

http://myfwc.com/conservation/you-conserve/lighting/
Wildlife Lighting
Florida Fish and Wildlife Conservation Commission, 2017

http://www.nature.org/ourinitiatives/regions/northamerica/areas/centralappalachians/recommended-shale-practices-artificial-lighting.pdf
Reducing Ecological Impacts of Shale Development: Recommended Practices for the Appalachians, Artificial Lighting
The Nature Conservancy, 2015

http://darksky.org/wp-content/uploads/bsk-pdf-manager/Wildlife-Brochure-FINAL2_32.pdf
Light Pollution Can Harm Wildlife (Brochure)
International Dark-Sky Association

Lighting Design Solution

What is the best way to light this path and meet the above objectives? The typical method of lighting a multi-use path is to place light poles 50-80 feet apart along the pathway. These poles are usually 12 to 16 feet tall. The light fixture may distribute the light in all directions (symmetrical distribution), or employ an optical system to direct the light more along the length of the walkway. For parks in Cambridge, the symmetrical distribution is used in order to spread the light out into the landscape, to push back the shadows for an improved sense of security. Due to the sensitive nature of the Greenway along the Fresh Pond Reservation, we recommend a fixture with an optical distribution that keeps the light contained on the walkway, with only a very small amount of lighting beyond the edge of the path, to create a sense of security.

The closer the fixtures are to the walkway (the shorter the pole), the less light will fall beyond the edges of the walkway. It has been suggested that bollard-style lights might be a solution. Bollard lights are very low to the ground, typically only 36″-48″ tall. There are many disadvantages to using bollard- type fixtures to light the Greenway. Because they are so near to the ground, they are much more subject to vandalism and damage by snow removal equipment or maintenance vehicles. These fixtures would have to be spaced much more closely together than taller light poles. This would require approximately three times as many fixtures, at close to three times the total cost. Additionally, it would be impossible to utilize a wireless dimming control system (see below) with bollard type fixtures.

We believe that the best solution is to use pedestrian scale poles along the path, but using a fixture with the optimal optical and control system. The standard LED fixture used in Cambridge Parks (Cree "Edge Round") is available with what is known as a Type 2 light distribution with backlight shield. This light distribution pattern is designed specifically to distribute the light along the walkway from a pole at the side of the walkway, and to minimize light shining beyond the walkway surface. The light distribution of the fixture is graphically described in the drawings that follow.

For pathways in Cambridge Parks, the standard pole height is 13 feet, with a typical pole spacing of 70 feet. Based on our computer modeling performed for this study using the Cree Edge Round Type 2 with backlight shield, we recommend a pole height of 11 feet, with poles spaced 100-105 feet apart. This will minimize light spilling beyond the pathway, and minimize the quantity of poles, but will still provide sufficient light levels and enough uniformity to create a sense of safety but do an excellent job of limiting effects on the surrounding environment.

The Cree Edge Round fixture can also accept the wireless dimming control module that the City uses to control all street and park lights. Hundreds of these fixtures are already installed in City Parks, controlled by the wireless dimming system. The wireless dimming system allows one to set the exact light output that is desired (no more than needed), and later at night, dim to a lower output, or turn the fixture completely off. For Cambridge Parks, the fixtures turn on at dusk to their normal level (set for each park) and then at 10:00 (park closing) dim to 50% of normal for a late night security mode. For the Greenway, we suggest that the fixtures be programmed to turn on at dusk / sunset to a suggested minimum output that introduces a level of safety. (We can precisely "tune" this output based on light level measurements after the fixtures are installed.) At 9:30 pm, the fixtures should be dimmed to 10% as a warning that the lights will soon be shut off completely. At 10:00 pm, the lights would shut off completely. We also suggest that entrances to the Cambridge portion of the Greenway be signed, to warn that the Greenway is not lighted after 9:30 pm.

We recommend that the fixture be specified with a color temperature of 3000K ("warm" white). This will minimize shorter wavelength "blue" light, similar to the color temperature that is used in Cambridge parks. Because we are using an LED fixture, there will be no ultraviolet (UV) emissions.

PATH LIGHTING DIAGRAM

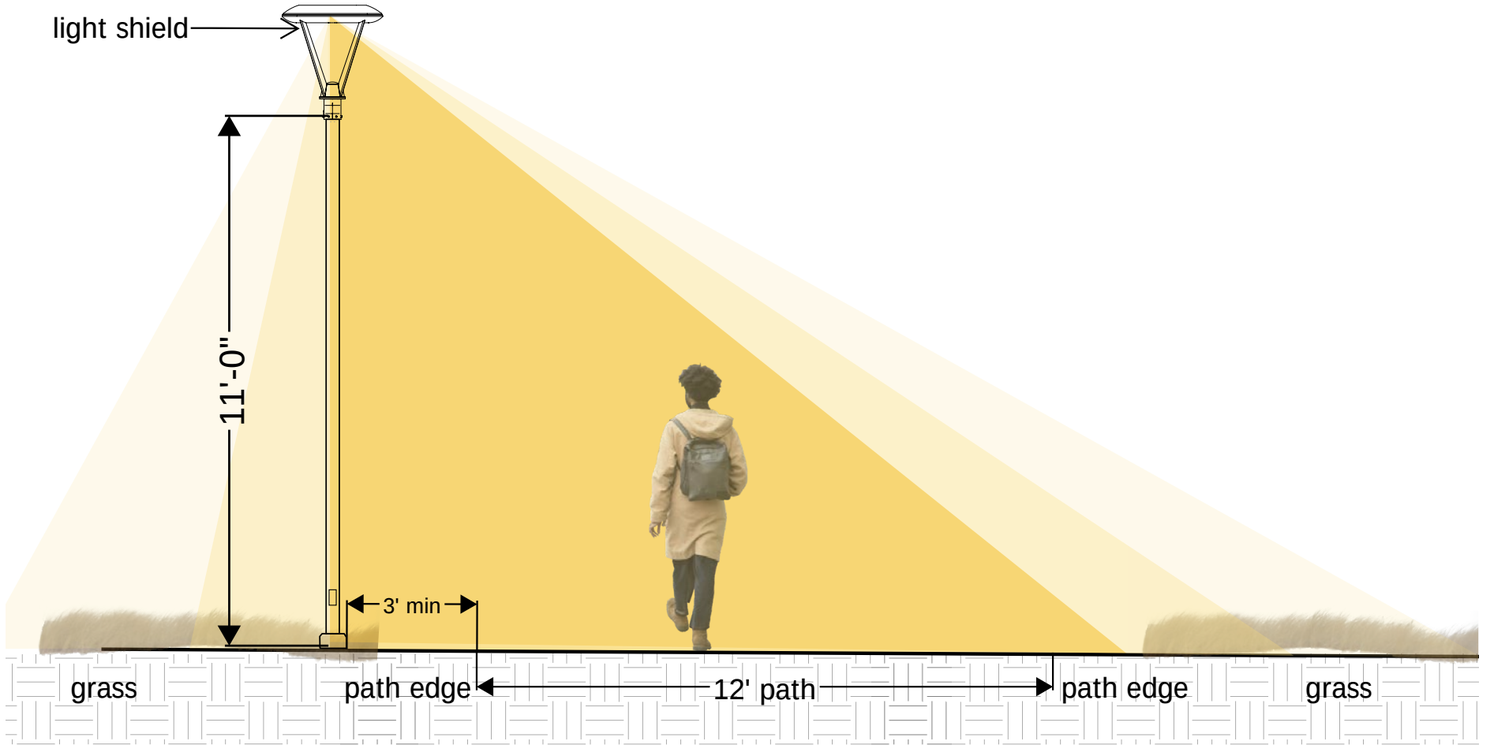
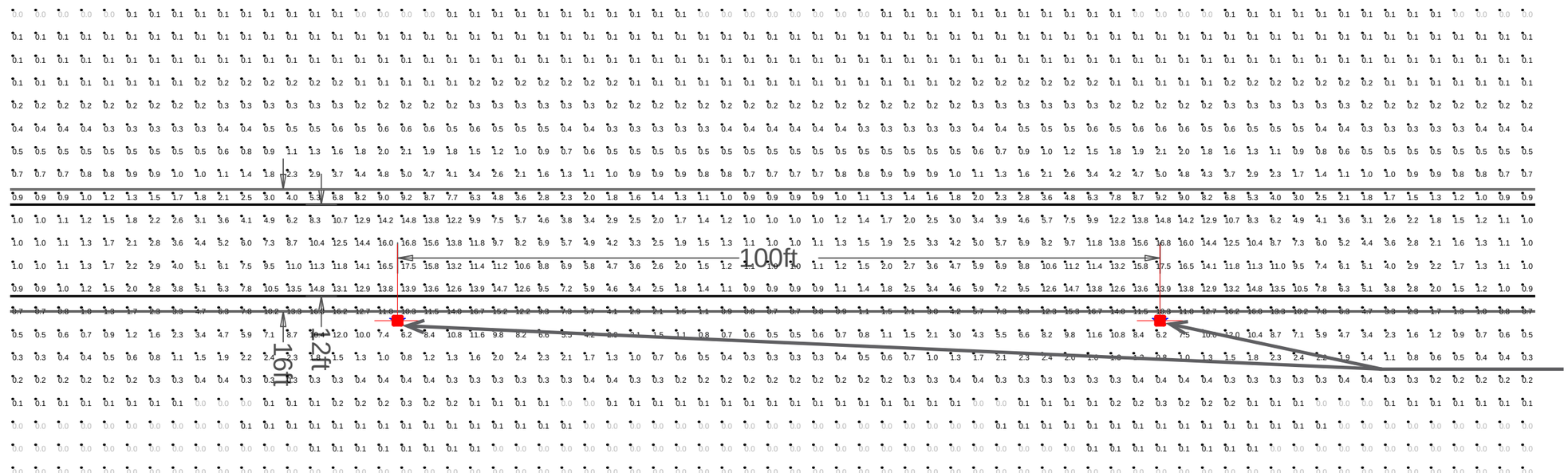


PHOTO SIMULATION
11′ POLES, 100′ APART

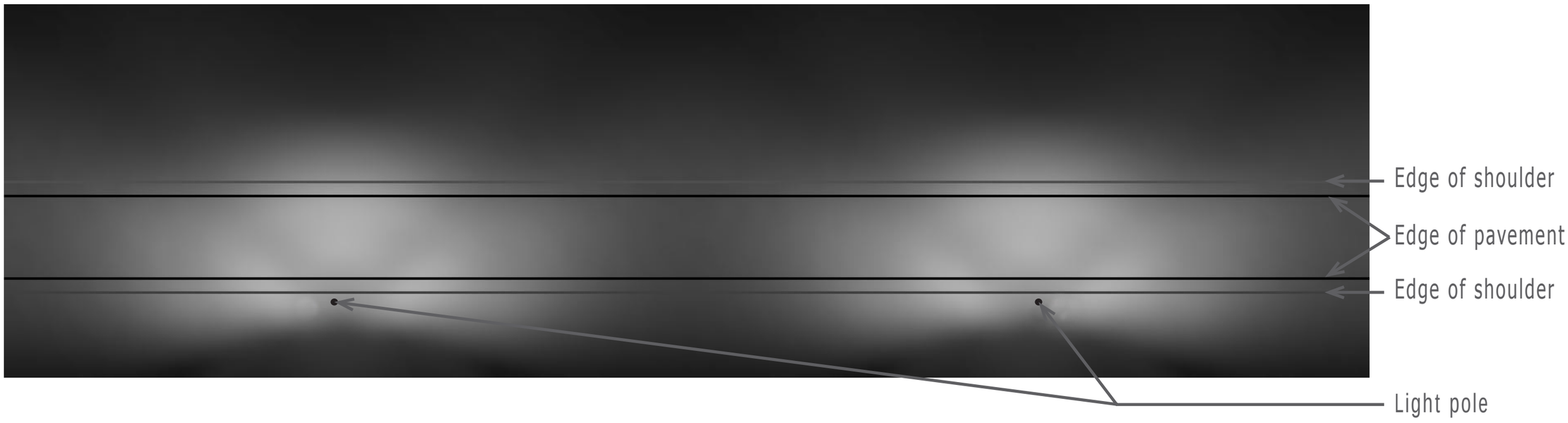
PHOTOMETRIC PLAN



Statistical Summary
Horizontal Lux on Path
Average: 5.8 Lux
Minimum: 0.7 Lux
Avg/Min: 8:1 Lux

Cree Edge Round Type II
350 mA, 3000K, dimmed to
40%, 11 pole, 100’ spacing

BIRD’S-EYE VIEW RENDERING OF LIGHT ON PATH



Cree Edge™ Series

LED Area Luminaire – Round

Product Description

The Cree Edge™ Series has a slim, low profile design. Its rugged cast aluminum housing minimizes wind load requirements and features an integral, weathertight LED driver compartment, spun vented cover, high performance aluminum heat sinks and leaf/debris guard.
Applications: Auto Dealerships, parking lots, campuses, facade lighting and general site lighting applications

Performance Summary

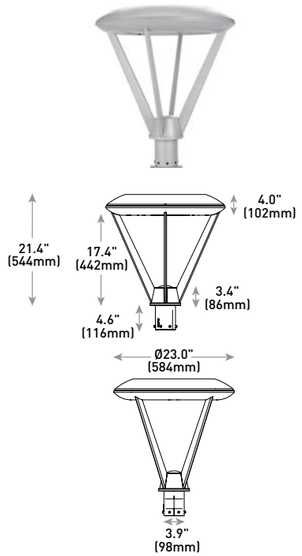
- Patented NanoOptic® Product Technology
- Made in the U.S.A. of U.S. and imported parts
- **CRI:** Minimum 70 CRI
- **CCT:** 4000K (+/- 300K), 5700K (+/- 500K) standard
- **Limited Warranty†:** 10 years on luminaire/10 years on Colorfast DeltaGuard® finish

† See http://lighting.cree.com/warranty for warranty terms

Accessories

Field-Installed	
Bird Spikes XA-BRDSPK	**Backlight Control Shields** XA-20BLS-4 - Four-pack - Unpainted stainless steel

R3 Mount



LED Count (x10)	Weight
04	33.8 lbs. (15.3kg)
06	35.2 lbs. (15.9kg)
08	37.0 lbs. (16.8kg)
10	40.7 lbs. (18.5kg)
12	42.4 lbs. (19.3kg)

R4/R5 Mount - see page 14 for weight & dimensions

Ordering Information

Example: ARE-EDR-2M-R3-12-E-UL-SV-350

ARE-EDR				E				
Product	**Optic**		**Mounting***	**LED Count (x10)**	**Series**	**Voltage**	**Color Options**	**Drive Current**	**Options**
ARE-EDR	**2M** Type II Medium **2MB** Type II Medium w/BLS **2MP** Type II Medium w/Partial BLS **3M** Type III Medium **3MB** Type III Medium w/BLS	**3MP** Type III Medium w/Partial BLS **4M** Type IV Medium **4MB** Type IV Medium w/BLS **4MP** Type IV Medium w/Partial BLS **5M** Type V Medium **5S** Type V Short	**R3** Spider, Center Tenon, 2-3/8" to 3" OD **R4** Spider, Center Direct, 4" Square **R5** Spider, Center Direct, 5" Round	**04**** **06**** **08**** **10** **12**	**E**	**UL** Universal 120-277V **UH** Universal 347-480V	**BK** Black **BZ** Bronze **SV** Silver **WH** White	**350** 350mA **525** 525mA **700** 700mA - Available with 40-60 LEDs	**DIM** **0-10V Dimming** - Control by others - Refer to Dimming spec sheet for details - Can't exceed specified drive current **F** **Fuse** - When code dictates fusing, use time delay fuse - Available with UL voltage only - Available for U.S. applications only **HL** **Hi/Low (Dual Circuit Input)** - Refer to HL spec sheet for details - Sensor not included **P** **Photocell** - Available with UL voltage only **40K** **4000K Color Temperature** - Minimum 70 CRI - Color temperature per luminaire

* Reference EPA and pole configuration suitability data beginning on page 14
** Consists of multiple 20 LED light bars. 40, 60, and 80 LED units use blanks as needed in place of populated light bars
NOTE: Price adder may apply depending on configuration

30K 3000K Color Temperature

US: lighting.cree.com/lighting T (800) 236-6800 F (262) 504-5415

Rev. Date: V4 09/20/2016

Canada: www.cree.com/canada T (800) 473-1234 F (800) 890-7507

Product Specifications

CONSTRUCTION & MATERIALS

- Slim, low profile, minimizing wind load requirements
- Luminaire sides are rugged die cast aluminum with integral, weathertight LED driver compartment, spun vented cover, and high performance aluminum heat sinks
- R3 spider mount hub slip-fits over a 2.375" (60mm) to 3" (76mm) O.D. steel or aluminum tenon or pole and secures with eight set screws
- R4 spider mount fits directly inside 4" (102mm) square pole and secures to pole with four set screws
- R5 spider mount fits directly inside of a 5" (127mm) round pole to provide a clean hardware-less outer appearance
- Includes leaf/debris guard
- Exclusive Colorfast DeltaGuard® finish features an E-Coat epoxy primer with an ultra-durable powder topcoat, providing excellent resistance to corrosion, ultraviolet degradation and abrasion. Black, bronze, silver, and white are available
- **Weight:** See Dimensions and Weight charts on pages 1 and 14

ELECTRICAL SYSTEM

- **Input Voltage:** 120-277V or 347-480V, 50/60Hz, Class 1 drivers
- **Power Factor:** > 0.9 at full load
- **Total Harmonic Distortion:** < 20% at full load
- **10V Source Current:** 40-80 LEDs: 0.15mA; 100-120 LEDs: 0.30mA
- Integral 10kV surge suppression protection standard
- When code dictates fusing, a slow blow fuse or type C/D breaker should be used to address inrush current

REGULATORY & VOLUNTARY QUALIFICATIONS

- cULus Listed
- Suitable for wet locations
- Meets FCC Part 15, Subpart B, Class A standards for conducted and radiated emissions
- Enclosure rated IP66 per IEC 60529 when ordered without P option
- Certified to ANSI C136.31-2001, 1.5G normal vibration standards when ordered with R3, R4 and R5 mounts
- 10kV surge suppression protection tested in accordance with IEEE/ANSI C62.41.2
- Luminaire and finish endurance tested to withstand 5,000 hours of elevated ambient salt fog conditions as defined in ASTM Standard B 117
- DLC qualified. Exceptions apply when ordered with full backlight control or 3MP optic. Please refer to www.designlights.org/QPL for most current information
- Meets Buy American requirements within ARRA

Electrical Data*							
LED Count (x10)	System Watts 120-480V	Total Current (A)					
		120V	208V	240V	277V	347V	480V
350mA							
04	46	0.36	0.23	0.21	0.20	0.15	0.12
06	66	0.52	0.31	0.28	0.26	0.20	0.15
08	90	0.75	0.44	0.38	0.34	0.26	0.20
10	110	0.92	0.53	0.47	0.41	0.32	0.24
12	130	1.10	0.63	0.55	0.48	0.38	0.28
525mA							
04	70	0.58	0.34	0.31	0.28	0.21	0.16
06	101	0.84	0.49	0.43	0.38	0.30	0.22
08	133	1.13	0.66	0.58	0.51	0.39	0.28
10	171	1.43	0.83	0.74	0.66	0.50	0.38
12	202	1.69	0.98	0.86	0.77	0.59	0.44
700mA							
04	93	0.78	0.46	0.40	0.36	0.27	0.20
06	134	1.14	0.65	0.57	0.50	0.39	0.29

* Electrical data at 25°C (77°F). Actual wattage may differ by +/- 10% when operating between 120-480V +/- 10%

Recommended Cree Edge™ Series Lumen Maintenance Factors (LMF)[1]					
Ambient	Initial LMF	25K hr Projected[2] LMF	50K hr Projected[2] LMF	75K hr Calculated[3] LMF	100K hr Calculated[3] LMF
5°C (41°F)	1.04	1.01	0.99	0.98	0.96
10°C (50°F)	1.03	1.00	0.98	0.97	0.95
15°C (59°F)	1.02	0.99	0.97	0.96	0.94
20°C (68°F)	1.01	0.98	0.96	0.95	0.93
25°C (77°F)	1.00	0.97	0.95	0.94	0.92

[1] Lumen maintenance values at 25°C are calculated per TM-21 based on LM-80 data and in-situ luminaire testing
[2] In accordance with IESNA TM-21-11, Projected Values represent interpolated value based on time durations that are within six times (6X) the IESNA LM-80-08 total test duration (in hours) for the device under testing (DUT) i.e. the packaged LED chip)
[3] In accordance with IESNA TM-21-11, Calculated Values represent time durations that exceed six times (6X) the IESNA LM-80-08 total test duration (in hours) for the device under testing (DUT) i.e. the packaged LED chip)

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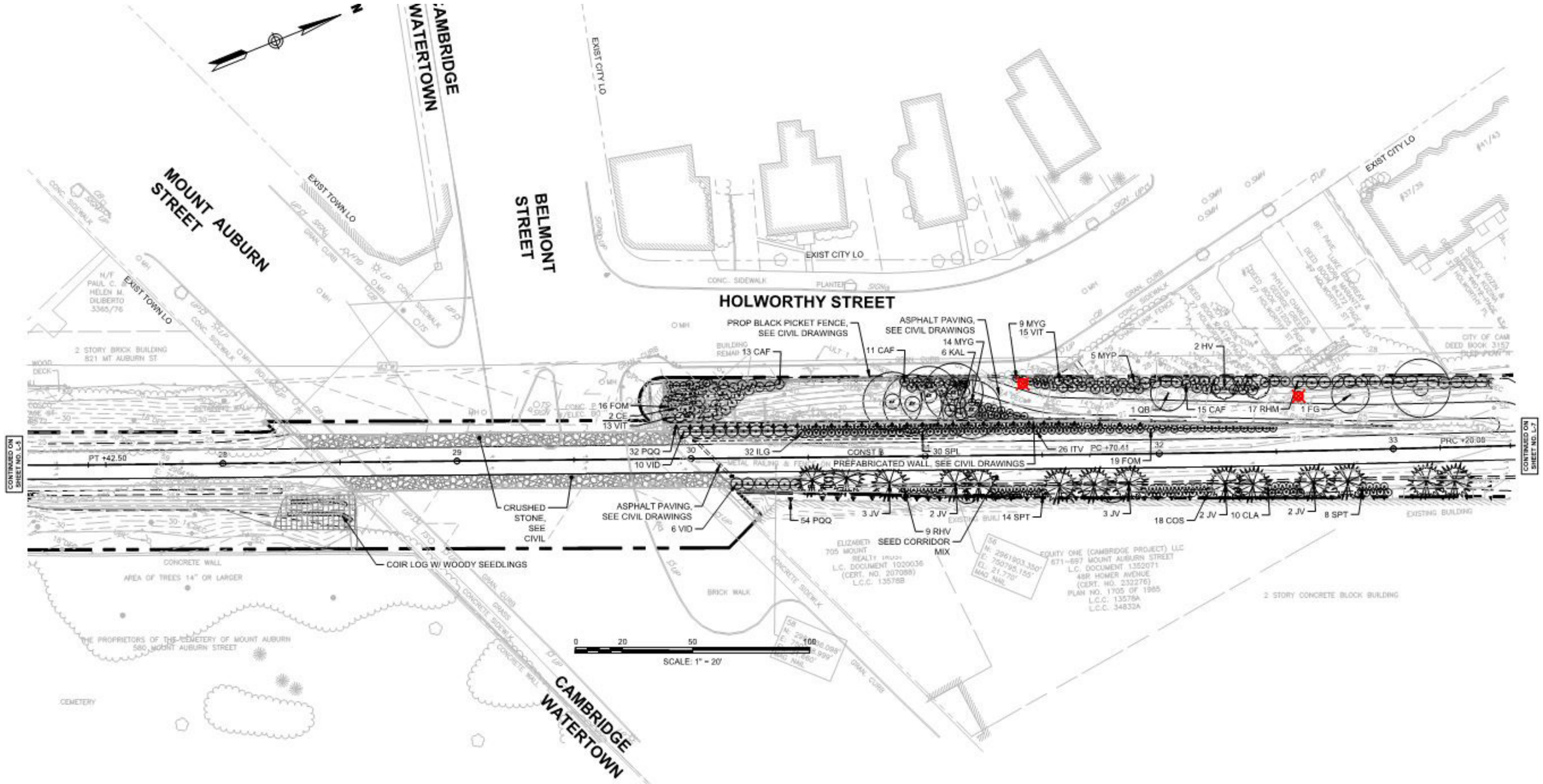
PROPOSED POLE LOCATIONS



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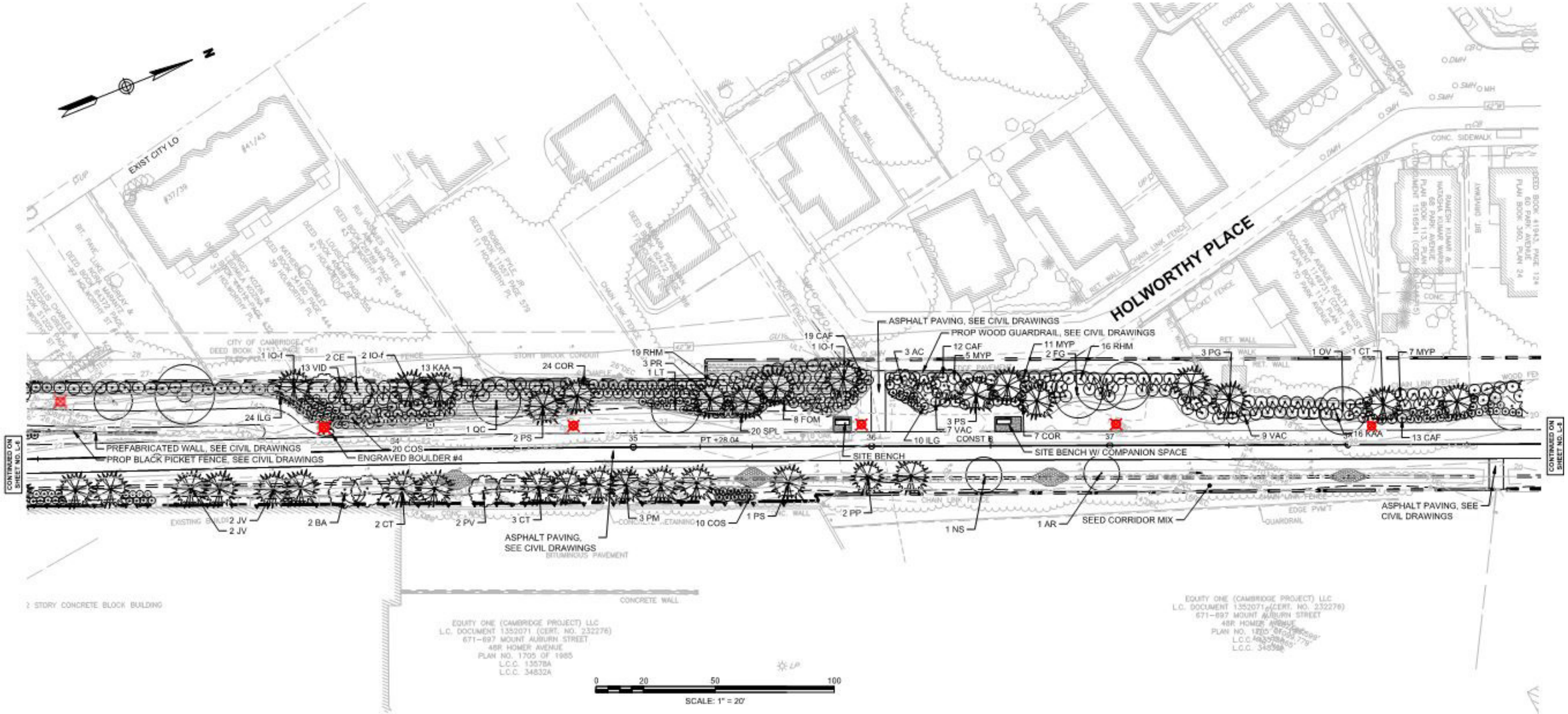

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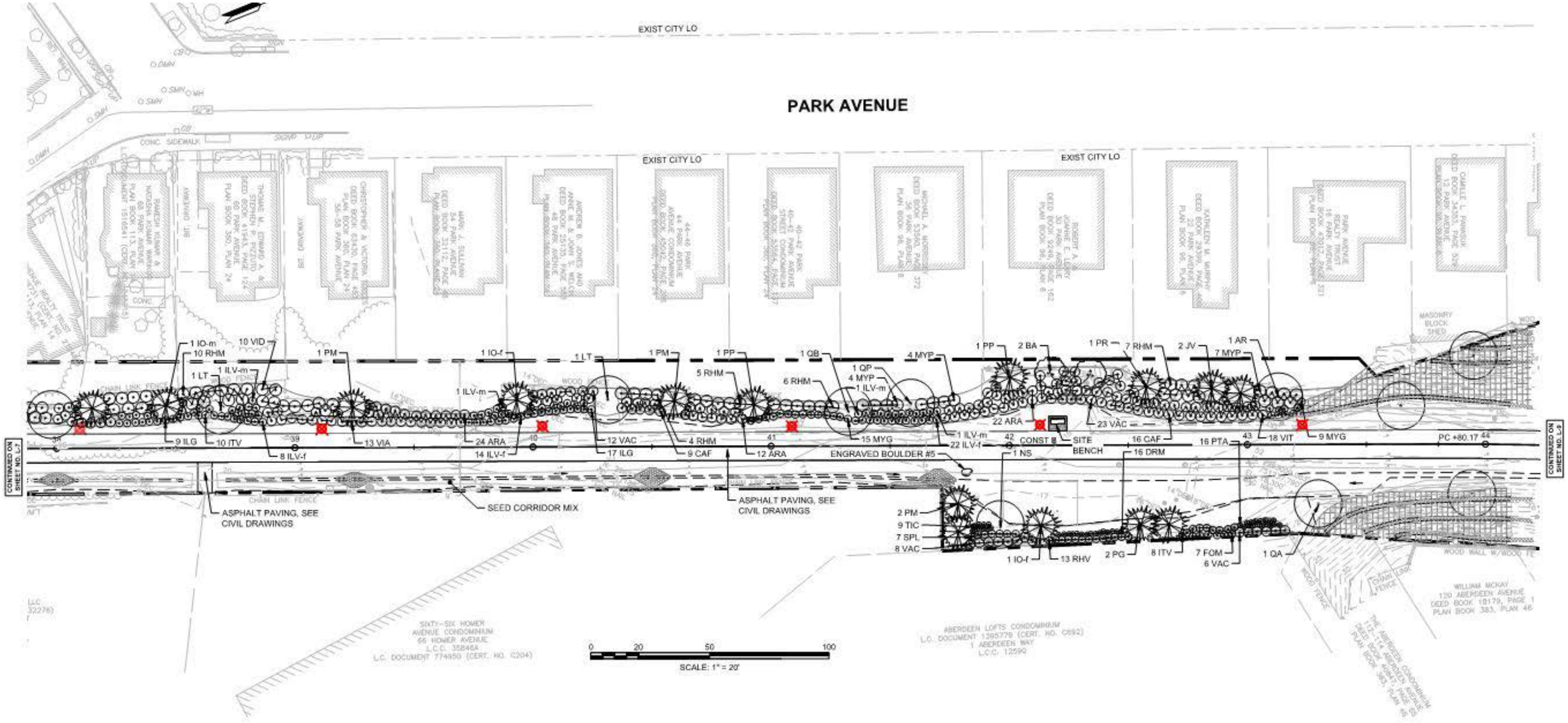

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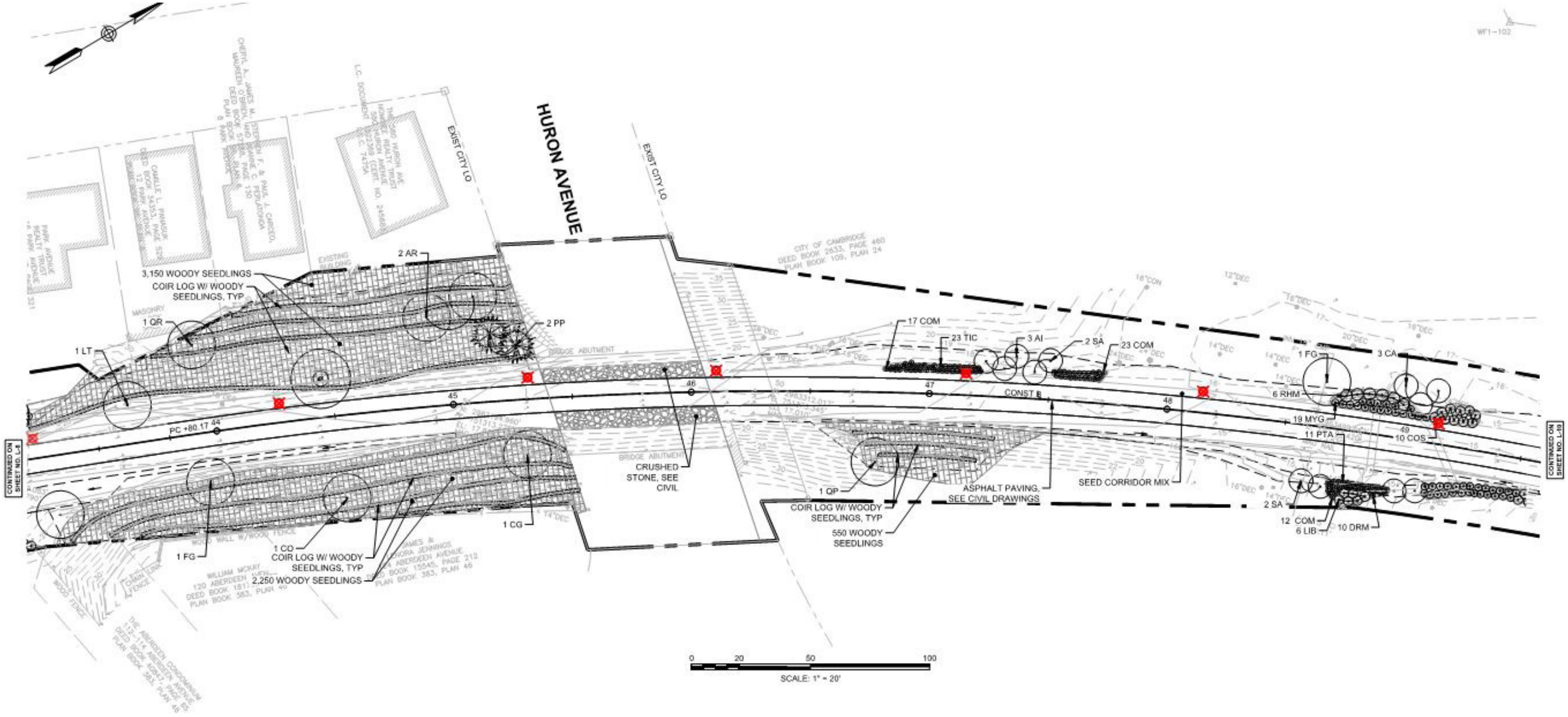
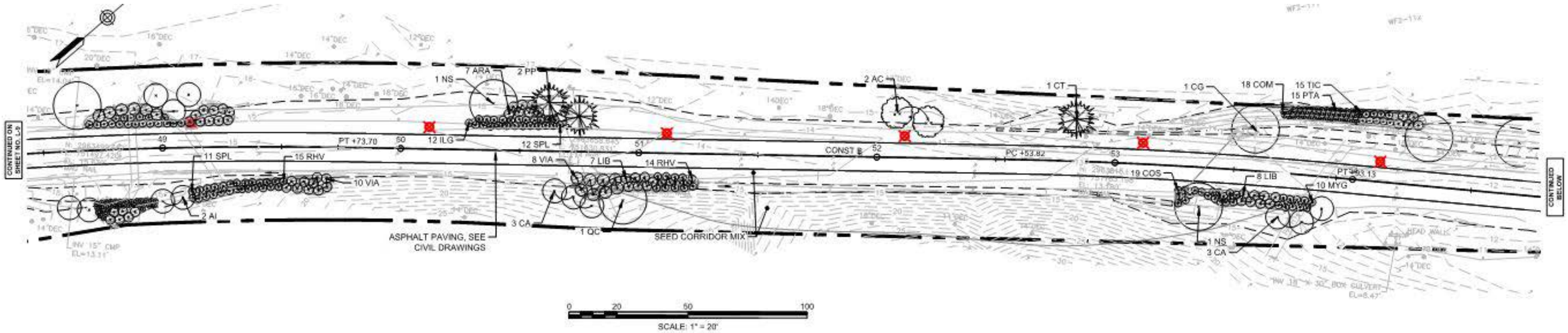


PROPOSED POLE LOCATIONS



PROPOSED POLE LOCATIONS