INTRODUCTION

The purpose of this report is to put forth several recommendations for the design of the Arena Green project that mitigate the effect of artificial lighting on the environment in the proposed project site.

- Current studies show migratory bird species are most negatively affected by steady beams of light in both full-spectrum white light and low-wavelength red light
- Fish and other aquatic animals are also heavily affected by artificial light, especially low-wavelength light, while insects and small mammals are drawn to lights with high wavelengths
- Recommended mitigating measures include the use of kinetic light sources, limiting full-spectrum and low-wavelength lighting, and the use of timeclock controls to lower or shut off lighting during particularly sensitive times of the day or season.

This report will also examine the proposed site for its current lighting conditions. The proposed site (Figure 1) is currently a public park adjacent to the SAP Center at San Jose, through which runs a river that plays a role in the migration of several animal species as well as provides a home to resident flora and fauna.

Figure 1 - Arena Green Project Site, source: Google Maps 2019
The project will be “an artistic and iconic landmark in downtown San Jose” (San Jose… 2018) and through the conscious application of certain mitigating measures, a unique and creative design can be actualized that will fulfill the project’s mission while maintaining a minimum impact on the native ecosystem.

METHODS

To begin, BOLD held several meetings with the San Jose Light Tower Corporation and biologist Ginger Bolen, Ph.D. to understand both the goals of the project and the concerns about the potential impact such a project might have on its surrounding environment. From these meetings, BOLD formed a list of questions to address through research and data gathering. Research was focused around studies previously conducted on the effects of Artificial Lighting at Night (ALAN) on a variety of organisms and ecosystems, as well as the known impact of existing lit structures or similar projects on various species of migratory birds. A site visit was then conducted to gather data on the existing lighting conditions of the site in question. BOLD took baseline luminance and illuminance readings from the existing ALAN influencing the site, especially in areas of concern such as the riparian corridor and river which are used by a variety of migratory birds and fish. After examining the data from the site visit, BOLD established guidelines to be used in the design of the Arena Green project to mitigate the effect of its contribution to ALAN on the site, especially for those ecosystems and species most negatively affected by artificial changes to the lighting in their natural habitat.

EXISTING SITE CONDITIONS

The site survey was conducted between the hours of 11pm and 1am on February 14th, 2019 on an overcast, rainy night. BOLD took light level readings at various points around the proposed site, both in areas of interest to project placement (shown in blue) as well as areas with particularly sensitive ecosystems (Figure 2). Light level readings were not taken at areas of the site that would not be heavily affected by the proposed structure.
River, Riparian Corridor, and Setback

In the most sensitive areas (at the river, in the riparian area, and 100'-0" setback from the riparian area) the highest illuminance value is 12 foot candles (fc) and the lowest value is 0.2 fc. Areas of note include the bridges (ranging from 12 fc to 2.6 fc) (Image 1), the pedestrian paths (1.3 fc directly under the pole light down to 0.7 fc between pole lights) (Image 2), and at the river surface (0.2 fc) (Image 3). In these areas, the majority of the illuminance falling on and around the river is the result of the safety lighting at pathways and bridges (Image 4).

Sources of direct light from fixtures (luminance) in these areas include the pathway pole lights (Image 5) and flood lights on tall poles (Image 6). The luminance level of the pathway pole lights was recorded at 23 foot-lamberts (fL) while the flood lights were recorded at 210 fL.
East Site

On the east side of the site, in the first area identified as a potential location for the Arena Green project, the major source of illuminance is the lighting around the tennis courts. Unfortunately, these lights were turned off at the time of the site visit (Image 7). However, if the courts are lit to the recommended light levels for a recreational tennis court, the illuminance level at the court surface should measure approximately 25 fc. Each pole containing lights for the courts also contained a floodlight fixture for the areas directly around the courts, which when on, would significantly increase the illuminance reading in this area. With the lights turned off, the illuminance level was measured at 0.1 fc around the courts.

West Site

The west side of the site, also identified as a potential location for the Arena Green project, is directly adjacent to the SAP Center sports arena. This area includes several specialty spaces and art installations that utilize their own lighting, raising overall light levels in the vicinity. The pedestrian pathway illumination ranges from 9.2 fc under the pole lights to 1.1 fc along the roadway sidewalk. Other readings range from 1.9 fc at specialty areas (Image 8) down to 0.1 fc at the seating areas where tree foliage blocks the light from the overhead pole fixtures (Image 9).

Sources of luminance in this area include the following: street lights along the roadways (32 fL) (Image 10), light-wrapped palm tree trunks (6.6 fL) (Image 11), the LED screen on the SAP Center (75 fL) (Image 12), and the Children’s Carousel (37 fL) (Image 13).

Overall Site Brightness

According to the 2018 VIIRS/DMSP data recorded by the National Geophysical Data Center, which measures the nighttime light radiance value (rv, or, 10^9 w/cm^2*sr) of the earth, San Jose’s highest readings register at 100 rv, at the corner of Market Street and West San Fernando Street. Readings on the proposed Arena Green project site average at 80 rv, while the adjacent SAP center parking measures at 90 rv. The nearby airport has an average of 79 rv, while the lowest reading in the San Jose area is 0.5 rv at Mount Hamilton to the east. For reference, Times Square in New York City registers at 686 rv (Light pollution… 2018). These levels show that while there are areas of relative darkness within the proposed Arena Green project site, the overall radiance values of the site are comparable to adjacent areas in San Jose.
Site Specific Animal Species

Per our ecological consultant, the animal species that could potentially be impacted most by ALAN on the proposed project site are: Central California Coast Steelhead, Chinook Salmon, and Western Pond Turtles in the river; Yum Myotis, California Myotis, and Eptesicus Fuscus (Big Brown Bat) species of bat; and a variety of bird species – some migratory, some resident (Figure 3).

LITERATURE REVIEW

Many plants and animals, as well as complete ecosystems containing both, depend on natural light cues – from the sun, moon, and stars – to indicate when instinctual behaviors should occur; such behaviors include migration, navigation, reproduction, communication, and hunting/foraging (Longcore and Rich 2004; Longcore and Rich 2016; Berlin Institute… 2016). While ALAN can affect these behaviors (Longcore and Rich 2016), the existing research is inconclusive on the specific measure of ALAN which might have an adverse effect on wildlife.

ALAN is produced through two means: luminance and illuminance. Luminance, or “the brightness of the source of light”, can attract or repel animals; illuminance, or “the amount of light incident on objects in an environment”, can aid in animals’ orientation, cause disorientation, or alter mating and communication behaviors (Longcore and Rich 2004; Longcore 2010). While some animal species glean benefits from the introduction of ALAN into their environment, others do not.

Due to the nature of the project proposal, the highest potential for negative impact lies with the bird species that use the Guadalupe River as a migratory path. Past studies have shown that high levels of luminance from steady sources of light on structures can attract migrating birds and can confuse them so that they become trapped orbiting the light, eventually exhausting themselves (New York… c1997-2019, Van Doren et al. 2017; Gauthreaux Jr. and Belser. 2006). These effects can be amplified under cloudy nighttime conditions when the natural luminance of the moon and stars is covered and therefore unavailable as a directional guide, and artificial lighting increasingly contributes to skyglow (Gauthreaux Jr. and Belser 2006; Longcore and Rich 2004).

Alternately, several studies have found that non-steady, or kinetic, light sources – pulsing, blinking, or set to turn off automatically for certain periods – are less attractive to migratory birds and therefore better for use where ALAN is introduced into migration paths (Blackwell et al. 2012; Longcore and Rich 2016; Van Doren et al. 2017; Gauthreaux Jr. and Belser 2006). Using this information has led to a drastic decrease in bird death around monuments such as the Tribute in Light memorial in New York – which shut off its lighting at periods of high migration.
and the Dungeness Light in Great Britain – which replaced a steady light source with one that flashed for a second every ten second cycle. The use of flashing lights on airplanes has also led to decrease in aerial bird strikes (New York… c1197-2019; Gauthreaux Jr. and Belser 2006).

Studies have also been conducted observing the effects of different wavelengths (Figure 4) of artificial light on animal behavior. Several studies found that full-spectrum white lighting (containing all wavelengths of visible light) and low-wavelength red lighting negatively impacted a bird's ability to use its magnetic compass. The birds in this study were better able to navigate around lights with higher wavelengths such as blue light and green light (Poot et al. 2008; Gauthreaux Jr. and Belser 2006).

![Figure 4 - Wavelengths of Visible Light, source: socratic.org](image)

Other native animal species at risk of behavioral alteration when faced with increased ALAN in their habitat are the steelhead and salmon in the Guadalupe River. Studies have found that fish, including migratory salmon, can be influenced by levels as low as 0.1 foot candles (fc) – as the majority of their growth, development, and behaviors are influenced by light changes across individual days and whole seasons (Longcore and Rich 2016; Berlin Institute… 2016). One study found that while lights in a variety of wavelengths (blue, red, and green) suppressed the production of melatonin in perch to varying degrees, blue light affected the fish's melatonin production least of the three lights tested (Berlin Institute… 2016).

Other studies have found that luminance from light approaching the UV end of the spectrum is more attractive and therefore more disruptive to natural behaviors in insects, amphibians, reptiles such as turtles, and animals that prey on these species. Different species of bats prefer hunting in different illuminance levels, and through the introduction of ALAN, the predation
habits of light-seeking bats are rewarded while those of bats who prefer to hunt in darker conditions are less successful (Longcore and Rich 2016). This example shows how the introduction of ALAN into an environment can alter more than just the behaviors of one animal species, affecting the interaction of different species and the wider ecosystem (Longcore and Rich 2004; Berlin Institute... 2016; Longcore 2016.).

Though it has long been recognized that humans have introduced a significant amount of ALAN into the natural world, the effects of ALAN on the environment have only recently been studied regarding ways to reduce their impact. Further scientific studies could be undertaken to better understand the relationship of animal behaviors with human-altered environments and to propose strategies aimed at mitigating harmful contact between the two (Blackwell et al. 2012). Even within the small amount of research done on the effects of ALAN on animals and ecosystems, the specific light intensities, wavelengths, and optical angles that most affect certain species widely vary (Longcore and Rich, 2016; Gauthreaux Jr. and Belser 2006). Therefore, the recommendations made in this report are for general mitigation efforts that reflect several common threads identified within the research sources.

RECOMMENDATIONS FOR ARENA GREEN PROJECT

Riparian Corridor and Setback

Light fixtures within the riparian corridor that are visible from the water surface should be shielded to prevent glare on the river. This ensures no ALAN, beyond what is already present on site, reaches these sensitive natural habitats. All additional lighting associated with the project, including additional life-safety lighting, should also be shielded from the river’s surface and optically designed to cast light where needed. These sources should also avoid the use of lighting that incorporates any UV wavelengths to minimize their attraction to local insect and bat populations. These methods will prevent further disruption to natural behaviors among the native and migratory aquatic animals, such as the steelhead, salmon, and pond turtles.

Main Structure

The structure itself should avoid using any steady sources of light that project upwards into migratory airspace which have been shown to attract and subsequently trap and confuse birds. Instead, the structure should use kinetic sources of light which are less attractive and therefore less disruptive to natural migration. Any necessary steady sources of light should be kept at the lowest possible level of luminance. Wherever possible, especially during periods of high migration, lights on the structure should be full-cutoff – shielded completely from casting any light up into the sky – to prevent attracting migratory birds off their natural path, and to minimize the project’s contribution to general skyglow.
For any necessary steady light sources projecting into migratory airspace, the project should use as little full-spectrum white light or long wavelength red light as possible to minimize impact to the bird’s magnetic compass. Instead, light from the shorter wavelength end of the spectrum—greens and blues—can be used as these interfere less with the magnetic detection of the migration path.

Finally, lights on the structure should incorporate time-clock controls. Research has shown that by turning lights off during the most sensitive times of the night or season, which can vary depending on the habitats or species in question, the most negative impacts of ALAN can be heavily reduced. This might mean shutting off any lights not necessary for life-safety after a certain time of night, like midnight or after the end of special events on site; alternately, lights could shut off during the dusk and dawn hours when many native species engage in light-triggered behaviors such as mating or hunting.

These are general suggestions based on the currently available research and current observations of the proposed site for the Arena Green project. If, during the structure design process, more specific questions are raised regarding the effect of light type, intensity, wavelength, etc. on certain animal species’ behavior, more research may be needed to address those specific questions.

Through the use of mitigating measures such as those described above, the Arena Green project can leave a minimal impact on the surrounding natural environment, while becoming a beautiful and iconic piece of the San Jose landscape in celebration of the town’s continued innovation and growth.
LITERATURE CITED


