APPENDIX A – SECTION 10

LIGHT

A. APPROACH

This section researches potential effects from light intrusion and other nighttime luminance issues that might be associated with the operation of Seattle-Tacoma International Airport. The existing and previous conditions relating to light in the study area were researched between 1997 and 2019. Unlike the previous sections (such as noise, air quality, mobility, etc.), concerns regarding light are not common metrics tracked by the Port of Seattle or other local agencies. Few data sets provide annual, comparable evaluation of electric light conditions throughout a large geographic area, such as the communities surrounding the Seattle-Tacoma International Airport. However, satellite composite imaging of nighttime light emissions (sometimes called sky glow) is one data set that provides the ability to compare electric light conditions over the course of many years. Beginning in 2012, satellite composite imaging deployed sensing technologies that provide adequate resolution to support the review of electric lighting at night, over a large-scale area.

Review of this data over many years will provide a means of reviewing the changes and intensity of developments that incorporate electric lighting systems. To provide comparisons, the consultant team evaluated the nighttime light emissions in the Central Puget Sound, the City of Seattle and the study area.

Review of data sources and methodology

Through the evaluation of nighttime light emissions over time, patterns and intensity of development emerge.

Evaluation of nighttime light emissions provides an insight into the changes of lighting installations over a large area. While there is not a single factor that contributes to nighttime light emissions, the primary contribution is created by two aspects of electric lighting systems:

- Light directly entering the atmosphere from light sources
- Light reflected off illuminated surfaces, such as roadways or parking lots, that enters the atmosphere.

The National Oceanic and Atmospheric Administration (NOAA), Earth Observation Group and the Colorado School of Mines maintain satellite data. To identify the changes in light conditions at Seattle-Tacoma International Airport, as well as the surrounding communities, between 1998 and 2018, this report used this data, processed in the online tool (lighttrends.lightpollutionmap.info, supported by the ERA-Planet GEOEssential project, of the GFZ German Research Centre for Geoscience).

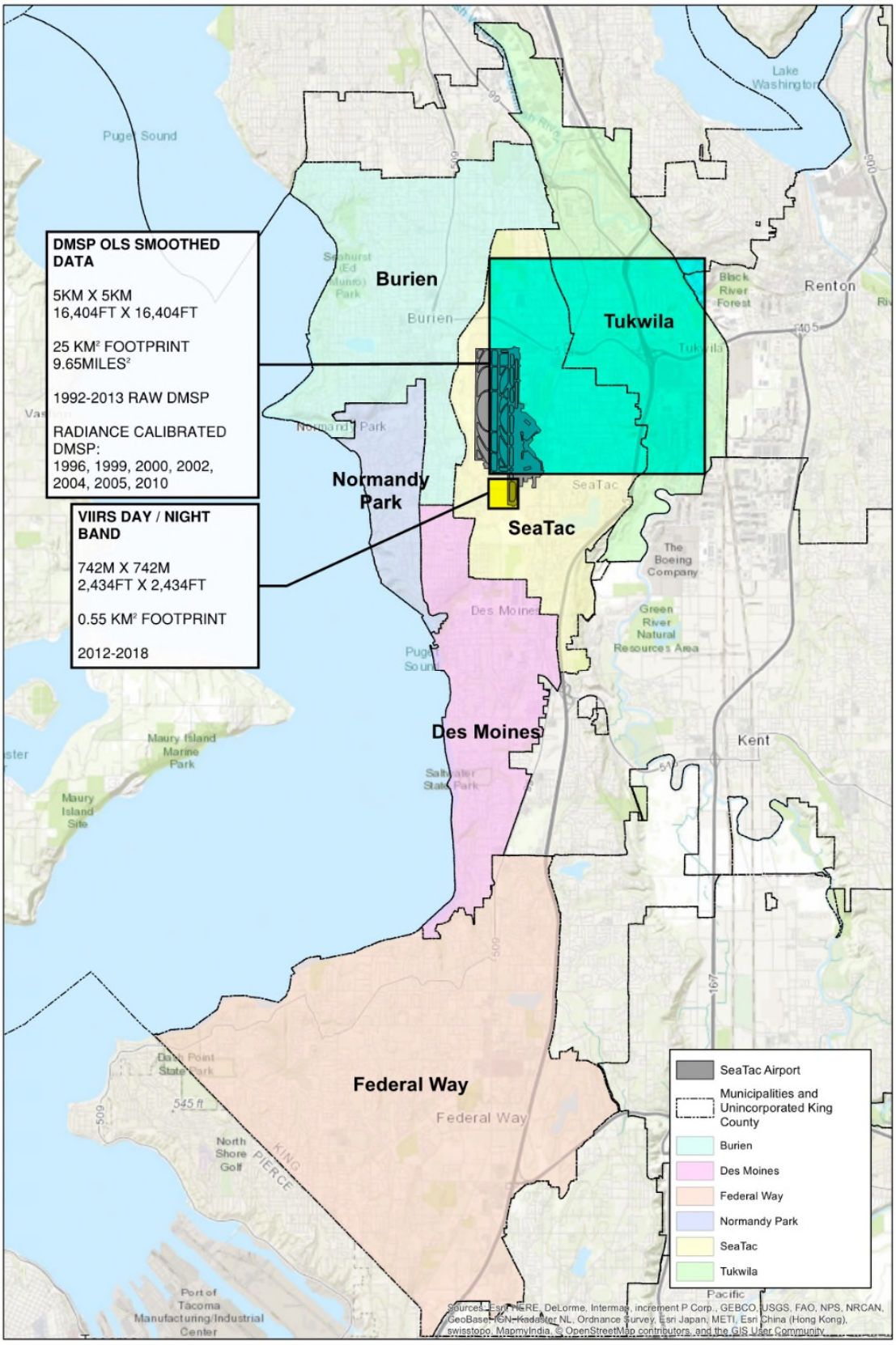
From 1992 to 2013, data comes from the Operational Linescan System of the Defense Meteorological Satellite Program (DMSP) satellites.

- Qualitative: Baseline annual data not calibrated
- Radiometrically calibrated data produced for select years: 1999 and 2010 Reviewed
- Low-resolution data provides information for region only.

From 2012 to the present, data comes from the day/night band of the Visible Infrared Imaging Radiometer Suite instrument (VIIRS DNB):

- Quantitative: calibrated digital measurements
- Measured spectral range is greater than human vision, including infrared wavelengths.

Figure 10.1
DMSP and VIIRS Data-Point Resolution, shown on Airport and Study Area Maps



Variations in data

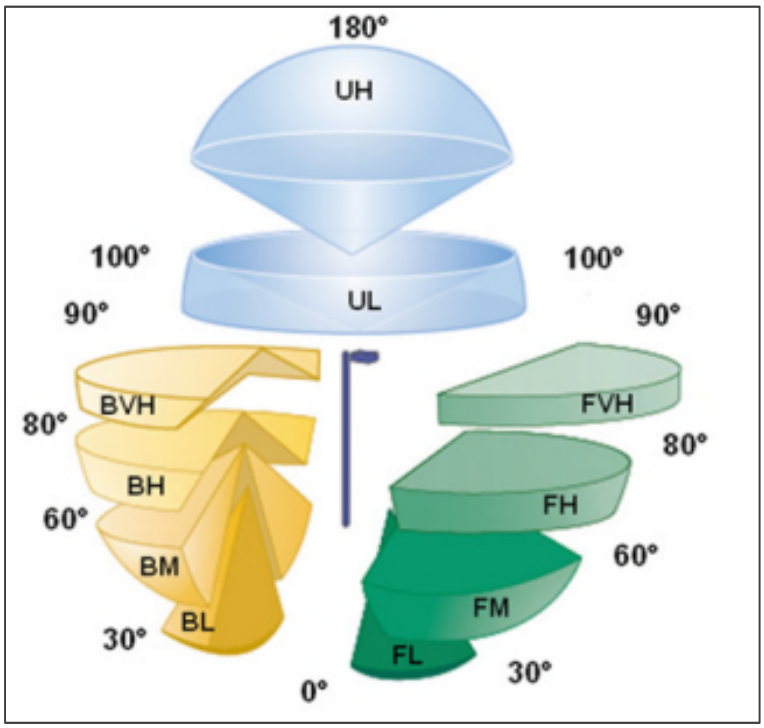
Variations in nighttime light emissions may vary from 15% to 20% due to a variety of factors. These factors are:

- Imaging angle
- Time of night
- Seasonal vegetation
- Atmospheric conditions – aerosol
- Changes in sample area for composites
- Changes imaging sensor
- The presence or absence of moonlight
- Temporary electric lighting
- Electrical blackouts and disasters
- Actual changes in permanently installed lighting.

Sources of light emissions: electric light sources

Light fixture classifications identify fixtures that may create more skyglow. Fixtures with higher values in the UH and UL categories are the most offensive, followed by those in the BVH, BH, FVH and FH regions. The other categories are primarily aimed down and only reflected light from them adds to skyglow.

Figure 10.2
Illustration of Light Fixture Classification System: Backlight, Uplight, Glare (BUG) Ratings

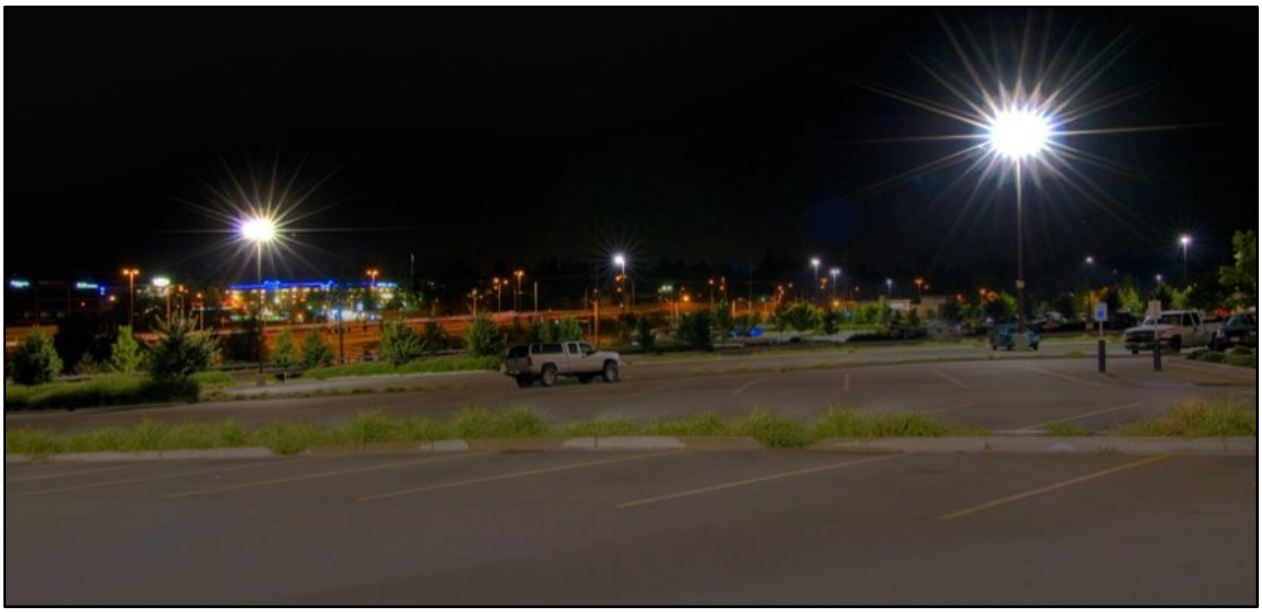


Sources of light emissions: illuminated surfaces

Lighting controls can reduce light levels when spaces are not occupied. As seen in Figure 10.3, reflected light from illuminated surfaces enters the atmosphere as skyglow (evaluated in this study as nighttime light emissions). Figure 10.4 shows the same parking lot as unoccupied, but with lighting controls to lower light level during unoccupied periods to reduce energy use and light pollution.

Figure 10.3
Illustration of Fully Occupied and Fully Illuminated Parking Lot at Northgate Mall
(photo by Stantec)

Figure 10.4
Illustration of Unoccupied and Fully Illuminated Parking Lot (Northgate Mall)
(photo by Stantec)



B. OVERVIEW OF CHANGES IN LIGHT EMISSIONS

Nighttime light emissions for the following geographic areas were:

- Seattle-Tacoma International Airport..... 1.30% Increase per year.
- Neighboring Communities ..... 0.51% Increase per year.
- Central Puget Sound Region ..... 0.31% Increase per year.
- City of Seattle..... -1.33% Decrease per year.

Figure 10.5
Areas of Review for nighttime light emissions

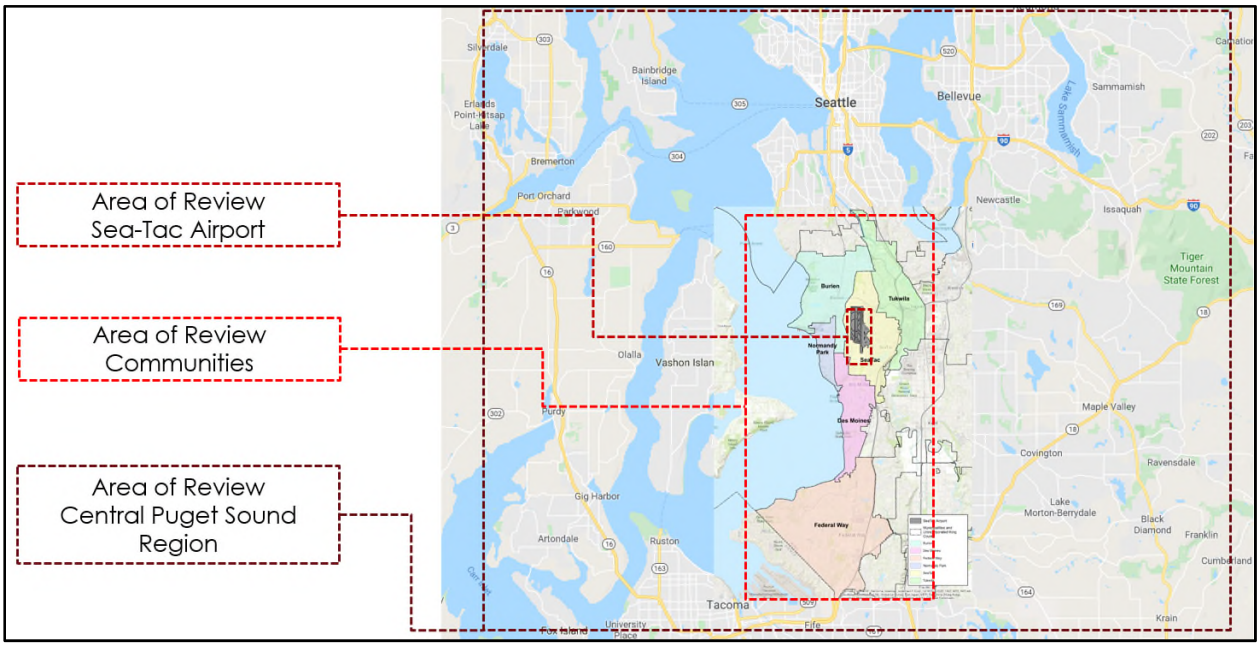


Figure 10.6
Review of nighttime light emissions: 2012 - 2018

Location	Average nW/cm² sr 2012-2018	% Annual Change 2012-2018
Seattle-Tacoma International Airport	51 – 58	1.30% Increase
Neighboring Communities	18.5 – 19.5	0.51% Increase
Central Puget Sound Region	9.7 – 9.9	0.31% Increase
City of Seattle	29 – 27	-1.33% Decrease

Figure 10.7
Measured nighttime light emissions at Seattle-Tacoma International Airport

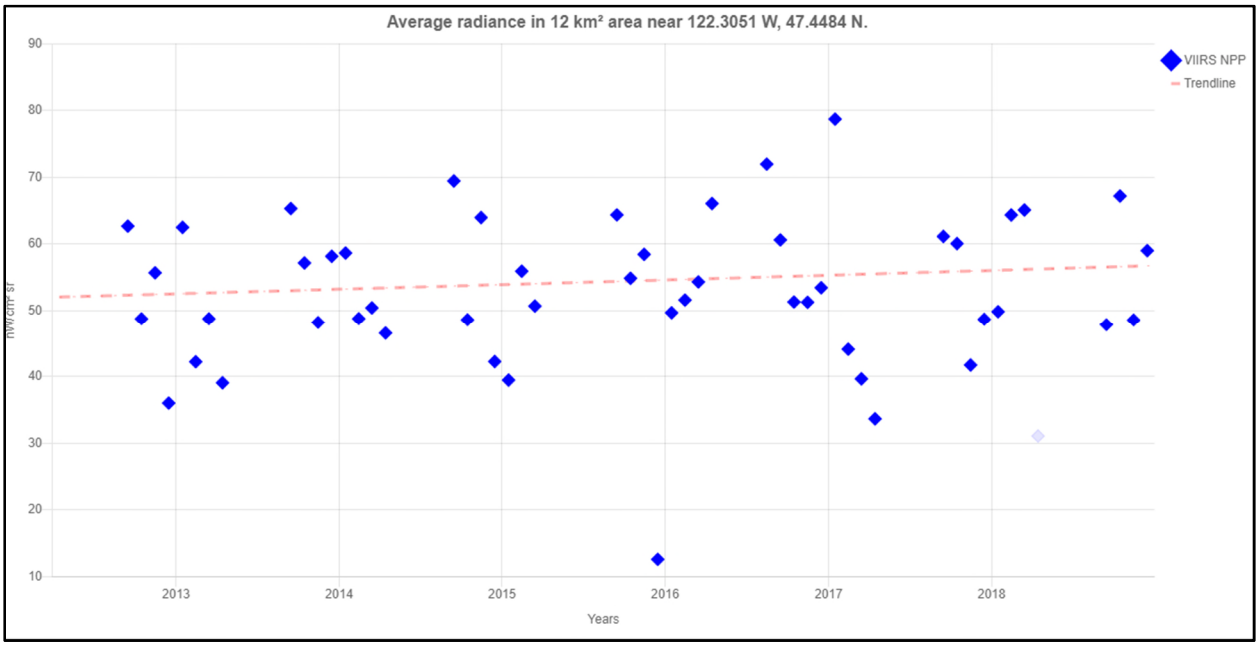


Figure 10.8
Measured nighttime light emissions in Study Area Communities (0.51% Increase per Year)

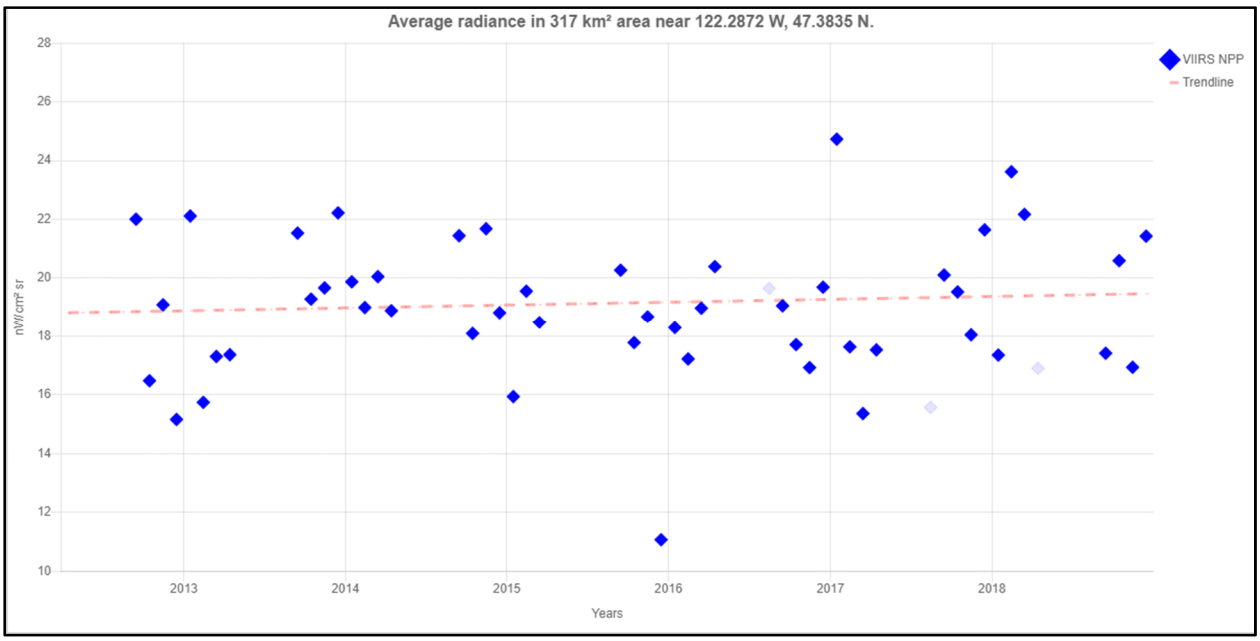


Figure 10.9
Nighttime light emissions in Central Puget Sound Region (0.31% Increase per Year)

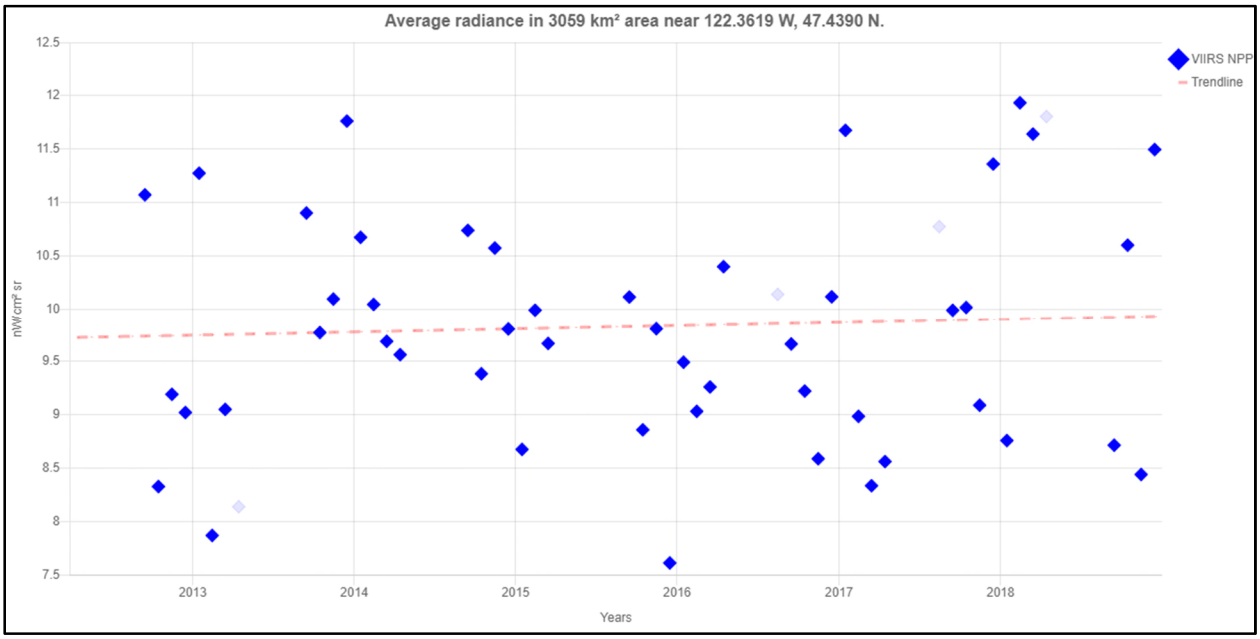
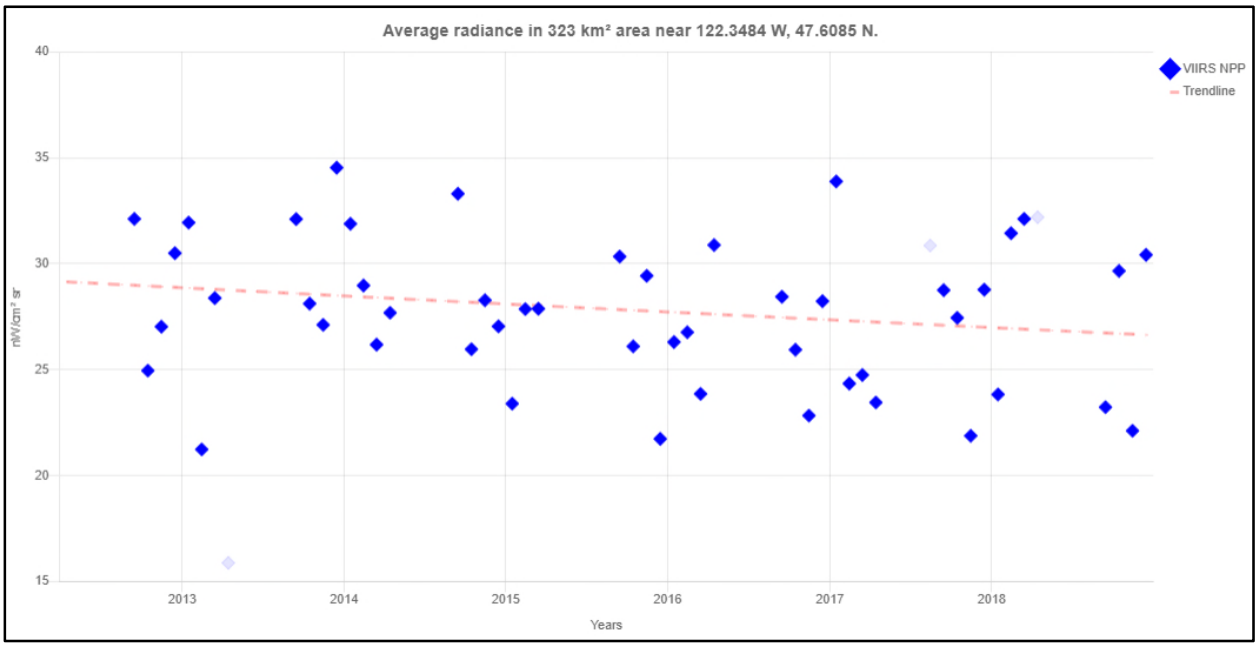


Figure 10.10
Nighttime light emissions in the City of Seattle (-1.33% Decrease per Year)



Nighttime light emissions

Widespread adoption of LED street lighting between 2012 and 2018 decreased nighttime light emissions, when illumination levels and areas of development are held constant. However, increased development and the addition of new electric light installations will result in increased level of nighttime light emissions.

Field observations

To identify the visibility of the Seattle-Tacoma International Airport from the surrounding communities, the consultant team conducted 60 field observations from locations with direct visibility of the Seattle-Tacoma International Airport. Of all the lighting infrastructure at the Seattle-Tacoma International Airport, two locations created high luminance conditions within the adjacent residential communities.

- **Consolidated rental car facility**
  Visibility of the consolidated rental car facility from adjacent residential locations is illustrated in Figure 10.11 through Figure 10.13. From these locations, consistent glare potential is present due the visibility of car headlights emanating from the interior of the consolidated rental car facility. Additionally, high brightness interior lighting and pole-mounted exterior lighting present direct visibility of light sources.

- **High mast lighting near North Loop Road and cargo facilities**
  The high mast area lighting located within the Seattle-Tacoma International Airport cargo area, adjacent to the North Loop Road, presents uncontrolled visibility of light sources. These fixtures use high-intensity light sources and are aimed nearly horizontally. As a result, no part of the housing conceals the light source from view and these fixtures present direct visibility of the light source to locations adjacent to the North Loop Road (see Figure 10.14 through Figure 10.17).

Figure 10.11
Description of Field Observations

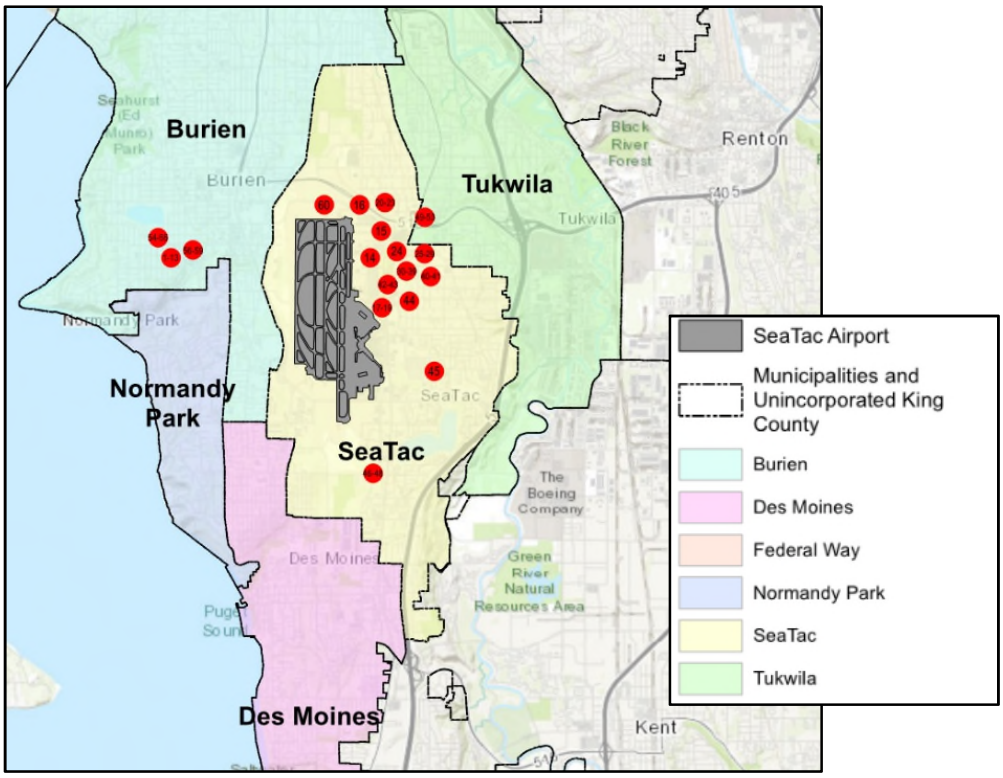


Figure 10.12
View to Consolidated Rental Car Facility (South 164th Street & 32nd Avenue South, Facing North)
(photo by Stantec)

Figure 10.13
View to Consolidated Rental Car Facility (South 164th Street & 32nd Avenue South, Facing North)
(photo by Stantec)

Figure 10.14
View to Consolidated Rental Car Facility (South 164th Street & 32nd Avenue South, Facing Northwest)
(photo by Stantec)

Figure 10.15
View from North Loop Road (Southwest 162nd Street & 9th Avenue Southwest, Facing East)
(photo by Stantec)

Figure 10.16
View from North Loop Road (Southwest 162nd Street & 9th Avenue Southwest, Facing East)
(photo by Stantec)

Figure 10.17
Airport Expressway (Facing East)
(photo by Stantec)

Figure 10.1*8*
Air Cargo Road (Facing West)
(photo by Stantec)

Terminal apron lighting

The Seattle-Tacoma International Airport terminal apron lighting is undergoing upgrades in which LED sources replace less efficient high-intensity discharge light sources. Not only do these fixtures reduce energy use, they also conceal the visibility of the light source. This results in increased visual comfort for airport users, as well as the surrounding communities. To further reduce skyglow, controls could be implemented to lower or turn off these sources when gates are not in use because they are instant "on" sources and do not require a warm-up time the way the current sources do.

Figure 10.19 shows the typical apron lighting fixture found at Seattle-Tacoma International Airport.

Figure 10.20 shows the difference between metal halide light sources with limited control of uplight and glare potential (left side) and usage of LED sources, which minimize uplight and glare potential (right side). Figure 10.19 shows the difference at Vancouver International Airport.

Figure 10.19
Typical Apron Light Fixture (Illustrative Purposes Only)

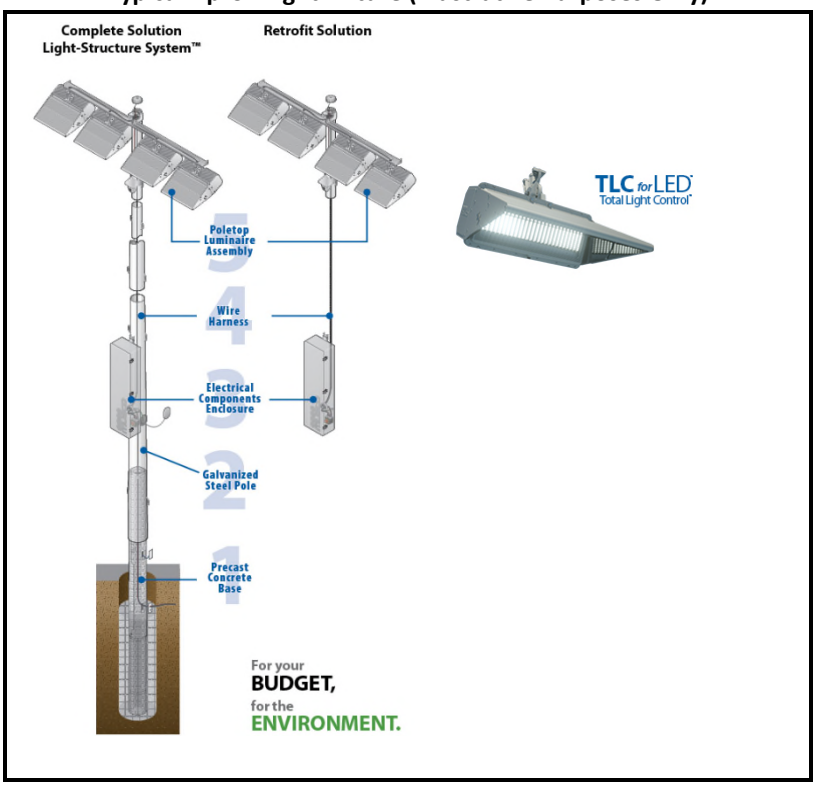
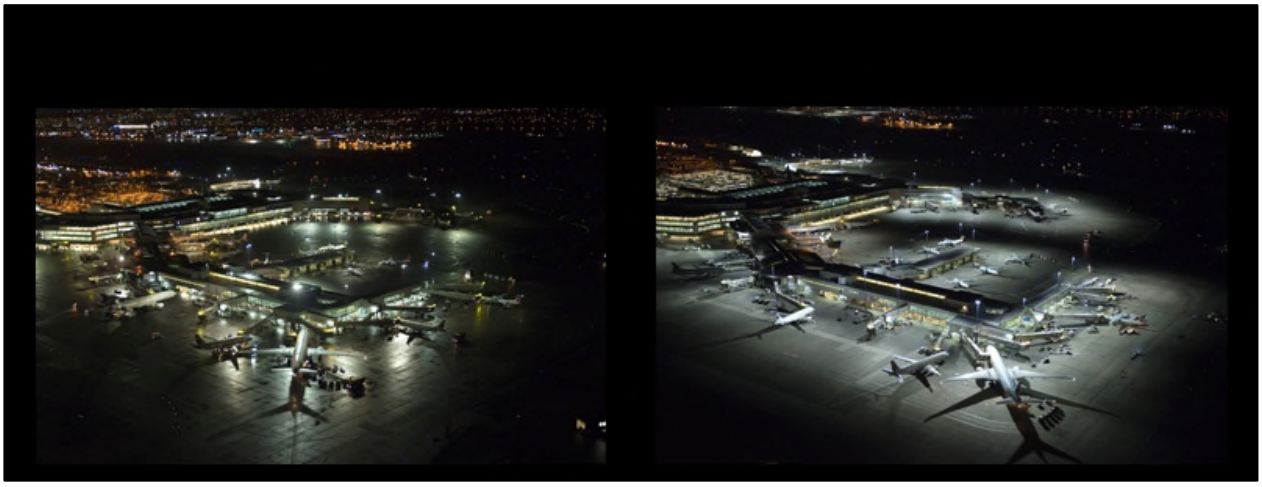


Figure 10.20
Metal Halide versus LED Light Sources at Vancouver International Airport (Illustrative Purposes Only)



C. LIGHTS EFFECTS ATTRIBUTABLE TO AVIATION ACTIVITY

Positive effects from light

Seattle-Tacoma International Airport is replacing the older-generation of lighting (metal halide) with energy-efficient LED fixtures. LED is much more controllable than older-style lights, which often create glare and skyglow. LED lights use less energy, have a higher degree of controllability, and can reduce or eliminate glare and night-sky disruption in surrounding neighborhoods.

As mentioned previously, the new LED fixture could also include controls to lower or turn off these sources when gates are not in use (since they do not require a warm-up period to reach the required level of brightness).

Neutral effects from light

There are no known neutral effects from the lighting in and around Seattle-Tacoma International Airport.

Negative effects from light

There are no known negative effects from the lighting in and around Seattle-Tacoma International Airport. This was also not an issue that mentioned by study area citizens as a significant concern, both in the past (to 1997) and currently.

Summary of light effects attributable to aviation activity

The graphs and tables in this section present various effects associated with light, including magnitude and intensity. However, Figure 10.21 presents a general assessment of light effects in the study area attributable to aviation activity, categorized into four effect types:

- Positive effect attributable to aviation activity
- Negative effect attributable to aviation activity
- Neutral or no effect attributable to aviation activity
- Inconclusive data/needs additional study.

Figure 10.21
Summary of Light Effects Attributable to Aviation Activity – 1997 to 2019

Positive effect attributable to aviation activity
Neutral/no effect attributable to aviation activity
Negative effect attributable to aviation activity
Inconclusive data/needs additional study

LIGHT METRIC	STUDY AREASTUDY AREA CITY																	
	Burien			Des Moines			Federal Way			Normandy Park			SeaTac			Tukwila		
	1997	2009	2019	1997	2009	2019	1997	2009	2019	1997	2009	2019	1997	2009	2019	1997	2009	2019
Light	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Because of the ongoing replacement and improvement of older-generation exterior light fixtures with energy efficient/low glare LED fixtures, the Port of Seattle has addressed issues with light intrusion and glare. There may be isolated instances where older light fixtures intrude on adjacent neighborhoods, but there were no reports of such intrusions. Similarly, there were no reports of study area concerns regarding aircraft lights from the study area cities. Therefore, light and glare associated with Seattle-Tacoma International Airport is determined not to be an issue in the study area.

D. RECOMMENDATIONS

In reviewing the available data relating to lighting in the study area, the consultant team offers the following findings:

- Seattle-Tacoma International Tac Airport shows the highest evaluated average nighttime light emission (ranging from 51 to 58 nW/cm^2 sr) and the greatest average annual increases of 1.30%.
- The neighboring communities had a significantly lower average nighttime light emission (ranging from 18.5 to 19.5 nW/cm^2 sr) and lower rate of annual increase of 0.51%.
- The Central Puget Sound Region showed lower average nighttime light emissions (ranging from 9.7 to 9.9 nW/cm^2 sr) and lower annual increase 0.31%.
- The city of Seattle showed greater average nighttime light emissions, than the neighboring communities (ranging from 29 – 27 nW/cm^2 sr); however, in the city of Seattle from 2012 to 2018, nighttime light emissions did not increase – they actually decreased by -1.33% annually.
- Lighting was not a primary concern raised by citizens in the study area at either of the public workshops or through the series of stakeholder interviews.

Based on this analysis, the consultant team offers the following recommendations:

- **Lighting recommendation #1: Update airport high mast lighting**
  To reduce glare potential, Seattle-Tacoma International Airport should replace the high mast flood lighting with LED sources similar to those used around the terminal aprons, at locations in the cargo area and adjacent to North Loop Road. This may be phased in over a period of time – no longer than five years is suggested.

- **Lighting recommendation #2: Adoption of study area lighting standards**
  Seattle-Tacoma International Airport and the study area cities should consider implementing coordinated lighting guidelines for development of community friendly infrastructure. The lighting installations for off-site parking, transit, and the consolidated rental car facility are currently not aligned with industry standards for similar developments within neighborhoods or residential communities. To better support the communities that are directly adjacent to such infrastructure, the study area cities (notably the city of SeaTac) should consider the adoption of community lighting standards that would establish guidelines for future developments and renovations of existing facilities.

E. THE FUTURE

It is conceivable that lighting technology will continue to evolve and offer more energy-efficient technologies. These have the benefit of saving energy, saving money, and generating less heat than previous lighting standards. Lighting improvements may also extend to mobile sources (cars, trucks, aircraft) that will give operators a better degree of control and energy savings. "Smarter" lighting will also be able to detect appropriate movement to illuminate when needed or on an intricate complex schedule.

Improved lighting will also enhance areas like U.S. Highway 99, which experiences the highest degree of pedestrian activity immediately adjacent to Seattle-Tacoma International Airport. Conversely, sensitive areas (residential neighborhoods, wildlife habitats, the Puget Sound coastline, etc.) will be better served by the current and future generations of lighting technology.

F. SUMMARY

This section has identified some areas in need of improvement, but generally airport-area lighting has not been a primary issue with area residents. Seattle-Tacoma International Airport is taking steps to replace older-style lighting, which has benefits to both the Port of Seattle (energy efficiency) and the study area (reduced glare and skyglow).

This study projects that there would be a benefit throughout the study area for the Port of Seattle and the study area cities to collaborate on a standardize set of lighting guidelines to help guide future growth.

G. REFERENCES

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Radiance Light Trends (Light pollution mapping software). https://lighttrends.lightpollutionmap.info/#zoom=5&lon=-120.92707&lat=47.30752