

# **NNSS Lightning Climatology**

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National Oceanic and Atmospheric Administration (NOAA)  
Office of Oceanic and Atmospheric Research (OAR)  
Air Resources Laboratory (ARL)  
Special Operations and Research Division (SORD)**

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## 1.0 INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory/Special Operations and Research Division (ARL/SORD) operates a lightning detection network, Figure 1, consisting of four Vaisala Advanced Total Lightning Sensors (LS7001), Figure 2, tuned to detect cloud-to-ground lightning flashes on the Nevada National Security Site (NNSS). This report describes the lightning climatology products for the NNSS developed with the Vaisala Fault Analysis and Lightning Location Software Client for Windows (FALLS® 5.4.0) using data from the ARL/SORD network.

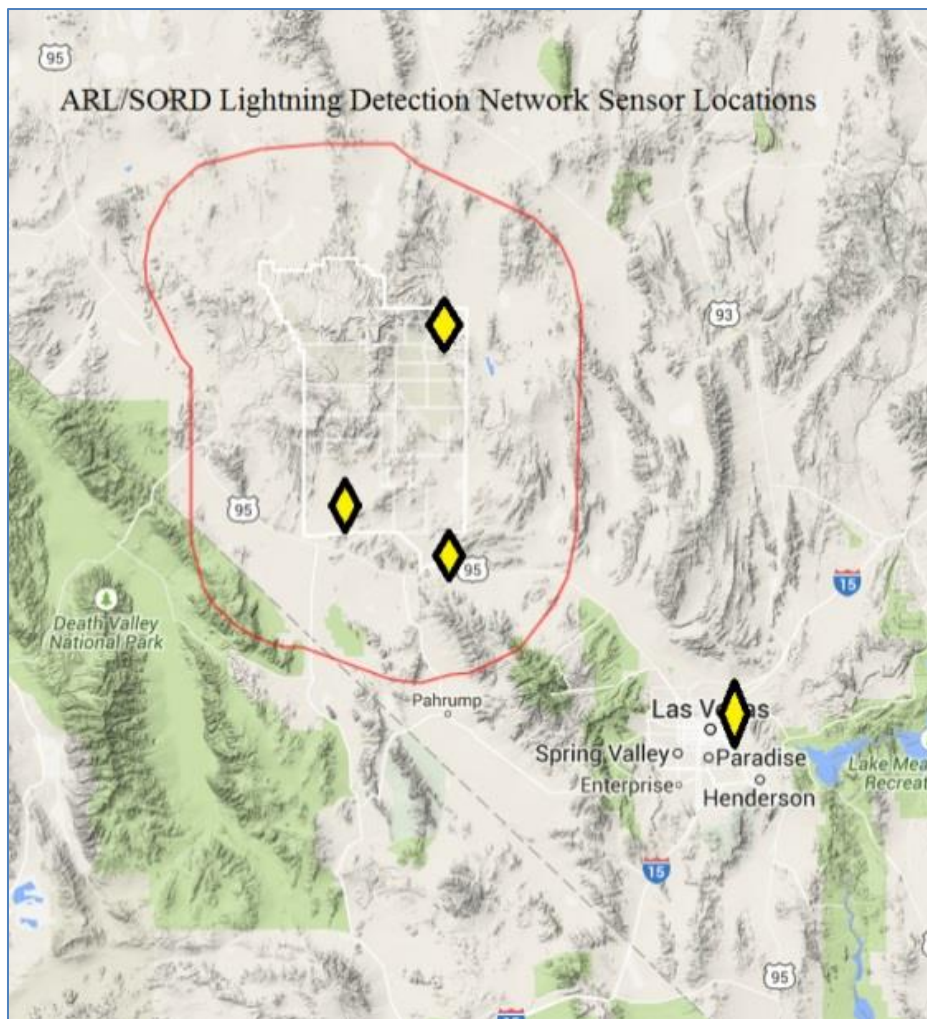


Figure 1. ARL/SORD Lightning Detection Network Sensor Locations.

The local database contains 162,984 flashes from 2001-03-26 13:07:55 through 2015-02-28 23:59:59 within the area bounded by longitudes 116.945°W and 115.550°W and latitudes 36.280°N and 37.683°N, Figure 3.

The analysis was conducted using all available data. When using a 14 year period of record, a single storm or series of storms during a particularly active monsoon can significantly influence the climatology. For example, 18.9% of all flashes recorded in the local database occurred in the summer (Jun-Aug) of 2005. Winter (Dec-Feb) flashes account for less than 0.5% of the total and are barely perceptible on the histograms.



Figure 2. LS7001 Lightning Sensor at the Desert Rock Weather Observatory.

Three types of plots were produced to illustrate the lightning climatology of the selected high hazard and elevated risk facilities on the NNSS:

- 1) Flash density maps indicate the flash density per square kilometer per year and are rendered at a 1 km resolution.
- 2) Hourly histograms indicate the total number of flashes by hour-of-the-day (PST).
- 3) Seasonal histograms indicate the total number of flashes plotted by season for night (0000-0600), morning (0600-1200), afternoon (1200-1800), and evening (1800-0000) periods of the day. All times are in PST.

Flashes can be positively or negatively charged. Positively charged flashes make up 13% of the total flashes on the NNSS. Negatively charged flashes make up the remaining flashes on the NNSS.

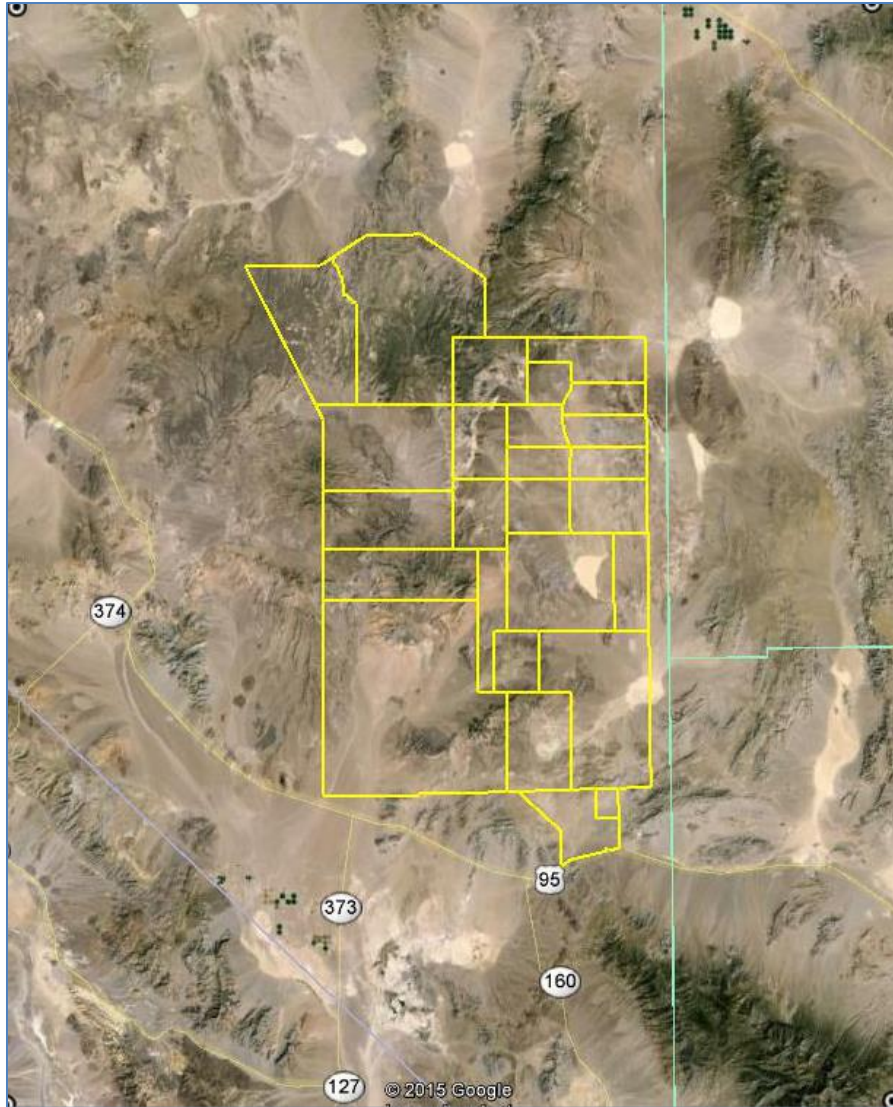


Figure 3. NNSS Lightning Climatology Area.

## 2.0 DESCRIPTION OF LIGHTNING

There are two main types of lightning, intra-cloud and cloud-to-ground. The ARL/SORD lightning detection system is capable of detecting both types. The following is a brief discussion of the different types of lightning.

### 2.1 *Intra-cloud lightning*

Intra-cloud or cloud-to-cloud lightning, Figure 4, is an electrical discharge between oppositely charged areas within a thunderstorm or between nearby thunderstorms. When they occur, these flashes are displayed on the ARL/SORD Website Lightning pages (click hyperlink or paste into browser <http://www.sord.nv.doe.gov/Lightning.php?Location=Southwest&Ltime=30>) as colored circles without black outlines. In some cases, intra-cloud or cloud-to-cloud lightning occurs prior to cloud-to-ground lightning and can be interpreted as a precursor to cloud-to-ground flashes.

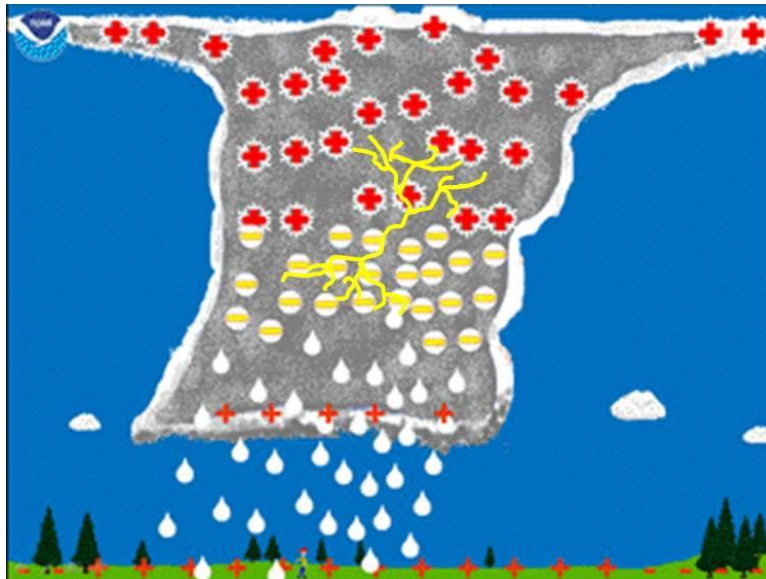


Figure 4. Intra-cloud Lightning

### 2.2 *Cloud-to-ground (CG) lightning*

Cloud-to-ground (CG) lightning, is an electrical discharge between opposite charges in the cloud and on the ground. When cloud-to-ground lightning occurs, the flashes are displayed on the ARL/SORD Website Lighting pages by colored circles with black outlines (click hyperlink or paste into browser <http://www.sord.nv.doe.gov/Lightning.php?Location=Southwest&Ltime=30>). CG lightning can occur between negative charges in the cloud and positive charges on the ground (a negative flash) or vice versa, between positive charges in the cloud and negative charges on the ground (a positive flash). A CG lightning flash consists of one or more *leaders* followed by one or more *return strokes*. The *leader* is the initial step in the lightning flash and establishes the conductive channel that the electrical discharge (lightning flash) will take. The

*return stroke* is the large electrical discharge we see as the bright light. The return stroke occurs very quickly (about 200 million miles per hour) and the channel appears to light up all at once (this is because our eyes cannot perceive things moving at these speeds).

There are two types of CG lightning, negative flashes and positive flashes. The ARL/SORD lightning detection system is capable of detecting both types.

### **2.2.1 CG lightning – Negative Flash**

A negative flash, Figure 5, is the most common and occurs when the leaders originate from the negatively charged area of the thunderstorm.

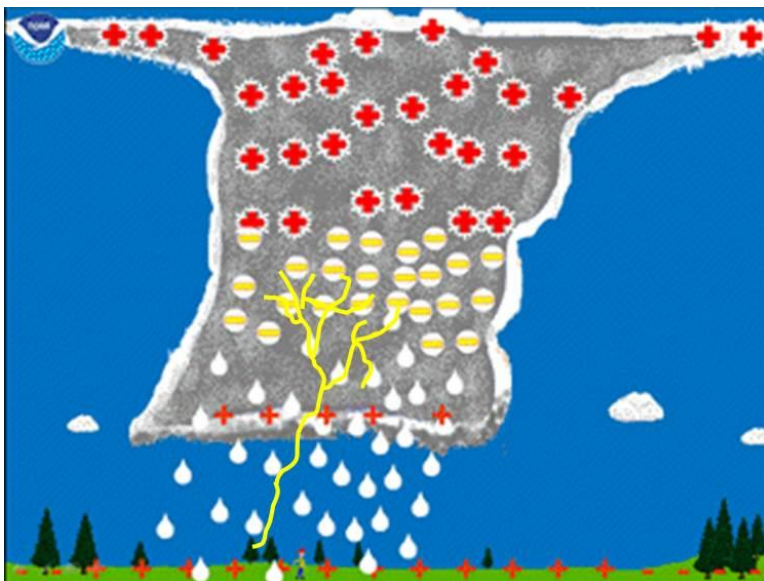


Figure 5. Negative Flash Cloud-to-Ground Lightning

### **2.2.2 CG lightning – Positive Flash**

A positive flash, Figure 6, occurs when the leaders originate from a positively charged area of the thunderstorm, typically the upper part of a thunderstorm. Most of the time, these positive leaders are shielded from the ground by the negatively charged central area of the cloud. However, if the storm becomes tilted or if the anvil spreads out in front of or behind the main thunderstorm cloud, the ground is no longer shielded from this upper positive charge. If a large charge differential develops between the upper cloud and the ground, a downward moving positive leader can develop. Since a positive leader usually is the result of a tilted cloud or an anvil cloud out in front or behind the main storm and rain area, positive flashes can occur at significant distances from the main storm. These distances can be at least 5 to 10 miles. These distant flashes are sometimes called “blue sky” lightning since the sky directly above the ground impact may not be experiencing stormy conditions. In addition, since the genesis area of the positive leader usually is at the top of the cloud and higher in the atmosphere, a much greater charge differential is required to initiate a positive flash as compared to a negative flash. As a

result, positive flashes occur much less frequently with much greater distances between flashes. On average positive flashes make up only about 13% of the total flashes on the NNSS.

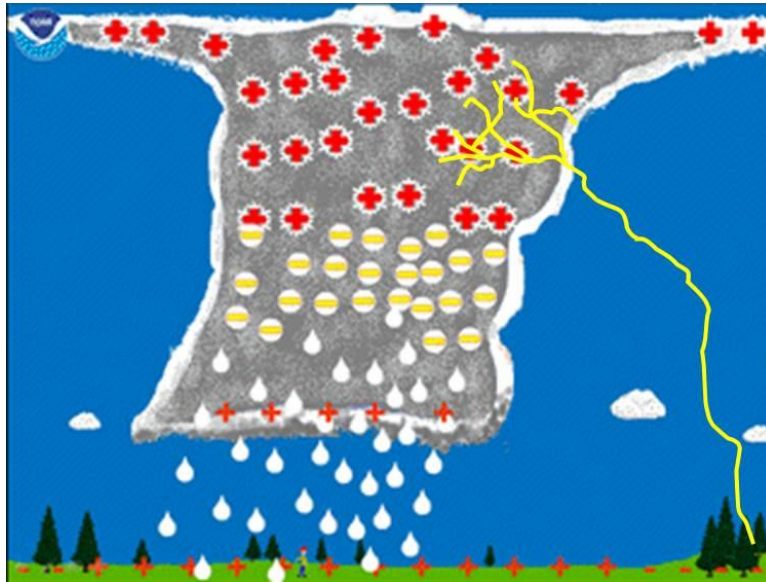


Figure 6. Positive Flash Cloud-to-Ground Lightning



### 3.0 FACILITY REPORTS

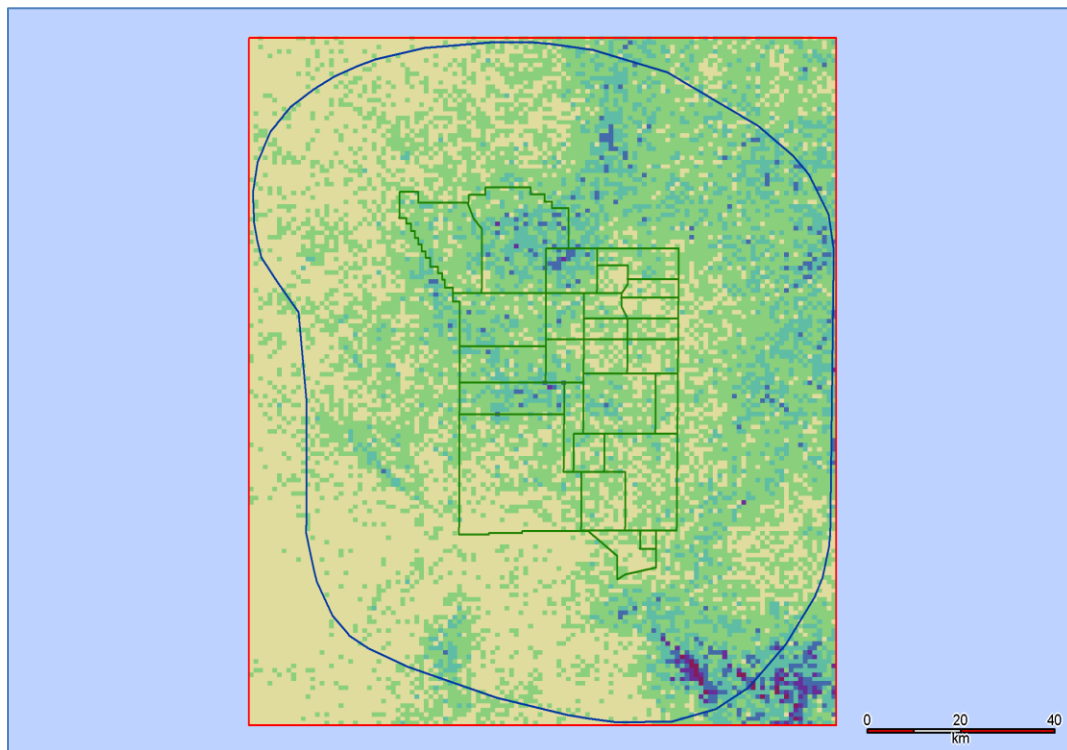
|                                    |                                      |   |
|------------------------------------|--------------------------------------|---|
| <b>3.1</b>                         | <b>Nevada National Security Site</b> | Data Range                                    |
| ARL\SORD<br>NNSS Lightning Summary | Within 20 Miles                      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

162,984 flashes were recorded over the period of record. The maximum flash densities observed were > 2.5 km<sup>2</sup>/per year but < 3.5 km<sup>2</sup>/per year and were recorded over the elevated terrain of the Spring Mountain range southeast of the NNSS.

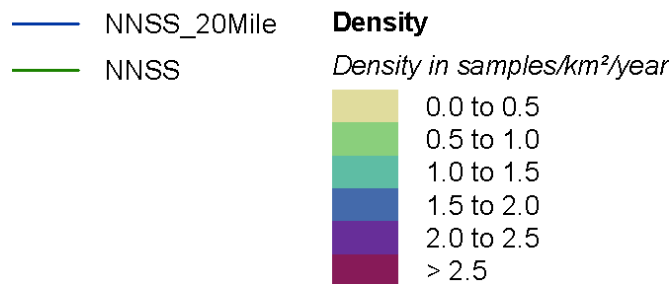
141581 – Charged Flashes

21403 + Charged Flashes

%+ 13.1

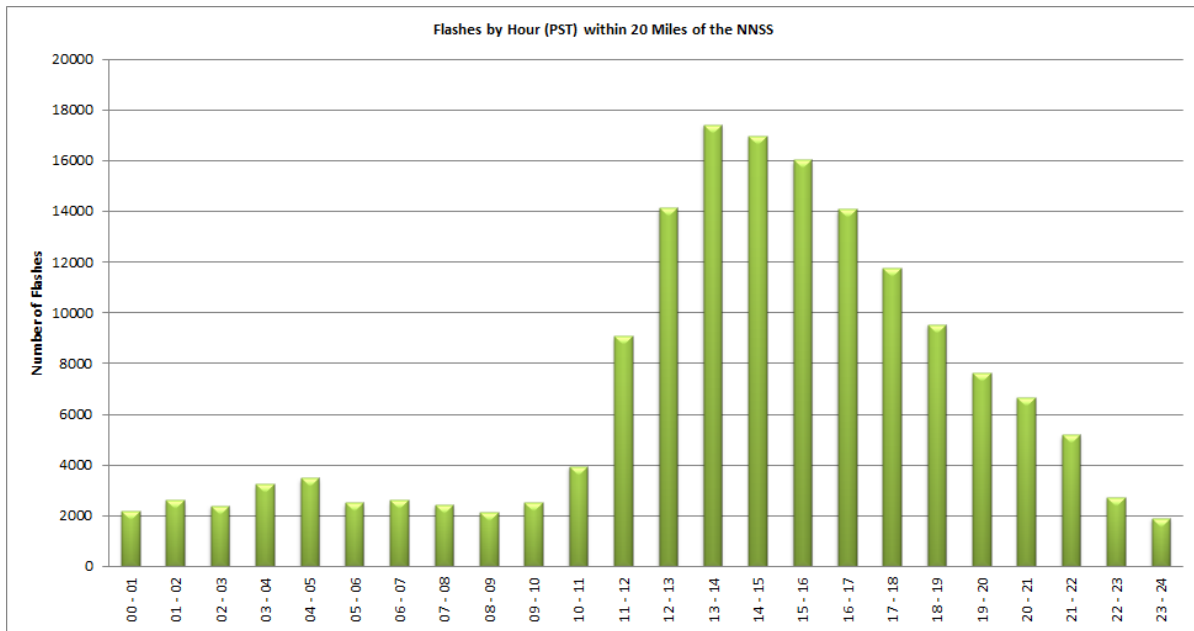


Legend

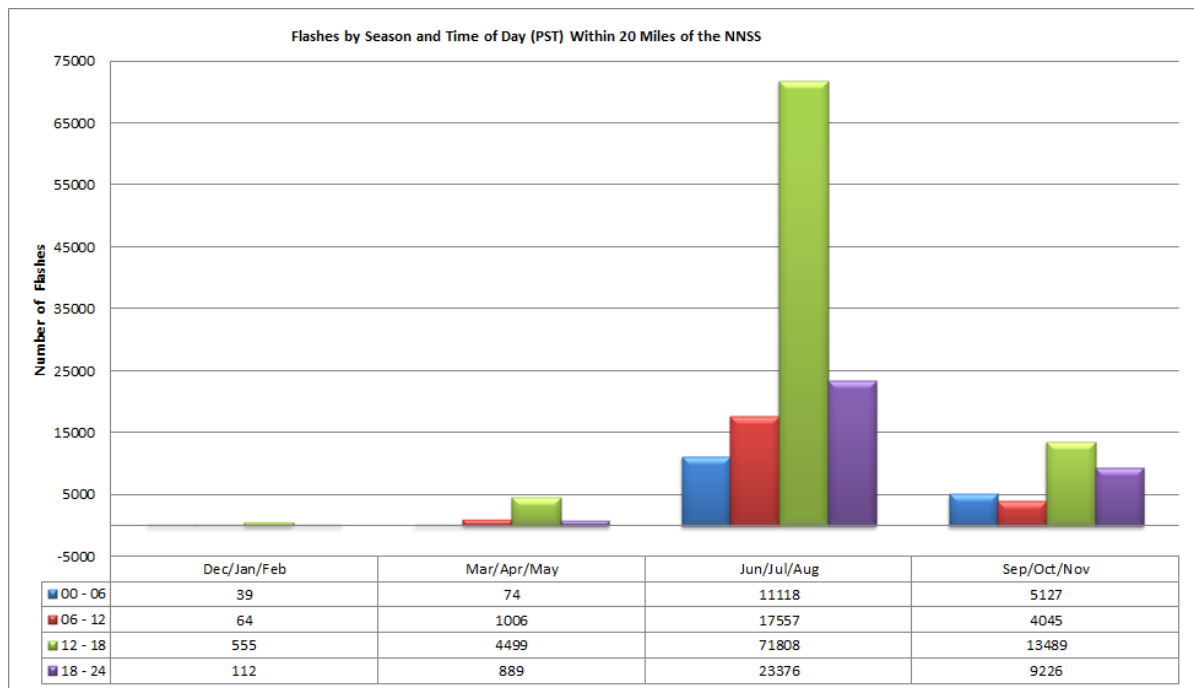


Thunderstorms over the NNSS occur mostly during the summer season June, July and August (JJA). Most of the lightning starts around mid-day over the higher terrain and moves outward to lower elevations in the late afternoon and early evening.

|                                    |                                      |   |
|------------------------------------|--------------------------------------|---|
| <b>3.1</b>                         | <b>Nevada National Security Site</b> | Data Range                                    |
| ARL\SORD<br>NNSS Lightning Summary | Within 20 Miles                      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



Cloud to ground lightning activity during the afternoon (noon through 6 PM PST) comprises over 50% of all flashes occurring within 20 miles of the NNSS. Further analysis shows that the bulk of NNSS lightning (44%) occurs during the summer months.



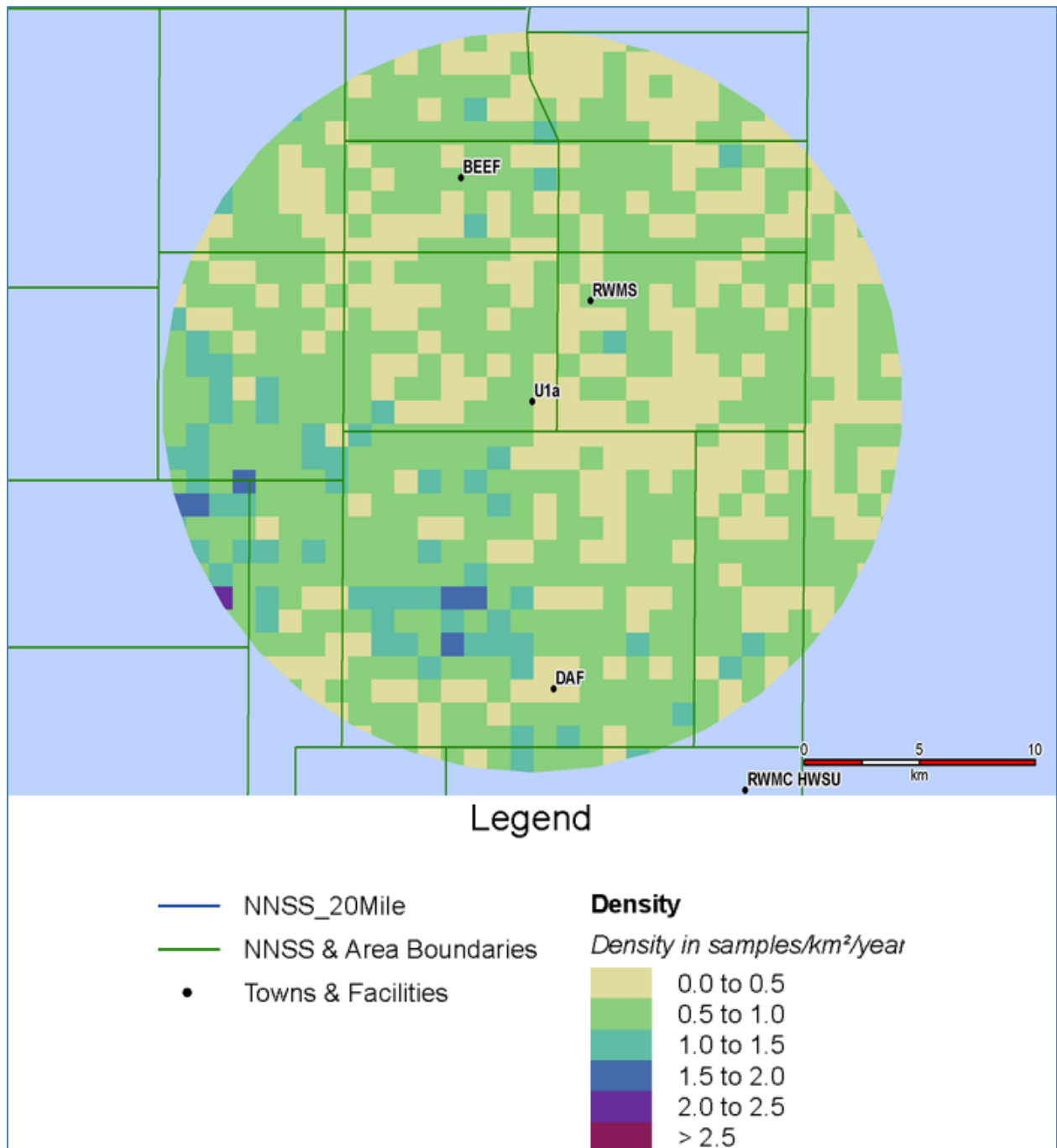
|                                   |                      |   |
|-----------------------------------|----------------------|---|
| <b>3.2</b>                        | <b>Area 1S - U1a</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6594 flashes were detected within 10 miles of U1a. The highest flash densities occurred on the elevated terrain southwest and west of U1a.

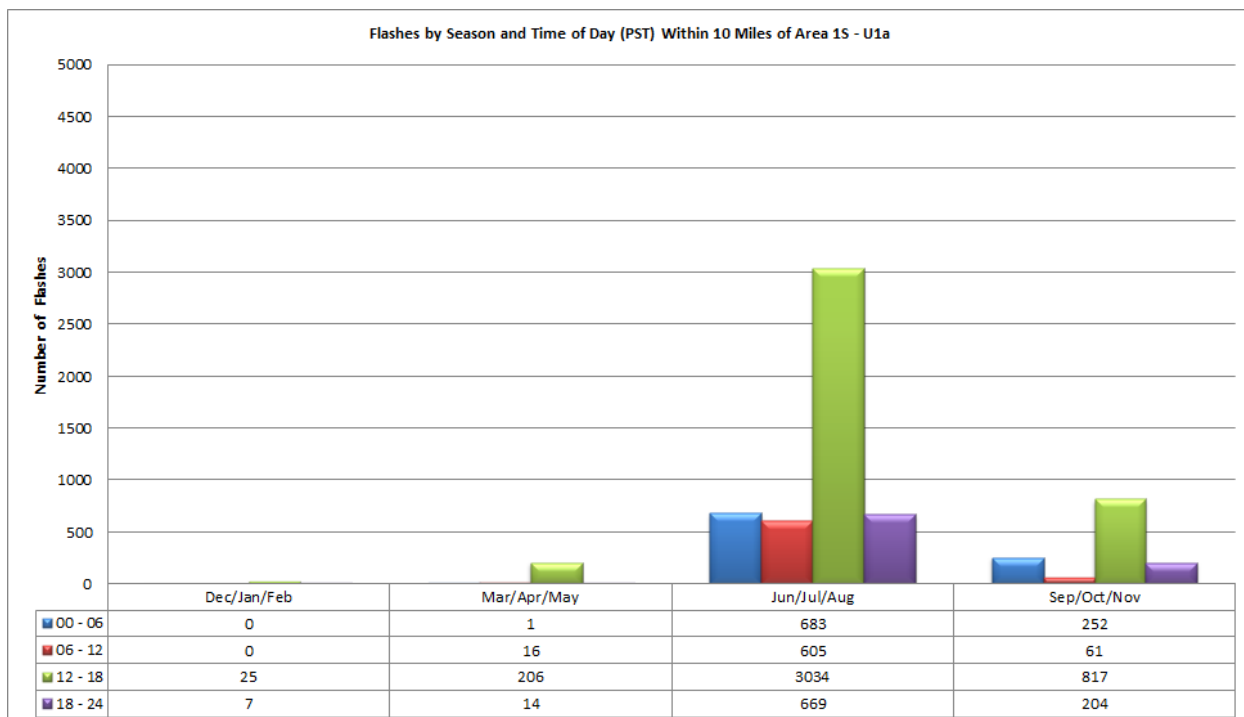
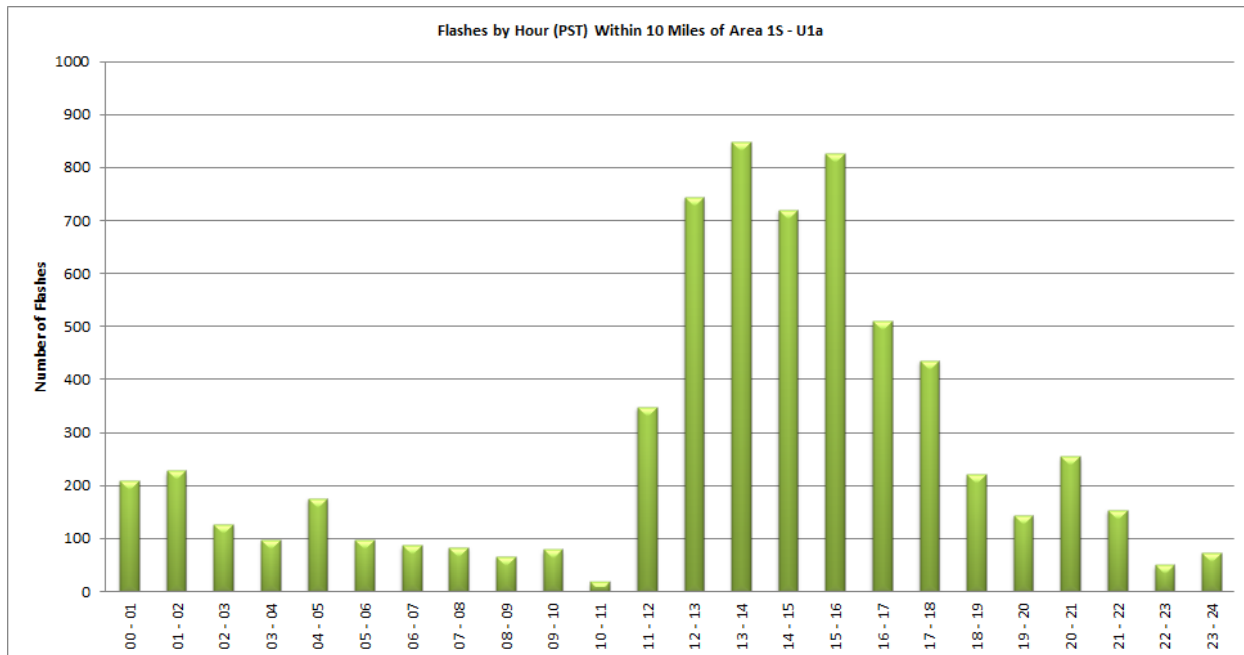
5583 – Charged Flashes

1011 + Charged Flashes

% + 15.3



|                                    |                      |   |
|------------------------------------|----------------------|---|
| <b>3.2</b>                         | <b>Area 1S - U1a</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



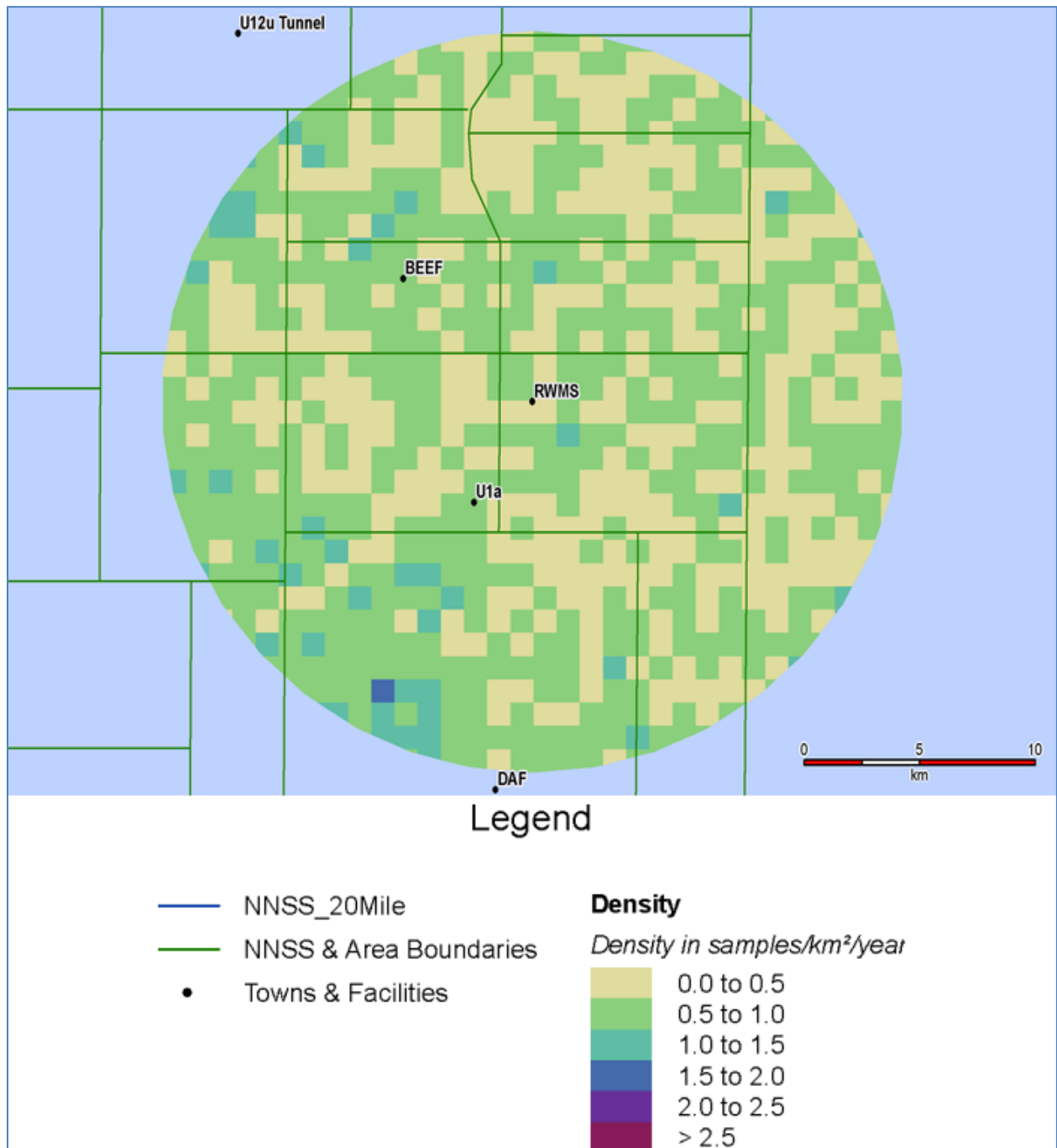
|                                   |                      |   |
|-----------------------------------|----------------------|---|
| <b>3.3</b>                        | <b>Area 3 - RWMS</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6100 flashes were detected within 10 miles of the RWMS. The highest flash densities occurred on the elevated terrain southwest of RWMS.

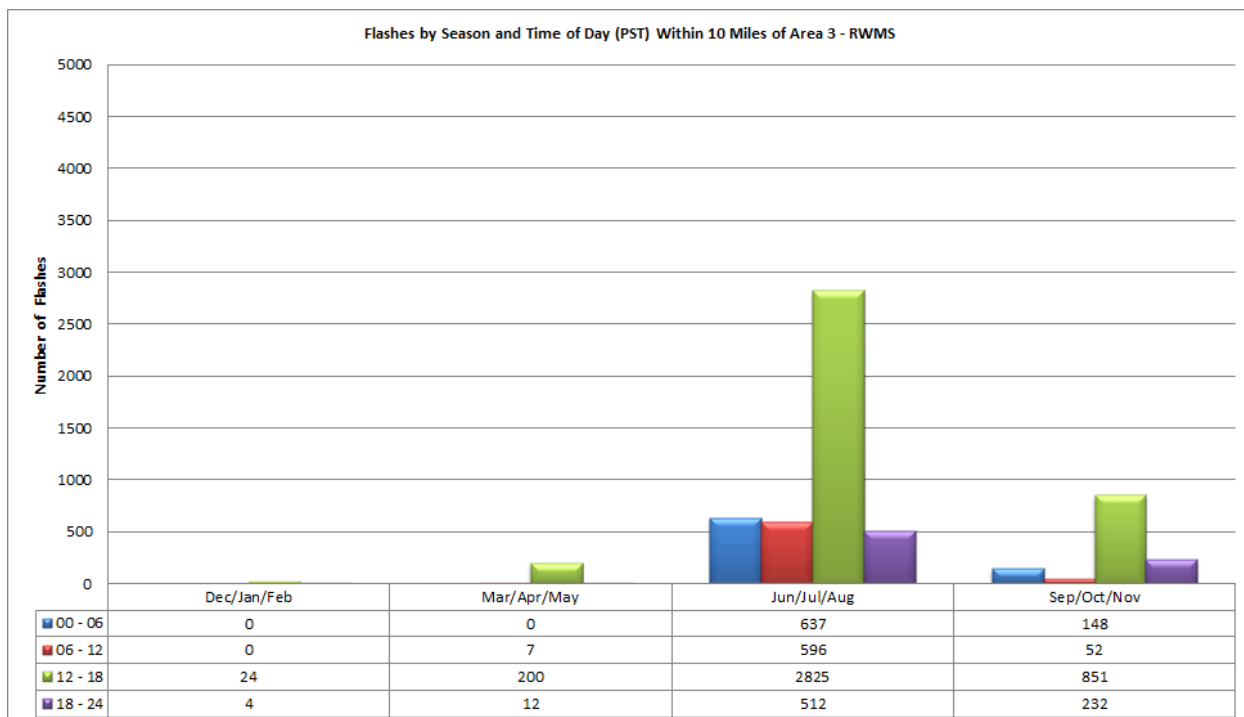
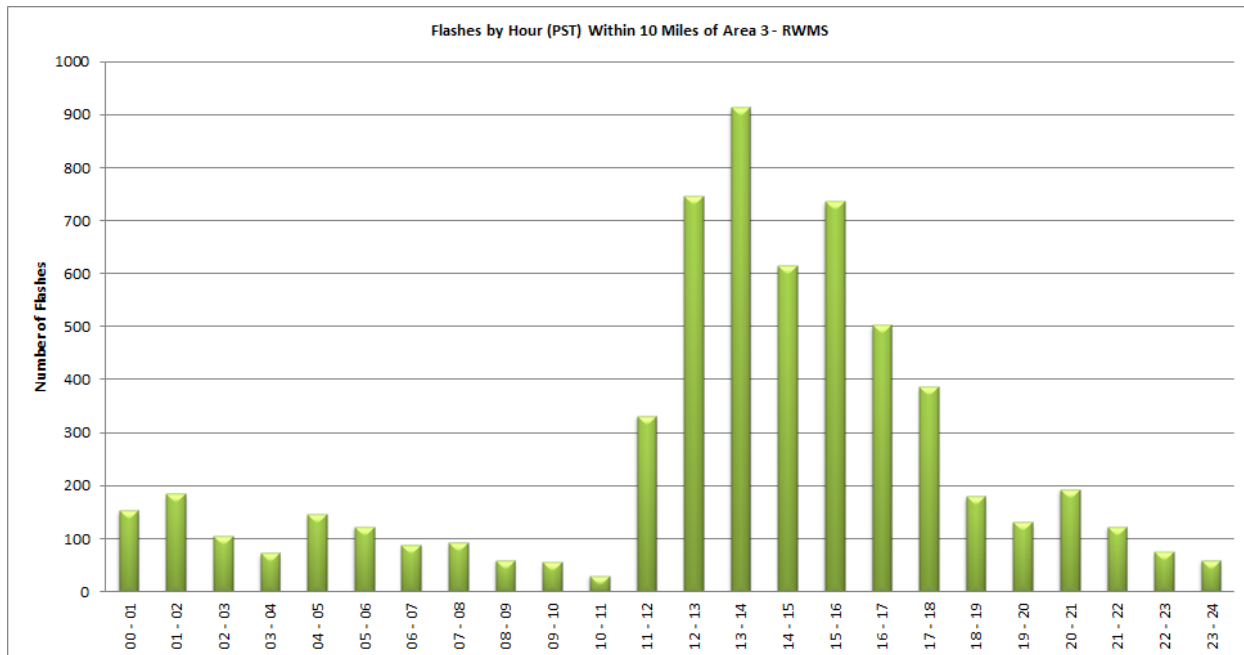
5233 – Charged Flashes

867 + Charged Flashes

%+ 14.2



|                                    |                      |   |
|------------------------------------|----------------------|---|
| <b>3.3</b>                         | <b>Area 3 - RWMS</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



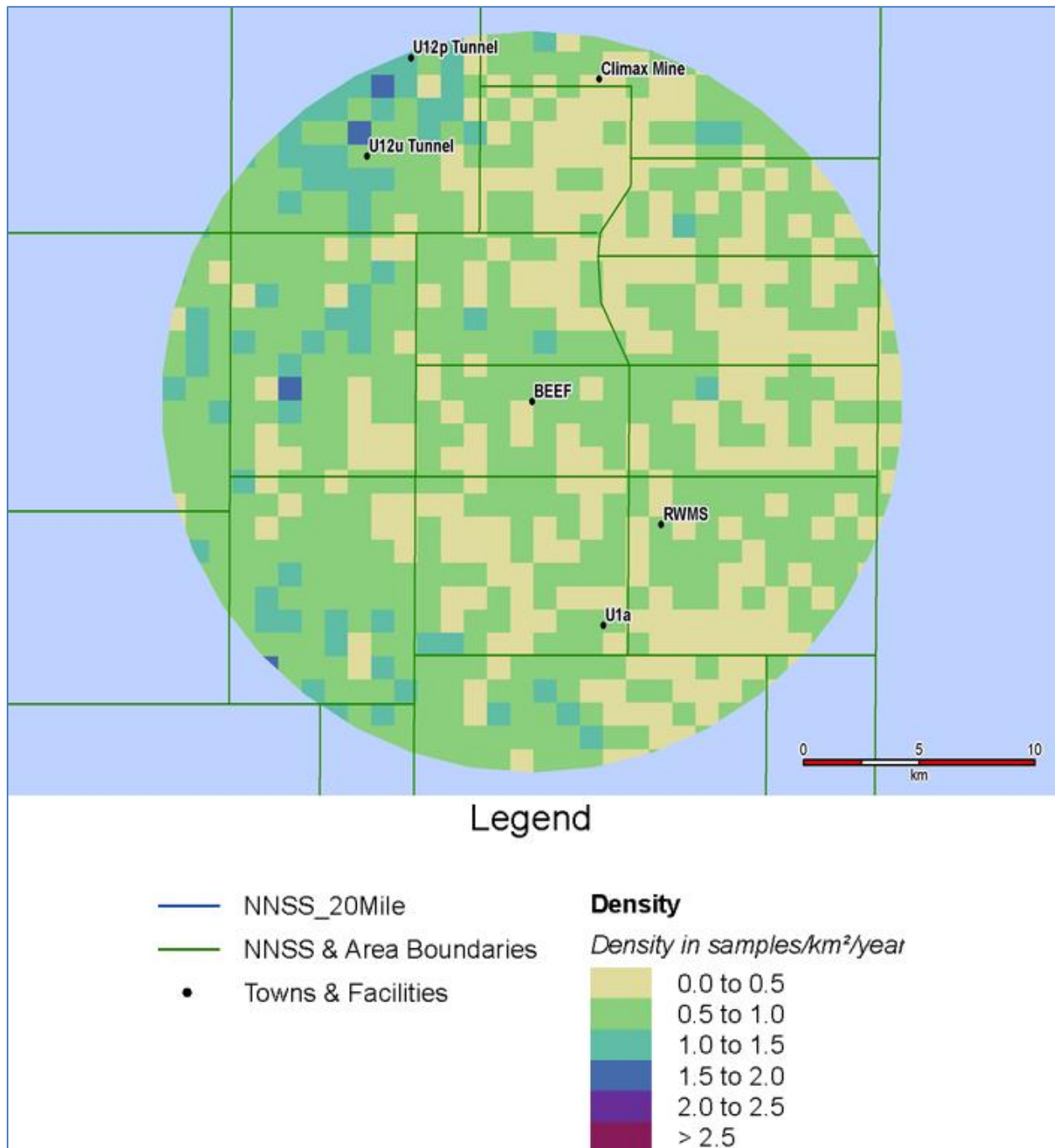
|                                   |                      |   |
|-----------------------------------|----------------------|---|
| <b>3.4</b>                        | <b>Area 4 - BEEF</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6645 flashes were detected within 10 miles of BEEF. The highest flash densities occurred on the elevated terrain west and north-northwest of BEEF.

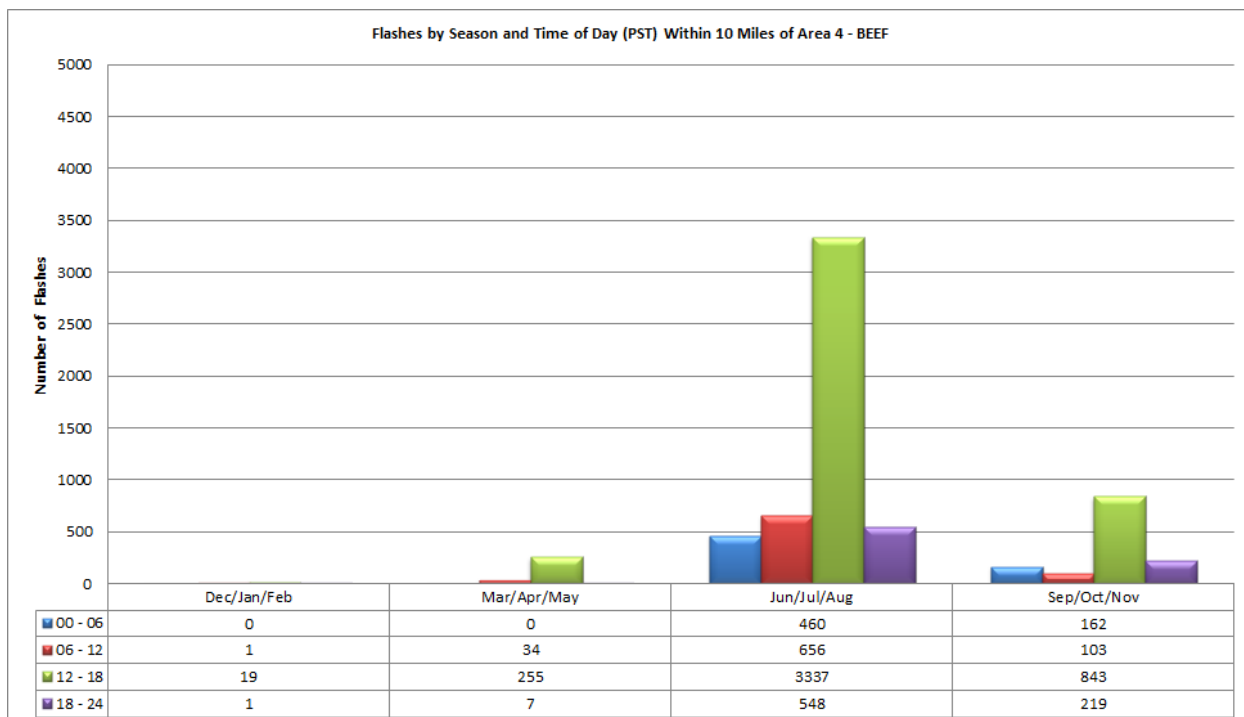
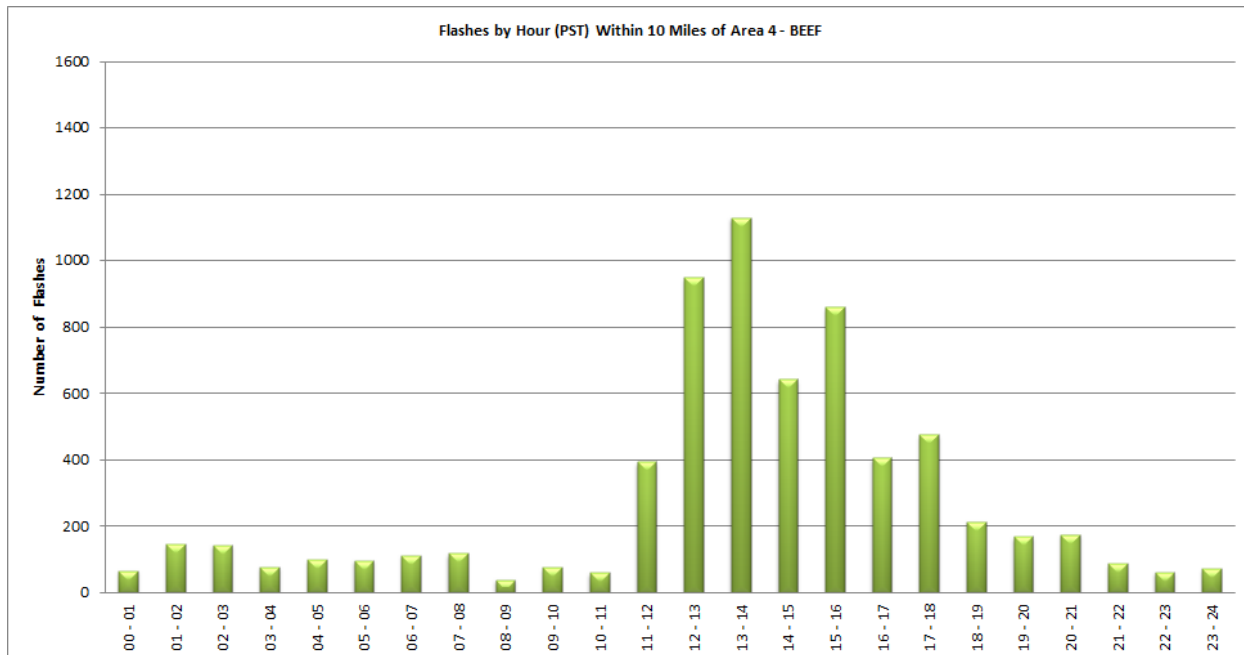
5706 – Charged Flashes

939 + Charged Flashes

%+ 14.1



|                                    |                      |   |
|------------------------------------|----------------------|---|
| <b>3.4</b>                         | <b>Area 4 - BEEF</b> | Data Range                                    |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |





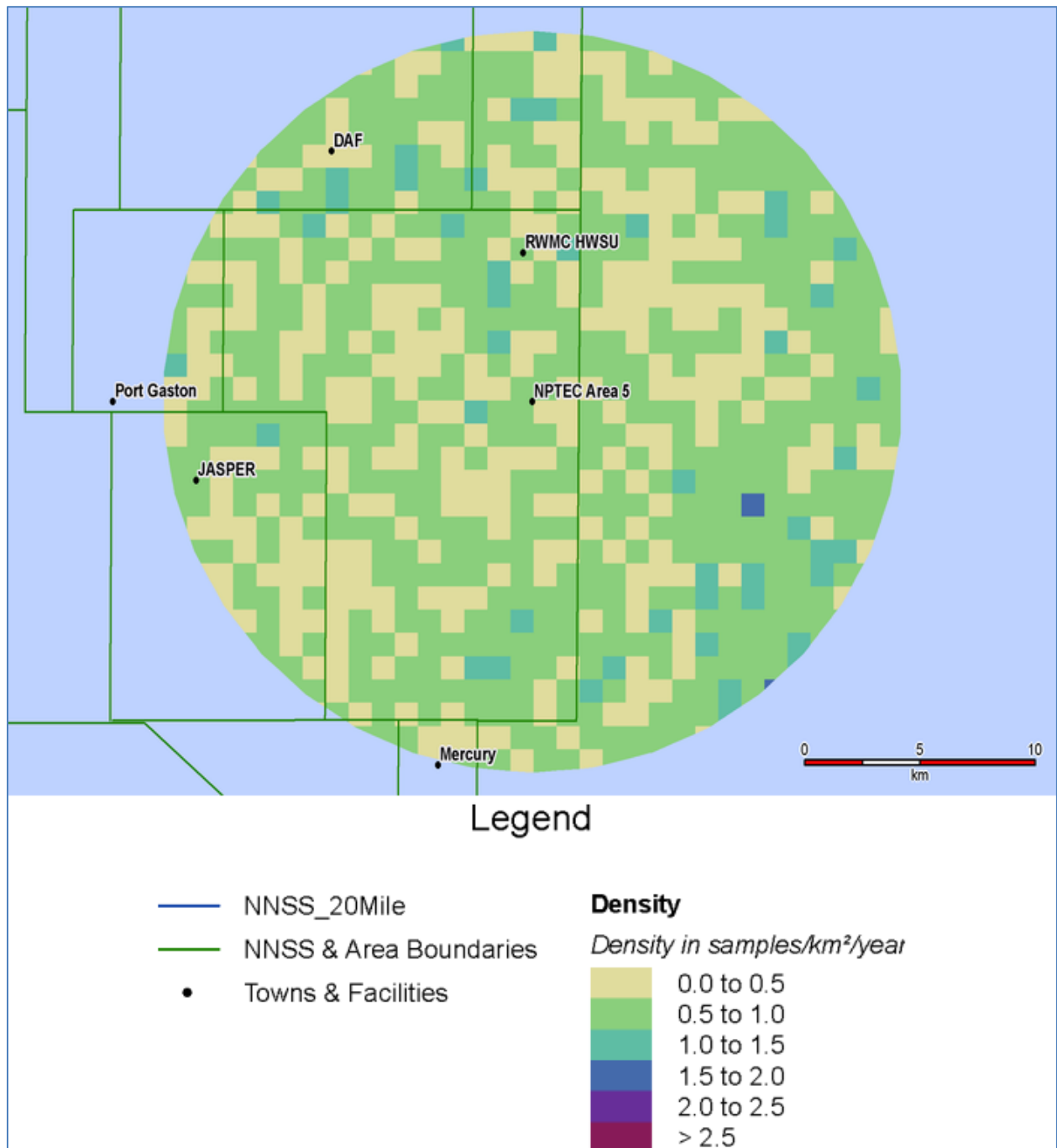
|                        |                        |                        |
|------------------------|------------------------|------------------------|
| <b>3.5</b>             | <b>Area 5C - NPTEC</b> | Data Range             |
| ARL\SORD               | Within 10 Miles        | 2001/03/26 13:07:55 to |
| NNSS Lightning Summary |                        | 2015/02/28 23:59:59    |

For the period of record, 6396 flashes were detected within 10 miles of NPTEC. The highest flash densities occurred on the elevated terrain east-southeast NPTEC.

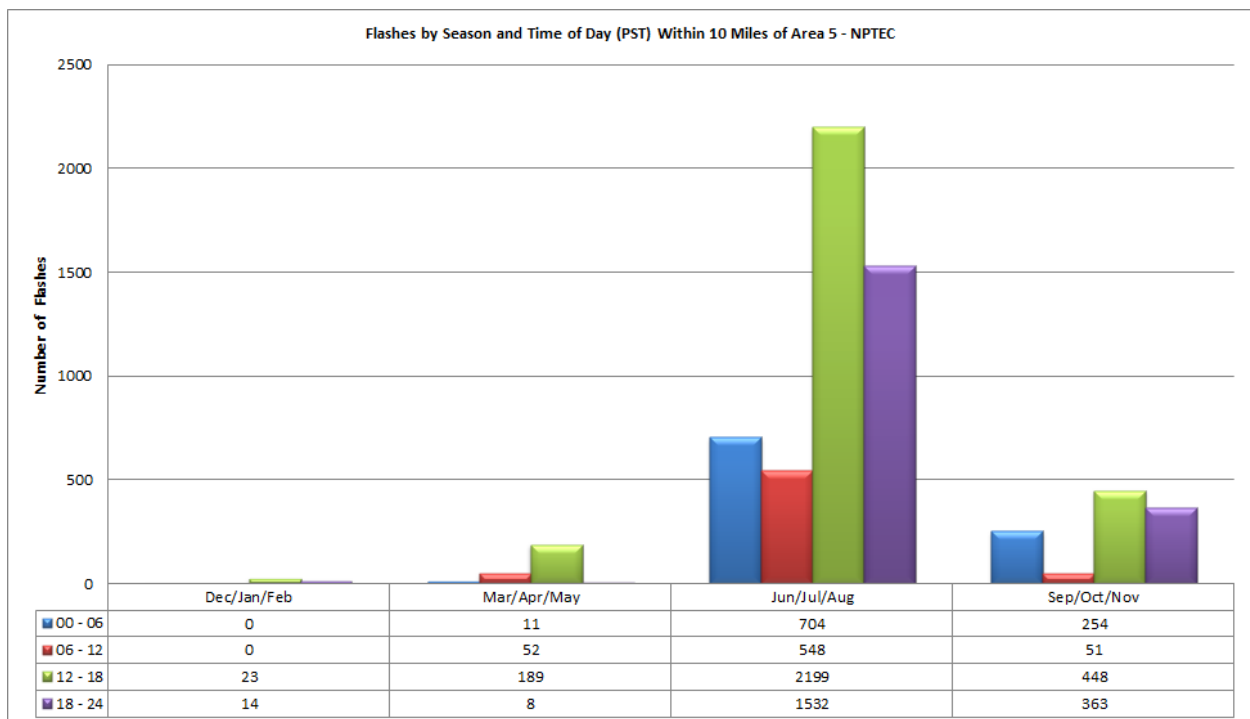
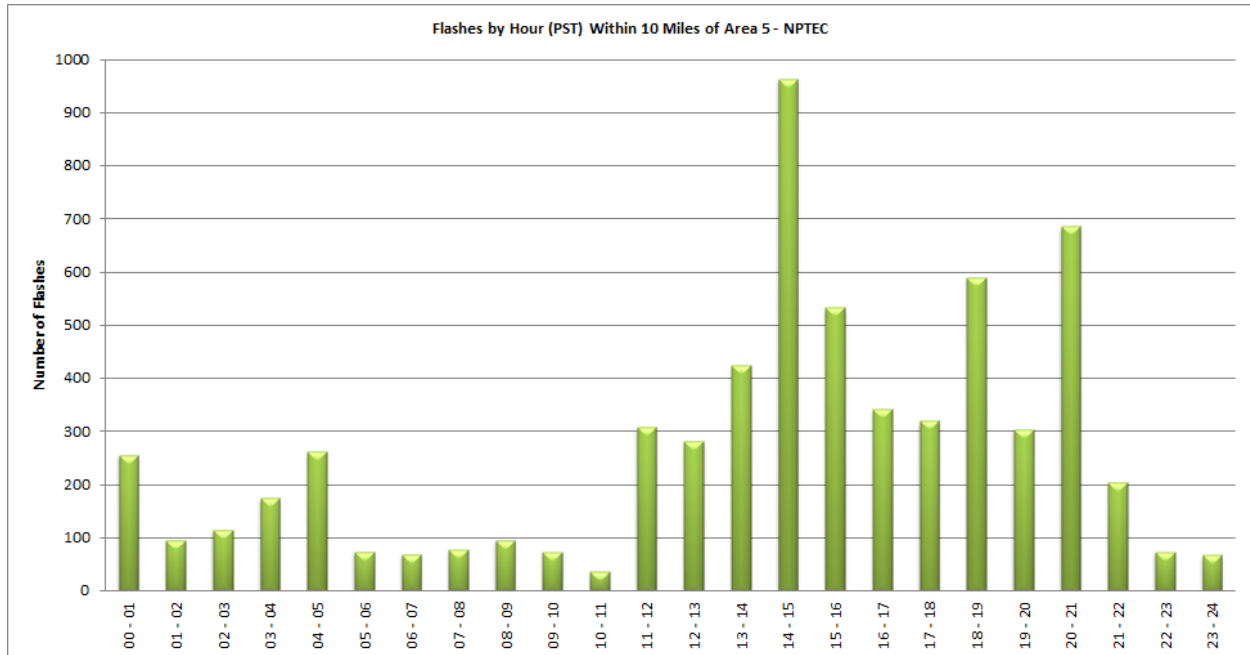
5236 – Charged Flashes

1160 + Charged Flashes

%+ 18.1



|                        |                        |                        |
|------------------------|------------------------|------------------------|
| <b>3.5</b>             | <b>Area 5C - NPTEC</b> | <b>Data Range</b>      |
| ARL\SORD               | Within 10 Miles        | 2001/03/26 13:07:55 to |
| NNSS Lightning Summary |                        | 2015/02/28 23:59:59    |



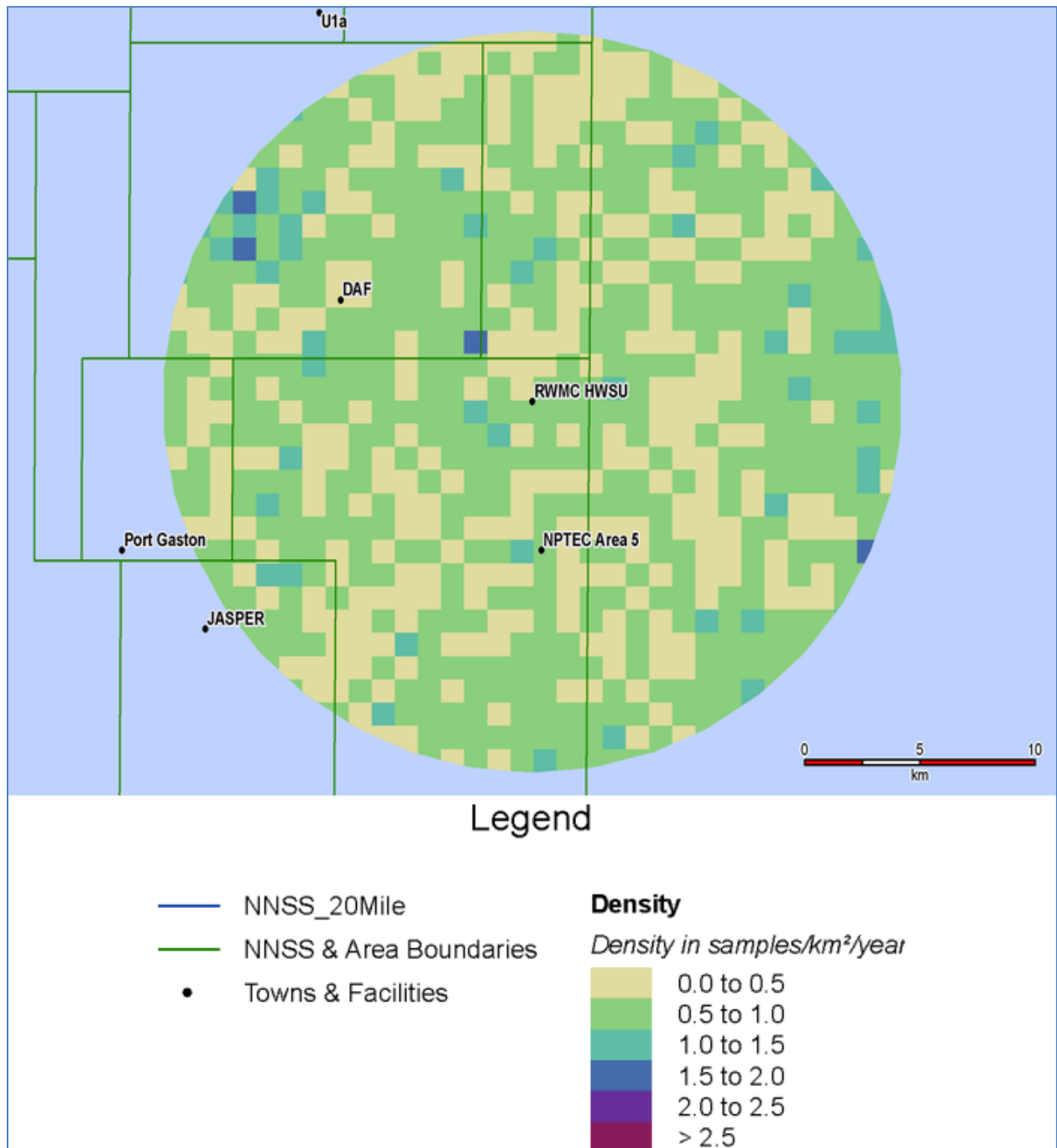
|                                    |  |   |
|------------------------------------|--|---|
| <b>3.6</b>                         | <b>Area 5NE - RWMC &amp; HWSU/HWAA</b> | Data Range                                    |
| ARL\SORD<br>NNSL Lightning Summary | Within 10 Miles                        | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6359 flashes were detected within 10 miles of RWMC. The highest flash densities occurred on the elevated terrain northwest of the RWMC.

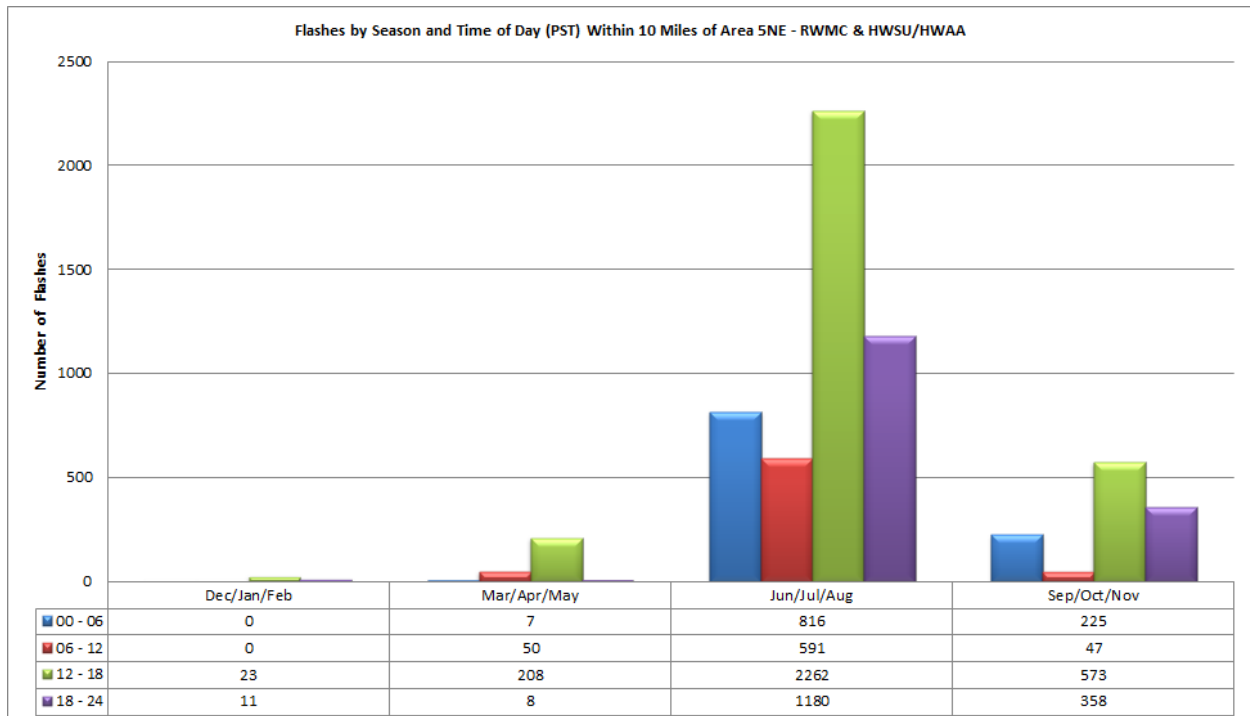
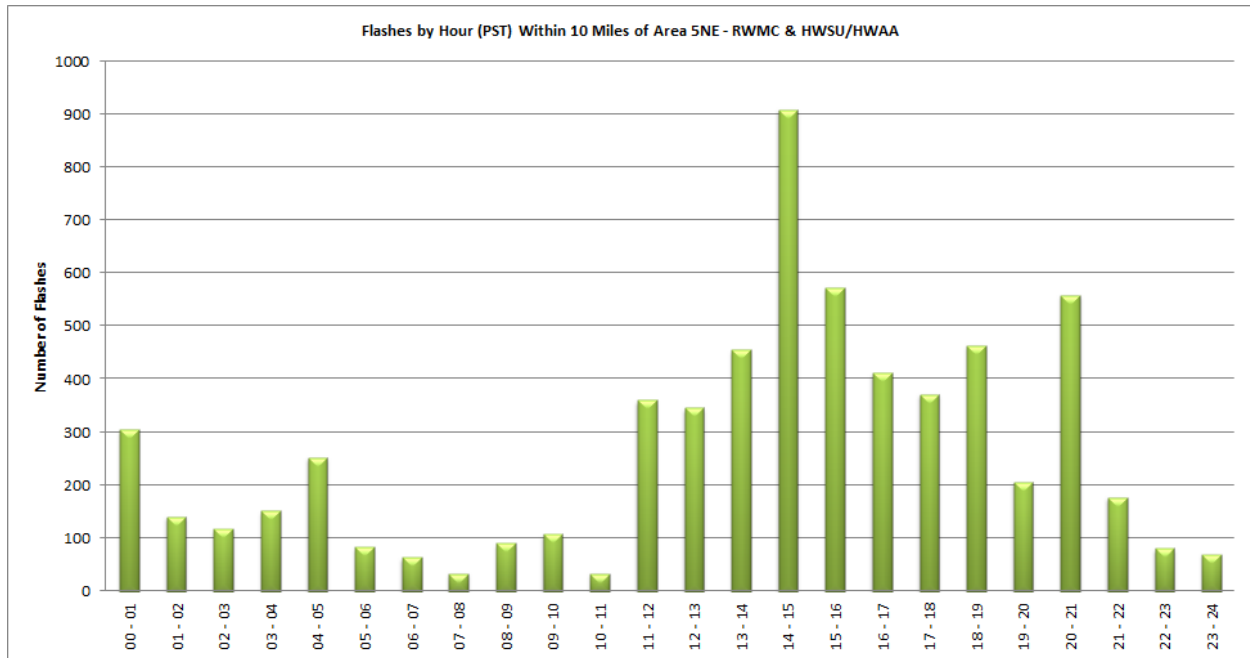
5190 – Charged Flashes

1169 + Charged Flashes

%+ 18.3



|                                   |                                      |   |
|-----------------------------------|--------------------------------------|---|
| <b>3.6</b>                        | <b>Area 5NE - RWMC<br/>HWSU/HWAA</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles                      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



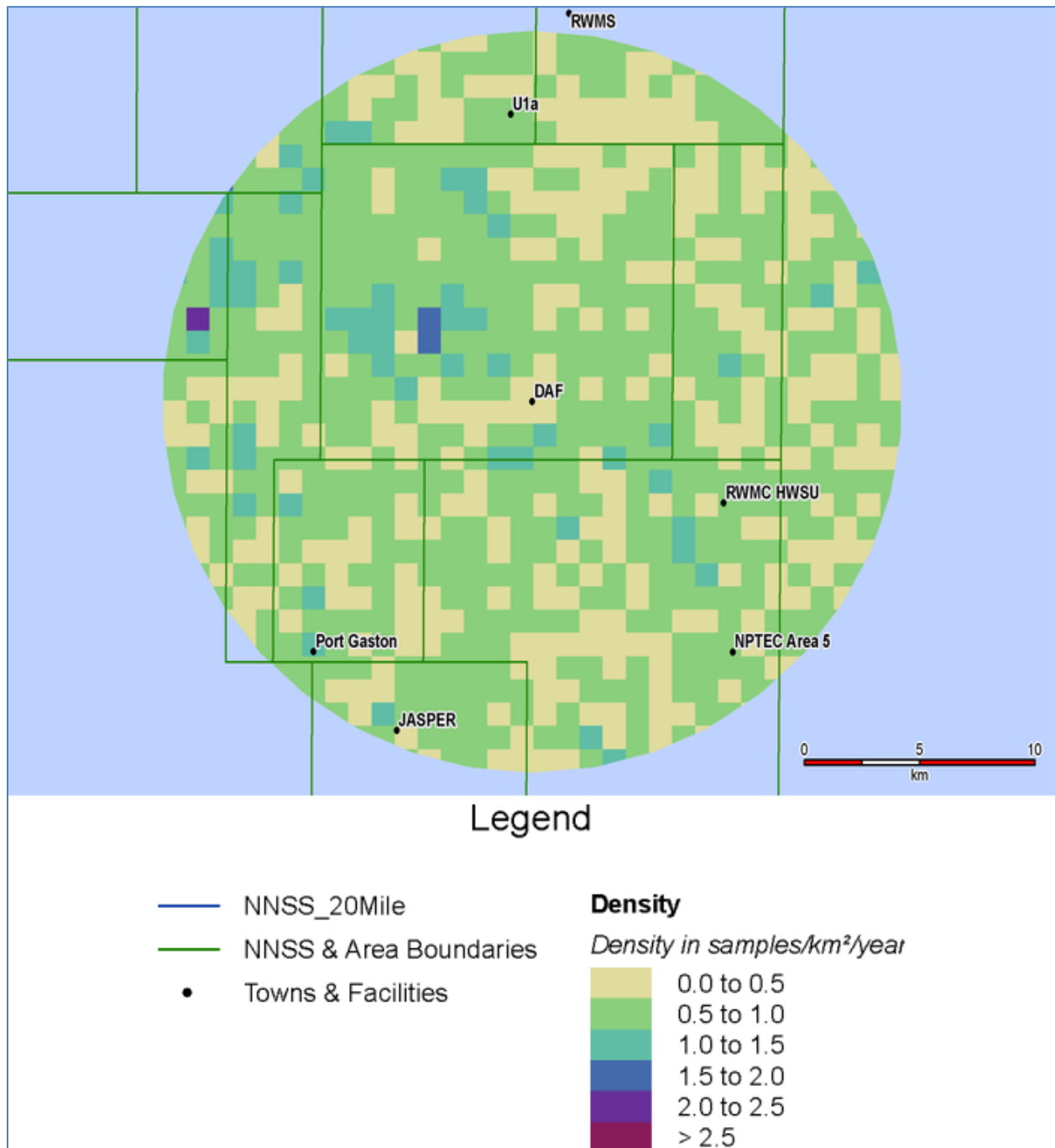
|                                   |                      |   |
|-----------------------------------|----------------------|---|
| <b>3.7</b>                        | <b>Area 6S - DAF</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6563 flashes were detected within 10 miles of the DAF. The highest flash densities occurred on the elevated terrain west of the DAF.

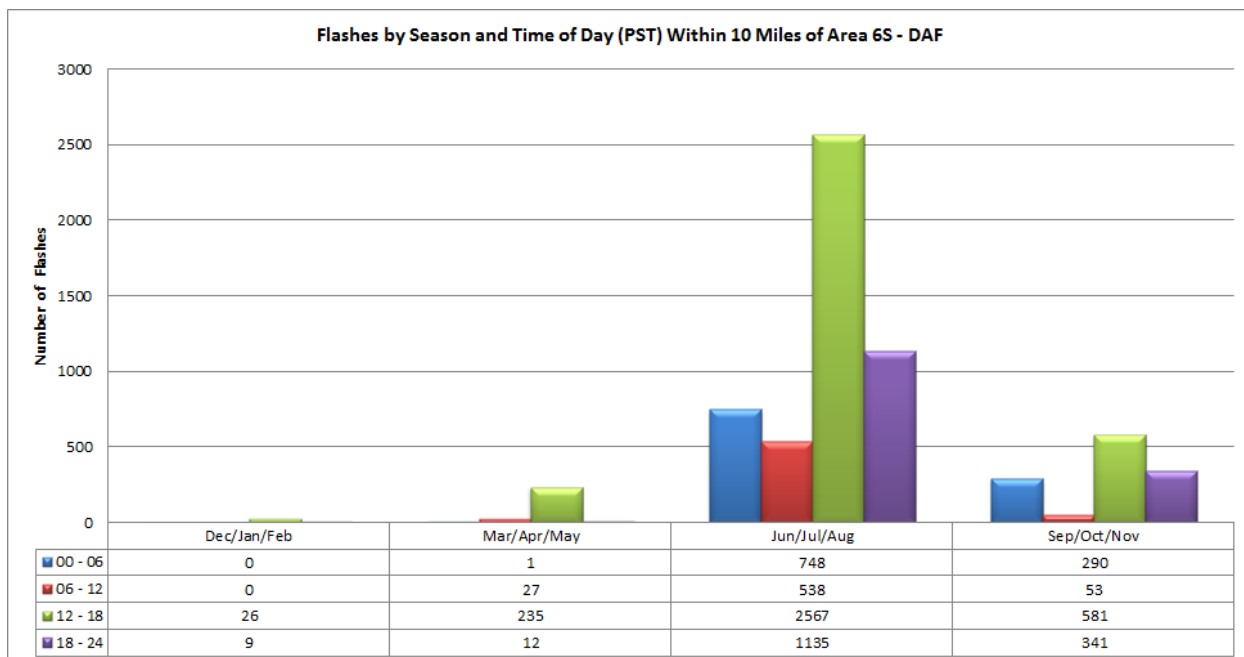
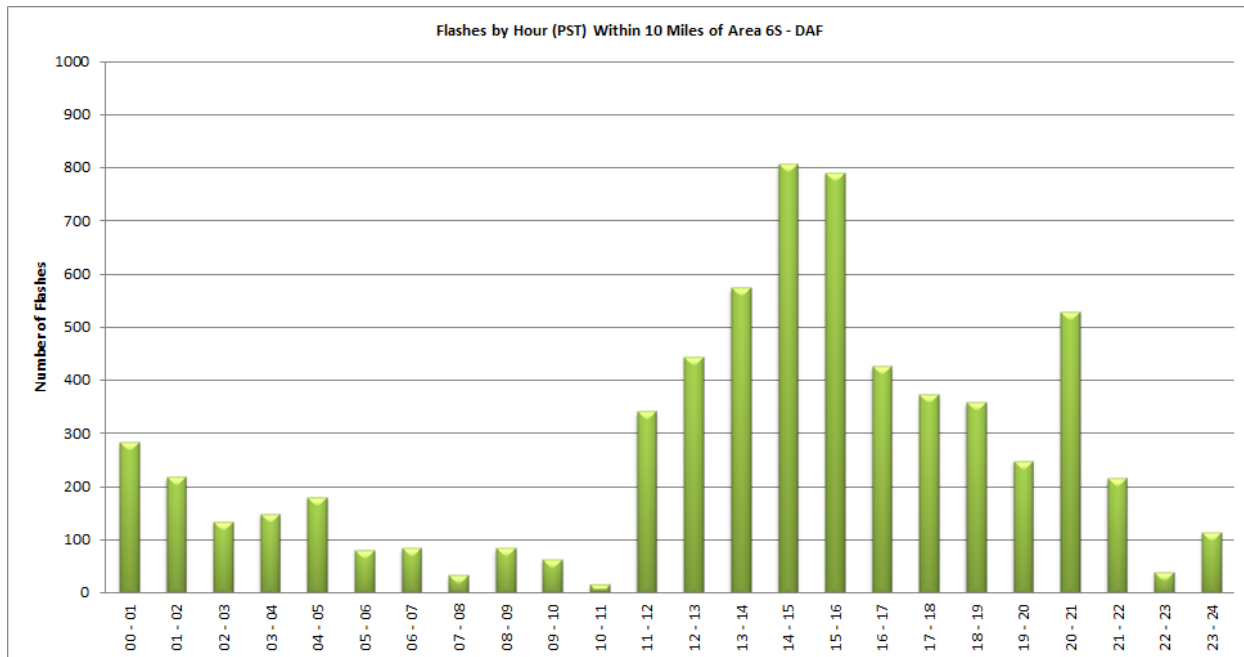
5456 – Charged Flashes

1107 + Charged Flashes

% + 16.9



|                                    |                      |   |
|------------------------------------|----------------------|---|
| <b>3.7</b>                         | <b>Area 6S - DAF</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles      | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



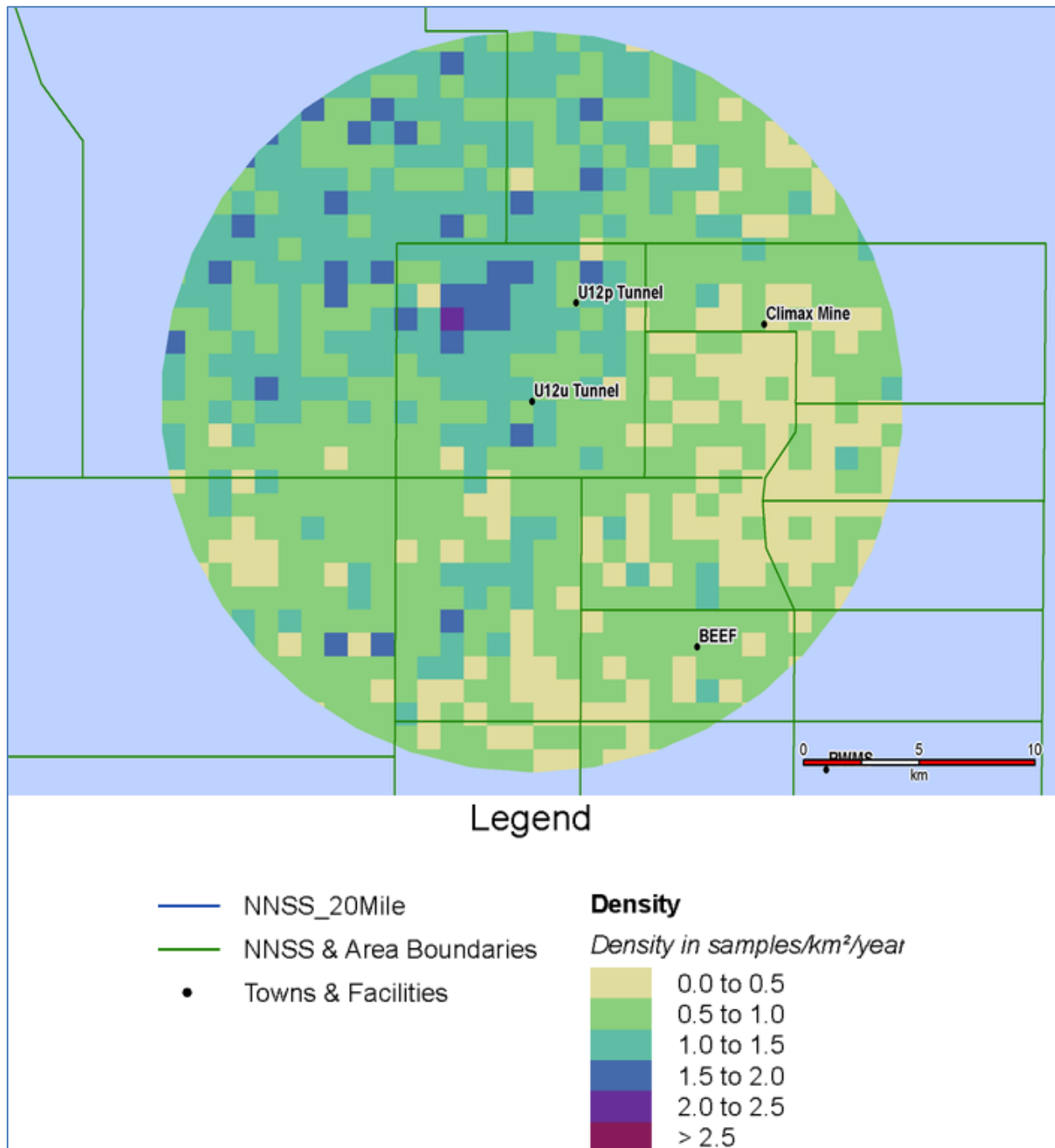
|                                    |                               |   |
|------------------------------------|-------------------------------|---|
| <b>3.8</b>                         | <b>Area 12C - U12u Tunnel</b> | Data Range                                    |
| ARL\SORD<br>NNSL Lightning Summary | Within 10 Miles               | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 8774 flashes were detected within 10 miles of U12u Tunnel. The highest flash densities occurred on the elevated terrain just northwest of U12u Tunnel.

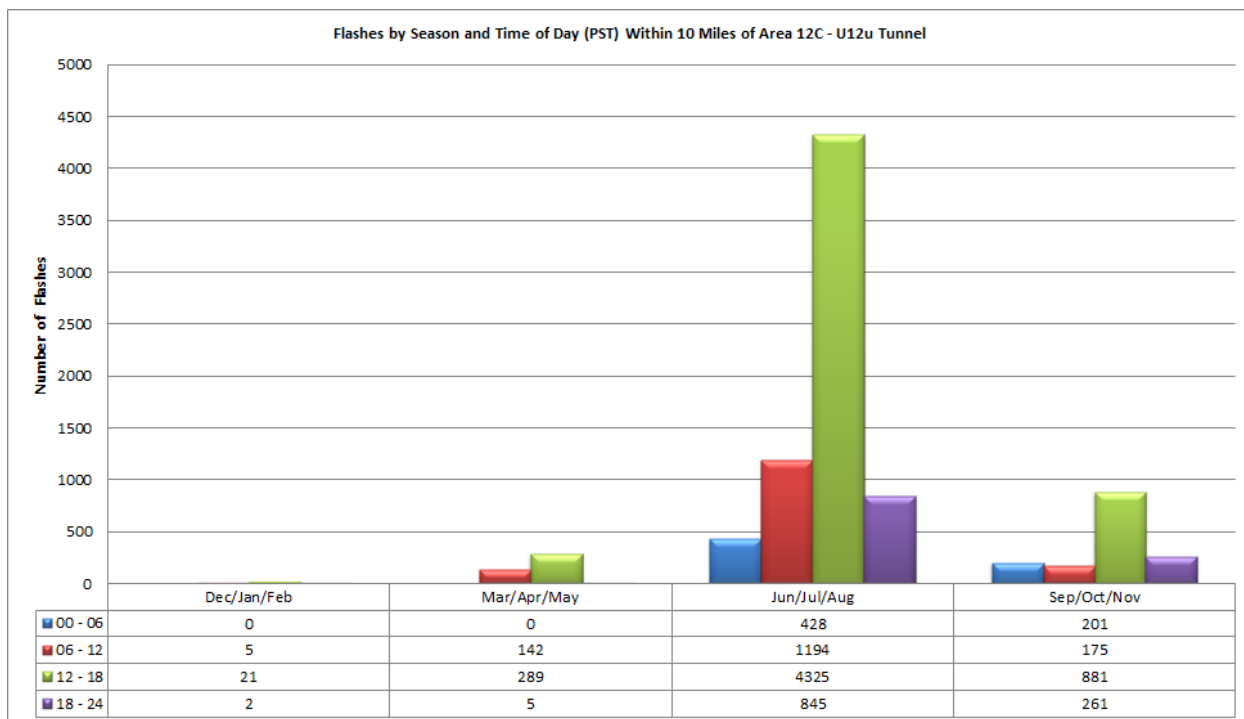
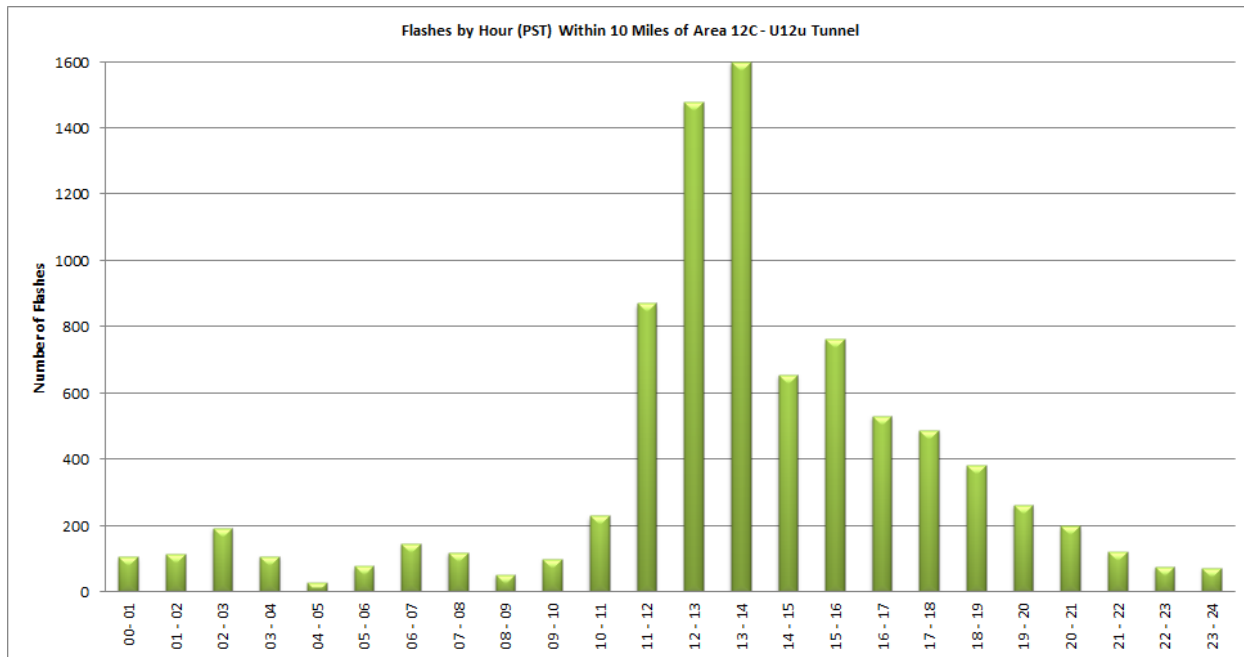
7217 – Charged Flashes

1557 + Charged Flashes

%+ 17.7



|                                    |                               |   |
|------------------------------------|-------------------------------|---|
| <b>3.8</b>                         | <b>Area 12C - U12u Tunnel</b> | Data Range                                    |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles               | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |





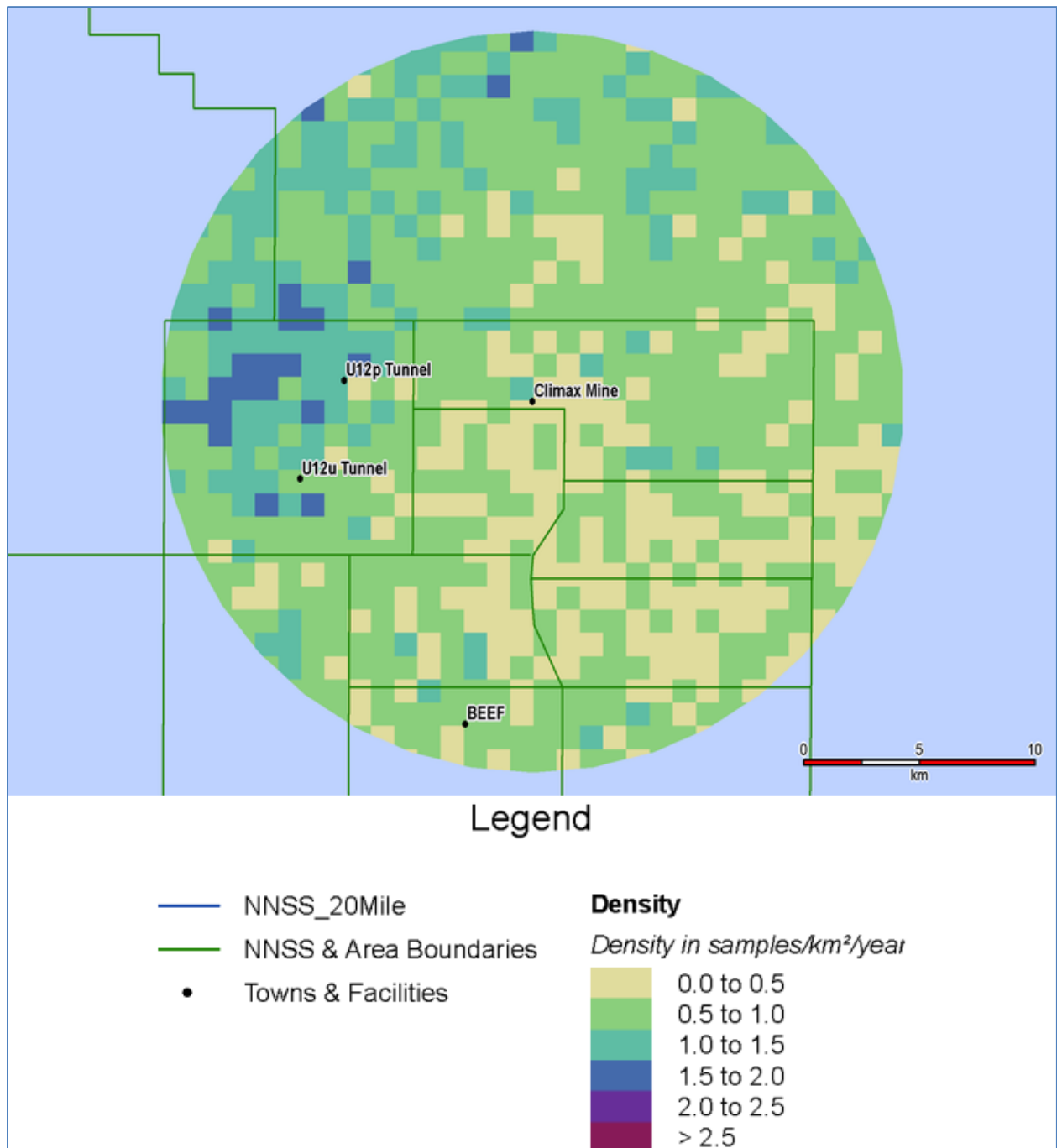
|                                   |                              |   |
|-----------------------------------|------------------------------|---|
| <b>3.9</b>                        | <b>Area 15 - Climax Mine</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles              | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 7980 flashes were detected within 10 miles of Climax Mine. The highest flash densities occurred on the elevated terrain west and northwest of Climax Mine.

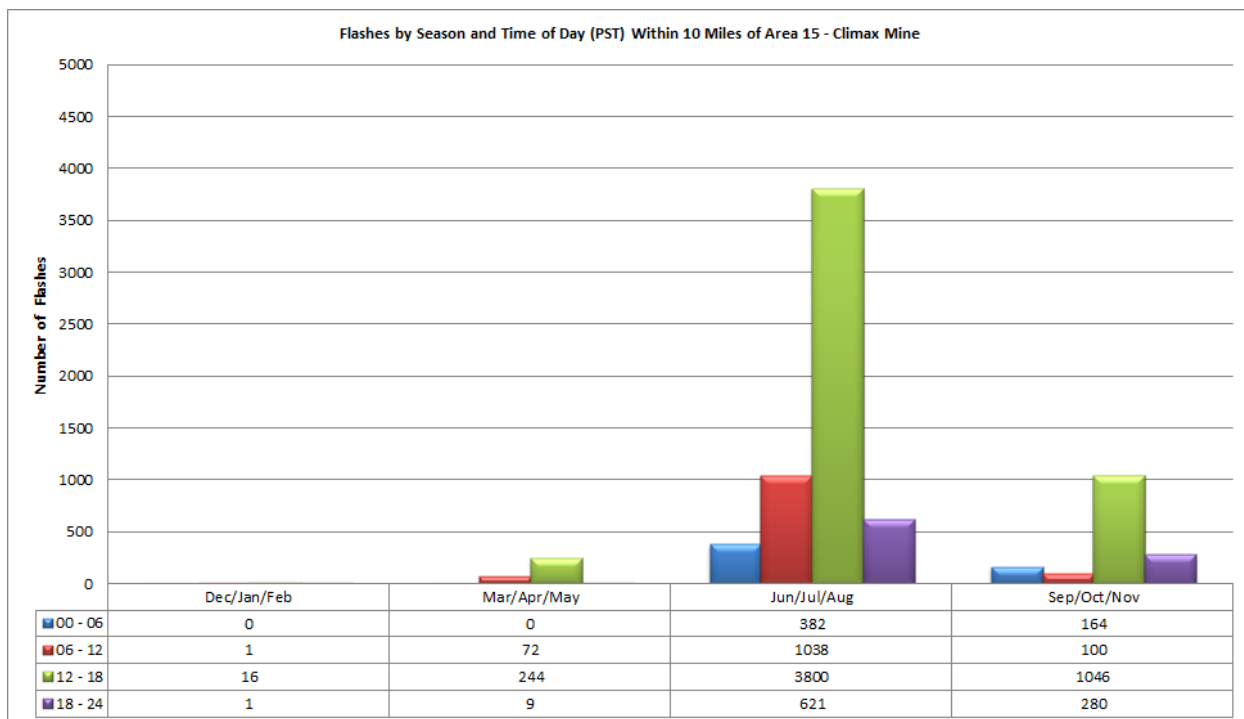
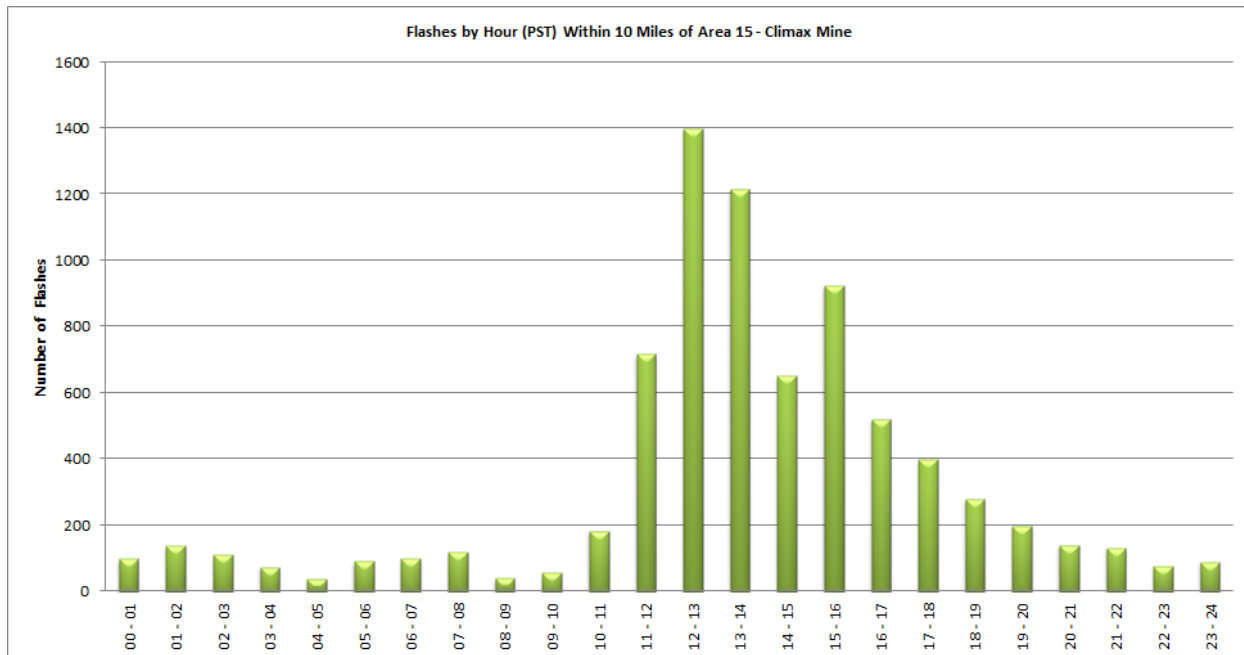
6877 – Charged Flashes

1103 + Charged Flashes

%+ 13.8



|                                    |                              |   |
|------------------------------------|------------------------------|---|
| <b>3.9</b>                         | <b>Area 15 - Climax Mine</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles              | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



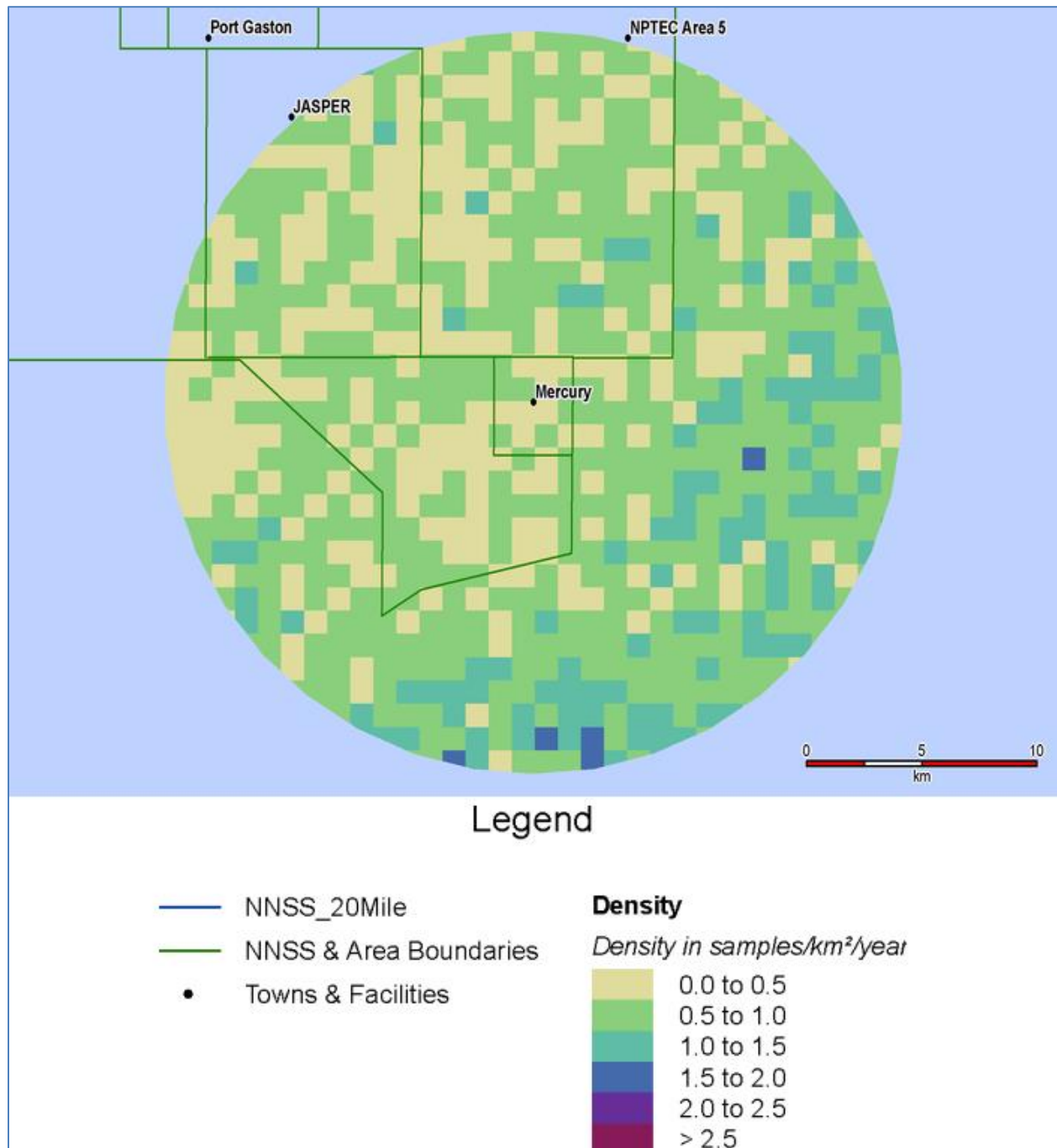
|                                   |                          |   |
|-----------------------------------|--------------------------|---|
| <b>3.10</b>                       | <b>Area 23 - Mercury</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles          | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6929 flashes were detected within 10 miles of Mercury, NV. The highest flash densities occurred on the elevated terrain east-southeast and south of Mercury.

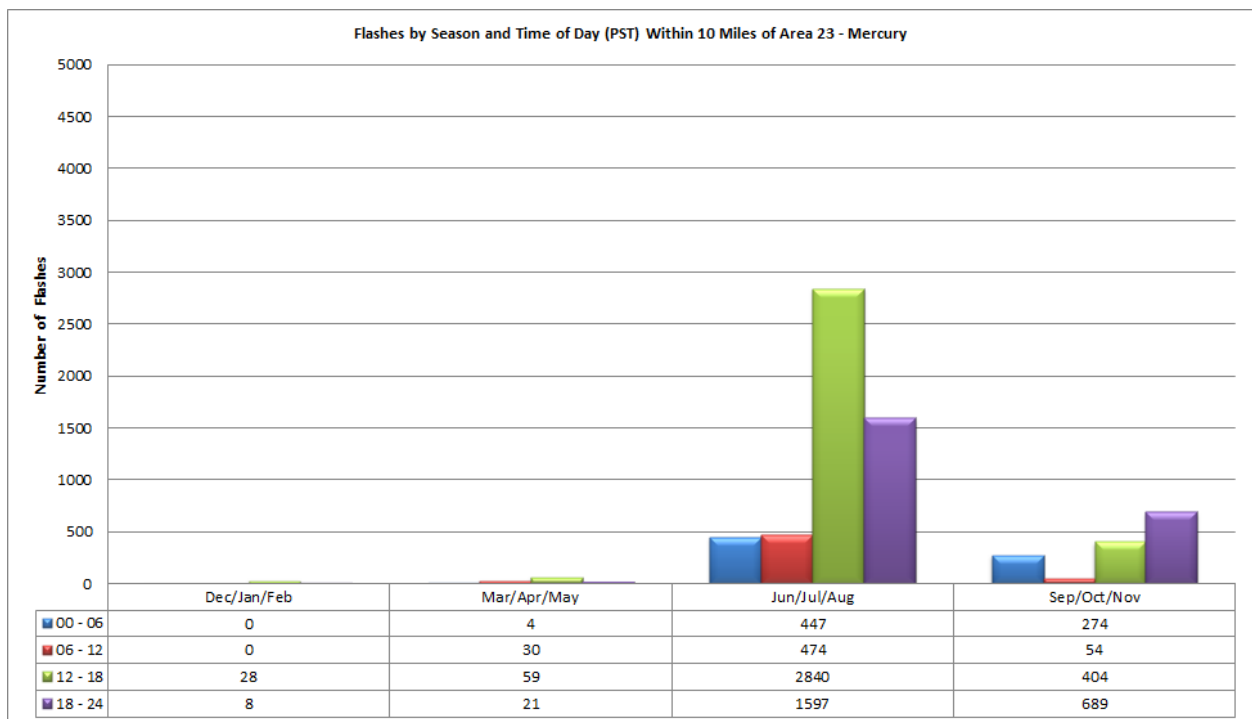
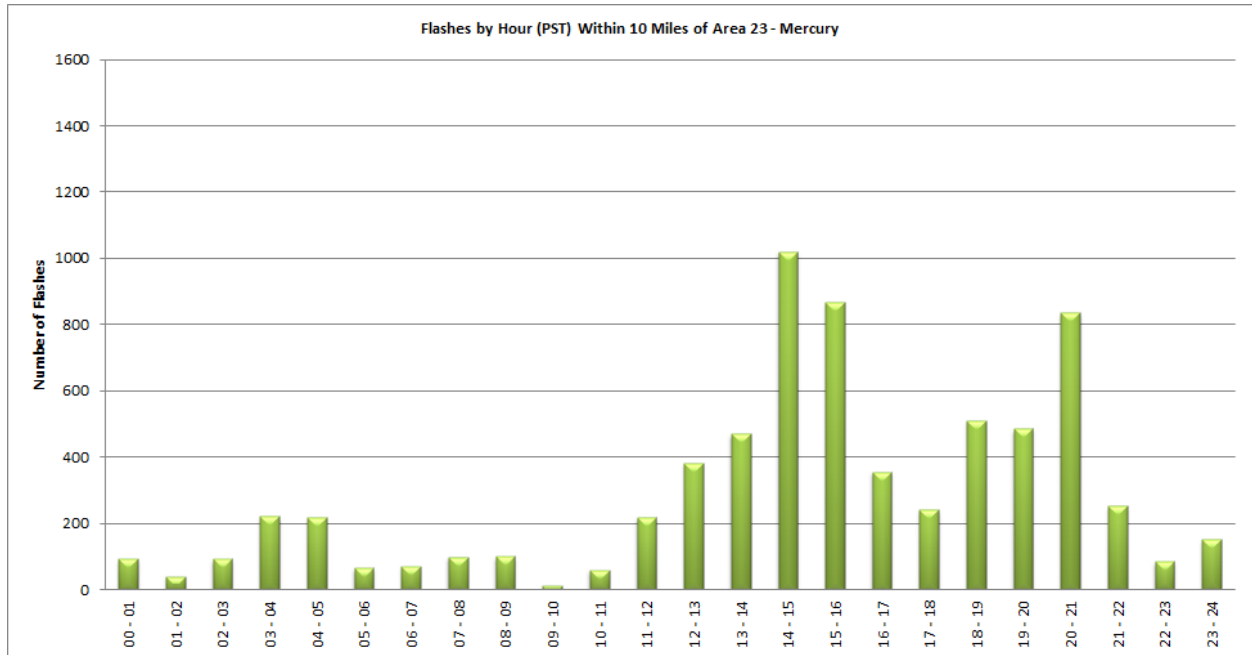
5906 – Charged Flashes

1023 + Charged Flashes

%+ 14.8



|                                    |                          |   |
|------------------------------------|--------------------------|---|
| <b>3.10</b>                        | <b>Area 23 - Mercury</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles          | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



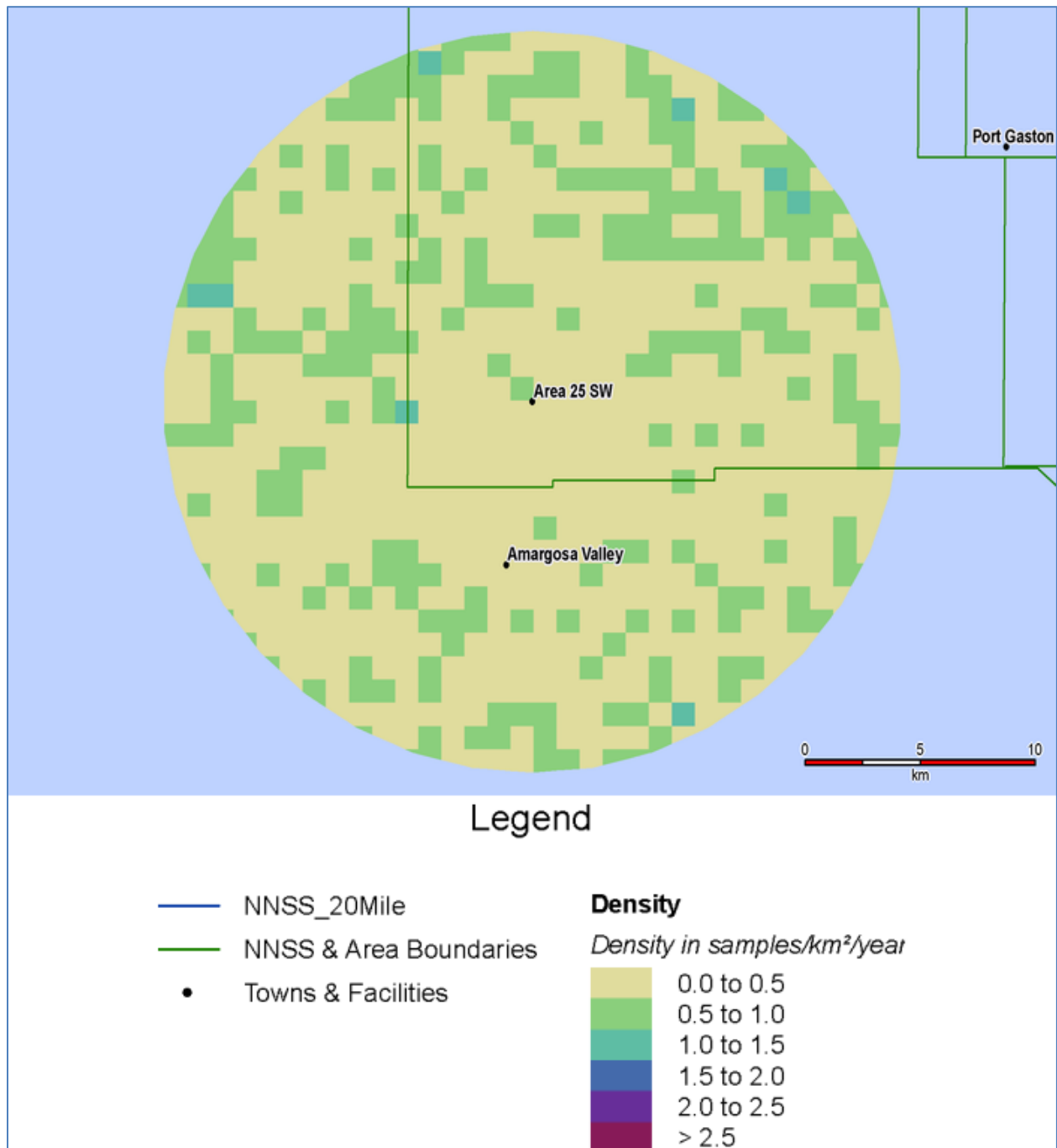
|                                   |                  |   |
|-----------------------------------|------------------|---|
| <b>3.11</b>                       | <b>Area 25SW</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles  | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 4225 flashes were detected within 10 miles of Area 25SW. The highest flash densities occurred on the elevated terrain northwest, north and northeast of Area 25SW.

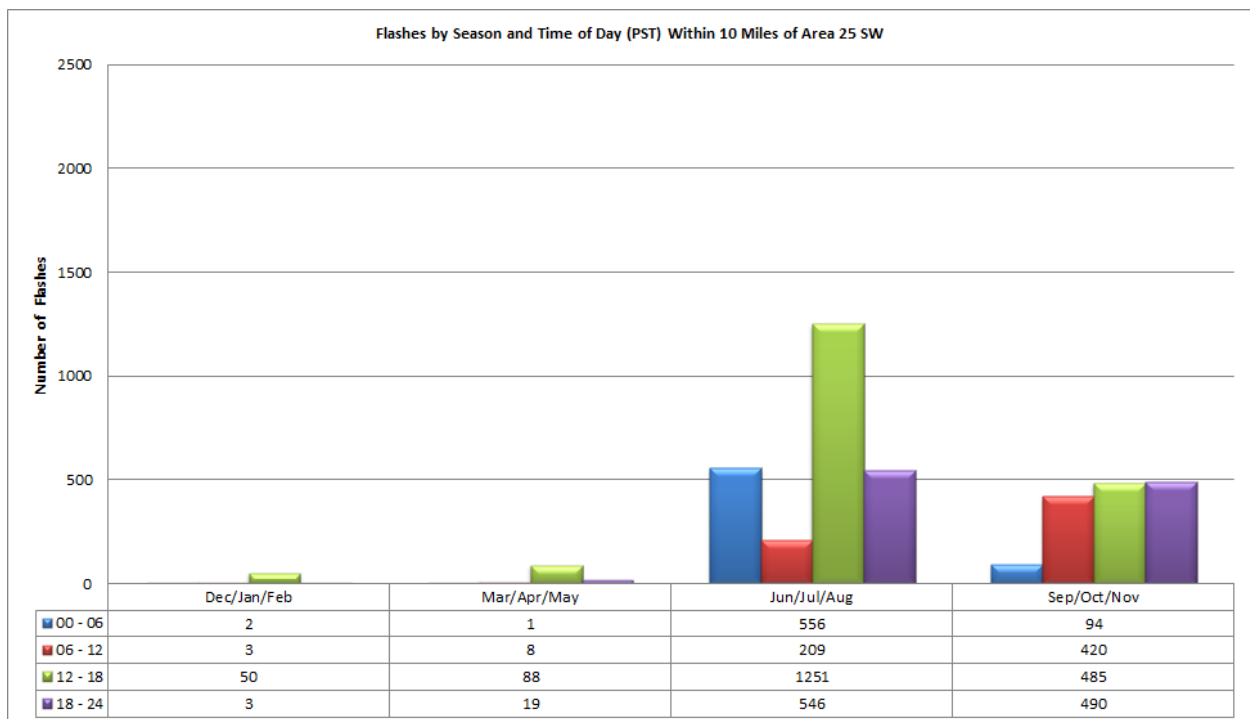
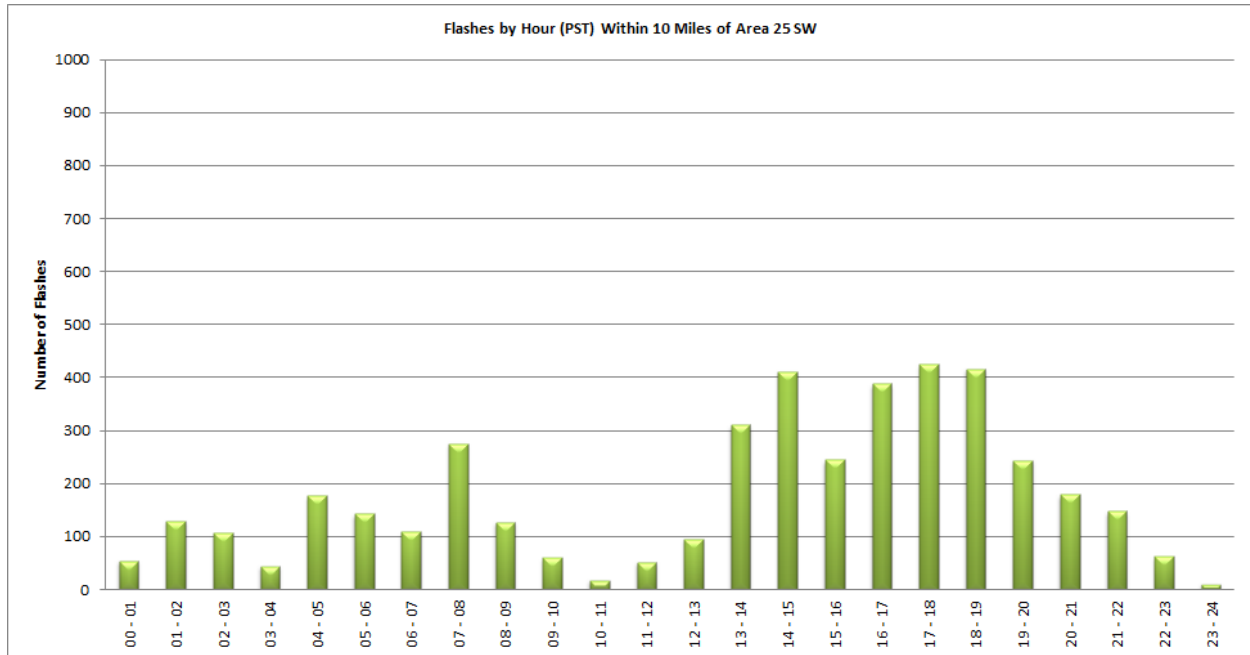
3710 – Charged Flashes

515 + Charged Flashes

%+ 12.2



|                                    |                  |   |
|------------------------------------|------------------|---|
| <b>3.11</b>                        | <b>Area 25SW</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles  | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



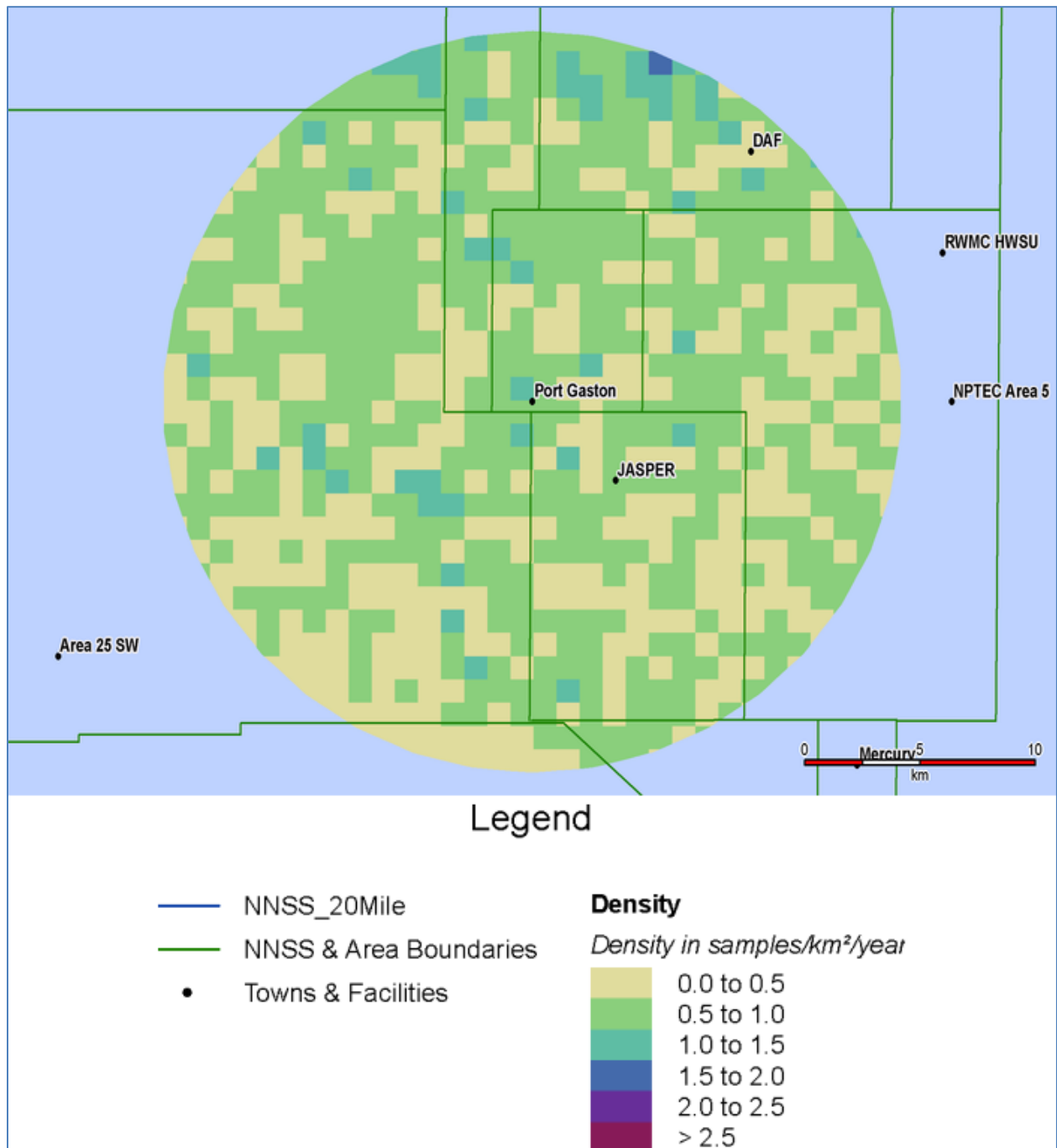
|                                   |                              |   |
|-----------------------------------|------------------------------|---|
| <b>3.12</b>                       | <b>Area 26 - Port Gaston</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles              | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

For the period of record, 6132 flashes were detected within 10 miles of Port Gaston. The highest flash densities occurred on the elevated terrain north-northeast of Port Gaston.

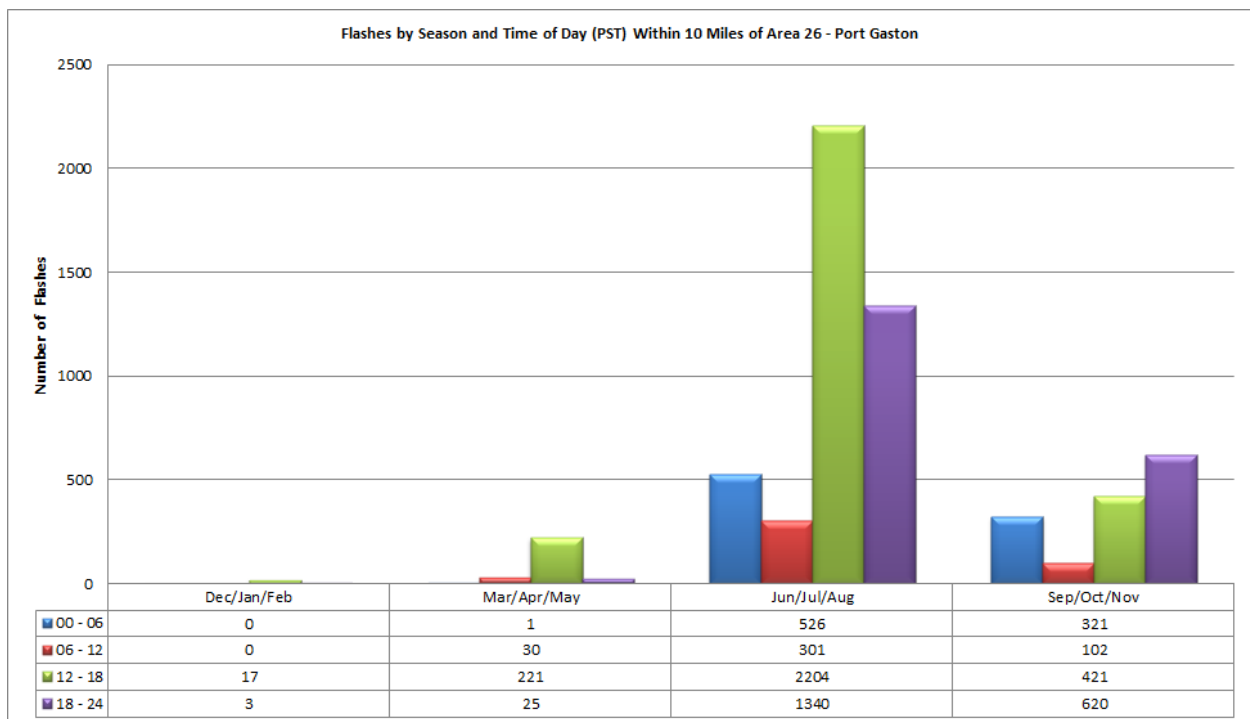
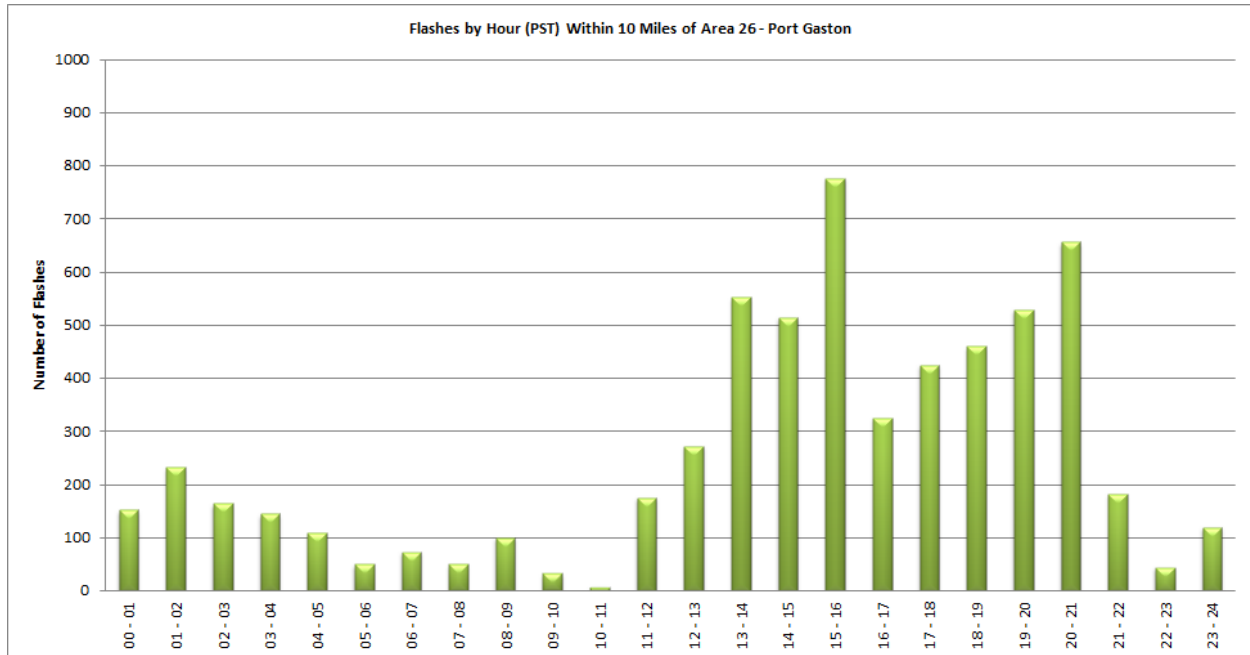
5193 – Charged Flashes

939 + Charged Flashes

%+ 15.3



|                                    |                              |   |
|------------------------------------|------------------------------|---|
| <b>3.12</b>                        | <b>Area 26 - Port Gaston</b> | <b>Data Range</b>                             |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles              | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |





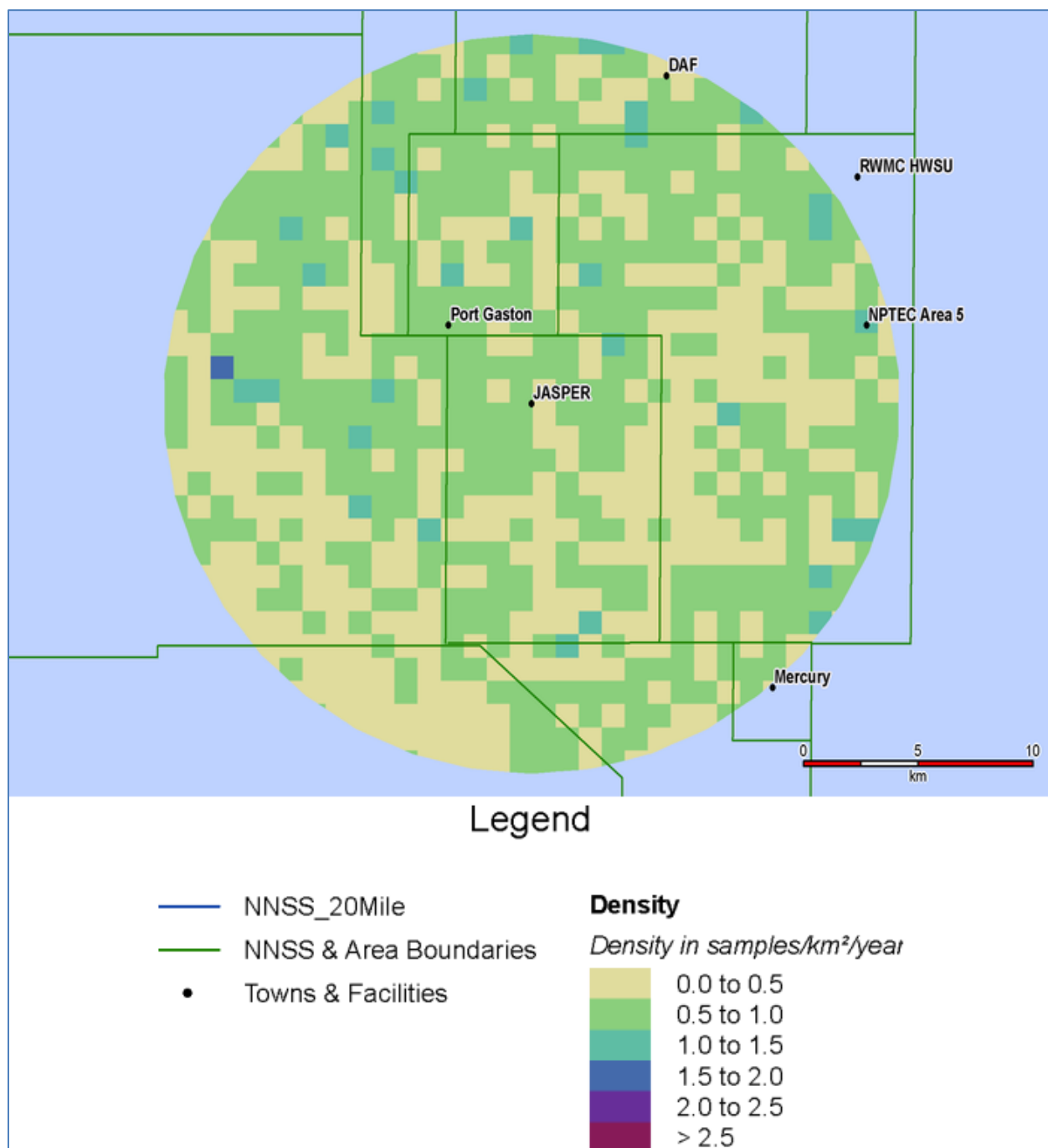
|                                   |                         |   |
|-----------------------------------|-------------------------|---|
| <b>3.13</b>                       | <b>Area 27 – JASPER</b> | Data Range                                    |
| ARL\SORD<br>NNS Lightning Summary | Within 10 Miles         | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |

Due their close proximity JASPER and BAKER sites have been included in one report. For the period of record, 5938 flashes were detected within 10 miles of JASPER and BAKER sites. The highest flash densities occurred on the elevated terrain surrounding JASPER.

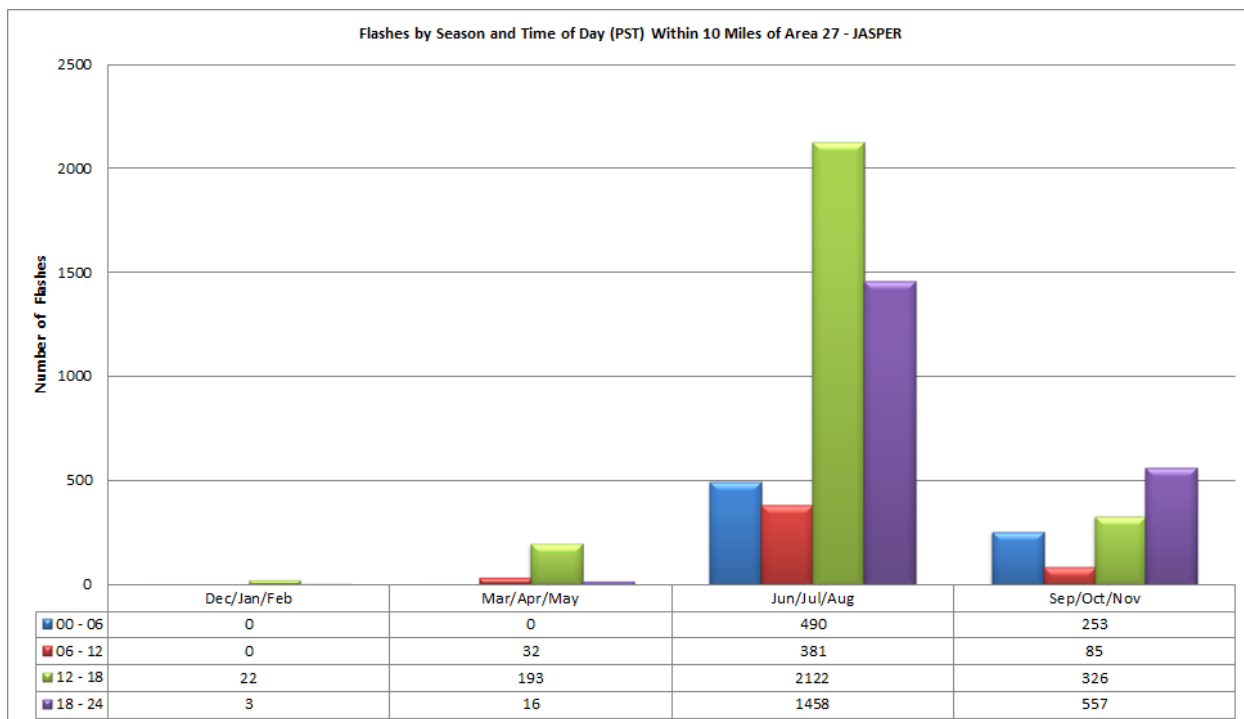
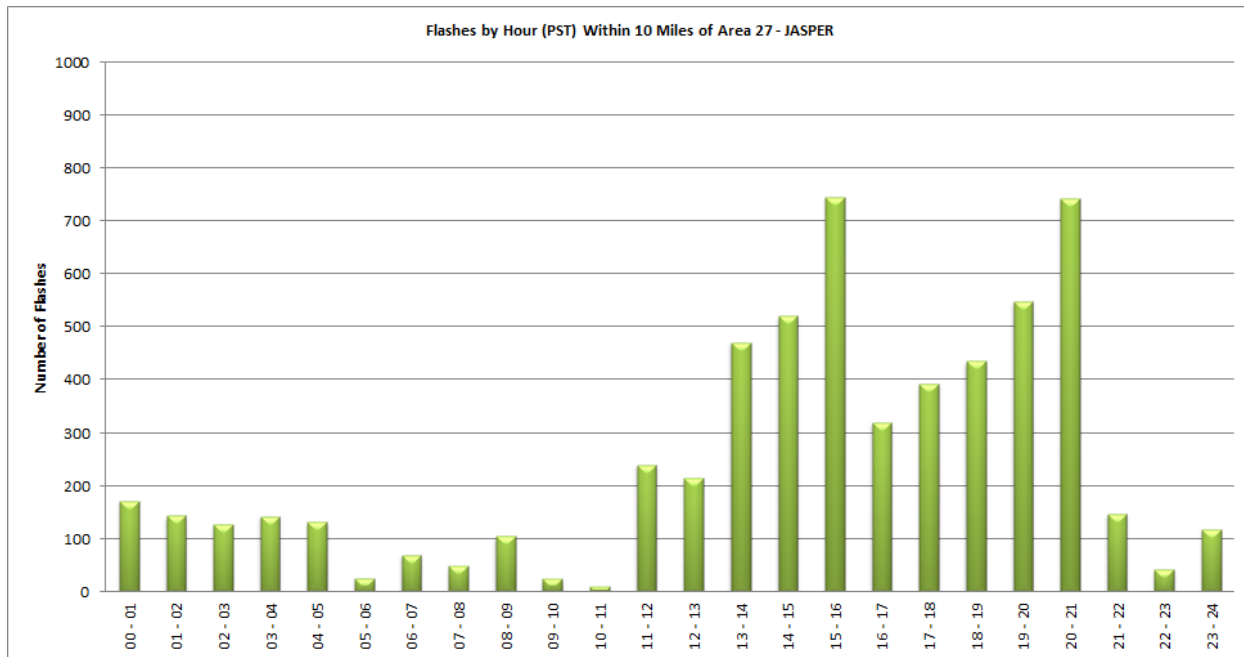
4975 – Charged Flashes

963 + Charged Flashes

%+ 16.2



|                                    |                         |   |
|------------------------------------|-------------------------|---|
| <b>3.13</b>                        | <b>Area 27 - JASPER</b> | Data Range                                    |
| ARL\SORD<br>NNSS Lightning Summary | Within 10 Miles         | 2001/03/26 13:07:55 to<br>2015/02/28 23:59:59 |



## 4.0 REFERENCE

Information in Section 2 of this document was obtained from the following source:

Jensenius, John S. Jr., National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (DOC). [accessed 2015 May 25]. .  
Understanding Lightning . <http://www.lightningsafety.noaa.gov/science/scienceintro.shtml>