



## Williwaw Engineering

April 2, 2016

Luis A. Vega, Ph.D.  
Manager  
National Marine Renewable Energy Center  
University of Hawaii  
1680 East West Road, POST 112A  
Honolulu, HI 96822

Subject: March 2016 Monthly Report – RCUH P.O. #Z10115098

Dear Luis,

The following constitutes my monthly report for the subject agreement for services associated with March 2016.

***Work Completed under Activity 1: “Provide technical and software support services to HNEI technical staff in programming data acquisition (DAS) controllers and analyzing data records in the following areas as assigned”:***

- Monitored the device regularly via remote connection to the NWEI host PC in Room 106, Battery French. Downloaded data from PC as necessary, and updated device control settings when necessary.
- Updated MATLAB power performance analysis scripts to be consistent with normalized power matrix calculation from capture length and representative spectra as described in IEC Technical Specification 62600-100. Analyzed power data to produce monthly power performance data plot using this method; see Attachment 1 for results.
- Analyzed Azura float angle data using MATLAB to produce a plot of 30 minute average float angle data for the deployment period. The Azura hull ballast has continued to be stable since the beginning of 2016.
- Plotted daily humidity sensor data for the cRIO controller enclosure and drybox on board the Azura. The drybox, which is entirely sealed from the Azura hull, has maintained humidity less than 10% throughout the deployment period while humidity inside the cRIO enclosure continues to stabilize at less than 30%. See Attachment 3 for a plots of these results.
- Began writing an interim test report covering Azura testing for the period June 2015 – March 2016. This report will be completed and submitted to HNEI during the month of April.

Please let me know if you have any questions or comments concerning this project.

Sincerely,

Terry Lettenmaier

Attachment 1: Azura power performance data plots

Attachment 2: Azura 30 minute average float angle data plots

Attachment 3: Azura cRIO enclosure and drybox humidity

## **Attachment 1**

### **Azura power performance data plots**

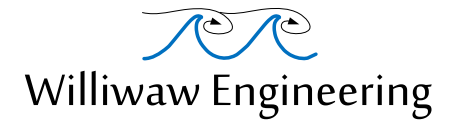
# Azura Power Performance – March 2016

## Summary

- Azura power performance was calculated and is presented as described in IEC Technical Specification 62600-100.
- Device performance is presented per IEC 62600-100 using capture length and normalized power matrices. Normalized power was calculated from capture length and energy flux of representative spectra for each Hm0-Te bin.
- Average power matrices, 95<sup>th</sup> percentile power matrices, and percent difference between normalized power and average power are also presented.
- The representative spectra for IEC 62600-100 calculations were calculated by taking the average of all spectra recorded for each bin, then shifting the magnitude and frequency of the average spectra so that their Hm0 and Te are at the center of each bin.
- Plots of March 2016 data only are shown on Slides 3-11
- Plots of cumulative data for the entire deployment period January-March 2016 are shown on Slides 13-21
- Azura was operated (output connected to grid) for 729 hours in March (98% of month). Most of the down time was during temporary shut downs until the device controller was manually reset after brief grid voltage interruptions.
- Device control was continued through all of March in constant hydraulic motor displacement mode, with the settings cycled between six different settings. This is the simplest control method possible for the Azura.

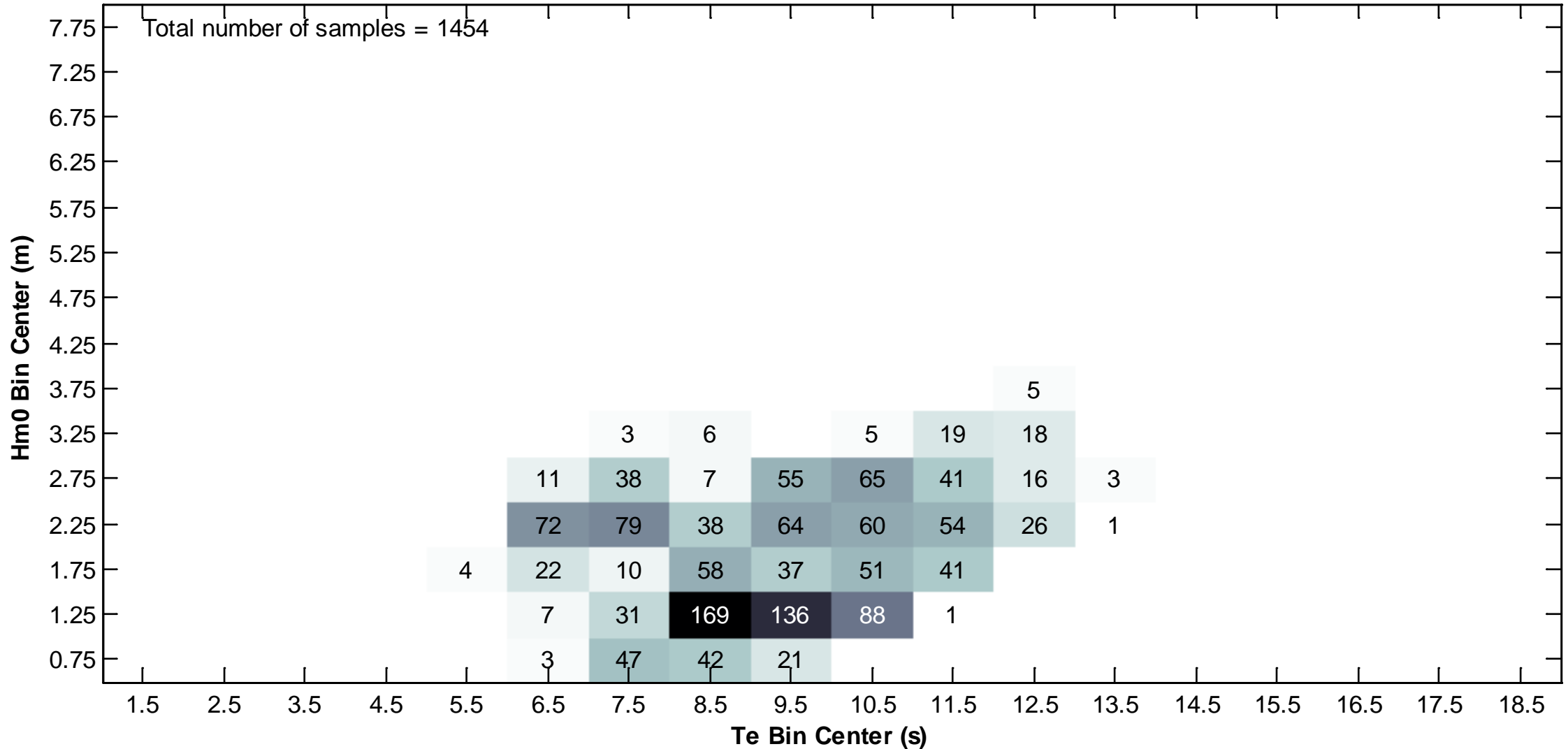
# Azura Power Performance Monthly Data March 2016

# Azura Power Performance – March 2016



Data samples collected

**Sample Count (30 min sample periods)**  
**Month of Mar 2016; 30 minute periods with > 20 minutes operation included**



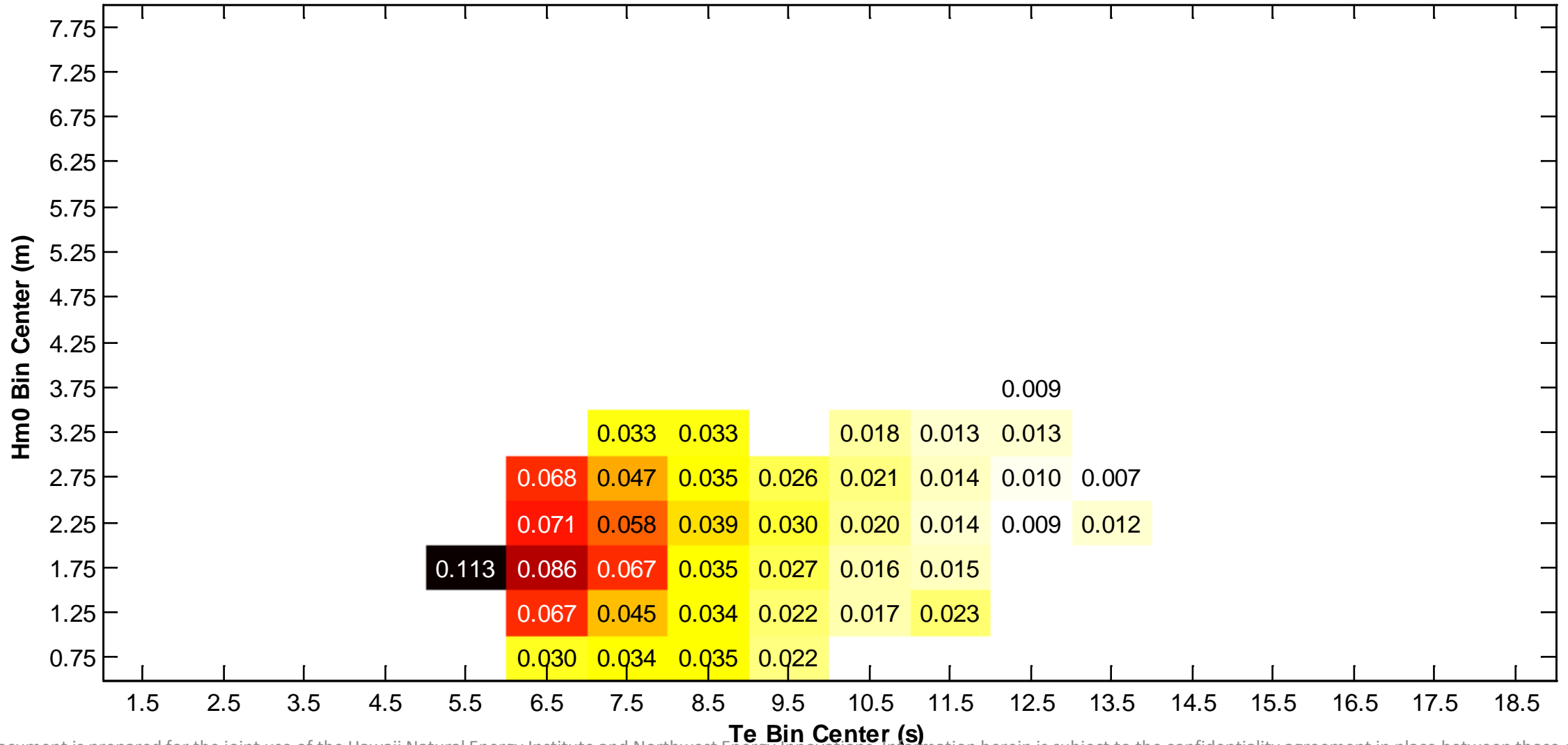
# Azura Power Performance –March 2016

Mean capture length matrix



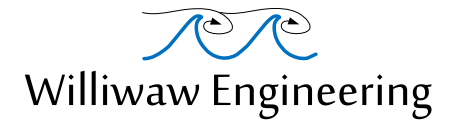
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**Mean Capture Length (device dc output power/wave energy flux, m)**  
**Month of Mar 2016; 30 minute periods with > 20 minutes operation included**

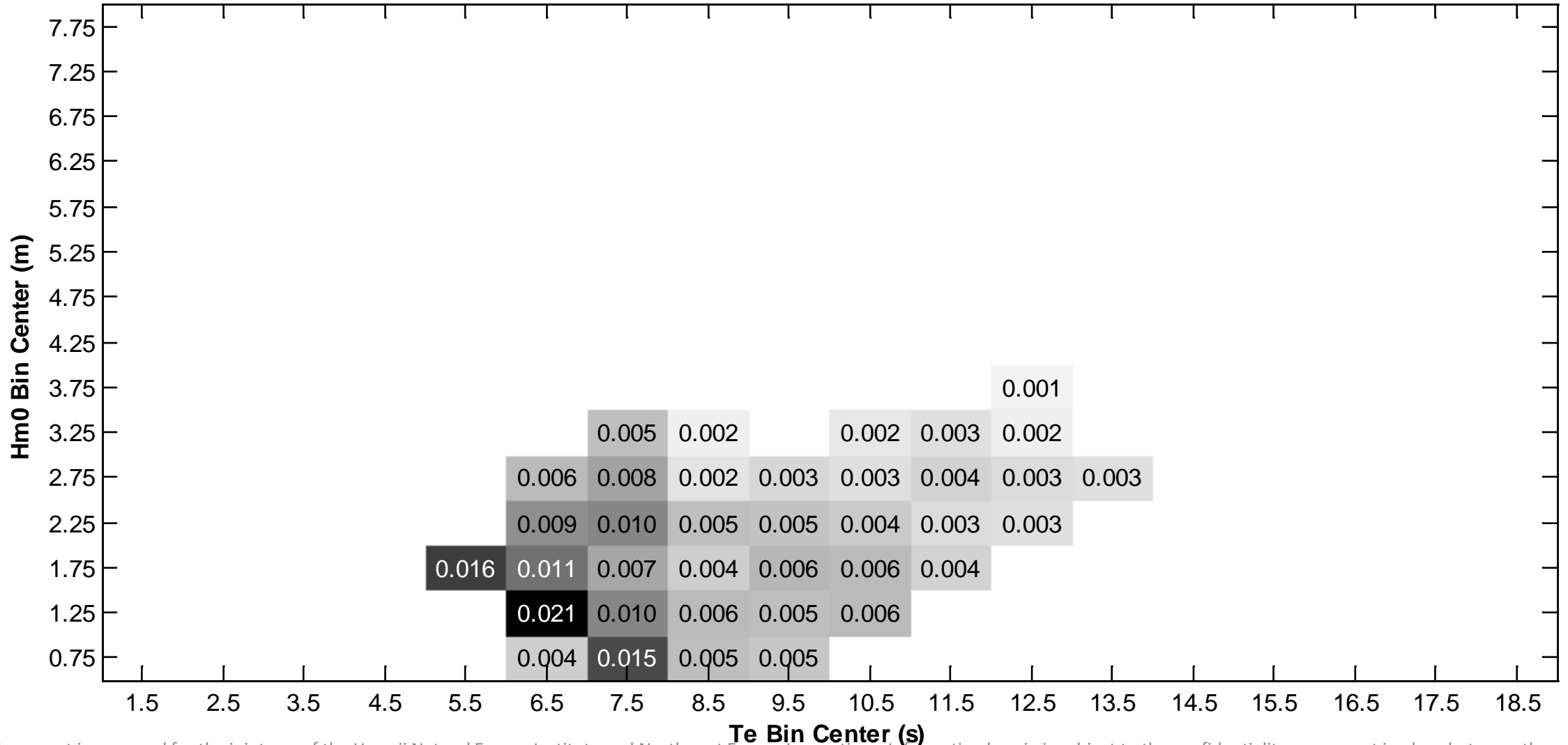


# Azura Power Performance –March 2016

Standard deviation of capture length



**Standard Deviation of Capture Length (m)**  
**Month of Mar 2016; 30 minute periods with > 20 minutes operation included**



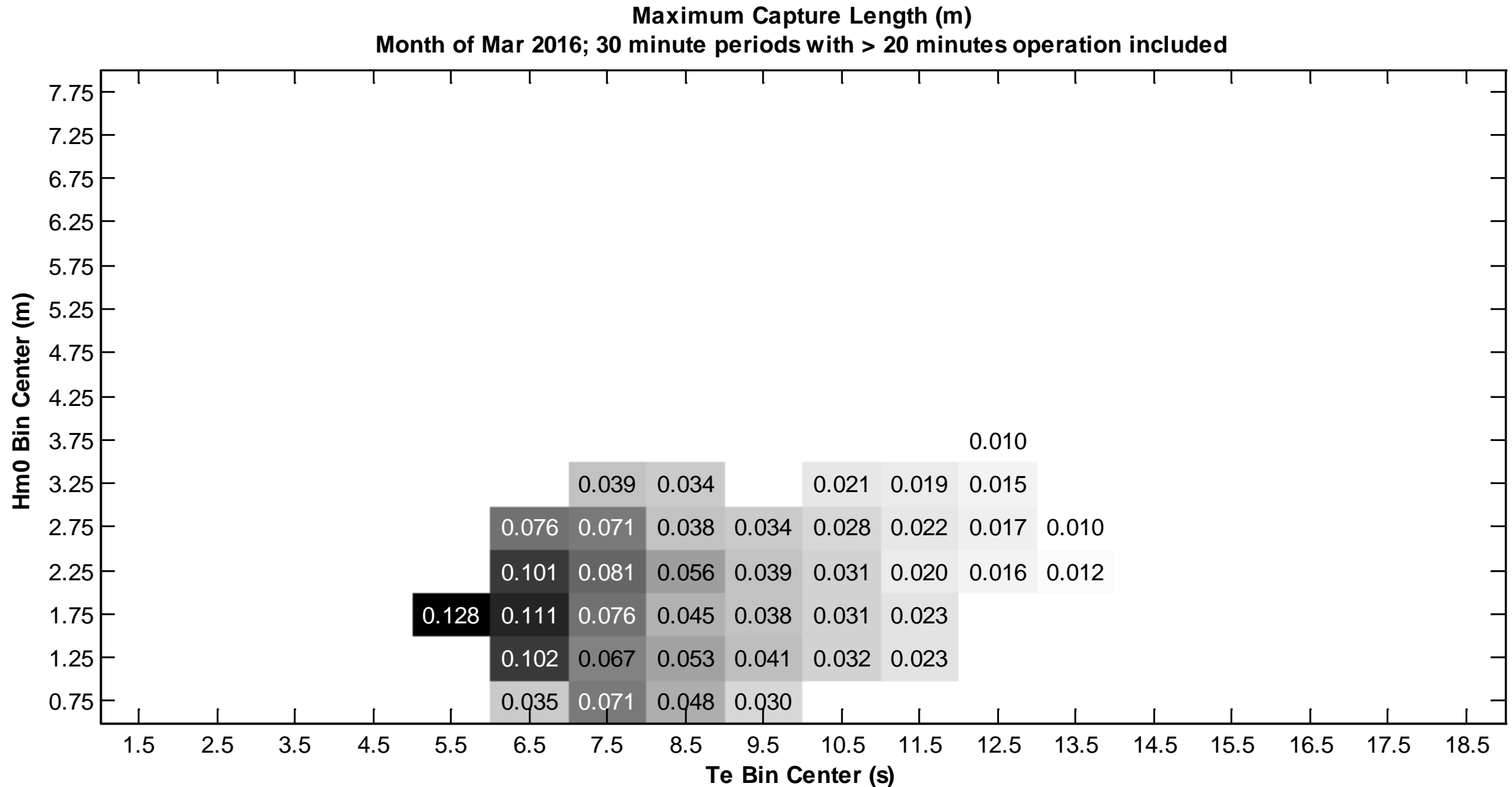


# Azura Power Performance –March 2016

Maximum capture length matrix

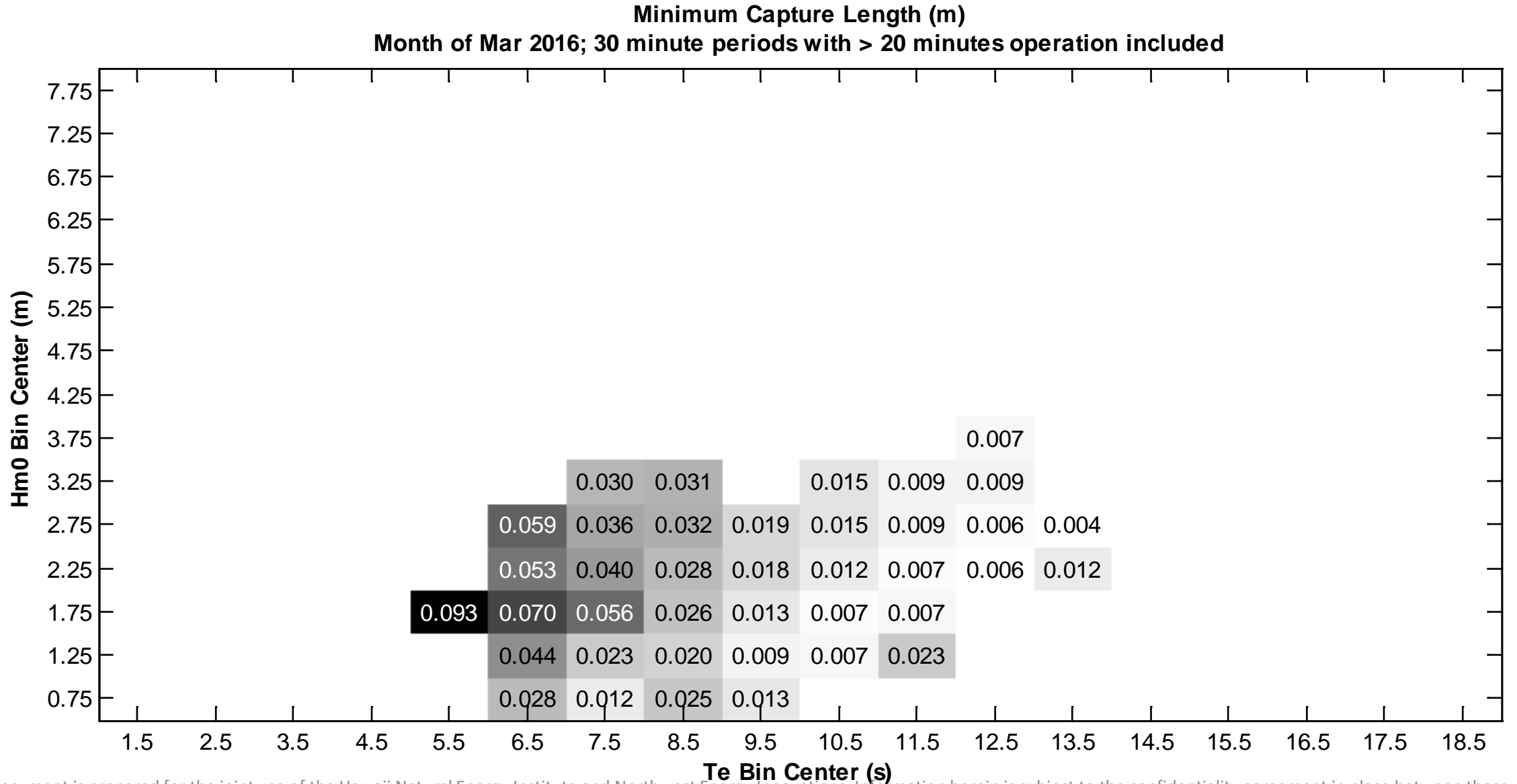
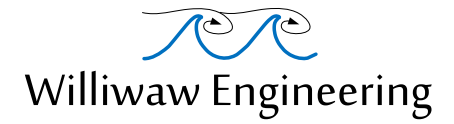


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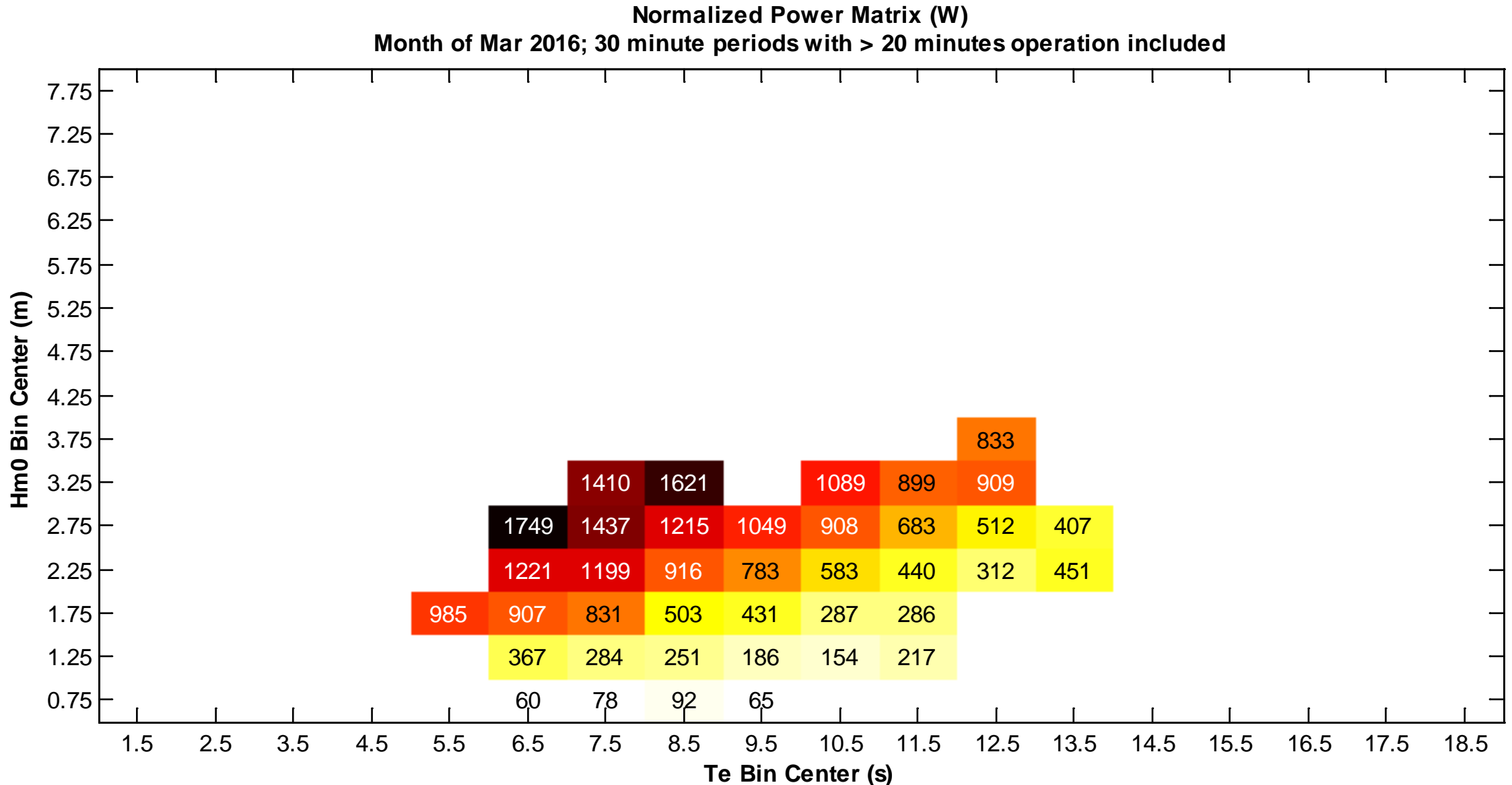
# Azura Power Performance –March 2016

Minimum capture length matrix



# Azura Power Performance – March 2016

Normalized power matrix



# Azura Power Performance – March 2016

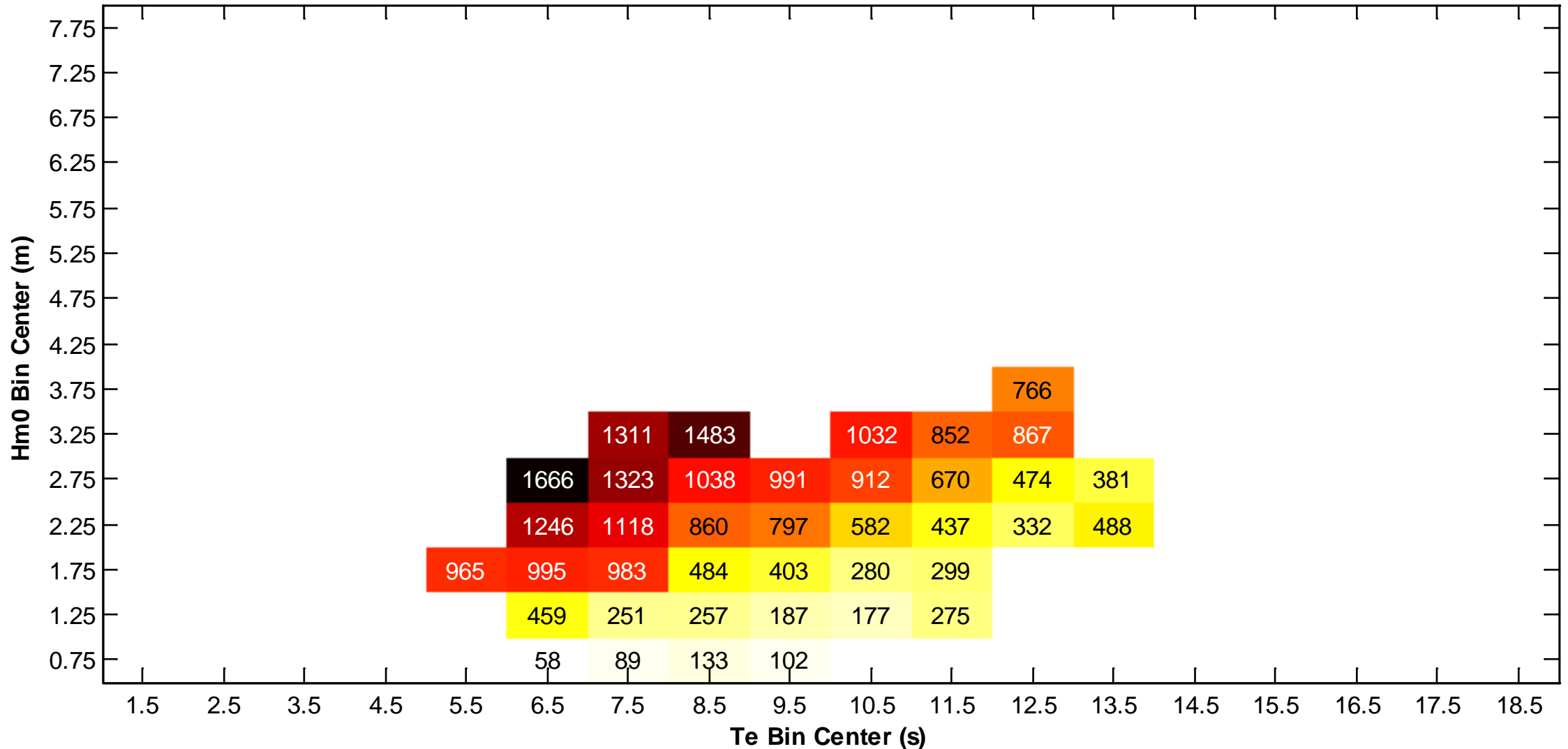


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Mean power matrix

Mean Device Output Power (W)

Month of Mar 2016; 30 minute periods with > 20 minutes operation included

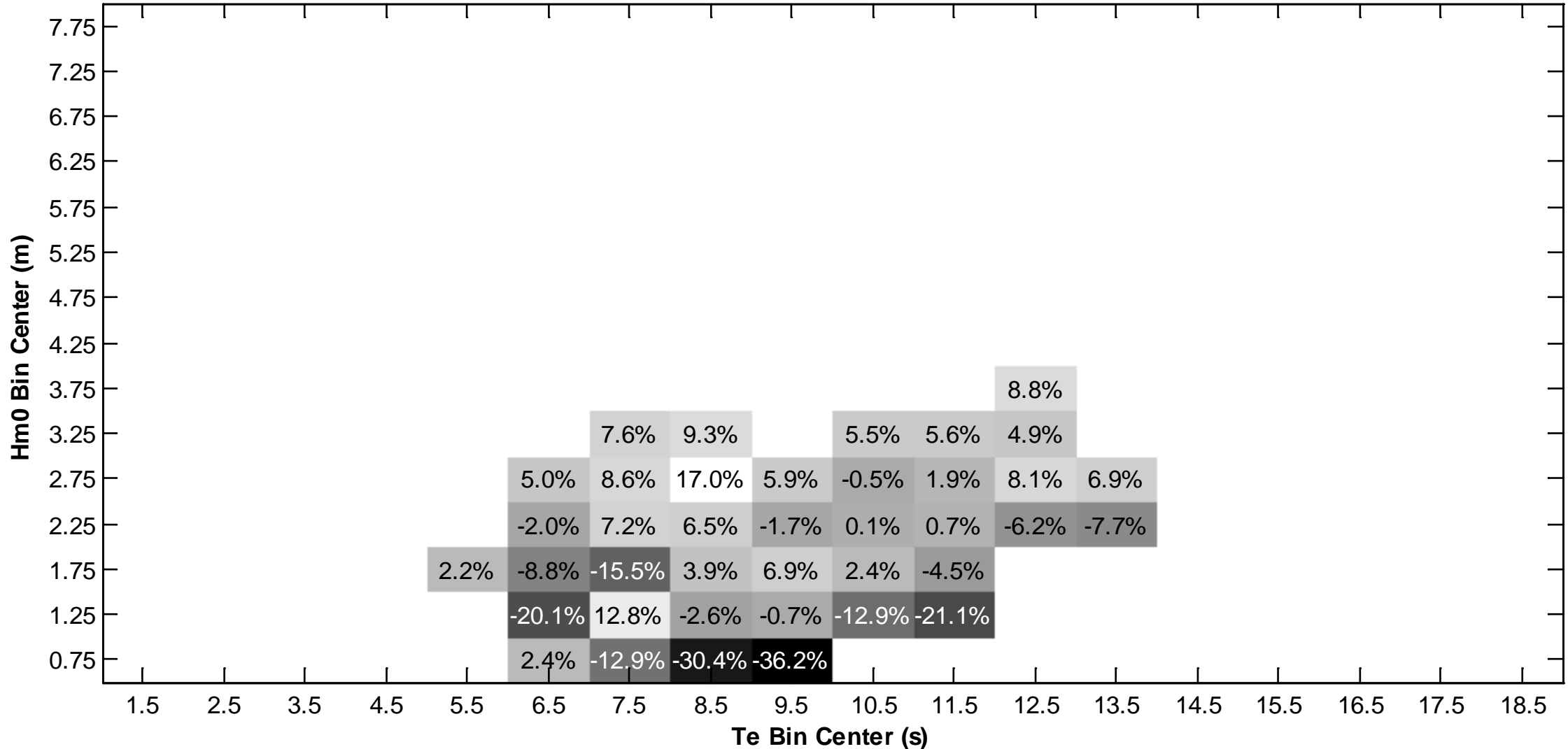


# Azura Power Performance – March 2016



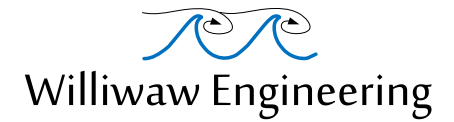
Percent difference between normalized and mean power matrix

**Percent difference between normalized and direct measured power matrices  
Month of Mar 2016; 30 minute periods with > 20 minutes operation included**

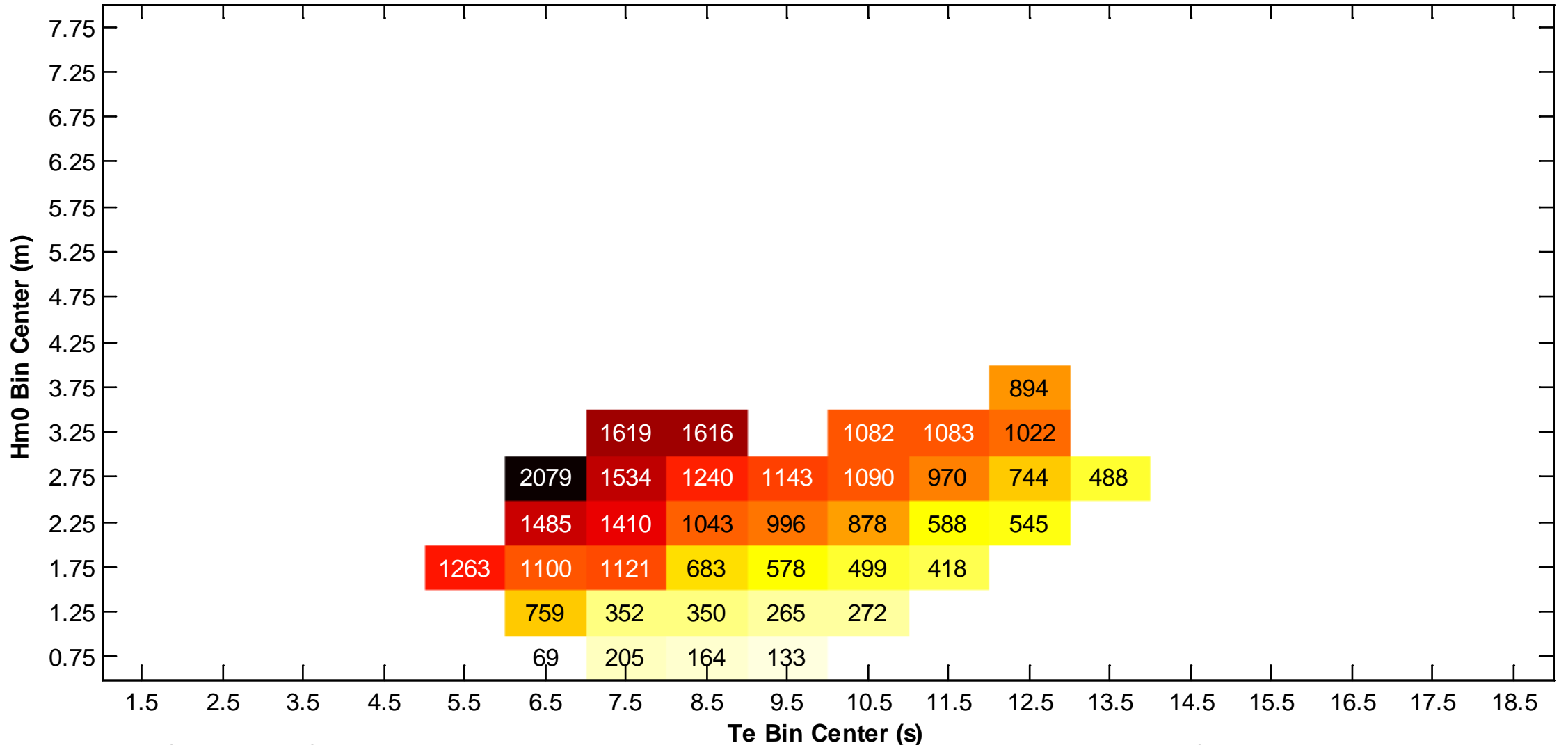


# Azura Power Performance – March 2016

95<sup>th</sup> percentile power matrix



**95th Percentile Device Dc Output Power (W)**  
**Month of Mar 2016; 30 minute periods with > 20 minutes operation included**



# Azura Power Performance Cumulative Data January – March 2016

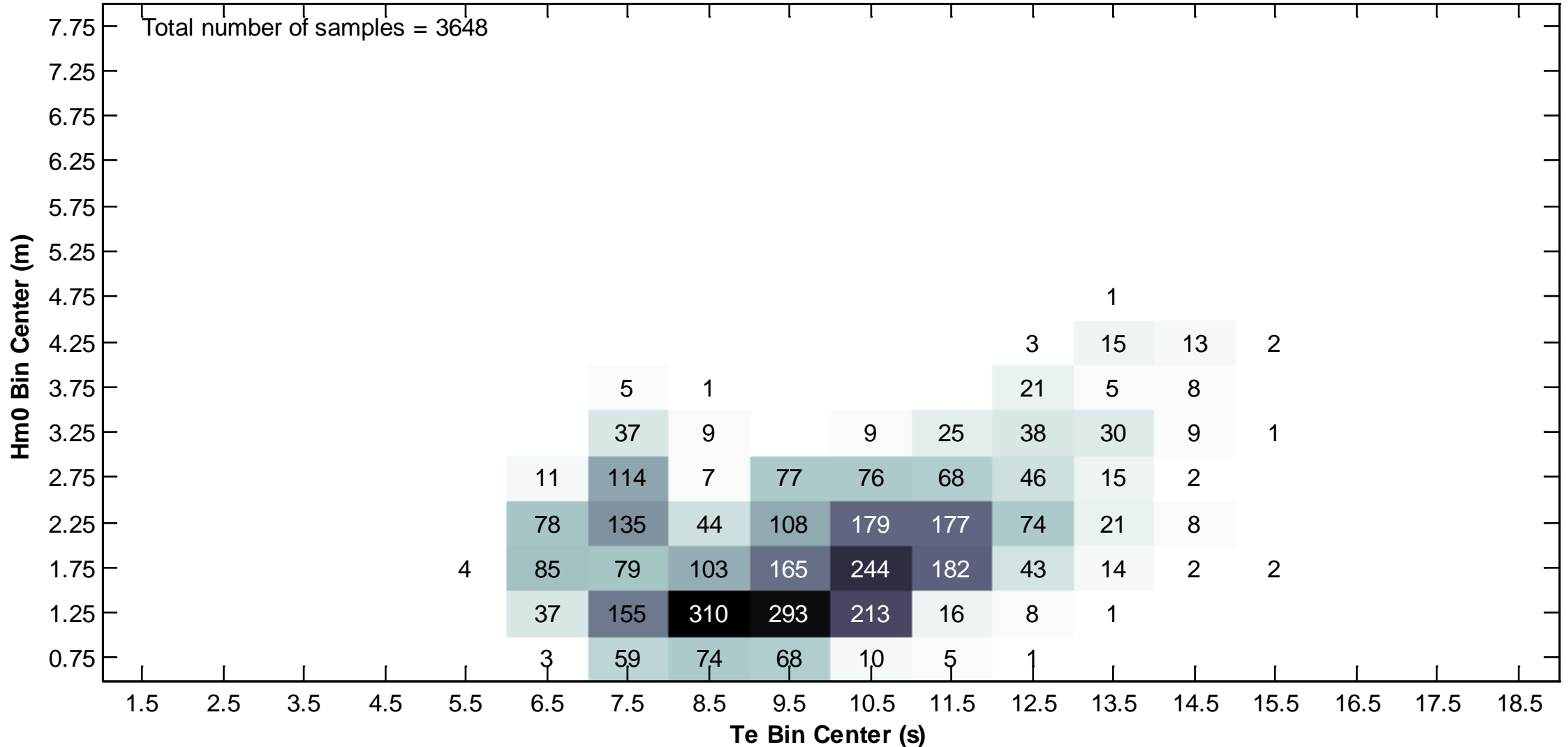
# Azura Power Performance – Jan-March 2016



Data samples collected

Sample Count (30 min sample periods)

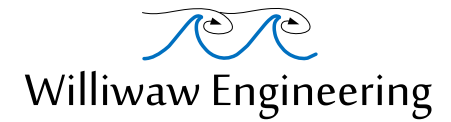
Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included



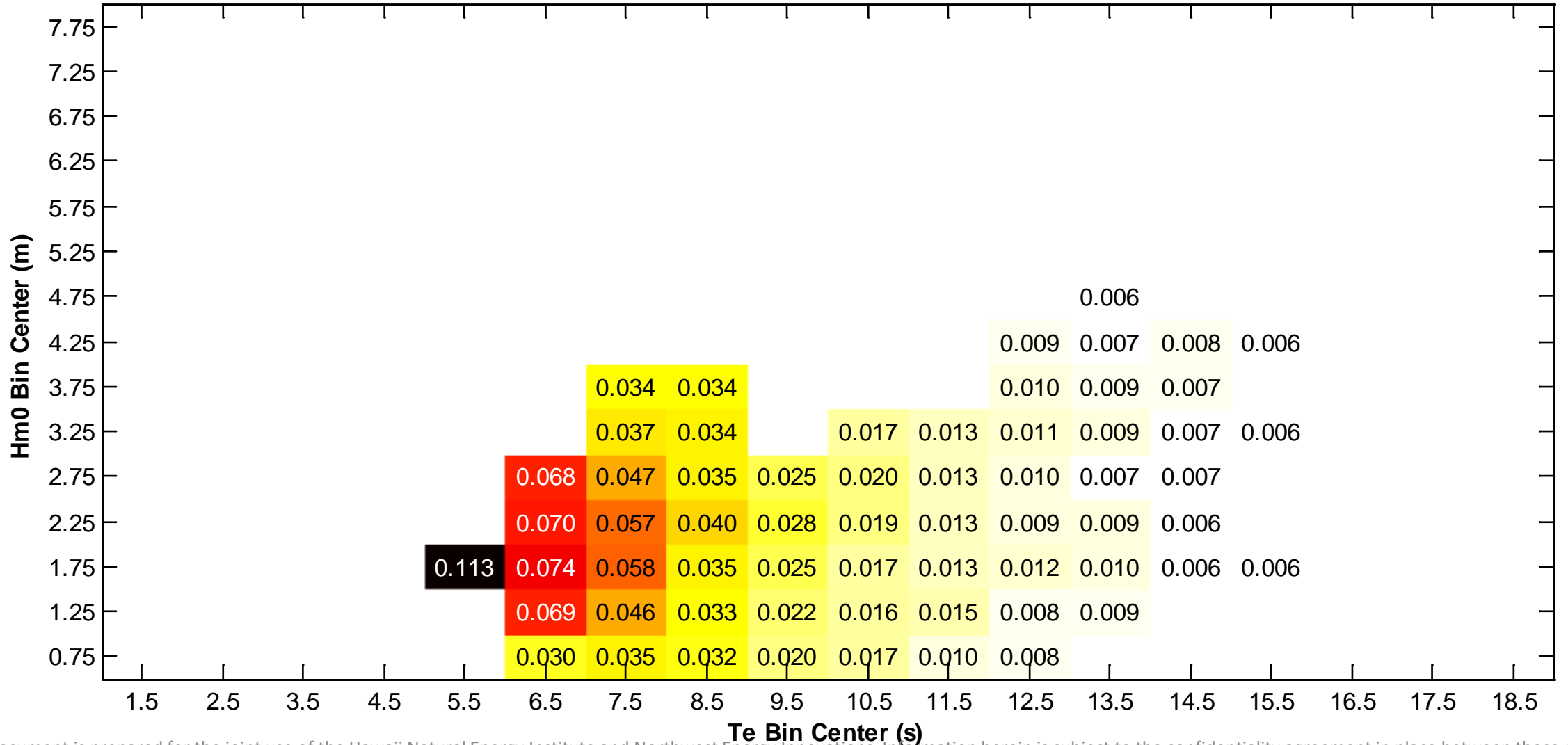


# Azura Power Performance – Jan-March 2016

Mean capture length matrix



**Mean Capture Length (device dc output power/wave energy flux, m)**  
**Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included**



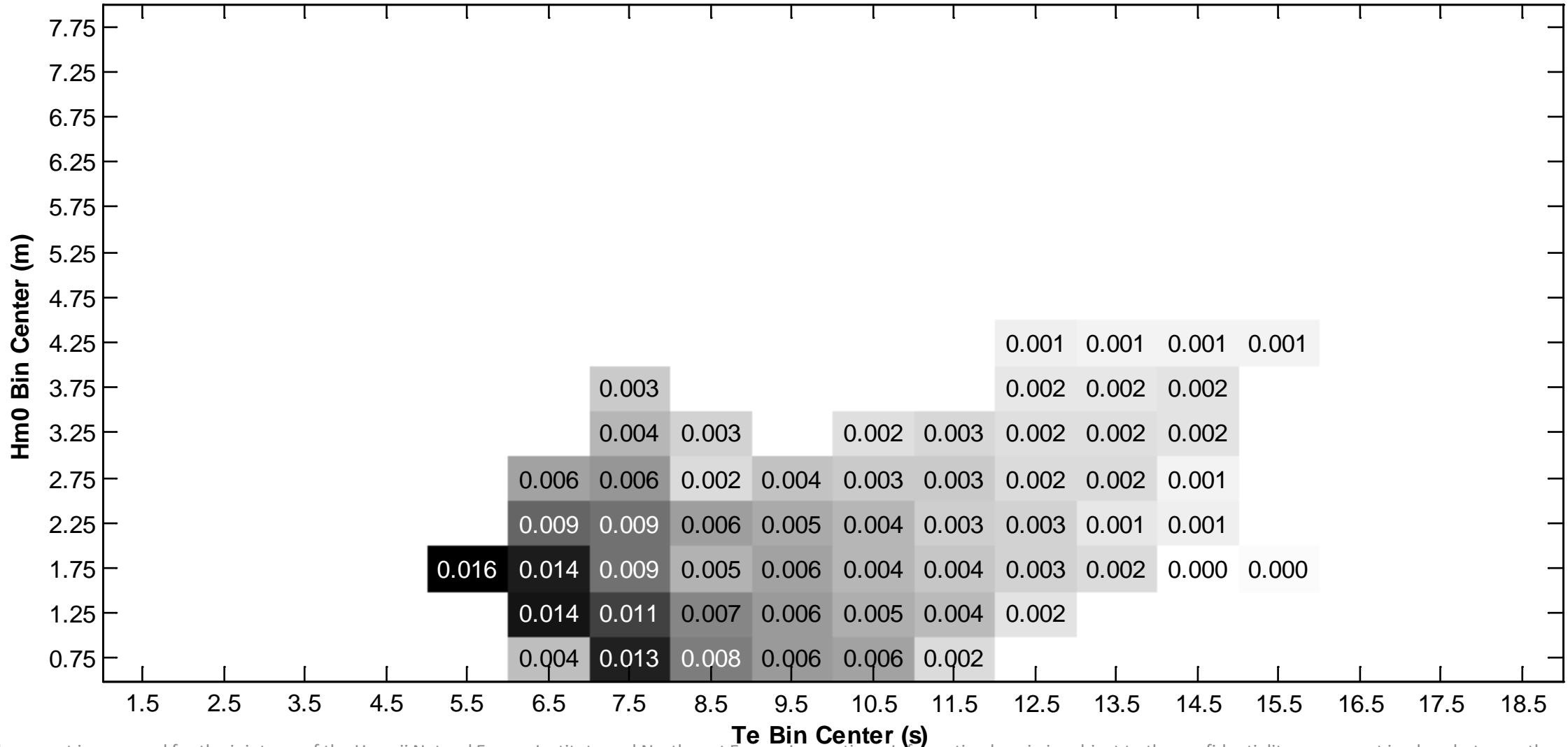
# Azura Power Performance – Jan-March 2016

Standard deviation of capture length



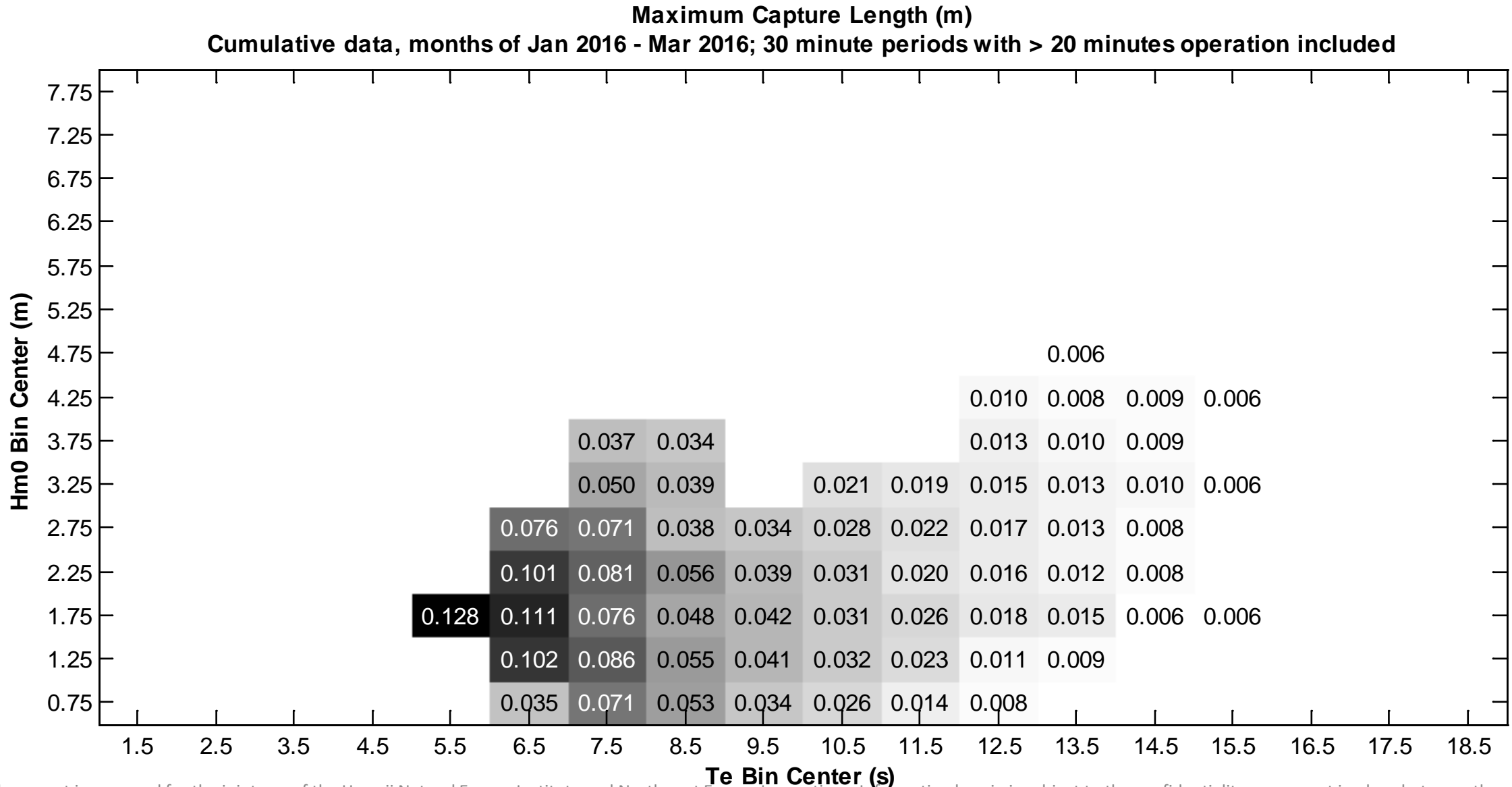
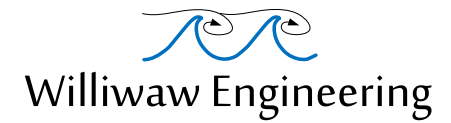
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**Standard Deviation of Capture Length (m)**  
**Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included**



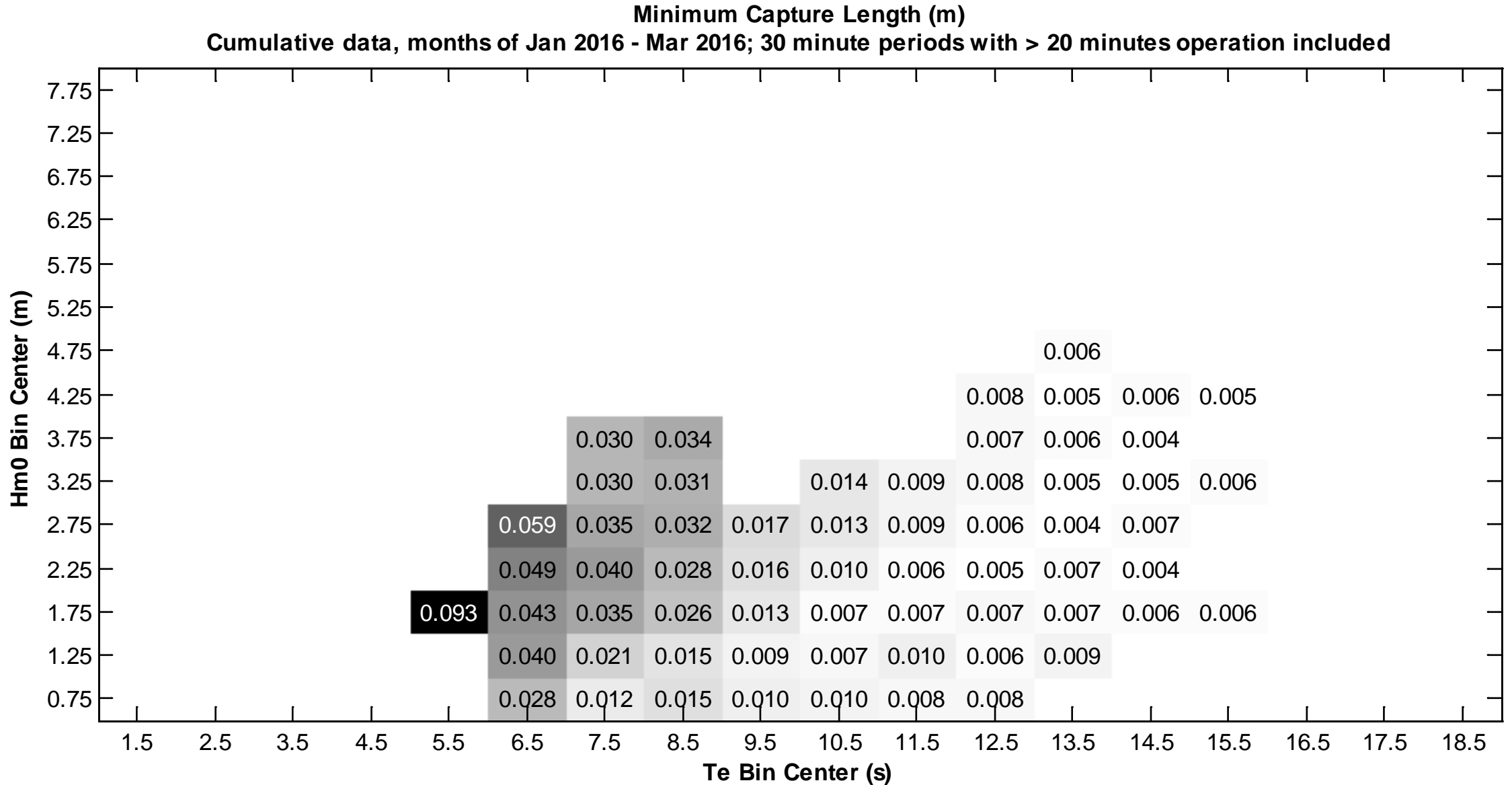
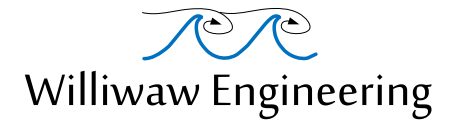
# Azura Power Performance – Jan-March 2016

Maximum capture length matrix



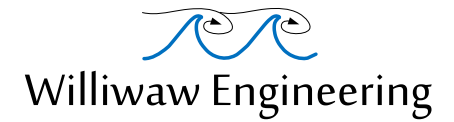
# Azura Power Performance – Jan-March 2016

Minimum capture length matrix



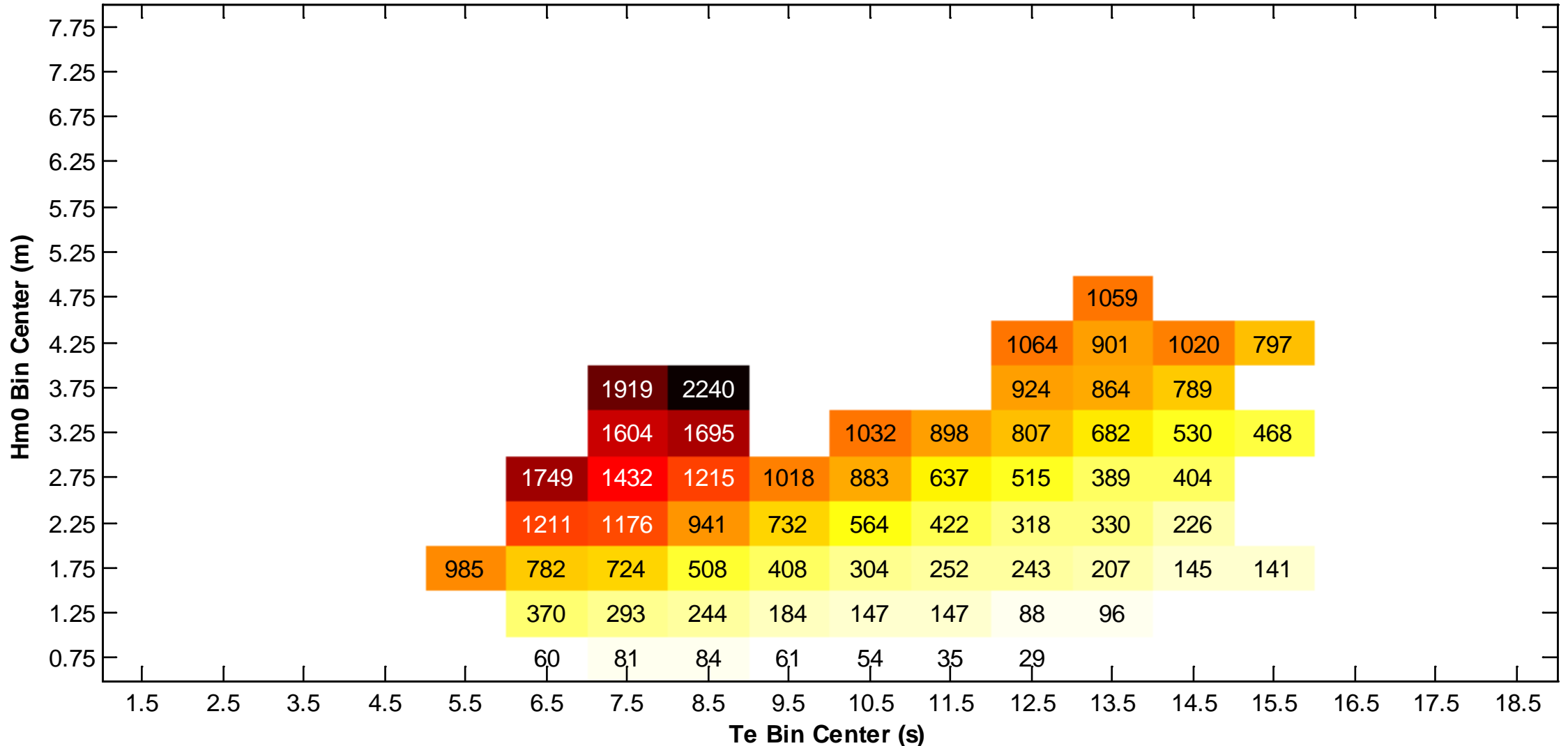
# Azura Power Performance – Jan-March 2016

Normalized power matrix



**Normalized Power Matrix (W)**

Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included



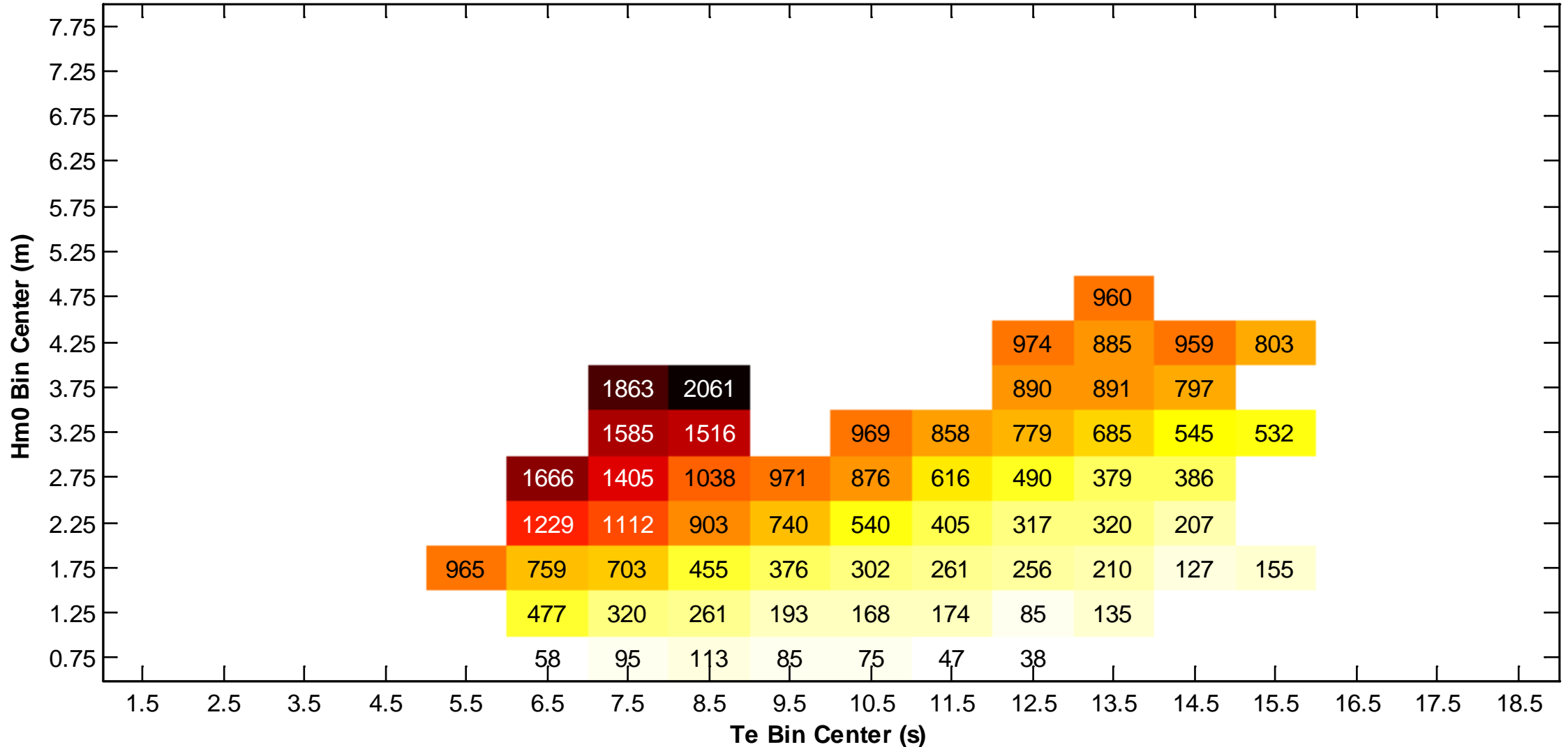
# Azura Power Performance – Jan-March 2016



Mean power matrix

Mean Device Output Power (W)

Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included

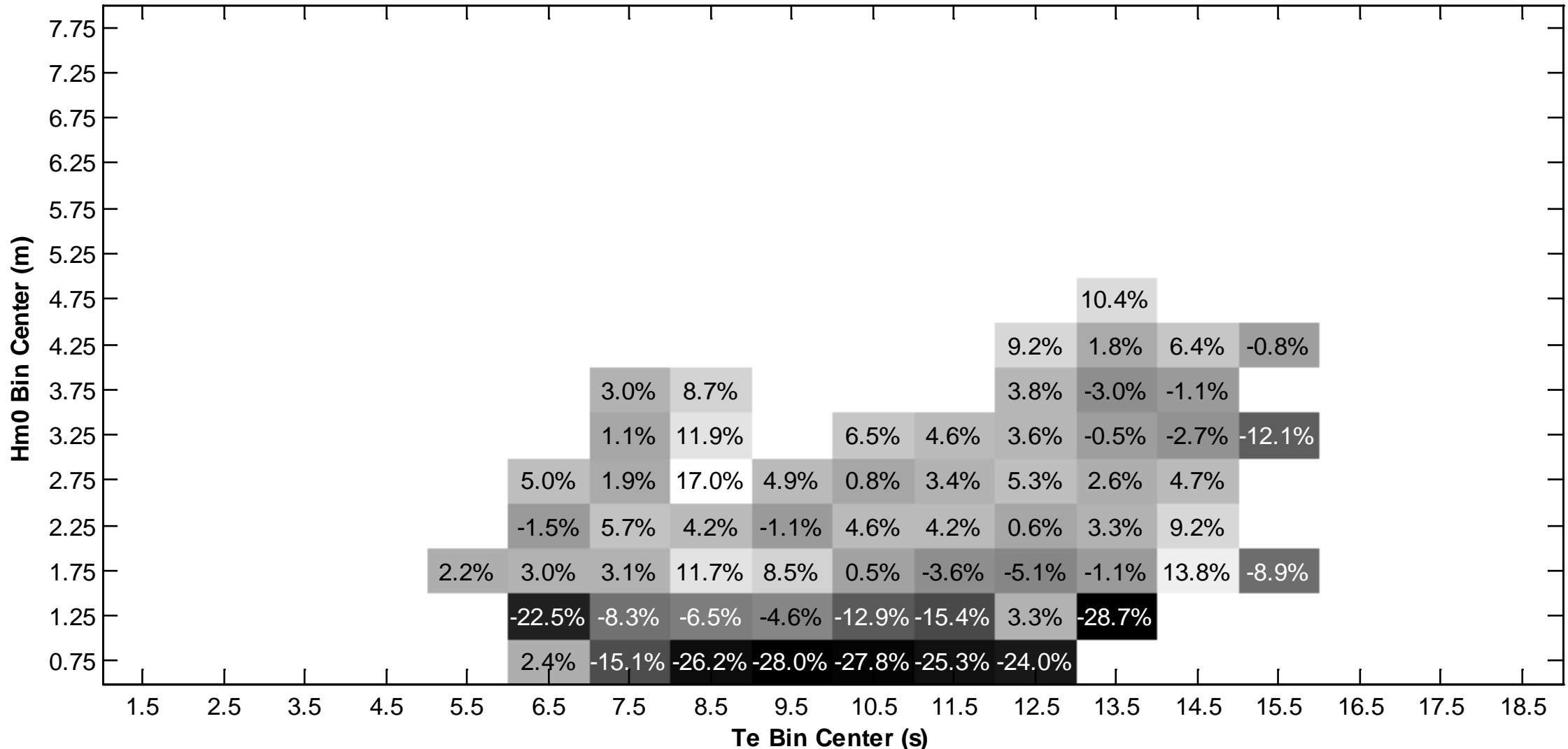


# Azura Power Performance – Jan-March 2016



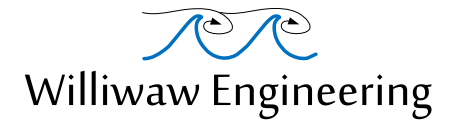
Percent difference between normalized and mean power matrix

**Percent difference between normalized and direct measured power matrices**  
**Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included**



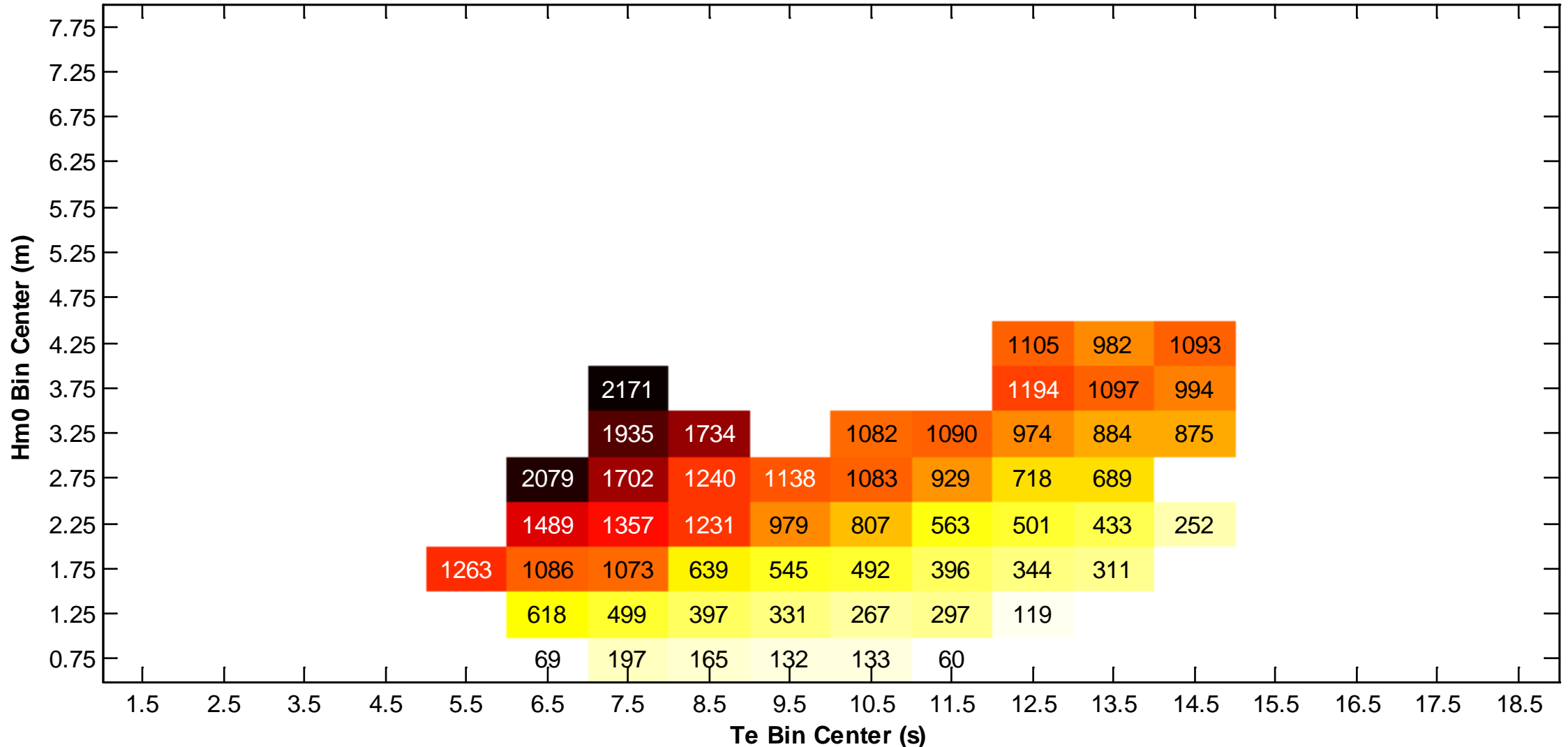
# Azura Power Performance – Jan-March 2016

95<sup>th</sup> percentile power matrix



## 95th Percentile Device Dc Output Power (W)

Cumulative data, months of Jan 2016 - Mar 2016; 30 minute periods with > 20 minutes operation included





## **Attachment 2**

**Azura 30 minute average float angle data plots**

# Azura 30 minute average float angle data – March 2016

## Summary

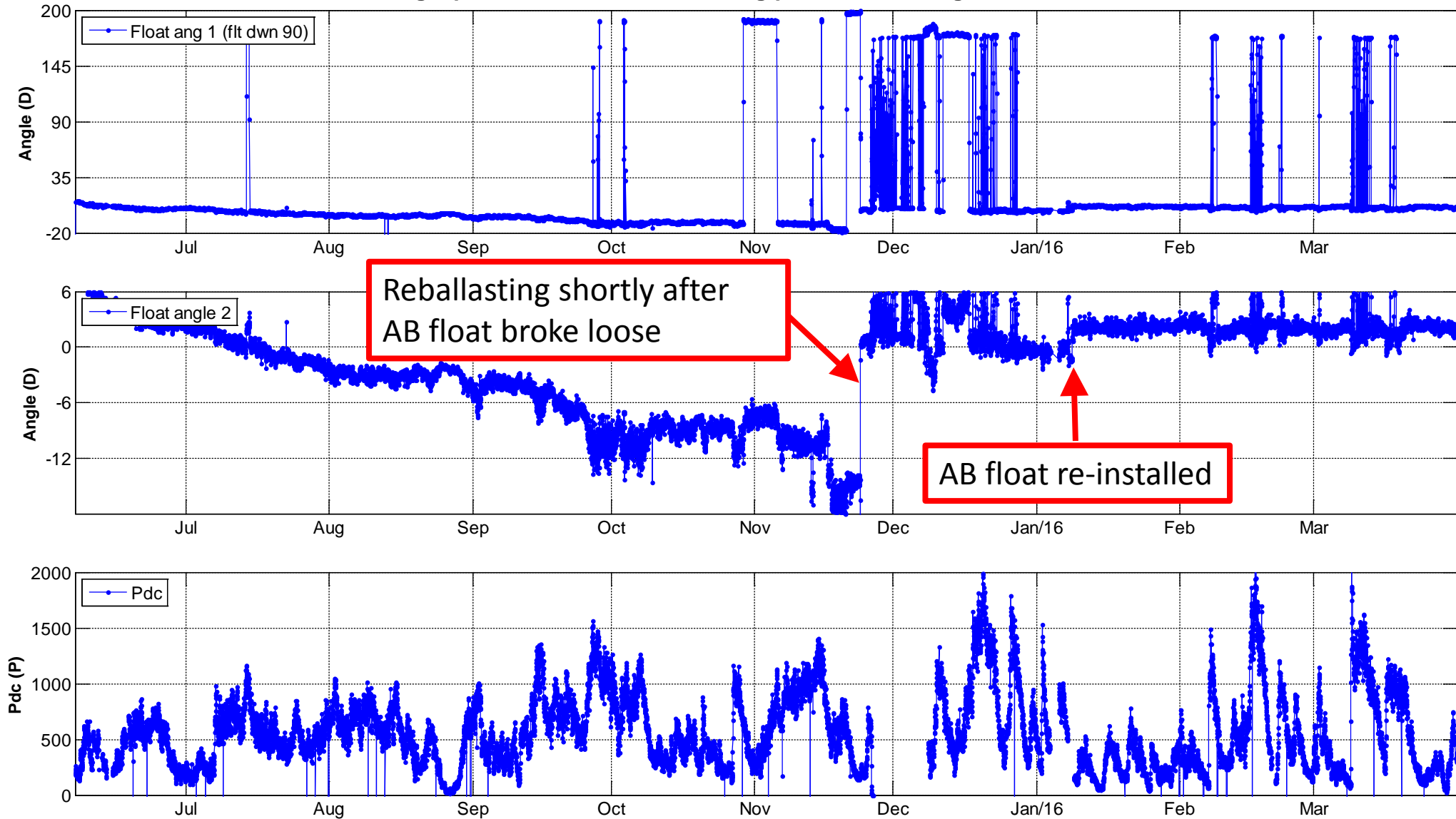
- See Slide 2 for plot of June 2015 – March 2016 data
- Average float angle has been steady near zero angle since the AB subsurface float was re-installed on January 9.

## Azura 30 min average float angle data through Mar 2016



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Float angle plots from file NWEI 30m avg power w float angle 201506 to 201603.txt



## **Attachment 3**

**Azura cRIO enclosure and drybox humidity plots**

