FREQUENCY MONITORING – THREE YEAR HISTORICAL TRENDS

FOR THE NATIONAL ELECTRICITY MARKET

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

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1. INTRODUCTION

AEMO is responsible under the National Electricity Rules (NER) for ensuring that the power system is operated in a safe, secure and reliable manner. As part of this obligation, AEMO is required to maintain power system frequency and time error to within the limits specified in the frequency operating standards (FOS) determined for the National Electricity Market (NEM) regions by the Reliability Panel.[1]

Frequency control ancillary services (FCAS)[2] are central to AEMO's management of power system frequency, and the Market Ancillary Services Specification (MASS)[3] defines the technical requirements for the provision of FCAS.

This report provides a summary of emerging trends in power system frequency performance in the NEM observed from June 2014 to June 2017.

[1] http://aemc.gov.au/Australias-Energy-Market/Market-Legislation/Electricity-Guidelines-and-Standards?publisher=2&type=2
[2] http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services
[3] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification

2. FREQUENCY PERFORMANCE

The mainland frequency was within the Normal Operating Frequency Band (NOFB)[4] more than 99% of the time over any 30-day period from June 2014 to June 2017, as required by the FOS[5]. However, the Tasmanian frequency did not meet the standard at all times, notably during the following two extended periods:

- January 2016 to July 2016 – the Basslink Interconnector was out of service from 20 December 2015 to 13 June 2016, and this coincided with low dam water levels and drought conditions in Tasmania. Initially, fast FCAS was provided by hydro generators. From 29 December 2015 onwards, fast FCAS was no longer sourced from the market in order to improve the operational efficiency of hydro generators and conserve water. Instead fast FCAS was provided by a generator tripping scheme and a temporary adaptive under-frequency load shedding scheme. Also temporary diesel units were brought online to augment the reduced hydro generation during this time. Several factors contributed to the frequency in Tasmania being within NOFB for less than 99% of the time in a 30 day period.
  - Loss of support from the mainland to manage frequency due to the Basslink outage.
  - Reduction in FCAS provided by governor droop control.
  - Detuning of the automatic generation control (AGC) system – During this period sustained frequency oscillations were observed in Tasmania, and investigations showed that the AGC participated in these oscillations. However, it was not determined if AGC caused the oscillations. AGC was detuned by reducing certain gains to resolve the problem, which made the AGC less response to frequency deviations.
- October 2016 to June 2017 – AEMO investigated the gradual decline in frequency performance and identified that times of prolonged frequency deviations coincided with a large portion of regulation FCAS enabled in Tasmania. During these times, the AGC system at AEMO was not able to dispatch the full enablement in Tasmania due to its detuned configuration at the time. On 1 May 2017, AEMO constrained the regulation FCAS from Tasmania to the mainland to 34 MW to ensure that the NEM dispatch engine (NEMDE) only enabled regulation FCAS in Tasmania to the extent that the AGC system could dispatch it under the existing configuration. On 5 May 2017, the AGC gains were increased[6] such that up to 50 MW of regulation enabled in Tasmania by NEMDE could be successfully dispatched by the AGC. These changes have contributed an improvement during May and June 2017. However, more data over a longer period will be required to properly assess the impact. AEMO is further investigating possible changes to the AGC and will review the current configuration when more data is available.

The minimum 30-day rolling average percentage of time that the mainland and Tasmania frequencies remained inside the NOFB is shown in Figure 1.

Figure 2 shows the number of frequency excursions in mainland with the following details:

- Excursions outside NOFB (49.85 Hz to 50.15 Hz).
- Excursions outside the normal operating frequency excursion band (49.75 Hz to 50.25 Hz).
- Excursions outside the generation and load event tolerance bands (49.5 Hz to 50.5 Hz).
- Excursions outside the operational frequency tolerance band (49.0 Hz to 51.0 Hz).
- Excursions outside the extreme frequency excursion tolerance limits (47.0 Hz to 52.0 Hz).

[4] Frequency range of 49.85 Hz – 50.15 Hz.
[5] AEMO uses a rolling average to assess if the requirement for power system frequency to remains in the NOFB for 99% of the time in a 30 day period.
[6] The increase in gains is still less than the gains before the extended Basslink outage to ensure that oscillations will not occur in Tasmania for periods when Basslink is not in service.

Figure 3 shows the number of frequency excursions in Tasmania with the following details:

- Excursions outside the NOFB (49.85 Hz to 50.15 Hz).
- Excursions outside the normal operating frequency excursion band (49.75 Hz to 50.25 Hz).
- Excursions outside the generation and load event tolerance bands (48.0 Hz to 52.0 Hz).
- Excursions outside the operational frequency tolerance band (48.0 Hz to 52.0 Hz).
- Excursions outside the extreme frequency excursion tolerance limits (47.0 Hz to 55.0 Hz).

Figure 4 shows excursions outside the NOFB (49.85 Hz to 50.15 Hz) for more than five minutes in the mainland NEM.

Figure 5 shows excursions outside the NOFB (49.85 Hz to 50.15 Hz) for more than five minutes in Tasmania.

Figure 1 Minimum 30-day rolling average of percentage of time mainland and Tasmania frequencies remained within NOFB

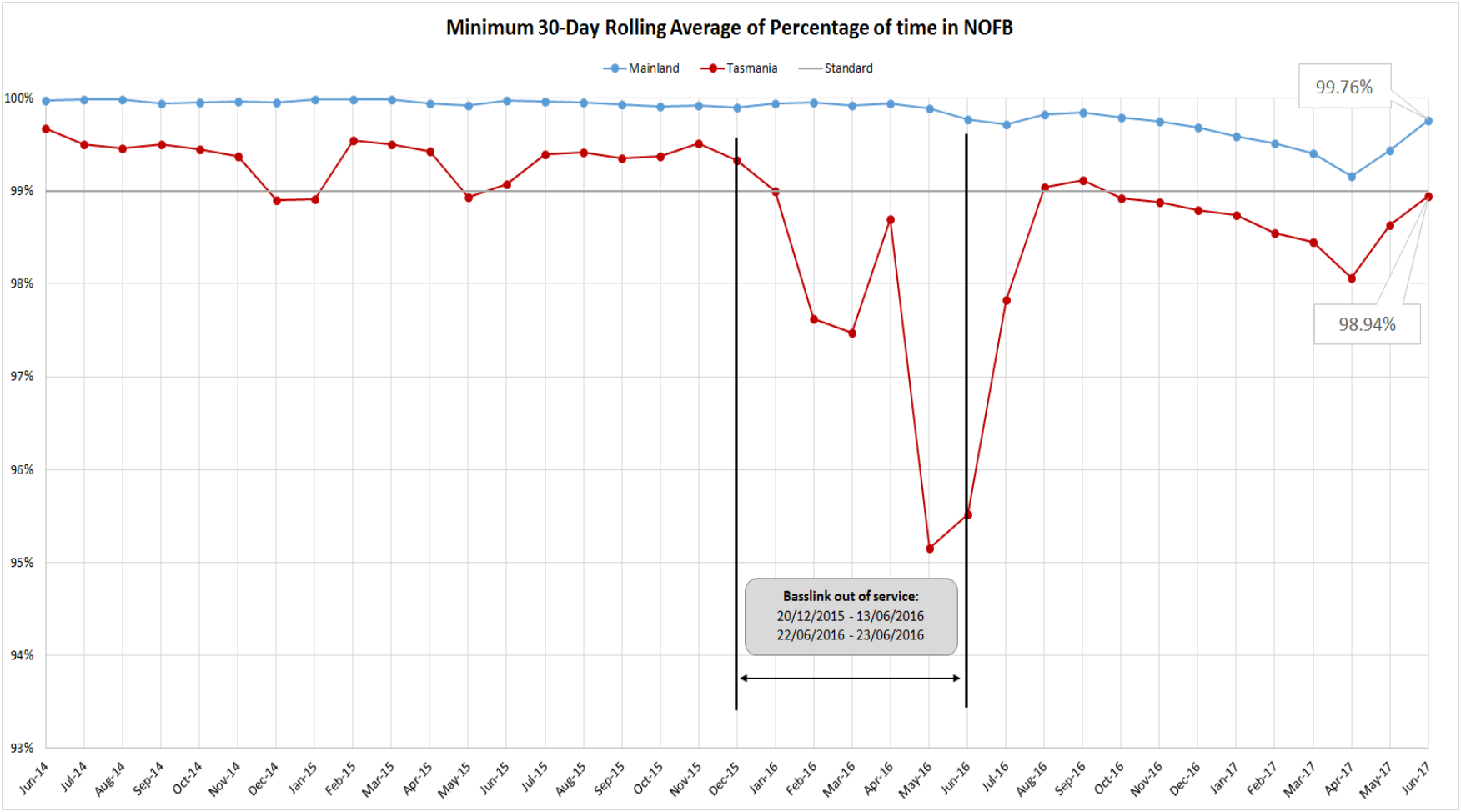
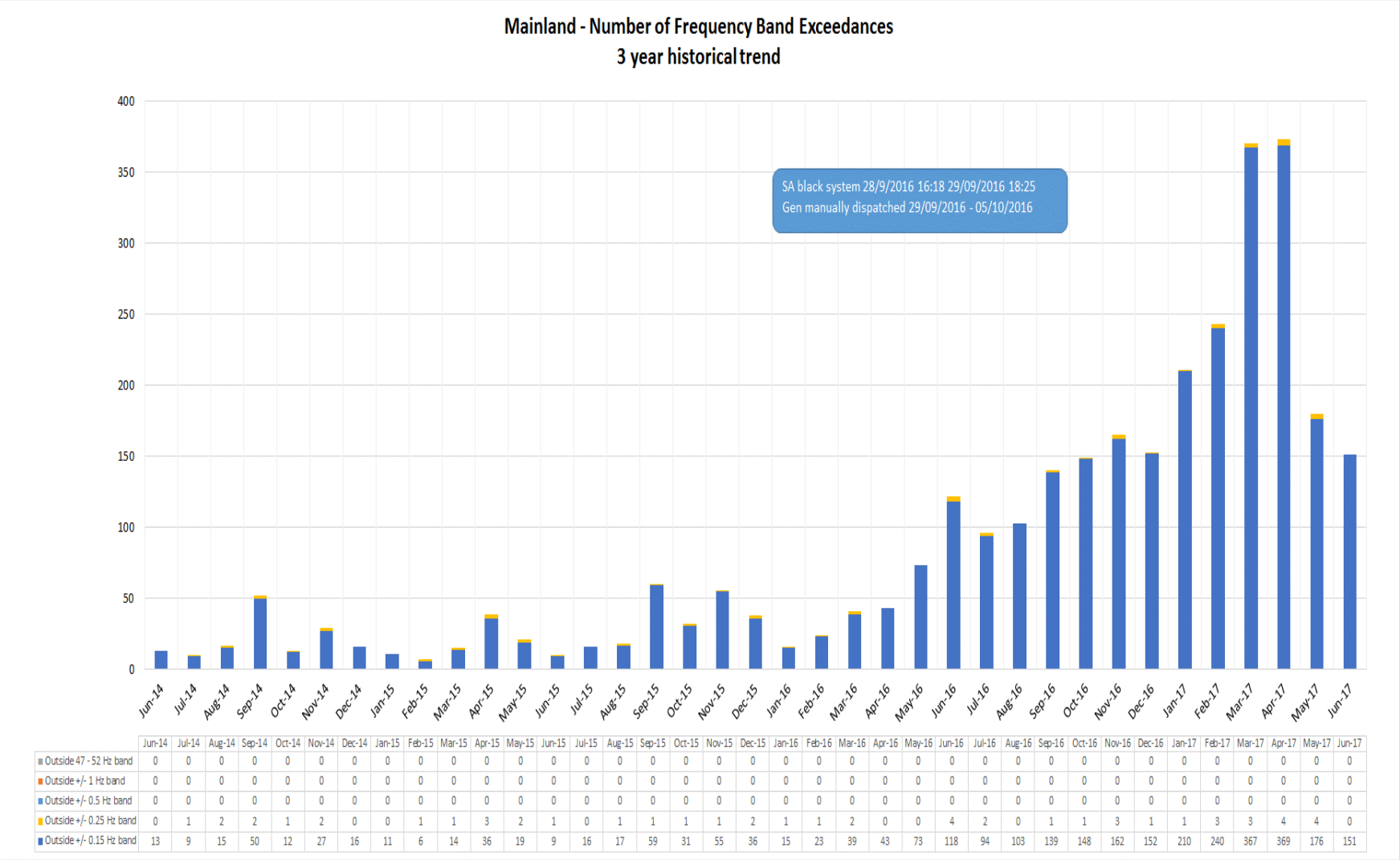
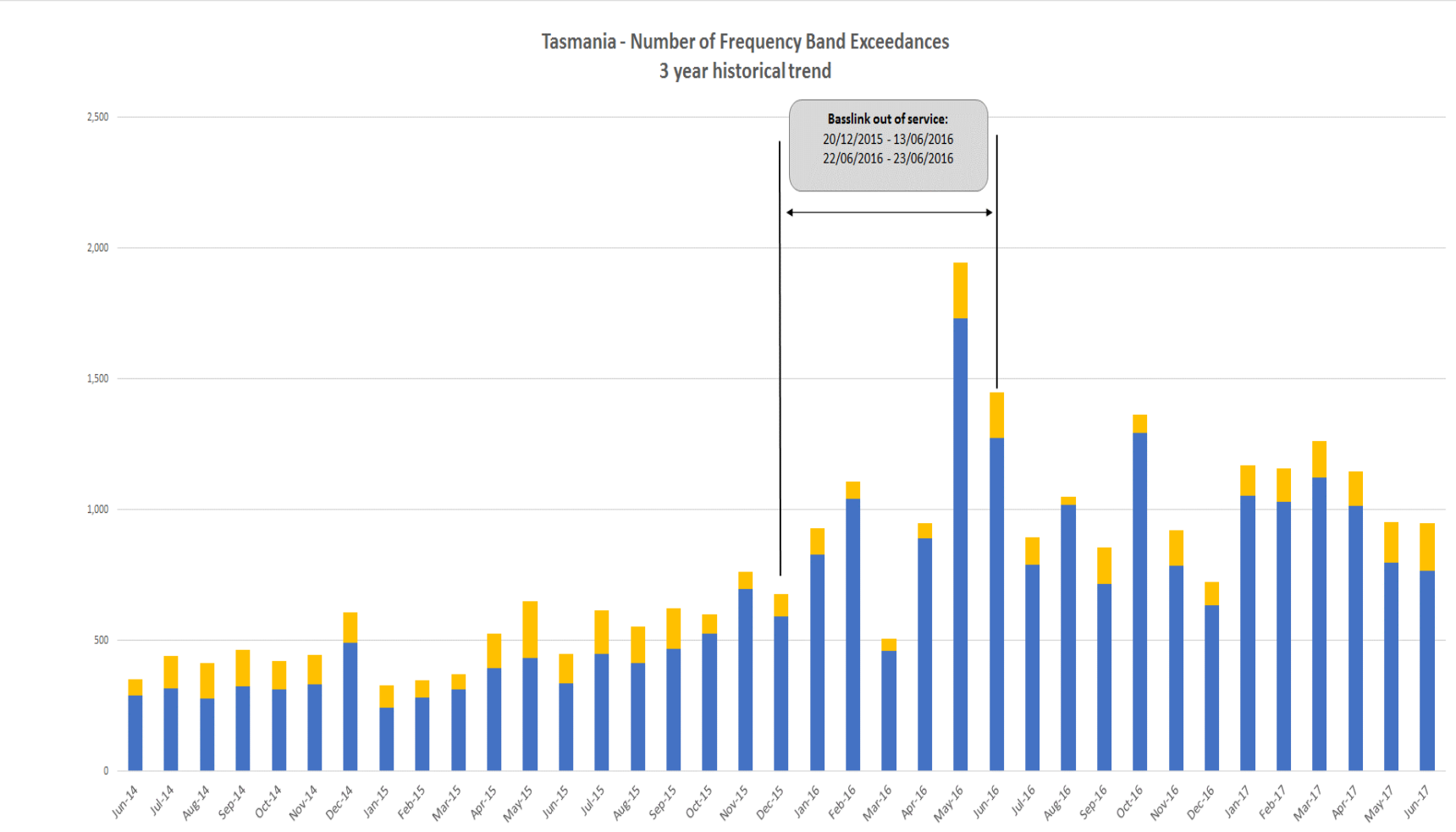


Figure 2 Mainland – Number of frequency band exceedances



	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17
Outside 47 - 52 Hz band	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outside +/- 1 Hz band	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outside +/- 0.5 Hz band	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outside +/- 0.25 Hz band	0	1	2	2	1	2	0	0	1	1	3	2	1	0	1	1	1	1	2	1	1	2	0	0	4	2	0	1	1	3	1	1	3	3	4	4	0
Outside +/- 0.15 Hz band	13	9	15	50	12	27	16	11	6	14	36	19	9	16	17	59	31	55	36	15	23	39	43	73	118	94	103	139	148	162	152	210	240	367	369	176	151

Figure 3 Tasmania – Number of frequency band exceedances



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Outside 47 - 55 Hz band	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outside +/- 2 Hz band	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outside +/- 0.25 Hz band	62	121	138	139	109	113	115	87	69	59	134	215	113	167	136	155	71	65	85	103	65	46	57	216	174	103	30	142	68	136	92	117	126	138	135	156	181
Outside +/- 0.15 Hz band	292	319	278	325	313	331	491	243	281	314	394	434	336	450	416	470	528	698	591	828	1041	462	892	1730	1273	791	1020	715	1295	785	634	1054	1031	1124	1013	796	768

Figure 4 Mainland – Number of frequency band exceedances outside NOFB for more than five minutes

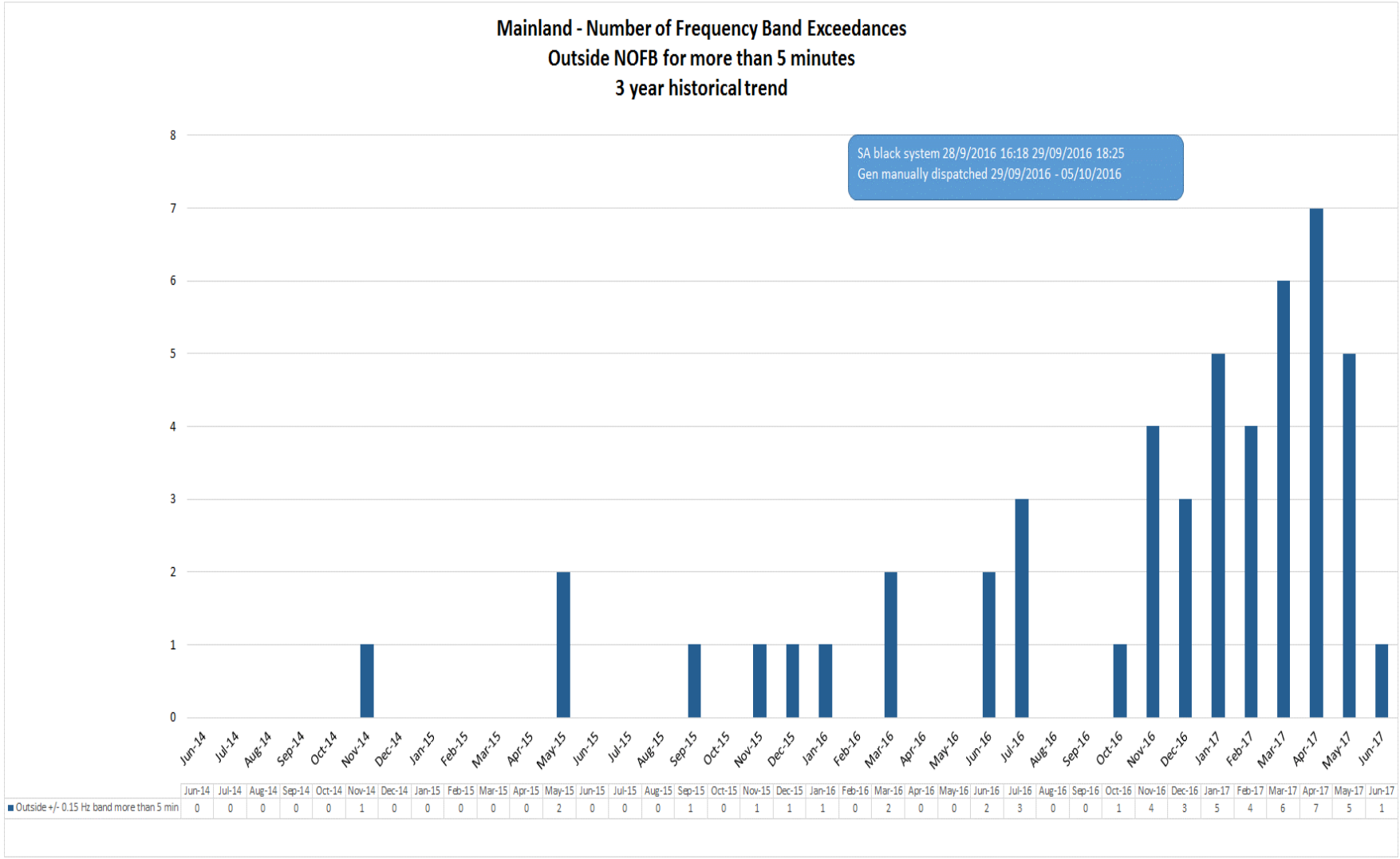
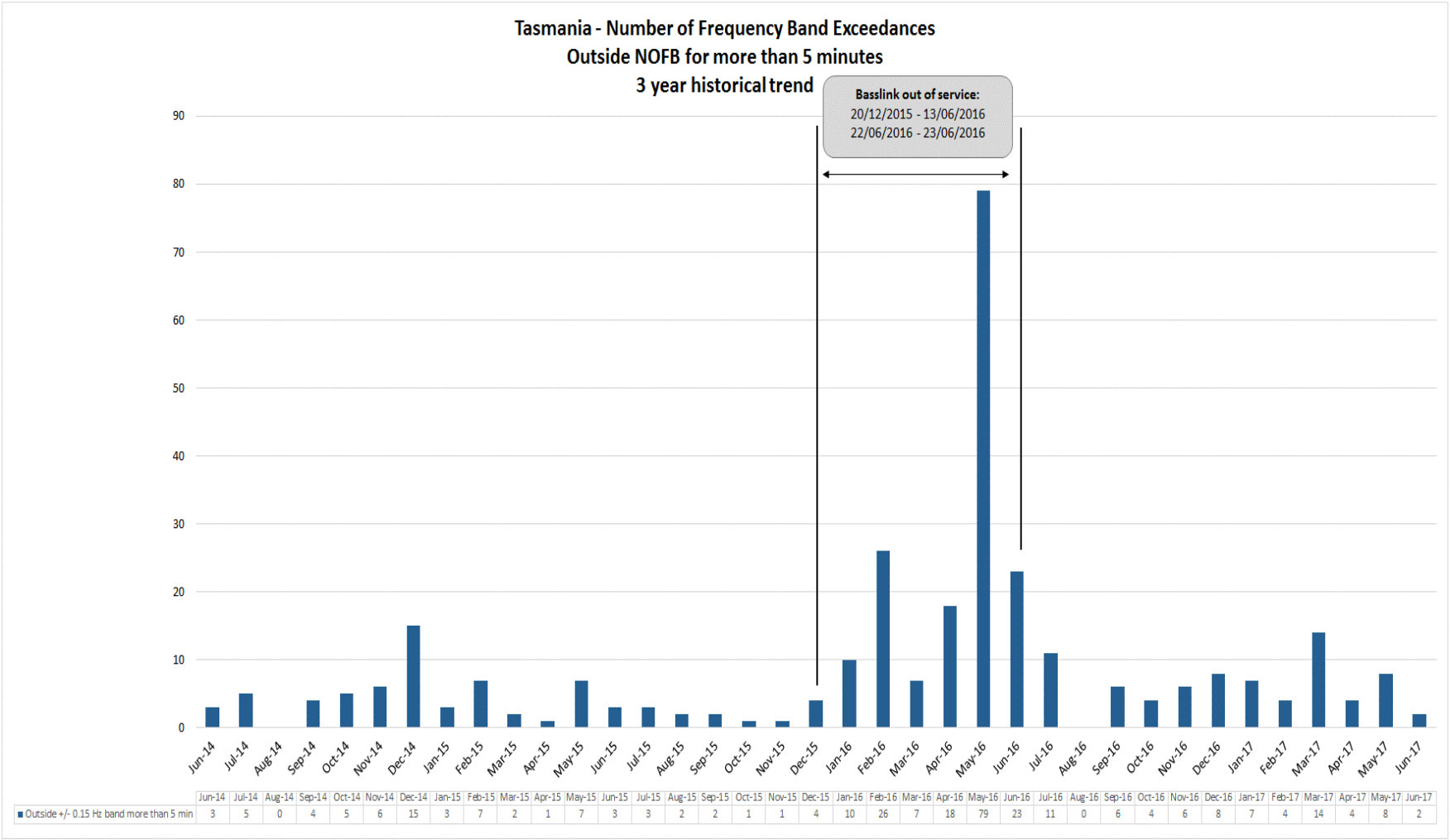


Figure 5 Tasmania – Number of frequency band exceedances outside NOFB for more than five minutes



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Outside +/- 0.15 Hz band more than 5 min	3	5	0	4	5	6	15	3	7	2	1	7	3	3	2	2	1	1	4	10	26	7	18	79	23	11	0	6	4	6	8	7	4	14	4	8	2