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## Feeder Reliability Investment Case

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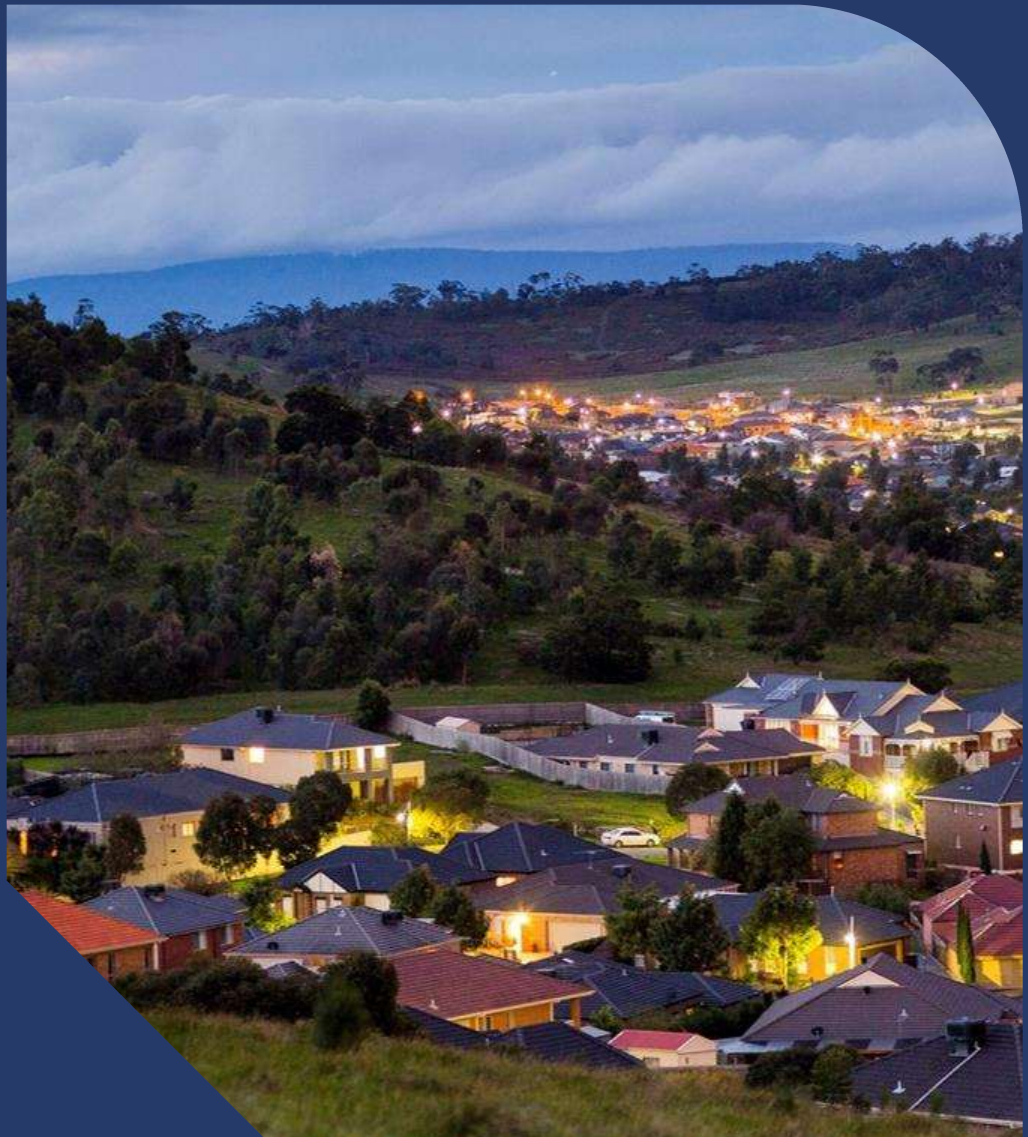
Business case: Reliability Program – MSD1

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# 1. Introduction

## 1.1. Background

The document outlines a business case for intervention investments as they relate to improving the reliability and resilience of Mansfield distribution feeder MSD1.

This business case outlines the following processes:

- **Analysed data to forecast risk:** Utilising historical network reliability and asset data to outline the current exposure risk associated with the investigated feeder.
- **Assessed various options:** Analysing potential investment factoring in cost and benefit, and comparing them against the status-quo / do-nothing options.
- **Identified the preferred option:** Costs and benefits from above were converted into cashflow streams to allow the Net Present Value (NPV) to be calculated. We have selected the preferred option based on the option that is able to deliver the highest NPV of all the options assessed, across all sensitivity scenarios.

## 1.2. Feeder Summary

The following table gives a summary into the feeder:

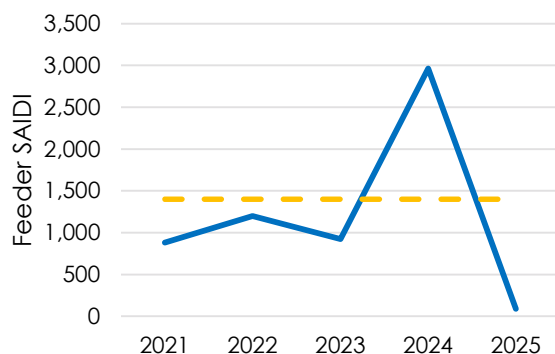
**Table 1: Feeder MSD1 Summary**

Feeder Name	MSD1			
Feeder Type	Rural Long			
Feeder Zone Substation	Mansfield			
Length of Line	Total	364.7km		
	OH	361.2km (99%)	UG	3.5km (0.1%)
Number of Customers	2206			
Number of Life Support Customers	38			
Number of Automated Protection Devices	Total 22kV Auto Reclosers	3	Total 12.7kV SWER ACRs	8
	Total FuseSavers	1		
Number of Gas Switches	Total	9	Automated (Sectionalisers)	4 (44%)
Tie points	Total	5	Automated	2 (40%)

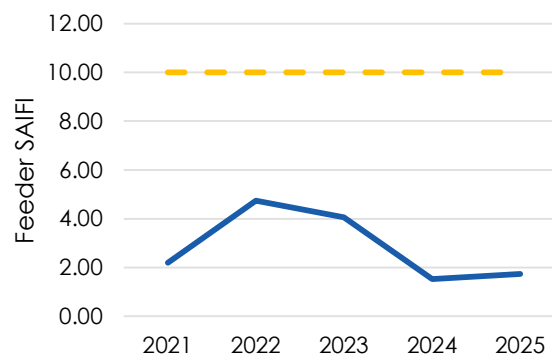
# 1.3. Feeder Reliability Summary

The following graphs show a rolling 12-month reliability summary for both frequency (SAIFI) and duration (SAIDI) of normalised unplanned sustained outages. This performance is compared against a performance threshold<sup>1</sup>.

**Feeder SAIDI**



**Feeder SAIFI**



As it can be seen from the above graphs, this feeder became poor performing during 2024 due to the major event day on 13<sup>th</sup> February which spanned over two days affecting the whole feeder. This event contributed 2395 to the feeder SAIDI. Excluding this event in 2024 would bring the feeder SAIDI down to 569, which is well below the limit for a long rural feeder. The feeder has been performing well against SAIFI during this time.

## 1.3.1. Cause Summary

Table 2 compares average historical sustained outage performance against the last 12 months.

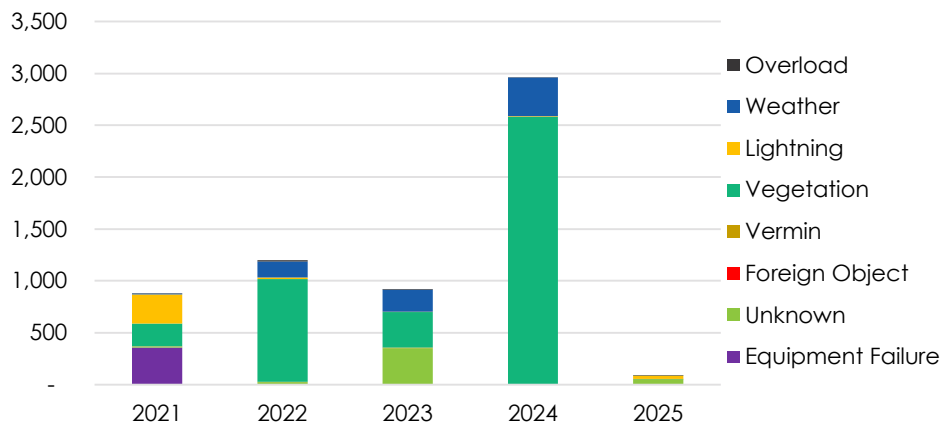
**Table 2: Cause type summary**

Cause Type	Quantity			Feeder CMOS			Average Contribution per event (Av CMOS / Av No Incidents)
	Avg p.a. (FY21-25)	Last 12 months	% of average	Avg p.a. (FY21-25)	Last 12 months	% of average	
Animal	4.8	2	42%	7,323	2,478	34%	1,526
Asset failure	4.8	11	229%	159,699	2,496	2%	33,271
Foreign Object	0.6	0	0%	58,563	0	0%	97,605
Lightning	6	4	67%	147,045	71,972	49%	24,508
Other	0.2	0	0%	364	0	0%	1,819
Overload	2.8	4	143%	51,463	5,875	11%	18,380
Unknown	5.4	6	111%	219,796	113,377	52%	40,703
Vegetation	4	3	75%	1,822,775	403,374	22%	455,694
Weather	5.6	5	89%	333,619	653,541	196%	59,575
Third Party	0.6	0	0%	71	0	0%	118
Corrosion	0.2	0	0%	57	0	0%	286
<b>Total</b>	<b>35</b>	<b>35</b>	<b>100%</b>	<b>2,800,775</b>	<b>1,253,113</b>	<b>45%</b>	

<sup>1</sup> As there are currently no published individual feeder thresholds for Victoria, the published NSW thresholds have been used for Short Rural, Urban and Long Rural Metrics.

As it can be seen from the above table, the feeder experiences an average of 35 sustained interruptions per year, with an average contribution of 2.8 million customer minutes. The predominate causes of incidents on this feeder are:

- **Vegetation**
  - attributing 65% of total CMOS and 11% of the number of sustained incidents.
  - The most common vegetation in this region are native Australian eucalyptus and mountain ash species. The radial section of MSD1 feeder travels through mountainous and hilly terrain, and heavily forested bushland.
  - Looking at historical outages, the highest impact is to customers in the radial section of the feeder downstream of MS034 sectionaliser and MS006 ACR. The highest impact faults have been due to falling vegetation damaging the HV conductors.
  - From arborist reports on failures in this section over the past 5 years, this section has experienced: 7 root ball failures, 1 poor structure (rotten tree) and 1 dead tree
  - Over 75% of these trees were located 16m or further from the conductors before failure.
- **Adverse weather** – contributing 12% of the CMOS and 16% of the number of sustained incidents.



**Figure 1 – Feeder performance due to cause**

### 1.3.2. Major Event Day Summary

The following gives a break down on the number and size of the major event days which have impacted this feeder.

**Table 3 – Recorded Major Event Days**

Date	Major Event Day Cause	Number of Customers Interrupted	Percentage of Customers on Feeder Affected	Total CMOS	Average customer outage duration mins (CMOS / No of Customers Interrupted)
29-Oct-21	Major Storm	27	1%	22,067	817
19-Dec-21	Major Storm	2,215	100%	601,205	271
21-Nov-22	Major Storm	952	43%	588,715	618
02-Jan-24	Major Storm	109	5%	157,127	1442
13-Feb-24	Major Storm	2,266	100%	5,303,137	2340
02-Sep-24	Major Storm	242	11%	223,366	923
<b>Total</b>		<b>5,811</b>		<b>6,895,617</b>	<b>6411</b>

The most significant impact to MSD1 was the Major Event Day on 13<sup>th</sup> Feb 2024. The contribution to feeder SAIDI from this event alone was 2395. On this day:

- the MSD1 feeder CB tripped to lockout.
- Given the high number of faults in the area, each section needed to be patrolled before it could be restored.
- The patrol crews were reassigned to higher priority faults elsewhere and so it was 20 hours before the first section of MSD1 feeder was restored. Remaining sections were patrolled and repaired progressively. The remaining customers were restored on 15<sup>th</sup> Feb at 21:05. This was two days and 6 hours after the initial interruption.

As it can be seen from the above table, this feeder is affected regularly by major storm events, averaging 1.2 events per year, where on average 969 customers are affected with customers experiencing an average 1069 minutes (17.8 hour) outage each instance.

It is likely that the impact to the feeder on Major Event Days depends on whether the storm is localised to this particular region or elsewhere across the network.

Analysis of sustained incidents indicates that MSD1 feeder is more likely to be impacted during localised weather events of lightning, strong winds and heavy rainfall.

### 1.3.3. Overall Feeder Summary

The MSD1 22kV feeder supplies 2206 customers and is classified as a Rural Long feeder. It is one of three 22kV feeders supplied by the Mansfield Zone Substation. Mansfield is located approximately 180km north-east of Melbourne and the region is part of Victoria's high country.

The feeder is 365km long and is predominantly constructed with bare overhead conductors (99%).

MSD1 feeder supplies the areas to the east and south of the town of Mansfield. To the east it supplies the area between Mansfield and Merrijig, and to the south it supplies the towns all the way down to Woods Point. Woods Point is over 90km south of Mansfield with a travel time by car of over 90 mins. The section of the feeder from south of the Mansfield Airport down to Woods Point is radial and supplies 69% of the MSD1 customers.

These areas include historic gold mining towns, mountainous and hilly terrain, and heavily forested bushland. The most common vegetation in this region are native Australian eucalyptus and mountain ash species.

MSD1 feeder has remote-controlled ties to MSD4 and MJG11 feeders, however the sections of the feeder downstream of MS005 ACR are radial. These locations are remotely located, with no adjacent feeders in the nearby vicinity able to provide support.

## 2. Investment Analysis

### 2.1. No Proactive Interventions

With no proactive intervention, the business as usual (BAU) reliability risk costs are detailed in Table 4 and Table 5. Reliability risk costs are calculated using the Values of Customer Reliability (VCR) and an average of Customer Minutes Off Supply (CMOS) per annum across 5 years of historical interruptions.

**Table 4: Summary of risk by cause type**

Cause Types	Avg CMOS p.a. (between FY20 & FY25)	Reliability risk cost p.a. (between FY20 & FY25)
Animal	7,323	\$ 3,875
Asset failure	159,699	\$ 84,510
Foreign Object	58,563	\$ 30,990
Lightning	147,045	\$ 77,814
Other	364	\$ 193
Overload	51,463	\$ 27,233
Unknown	219,796	\$ 116,312
Vegetation	1,822,775	\$ 964,578
Weather	333,619	\$ 176,545
Third party	71	\$ 38
Corrosion	57.2	\$ 30
	<b>2,800,775</b>	<b>\$ 1,482,117</b>

**Table 5: BAU risk cost summary**

	Total risk cost p.a.	PV20 of baseline risk
BAU reliability risk cost	\$1,482,117	\$19,106,143

## 2.2. Potential and Recommended Interventions

The following sections detail the potential investment options considered categorised in the three investment areas: Operational actions, network options and non-network options.

### 2.2.1. Operational Actions

There are currently no outstanding defects listed on the MSD1 22kV feeder and so there are no operational actions identified to improve the reliability.

### 2.2.2. Network Options

Table 6 outlines identified network options.

Consideration has been given to determine whether there are any feeder reconfigurations that could improve the reliability by permanently transferring some of the customers away from this feeder, however no beneficial reconfigurations have been identified. In terms of sustained outages, sections of the backbone close to MSD1 CB generally have good reliability. It is the radial sections downstream of MS005 ACR that experience the highest impact faults. 69% of the customers are in these sections.

**Table 6: Network options assessment**

Identified Options	Investigation assessment	Option credibility
<b>1. Install a new Remote Controlled Sectionalizer at pole 3917795</b>	<p>There are 742 customers located in the section between MS034 and MS006, and a further 199 customers downstream of MS006 that experience a long duration outage when the HV backbone conductors are damaged in this section.</p> <p>The installation of a remote controlled sectionaliser at the proposed location would save 340 customers from a sustained outage for any faults downstream of the new sectionaliser.</p> <p>While the installation of a new remote-controlled sectionaliser won't resolve vegetation problems, it will reduce the number of customers impacted for faults downstream. Looking at historical outages, the towns of Macs Cove and Howqua Inlet would have remained on supply if there had been an additional remote-controlled sectionaliser.</p>	Credible
<b>2. Targeted Removal of Hazardous Trees in Radial Locations</b>	<p>1. Survey/review ex MS034 sectionaliser to identify hazardous trees posing a high risk.</p> <p>2. Targeted removal of highest priority hazardous trees.</p>	Credible
<b>3. New covered conductor section to bypass Howqua Inlet and provide an alternate path to continue supply down to MS006, including new R/C switches</b>	<p>This option is to run a new section of HV covered conductor from a span near Jamieson 180 substation over to Trails 2 substation. This could provide an option to create a loop to create an alternate path to restore supply to MS006 and beyond in the event of a sustained outage in the Howqua Inlet area.</p> <p>This has been deemed Not Credible due to the high cost for little benefit. It has a benefit to cost ratio of 0.128.</p>	Not Credible
<b>4. Relocate problem spans underground</b>	In the past 5 years there has been a particular section (between poles 3917825-3917827) that has experienced	Not Credible



Identified Options	Investigation assessment	Option credibility
	<p>damage due to falling trees, resulting in conductor breakage, requiring repairs to the conductor on 3 separate occasions.</p> <p>The option to move these 4 spans to underground cable has been deemed not credible as it has a benefit to cost ratio of 0.152.</p>	
<b>5. Upgrade existing Manual Gas Switch 821236 to a Remote Controlled Sectionalizer.</b>	<p>There is an existing Manual Gas Switch located in the section between MS034 and MS006, this could be upgraded to a Remote Control Sectionalizer.</p> <p>This option has been deemed not-credible, as it will be a similar cost to Option 1 that has been identified, but will provide less benefit. A sectionaliser in this location would only save 200 customers (including Macs Cove) from a sustained outage for faults downstream and would not provide any benefit to the 140 customers in Howqua Inlet and surrounds.</p>	Not Credible

### 2.2.3. Non-Network Options

Table 7 outlines identified non-network options.

**Table 7: Non-network option assessment**

Identified Options	Investigation assessment	Option credibility
<b>Grid Connected Backup Generation</b>	<p>There is currently a temporary HV Generator connection site located at pole 3915296 (near BN18922GF).</p> <p>This site could be used as required for long term emergency outages or planned work but would take 24-48 hours to mobilise.</p> <p>This is part of the BAU management of this feeder when long duration outages are expected. No additional investment has been considered.</p>	Not credible

## 2.2.4. Economic Evaluation

Table 8 details the credible network investments identified in this investigation, their cost and residual reliability risk if implemented.

**Table 8: Investment summary**

Option	Investment details	Estimated OPEX Cost (\$)	Estimated CAPEX Cost (\$)	PV <sub>20</sub> of residual risk
1	Install a new Remote Controlled Sectionaliser at pole 3917795	CIC	CIC	\$17.49M
2	Targeted Removal of Hazardous Trees in Radial Locations	CIC	CIC	\$17.93M
1&2	Install a new Remote Controlled Sectionaliser at pole 3917795 Targeted Removal of Hazardous Trees in Radial Locations	CIC	CIC	\$17.19M
3	New loop to bypass Howqua Inlet	CIC	CIC	\$16.25M
4	Underground 3 spans between poles 3917824 to 3917827	CIC	CIC	\$15.95M

Table 9 summarises the cost-benefit assessments for proposed investments as compared to the BAU case using net present value (NPV) calculations over a 20-year assessment period.

**Table 9: Economic evaluation summary**

Option	Residual risk cost	PV of benefits	PV of investment	NPV	BCR	Rank	Comments
BAU	\$19.11M	-	-	-	-		BAU – Does not capture benefits
1	\$17.49M	\$1.6M	\$0.13M	\$1.49M	1.060	2	
2	\$17.93M	\$1.2M	\$0.08M	\$1.10M	1.142	1	
1&2 combined	\$17.19M	\$1.9M	\$0.21M	\$1.71M	0.751	3	
3	\$16.25M	\$2.9M	\$1.85M	\$1.01M	0.128	4	
4	\$15.95M	\$3.2M	\$1.72M	\$1.44M	0.152	5	

The proposed investment cost of \$80k is economically viable, with a positive NPV of \$1.10M and BCR of 1.142 over a 20-year assessment period.

### 2.2.5. Preferred Option Details

The preferred investment is Option 2 in which there is a survey and targeted removal of Hazardous trees in radial locations.

A summary of the CMOS, feeder SAIDI and risk costs for the residual and benefit of the preferred investment is detailed in Table 10.

**Table 10: Residual risk and annualised benefit summary**

	Baseline p.a.	Outcome p.a.	Annualised Benefit
<b>CMOS</b>	2,800,775	2,628,161	6% Reduction
<b>Customers Interrupted</b>	6988	6751	3% Reduction
<b>Reliability Risk Cost</b>	\$1,482,117	\$1,390,772	\$91,344

A targeted removal of hazardous trees will provide an approximate 6% improvement in reliability for the customers on this feeder.

### 2.2.6. Sensitivity Analysis

Option 2 provides an optimal solution by conducting a targeted removal of hazardous trees on radial sections of the feeder. The sensitivity on this solution is also favourable with a positive Net Present Value in all cases as indicated in Table 11.

**Table 11: Net Present Value (\$m, 2025 dollars)**

	Central assumptions	Higher WACC	10% increase in capex	Comments
<b>Do nothing</b>	-	-	-	
<b>Option 1 – Install a new Remote Controlled Sectionalizer at pole 3917795</b>	\$1.49M	\$1.33M	\$1.48M	
<b>Option 2 – Targeted Removal of Hazardous Trees in Radial Locations</b>	\$1.10M	\$0.98M	\$1.09M	The preferred Option 2 remains positive under all scenarios.

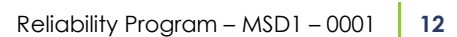
### 2.2.7. Proposed Investment Timing

The proposed Option 2 is recommended to be completed by 1<sup>st</sup> October 2028.

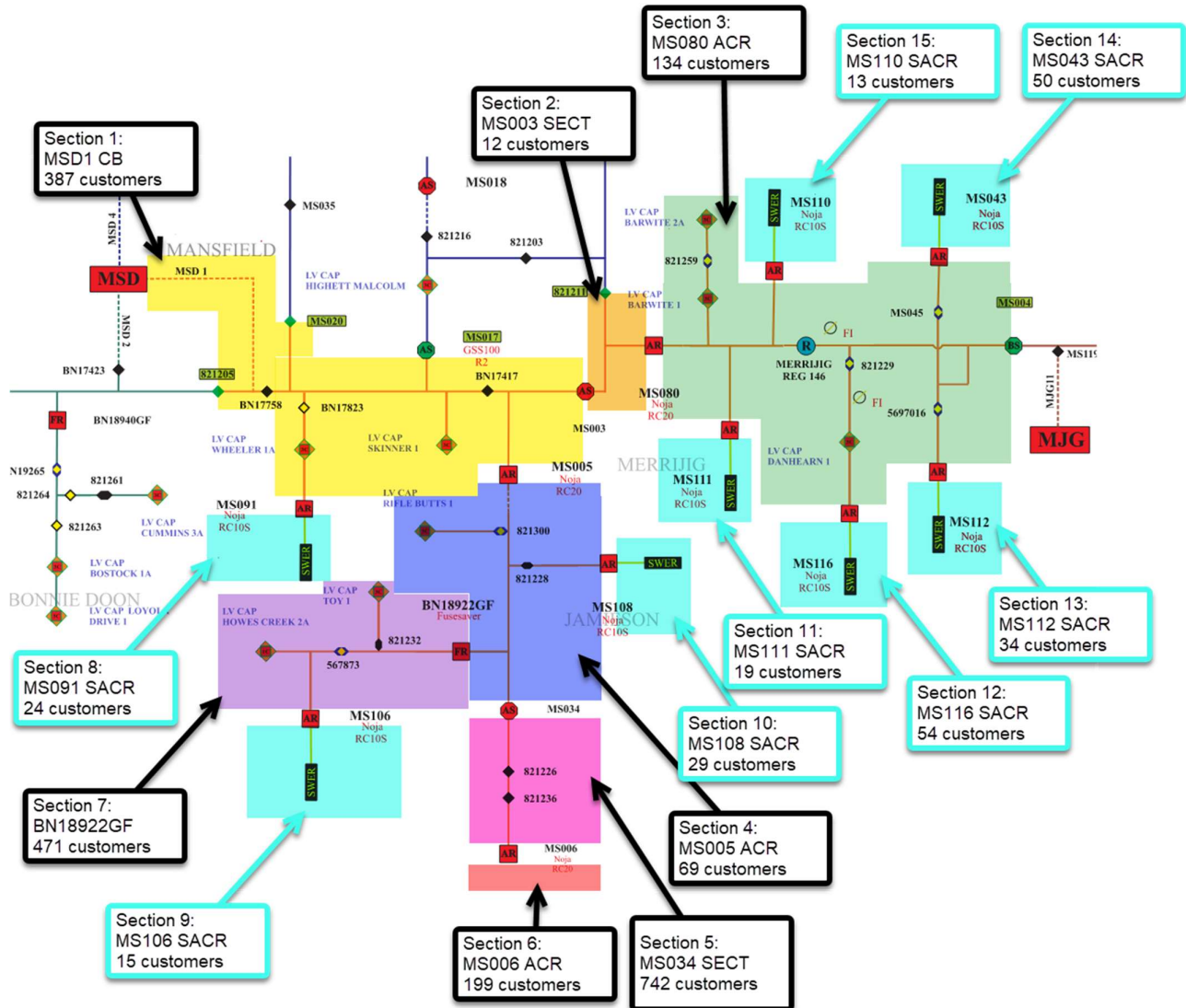
### 3. Investment Recommendation

To improve the reliability performance of MSD1 22kV feeder, it is recommended that the following project is included within the current Reliability Works Program.

- **Network Options**
  - Targeted removal of Hazardous trees in radial sections: CIC



## Single Line Diagram showing Remote Controlled Sections





## 4.2. Geographic Location of Feeder

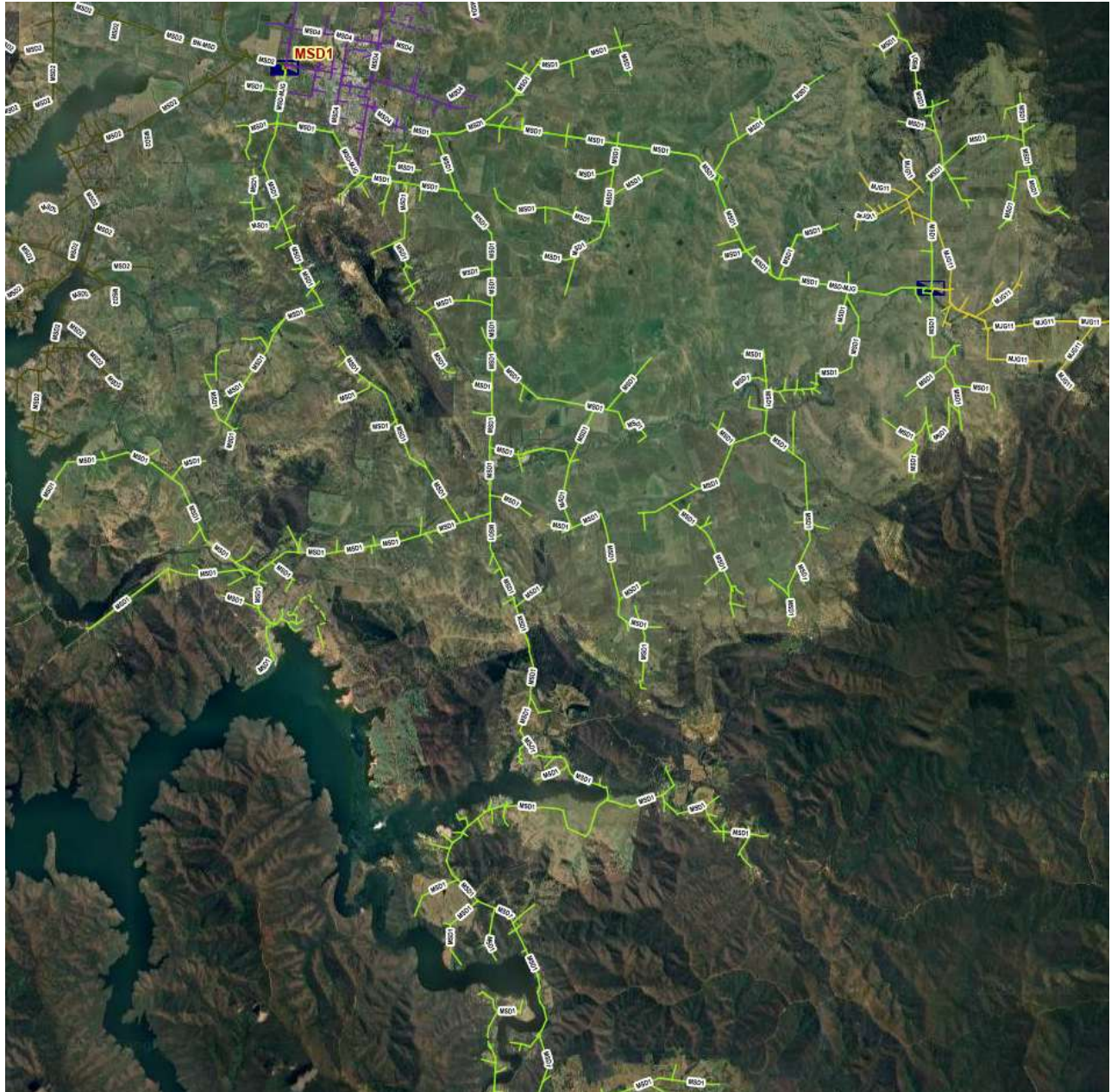


Figure 2a: Map view of the MSD1 feeder (continued on next page)



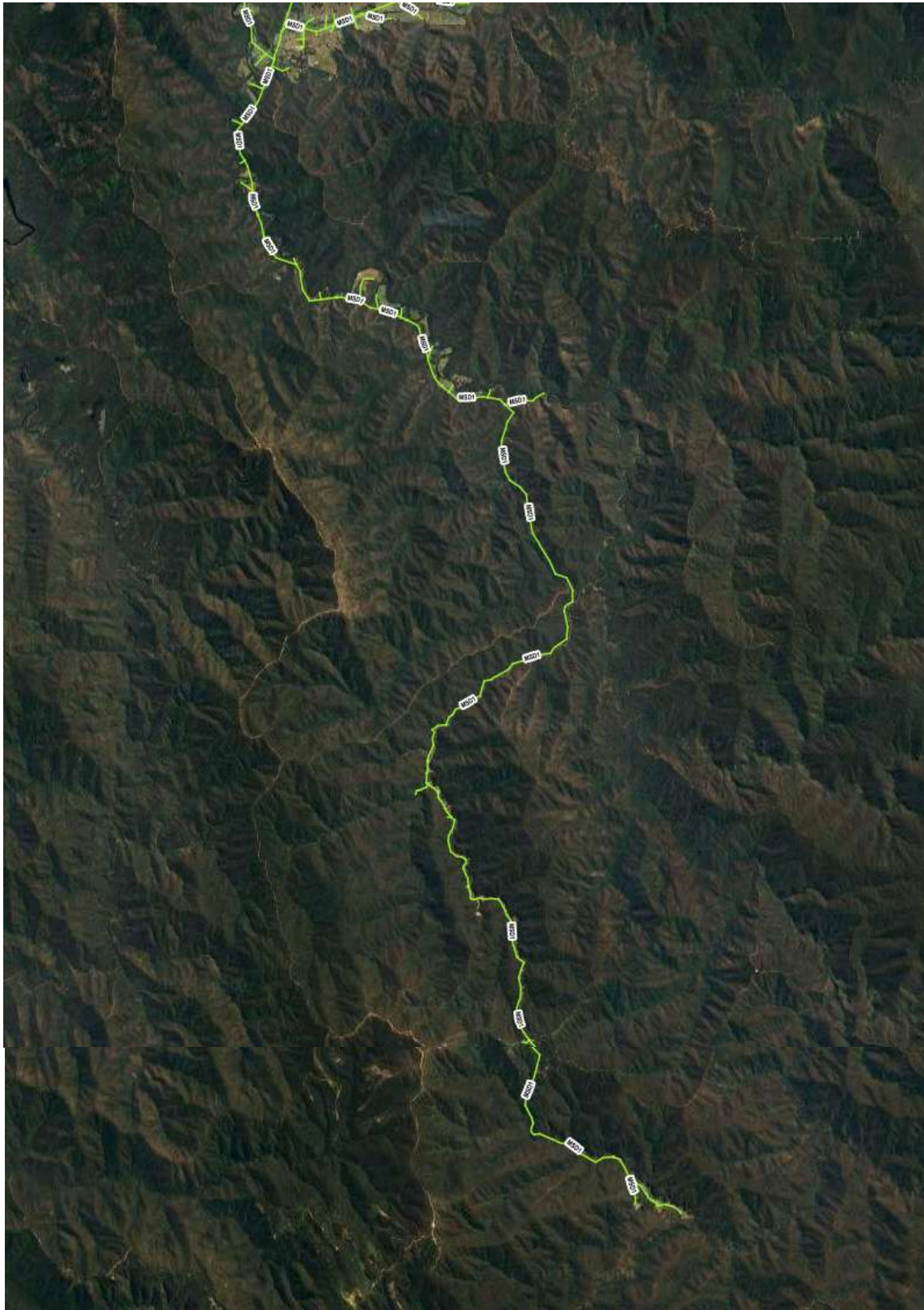
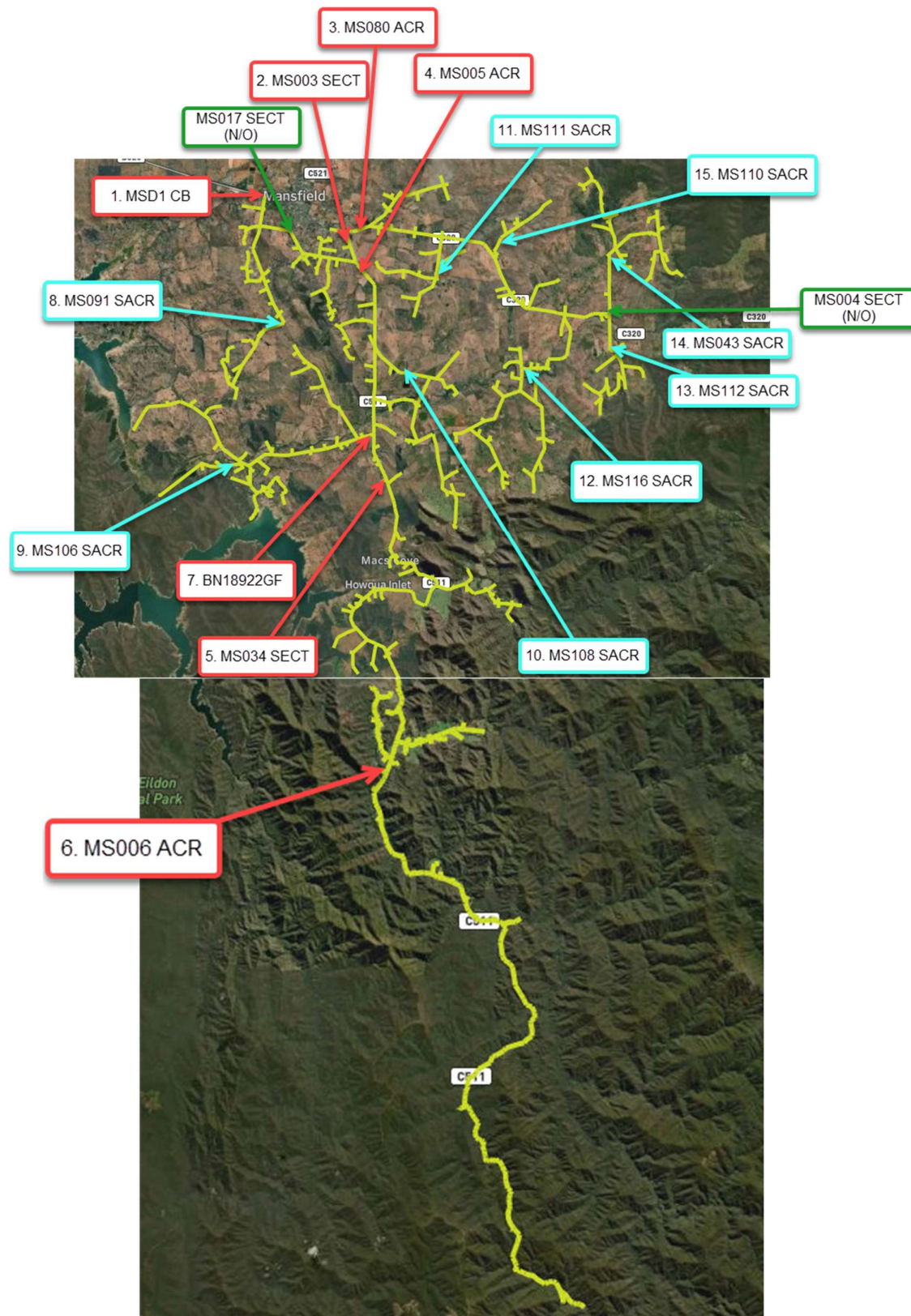


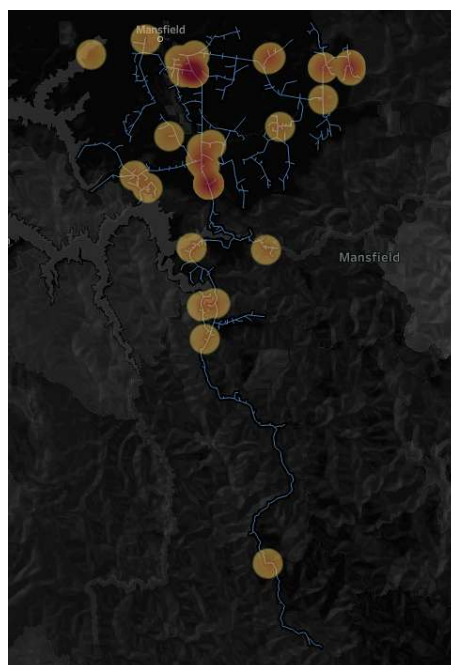
Figure 3b: Map view of the MSD1 feeder (continuation from previous page)



## Geographic Location of the Feeder showing Remote Controlled Switch Locations

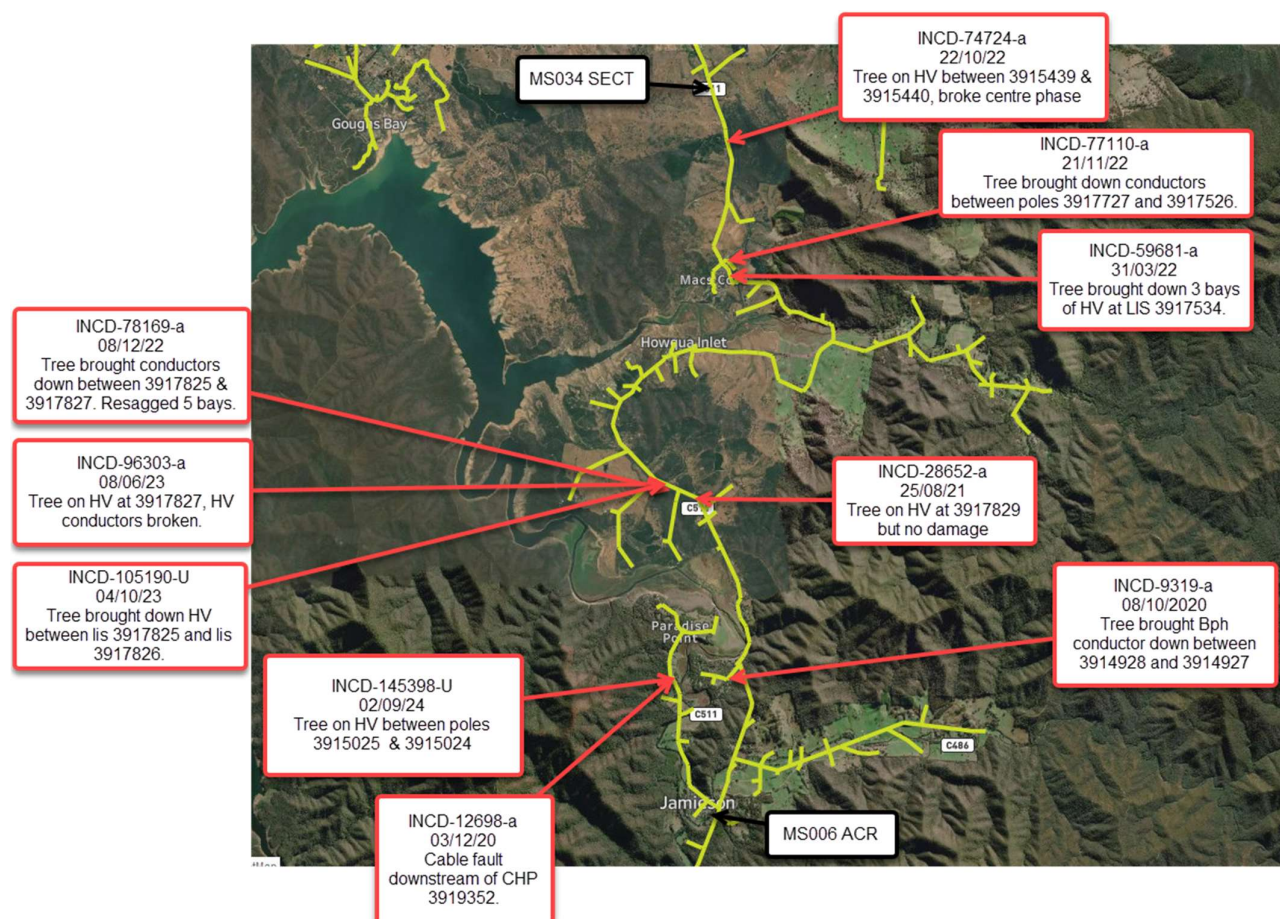


## 4.3. Heat Map of Outages



**Figure 4 - FY21-25 Heat Map**

The heat map above assigns some of the fault locations to the device that opened. The following shows more detailed fault locations for vegetation faults in the radial section between MS034 to MS006.



## 4.4. Outage Summary

Table below only shows incidents where the outage was sustained and caused a Feeder CB or Recloser to trip.

Those coloured in green were attributed to vegetation (some of these were recorded in the incident as 'foreign object' or 'weather'.)

Date	Incident Number	Cause	CMOS	SAIDI Contribution	Customer Count	Sustained?	Commentary
17/07/2020	INCD-2095-a	Unknown	2,001	0.91	15	YES	Repairs to earth. Issue found during site testing.
08/10/2020	INCD-9319-a	Foreign Object	218,568	99.08	913	YES	Tree brought blue phase conductor down between 3914928 and 3914927. Eucalyptus has failed 17 metre to the side of the conductors from root failure. Ground conditions are quite wet, so weight of tree has allowed the tree to fail coming into contact with one phase bringing it to the ground.
14/11/2020	INCD-11228-a	Animal	2,328	1.06	53	YES	Blown iso fuse. Magpie found.
03/05/2021	INCD-21522-a	Unknown	705	0.32	47	YES	Protection -did not reclose
27/07/2021	INCD-27398-a	Equipment Failure	785,952	356.28	1470	YES	Burnt out D & live line clamp at pole 3915454.
25/08/2021	INCD-28652-a	Vegetation	428,171	194.09	912	YES	Tree on HV at 3917829 but no damage to conductors. Large Eucalyptus Viminalis has failed at the roots coming into contact with the conductors. The soil conditions were quite wet. The wind at the time of failure was quite strong and gusty.
31/03/2022	INCD-59681-a	Weather	306,693	139.03	921	YES	Tree brought down 3 bays of HV at LIS 3917534. Large rotten eucalyptus failed in strong wind bringing conductors to ground.
11/06/2022	INCD-65299-a	Unknown	6,124	2.78	49	YES	Protection setting issue.
22/10/2022	INCD-74724-a	Vegetation	467,125	211.75	925	YES	Tree on HV between 3915439 & 3915440, broke centre phase. Pinus Radiata has failed at the root plate coming into contact with the conductors. Very wet soils.



Date	Incident Number	Cause	CMOS	SAIDI Contribution	Customer Count	Sustained?	Commentary
21/11/2022	INCD-77110-a	Vegetation	558,151	253.01	906	YES	MED. Tree brought down conductors between 3917727 and 3917526. Root ball failure causing tree to fail and come into contact with conductors.
08/12/2022	INCD-78169-a	Vegetation	1,009,175	457.47	925	YES	Tree brought conductors down between 3917825 & 3917827. Eucalypt. Root ball unstable.
08/06/2023	INCD-96303-a	Vegetation	581,326	263.52	1486	YES	Tree brought conductors down at 3917827. Euc above line height has failed coming into contact with conductors, stay wire and pole. More than 1 day of heavy rain and strong wind. There are other hazard trees in the span, need to work out how to get them into system.
08/06/2023	INCD-96336-a	Unknown	253,561	114.94	338	YES	Failed transformer JAMIESON 210E
15/09/2023	INCD-100809-V	Unknown	97,734	44.3	1491	YES	Location was ex fuse 821223. No longer exists -is now BN18922GF. Unplanned emergency outage to straighten a leaning pole.
04/10/2023	INCD-105190-U	Weather	462,000	209.43	924	YES	Tree brought down HV between poles 3917825 and 3917826. Eucalypt on upside of very steep shaley bank has failed at root ball. There are more trees to be actioned in the span.
15/01/2024	INCD-118022-U	Lightning	1,575	0.71	15	YES	1 fuse blown at ISO Transformer 822405.
13/02/2024	INCD-121279-U	Vegetation	5,277,621	2392.39	2201	YES	MED. Significant activity across the network due to a Major Storm. Impacted the entire MSD1 feeder. Multiple faults, was over two days before the feeder was restored.

Date	Incident Number	Cause	CMOS	SAIDI Contribution	Customer Count	Sustained?	Commentary
25/08/2024	INCD-142739-U	Weather	648,720	294.07	477	YES	GSL MED 3 bays HV conductor down and 2 poles snapped between 3915275 & 3915278.
18/12/2024	INCD-155490-U	Vegetation	175,660	79.63	191	YES	Dead Mountain ash failed 3-4 meters above the ground, the dead tree was located approximately 30 meters from line up a steep incline.
18/03/2025	INCD-162984-U	Unknown	112,149	50.84	2216	YES	MS080 ACR tripped. Patrol required. Found faulty transformer at pole 3915615 WINERY ss.
26/03/2025	INCD-114149-V	Lightning	70,453	31.94	1499	YES	Replaced surge diverter at CHP 3914954. (Close to MS005)

## 4.5. Assumptions

The following assumptions have been taken:

- WACC: 5.56
- PV Period: 20 years
- Historical Risk Period: 5 years (1/7/2020-1/07/2025)
- Sensitivity Analysis: Higher WACC = 7.00; Increase in CapEx = 10%
- Estimated on-going annual OPEX cost for new equipment: 0.5% of CAPEX

### Unit Costs:

Item	Value	Units
ACRs/Sectionalisers	CIC	\$ per unit
MV Switches - Ground/Indoor	CIC	\$ per unit
Covered Conductor ("Bare conductor condition/risk-based replacement (Codified Areas)")	CIC	\$ per km
Cables	CIC	\$ per km
Vegetation removal (2 hazard tree removals or multi tree trim)	CIC	\$ per span

### Unit cost assumptions:

- That a three switch Ring Main Unit is 3x 'MV Switches - Ground/Indoor'
- That 'Covered Conductor' and 'Cables' is the cost per phase per km

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