Flood Resilience of High Voltage Overhead Conductors and Switchgear

Case for investment FY23-FY29
August 2022

Investment Title	**Flood event HV network resilience improvement**
<< project # / code >>	
Portfolio	Repex
CFI Date	31/10/2022
Pre RIT-D	☐
Final CFI	☒
Other	☐

Version control and endorsements

Version	Date	Comments
0.1	24 August 2022	Initial draft
0.2	16 September 2022	Issued for review
0.3	27 October 2022	Issued for approval

Contents

1. Executive summary

This case for investment (CFI) recommends investment in the reconstruction of high voltage (HV) and transmission overhead conductor spans identified as being at risk of flood impact, as well as the installation of automated switches across the network during the period of FY23 – FY29. These investments will improve network resilience by addressing the reliability risks associated with these assets being affected by flood events.

Communities serviced by Endeavour Energy have experienced three significant flood events in the 16 months from March 2021 to July 2022. The main impact of these floods has been on the Hawkesbury-Nepean river system, with communities experiencing an average electricity supply interruption of 22,945,770 customer minutes.

Flood events on the Hawkesbury-Nepean river system classified as “major” (above 12.2m at Windsor Bridge) have historically occurred once every 10 years, with more severe floods of the magnitude recorded in March 2022 (13.7m) and July 2022 (13.9m) occurring on average once every 20 years. Climate modelling provided to Endeavour Energy in August 2022 indicates that future flood events can be expected to remain similar to the past or slightly increase in frequency and severity.

To mitigate the public safety risk, Endeavour Energy will de-energise powerlines over flooded areas as the flood water levels approach minimum safe clearance distances to HV assets, or when rising flood waters risk cutting access to HV switchgear. This can result in a secondary public safety risk as communities are left without power, which may impact communication, life support equipment, food storage, and other essential services.

There are two focus areas which will minimise customer disruption during flood events:

1) Increasing the height of HV overhead conductors above the 1-in-50 year flood level (Distribution) and 1-in-100 year flood level (Transmission) will increase electrical network resilience to the increasingly severe major flood events.
2) Upgrading HV switches will enable isolation to be delayed until flood waters reach critical levels, rather than needing pre-emptive intervention.

This CFI recommends investment to improve 26 HV Distribution overhead feeders with spans identified as being at risk from a 1-in-50 year flood event and 7 Transmission overhead feeders with spans identified as being at risk from a 1-in-100 year flood event, along with the installation of 32 automated HV switches to improve network operability. This option provides a benefit of $88.2 million compared to the counterfactual case and the NPV overall is $81.0 million. Performing sensitivity analysis, and under a low benefit, high cost scenario, this option remains NPV positive.

The total cost of these works is estimated to be $7.2 million and it is recommended that the program be approved for consideration in the FY23-29 Portfolio Investment Plan (PIP) for optimisation.

2. Purpose

The purpose of this CFI is to seek endorsement of investment to manage the risks to the HV Distribution and Transmission network posed by flooding in the Hawkesbury / Nepean catchment.

Widespread flood events centred on the Hawkesbury and Nepean rivers cause significant electricity supply interruption as network assets are at risk of impact from flood water and debris or are made inaccessible by flood water.

This investment will ensure the electrical network is more resilient to climate change and the risk of increasing frequency and severity of flood events.

This CFI recommends proactive intervention for the reconstruction to raise specific spans of overhead conductors as well as the replacement of HV switches with automated units during the FY23 – FY29 period.

3. Identified needs and/or opportunities

3.1 Background

Communities serviced by Endeavour Energy have experienced three significant flood events in the 16 months from March 2021 to July 2022. The main impact of these floods have been on the Hawkesbury-Nepean river system, with communities experiencing an average electricity supply interruption of 22,945,770 customer minutes.

Flood events on the Hawkesbury-Nepean river system classified as “major” (above 12.2m at Windsor Bridge) have historically occurred once every 10 years, with more severe floods of the magnitude recorded in March 2022 (13.7m) and July 2022 (13.9m) occurring on average once every 20 years (see Figure 1 below).

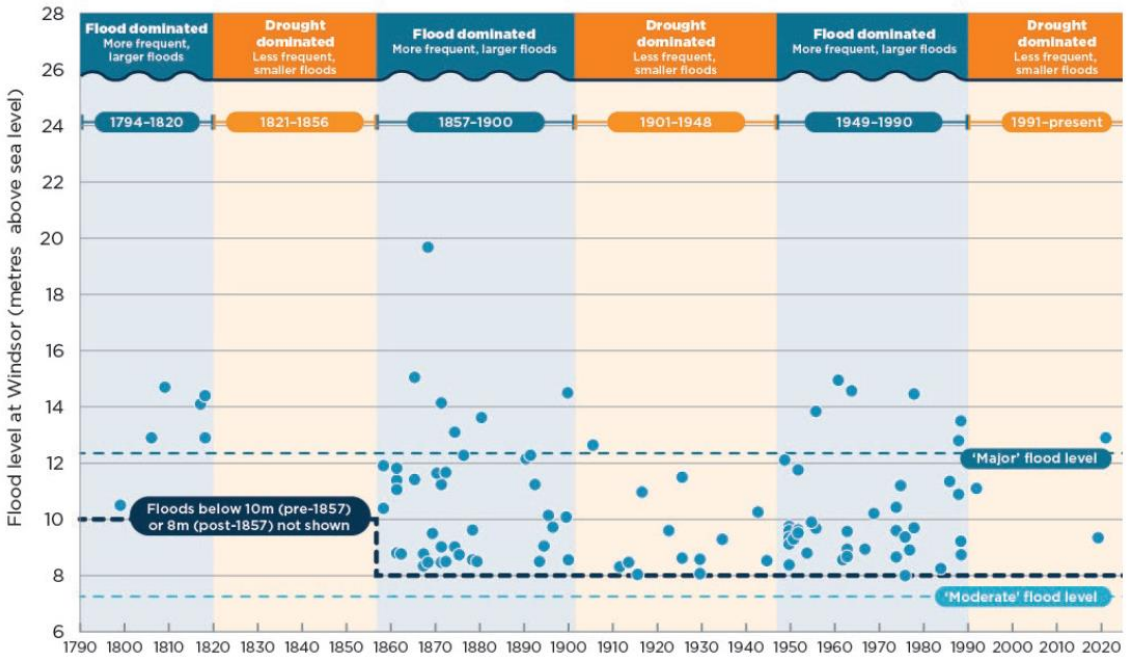


Figure 1: Flood history, Hawkesbury River at Windsor, 1794-2021[1]

[1] Hawkesbury-Nepean River March 2021 Flood Review, December 2021(Infrastructure NSW)

Climate modelling provided to Endeavour Energy in August 2022 indicates that wettest day rainfall in the Hawkesbury region will change by -2% by 2050 and +3.5% by 2090 under a moderate emissions scenario. More significant changes of +10.5% by 2050 and +29.6% by 2090 under a high emissions scenario are forecast.

Based on this advice, future flood events can be expected to remain similar to the past or increase in frequency and severity.

When compared with other climate related hazards such as bushfires and high winds, the location and severity of flooding is generally more predictable. This enables mitigation actions to be reliably taken in advance to ensure safety and protect assets in response to rising flood waters and short-term weather forecasts.

3.2 Risks and identified need

3.2.1 Overhead conductors

The primary risks associated with overhead conductors over water ways during major flood events result from the clearance to live conductors reducing as flood levels rise. The specific risks include:

- **Asset integrity risk:** Network assets may be impacted and damaged by debris being carried by flood water.
- **Public safety risk:** Members of the public may come into contact with a live conductor when moving through flooded areas using watercraft or other means.
- **Secondary safety risk caused by pre-emptive isolation:** To mitigate the public safety risk, Endeavour Energy will often isolate powerlines over flooded areas as the flood water levels approach minimum safe clearance distances. This can result in a broader community safety risk as communities are left without power, which may impact communications, heating, food storage, life support equipment, and more.

There is an opportunity to improve the resilience of feeders over flooded areas to minimise the customer outages from proactive isolation of conductors, and the potential safety risk to the public should this mitigation activity not be completed in sufficient time.

Across the Endeavour Energy network there have been up to 26 11kV distribution feeders and seven (7) 33kV sub-transmission feeders with sections of overhead conductors impacted by flood events since March 2021. While current design standards require substations to be constructed above projected 1-in-100 year flood levels, mains supplying these assets do not currently have specified flood resilience standards and as a result have been impacted by flood water during recent events.

3.2.2 HV Switch Automation

As flood waters rise, particular HV switches may be required to be accessed to isolate portions of the electrical network to manage safety risks. Flooding can result in road closures, which restricts the ability for Endeavour Energy to physically access the HV switches to manually operate these in a timely manner and mitigate the significant safety risks associated with rising flood waters.

As a result Endeavour Energy will pre-emptively de-energise the HV switches for which access is at risk from rising flood waters. This results in customer interruption, even if the final flood levels do not reach dangerous levels. This has secondary safety impacts for customers by impacting communications, heating, food storage and more.

Once flood waters commence receding, the re-energisation of otherwise safe electricity network assets can be delayed by the inability to physically access critical switches, potentially extending the period customers are without electricity supply.

Installation of switches with remote operation allows Endeavour Energy to minimise customer impact during flooding, by switching off power (and then restoring) only when absolutely required for safety reasons.

Field staff involved in recent flood response incidents have identified locations that would benefit from having manual switches converted to automated devices. In one example, an automated switch eliminates the need for a four-hour drive to a remote location in flood conditions, reducing the customer outage impact on that feeder by approximately 66,000 minutes or 2% for the flood incident.

4. Consequence of nil intervention

4.1 Consequences of nil capital intervention

The nil intervention case involves not carrying out any capital works. Therefore, feeders and assets would be operated until they have failed and are then retired and not repaired or replaced and includes the following course of action:

- Continue time-based maintenance and carry out repairs where possible after minor damage;
- Nil replacement of assets and sections of feeders after non-repairable/destructive failures;
- Provide alternate supply to customers through back feeding where possible (transferring load to adjacent feeders); and
- Provide supply to customers by hiring and operating generators where customers are unable to be back-fed through the network.

The consequences of this would include:

- Destructive failures lead to extended loss of supply while alternate arrangements are made;
- Outages larger and more widespread due to the inability to access devices through the loss of access tracks;
- Where suitable alternative network supply is not available, portable generators will remain in use for an extended period;
- Potential for overload of adjacent feeders during peak periods requiring generator support; and
- Loss of redundancy for adjacent feeders will lead to customer outages during planned and unplanned work on those substations.

Note that the impact of these consequences depends on the ongoing integrity of the surrounding network to allow failed overhead conductors to be partially offloaded for perpetuity. Under a nil intervention scenario, the risk costs would increase exponentially over time as other supporting elements in the network also failed and were not replaced. These exponential additional risk costs have not been modelled or included in the assessments as part of this CFI.

On this basis, the reactive replacement and repair of assets which fail will be undertaken, subject to an assessment of the ongoing need for the asset, and the nil intervention case will not be considered further in this CFI.

4.2 Counterfactual (business as usual)

The business as usual (BAU) “counterfactual” scenario includes operating network assets until they fail and then repair the asset, providing its service is still required. Nil proactive capital intervention is carried out.

Due to the inevitable flood impact on currently populated areas, repair and replacement of Endeavour Energy network assets will be required. Impacted assets are predominantly substations, poles, and low voltage mains in the proximity of low-lying properties. The positioning of these assets is governed by the location of connected customers and repositioning these assets is not feasible. As this particular network

impact is dependent on the ultimate severity of each flood event and is not mitigated by any proposal, no consideration is made for this in this CFI.

The consequences of BAU include:

- Proactive isolation of customers at pre-planned flood water levels;
- Progressive restoration of feeders as flood waters recede, assets can be confirmed safe, and accessed to be operated; and
- Reactive repair after damage is identified and assets can be accessed.

A summary of the risk presented by the counterfactual case has been calculated based on the value of customer reliability (VCR) for 19 impacted feeders, averaged over the past three 1-in-20 year flood level events. All costs are in real FY23 terms and are present values (PV). A discount rate of 3.26% has been used throughout the economic evaluation.

The annualised residual risk presented by the BAU case totals $6.46 million. The residual risk value presented by individual feeders ranges from $15,984 to $1.07 million dollars and averages $0.34 million across the feeders assessed.

5. Options considered

5.1 Non-network options

Overhead conductors and HV switches are a vital component of the electrical network by provide a physical medium to distribute and control electricity. There are no credible non-network solutions capable of replacing their functionality under the assumption that the feeder in which they service is still required.

5.2 Risk treatment options

A range of options have been considered to address the risk presented by flood impacts on network assets. These approaches are summarised in Table 1 below.

Table 1 – Network asset flood impact risk treatment options

Option	Assessment of effectiveness	Conclusion
Reactive repair and/or replacement of assets after conditional or functional failure	This approach reflects existing business-as-usual practice but does not mitigate the impact of flooding above the 1-in-10 year level.	Technically feasible solution but does not effectively mitigate the risk of future flood events
Underground impacted feeders	Undergrounding impacted feeder segments will mitigate the risk of flood impact but the relative cost is in excess of 4 times the construction cost of an equivalent overhead line.	Technically feasible solution but not prudent investment
Re-routing impacted overhead feeders	Modifying feeder routes may effectively avoid flood impacts to some feeder sections, however options are limited by access issues as well as constraints imposed by terrain and the network limited to radial configuration with no alternative points supply. Re-routing is also expected to increase cost over equivalent replacement in existing easements due to the additional cost of recovering redundant assets and establishing new easements.	Technically feasible solution but not prudent investment

Option	Assessment of effectiveness	Conclusion
Raising specific assets and conductor spans of HV overhead feeders above flood height anticipated during asset life	Raising 'at risk' distribution overhead assets above the 1-in-50 year flood level and transmission overhead assets above the 1-in-100 year flood level effectively mitigates the impact of flood water in the majority of historical flood events. Note there remains a practical limitation on maintaining network supply during floods above the 1-in-100 year event level.	**Recommended approach for further consideration**
Automate all HV switches in flood effected areas	While complete automation of HV field switches through flood effected areas provides flexibility, the terrain of the river valleys of the Lower Hawkesbury and tributaries prevents communication with all network locations. Additionally, only strategic devices are required to be automated to maintain supply.	Not technically feasible in some situations or economically justified in others.
Automate specific HV switches utilised for planned flood switching	Automation of specific network HV switches critical for planned flood switching and those with known access issues will improve network incident response and reduce customer outage durations during flood and storm events.	**Recommended approach for further consideration**

5.3 Credible network options

Raising the height of specific spans of HV overhead conductor based on historical and modelled flood impact, along with automating specific existing HV switch points utilised in planned flood switching is considered a credible network option.

5.3.1 Option 1 - Overhead conductor raising and switch automation

Under this option, the intervention includes the redesign and reconstruction of specific HV overhead conductor spans identified to have insufficient clearance over flood water in a:

- 1-in-100 year event for transmission overhead mains; and,
- 1-in-50 year event for distribution overhead mains.

The 1-in-100 year level has been identified for transmission mains to safely maintain supply to Zone Substations across flood affected areas. During "major" flood events of 1-in-10 to 1-in-20 magnitude recorded in March 2021, March 2022, and July 2022, transmission lines supplying Cattai ZS, Wisemans ZS, and North Richmond ZS were de-energised due to insufficient clearance over flooded areas interrupting supply to approximately 4,400 customers for several days. The 1-in-100 year flood level is a sound maximum design level for transmission mains as supply to Hawkesbury TS is expected to be interrupted at flood levels above this negating any benefit of transmission mains being constructed above this height.

The 1-in-50 year level has been identified for distribution HV mains as preliminary investigation has identified that existing spans generally exceed this height, with limited sections at risk of flood impact. Designing distribution mains to be above the 1-in-100 year level would require significant additional investment estimated to range from approximately 380% to 2100% above the cost of reconstructing feeder sections to achieve 1-in-50 year event clearances. In addition, non-standard constructions at exceptional

heights will not be accessible by standard plant and equipment, increasing the cost and complexity of future maintenance work on any assets at 1-in-100 year level. On this basis, 1-in-100 year flood level has been identified as unsuitable for distribution HV assets.

To support this intervention a number of existing HV switch points on the network have been identified as posing network operation limitations due to physical access issues despite supplying customers otherwise unaffected by major flood events. These access issues and delays result in customers experiencing additional time without supply.

Preliminary design figures and nominal cost estimates based on similar tasks carried out within Endeavour Energy's network have been used for intervention values.

5.4 Evaluation summary

Table 2 below summarises the outcomes of the cost-benefit assessment for intervention option compared to the BAU case.

Table 2 – Option economic evaluation summary

Option	Option type	Volume of inter-ventions	Residual risk ($M)	PV of benefits ($M)	PV of investment ($M)	NPV ($M)	Rank	Comments
BAU	Counter -factual	-	6.46	-	-	-	2	BAU – Does not capture benefits
1 - Overhead conductor raising and switch automation	Network	- 26 HV feeders - 7 TR Feeders - 32 HV switches	0.79	88.2	7.2	81.0	1	Preferred option

As outlined in Table 2, Option 1 is the preferred option as a combination of raising selected overhead conductor spans above the 1-in-50 flood level combined with automation of specific switches addresses identified network flood resilience issues, while providing a high NPV and therefore delivers an optimised economic value.

5.5 Economic evaluation assumptions

There are a wide range of assumptions of risk, their likelihoods and consequences which support the cost benefit assessment outlined within this CFI. Refer to Appendix B for details of the economic evaluation assumptions.

5.6 Sensitivity and scenario analysis

A scenario assessment has been carried out on the various elements of the risk and cost assumptions used in the economic analysis in order to test the robustness of the evaluation.

Three scenarios have been assessed:

- Scenario 1 - discourages investment with low benefits and high capital costs;
- Scenario 2 - represents the most likely central case based on estimated or established values;
- Scenario 3 - encourages investment with the high benefits with low capital costs.

The values for each of the variables used for each scenario are shown in Table 3.

Table 3 – Summary of scenarios investigated

Variable	Scenario 1 – low benefits, high capital costs	Scenario 2 – central values	Scenario 3 – high benefits, low capital costs
Capital cost	50% increase in the estimated network capital costs	Estimated network capital costs	10% decrease in the estimated network capital costs
Value of risk (frequency of major flood event)	Decreased major flood frequency – 1 in 40 years	Historical major flood frequency – 1 in 20 years	Increased major flood frequency – 1 in 15 years
NPV of scenario ($m)	**33.3**	**81.0**	**110.8**

As it can be seen from the above table, even under a low benefit, high cost scenario, this option still remains NPV positive, and as such is still a justified investment.

6. Preferred option details

6.1 FY23 – FY29 scope and timing

The recommended option is Option 1, which includes reconstruction of 26 segmented HV Distribution overhead feeders, 7 segmented Transmission feeders, and installation of 32 automated HV switches. The realised benefit of this investment is based on weather exposure, and as such the optimal timing of the delivery of this investment is hard to estimate. Due to the geographic properties of the region, in times of non-drought, flooding is a common event which occurs multiple times per decade. As such, it is recommended works to commence as soon as possible, factoring in resource availability and investment portfolio optimisation.

The overall cost of the proposed program is estimated to be $7.2 million (in real $ FY23 terms). A contingency is not proposed to be applied as there are multiple sites in the program and the estimated costs are based on mean values with variations in individual site costs expected to even out across the proposed program.

7. Regulatory investment test

The project cost of the credible option(s) for each site falls below the threshold for application of the Regulatory Investment Test for Distribution (RIT-D) (currently $6.0 million) and therefore the RIT-D is not applicable to this project.

8. Recommendation

It is recommended that Option 1 for HV overhead conductor raising and switch automation, totalling $7.2 million be included in the PIP FY23 – FY29 and to proceed to the investment portfolio optimisation stage.

9. Appendices

Appendix A – Details of recommended scope

Transmission Feeders

Area	Feeder	Type	Scope	Rationale	Estimated cost
Hawkesbury	**425**	Raise mains	Raise 33kV feeder above flood level	Network security - maintain supply to East Richmond ZS	$145,000
Hawkesbury	**438**	Raise mains	Raise 33kV feeder above 17m flood level - Rickabys Creek crossing area in particular	Network security - maintain supply to East Richmond ZS	$145,000
Hawkesbury	**439**	Raise mains	Raise 33kV feeder above 17m flood level	Network security - maintain supply to Glossodia ZS	$145,000
Hawkesbury	**443**	Raise mains	Raise 33kV feeder above 17m flood level	Safety - clearance over Hawkesbury river during moderate - major flood events Network security - maintain supply to Cattai ZS + Wisemans ZS	$523,000
Hawkesbury	**444**	Raise mains	Raise 33kV feeder above flood level - underbonding at TG feeder adjacent Vineyard BSP requires reconstruction to raise level	Network security - maintain supply to Riverstone ZS	$145,000
Hawkesbury	**452**	Raise mains	Raise 33kV feeder above flood level - Rickabys Creek crossing area in particular	Network security - maintain supply to North Richmond ZS	$145,000
Hawkesbury	**458**	Raise mains	Raise 33kV feeder above 17m flood level; separate and move upstream from underbuilt 11kV feeder	Network security - maintain supply to Cattai ZS + Riverstone ZS. Flood-borne debris catches on 11kV feeder and causes 33kV to trip or be pro-actively isolated for safety	$285,000
Transmission Total					**$1,533,000**

Distribution Feeders

Area	Feeder	Type	Scope	Rationale	Estimated cost
Cattai	**CX1206**	Install switch - HV	Install switch upstream of Sub 5450	Install switch upstream of Sub 5450 so we can isolate Mitchell park & keep customers on 2 other subs	$40,000
Maraylya	**CX1206**	Raise mains	Review for major flood impact. Improve 11kV + LV network operability and reliability during moderate - major flood events	CCT upgrade project planned	$60,000
Cattai	**CX1206**	Augment & switches	Install Automated Pole 419786 Cattai Rd, Install Mains between Sub 3486 and 1426 and Automated Cross Feeder Tie Sw	Cattai Mobile phone tower is on the Cnr of Millers Rd and Cattai Rd The mobile phone tower is Number 7 on Telstra's Priority List	$260,000
Cattai	**CX1210**	Install switch - HV	Install new switch upstream of 89241 at tee-off from main line at entry to National Park	Install new switch upstream of 89241 at tee-off from main line at entry to National Park so it can be accessed to get the main feeder into Wilberforce back on without accessing the National Park (gates locked)	$40,000
Ebenezer	**CX1210**	Raise mains	Improve 11kV network security - raise 11kV mains above flood level in vicinity of pole sub 8672 to secure supply to Grono Farm Rd	55 customers impacted July 2022 flood	$85,000
Colo	**CX1232**	Automate switch	Replace DOF F9919 with ALBS	Colo – Replace DOF F9919 with ALBS – will save 4 hours round trip & removes need to cross small body of water once Colo river reaches 4m	$40,000

Area	Feeder	Type	Scope	Rationale	Estimated cost
Colo	**CX1232**	Automate switch	Replace USL 19956 with ALBS	Replace USL 19956 with ALBS & relocate Sub 17544 to higher ground – will save 4 hours round trip for DO/network switcher & replacing tank each flood	$40,000
Colo	**CX1232**	Relocate - sub	Relocate Sub 17544 to higher ground	Replace USL 19956 with ALBS & relocate Sub 17544 to higher ground – will save 4 hours round trip for DO/network switcher & replacing tank each flood	$50,000
Colo	**CX1232**	Automate switch	Install ALBS @ E503	Install ALBS @ E503 so we can remotely energise generator to backfeed Colo Heights	$40,000
Colo	**CX1232**	Relocate - reg	Relocate Reg 22896 to higher ground closer to ABS 38763	Move Upper Colo Rd Voltage Reg 22896 to higher ground closer to ABS 38763 (10m higher will save control boxes going under each flood > $30k each time)	$40,000
Colo	**CX1232**	Relocate - SCADA VT	Relocate SCADA repeater (DS 27152) to Colo Heights generator side of USL E503	Relocate SCADA repeater (DS 27152) to Colo Heights generator side of USL E503 so ALBS & A/R in area will remain in scan & install 24v solar backup	$10,000
Cattai	**CX1284**	Augment mains	Install Mains or Cable Between Sub 15821 and Sub 28276, This would give us a flood free back up on the 11kV network Between the 2 Zones on feeders CX1284 and GL1207	To allow for the 33KV feeder to be built between Cattai and Glenorie a Section of 11kV mains was removed at the under crossing of the 500kV Line	$300,000
St Albans	**D814**	Raise mains	Review for major flood impact. Improve 11kV + LV network operability and reliability during moderate - major flood events	CCT upgrade project planned	$60,000

Area	Feeder	Type	Scope	Rationale	Estimated cost
North Richmond	**ER1252**	Raise mains	Raise 11kV feeder above flood level	Network security at Richmond Bridge river crossing.	$60,000
Freemans Reach	**L948**	Install mains	Extend 11kV mains between sub 27870 and sub 5350	Extend 11KV feeder between Sub 27870 and sub 5350 to be able to keep subs on down Hibberts Lane & not be reliant on water draining from Gorricks Lane	$60,000
Camden	**NN1233**	Augment & switches	Carry out Survey on Conductors Heights From DOF`s 84066 Replace USL 88260 with Automated LB/SW 8 bays of mains to raise if required + single auto switch	Subs 11473 and Sub 11470 Potential Impacted by flooding	$150,000
Windsor	**SZ1132**	Raise mains	Separate 11kV feeder SZ1132 under 458 across South Creek flood plain	Network security. Remove risk of flood-borne debris damaging transmission feeder	$200,000
Mulgrave	**SZ1222**	Relocate - sub	Raise / relocate subs 6880 and 54477 to avoid dumping SZ1222	Elf Mushroom Farm at Mulgrave is located on the east bank of the South Creek. It was supplied by five pad mounted substations on James Meeham Street FDR SZ1222 from South Windsor ZS. Although FDR SZ1222 crosses South Creek using underground cable, the exposure to flood at DS 6880 and 54477 had forced Operators to switch-off supply to Elf and 50 customers in Harris St Mulgrave.	$100,000

Area	Feeder	Type	Scope	Rationale	Estimated cost
Windsor Downs	**SZ1242**	Raise mains	Improve 11kV network security - raise 11kV mains above flood level to secure supply to waste treatment plant & Windsor Downs (UG from treatment plant)	28 customers impacted July 2022 flood	$60,000
Londonderry	**SZ1322**	Raise mains	Improve 11kV + LV network security - Carrington Rd / Bowman Rd / Purcell Rd Londonderry	119 customers impacted July 2022 flood	$60,000
Londonderry	**SZ1322**	Raise mains	Improve 11kV + LV network security - The Driftway Londonderry. Low point over Rickabys Creek?	160 customers impacted July 2022 flood	$60,000
South Windsor	**SZ1322**	Raise mains	Improve 11kV + LV network security - George St South Windsor. Low point over Rickabys Creek?	79 customers impacted July 2022	$60,000
Windsor	**SZ1342**	Relocate - sub	Flooded pad sub 20449 Brabyn St Windsor	Pad sub has been innundated several times. Pole sub built as temporary solution while relocation is investigated.	$100,000
Freemans Reach	**WD1221**	Raise mains	Improve 11kV + LV network security - Freemans Reach Rd	115 customers impacted July 2022 flood	$670,000
Windsor	**WD1225**	Relocate - sub	Relocate sub 7648 to higher ground	Relocate sub 7648 North St 3 pole back to higher ground so we can keep one side of LV on & keep access in the floods	$40,000
Windsor	**WD1225**	Install switch - HV	Sectionalise feeder - install HV switch North St Windsor north-east of sub 7648 to maintain supply to customers in Arndell St / Pitt St / North St	69 customers impacted July 2022 flood	$40,000

Area	Feeder	Type	Scope	Rationale	Estimated cost
Windsor	**WD1247**	Raise mains	Raise / UG 11kV feeder WD1247 Windsor ZS - Pitt Town at overhead HV ABC crossing of South Creek near Court Street Windsor	Isolated at 13.9m @ Windsor - loss of 158 (1000 plus?) customers? Otherwise UG supply from Windsor ZS to Pitt Town	$70,000
Pitt Town	**WD1251**	Raise mains	Improve 11kV network security - raise 11kV mains above flood level to secure supply to Pitt Town	1003 customers impacted July 2022 flood	$1,610,000
McGraths Hill	**WD1258**	Raise mains	Improve 11kV network security - raise 11kV mains above flood level to secure supply to McGraths Hill	Network security	$60,000
Theresa Park	**X877**	Augment & switches	11kV Install Mains Between Poles 648050 and 648020, Remove mains Between Pole 848020 and Sub 12046, Replace ABS 68084 with an Automated LB/SW, Assume 3 bay construction + 2 auto switches	By Re-arrange the 11kV OH mains we keep Customers that are not affected by the flooding on and we do not have to access the Quarantine Property removing the access issues and safety risks	$110,000
Marsden Park	**MS1202**	Raise mains	Raise mains at South Creek	Network security	$130,000
Lower Nepean / Hawkesbury	**Various**	Install switch - HV	Installation of 18 switches to allow remote operation of flood switching / restoration steps	Reduce customer outage times during flooding events	$720,000
Upper Nepean / Camden	**Various**	Install switch - HV	Installation of 6 switches to allow remote operation of flood switching / restoration steps		$240,000
Distribution Total					**$5,665,000**
Combined Transmission and Distribution Works					**$7,198,000**

Appendix B – Summary of key assumptions and variables

General variables and assumptions

Parameter	Value	Description/justification	Source/assumptions
Discount rate (WACC)	3.26%	Weighted average cost of capital for EE	Regulated rate. Applied to all risk and investment values used in the cost-benefit assessment.
Base year of investment	FY23	All investments for budgeting purposes are expressed in real FY23 dollars	For inclusion into the FY23 PIP after optimisation
Calculation horizon	20 years	The timeframe over which the cost-benefit analysis is performed	Historical major flood frequency
Planned intervention costs – replacement of overhead assets	Assumed costs: Distribution HV: $15,000/span Transmission: $45,000/span HV Automated Switch: $40,000/unit	Reconstruction of existing overhead conductors to Endeavour Energy overhead construction standards.	This estimate is based on estimates or actual costs of previously delivered works and includes: - Project Management - Design - Materials - Labour and plant - Traffic management

Safety risk inputs

Parameter	Value	Description/justification	Source/assumptions
N/A			

Reliability risk inputs

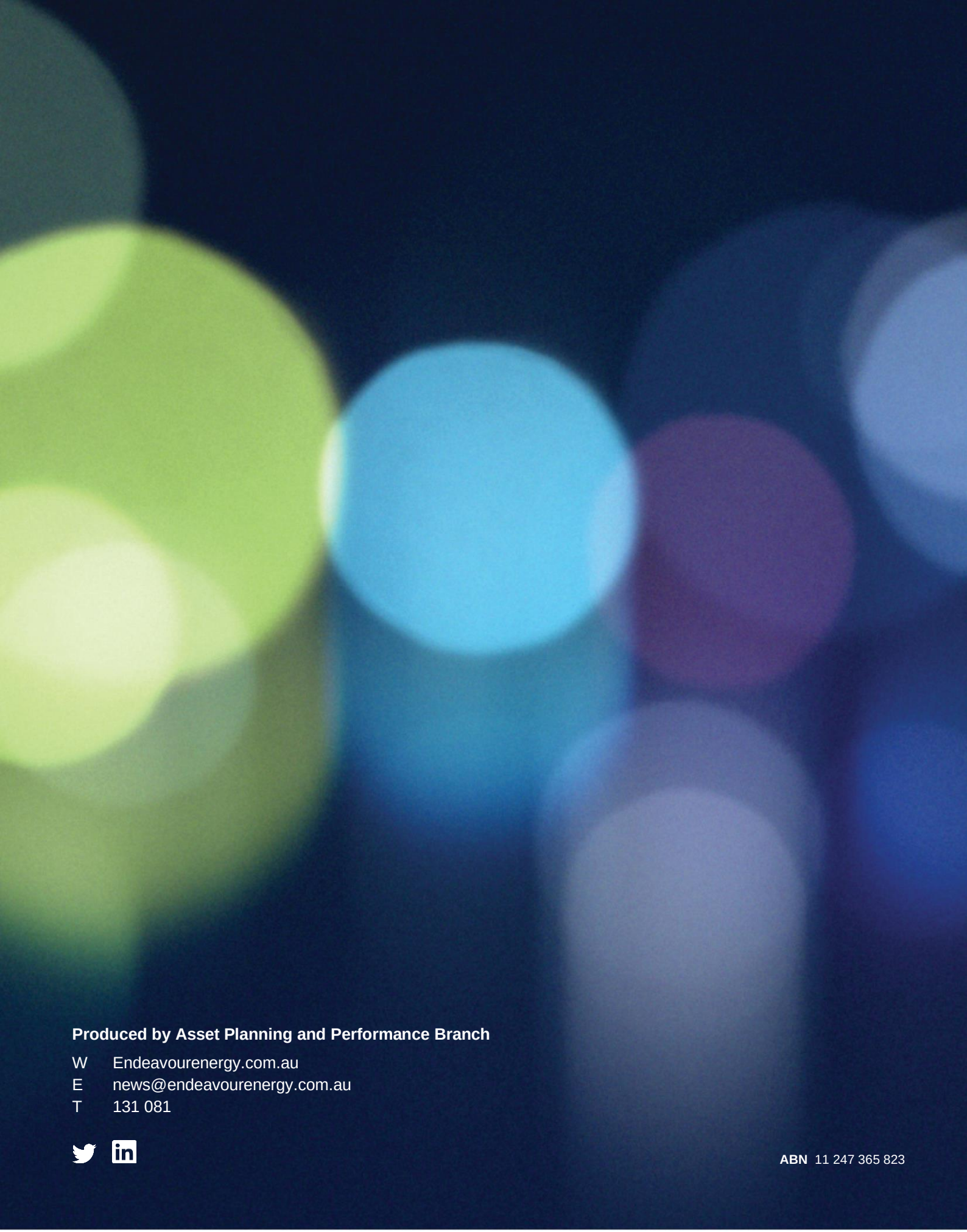
Parameter	Value	Description/justification	Source/assumptions
Load impacted	Varies based on the estimated load of supported by section of conductor	Network Planning distribution feeder loads.	Endeavour Energy specific VCRs.xlsx
VCR	Varies based on the customer make-up supplied by a section of overhead conductor	Value of customer reliability for an occasional short-term outage. This value varies based on the make-up of customer types supplied by the section of overhead conductor.	Endeavour Energy specific VCRs.xlsx

Bushfire risk inputs

Parameter	Value	Description/justification	Source/assumptions
N/A			

Financial and Environmental risk inputs

Parameter	Value	Description/justification	Source/assumptions
N/A			



Produced by Asset Planning and Performance Branch

W Endeavourenergy.com.au
E news@endeavourenergy.com.au
T 131 081

ABN 11 247 365 823

Endeavour Energy