West Lake Illawarra Area Plan

Review of the long term electricity infrastructure requirements in the West Lake Illawarra Precincts

Asset Strategy and Planning

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Endeavour Energy

REVIEW AND ENDORSEMENT

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1.0 Executive Summary

This report outlines the investment needs and strategy to accommodate the development of an estimated 25,770 residential dwellings and 3.1km² of employment lands in West Lake Illawarra precincts. The development area is bounded by the Moss Vale to Unanderra Railway Line to the north, the Illawarra Escarpment to the West, the Illawarra Highway to the South and the eastern boundary by Brownsville, Dapto, Lake Illawarra at Tallawarra, Albion Park Rail and Albion Park.

It is expected when fully developed the West Lake Illawarra precinct will result in a load in the order of 128MVA being added to Endeavour Energy's network.

The network that is proposed to supply the ultimate load comprises of three Endeavour Energy (EE) zone substations (ZS) along with a private high voltage customer (HVC) substation. This strategy aims to maximise the use of the existing infrastructure currently in place within the development area, which consists mostly of 132kV and 33kV construction. Consideration is given to staging the implementation of the ultimate network with immediate existing network utilisation, short-term (five year) and medium-term (ten year) network configurations proposed for supplying the land that is currently zoned or is being planned for development.

The need to continue engagement with various stakeholders, including the NSW Department of Planning and Environment, Councils, developers and landowners, is highlighted as crucial for the appropriate acquisition of line corridors and zone substation sites.

In summary, the report recommends the following actions:

1. The proposed Ultimate Network Topology – Option 1 Combined 132kV and 33kV Transmission Solution is adopted as the preferred long term network configuration and basis for further planning within the West Lake Illawarra area. This option is estimated to cost $105million with incremental investment over the next 2 decades. Individual projects for each stage will be developed separately and funding approval sought at the appropriate time.

2. Continue Joint Planning with TransGrid for the additional load required to be supplied by 330/132kV Dapto BSP and potential N-1 backup security from Marulan BSP.

3. Continue discussions with the Department of Planning and Environment to ensure that zone substation sites and line corridors are included in the development of master plans for West Lake Illawarra precincts.

4. Continue discussions with the Illawarra Urban Development Committee - chaired by NSW Department of Planning and Environment, Wollongong City Council and Shellharbour City Council on an ongoing basis to ensure that Endeavour Energy's long term plan for the establishment of major infrastructure is in line with projected development timing.

2.0 Introduction

This report outlines the strategy for supplying the West Lake Illawarra precincts, which is a Greenfield development area located within the boundaries of Wollongong and Shellharbour local government areas. The West Lake Illawarra release areas incorporate West Dapto (North & South), Calderwood and Tallawarra. The area has an expected ultimate yield of 25,770 residential lots and 3.1km² of employment lands – the majority of land in these areas is already zoned and additional planning proposals are being considered. The boundaries of the West Lake Illawarra precinct are shown in Appendix 1.

This area was previously the subject of supply arrangement options. A report titled 'West Dapto and Tallawarra Supply Arrangement Options – Discussion Paper' was published in September 2010. The paper considered the Calderwood development large enough to warrant its own zone substation (ZS). The supply options reviewed the merits of 33/11kV and 132/11kV ZS options. On balance the 132/11kV ZS supply options were considered, at the time, a better technical and economical solution.

It should also be noted that Endeavour Energy purchased a block of land (30 July 2010) in the West Dapto North area with the intention of establish a zone substation when required. The parcel owned by Endeavour Energy is Lot 1 DP 818199 on West Dapto Rd Kembla Grange.

3.0 West Lake Illawarra Precinct

The NSW Government Department of Planning and Environment has identified three precincts within the subject Greenfield growth area. The locations of these precincts are shown in Appendix 1 and their expected dwelling numbers and employment land yields are shown in the Table 1 below.

Precinct	LGA	Number of Dwellings	Employment land (km²)
Calderwood	Shellharbour	6,555[1]	-
Calderwood	Wollongong	1,145[1]	0.500
Tallawarra	Wollongong	1,071[1]	0.668
West Dapto	Wollongong	16,999[1]	1.932
Total		**25,770**	**3.100**

Table 1: Precinct yields (dwellings and employment land)

[1] Source: NSW Government Planning & Environment – Illawarra Urban Development Program Update 2013 http://www.planning.nsw.gov.au/Portals/0/PlanningYourRegion/Illawarra/IUDP_Update_Report_2013.pdf

Table 1 shows the West Lake Illawarra precinct is expected to have a yield of 25,770 residential dwellings and 3.1km² of employment lands.

The main West Lake Illawarra development precincts (West Dapto and Calderwood) are sandwiched between the Illawarra escarpments (west) and existing suburbs of Horsley and Dapto (east). The northern boundary is the existing Kembla Grange employment lands and the southern boundary is the Illawarra Highway west of Albion Park. The Tallawarra precinct is located on the western shore of Lake Illawarra.

4.0 Network Need

This report aims to provide a strategy that meets the load requirements of the West Lake Illawarra precinct while addressing the needs of the network, including those based on capacity and asset condition. There are various options for catering for these needs, which are to be assessed in term of their viability and present value in order to determine a preferred option.

4.1 Expected Ultimate Load

Based on the total number of dwellings and employment land area, the total load for the development has been estimated. Firstly, the load of the residential dwellings was estimated as follows:

Dwellings: 25,770 at 4.0kVA per dwelling		=	103.0MVA

The employment lands, consisting of industrial (warehousing and light fabrication) plus commercial development, are estimated to have the load shown below:

Industrial:	3.1km² x 67% at 6MVA/km²	=	12.5MVA
Commercial:	3.1km² x 33% at 12MVA/km²	=	12.3MVA
	Subtotal	=	24.8MVA

The total load for the West Lake Illawarra Precinct is estimated as:

Total	=	**127.8MVA**

Special Report S696 – 2014 is a recent investigation into the maximum demand of residential housing in new release areas of Western Sydney has shown an average demand of 4kVA per dwelling. This is less than the 5.2kVA, derived from a 2001 and 2005 study, due to a combination of factors that include the impacts of the BASIX energy efficiency requirements for new housing construction, solar PV generation and the increased density resulting in a mix of dwelling size. The Horsley area is inland coastal and exhibits the similar summer and winter demand profiles western Sydney, therefore 4.0kVA per dwelling has been adopted for the West Lake Illawarra precinct.

The existing transmission lines in the West Lake Illawarra precinct are a mix of 132kV and 33kV. The 132kV lines have spare capacity with only some the 33kV lines having limited spare capacity.

There is also an existing customer application (ENL0971 & UCL5915 – Illawarra International Health Precinct) for large load in the order of **12.1MVA**. It has been communicated to the proponent that they will need to become a private HV customer substation connected at 33kV.

Based on the expected total load of 127.8MVA two possible solutions based on standard ZS firm ratings have been studied as follows:

Option 1: Combined 132kV and 33kV Transmission Solution

Assuming a combined 132kV and 33kV transmission utilisation solution indicates a credible solution may involve establishing the following number of firm Endeavour Energy Zone Substations (source: SDI 501 – Network Configuration) and a private High Voltage Customer (HVC) substation:

- Two 132/11kV 45MVA firm Zone Substations
- One 33/11kV 25MVA firm Zone Substation
- One 33kV 15MVA capacity HVC substation

The installed ZS firm capacity would equal 115MVA plus a 15MVA HVC provides a total capacity of 130MVA.

Options for 33/11kV zone substations will include package substations as well as conventional substation design.

Option 2: 33kV Transmission Solution

Assuming utilising the 33kV transmission system a solution may involve establishing the following number of firm Endeavour Energy Zone Substations (source: SDI 501 – Network Configuration) and a private HVC Customer substation:

- One 33/11kV 50MVA firm Zone Substation
- One 33/11kV 35MVA firm Zone Substation
- One 33/11kV 25MVA firm Zone Substation
- One 33kV 15MVA capacity HVC substation

The Installed ZS firm capacity would equal 110MVA plus a 15MVA HVC equals 125MVA.

Options for 33/11kV zone substations will include package substations as well as conventional substation design.

Either of two options 1 or 2 as detailed above could potentially be used to service the ultimate load requirement of the West Lake Illawarra development area. The specifics of the planned ultimate supply arrangement are further discussed Section 6.0 and 8.0, with the staging plan shown in Section 9.0.

4.2 Renewal Needs

The existing zone and transmission substations that supply the West lake Illawarra area, as well as their ages and currently identified renewal needs, are listed in the following table.

Location	Year Built	Age (years)	Renewal Needs
Albion park ZS	1968	47	Renewal needs which are included in the SARP 2014/15 for consideration within the next 10 years include: TS610 – No 2 33/11kV Transformer TS611 – No 3 33/11kV Transformer
Dapto ZS	1962	53	Nil
Kembla Grange ZS	1999	16	Nil
Mount Terry TS	1968	47	Nil
Springhill TS	2008	7	Nil
Tallawarra SS	2008	7	Nil
Unanderra ZS	1963	52	Renewal needs which are included in the SARP 2014/15 for consideration within the next 10 years include: TS163 – Renewal: Control Building, New 11kV switchboard, auxiliaries, P&C, TS005 – Replace: 33kV CBs, TS600 – Replace: VT & CT

Table 2: Zone and transmission substation renewal needs

The above table shows that there are limited renewal needs in the area, therefore renewal needs have minimal impact on determining the ultimate supply strategy for increased capacity. As there is little scope for installing new capacity based on the condition of the existing assets, at least in the short to medium term, the installation of new assets is anticipated to be driven by capacity constraints.

5.0 Study Design Considerations

The majority of the existing electricity infrastructure in the study area is of a light, rural nature and is limited in its ability to supply any substantial load arising from greenfield development in the West Lake Illawarra precincts.

Augmentation of existing infrastructure where possible will be undertaken to provide supply to initial phases of developments. This will provide some lead time to undertake detailed network investment option studies prior to committing to capital investment in new infrastructure.

Due to the difficulties in establishing overhead electricity infrastructure and obtaining line corridors and easements the following basic design considerations have been used in the determination of a suitable network topology:

a) The use of standard capacity overhead feeders will allow standard underground installations where required.

b) Existing lines should be used wherever practicable. Both 132kV feeders 981 (Dapto BSP to Bellambi TS) and 988 (Dapto BSP to Fairfax Lane TS) traverse major parts of the development area. In addition, 33kV feeders 7341 (Kembla Grange ZS to Dapto ZS), 7041 (Mt Terry TS to Dapto ZS), 7123 (Albion Park ZS to Avon Colliery) and 7099 (Springhill TS to Wongawilli) also traverse the development. The existing 132kV and 33kV feeders and the associated corridors and easements they occupy should be utilised where possible.

c) The use of 11kV as the distribution voltage. Although a majority of the existing 11kV in the area is of light, rural design, there are enough assets in place to make any conversion to an alternative distribution voltage difficult, involving complex changeover procedures and possibly lengthy and multiple interruptions to customers.

6.0 Existing Supply Arrangements

The existing West Lake Illawarra development area is predominately serviced by a rural overhead 11kV feeder network beyond the existing mature suburbs. The existing ZS's are located geographically to far from the proposed load centre to be able to support the required capacity in the Greenfield development area. Therefore, the existing 11kV network cannot service the significant step change in load which will ultimately materialise.

The existing transmission and sub-transmission network within the West Lake Illawarra precinct is shown in Figure 1 below.

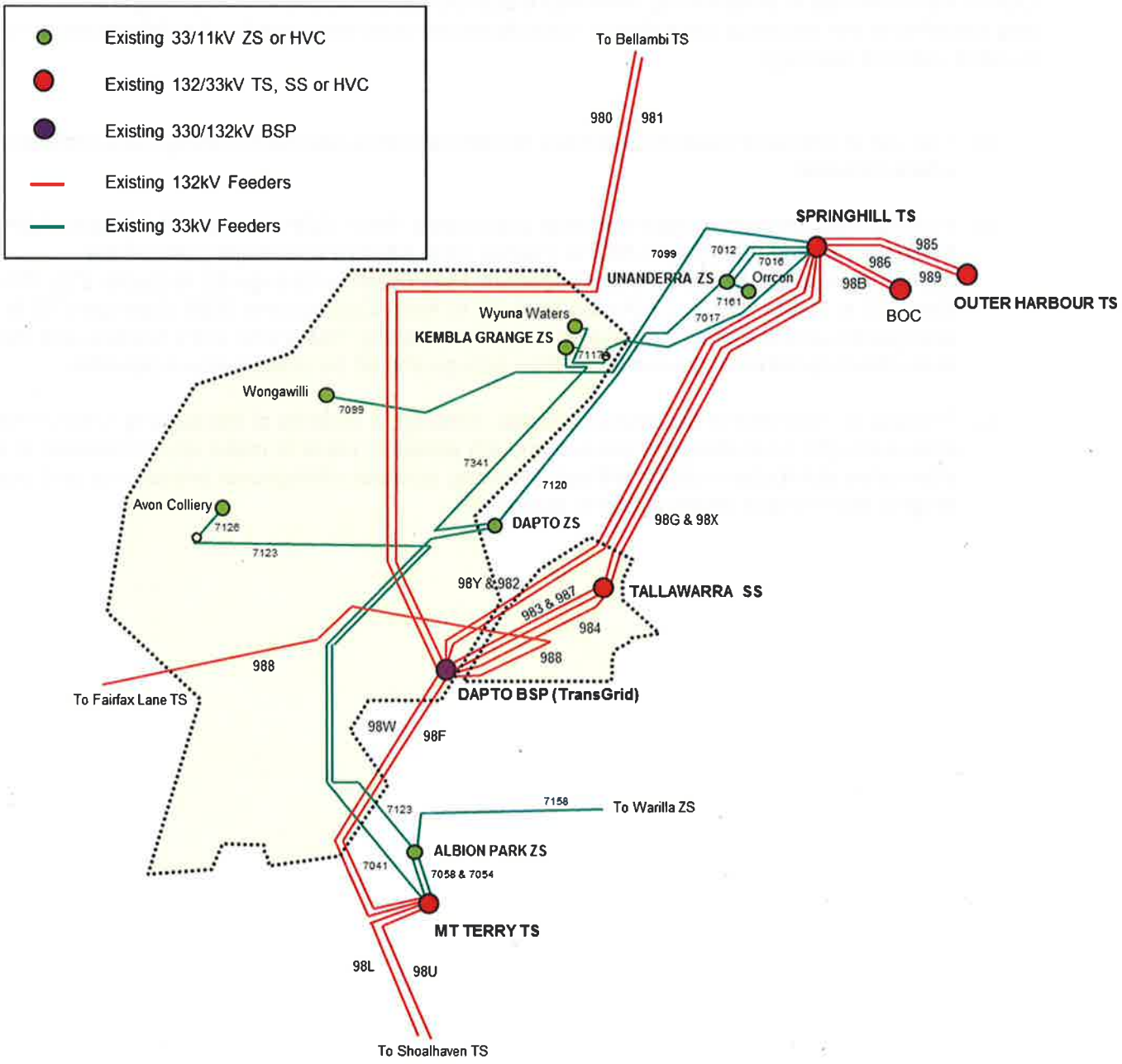


Figure 1: Existing Network & Development Area (sketch not to scale)

Sub-transmission Line Capacity

The existing sub-transmission 132kV and 33kV network in the vicinity of the West Lake Illawarra development area is show in Figure 1.

Existing 132kV feeders 980 and 981 (Dapto BSP to Bellambi TS) and 988 (Dapto BSP to Fairfax Lane TS) presently do not supply any load in the development area. These feeders along with Dapto BSP have ratings that can support additional load in the West Lake Illawarra precinct. The feeder ratings are shown in Table 3 below; these ratings include emergency ratings where available.

Feeder	TNPR N-1 (S)2025 (MVA)	SPARE Capacity (MVA)	Rating (S) (MVA)
980	65	98	163
981	65	98	163
988	87	46	133

Table 3: Existing 132kV Feeder Capacity

Source: Transmission Planning Review 2015-2024

Table 3 shows spare capacity of 98MVA under N-1 scenarios for both feeders 980 & 981. Either of these feeders will support a standard firm 45MVA 132/11kV ZS in the West Dapto North development area as show in Figure 2. Also refer Appendix 1 - West Lake Illawarra Precinct Overlay. There is spare capacity of 46MVA under an N-1 scenario for feeder 988. It is considered that 988 has sufficient capacity for a firm 45MVA to be installed and 988 would only need to be augment when the load take up on the proposed Avondale ZS materialises.

Presently existing 33kV feeders 7012 & 7016 (Springhill TS to Unanderra ZS), 7017 & 7117 (Springhill TS to Kembla Grange ZS), 7041 (Mt Terry TS to Dapto ZS), 7054 & 7058 (Mt Terry TS to Albion Park ZS), 7099 (Springhill TS to Wongawilli), 7120 (Unanderra ZS to Dapto ZS), 7123 (Albion Park ZS to Avon Colliery 'not in service') and 7341 (Kembla Grange ZS to Dapto ZS) supply load within and adjacent to the development area. The feeder ratings and spare capacity are shown in Table 4 below; these ratings include emergency rating where available.

Feeder	TNPR N-1 (S) 2025 (MVA)	SPARE Capacity (MVA)	Rating (S) (MVA)
Springhill TS			
7012	32.8	11.6	44.4
7016	32.9	0.3	33.2
7017/7117	33.6	-0.4	33.2
7099	N only, 0.4	32.5	32.9
7120	32.6	0.6	33.2
7341	28.4	3.7	32.1
Mount Terry TS			
7041	14.6	12.8	27.4
7054	35.2	10.5	45.7
7058	34.8	10.9	45.7
7123	N only, 0.0	16.8	16.8

Table 4: Existing 33kV Feeder Capacity

Source: Transmission Planning Review 2015-2024 & PowerFactory model: EE_Transmission_MasterTNPR2015(1)

Table 4 shows the maximum spare capacity under N-1 on 33kV feeders from Springhill TS is 16.5MVA on 7012 and from Mount Terry TS is 16.8MVA on 7123. It can be seen that there is extremely limited 33kV feeder capacity to support three new 33/11KV ZS's and one 33kV HV Customer substation in the Greenfield development area.

Substation Demand Forecast

To determine whether the existing TS's and BSP have sufficient spare capacity to supply the long term needs of the West Lake Illawarra precinct, the substation capacity can be compared to the expected ultimate demand on the network.

The demand on the subject network is reviewed Table 5 below.

Substation	Firm Capacity (MVA)	SPARE Capacity (MVA)	#Winter 2014 (MVA) Undiversified
Mount Terry TS	120	33.5	86.5
Springhill TS	240	86.8	152.3
Dapto BSP	750	78.6[1] / 508.6[2]	671.4[1] / 241.4[2]

Table 5: Existing Substations (TS - 132/33kV) and (BSP - 330/132kV) Capacity

[1] This ultimate load is without Tallawarra Generator -0.0MVA
[2] This ultimate load is with Tallawarra Generator -430MVA

Table 5 shows Mt Terry TS has sufficient spare capacity for at least one new 33/11kV ZS. Springhill TS also has sufficient capacity for at least two new 33/11kV ZS's. However, together Mt Terry TS and Springhill TS would be stretched to support three 33/11kv ZS's and one 33kV HV Customer Substation. Given Tallawarra generation -430MW, Dapto BSP could easily support two 132/11kV ZS's.

7.0 Demand Management Strategy

Endeavour Energy investigates demand management (DM) options for all major projects that meet the criteria as stipulated in the National Electricity Rules (NER) Chapter 5 Part B – Network Planning & Expansion. The Rules state that all distribution network limitations with a credible network option greater than $5 million must be screened for non-network (demand management) options and, if feasible, investigate non-network alternatives via a RIT-D consultation process.

The screening test is a test applied to ascertain whether it is feasible to expect that the number and type of electricity customers driving the identified electricity network limit will respond to demand management initiatives. Generally, demand management can be effective in deferring network augmentation where demand growth is organic as part of normal customer behaviour. Where the area is a substation "green field" site, demand management has little opportunity to effectively reduce peak demand. This is the case with the West Lake Illawarra precincts, which mainly consists of rural lands that are to be converted to urban and industrial use. Demand management will not avoid the need to establish or augment electricity assets in order to supply the West Lake Illawarra Precinct but may have the potential to defer future network augmentation. As such DM may affect staging of network augmentation but not the ultimate long term strategy for the West Lake Illawarra Precinct.

The ability to postpone augmentation of the electricity network in the future depends on the type of demand management program and the uptake by customers. Programs may be either permanent or temporary demand reducing initiatives. Permanent demand reduction is preferred in the early stages of the program where temporary demand reduction initiatives may be utilised as the peak demand is approaching network capacity limits. Examples of temporary demand reducing initiatives include peak time rebate and air conditioning cycling in the residential sector and load curtailment programs in the industrial/commercial sectors. Permanent demand reduction initiatives may include dynamic pricing in the residential sector and efficient appliances and lighting in the industrial/commercial sectors.

8.0 Options to Supply the Ultimate Load

This section outlines two strategies that have been developed to establish major electrical infrastructure that is required to service the expected ultimate demand of the West Lake Illawarra precinct. Depending on the option major infrastructure includes the use of 132/11kV ZS's, 33/11kV ZS's, 132kV sub-transmission network feeders, 33kV sub-transmission network feeders and a private 33kV HV Customer substation. The existing network is presented as well as additional works for each option to modify the network in order to meet the network need. Note that the strategy for the distribution network (11kV) is not discussed within this document as it will be planned for and established as part of individual developments through the normal customer application for load process administered by the Customer Connections Branch.

8.1 Proposed Ultimate Network Topology

Given the anticipated load of the West Lake Illawarra development area and the geographical spread of this load across the various precincts, a network topology has been developed in order to service the growth area by best utilising the existing assets. Further, the proposed network is broadly based on the design requirements of Section 5.0 and Endeavour Energy's SDI 501 Network Configuration Standard.

TransGrid owns and operates Dapto BSP which will ultimately serve the purpose of supplying growth in the West Lake Illawarra development area and greater Illawarra region.

It has been determined that it will be possible to service the development through two solutions;

Option 1 – Combined 132kV and 33kV transmission Solution

Establish two 132kV 45MVA ZS's, one 33kV 25MVA ZS and one 33kV 15MVA private HV Customer substation along with the required feeder connection works

Option 2 – 33kV Transmission Solution

Establish requiring three 33kV (1 x 50MVA, 1 x 35MVA & 1 x 25MVA) ZS's and one 33kV 15MVA private HV Customer substation along with the required feeder connection works. This would also require significant feeder augmentation works along with new 33kV feeders establish to both West Dapto & Avondale ZS's.

8.1.1 Option 1 – Combined 132kV and 33kV Transmission Solution

In order to cater for the shortfall in supply capacity, it is proposed to establish two 132/11kV 45MVA ZS's (West Dapto and Avondale) along with the establishment of two 33/11kV substations (Calderwood ZS and Illawarra International Health Precinct HVC). The proposed network topology, with these substations established, is shown in Figure 2, below.

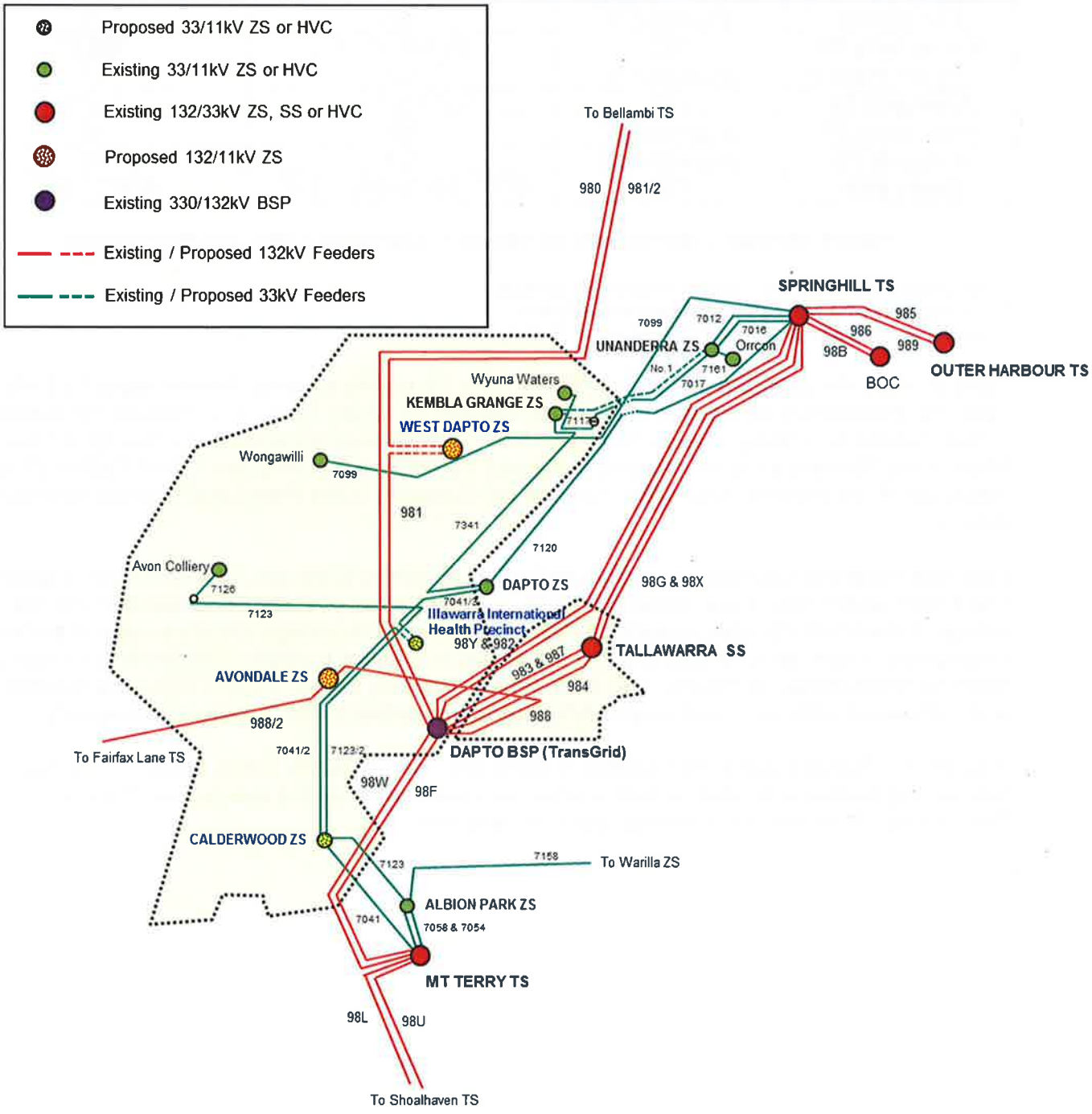


Figure 2: Proposed Option 1 - Network Topology for Development Area (sketch not to scale)

To determine whether the existing TS's and BSP have sufficient capacity to supply the long term needs of the West Lake Illawarra precinct, the additional substation capacity can be compared to the expected ultimate demand on the network.

Substation	Firm Capacity (MVA)	W 2024 & S 2025 (MVA) Undiversified	Expected Ultimate Load (MVA) Undiversified
Calderwood	*proposed 25*	*N/A*	*25*
Mount Terry TS	120	88.0 & 101.7	**126.7**[3]
I.I. Health Precinct	*proposed 15*	*N/A*	*15*
Springhill TS	240	162.9 & 153.1	177.9
West Dapto ZS	*proposed 45*	*N/A*	*45*
Avondale ZS	*proposed 45*	*N/A*	*45*
Dapto BSP	750	671[1] / 241[2] & 662[1] / 232[2]	**801**[1,3] / 371[2]

Table 6: Ultimate Load Forecast for Option 1 - Combined 132kV and 33kV solution

[1] This ultimate load is without Tallawarra Generator -0.0MVA
[2] This ultimate load is with Tallawarra Generator -430MVA
[3] Diversity in actual load may prevent load at risk at Mt Terry TS

Table 6 shows the expected demand on Mount Terry TS slightly exceeds the firm rating by 5.6%. Typically, the diversity between all substations supplied by Mount Terry TS will reduce the actual load to less than the firm rating. Overall, the Dapto BSP (with Tallawarra Generation), Springhill TS and Mount Terry TS have sufficient capacity to support the solution requiring two 132kV 45MVA ZS's, one 33kV 25MVA ZS and one 33kV 15MVA private HV Customer in the West Lake Illawarra development area.

Load flow modelling has been carried out for Option 1 (refer to appendix 3) for contingency tables. The 132kV system load flows (tables 3.1 and 3.2) show a small overload on feeder 988 and the voltage at Avondale ZS falling outside the NER mandated -10% voltage tolerance under a system contingency. It was demonstrated that the installation of reactive support (15MVAr) at Avondale ZS would eliminate these constraints. The 33kV system load flow (tables 3.3 and 3.4) show feeders 7041 and 7123 would ultimately need augmenting due to an overload under a system contingency.

In summary, Tables 3 and 4 from Section 6 along with Table 6 clearly shows Option 1 requires minimal augmentation projects to subtransmission lines and either the Bulk Supply Point or Transmission Substations minimising capital expenditure.

8.1.2 Option 2 – 33kV Transmission Solution

In order to cater for the shortfall in supply capacity, it is proposed to establish three 33/11kV ZS's (Calderwood, West Dapto and Avondale) along with one 33kV (Illawarra International Health Precinct HVC) substation be established. The proposed network topology, with these substations established, is shown in Figure 3, below.

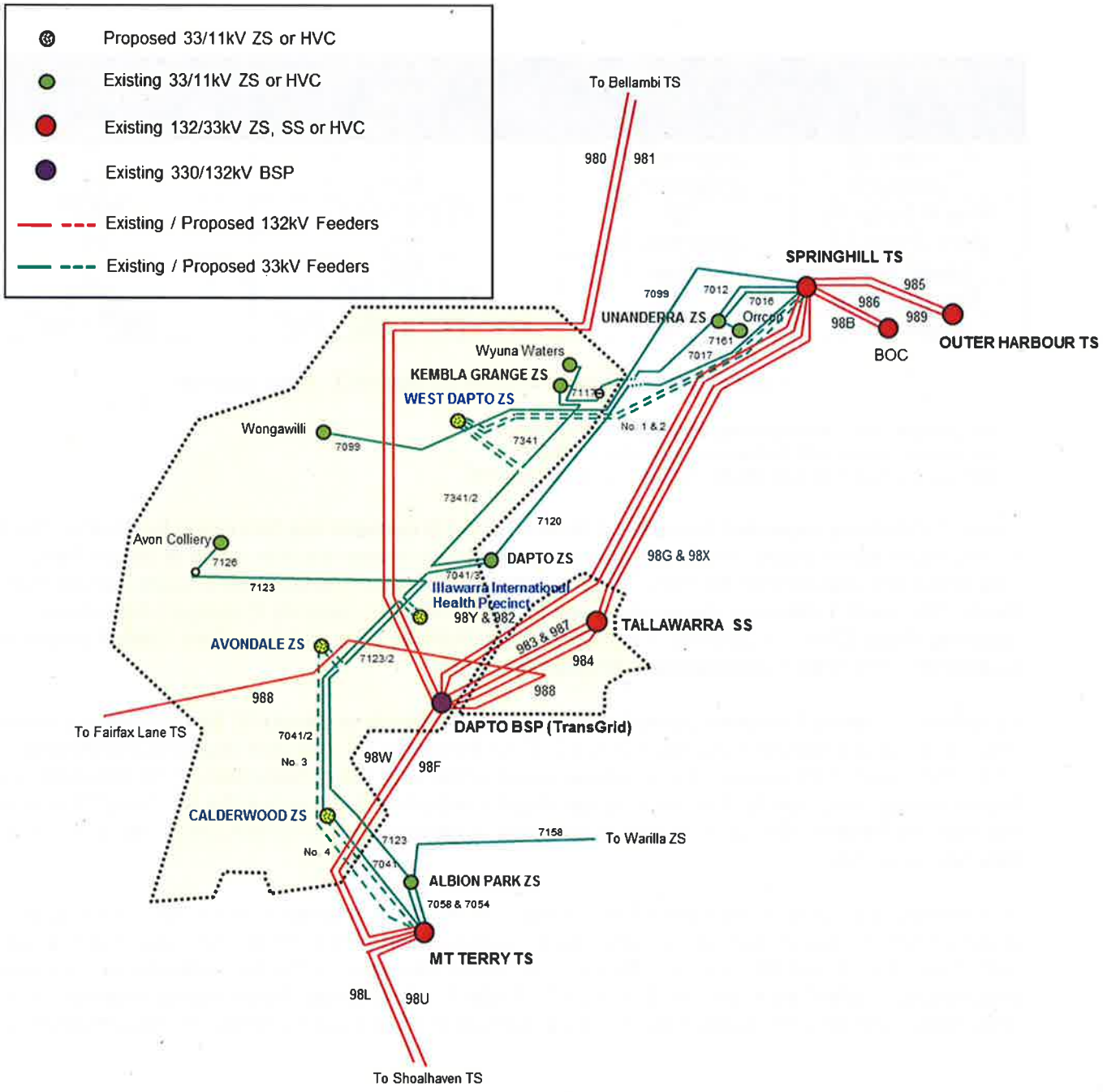


Figure 3: Proposed Option 2 - Network Topology for Development Area (not to scale)

Figure 3 shows that Option 2 would require a total of four new 33kV feeders to be developed. This includes two new feeders from both the Springhill and Mt Terry TS's. Both of these Transmission Substations have future 33kV feeder bays that can be developed to accommodate the requirement.

To determine whether the existing TS's and BSP have sufficient capacity to supply the long term needs of the West Lake Illawarra precinct, the substation capacity can be compared to the expected ultimate demand on the network.

Substation	Firm Capacity (MVA)	W 2024 & S2025 (MVA) Undiversified	Expected Ultimate Load (MVA) Undiversified
Avondale ZS	*proposed 35*	*N/A*	*35*
Calderwood	*proposed 25*	*N/A*	*25*
Mount Terry TS	120	88.0 & 101.7	**161.7**[3]
West Dapto ZS	*proposed 50*	*N/A*	*50*
I.I. Health Precinct	*proposed 15*	*N/A*	*15*
Springhill TS	240	162.9 & 153.1	237.9
Dapto BSP	750	671[1] / 241[2] & 662[1] / 232[2]	**796**[1,3] / 366[2]

Table 7: Ultimate Load Forecast for Option 2 - 33kV solution

[1] This ultimate load is without Tallawarra Generator -0.0MVA
[2] This ultimate load is with Tallawarra Generator -430MVA
[3] Diversity in actual load may prevent load at risk at Mt Terry TS

Table 7 shows the expected demand on Mount Terry TS exceeds the firm rating by 34.8%. The level of this exceedance would initiate an augment project to increase the firm rating of Mount Terry TS. The single line diagram for Mt Terry TS shows there is provision to facilitate a future transformer. Dapto BSP (with Tallawarra Generation) would have sufficient capacity to support the solution requiring three 33kV (1 x 50MVA, 1 x 35MVA & 1 x 25MVA) ZS's and one 33kV 15MVA private HV Customer in the West Lake Illawarra development area.

Load flow modelling has been carried out for Option 2 (refer to appendix 5) for contingency tables. The 33kV system load flow (tables 5.1 and 5.2) for Springhill TS indicates four existing feeders 7016, 7120, 7017 and 7341 would require augmentation along with the construction of the required new feeder works. Additionally, the 33kV system load flow (tables 5.3 and 5.4) for Mt Terry TS indicates two existing feeders 7041 and 7123 would require augmentation along with the construction of the new feeder works.

In summary, it can clearly be seen Option 2 requires no major augmentation project at the Bulk Supply Point. However, substantial 33kV feeder construction and augmentation works are required at both Springhill TS and Mt Terry TS. Mt Terry TS would also require the firm rating to be increased. Additionally, Table 4 from Section 6 along with Table 7 indicates significant capital expenditure in short term medium term is required to ensure appropriate 33kV subtransmission feeder capacity.

8.1.3 Cost estimate and preferred ultimate option

The cost of implementing options 1 and 2 has been estimated and is shown in Table 8 below.

Asset	Cost per unit ($/Sub or $/km)	Option 1 (works)	**Option 1** (estimate)	Option 2 (works)	**Option 2** (estimate)
240MVA Augment Mt Terry TS	$10.0m	-	-	1	$10.0m
33kV feeder Bay TS	$2.5m	-	-	4	$10.0m
360MVA Augment Springhill TS	$10.0m	-	-	-	-
33kV feeder Bay ZS	$2.5m	2	$5.0m	-	-
45MVA 132/11kV ZS	$19.5m	2	$39.0m	-	-
15MVAr Reactive Support	$2.0m	1	$2.0m	-	-
132kV Line Works	$0.92m	6.5km	$6.0m	-	-
50MVA 33/11kV ZS	$18.0m	-	-	1	$18.0m
35MVA 33/11kV ZS	$17.5m	-	-	1	$17.5m
25MVA 33/11kV ZS	$17.0m	1	$17.0m	1	$17.0m
33kV Line Works	$0.99m	35.7km	$35.3m	73.0km	$72.3m
33kV Line 7017 & 7120 Reconfiguration Works	$0.25m	1	$0.25m	1	$0.25m
Total	-	-	**$104.6m**	-	**$145.1m**

Table 8: Ultimate topology cost estimate and comparison

Note:

1 Table 8 excludes cost estimate of 33kV line works associated with Illawarra International Health Precinct?
2 Reference appendixes 7 & 8 estimated feeder works (Excel spreadsheet Line_Works_v3) for detailed feeder works required

Table 8 shows Option 2 is the more expensive of the two options ($40.5m more than Option 1) as it requires the largest amount of line works. Note that the unit cost of the 33kV lines works is higher than the 132kV unit cost as it has been assumed that there will be a higher proportion of underground, when compared to 132kV, due to increased congestion, feeder de-rating and the higher risk of acceptable line routes. Option 1 is the preferred option due to a lower total cost.

9.0 Staging Scenarios

This section proposes network configurations that will allow for the staged implementation of the proposed ultimate network and cater for the expected immediate, short and medium-term network needs.

In relation to establishing individual zone substations, a strategy has been developed to minimise the present value of cost of servicing the Greenfield development by taking a staged approach with a combined 33/11kV and 132/11kV zone substation delivery model.

The short and medium-term network strategy's may involve the establishment of either a 33/11kV package ZS or traditional 33/11kV ZS for the Calderwood area. A package ZS can defer the cost of constructing a traditional zone substation, potentially minimising the net present value, and provide flexibility in managing areas with uncertain growth rates. In addition establishing a 132/11kV relocatable/mobile/temporary ZS as the initial stage of the West Dapto North area will also defer the cost of constructing a traditional zone substation, minimising the net present value, and provide flexibility in managing areas with uncertain growth rates. It is proposed that this strategy will be considered in establishing zone substations for the West Lake Illawarra development area.

9.1 Immediate Network Utilisation

In the interim the immediate network solution to enable continued staged development within the West Lake Illawarra development area is through providing limited capacity from the existing distribution network. This capacity will be made available prior to capital investment projects leading to the eventual ultimate network strategy refer section 8.0. The interim supply capacity and availability from the existing distribution network at September 2015 is estimated and shown in Table 9.

Precinct	Spare Lot Capacity (No.)	Spare Load Capacity (MVA)	Existing Zone Substation
Calderwood	500	2.0	Albion Park
West Dapto – North	1,250	5.0	Kembla Grange
West Dapto – South & Tallawarra	1,500	6.0	Dapto
Total	3,250	13.0	

Table 9: Estimated Interim Supply Capacity @ September 2015

The network augmentation required in the short and medium term strategy's presented below will be subject to individual business case approval and the timing of projects will depend on the actual pace of development.

9.2 Short-term (five years) Network Topology

The dwelling yield expected to materialise within the next five years (to summer 2020) has been based on historical and forecast dwelling completions provided by NSW Government Department of Planning & Environment through the Illawarra Urban Development Program update 2014 report . There is more uncertainty surrounding the development of the employment lands, so this has not been allowed for within this timeframe. The expected precinct yields are shown in Table 10.

Precinct	Number of Dwellings	Employment land (km²)	Expected Load (MVA)	Planning Status
Calderwood (part)	1,400	0	5.60	Partially Rezoned and Released for planning
West Dapto – North (part)	1,790	0	7.16	Partially Rezoned and Released for planning
West Dapto – South (part)	1,790	0	7.16	Partially Rezoned and Released for planning
Tallawarra	0	0	0	Released for planning
Total	4,980	0	19.92	

Table 10: Zoned and planned for precincts

It can be seen in the short-term (five years) dwelling yield and demand is greater than the spare capacity available in the existing distribution network for the Calderwood Precinct. The estimated 5-year load is 180% greater than the existing spare capacity of 2.0MVA shown in Table 9. The West Dapto North & South expected 5-year load is 30% greater than the existing spare capacity of 11MVA shown in table 9.

In order to service the development within the Calderwood precinct it is proposed that consideration be given to developing a Calderwood ZS. Initially the development of 2 x 5MVA 33kV to 11kV packaged substations (refer to ETS 0025, 33kV to 11kV Packaged Substations) may provide an appropriate staged implementation process to secure supply capacity prior to the final ultimate arrangement required. This approach offers an opportunity to minimise expenditure risk. Load flow modelling has been carried out (refer to appendix 9) for contingency tables. Load flow modelling indicates no significant existing 33kV line augments would be required on the Mt Terry TS system.

To service the West Dapto North & South load the establishment a 132/11kV ZS will be required as there is insufficient capacity in the existing 33kV subtransmission system from Springhill TS to service the expected short term 5-year load. Consideration of either a mobile 132/11kV ZS or single temporary 132/11kV ZS established on the greenfield ZS site owned by Endeavour Energy on West Dapto Rd. It is unlikely that the mobile 132/11kV ZS will be available given the requirement in the South West Sector. Depending on the availability the Marsden Park Industrial ZS with a temporary single 16.5MVA transformer may be available for redeployment. Load flow modelling carried out for the ultimate load Option 1 (refer appendix 3) confirms availability of capacity in the 132kV system.

The network topology proposed to supply the precincts for the next five years is shown in Figure 4, with the corresponding contingency analysis shown in appendix 9 and appendix 3. The actual network configuration in the next five years could vary from Figure 4 subject to detailed cost benefit analysis as part of the Network Investment Options process for individual augmentation projects.

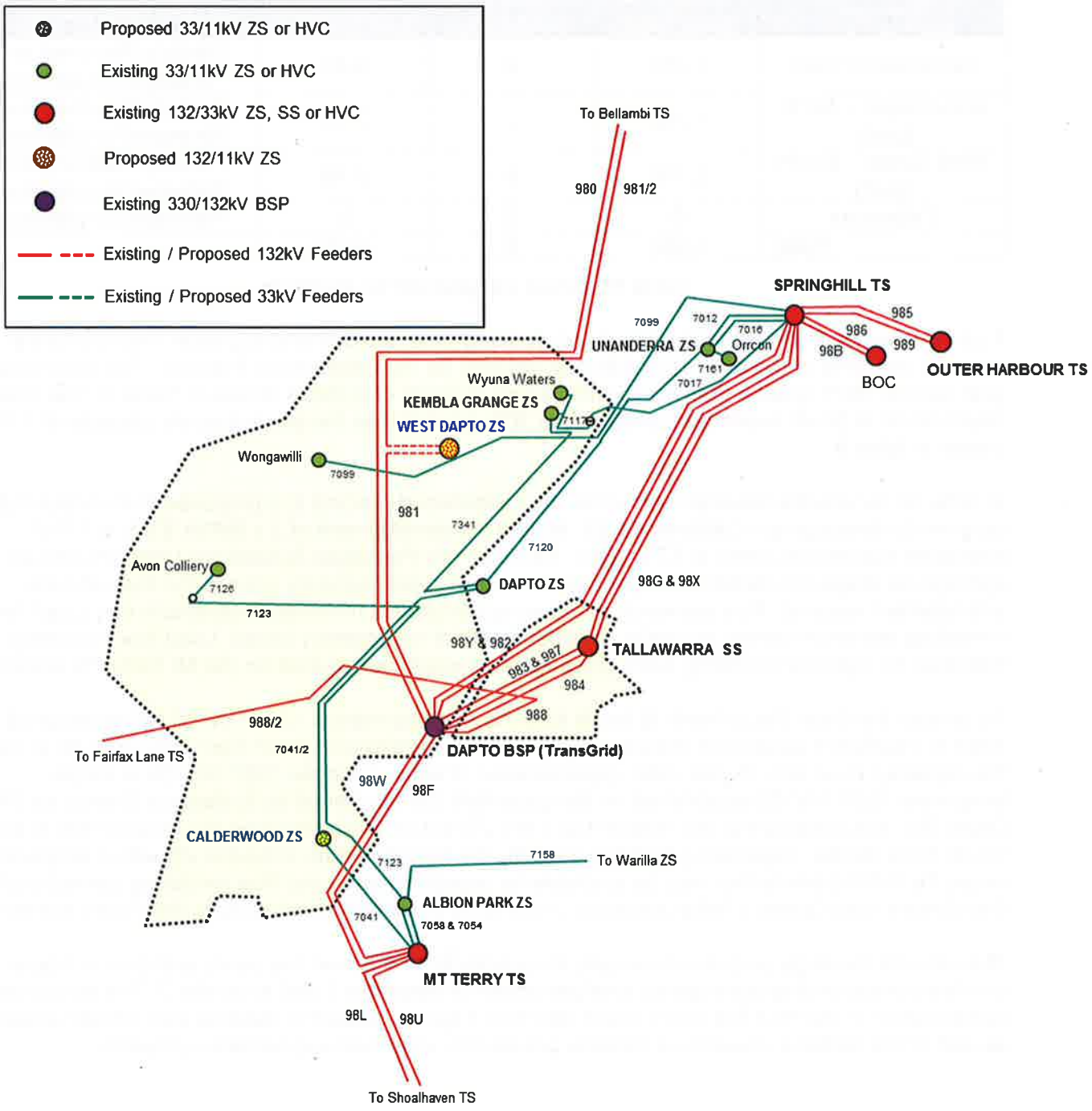


Figure 4: Potential Short-term Network Topology (sketch not to scale)

9.3 Medium-term (ten years) Network Topology

The dwelling yield expected within the next ten years (to summer 2025) has been based on historical and forecast dwelling completions provided by NSW Government Department of Planning & Environment through the Illawarra Urban Development Program update 2014 report . There is more uncertainty surrounding the development of the employment lands, so this has not been allowed for within this timeframe. The expected precinct yields are shown in Table 11.

Precinct	Number of Dwellings	Employment land (km^2)	Expected Load (MVA)	Planning Status
Calderwood (part)	2,800	0	11.2	Partially Rezoned and Released for planning
West Dapto – North (part)	3,580	0	14.32	Partially Rezoned and Released for planning
West Dapto – South (part)	3,580	0	14.32	Partially Rezoned and Released for planning
Tallawarra	0	0	0	Released for planning
Total	9,960	0	39.84	

Table 11: Zoned and planned for precincts

It can be seen in the medium-term (ten years) dwelling yield and demand is greater than the spare capacity available in the existing distribution network for the Calderwood Precinct. The estimated 10-year load is 460% greater than the existing spare capacity of 2.0MVA shown in Table 9. The West Dapto North & South expected 10-year load is 262% greater than the existing spare capacity of 11MVA shown in table 9.

In order to service the development within the Calderwood precinct it is proposed that consideration be given to redeveloping Calderwood ZS as a traditional ZS with 2 x 25MVA transformers and a 33kV bus-bar to facilitate two incoming and two outgoing 33kV feeders. Potentially the 33kV to 11kV packaged substations installed as part of the short-term plan would become redundant. Load flow modelling has been carried out (refer to appendix 10) for contingency tables. Load flow modelling indicates no existing 33kV line augments would be required on the Mt Terry TS system.

To service the increasing West Dapto North & South load the establishment a permanent 132/11kV ZS with 2 x 45MVA transformers would be required to replace the mobile/temporary 132/11kV ZS. This new ZS along with existing Dapto and Kembla Grange ZS's are likely to provide sufficient capacity beyond the medium term 10 year forecast. This will ultimate hinge on economic conditions at the time driving demand. Load flow modelling carried out for the ultimate load Option 1 (refer appendix 3) confirms availability of capacity.

The network topology proposed to supply the precincts for the medium-term is shown in Figure 4, with the corresponding contingency analysis shown in appendix 10 and appendix 3. The actual network configuration in ten years could vary from Figure 5 subject to detailed cost benefit analysis as part of the Network Investment Options process for individual augmentation projects.

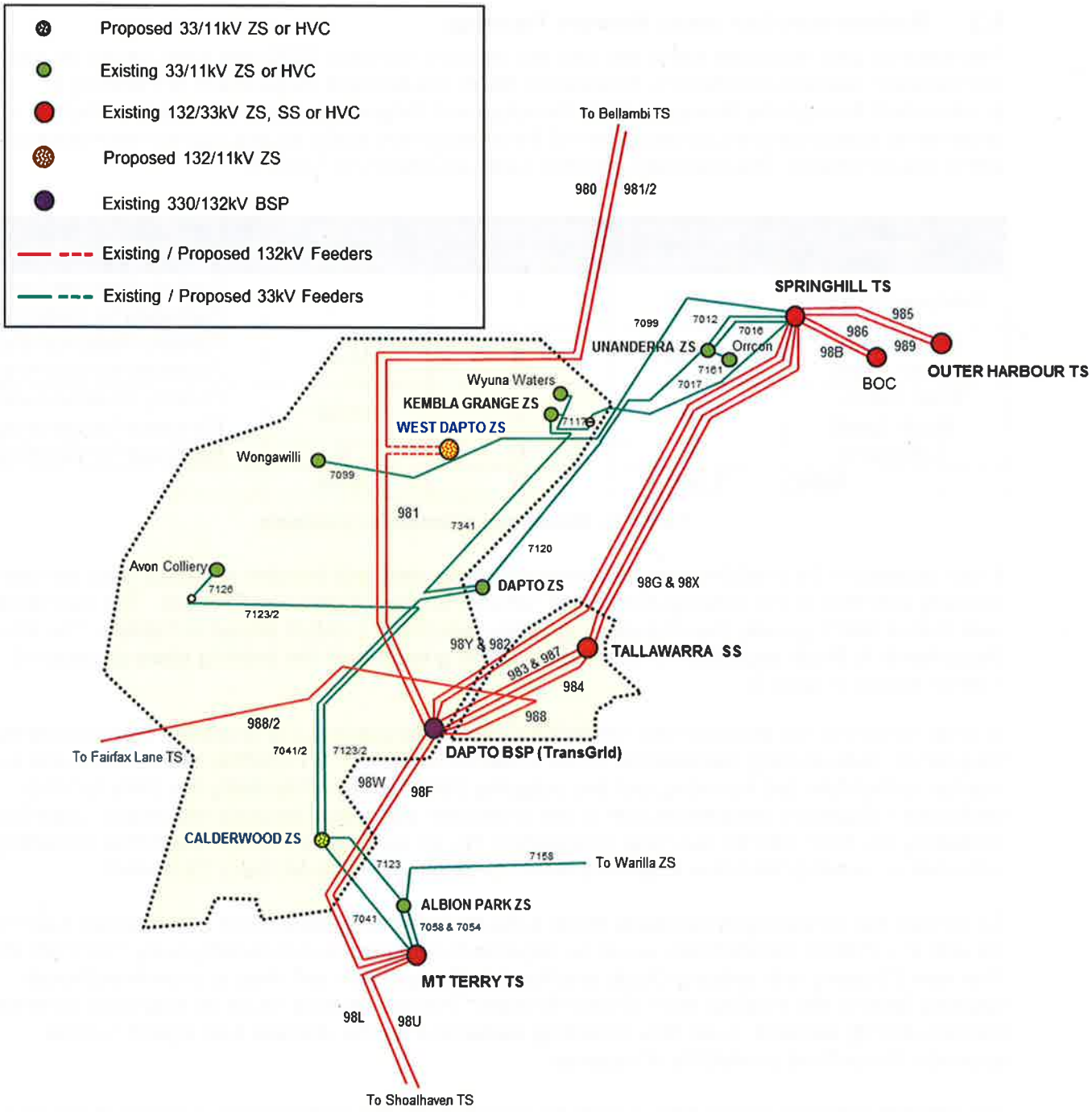


Figure 5: Potential Medium-term Network Topology (sketch not to scale)

10.0 Stakeholder Issues

10.1 TransGrid Works

TransGrid is the Transmission Network Provider in NSW.. The estimated 128MVA of load in the West Lake Illawarra development area will impact TransGrid's network. TransGrid's Dapto BSP will ultimately be required to provide the capacity the development area and the Marulan BSP may be required to provide support under an N-1 contingency should Avondale ZS be connected as a 132/11kV ZS. The issues concerning this option will be progressively explored in future joint planning meetings between the two organisations.

10.2 Developers and Landowners

In order to obtain the appropriate land to build each ZS and the corridors for the connecting feeders, it is important that Endeavour Energy is involved in the subdivision planning stage of the developments. The manner in which developments take place is important from a land acquisition and corridor development perspective. Areas with fragmented land ownership can make the delivery of major infrastructure to large development risky, costly, time inefficient and difficult to achieve. Past experience has shown that these issues can be exacerbated by negotiations with private landowners that have either no vested interest in the development requiring supply or that have no long term view of the infrastructure servicing needs. However, areas of fragmented land ownership are also less likely to develop at a fast pace. It is critical that the following issues be considered and addressed where appropriate base on learnings from past experience:

- Endeavour Energy needs to actively support Department of Planning & Environment in their efforts to coordinate development in areas of fragmented land ownership.
- Early discussions need to be held to determine options for incorporating existing and future infrastructure into precinct master plans (involving the NSW Department of Planning and Environment). This should incorporate the need for relocation and the identification of feasible options where required.
- Zone substation sites and line corridors should be identified on precinct master plans from the outset where appropriate.
- Early strategic acquisition of zone substation sites and transmission line corridors can be advantageous due to lower land prices (pre-rezoning) and fewer environmental constraints (not surrounded by existing residential dwellings). It is also necessary to compare the cost of easement acquisition for overhead transmission lines versus undergrounding or use of the road reserve.
- Transmission line design and construction has a longer lead time than zone substations due to the ability to secure appropriate line routes. Consideration should be given to issuing projects for transmission line design and easement acquisition ahead of approval for final construction of the transmission lines and zone substations.

There is a need to have a consistent process by which the necessary properties and line easements can be acquired. The preferred option would be that suitable substation locations and line corridors are identified at an early stage and these included on precinct master plans. As design work on the development proceeds, final details of sites and corridors can be determined in discussions between developers and Endeavour Energy. Upon finalisation of the infrastructure location, Endeavour Energy

will make arrangements with the developer to acquire the appropriate tenure over the agreed locations.

10.3 General Environmental Considerations

The construction and upgrading of transmission/zone substations and the connecting lines will be assessed under the Environmental Planning and Assessment Act (1979) (the Act). Reviews of Environmental Factors (REFs) will be prepared for all activities and depending on the impacts of the proposals, Environmental Assessments may be required for some of the works and therefore extensive community involvement and community consultation would be required. Depending on the complexity of a project, the Environmental Assessment process can take between 12 – 24 months before environmental approval is obtained and construction of a project can commence. Allowance of sufficient forward planning time is therefore essential. The planning process needs to ensure that electrical infrastructure can be installed in strategic locations and be located adjacent to suitable compatible land uses to minimise the impacts to the environment and the community.

11.0 Recommendations

It is recommended that the following points be adopted:

1. The proposed Ultimate Network Topology – Option 1 (Combined 132kV and 33kV Transmission Solution) outlined within this report be carried forward as the basis for further planning within the West Lake Illawarra development area. Individual projects based on the principles outlined in this report will be developed separately and funding sought for each of these projects at the appropriate level and time.

2. Continue Joint Planning with TransGrid on the establishment of a second transformer at Marulan BSP (note that this is not expected to be required for the West Lake Illawarra development area for some time).

3. Continue to engage in discussions with participants in Illawarra Urban Development Plan (IUDP) committee meetings (mainly the Department of Planning and Environment, Wollongong City Council and Shellharbour City Council) to ensure that zone substation sites and line corridors are included in the development of master plans for the West Lake Illawarra development area.

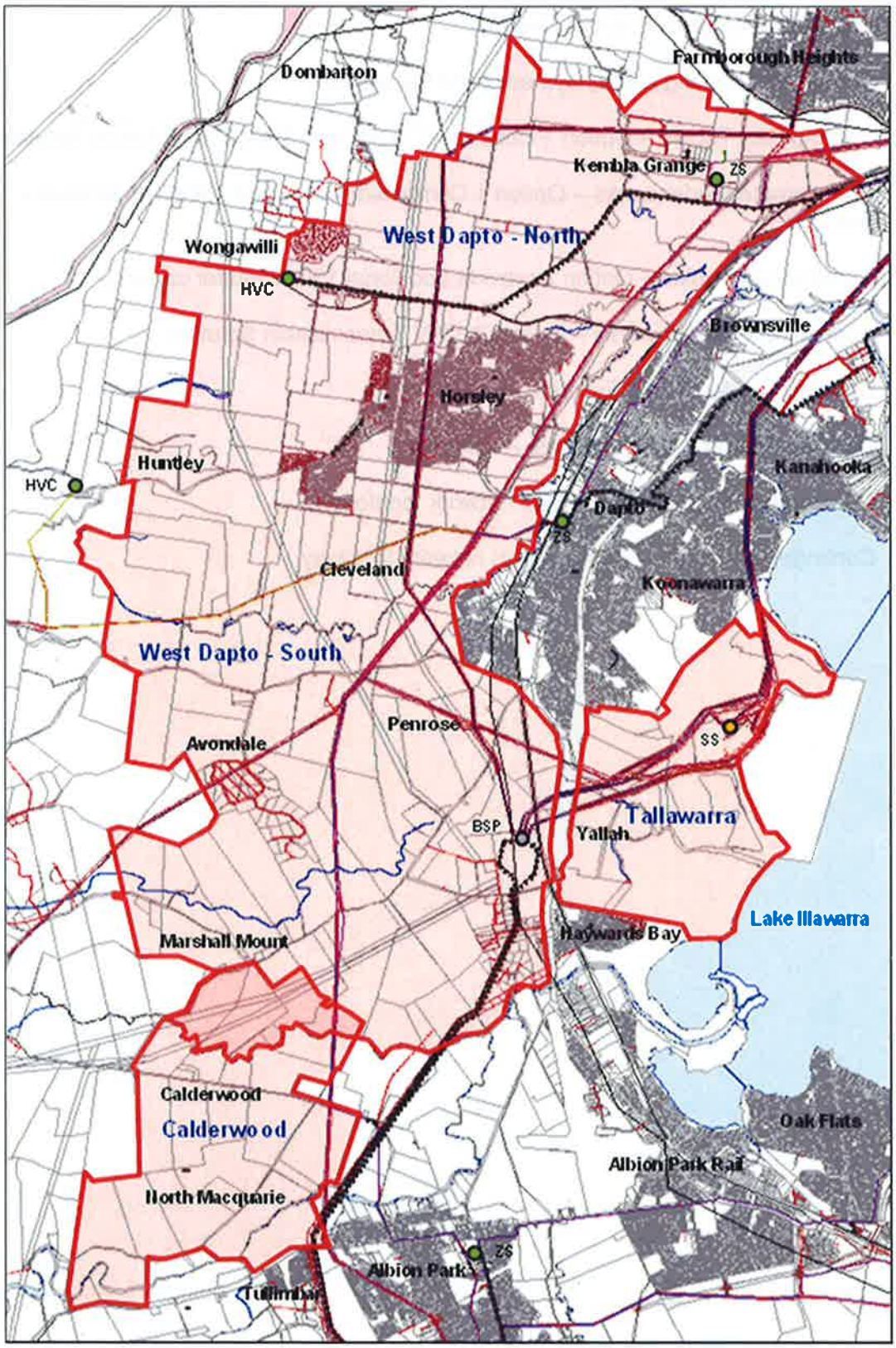
4. Continue discussions with developers and their consultants on an ongoing basis to ensure that Endeavour Energy's staging for the establishment of major infrastructure is in line with projected development timing.

It is noted that demand management initiatives and changes in electricity demand may modify the ultimate load of the West Lake Illawarra development area as well as the timing of the required infrastructure. It has, however, been shown that Option 1 the recommended ultimate network strategy along with the immediate, short and medium-term network strategy's is flexible enough to cater for the uncertainty in the greenfield West lake Illawarra development area.

12.0 Appendices

Appendix 1	West Lake Illawarra Precinct Overlay
Appendix 2	Greenfield Dwelling & Employment Land Forecasts
Appendix 3	Contingency Tables – Option 1 Combined 132kV and 33kV Transmission Solution
Appendix 4	Approximate feeder works – Option 1 Combined 132kV and 33kV Transmission Solution
Appendix 5	Contingency Tables – Option 2 provide additional 132kV feeder capacity
Appendix 6	Approximate feeder works – Option 2 33kV Transmission Solution
Appendix 7	Detailed Feeder Works Estimate – Option 1
Appendix 8	Detailed Feeder Works Estimate – Option 2
Appendix 9	Contingency Tables – Short-term network topology
Appendix 10	Contingency Tables – Medium-term network topology

Appendix 1 West Lake Illawarra Precinct Overlay



Appendix 2 Greenfield Dwelling and Employment Land Forecasts

Release Area	Dwellings	Commercial (km^2)	Industrial (km^2)
Calderwood	6,555	0.500	-
Calderwood #	1,145	-	-
West Dapto	16,999	0.032	1.900
Tallawarra	1,071	0.334	0.334
Total	**25,770**	**0.866**	**2.234**

Table 2.1 Greenfield Land Forecast

Note, 100ha of Calderwood is within the Wollongong LGA

Source: 1. Illawarra Urban Development Program: Update 2013 &
2. Endeavour Energy West Dapto Tallawarra Supply Arrangement Options – Discussion Paper Sep. 20010

Demand Forecast – Existing/Ultimate (MVA)				
Substation	**Firm Rating**	**Summer**		
		Existing		**Ultimate**
		2015	**2025**	**-**
Dapto BSP	**750**	**232**	**232**	**334**
Avondale ZS #	45 #	-	-	45
West Dapto ZS #	45 #	-	-	45
Springhill TS	**240**	**150**	**153**	**168**
Avon Colliery	-	-	-	-
Dapto ZS	45.7 *	25.1	27.4	27.4
I.I. Health Precinct #	Non-Firm	-	-	15.0
Kembla Grange ZS	10	3.4	3.7	3.7
Orrcon	-	-	-	-
Unanderra ZS	24	16.1	16.2	16.2
Wongawilli	-	0.6	0.6	0.6
Wyuna Waters	-	-	-	-
Mt Terry TS	**120**	**65.6**	**101.7**	**127@**
Albion Park ZS	23.2^	17.5	21.5	21.5
Calderwood #	-	-	-	25
Croom (RIC)	-			6.1
Shellharbour	40			28.6
Warilla	20			16.8

Table 2.2 Demand Forecast

Note. 1. # Proposed substations
2. * Capacity limited by 11kV Tx CB's
3. @ Diversity in actual load may prevent load at risk at Mt terry TS.
4. ^ Capacity limited by mismatch in Tx impedance

Appendix 3 Contingency Tables – Option 1 (132kV) Dapto BSP & Marulan BSP

Faulty →	Nil	980	981	981/2	988	988/2	98C	Existing Rating	Proposed Rating
980: DPT BSP to BLLMB TS	41	x	120	68	41	41	41	163	163
981: DPT BSP to WST DPT ZS	75	117	x	51	75	75	75	163	163
981/2: WST DPT ZS to BLLMB TS	27	68	52	x	27	27	27	163	163
988: DPT BSP to VNDL ZS	57	57	57	51	x	51	#137	133	133
988/2: VNDL ZS to TEE1	7	7	7	7	65	x	85	133	133
98C: MRLN TG to FRFX LN	76	-	-	-	151	-	x	168	168

Table 3.1 Loads (MVA) - Contingency analysis Dapto BSP & Marulan BSP

Faulty →	Nil	980	981	981/2	988	988/1	98C	Min.	Max.
Dapto BSP 132kV	105.3	105.2	104.9	104.9	105.3	105.4	104.8	90	110
Dapto BSP Tap	14	14	14	14	14	14	15	1	
West Dapto ZS 132kV	104.6	104.1	98.5	104.6	104.5	104.7	104.1	90	110
West Dapto ZS 33kV	100.5	99.8	98.8	98.9	100.4	100.6	99.8	90	110
West Dapto Tap	13	13	17	12	13	13	13	1	31
Bellambi TS 132kV	104.3	102.8	100.5	103.6	104.2	104.4	103.7	90	110
Bellambi TS 33kV	104.3	102.8	103.0	103.6	104.2	104.4	103.8	90	110
Bellambi TS Tap	6	6	8	6	6	6	6	1	17
Avondale ZS 132kV	104.6	104.4	104.1	104.5	*,#87.5	104.7	103.1	90	110
Avondale ZS 33kV	100.5	98.6	99.9	99.7	*,#89.7	100.7	101.2	90	110
Avondale Tap	13	12	13	12	22	13	14	1	31
Burrawang HVC 132kV	104.3	104.1	103.8	104.2	91.1	-	100.7	90	110
Burrawang HVC 33kV	N/A	N/A	N/A	N/A	N/A	-	N/A	-	-
Burrawang Tap	N/A	N/A	N/A	N/A	N/A	-	N/A	-	-
Fairfax Lane TS 132kV	100.3	-	-	-	92.9	100.3	102.2	90	110
Fairfax Lane TS 33kV	105.9	-	-	-	105.3	105.9	106.2	90	110
Fairfax Lane Tap	11	-	-	-	16	11	13	1	17
Marulan TG 132kV	104.5	-	-	-	102.8	104.5	-	90	110
Marulan TG Tap	27	-	-	-	^,#31	27	-	1	31

Table 3.2 Voltages and Tx. Taps - Contingency analysis with Dapto BSP & Marulan BSP

Notes:
1. A shaded result indicates a constraint
2. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV.
3. * Voltage exceeds NER mandated -10% voltage tolerance
4. ^ Substation Transformer has reached maximum boost tap
5. # The installation of reactive support (15MVAr) at Avondale ZS will overcome constraints
6. Marulan TG has only one (160MVA) transformer installed

Contingency analysis tables 3.1 and 3.2 were produced using DINIS file "West_Lake_Illawarra_Dapto_BSP_N.per".

Cont'd Contingency Tables – Option 1 (33kV) Mt Terry TS

Faulty →	Nil	7054	7058	7158	7041	7123	7041/2	7123/2	7004	7059	7047	7147	7041/3	T'fer HP & DAPTO Tx 3	Existing Rating	Proposed Rating
7054: MT TRRY to LBN PRK	25	x	41	18	33	20	-	-	27	19	28	27	29	31	45.7	45.7
7058: MT TRRY to LBN PRK	21	40	x	15	29	17	-	-	23	23	24	23	25	27	45.7	45.7
7158: LBN PRK to WRLL	14	13	13	x	13	14	-	-	18	19	20	19	14	14	~~19.7~~ (32.0)	32.0
7041: MT TRRY to CLDRWD	17	22	21	15	x	27	-	-	17	17	17	17	24	**28**	27.4	(46.0)
7123: LBN PRK to CLDRWD	10	5	6	11	**27**	x	-	-	9	9	9	9	**18**	**22**	16.8	(46.0)
7041/2: CLDRWD to HP HVC	S/B	-	-	-	-	-	x	-	-	-	-	-	15	23	27.4	27.4
7123/2: LBN PRK to PN BND AT PL 4AV794	-	-	-	-	-	-	-	x	-	-	-	-	-	-	16.8	16.8
7004: SHLLHRBR to WRLL	4	5	5	17	4	3	-	-	x	2	3	2	4	4	~~19.7~~ (32.1)	32.1
7059: MT TRRY to SHLLHRBR	16	17	16	22	16	16	-	-	15	x	26	24	16	16	33.2	33.2
7047: MT TRRY to CRM SS	19	20	20	26	20	19	-	-	18	28	x	3	20	20	33.2	33.2
7147: CRM SS to SHLLHRBR	16	16	16	22	16	16	-	-	14	24	3	x	16	16	33.2	33.2
7041/3: HP HVC to DPT	-	-	-	-	-	-	-	-	-	-	-	-	x	7	27.4	27.4

Table 3.3 Loads (MVA) - Contingency Analysis Mt Terry TS

Notes:
1. A shaded result indicates a constraint
2. Brackets (46.0) indicate either approved project rating or proposed future rating

Cont'd Contingency Tables – Option 1 (33kV) Mt Terry TS

Faulty →	Nil	7054	7058	7158	7041	7123	7041/2	7123/2	7004	7059	7047	7147	7041/3	T'fer DAPTO Tx 3	Min.	Max.
Mt Terry TS 33kV	102.5	102.5	102.5	102.2	102.3	102.3	-	-	102.3	101.9	103.1	102.0	103.9	103.1	90	110
Mt Terry TS Tap	8	8	8	8	8	8	-	-	8	8	9	8	9	9	1	17
Albion Park ZS 33kV	101.8	101.1	101.3	101.7	101.4	101.8	-	-	101.5	101.1	102.3	101.2	103.0	102.2	90	110
Albion Park ZS 11kV	99.3	99.8	100.0	99.1	98.8	99.2	-	-	98.9	99.8	101.0	99.9	100.5	101.0	90	110
Albion Park Tap No. Tx 3 & 2	3	3	3	3	3	3	-	-	3	3	3	3	2	3	1	15
Albion Park Tap No. Tx 1	3	4	4	3	3	3	-	-	3	4	4	4	3	4	1	15
Calderwood ZS 33kV	101.3	100.9	101.0	101.1	100.1	100.3	-	-	101.0	100.6	101.8	100.7	102.2	101.3	90	110
Calderwood ZS11kV	99.6	99.1	99.2	99.4	99.8	98.5	-	-	99.3	98.9	100.2	99.0	100.6	101.1	90	110
Calderwood ZS Tap	9	10	10	10	11	10	-	-	10	10	10	10	10	11	1	22
I.I. Health Precinct HVC 33kV	-	-	-	-	-	-	-	-	-	-	-	-	100.7	99.0	90	110
I.I. Health Precinct HVC Tap	-	-	-	-	-	-	-	-	-	-	-	-	N/A	N/A	N/A	N/A
Shellharbour ZS 33kV	99.8	99.6	99.6	98.3	99.5	99.6	-	-	99.9	97.6	98.6	97.7	101.1	100.3	90	110
Shellharbour ZS 11kV	99.7	100.8	100.9	100.9	100.8	100.9	-	-	99.8	100.2	101.2	100.2	101.1	101.6	90	110
Shellharbour Tap No. Tx 1 & 2	4	5	5	6	5	5	-	-	4	6	6	6	4	5	1	15
Shellharbour Tap No. Tx 3	9	10	10	11	10	10	-	-	9	11	11	11	9	10	1	22
Warilla ZS 33kV	99.2	98.2	98.9	96.3	98.9	99.1	-	-	97.8	97.5	98.6	97.6	100.5	99.7	90	110
Warilla ZS 11kV	100.1	99.7	99.8	100.9	99.7	99.9	-	-	99.8	100.9	100.7	99.7	101.5	102.0	90	110
Warilla ZS Tap	5	8	5	8	5	5	-	-	6	7	6	6	5	6	1	15
Dapto ZS Tx 3 33kV	-	-	-	-	-	-	-	-	-	-	-	-	-	98.7	90	110
Dapto ZS Tx 3 11kV	-	-	-	-	-	-	-	-	-	-	-	-	-	102.2	90	110
Dapto ZS Tap	-	-	-	-	-	-	-	-	-	-	-	-	-	11	1	22

Table 3.4 Voltages and Tx. Taps - Contingency analysis with Mt Terry TS

Notes:
1. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV.

Contingency analysis tables 3.3 and 3.4 were produced using DINIS file "West_Lake_Illawarra_Mt_Terry.per".

Cont'd Contingency Tables – Option 1 (33kV) Springhill TS

Faulty →	Nil	7012	7016	7120	No.1	7017	7341	7041/3	Existing Rating	Proposed Rating
7012: SPRNGHLL TS to NNDRR ZS	20	x	40	32	19	19	10	16	44.4	44.4
7016: SPRNGHLL TS to NNDRR ZS	22	**40**	x	34	20	20	10	17	33.2	(46.0)
7120: SPRNGHLL TS to DPT ZS	23	24	24	x	26	26	**45**	15	33.2	(46.0)
No.1: NNDRR ZS to KML GRNG ZS	13	12	12	25	x	22	2	8	-	(46.0)
7017: NNDRR ZS to ABS 73318	12	12	12	24	22	x	2	8	33.2	33.2
7341: KML GRNG ZS to DPT ZS	21	20	20	**45**	18	18	x	13	32.1	(46.0)
7041/3: DPT ZS to HP HVC	15	15	15	15	15	15	15	X	27.4	27.4
7099: SPRNG HLL to WNGWLL MN HVC 28295	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	32.9	32.9

Table 3.5 Loads (MVA) - Contingency Analysis Springhill TS

Faulty →	Nil	7012	7016	7120	No.1	7017	7341	7041/3	Min.	Max.
Springhill TS 33kV	100.1	100.0	100.0	99.6	100.0	100.0	99.7	99.5	90	110
Springhill TS Tap	5	5	5	5	5	5	5	5	1	21
Dapto ZS 33kV	97.1	96.9	96.9	92.3	96.6	96.6	94.6	97.6	90	110
Dapto ZS 11kV	101.6	99.8	99.7	100.6	99.4	99.5	101.0	100.5	90	110
Dapto ZS Tap	12	11	11	14	11	11	14	11	1	22
I.I. Health Precinct HVC 33kV	96.3	96.1	98.4	92.4	95.8	95.8	92.7	0.0	90	110
I.I. Health Precinct HVC Tap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kembla Grange 33kV	98.8	98.5	98.4	97.0	98.0	98.0	99.3	98.6	90	110
Kembla Grange 11kV	100.7	99.1	99.1	98.9	99.9	99.9	100.0	100.5	90	110
Kembla Grange Tap	7	6	6	7	7	7	6	7	1	17
Unanderra ZS 33kV	99.7	99.4	99.3	99.0	99.7	99.7	99.5	99.2	90	110
Unanderra ZS 11kV	100.7	100.3	100.3	100.0	100.6	100.7	100.5	101.5	90	110
Unanderra Tap No. Tx 3 & 2	5	5	5	5	5	5	5	6	1	15
Wongawilli Mine HVC 28295 33kV	100.0	99.9	99.9	99.5	99.9	99.9	99.6	99.4	90	110
Wongawilli Mine HVC 28295 11kV	101.3	101.0	99.8	100.9	99.7	99.8	99.4	100.7	90	110
Wongawilli Mine HVC 28295 Tap	9	8	8	9	8	8	8	9	1	22

Table 3.6 Voltages and Tx. Taps - Contingency analysis with Springhill TS

Notes:
1. A shaded result indicates a constraint
2. Brackets (46.0) indicate either approved project rating or proposed future rating
3. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV

Contingency analysis tables 3.5 and 3.6 were produced using DINIS file "Wst_Lk_Ilwrr_Sprnghll_Op1_B.per".

Appendix 4 Approximate feeder works - Option 1 Combined 132kV and 33kV Transmission Solution

132kV Feeder Works	Construct New (km)	Augment (km)	Total Works (km)
Dapto BSP to West Dapto ZS	4.5	-	4.5
Mt Terry TS to Avondale ZS	2.0	-	2.0
Sub Total (1)	*6.5*	-	*6.5*
33kV Feeder Works	**Construct New (km)**	**Augment (km)**	**Total Works (km)**
Mt Terry TS to Calderwood ZS	1.3	7.1	8.4
Springhill TS to Unanderra ZS	-	1.3	1.3
Springhill TS to Kembla Grange ZS	-	6.7	6.7
Unanderra ZS to Kembla Grange ZS	5.3	-	5.3
Unanderra ZS to Dapto ZS	-	8.1	8.1
Kembla Grange ZS to Dapto ZS	-	6.0	6.0
Sub Total (2)	*6.6*	*29.2*	*35.7*
Total	***13.1***	***29.2***	***42.3***

Table 4.1 Approximate feeder works – Option 1

Appendix 5 Contingency Tables – Option 2 (33kV) Springhill TS

Faulty →	Nil	7012	7016	7120	7017	No.1	No.2	7341	7341/2	7041/3	7099	Existing Rating	Proposed Rating
7012: SPRNGHLL TS to NNDRR ZS	19	x	37	24	8	23	23	10	16	17	19	44.4	44.4
7016: SPRNGHLL TS to NNDRR ZS	20	**37**	X	25	9	**33**	33	10	18	19	20	33.2	(46.0)
7120: SPRNGHLLTS to DPT ZS	30	30	30	x	**34**	**35**	**35**	**34**	**46**	22	30	33.2	(46.0)
7017: NNDRR ZS TS to ABS 73318	23	21	20	**33**	x	32	32	4	18	20	23	33.2	(46.0)
No .1: SPRNGHLL TS to WST DPT ZS	26	26	26	37	35	x	37	34	20	23	26	-	(46.0)
No. 2: SPRNGHLL TS to WST DPT ZS	26	26	26	37	35	37	x	34	20	23	26	-	(46.0)
7341: KML GRNG ZS to WST DPT ZS	19	17	16	28	4	28	28	x	14	14	19	32.1	32.1
7341/2: WST DPT ZS to DPT ZS	15	15	15	**44**	11	10	10	12	x	7	15	32.1	(46.0)
7041/3: DPT ZS to HP HVC	15	15	15	15	15	15	15	15	15	x	15	27.4	27.4
7099: SPRNG HLL to WNGWLL MN HVC 28295	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	x	32.9	32.9

Table 5.1 Loads (MVA) - Contingency analysis Springhill TS

Notes:
1. A shaded result indicates a constraint
2. Brackets (46.0) indicate either approved project rating or proposed future rating

Cont'd Contingency Tables – Option 2 (33kV) Springhill TS

Faulty →	Nil	7012	7016	7120	7017	No.1	No.2	7341	7341/2	7041/4	7099	*Min.*	Max.
Springhill TS 33kV	99.3	99.3	99.3	99.7	100.3	100.3	100.3	99.1	99.1	99.9	99.3	*90*	110
Springhill TS Tap	10	8	8	9	9	9	9	8	8	7	10	1	21
Dapto ZS 33kV	94.5	95.0	95.0	91.1	95.4	95.1	95.1	94.2	93.0	96.8	94.5	90	110
Dapto ZS 11kV	100.1	100.9	100.9	99.8	101.3	101.0	101.0	99.9	100.3	99.7	100.1	90	110
Dapto ZS Tap	13	13	13	15	13	13	13	13	14	11	13	1	22
I.I. Health Precinct HVC 33kV	93.6	94.2	94.1	90.2	94.5	94.3	94.3	93.3	92.1	-	93.6	90	110
I.I. Health Precinct HVC Tap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kembla Grange 33kV	94.4	94.6	94.5	94.1	94.6	96.7	96.7	98.5	96.9	97.7	94.4	90	110
Kembla Grange 11kV	99.5	99.7	99.7	99.2	100.1	101.1	101.1	99.2	100.0	99.6	99.5	90	110
Kembla Grange Tap	8	8	8	8	9	9	9	6	8	7	8	1	17
Unanderra ZS 33kV	101.1	101.4	101.4	99.2	100.2	99.8	99.8	98.8	98.8	100.4	101.1	90	110
Unanderra ZS 11kV	100.9	100.8	100.8	100.2	101.2	102.1	102.1	99.8	101.0	100.6	100.9	90	110
Unanderra Tap No. Tx 3 & 2	6	6	6	5	5	6	6	6	6	5	6	1	15
West Dapto 33kV	95.5	93.9	93.9	94.9	95.8	95.5	95.5	94.7	96.2	97.0	95.5	90	110
West Dapto 11kV	100.7	100.4	100.4	100.9	102.0	101.6	101.6	100.6	100.8	100.1	100.7	90	110
West Dapto Tap	16	15	15	16	16	16	16	16	15	14	16	1	22
Wongawilli Mine HVC 28295 33kV	99.2	99.2	99.2	99.6	100.2	100.2	100.2	99.0	99.0	99.8	-	90	110
Wongawilli Mine HVC 28295 11kV	100.6	100.5	100.5	99.5	101.6	101.6	101.6	100.3	100.3	99.7	-	90	110
Wongawilli Mine HVC 28295 Tap	9	9	9	8	9	9	9	9	9	8	-	1	22

Table 5.2 Voltages and Tx. Taps - Contingency analysis with Springhill TS

Notes:
1. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV.

Contingency analysis tables 5.1 and 5.2 were produced using DINIS file "Wst_Lk_Ilwrr_Springhill_Op_2C2".

Cont'd Contingency Tables – Option 2 (33kV) Mt Terry TS

Faulty →	Nil	#7054	#7058	7158	7041	No.4	7123	No. 3	7123/2	7041/2	7004	7059	7047	7147	Existing Rating	Proposed Rating
7054: MT TRRY to LBN PRK	30	x	42	23	30	30	20	43	-	-	32	32	33	33	45.7	45.7
7058: MT TRRY to LBN PRK	26	42	x	20	26	26	17	35	-	-	28	28	29	28	45.7	45.7
7158: LBN PRK to WRLL	14	-	-	X	14	14	14	13	-	-	18	18	20	18	~~19.7~~ (32.0)	(32.0)
7041: Mt TRRY to CLDRWD	16	16	16	16	x	**27**	16	16	-	-	16	16	16	16	27.4	(46.0)
No. 4: MT TRRY to CLDRWD	11	11	11	11	27	x	11	11	-	-	11	11	11	11	-	(46.0)
7123: LBN PRK to VNDL	**20**	**19**	**20**	**21**	**20**	**20**	x	**40**	-	-	**20**	**20**	**20**	**20**	16.8	(46.0)
No. 3: MT TRRY to VNDL	18	20	19	18	18	18	**41**	X	-	-	18	18	19	18	-	(46.0)
7123/2: VNDL to PN BND AT PL 4AV794	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16.8	16.8
7041/2: CLDRWD to HP HVC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.4	27.4
7004: SHLLHRBR to WRLL	4	17	17	17	4	4	3	5	-	-	x	2	3	2	~~19.7~~ (32.1)	32.1
7059: MT TRRY to SHLLHRBR	16	22	22	22	16	14	16	16	-	-	15	x	26	24	33.2	33.2
7047: MT TRRY to CRM SS	20	26	26	26	20	20	19	20	-	-	18	28	x	3	33.2	33.2
7147: CRM SS to SHLLHRBR	16	22	22	22	16	16	16	16	-	-	14	24	3	x	33.2	33.2

Table 6.1 Loads (MVA) - Contingency Analysis Mt Terry TS

Notes:
1. A shaded result indicates a constraint
2. Brackets (46.0) indicate either approved project rating or proposed future rating
3. # for an outage on feeder 7054 & 7058 use NON STANDARD automated SCADA routine to open off 7158 to reduce overload (52MVA) on 7054 & 7058. Otherwise duplicate 7054 such that 7158 is direct feeder form MT Terry TS to Warilla ZS.

Cont'd Contingency Tables – Option 2 (33kV) Mt Terry TS

Faulty →	Nil	#7054	#7058	7158	7041	No.4	7123	No. 3	7123/2	7041/2	7004	7059	7047	7147	Min.	Max.
Mt Terry TS 33kV	102.7	102.5	102.5	102.5	102.6	102.7	102.2	102.3	-	-	102.7	102.5	102.5	102.5	90	110
Mt Terry TS Tap	9	9	9	9	9	9	9	9	-	-	9	9	9	9	1	17
Albion Park ZS 33kV	101.9	101.4	101.4	101.9	101.9	101.9	101.7	101.2	-	-	101.9	101.7	101.6	101.7	90	110
Albion Park ZS 11kV	100.0	99.4	99.4	100.0	99.9	100.0	99.8	100.5	-	-	99.9	99.8	99.7	99.7	90	110
Albion Park Tap No. Tx 3 & 2	3	3	3	3	3	3	3	4	-	-	3	3	3	3	1	15
Albion Park Tap No. Tx 1	3	3	3	3	3	3	3	4	-	-	3	3	3	3	1	15
Calderwood ZS 33kV	101.7	101.5	101.5	101.5	100.5	100.9	98.8	101.3	-	-	101.7	101.6	101.5	101.5	90	110
Calderwood ZS11kV	99.1	98.8	98.8	98.9	98.8	99.7	100.0	100.2	-	-	99.1	98.9	98.8	98.9	90	110
Calderwood ZS Tap	9	9	9	9	10	10	10	10	-	-	9	9	9	9	1	22
Avondale ZS 33kV	89.9	98.4	98.4	98.8	98.8	98.8	93.7	94.7	-	-	98.8	98.7	98.6	98.6	90	110
Avondale ZS 11kV	101.7	101.1	101.1	101.6	101.6	101.6	100.4	101.7	-	-	101.6	101.4	101.3	101.4	90	110
Avondale Tap	14	14	14	14	14	14	17	17	-	-	14	14	14	14	1	22
Shellharbour ZS 33kV	100.3	99.0	99.0	99.1	100.2	100.2	98.8	98.8	-	-	100.6	98.8	98.4	98.7	90	110
Shellharbour ZS 11kV	100.3	100.5	100.5	100.5	100.2	100.3	99.8	99.8	-	-	100.7	100.2	99.8	100.1	90	110
Shellharbour Tap No. Tx 1 & 2	4	5	5	5	4	4	4	5	-	-	4	5	5	5	1	15
Shellharbour Tap No. Tx 3	9	10	10	10	9	9	9	10	-	-	9	6	10	10	1	22
Warilla ZS 33kV	99.7	97.3	97.3	97.3	99.6	99.7	99.3	98.1	-	-	98.6	98.7	98.4	98.6	90	110
Warilla ZS 11kV	100.8	100.8	100.8	100.8	100.7	100.7	100.4	101.5	-	-	100.9	101.0	100.6	100.9	90	110
Warilla ZS Tap	5	7	7	7	5	5	5	6	-	-	6	6	6	6	1	15

Table 6.2 Voltages and Tx. Taps - Contingency analysis with Mt Terry TS

Notes:
1. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV.

Contingency analysis tables 6.1 and 6.2 were produced using DINIS file "Wst_Lk_Illwrr_Mt_Tery_Op_2B.pe

Appendix 6 Approximate feeder works - Option 2 33kV Transmission Solution

33kV Feeder Works	Construct New (km)	Augment (km)	Total Works (km)
Springhill TS to West Dapto ZS	15.2	-	17.8
Dapto ZS to West Dapto ZS	1.3	-	1.3
Kembla Grange ZS to West Dapto ZS	1.3	2.8	4.1
Mt Terry TS to Avondale ZS	8.9	-	8.9
Albion Park ZS to Avondale ZS	0.2	7.5	7.7
Mt Terry TS to Calderwood ZS	8.0	4.6	12.6
II Health Precinct HVC to Calderwood ZS	0.2	7.0	7.2
Springhill TS to Kembla Grange ZS	-	6.6	6.6
Springhill TS to Unanderra ZS	-	1.3	1.3
Unanderra ZS to Dapto ZS	-	8.1	8.1
Total	***35.1***	***37.9***	***73.0***

Table 6.1 Approximate feeder works – Option 2

Appendix 7 Detailed Feeder Works Estimate - Option 1

Option 1: 132kV & 33kV Feeder Connection Works

Element Required	Feeder Linkage	Element Existing	Construct Construct	Augment Augment	Redundant / Remove	Rating (S) - MVA Existing	Rating (S) - MVA Proposed	Length km	Details
Feeder Works Required to Establish 2 x 132kV & 1 x 33kV ZS's "Option 1"									
West Dapto ZS						Nil	2 x 45		Establish 2 x 45MVA ZS
New_981	**Dapto BSP** to West Dapto ZS	981	√			163	163	2.25	Construct new section of 132kV feeder to West Dapto ZS
New_981/2	**West Dapto ZS** to Bellambi TS	981	√			163	163	2.25	Construct new section of 132kV feeder to West Dapto ZS
							Sub Total	*4.50*	
							Total	***4.50***	
Avondale ZS						Nil	2 x 45		Establish 2 x 45MVA ZS
988	**Dapto BSP** to Avondale ZS	988				133		6.70	# Install Reactive Support 15MVAr at Avondale ZS
New_988	**Dapto BSP** to Avondale ZS	988	√			133	163	1.00	Construct new section of 132kV feeder to Avondale ZS
New_988/2	**Avondale ZS** to Fairfax Lane TS	988	√			139	163	1.00	Construct new section of 132kV feeder to Avondale ZS
							Sub Total	*2.00*	
							Total	***2.00***	
Calderwood ZS						Nil	2 x 25		Establish 2 x 25MVA ZS
New_7041	**Mt Terry TS** to Calderwood ZS	7041	√			0.0	46	1.10	Construct new along Calderwood Rd tryout of Calderwood ZS
New_7123	**Mt Terry TS** to Calderwood ZS	7041	√			0.0	46	0.20	Construct new along Calderwood Rd tryout of Calderwood ZS
7041_A	**Mt Terry TS** to Calderwood ZS	7041		√		28.0	46	1.21	Augment Existing
7041_B	**Mt Terry TS** to Calderwood ZS	7041		√		27.4	46	2.91	Augment Existing
7041_C (Part)	**Mt Terry TS** to Calderwood ZS	7041		√		27.4	46	0.48	Augment Existing
							Sub Total	*5.90*	
7123_A	**Calderwood ZS** to Albion Park ZS	7123		√		16.8	46	1.53	Augment Existing
7123_B (Part)	**Calderwood ZS** to Albion Park ZS	7123		√		16.8	46	0.97	Augment Existing
							Sub Total	*2.50*	
							Total	***8.40***	
Unanderra ZS						24			
7016_A	**Springhill TS** to Unanderra ZS	7016				50	46	0.36	
7016_B	**Springhill TS** to Unanderra ZS	7016		√		33.2	46	0.96	Augment Existing
							Sub Total	*1.32*	
New_No_1	**Unanderra ZS** to Kembla Grange ZS		√			Nil	46	5.33	Construct new 33kV feeder Springhill TS to West Dapto ZS
							Sub Total	*5.33*	
							Total	***6.65***	
Kembla Grange ZS						10			
7017_A	**Springhill TS** to ABS 73318	7017_A				50			
7017_B	**Springhill TS** to ABS 73318	7017_B		√		33.2	55	0.19	Augment Existing
7017_C	**Springhill TS** to ABS 73318	7017_C		√		46.3	55	0.23	Augment Existing
7017_D	**Springhill TS** to ABS 73318	7017_D		√		46.3	55	1.50	Augment Existing
7017_E	**Springhill TS** to ABS 73318	7017_E		√		35.2	55	0.41	Augment Existing
							Sub Total	*5.33*	
7117_A	**ABS 73318** to Tee 1	7117_A		√		35.1	55	0.63	Augment Existing
7117_B	**ABS 73318** to Tee 1	7117_B		√		35.1	55	0.34	Augment Existing
7117_C	**Tee 1** to Kembla Grange ZS	7117_C		√		35.1	55	0.03	Augment Existing
7117_D	**Tee 1** to ABS 91828	7117_D		√		33.2	55	0.27	Augment Existing
							Sub Total	*1.27*	
									Split feeders 7017 and 7120 where they cross and redirect lines to create direct link from Springhill TS to Dapto ZS (estimate $200k)
							Total	***6.60***	
Dapto ZS						45.7			
7120_A	**Unanderra ZS** to Dapto ZS	7120_A		√		33.2	55	0.45	Augment Existing
7120_B	**Unanderra ZS** to Dapto ZS	7120_B		√		43.4	55	0.30	Augment Existing
7120_C	**Unanderra ZS** to Dapto ZS	7120_C		√		33.2	55	2.59	Augment Existing
7120_D	**Unanderra ZS** to Dapto ZS	7120_D		√		41.2	55	0.22	Augment Existing
7120_E	**Unanderra ZS** to Dapto ZS	7120_E		√		33.2	55	4.56	Augment Existing
7120_F	**Unanderra ZS** to Dapto ZS	7120_F		√		41.1	55	0.02	Augment Existing
							Sub Total	*8.08*	
									Split feeders 7017 and 7120 where they cross and redirect lines to create direct link from Springhill TS to Dapto ZS (estimate $200k)
7341_A	**Kembla Grange ZS** to Dapto ZS	7341_A		√		41.4	46	0.40	Augment Existing
7341_B	**Kembla Grange ZS** to Dapto ZS	7341_B		√		32.1	46	0.17	Augment Existing
7341_C	**Kembla Grange ZS** to Dapto ZS	7341_C		√		45.2	46	4.30	Augment Existing
7341_D	**Kembla Grange ZS** to Dapto ZS	7341_D		√		45.2	46	0.16	Augment Existing
7341_E	**Kembla Grange ZS** to Dapto ZS	7341_E		√		32.1	46	0.77	Augment Existing
7341_F	**Kembla Grange ZS** to Dapto ZS	7341_F		√		41.1	46	0.22	Augment Existing
							Sub Total	*6.02*	
							Total	***14.10***	

West Lake Illawarra	**Summary**	1. 132kV Feeder Construction	√	Total	6.6
		1. 132kV Feeder Augment	√	Total	
		2. 33kV Feeder Configuration	√	Total	
		3. 33kV Feeder Construction	√	Total	6.6
		4. 33kV Feeder Augment	√	Total	29.1
	Dinis Model:			**Total Feeder Works**	**42.3**

Copy of Line_Works_v3.xlsx

Appendix 8 Detailed Feeder Works Estimate - Option 2

Option 2: 33kV Feeder Connection Works

Element Required	Feeder Linkage	Element Existing	Works Required to Establish 3 x 33kV ZS's "Option 2"						
			Construct	Augment	Redundant / Remove	Rating (%) - MVA Existing	Rating (%) - MVA Proposed	Length km	Details
West Dapto ZS						Nil	3 x 25		Establish 2 x 25MVA with scope for 3 x 25MVA for firm 50MVA ZS
New_No.1	Springhill TS to West Dapto ZS		√			Nil	46	7.60	Construct new 33kV feeder Springhill TS to West Dapto ZS
							Sub Total	7.60	
New_No.2	Springhill TS to West Dapto ZS		√			Nil	46	7.60	Construct new 33kV feeder Springhill TS to West Dapto ZS
							Sub Total	7.60	
7341	Dapto ZS to West Dapto ZS	7341				32.1			
			√				46	1.30	Darkes Rd to West Dapto ZS
							Sub Total	1.30	
7341/2	West Dapto ZS to Kembla Grange ZS	7341		√		32.1	46	2.80	Augment Existing
			√				46	1.30	Darkes Rd to West Dapto ZS
							Sub Total	4.10	
							Total	**23.60**	
Avondale ZS						Nil	2 x 25		Establish 2 x 25MVA ZS
New_No.3	Mt Terry TS to Avondale ZS		√				46	0.90	Construct new 33kV feeder Mt Terry TS to Avondale ZS
							Sub Total	0.90	
New_7123	Albion Park ZS to Avondale ZS	7123		√		16.9	46	7.50	Augment Existing
			√				46	0.30	Augment Existing
							Sub Total	7.70	
New_7123 #2	Avondale ZS to Avon Colliery	7123				16.9	16.9	0.00	No augment required
							Sub Total	0.00	
							Total	**16.60**	
Calderwood ZS						Nil	2 x 25		Establish 2 x 25MVA ZS
7041	Mt Terry TS to Calderwood ZS	7041		√		27.4	46	4.80	Augment Existing
			√				46	0.40	New Section
							Sub Total	5.20	Augment Existing
New_7041 / 2	Calderwood ZS to Illawarra Precinct	7041		√		27.4	46	7.00	Augment Existing
			√				46	0.20	New Section
							Sub Total	7.20	
New_No_4	Mt Terry TS to Calderwood ZS		√			Nil	46	7.60	Construct new 33kV feeder Springhill TS to West Dapto ZS
							Sub Total	7.60	
							Total	**19.00**	
Albion Park ZS						3 x 12.5	Nil		Existing 3 x 12.5MVA ZS
7059	Mt Terry TS to Albion Park ZS	7059				45.7	Nil		No augment required
							Sub Total	0.00	
7054	Mt Terry TS to Albion Park ZS	7054				45.7	Nil		No augment required
							Sub Total	0.00	
							Total	**0.00**	
Kembla Grange ZS						2 x 10	Nil		Existing 2 x 10MVA ZS
7017 / 7117	Springhill TS to Kembla Grange ZS	7017 / 7117		√		33.2	46	6.80	Augment Existing
									Split feeders 7017 and 7120 where they cross and redirect lines to create direct link from Springhill TS to Dapto ZS (estimate $200k)
							Sub Total	6.80	
							Total	**6.80**	
Unanderra ZS						3 x 12	Nil		Existing 3 x 12MVA ZS
7012	Springhill TS to Unanderra ZS	7012				44.4	Nil	0.00	No augment required
7016	Springhill TS to Unanderra ZS	7016		√		33.2	46	1.30	Augment Existing
							Sub Total	1.30	
							Total	**1.30**	
Dapto ZS						3 x 25	Nil		Existing 3 x 25MVA ZS
7120	Unanderra ZS to Dapto ZS	7120		√		33.2	46	6.80	
									Split feeders 7017 and 7120 where they cross and redirect lines to create direct link from Springhill TS to Dapto ZS (estimate $200k)
							Sub Total	6.80	
							Total	**6.80**	

West Lake Illawarra	Summary				
		1. 132kV Feeder Construction	√	Total	35.1
		2. 33kV Feeder Configuration	√	Total	
		4. 33kV Feeder Augment	√	Total	37.9
	Dimis Model:			Total Feeder Works	73.0

Appendix 9 Contingency Tables – Short-term Network (33kV) Mt Terry TS

Faulty →	Nil	7054	7058	7158	7041	7123	7041/2	7004	7059	7047	7147	T'fer DAPTO Tx 3	Existing Rating	Proposed Rating
7054: MT TRRY to LBN PRK	20	x	36	12	20	20	-	21	22	23	22	19	45.7	45.7
7058: MT TRRY to LBN PRK	17	35	x	10	17	17	-	19	19	20	19	17	45.7	45.7
7158: LBN PRK to WRLL	14	13	13	x	14	14	-	18	19	20	19	14	~~19.7~~ (32.0)	32.0
7041: Mt TRRY to CLDRWD	6	6	6	6	x	6	-	6	6	6	6	13	27.4	27.4
7123: LBN PRK to PN BND AT PL 4AV794	-	-	-	-	-	x	-	-	-	-	-	-	16.8	16.8
7004: SHLLHRBR to WRLL	3	5	4	17	3	3	-	x	2	3	2	3	~~19.7~~ (32.1)	32.1
7059: MT TRRY to SHLLHRBR	16	16	16	22	16	16	-	15	x	26	24	16	33.2	33.2
7047: MT TRRY to CRM SS	19	20	20	26	19	19	-	18	28	x	3	19	33.2	33.2
7147: CRM SS to SHLLHRBR	16	16	16	22	16	16	-	14	24	3	x	16	33.2	33.2

Table 9.1 Loads (MVA) - Contingency Analysis Mt Terry TS

Notes:
1. A shaded result indicates a constraint
2. Brackets (46.0) indicate either approved project rating or proposed future rating

Cont'd Contingency Tables – Short-term Network (33kV) Mt Terry TS

Faulty →	Nil	7054	7058	7158	7041	7123	7041/2	7004	7059	7047	7147	T'fer DAPTO Tx 3	Min.	Max.
Mt Terry TS 33kV	102.9	102.9	102.9	102.7	103.5	102.9	-	102.9	102.7	102.6	102.7	102.4	90	110
Mt Terry TS Tap	9	7	7	7	7	9	-	7	7	7	7	7	1	17
Albion Park ZS 33kV	102.4	101.7	101.9	102.3	103.0	102.4	-	102.3	102.1	102.0	102.1	98.1	90	110
Albion Park ZS 11kV	100..2	99.6	99.7	100.2	100.8	100..2	-	100.1	99.9	99.8	99.9	99.7	90	110
Albion Park Tap No. Tx 3 & 2	3	3	3	3	3	3	-	3	3	3	3	3	1	15
Albion Park Tap No. Tx 1	4	3	3	3	3	4	-	4	3	3	3	3	1	15
Calderwood ZS 33kV	102.5	102.4	102.5	102.3	-	102.5	-	102.5	102.3	102.2	102.3	101.6	90	110
Calderwood ZS11kV	100.3	99.0	99.0	100.1	-	100.3	-	100.3	98.9	98.8	98.9	99.4	90	110
Calderwood ZS Tap	3	2	2	3	-	3	-	3	2	2	2	3	1	15
Shellharbour ZS 33kV	100.2	100.0	100.1	98.8	100.8	100.2	-	100.5	98.6	98.1	98.5	99.7	90	110
Shellharbour ZS 11kV	101.5	99.9	100.0	101.4	100.8	101.5	-	101.8	99.8	100.7	99.7	100.9	90	110
Shellharbour Tap No. Tx 1 & 2	5	4	4	6	4	5	-	5	5	6	5	5	1	15
Shellharbour Tap No. Tx 3	10	9	9	11	9	10	-	10	10	11	10	10	1	22
Warilla ZS 33kV	99.7	99.4	99.4	96.8	100.3	99.7	-	98.6	98.5	98.2	98.5	98.2	90	110
Warilla ZS 11kV	101.9	100.2	100.3	101.4	99.9	101.9	-	100.7	100.6	100.3	100.6	100.0	90	110
Warilla ZS Tap	6	5	5	8	4	6	-	6	6	6	6	5	1	15
Dapto ZS Tx 3 33kV	-	-	-	-	-	-	-	-	-	-	-	100.6	90	110
Dapto ZS Tx 3 11kV	-	-	-	-	-	-	-	-	-	-	-	99.6	90	110
Dapto ZS Tap	-	-	-	-	-	-	-	-	-	-	-	8	1	22

Table 9.2 Voltages and Tx. Taps - Contingency analysis with Mt Terry TS

Notes:
1. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV.

Contingency analysis tables 9.1 and 9.2 were produced using DINIS file "West_Lake_Illawarra_Mt_Terry.per".

Appendix 10 Contingency Tables – Medium-term Network (33kV) Mt Terry TS

Faulty →	Nil	7054	7058	7158	7041	7123	7123/2	7041/2	7004	7059	7047	7147	T'fer DAPTO Tx 3	Existing Rating	Proposed Rating
7054: MT TRRY to LBN PRK	21	x	34	14	26	20	21	-	22	23	23	23	24	45.7	45.7
7058: MT TRRY to LBN PRK	18	33	x	12	22	17	18	-	19	20	20	20	21	45.7	45.7
7158: LBN PRK to WRLL	20	13	13	x	14	14	20	-	18	19	20	19	14	~~19.7~~ (32.0)	32.0
7041: Mt TRRY to CLDRWD	10	14	14	8	x	12	10	-	10	10	10	2	15	27.4	27.4
7123: Mt TRRY to CLDRWD	2	2	2	4	12	x	2		15	2	2	10	8	16.8	16.8
7123/2: LBN PRK to PL 4AV794	-	-	-	-	-	-	x	-	-	-	-	-	-	16.8	16.8
7004: SHLLHRBR to WRLL	3	5	4	17	4	3	3	-	x	2	3	2	4	~~19.7~~ (32.1)	32.1
7059: MT TRRY to SHLLHRBR	26	16	16	22	16	16	26	-	15	x	26	24	16	33.2	33.2
7047: MT TRRY to CRM SS	19	20	20	26	20	19	19	-	18	28	X	3	19	33.2	33.2
7147: CRM SS to SHLLHRBR	16	16	16	22	16	16	16	-	14	24	3	X	16	33.2	33.2

Table 10.1 Loads (MVA) - Contingency Analysis Mt Terry TS

Notes:
1. A shaded result indicates a constraint
2. Brackets (46.0) indicate either approved project rating or proposed future rating

Cont'd Contingency Tables – Medium-term Network (33kV) Mt Terry TS

Faulty →	Nil	7054	7058	7158	7041	7123	7123/2	7041/2	7004	7059	7047	7147	T'fer DAPTO Tx 3	Min.	Max.
Mt Terry TS 33kV	102.2	102.2	102.2	102.0	102.2	102.2	102.2	-	102.3	102.1	102.0	102.0	102.7	90	110
Mt Terry TS Tap	7	7	7	7	7	7	7	-	7	7	7	7	8	1	17
Albion Park ZS 33kV	101.7	101.2	101.3	101.6	101.5	101.7	101.7	-	101.6	101.4	101.3	101.4	102.1	90	110
Albion Park ZS 11kV	99.5	99.0	99.1	99.4	99.3	99.5	99.5	-	99.4	99.2	99.1	99.2	99.9	90	110
Albion Park Tap No. Tx 3 & 2	3	3	3	3	3	3	3	-	3	3	3	3	3	1	15
Albion Park Tap No. Tx 1	3	4	4	3	3	3	3	-	3	3	3	3	3	1	15
Calderwood ZS 33kV	101.6	101.2	101.3	101.5	101.0	101.4	101.6	-	101.5	101.3	101.2	101.3	101.8	90	110
Calderwood ZS11kV	99.6	99.3	99.3	99.5	99.0	99.4	99.6	-	99.6	99.4	99.3	99.3	99.8	90	110
Calderwood ZS Tap	8	8	8	8	8	8	8	-	8	8	8	8	8	1	15
Shellharbour ZS 33kV	99.5	99.4	99.4	98.1	99.5	99.5	99.5	-	99.9	97.9	97.4	97.8	100.0	90	110
Shellharbour ZS 11kV	100.8	100.6	100.5	100.7	100.7	100.8	100.8	-	99.8	100.4	99.9	100.4	99.9	90	110
Shellharbour Tap No. Tx 1 & 2	5	5	5	6	5	5	5	-	4	6	6	6	4	1	15
Shellharbour Tap No. Tx 3	10	10	10	11	10	10	10	-	9	11	11	11	9	1	22
Warilla ZS 33kV	99.0	98.7	98.7	94.1	98.9	99.0	99.0	-	97.9	97.8	97.5	97.8	99.5	90	110
Warilla ZS 11kV	99.9	100.8	100.8	100.7	99.7	99.9	99.9	-	100.0	99.9	100.8	99.8	100.3	90	110
Warilla ZS Tap	5	6	6	8	5	5	5	-	6	6	7	6	5	1	15
Dapto ZS Tx 3 33kV	-	-	-	-	-	-	-	-	-	-	-	-	100.1	90	110
Dapto ZS Tx 3 11kV	-	-	-	-	-	-	-	-	-	-	-	-	99.7	90	110
Dapto ZS Tap	-	-	-	-	-	-	-	-	-	-	-	-	9	1	22

Table 10.2 Voltages and Tx. Taps - Contingency analysis with Mt Terry TS

Notes:
1. The voltages given are percentage of nominal e.g. 105.3% of 132kV = 139kV.

Contingency analysis tables 10.1 and 10.2 were produced using DINIS file "West_Lake_Illawarra_Mt_Terry.per"