TRANSMISSION NETWORK PLANNING REVIEW

2017 - 2026

ASSET STRATEGY AND PLANNING BRANCH

Asset Management

October 2017

TRANSMISSION NETWORK PLANNING REVIEW 2017-2026

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ACKNOWLEDGMENTS

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1 INTRODUCTION

Endeavour Energy aims to service growth in electrical demand and manage the network in a reliable, safe, efficient and sustainable manner. The safety of employees, contractors and the community is the foundation of all Endeavour Energy objectives.

Achievement of these objectives requires both efficient use of capital investment and maintenance expenditure on network assets. Business initiatives aim at developing the organisation's culture and people to maximise performance; improve processes; and utilise technology where cost effective.

Endeavour Energy develops the Strategic Asset Management Plan (SAMP) to document the network needs that have been identified as needing to be addressed to ensure that Endeavour Energy manages its electrical network assets in a sustainable way for the long-term benefit of the stakeholders. It prioritises the asset management projects and programs in developing the ten-year network expenditure forecasts.

The annual Transmission Network Planning Review (TNPR) provides one input into the SAMP. The TNPR identifies capacity constraints on Endeavour Energy's 132kV, 66kV and 33kV subtransmission network. The annual Endeavour Energy Summer and Winter Demand Forecast reports provide the basis for the transmission analysis.

Specifically, the intent of the TNPR is to identify system constraints that will occur under "System Normal" and "Single Contingency" situations within the ten-year forecast period, and the year in which the constraints are likely to occur.

The level of supply security provided is based on internal company polices and standards including:

- 9.2.1 Network Planning
- SD1 501 Network Configuration

The System Need dates shown against projects reflect when a constraint is predicted to occur. This is not necessarily the date that investment will be required as an assessment of risk will be required.

Endeavour Energy has developed processes to apply probabilistic planning when assessing supply security constraints. Deterministic (N-1) criteria are used only as a trigger for investigation. The probabilistic planning approach will involve:

- An assessment of likelihood of failure of network elements
- An assessment of consequence in the event of failure. This includes expected outage duration and expected unserved energy. The unserved energy can be monetised by applying a Value of Customer Reliability.
- Consideration of back up capacity at other voltage levels (for example HV distribution feeder capacity when analysing zone substation contingencies)
- Sensitivity analysis for key parameters such as load growth, cost, WACC
- A determination of economic timing for network augmentation and Net Present Value of options based on demand forecasts.

It is not the intention of this review to commit to a solution for particular network constraints. Further Network Investment Options studies (NIO), together with capital evaluations, are carried out to a timetable dictated by the identified system need dates to finalise timing, solutions and budgets for approval.

2 TECHNICAL TERMS

Abbreviation/Term	Definition
ABS	Air break switch
BSP	Bulk Supply Point (Transgrid supply point)
CB	Circuit Breaker
CBD	Central Business District
Demand Management	A strategy of reducing the peak load on the network by effecting changes in customer behaviour, equipment used or by introducing generation at a local level in order to defer or remove the need to augment the network. Demand Management techniques also include direct control of loads such as off-peak hot water heaters.
Digsilent Power Factory	Network load flow (analysis) software package.
Distribution	Network assets designed to operate at a primary voltage of 22kV, 11kV, 400/230V or 12.7kV SWER to provide supply from zone substations to customers.
Diversified load	Coincident load, specifically of interest when considering peak load over a number of individual sites supplied by a common substation, such as a Transmission Substation
Firm capacity	The capacity available when one network element is out of service
HV	High Voltage (11kV, 22kV, 12.7kV SWER), also referred to as Medium Voltage (MV)
LDC	Line Drop Compensation. A feedback mechanism used at substations to boost the substation voltage at times of high load.
Licence Conditions	The reliability and performance licence conditions imposed on NSW distribution network service providers by the Minister for Energy from 1 July 2014.
Load at Risk	The potential load that is above the available firm capacity, which would be at risk under contingency conditions.
Network Element	An individual asset or combination of assets that forms a significant link within the network normally within a protection zone. Specifically: ▪ A transformer at either a Transmission Station or Zone Substation

	▪ A transmission feeder at 132, 66 or 33kV and its associated circuit breakers and protection systems located at each end of the feeder.
NIO	Network Investment Options Study. A study to determine the most economic and feasible method of addressing system constraints identified in a Statement of Network Need (SNN).
Non-urban	An area where the majority of available land is zoned for rural and/or rural residential use. A rural type of area which may include some industrial, commercial and residential land, but which does not have large contiguous areas of town or city development. This includes rural townships. Endeavour Energy will determine which areas will be considered to be non-urban.
OH	Overhead
Sydney Trains	The state-owned corporation responsible for operation of the rail network.
SAMP	Strategic Asset Management Plan
SCADA	Supervisory Control and Data Acquisition
Single Contingency (N-1)	A system configuration which occurs when a single network element is unavailable for service. The network element may be unavailable for service due to a planned or unplanned outage.
SNN	Statement of Network Need. A document that identifies an individual or collection of system constraints in a specific area that require detailed study.
Sub-transmission	Network assets designed to supply zone or customer substations and operate at a primary voltage of 132kV, 66kV or 33kV.
System Need Date	The nearest future date at which there is a Network Constraint or Load-at-Risk condition. This date is usually a Summer or Winter, i.e. Summer 2015, Winter 2015 etc.
System Normal Conditions	A system configuration which occurs when all network elements are available for service. This is the usual state of the network.
TG	TransGrid, being the NSW state transmission authority supplying the various distribution authorities including Endeavour Energy.
Transmission	Network assets designed to supply the bulk power to transmission substations, which operate at a primary voltage of 132kV.

	N ***both Endeavour Energy's transmission and sub-***
TRF	Transformer
TS	Transmission Substation. An Endeavour Energy substation with a primary voltage of 132kV and secondary voltage of 66 or 33kV, connected directly or indirectly to a TransGrid Bulk Supply Point (BSP) for supplying zone substations.
UG	Underground
Urban	An area where the majority of available land is zoned for residential and/or commercial and/or industrial use. A town or city type of area which is contiguous with other similar town or city areas. Endeavour Energy will determine which areas will be considered to be urban.
URD	Underground Residential Distribution
ZS	Zone Substation. An Endeavour Energy substation with primary voltage of 132, 66 or 33kV and secondary voltage of 22 or 11kV for supplying distribution networks.

3 METHODOLOGY AND ASSUMPTIONS

The TNPR uses the most recent 10 year summer and winter load forecasts to evaluate the peak load performance of Endeavour Energy's electricity transmission network under "System Normal" configuration with all network elements in service and each potential "Single Contingency" situation in turn.

Endeavour Energy's network substations predominantly experience peak demand during summer, with a relatively small number experiencing peak demand during winter. Asset ratings are lower under summer conditions. Therefore, more capacity constraints are identified during the summer period. Voltage limits may however be reached during summer or winter. Analysis of the transmission network uses substation peak demand and asset ratings that apply during the season of peak demand.

The Demand Forecasting Section determines peak load diversification across zone substations, transmission substations and bulk supply points. The transmission network analysis uses these peak loads. Bulk supply points supplying common multiple transmission substations or zone substations do not consider diversification. In these cases, the study represents worst case conditions, with no diversity of peak loads between the TS or ZS directly connected to the respective BSP.

An automated load flow process is applied to each individual transmission substation and bulk supply point network, which examines system normal and each potential single contingency scenario. The study process includes the peak demand for each year in the 10-year forecast for both summer and winter. Each chapter and results table within the report shows the interconnection of the system feeder loadings and busbar voltages. The report tables highlight unacceptable conditions that do not meet current planning guidelines.

The studies and results contained in this report are based upon the following assumptions:

1. Actual load and power factor data from metering and SCADA systems processed by the Forecasting Section.
2. Network analysis is based on up to date transmission network models that incorporate all approved augmentation projects.
3. Where network constraints rely upon embedded generation, the generation is included in the study. When an embedded generator consists of a number of separate machines or groups of machines, the single contingency considered in the analysis is the loss of the largest single machine or group of machines.
4. Ratings and Impedance data used in modelling is sourced from the Network Characteristics database.
5. Endeavour Energy operates its transmission and subtransmission overhead system so as not to exceed a continuous conductor temperature of 75°C. Operation of a feeder above 75°C under contingency conditions is possible only where the feeder design maintains statutory clearances at these higher temperatures. The use of contingency ratings at elevated temperatures is likely to be required for up to 30 event days per year, over the life

of the asset. Of these event days, it assumes that the peak load cycle would not exceed 10 hours. Endeavour Energy also has a limited number of XTACIR circuits. The designs of the XTACIR circuits are for continuous elevated temperature operation.

6. Under single contingency conditions, constraints are identified based on the following:
    - Transmission lines and busbars to be maintained within their thermal rating
    - Transformers to be maintained within their thermal rating. This includes a rating based on forced cooling
    - On-load tap changing equipment to be capable of maintaining the specified float voltage on the 11 / 22kV busbar at each affected zone substation. Also for transmission substations achieving 33 / 66kV on the subtransmission busbar
7. Solutions proposed to a constraint that appear under single contingency conditions are based on the cyclic rating of the remaining network elements, the relevant cyclic ratings being determined on a case by case basis, based on the summer or winter load profile as appropriate.
8. When determining potential solutions to identified constraints, the standard ratings and configurations identified in SDI 501 Network Configuration Standard are assumed for the augmented network sections.
9. In general, the standard line ratings used for new works in urban areas (Inland noon) in line with MDI0042 and MDI0046 are:

OVERHEAD LINES

33kV	continuous	54MVA winter / 36MVA summer
	contingency	69MVA winter / 57MVA summer
66kV	continuous	108MVA winter / 73MVA summer
	contingency	138MVA winter / 115MVA summer
132kV	continuous	217MVA winter / 145MVA summer
	contingency	277MVA winter / 230MVA summer

UNDERGROUND CABLES

33kV	In trefoil ducts 50MVA winter / 48MVA summer
66kV	In trefoil ducts 98MVA winter / 94MVA summer
132kV	In trefoil ducts 188MVA winter / 179MVA summer

The above ratings apply for new construction in built up areas. Ratings for rural areas will be determined on an “as need basis” to suit the expected demand over the asset life.

4 REPORT FORMAT

The chapters for each transmission substation and bulk supply points table the resultant network loadings. Each section provides the following information:

- The status of the TS / BSP. This section includes information concerning projects that are presently under way or approved in the area and a brief discussion of any capacity issues that may exist on the network. The section also discusses relevant operational details that apply to the supply system, for example, changeover schemes, hybrid arrangements etc.
- Zone or transmission substations rating including the amount of installed reactive power capacity. Identification of any substation transformer constraint and the year the constraint occurs. This section also identifies any major projects approved and included in the analysis.
- A network normal and contingency result table summarising transmission line loadings. Tables include line rating and voltage limit studies under each contingency at the end of the forecast period. Highlight of any constraints and the year it occurs.
- A detailed description of each identified constraint. The year in which the constraint occurs (system need date) and a suggested solution to overcome the constraint. A PR number is assigned for each solution that requires investigation of network investment options.
- Geographic diagrams showing constrained elements highlighted and the proposed network configuration to relieve all identified constraints.
- A transmission network schematic diagram

4.1 Interpreting Result Tables

4.1.1 Line Rating Analysis

The line rating result tables have been constructed to highlight all affected feeders during a single contingency feeder outage. The feeder numbers across the top (00, 01 and 02) represent the faulty feeder and the feeder numbers down the left side of the table represent the corresponding feeder results. The right side of the table shows the rating of the weakest link of a feeder, RR. The highlighted boxes in the result tables indicate an overloaded feeder under the specific contingency. The right most column of this table (YY) contains the year in which the exceeded rating of the weakest link of the feeder occurs. Specification of the final forecast year of analysis in the table (YY) signifies that no constraints for that feeder under normal or single contingency conditions.

Faulty ➔	**Nil**	**00**	**01**	**02**	**Rating**	**Year of Result**
00						
01				XX	RR	YY
02						

So from the sample, if Feeder 02 fails, the load on feeder 01 is XX MVA, in year YY. If XX is greater than RR, then the rating of the line has been exceeded.

4.1.2 Voltage Limit Analysis

The voltage limit result tables have been constructed to highlight all affected substations during a single feeder outage. The feeder numbers across the top (00, 01 and 02) represent the feeder that is out-of-service and the substation names down the left side of the table represent the corresponding substation results. The right side of the table shows the number of available transformer taps to either boost (AA) or buck (BB) the voltage to achieve the set target voltage at each substation. The right most column of the table (YY) contains either the year in which the voltage limit of the substation is exceeded, whenever a limit occurs, or the final year of analysis (forecast) for the resultant tap position reported. The entries in the table (VV) represent the actual transformer tap position at the substation; with a (-ve) number representing a boost tap and a (+ve) number representing a buck tap with a reference to nominal tap position. The highlighted boxes in the results tables indicate a substation whose voltage limit is expected to be exceeded, due to running out of transformer taps. That is, given the voltage drop in the transmission network under the contingency condition, the boost available is insufficient to maintain the distribution busbar float voltage at its normal level.

Faulty ➔	**Nil**	**00**	**01**	**02**	**Min Taps**	**Max Taps**	**Year**
Sub 1				VV	AA	BB	YY
Sub 2							
Sub 3							

So from the sample we can see that if Feeder 02 fails, the tap position at Sub 1 is VV, in year YY. If VV is equal to AA, then maximum boost tap has been reached. Alternately if VV is equal to BB then maximum buck tap has been reached. If VV is equal to either AA or BB, whilst maximum boost or buck has been reached, the correct voltage output of the substation may or may not have been achieved and will be quoted as a footnote. If VV is between AA and BB then there is no doubt that the correct voltage output has been achieved.

5 BAULKHAM HILLS TRANSMISSION SUBSTATION

5.1 Baulkham Hills Transmission Network Status

Baulkham Hills TS is supplied by Sydney West BSP via Blacktown TS on feeders 9J3 and 9J4. This system has a firm rating for one circuit outage of 512 / 618MVA summer / winter based on the line ratings. The 2400A switchgear at Baulkham Hills TS limits the winter rating to 548 MVA. The Baulkham Hills 132kV busbar supplies the Baulkham Hills 132/11kV supply point and Carlingford TS. Baulkham Hills TS has four 60MVA 132/33kV transformers, providing a firm capacity of 180MVA and is normally floated at 34kV.

132kV Feeder 229 has been disconnected from West Castle Hill ZS due to only two switch bays being available and is energised but open bonded pending future possible augmentation. Supply to Bella Vista ZS from Sydney West BSP via Baulkham Hills TS and feeder 212 will be retained as a backup option to cater for the loss of either of the Vineyard BSP source feeders 214 or 215, Rouse Hill SS to Parklea. Refer to the Sydney West and Vineyard sections of this report.

Northmead, Seven Hills and Jasper Road ZSs are normally operated with two transformers in service and one on standby. North Rocks ZS is normally operated with both transformers in service. Westmead ZS transformers are tail-ended to feeders 466 (Northmead ZS to Westmead ZS) and 477 (Baulkham Hills TS to Westmead ZS) and both feeders are in service normally. This has been made possible by an intertrip arrangement from both source feeder CBs into the Westmead transformer CBs.

Holroyd ZS is normally supplied from feeder 432 (Blacktown TS to Holroyd ZS), on changeover to feeder 474 (Baulkham Hills TS to Holroyd ZS). Marayong ZS is normally supplied from feeder 445 (Blacktown TS to Marayong ZS), on changeover to feeders 470 (Seven Hills ZS to Marayong ZS) and 473 (Baulkham Hills TS to Kellyville ZS tee to Marayong ZS). Feeders 470 and 473 are closed in at Marayong for high load conditions to avoid an overload on feeder 445. Feeders 473 and 469 (Jasper Rd to Kellyville) provide backup to Kellyville, which is normally supplied from Sydney North BSP via Kenthurst and feeder 476.

5.2 Baulkham Hills Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Baulkham Hills TS	4 x 60	180	65	Nil
Baulkham Hills 11kV	2 x 45	45		Nil
Jasper Rd	3 x 25	50		Nil
North Rocks	2 x 25	25	5	Nil
Northmead	2 x 35	35	5	Nil
Seven Hills	3 x 25	50	10	Nil
Westmead	2 x 35	35	5	2022

Note: Baulkham Hills ZS is supplied by Sydney West BSP via the 132kV system.

5.3 Results tables

5.3.1 Baulkham Hills TS Loads and Ratings Summary - Summer

Faulty ➔	Nil	471	484	469	472	480	478	466	477	475	479	445	476	432	Rating	Year of Result
471 Baulkham Hills to Jasper Rd ZS	18.2	x	39.2	18.1									21.6		42*	2026/27
484 Baulkham Hills to Jasper Rd ZS	20.2	39.0	x	20.1									24.0		42*	2021/22
469 Jasper Rd ZS to Kellyville ZS	0.1			x									6.7		21	2026/27
472 Baulkham Hills to North Rocks ZS	13.2				x	18.3	18.0	10.8	16.1						42	2026/27
480 Baulkham Hills to TEE/Northmead ZS	23.8				30.6	x	41.3	15.1	34.4						42	2026/27
480 TEE to North Rocks	5.0				18.4	x	1.5	7.6	2.8						42	2026/27
478 Baulkham Hills to Northmead ZS	22.7				29.1	41.4	x	13.9	32.7						42	2026/27
466 Northmead ZS to Westmead ZS	20.9					20.9	20.9	x	44.3						45	2026/27
477 Baulkham Hills to Westmead ZS	20.2					20.2	20.2	45.2	x						45	2026/27
475 Baulkham Hills to Seven Hills ZS	14.4									x	31.8	24.0			45	2026/27
479 Baulkham Hills to Seven Hills ZS	17.2									31.8	x	28.8			46	2026/27
470 Seven Hills ZS to Marayong ZS	-											20.8			34	2026/27
473 Baulkham Hills to Tee 1	0.6											20.0	10.6		32	2026/27
473_1 Tee 1 to Kellyville ZS	0.1											0.0	10.8		21	2026/27
473_2 Tee1 to Marayong ZS	-											20.2			31*	2026/27
474 Baulkham Hills to Holroyd ZS	-													38.4	48*	2026/27

Notes: 1. Kellyville ZS is normally supplied from feeder 476 (Sydney North via Kenthurst ZS) on changeover to Baulkham Hills TS via the 33kV feeder 473 and 469. On days when high demand is expected on Kellyville ZS, the 33kV busbar can be split via a motorised isolator, to transfer half of its load to the Baulkham Hills system.

2. Feeders 470 and 473 are closed in on days when high demand is expected to exceed 45MVA on Marayong ZS to avoid overload on feeder 445 (bus sections 1 & 3 supplied from Baulkham Hills TS). This has not been required for a number of years, nor is it expected to be required within the forecast period.

3. * Emergency rating

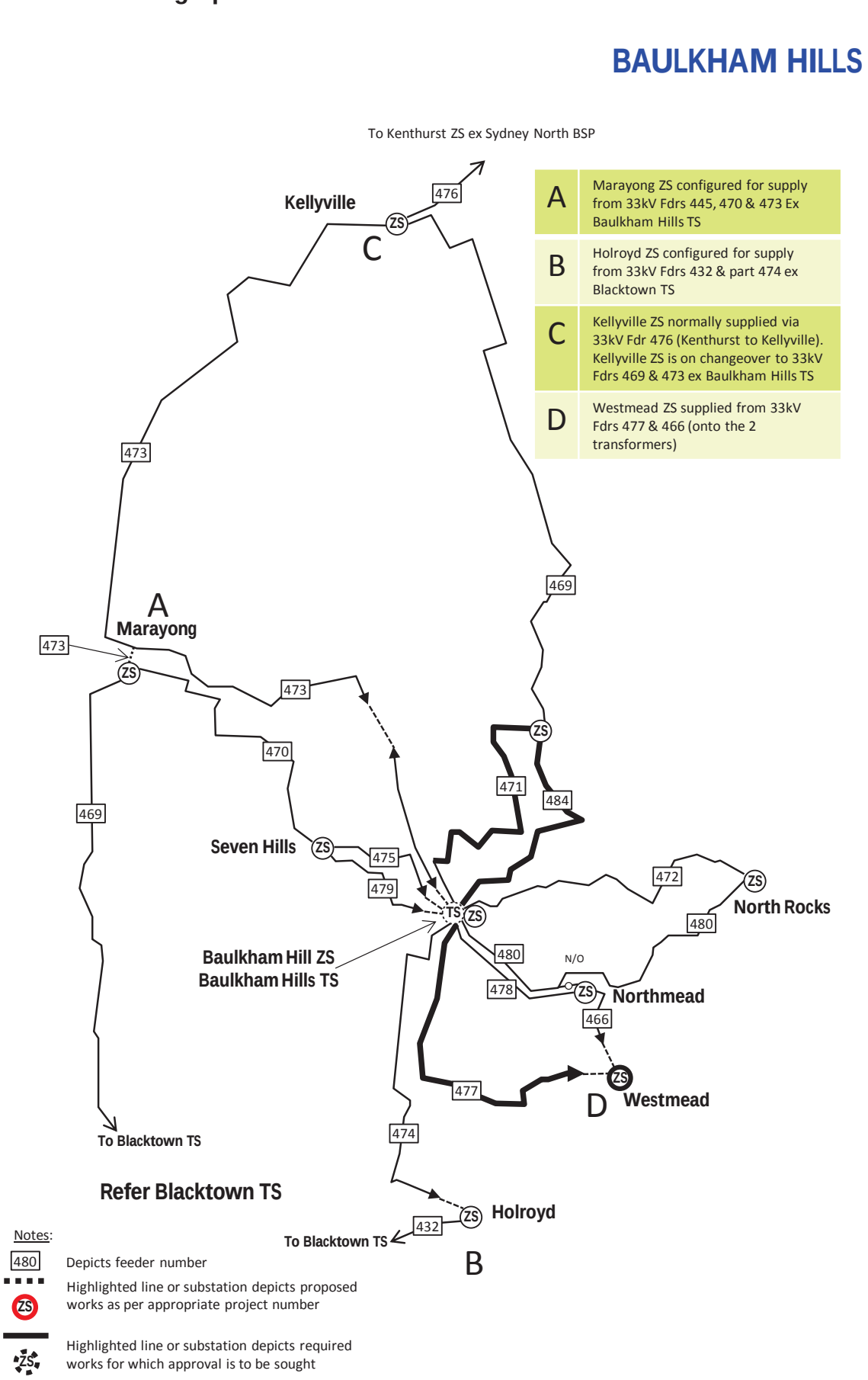
5.3.2 Baulkham Hills TS Voltage Levels (Resultant Tap Position) - Summer

Faulty ➔	Nil	471	484	472	480	478	466	477	475	479	445	476	432	Min Tap	Max Tap	Year of Result
Jasper Rd	0	0	0											-14	7	2026/27
North Rocks	1			1	1	1								-14	7	2026/27
Northmead	0			0	0	0								-14	7	2026/27
Westmead	-1						-7	-5						-14	7	2026/27
Seven Hills	0								0	0				-14	7	2026/27
Marayong	x										0			-14	7	2026/27
Kellyville	x											1		-14	7	2026/27
Holroyd	x												3	-14	7	2026/27

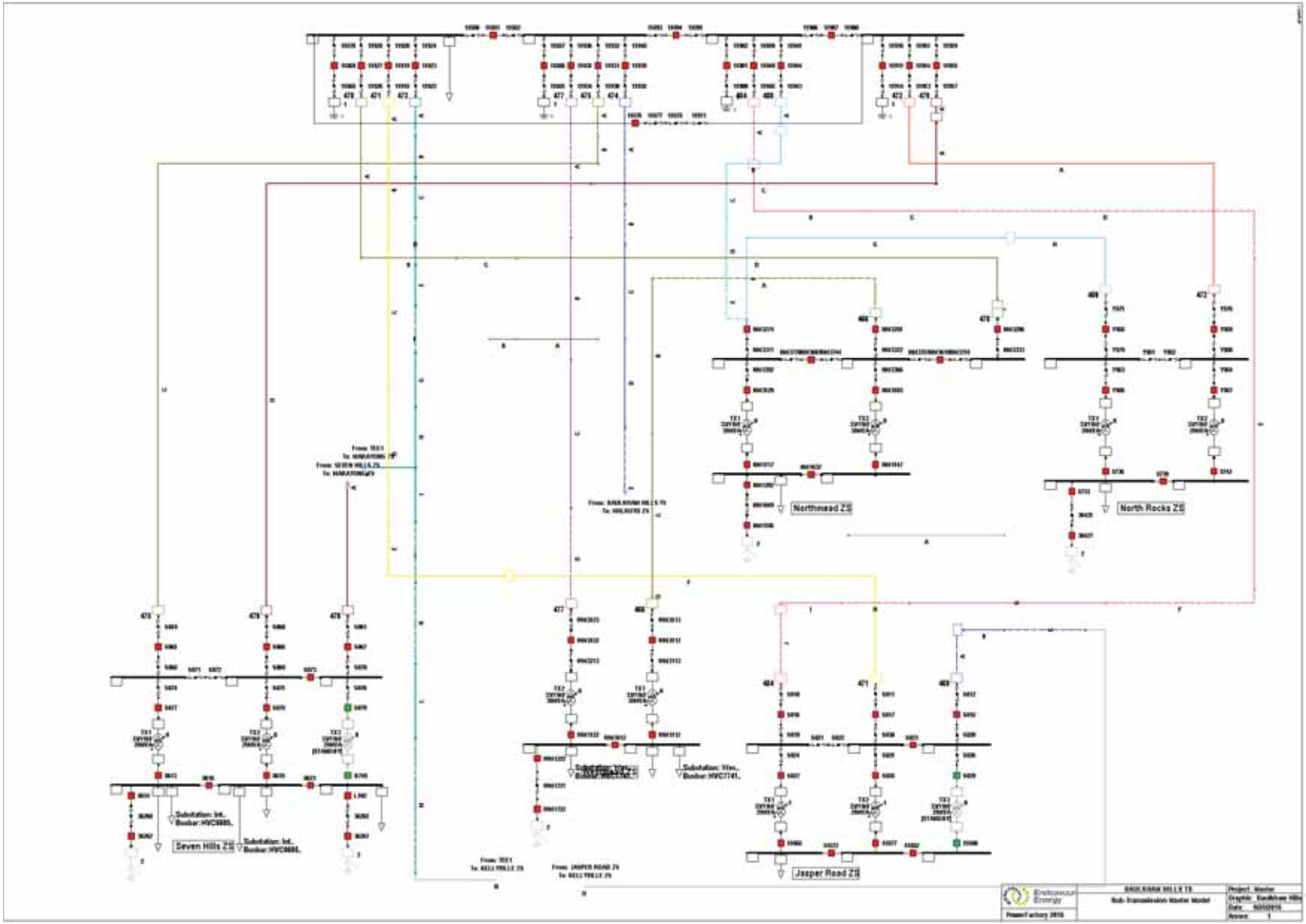
5.4 Analysis Results and Possible Solutions

Baulkham Hills	Network Constraint	Year	Investigation	Solution
	Capacity of feeders 477 is reached during outage of feeder 466	S2026/27	Continue to monitor development in area. Conduct non-network investigation when necessary	Continue to monitor
	Westmead ZS exceeds its firm capacity – Transformer capacity and 11kV busbar rating Transformer in 2021/22 and 11kV busbar in 2022/23	S2021/22	Monitor the loading yearly prior to this time and if Westmead UWS and the Westmead Hospital complex proceeds as forecast, then develop Options to provide capacity at Westmead ZS	Continue to monitor, Investigate options to expand Westmead ZS PR574
	Under Note 1 of the Loads and Ratings summary for Summer, the Summer contingency of splitting the bar at Kellyville ZS to allow supply from Sydney North and Baulkham Hills, it was found that an overload of Feeder 471 by 0.25 MVA under loss of Feeder 484 and a overload of Feeder 484 by 0.7 MVA under loss of Feeder 471 occurred in 2022/23	S2022/23	Continue to monitor loading of Kellyville ZS.	Continue to monitor. Possible future augment of Feeder 476 to cater for: (a) Kellyville ZS normal summer load and (b) Eliminate potential emerging constraint on Jasper Rd ZS feeders 471 an 484 in S2022/2023 under summer contingency configuration.

5.5 Baulkham Hills Geographic



5.6 Baulkham Hills Schematic



6 BELLAMBI TRANSMISSION SUBSTATION

6.1 Bellambi Transmission Network Status

Bellambi Transmission Substation has three 60MVA 132/33kV transformers providing a firm capacity of 120 MVA. The substation is currently floated at 33.5kV. Bellambi Transmission Substation is supplied from TransGrid's Dapto BSP via two 132kV feeders 980 & 981, each have respective ratings for summer / winter of 163 / 176MVA.

Feeder 7302 ties the Bellambi TS system to the Springhill TS system via Mt Keira Switching Station (normally open ABS 73326). 7302 can only provide limited contingency supply (250A) to the Springhill system, due to capacity and protection constraints.

A credible steel lattice tower failure and double circuit outage of 980/981 was desktop simulated prior to a real network switching event on Sunday 4 September 2016, where the entire Bellambi TS 33kV network was supplied (up to 80% of peak load) through three distinct radial 33kV substation groupings fed from Springhill TS.

No major network capacity projects are planned for the current forecast period.

6.2 Bellambi Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Bellambi TS	3 x 60	120	20	Nil
Bulli	2 x 15	15		Nil
Corrimal	2 x 25	25	5	Nil
Darkes Forest	2 x 5	5		Nil
Helensburgh	2 x 12.5	12.5		Nil
Mt Ousley	2 x 35	35		Nil
Russell Vale	2 x 25	25		Nil
Wombarra[1]	2 x 5	5		Existing[1]

Notes:

1. Firm capacity exceeded, though thermal capacity is provided for greater than 115% of forecast demand under N security for load up to 10MVA.

6.3 Results Tables

6.3.1 Bellambi TS Loads and Ratings Summary – Summer

Faulty ➔	Nil	7028	7253	7252	7022	7025	7026	7027	7293	7029	7291	7292	7030	7112	7121	7021	Transfer Nth W'gong	Rating	Result Year
7028: BLLMB TS to HLNSBGH ZS	6.8	x	10.7	8.6	11.3	11.1												44.4	2027
7253: DRKS FRST ZS to HLNSBGH ZS	6.7	10.8	x	8.7	1.0	11.4												21.2	2027
7252: DARKES FOREST ZS to TEE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		21.7	2027
7252/2: TEE to WOMBARRA ZS	3.7	6.7	6.8	x	7.3	4.9												21.7	2027
7252/3: TEE to HELENSBURGH ZS	3.7	6.7	6.8	x	7.3	4.9												21.2	2027
7022: BLLMB TS to DRKS FRST ZS	7.7	11.7	0.9	9.6	x	12.3												44.2	2027
7025: BLLMB TS to WOMBARRA ZS	8.3	11.4	11.5	4.6	11.9	x												44.2	2027
7026: BLLMB TS to BULLI ZS	10.0						x	13.2	9.1	12.7		8.5	11.7	9.4	9.3	11.1	10.9	19.7	2027
7027: BLLMB TS to RUSSEL VALE ZS	13.1						17.7	x		20.2	13.9	9.1	17.3	11.5	11.5	16.0	15.4	32.0	2027
7293: BULLI ZS to RUSSEL VALE ZS	0.9						9.3	4.0	x	3.6	1.2	0.8	2.5	0.2	0.2	2.0	1.7	13.4	2027
7029: BLLMB TS to SOUTH BULLI SS	12.4						16.3	19.4		x	13.0	9.0	16.0	11.0	11.0	14.8	14.4	32.1	2027
7291: STH BLL SS to RSSEL VALE ZS	9.7						13.6	16.7		3.1	10.4	6.3	13.3	8.4	8.4	12.1	11.7	32.0	2027
7292: CRRML ZS to RSSL VALE ZS	9.1						7.5	6.3		6.5	10.9	x	18.3	5.7	5.7	15.4	14.0	28.6[†]	2027
7030: BLLMB TS to CORRIMAL ZS	12.3						13.6	14.6		14.3	13.8	18.8	x	9.2	9.2	17.6	16.5	53.7	2027
7112: NTH WLLNGNG ZS to CRRML ZS	6.9						6.4	6.0		6.1	9.9	4.8	3.8	x	x	18.2	15.6	44.4	2027
7121: MT OSLY ZS to N. WLLNGNG ZS	6.9						6.4	6.0		6.1	9.9	4.8	3.8	x	x	18.2	2.0	35.4	2027
7021: BELLAMBI TS to MT OUSLEY ZS	11.1							12.0		11.9	22.0	13.7	14.3	18.2	18.2	x	17.9	35.4	2027
7257: HLNSBGH ZS to HLNSBGH COLLIERY	8.3						x	13.2	9.1	12.7		8.5	11.7	9.4	9.3	11.1	8.3	30.9	2027

Notes:

[†] Feeder ratings limited by the current transformers in the switchgear (to be confirmed by Southern Region Transmission). Feeder conductors are Rated / Restricted as follows:

- 7292: 32.0 / 28.6 MVA

6.3.2 Bellambi TS Voltage Levels Summary (Resultant Tap Position) – Summer

Faulty ➔	Nil	7028	7253	7252	7022	7025	7026	7027	7293	7029	7291	7292	7030	7112	7121	7021	Transfer Nth W'gong	Min. Tap	Max. Tap	Result Year
Darkes Forest	-1	-1	-1	-1	-2	-1												-13	5	2027
Helensburgh	0	-2	-1	-1	-2	-2												-12	2	2027
Wombarra	-3	-3	-3	-3	-3	-6												-12	2	2027
Bulli	1						1	1	1	1	1	1	1	1	1	1	1	-8	14	2027
Corrimal	0						0	0	0	0	0	0	0	0	0	0	0	-14	7	2027
Mt Ousley	0						-1	-1	0	-1	-1	-1	-1	-2	-2	-2	-2	-14	7	2027
Russell Vale	-1						-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-14	7	2027
N'th Wollongong	-3																0	-12	2	2027

6.3.3 Bellambi TS Voltage Levels Summary (Resultant Tap Position) – Winter

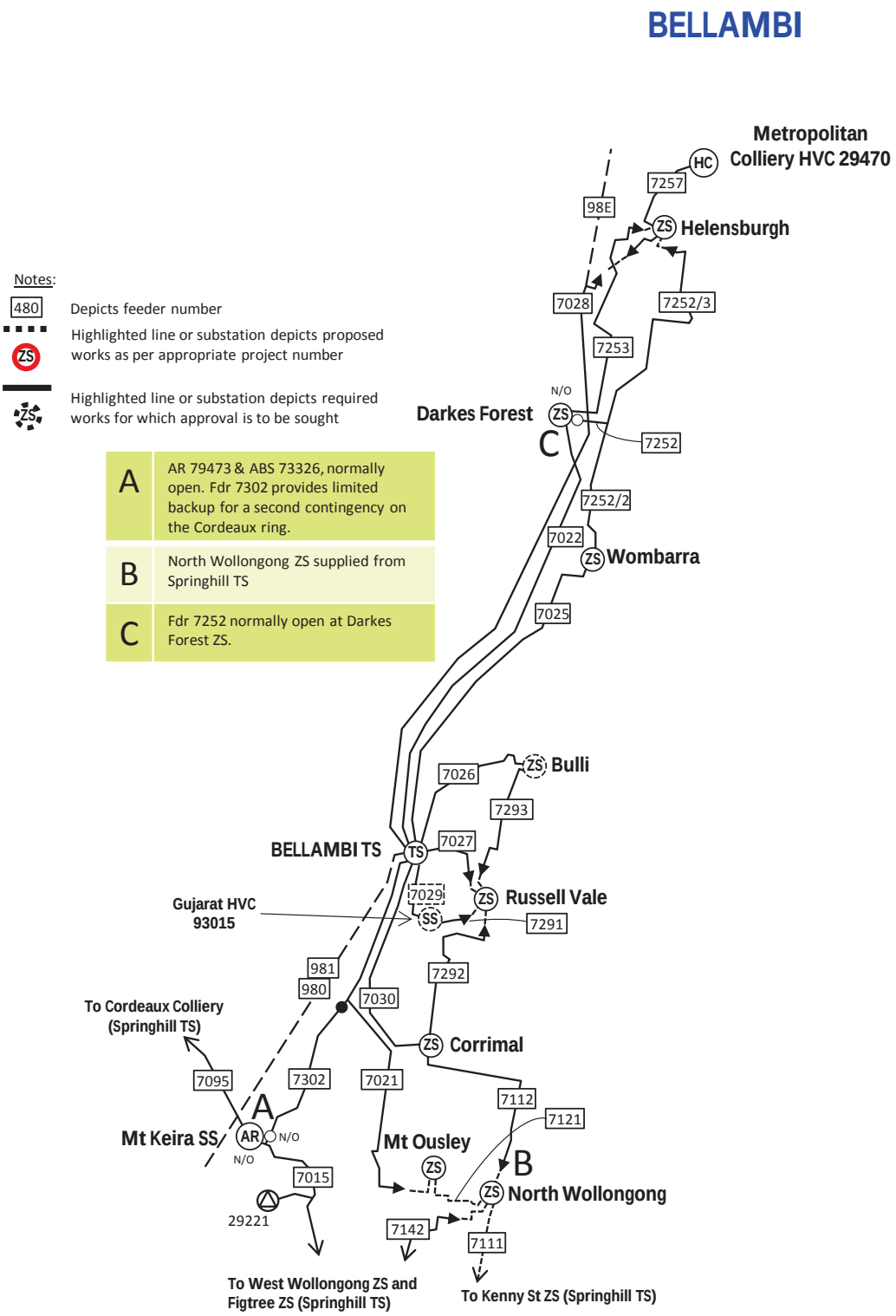
Faulty ➔	Nil	7028	7253	7252	7022	7025	7026	7027	7293	7029	7291	7292	7030	7112	7121	7021	Transfer Nth W'gong	Min. Tap	Max. Tap	Result Year
Darkes Forest	-1	-1	-1	-1	-2	-1												-13	5	2026
Helensburgh	-1	-3	-2	-1	-2	-3												-12	2	2026
Wombarra	-3	-3	-3	-3	-3	-7												-12	2	2026
Bulli	1						0	1	1	1	0	1	1	1	1	1	1	-8	14	2026
Corrimal	0						0	0	0	0	-1	0	-1	0	0	-1	0	-14	7	2026
Mt Ousley	-3						-3	-3	-3	-3	-3	-3	-4	-5	-5	-5	-2	-14	7	2026
Russell Vale	-1						-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-14	7	2026
N'th Wollongong	-2																0	-12	2	2026

6.4 Analysis Results and Possible Solutions

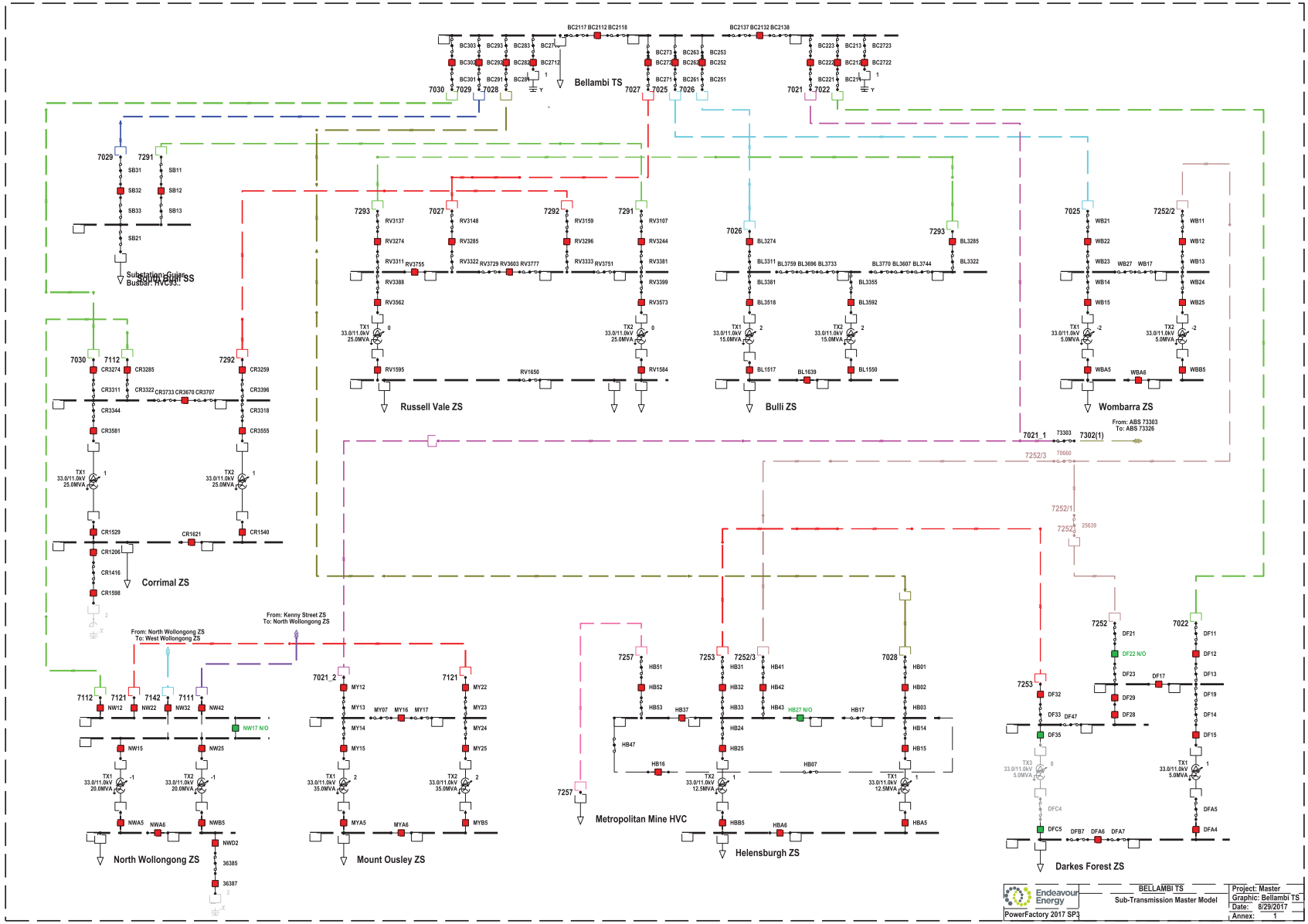
The load demand and voltage levels on all feeders and substations are within their design ratings and ranges, respectively, for this review period.

Bellambi	Network Constraint	Year	Investigation	Solution
	NIL			

6.5 Bellambi Geographic



6.6 Bellambi Schematic



7 BLACKTOWN TRANSMISSION SUBSTATION

7.1 Blacktown Transmission Network Status

Blacktown TS has four 120 MVA 132/33kV transformers providing a firm capacity of 360MVA and is supplied from Sydney West BSP via 132kV feeders 93Z/93A and 9J1/9J2. The float voltage at Blacktown TS is 34kV.

Feeder 450 from Blacktown TS and feeder 481 from Leabons Lane supplies Newton. Feeders 429 and 467 from Blacktown TS supply Leabons Lane. Feeder 450 supplies Newton and tees to Quakers Hill where it is normally open. Quakers Hill 132/33kV transformer provides the capability for a secondary 33kV injection point onto feeder 450 to Newton ZS. Feeder 432 from Blacktown TS supplies Holroyd ZS. Baulkham Hills TS feeder 474 backs up Holroyd ZS.

Blacktown Area Study (Special Report No.S454) highlights possible future sub-transmission network constraints beyond the forecast period, specifically within the North Blacktown / Kings Park Industrial and Blacktown CBD areas. Establishment of North Blacktown ZS will address the longer term constraints.

The “Prospect Ring” consisting of feeders 440, 431 and 427 supply the zone substations dedicated to the Sydney Catchment Authority (SCA) at Prospect East and Prospect South. Feeder 460 supplies ABC Tissues from Prospect East. Feeder 440 tees to and supplies Quarries ZS. Quarries ZS is also supplied from feeder 434. Due to the feeder geography and its associated impedance the load sharing of the system is uneven, with feeder 440 supplying the majority of the area load for an outage of feeder 434.

Project UCL5635 has recently been completed, esablishing two 33kV feeders from Blacktown TS to the Fujitsu data centre in Pemulwuy. The site has previously been supplied at 11kV from Quarries ZS but will soon transition to 33kV.

Leabons Lane ZS has been completely reburbished at the same location. A project to refurbish Marayong ZS is undergoing regulatory market consultation.

7.2 Blacktown Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVA)	Transformer Constraint (Year)
Blacktown TS	4 x 120	360	10	Nil
Greystanes	2 x 25	25	10	Nil
Holroyd	2 x 25 + 1 x 17.25	42.25	5	Nil
Leabons Lane	2 x 15/19/25	25	10	Nil
Marayong	3 x 15/19/25	50	5	Nil
Newton	3 x 15/19/25	50		Nil
Prospect	3 x 15	30	10	Nil
Prospect East	2 x 15/20/25	25		Nil
Prospect South	2 x 15/20/25	25		Nil
Quarries	2 x 35	35		Nil

7.3 Results Tables

7.3.1 Blacktown TS Loads and Rating – Summer Summary

Faulty ➔	Nil	433	463	426	430	679	434	440	431	427	460	450	481	467	429	445	483	Rating	Result Year
428: BLCKTWN TS to PROSPECT ZS	S/B	14	14															17	S2026/27
433: BLCKTWN TS to PROSPECT ZS	14	x	17															17	S2026/27
463: BLCKTWN TS to PROSPECT ZS	16	17	x															17	S2026/27
432: BLCKTWN TS to HOLROYD ZS	39																	42	S2026/27
426: BLCKTWN TS to GREYSTANES ZS	8			x	17	17												42	S2026/27
430: BLCKTWN TS to TEE1	9			17	x	24												42	S2026/27
430_1: TEE1 to GREYSTANES ZS	9			17	x	2												42	S2026/27
430_2: TEE1 to WOODPARK ZS	S/B			x	x	24												42	S2026/27
435: BLCKTWN TS to BOSSLEY PARK ZS	31																	42	S2026/27
434: BLCKTWN TS to QUARRIES ZS	29						x	32	30	32	28							42	S2026/27
440: BLCKTWN TS to TEE1	16						42	x	17	19	15							42	S2026/27
440: TEE1 to QUARRIES ZS	3						32	x	2	0	4							42	S2026/27
440: TEE1 to EAST PRSPCT ZS	13						10	x	15	18	10							42	S2026/27
431: STH PRSPCT ZS to EAST PRSPCT ZS	1						5	15	x	4	1							30	S2026/27
427: BLCKTWN TS to STH PRSPCT ZS	5						9	19	4	x	4							50	S2026/27
460: EAST PROSPECT ZS to ABC TSS	4										x							26	S2026/27
450: BLCKTWN TS to TEE1 to NEWTON	12											x	37	20	19			42	S2026/27
481: LEABONS LANE ZS to NEWTON ZS	23											36	x	16	17			50	S2026/27
467: BLCKTWN TS to LEABONS LANE ZS	24											31	12	x	40			42	S2026/27
429: BLCKTWN TS to LEABONS LANE ZS	22											28	11	39	x			42	S2026/27
445: BLCKTWN TS to MARAYONG ZS	43															x		45	S2026/27
470 SEVEN HILLS ZS to MARAYONG ZS	S/B															21		34	S2026/27
473 BLKM HLLS TS to Tee to MRAYONG ZS	S/B															20		21	S2026/27
482: BLACKTOWN TS to FUJITSU HVC	S/B																29	27.4	S2021/22
483: BLACKTOWN TS to FUJITSU HVC	29																x	27.4	S2021/22

[1] Marayong ZS is operated with 445(Blacktown TS) and 470/473 (Baulkham Hills TS) split during high loads above 45MVA. This has not been required for a number of years, nor is it expected to be required within the forecast period.

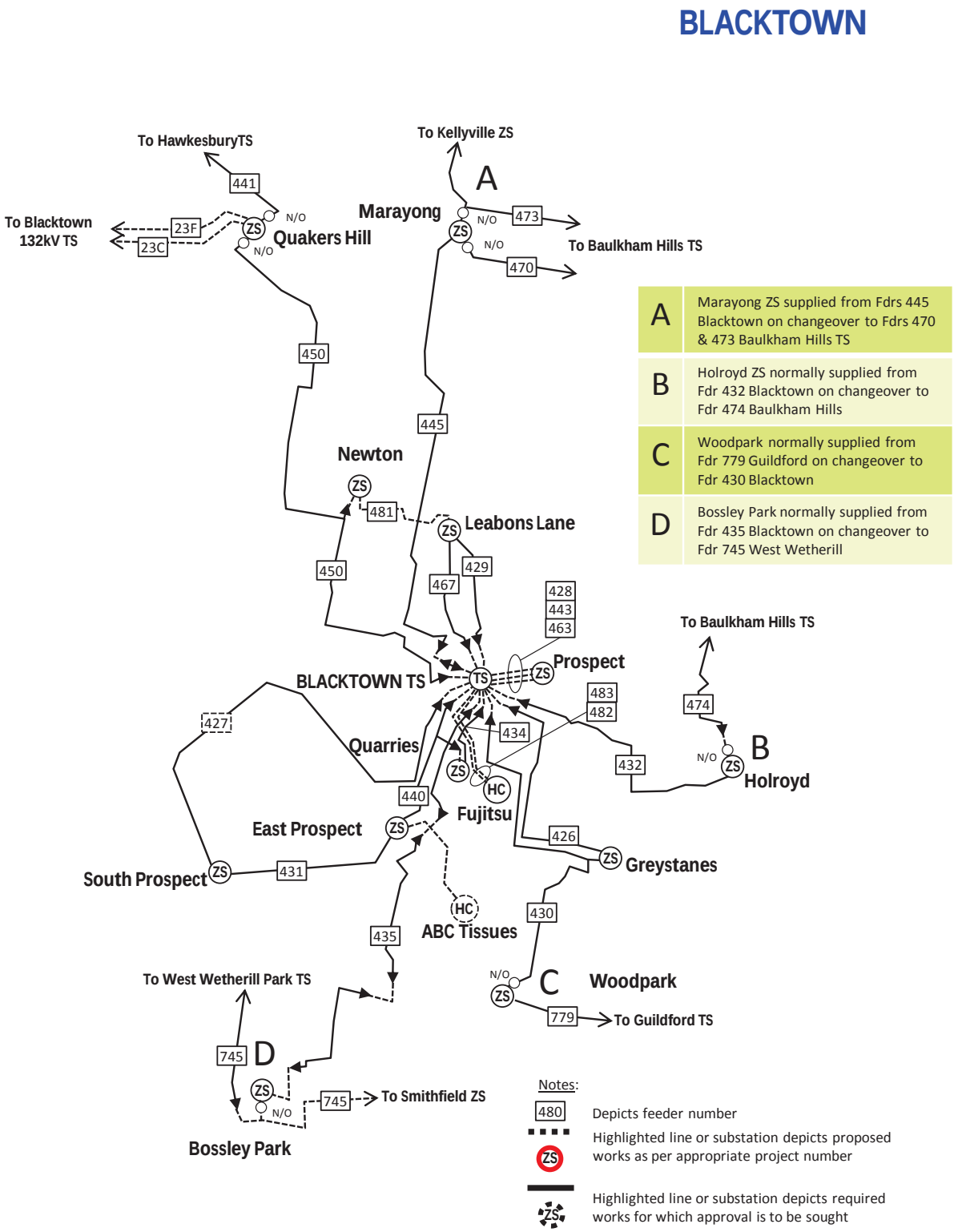
7.3.2 Blacktown TS Voltage Levels – Summer Summary

Faulty ➔	Nil	433	463	426	430	679	435	434	440	431	427	460	450	481	467	429	470	473	Min Tap	Max Tap	Result Year
Prospect	-1	-1	-1																-9	6	S2026/27
Holroyd	-3																		-13	7	S2026/27
Greystanes	1			1	1														-14	7	S2026/27
Woodpark	x					0													-14	7	S2026/27
Bossley Park	-1						-1												-15	7	S2026/27
Quarries	**-1**							-2	-1	-1	-1	0	0						-14	7	S2026/27
East Prospect	0							0	0	0	0	1	1						-14	7	S2026/27
South Prospect	1							1	1	2	1	1	1						-14	7	S2026/27
ABC Tissue	0							0	0	0	0								-14	7	S2026/27
Leabons Lane	-3												0	0	0	0			-14	7	S2026/27
Newton	-2												-2	-3	-2	-2			-14	7	S2026/27
Marayong	-4																-2	-2	-14	7	S2026/27

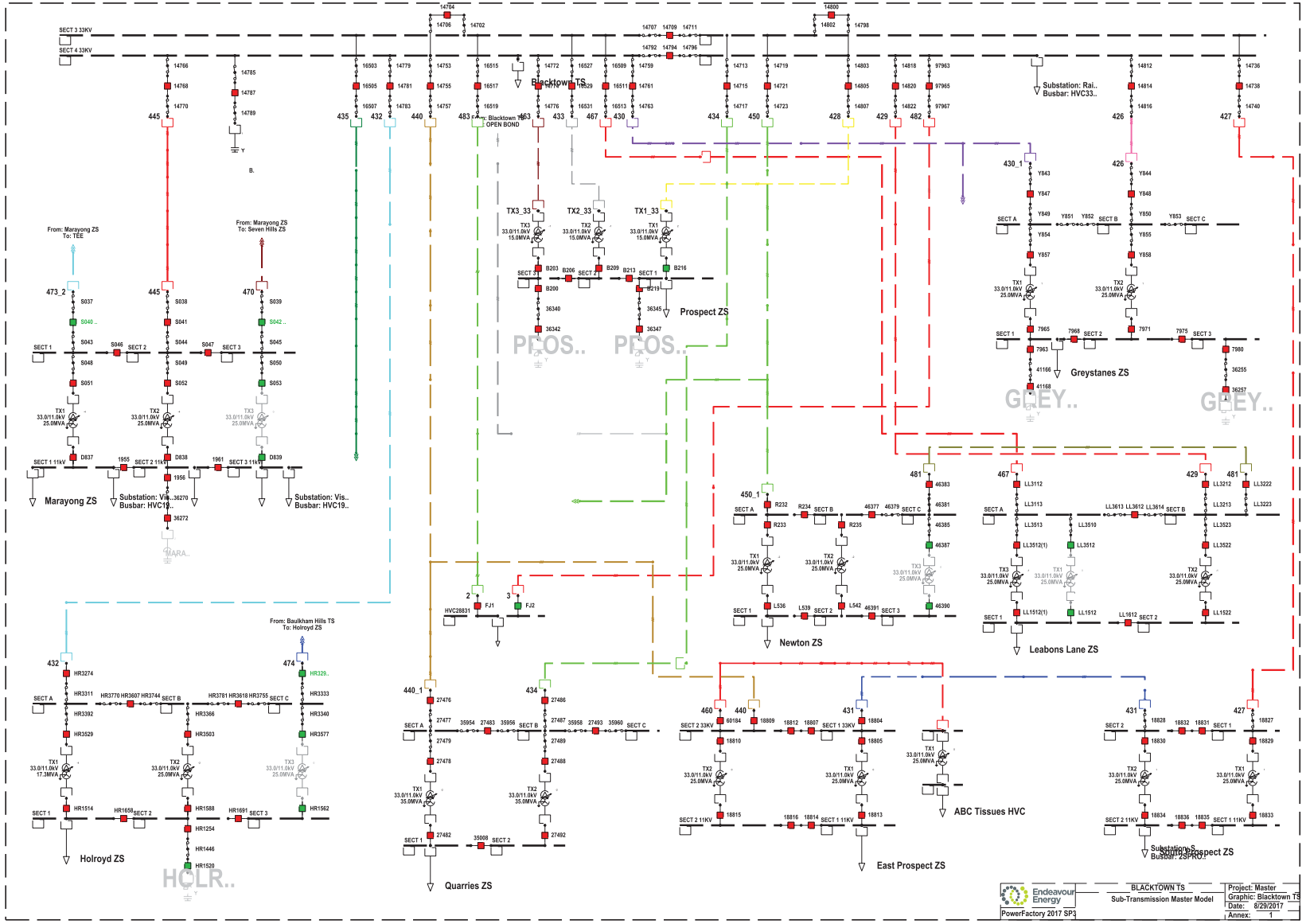
7.4 Analysis Results and Possible Solutions

Blacktown	Network Constraint	Year	Investigation	Solution
	Feeder 482 Ratings Check Required	2022	Check Ratings	Ratings
	Feeder 483 Ratings Check Required	2022	Check Ratings	Ratings

7.5 Blacktown Geographic



7.6 Blacktown Schematic



8 CAMELLIA TRANSMISSION SUBSTATION

8.1 Camellia Transmission Network Status

Camellia Transmission Substation is supplied at 132kV from the Holroyd Bulk Supply Point via Endeavour Energy's Guildford Transmission Substation. Camellia TS is floated at 34kV and presently supplies Lennox ZS and Rosehill ZS. Camellia TS also supplies customer substations for Viva Energy and ING. Viva Energy (formerly Shell) has ended its refining operations and now uses the existing Clyde site as a fuel import terminal. The Viva Energy site has significantly reduced its electrical load in recent years (42MVA to 4MVA). Viva Energy will have some surplus land which has been included in the Department of Planning and Environment's Camellia Priority Precinct for development. There is also expected to be a rezoning of Camellia industrial land for residential purposes in mid 2017.

Supply into the Parramatta CBD area also comes from North Parramatta ZS which is a 132/11kV zone substation supplied off the same 132kV network as Camellia TS, via the East Parramatta Switching Station.

There are small amounts of generation onto the 11kV bus at Rosehill ZS.

Endeavour Energy and Ausgrid have issued a joint planning study for the Auburn and Lidcombe Supply Strategy. Ausgrids Auburn ZS and Lidcombe ZS will be supplied from Camellia TS with the staged commissioning likely in 2019/20.

PR722 "Camellia TS Ausgrid Connection" has been initiated to fund costs associated with preparation of Endeavour Energy owned assets and technical advice for the connection of Ausgrid's two Zone Subs.

Refurbishment Project T616 at Camellia TS will replace 132/33kV Transformer No1, remove 132/33kV Transformer No.3 and reconfigure the 33kV busbar arrangement. This will reduce the Firm Transformer capacity to 120 MVA.

8.2 Camellia Transmission Network Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Camellia TS	3 x 120 (*2 x 120**)	240 (*120**)		Nil
Lennox	3 x 25	50	10	Nil
Rosehill	3 x 25	50	5	Nil

- Denotes works works under TS616 in 2018/19

8.3 Results Tables

This analysis has been completed with no generation at Shell or Bio Mass (Rosehill ZS)

8.3.1 Camellia TS Loads and Ratings – Summer Summary

Faulty ➔	Nil	403	404	405	410	411	413	417	418	Rating	Year of Result
403 Camellia to Shell HVC 6288	1.5	x	1.7	1.5						50	2026/27
404 Camellia to Shell HVC 6288	1.5	1.7	x	1.5						50	2026/27
409 Camellia to ING HVC 6289	S/B				1.9					17	2026/27
410 Camellia to ING HVC 6289	1.9				x					17	2026/27
411 Camellia to Rosehill ZS	17.2					x	20.6			47	2026/27
412 Camellia to Rosehill ZS	S/B					14.5	14.5			47	2026/27
413 Camellia to Rosehill ZS	17.1					20.6	x			47	2026/27
417 Camellia to Lennox ZS	13.9							x	27.1	50	2026/27
418 Camellia to Lennox ZS	13.1							27.1	x	43	2026/27

8.3.2 Camellia TS Voltage Levels (Resultant Tap Position) – Summer Summary

Faulty➔	Nil	411	413	417	418	Min Tap	Max Tap	Year of Result
Rosehill	2	2	2			-14	7	2026/27
Lennox	2			0	0	-14	7	2026/27

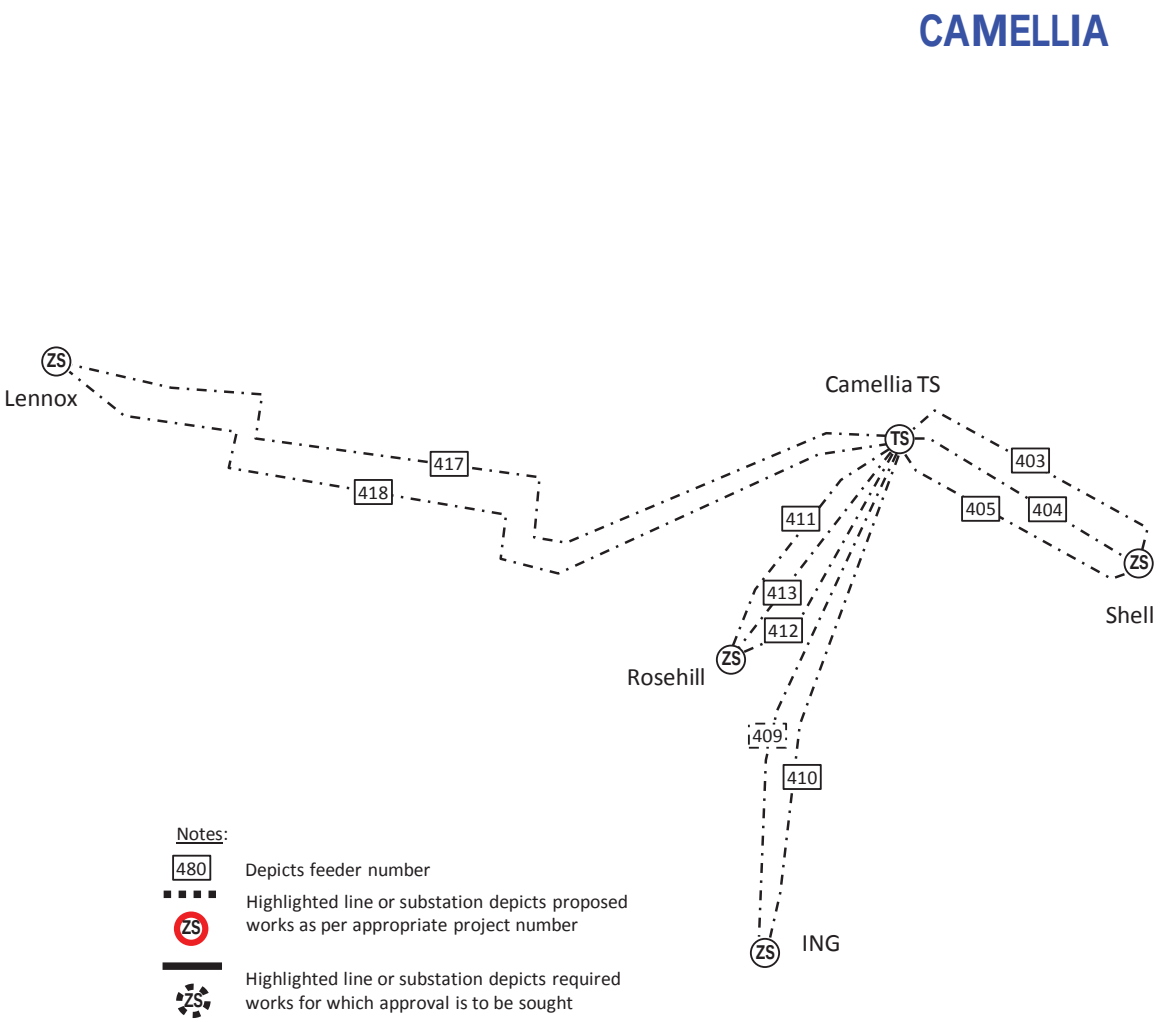
Note there are no Resultant Tap Positions for Shell or ING as they are HVC sites with no available information regarding their target voltage or tapchanger range.

8.4 Analysis Results and Possible Solutions

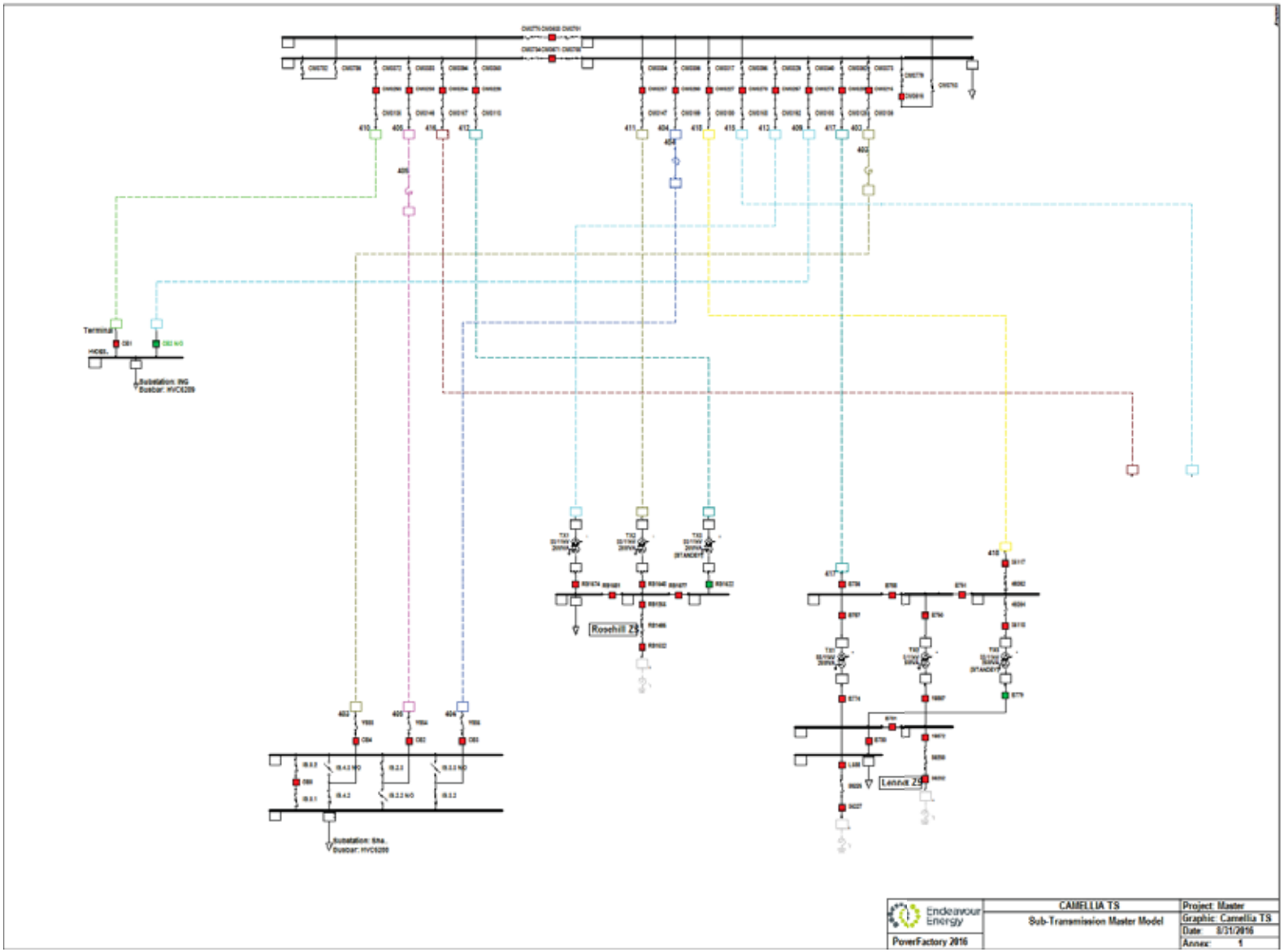
Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges, respectively, for this review period.

Camellia	Network Constraint	Year	Investigation	Solution
	NIL			

8.5 Camellia Geographic



8.6 Camellia Schematic



9 CARLINGFORD TRANSMISSION SUBSTATION

9.1 Carlingford Transmission Network Status

Carlingford Transmission Substation has three 120 MVA 132/66kV double-wound transformers and one 120 MVA 132/66kV auto transformer. The auto transformer was the former system spare and was installed at Carlingford following the failure of one of the original units. This unit has relatively lower impedance than the other units. This results in unequal load sharing and reduces effective capacity whenever the unit is in service. However, there is currently no constraint due to the reduced demand at Carlingford.

The Baulkham Hills – Carlingford 132kV transmission system has a firm summer rating of 512 MVA. Carlingford TS floats at 66kV with 5% LDC at 300MVA to cater for the light rating of the subtransmission system supplying Castle Hill and West Pennant Hills. Carlingford TS supplies approximately 100MVA to Ausgrid zone substations at Epping and Hunters Hill. Kenthurst ZS is normally supplied from 132kV feeder 221 Sydney North, backed up on changeover to 66kV feeder 830 (Castle Hill – Kenthurst).

Dundas ZS is normally operated with all three transformers in service and the 11kV busbar split into three separate sections. They are never operated in parallel due to the resultant high fault level. Dundas ZS transformers are directly connected to an extension of the Carlingford 66kV busbar. The 66kV busbar is rated at 96MVA summer and 128 MVA winter. Load is unequal across the three 11kV sections but this can be managed by System Operations if they elect to transfer an 11kV feeder across the duplicate busbar to an alternate section.

A new 66kV supply is to be made available to the operators of the Northconnex M1-M2 tunnel by 2019. Northconnex will become a HVC on completion of this project with the normal peak load of its operations advised as 7 MVA. Under a declared emergency condition of the M1-M2 tunnel a 22MVA supply is required.

The Northconnex 66kV supply will be sourced from the Carlingford TS 66kV busbar ex feeder CB 810 with a new feeder cable and a cable tee from existing feeder 818.

9.2 Carlingford Transmission Network Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Carlingford TS	4 x 120	360	80	Nil
Castle Hill	3 x 25	50	0	Nil
Dundas	3 x 35	70	10	Nil
Rydalmere	2 x 33 + 1 x 25	58	15	Nil
West Pennant Hills	2 x 35	35	5	Nil

9.3 Results tables

9.3.1 Carlingford TS Loads and Ratings – Summer Summary

Faulty ➔	Nil	810	814	815	816	818	825	*221	D1	D2	D3	Rating (MVA)	Result Year
810 Carlingford TS to Northconnex SS	3.2	x				5.2		3.4					
814 Carlingford to Rydalmere ZS	18.3		x		35.6			x				67.0	2018/19
815 Carlingford to Castle Hill ZS	12.4			x		17.8	30.8	18.5				33.6	2026/27
816 Carlingford to Rydalmere ZS	17.2		40.8		x			x				58.0	2018/19
818 Carlingford to West Pennant Hills ZS	23.3	25.4		30.3		X	23.8	30.6				40.0#	2026/27
818/2 Nortconnex SS to Tee	2.2	5.4		2.0			2.0	2.2				67.0	2026/27
825 Carlingford to Tee 1	17.1	18.1		22.4		33.2	x	22.6				33.6#	2026/27
825/1 Tee 1 to Castle Hill ZS	17.9			30.7		12.7	x	30.7				33.6	2026/27
825/2 Tee 1 to West Pennant Hills ZS	4.2			9.6		20.9	x	9.6				86.0	2026/27
830 Castle Hill ZS to Kenthurst ZS**	0.1							18.3				32.0	2026/27
D1 Carlingford to No1 Dundas ZS	9.2							x	x	22.8	28.2	96.0	2026/27
D2 Carlingford to No2 Dundas ZS	13.3							x	22.8	X	9.0	96.0	2026/27
D3 Carlingford to No3 Dundas ZS	14.6							x	14.5	14.5	x	96.0	2026/27

A Contingency Rating is to be determined for these feeders.
***** Normal supply to Kenthurst ZS from Sydney North BSP
****** Kenthurst ZS Backup supply from Carlingford TS

9.3.2 Carlingford TS Voltage Levels (Resultant Tap Position) – Summer Summary

Faulty ➔	Nil	814	815	816	818	825	D1	D2	D3	221[1]	Min Tap	Max Tap	Result Year
Castle Hill	-1		-3		-3	-3					-14	7	2026/27
Dundas 1	2						x	-1	0		-14	7	2026/27
Dundas 2	1						-1	x	-1		-14	7	2026/27
Dundas 3	0						-1	-1	x		-14	7	2026/27
Rydalmere	2	-3		-3							-14	7	2026/27
Wes Pen Hill	1		-2		-2	-2					-14	7	2026/27
Kenthurst										-6	-14	7	2026/27

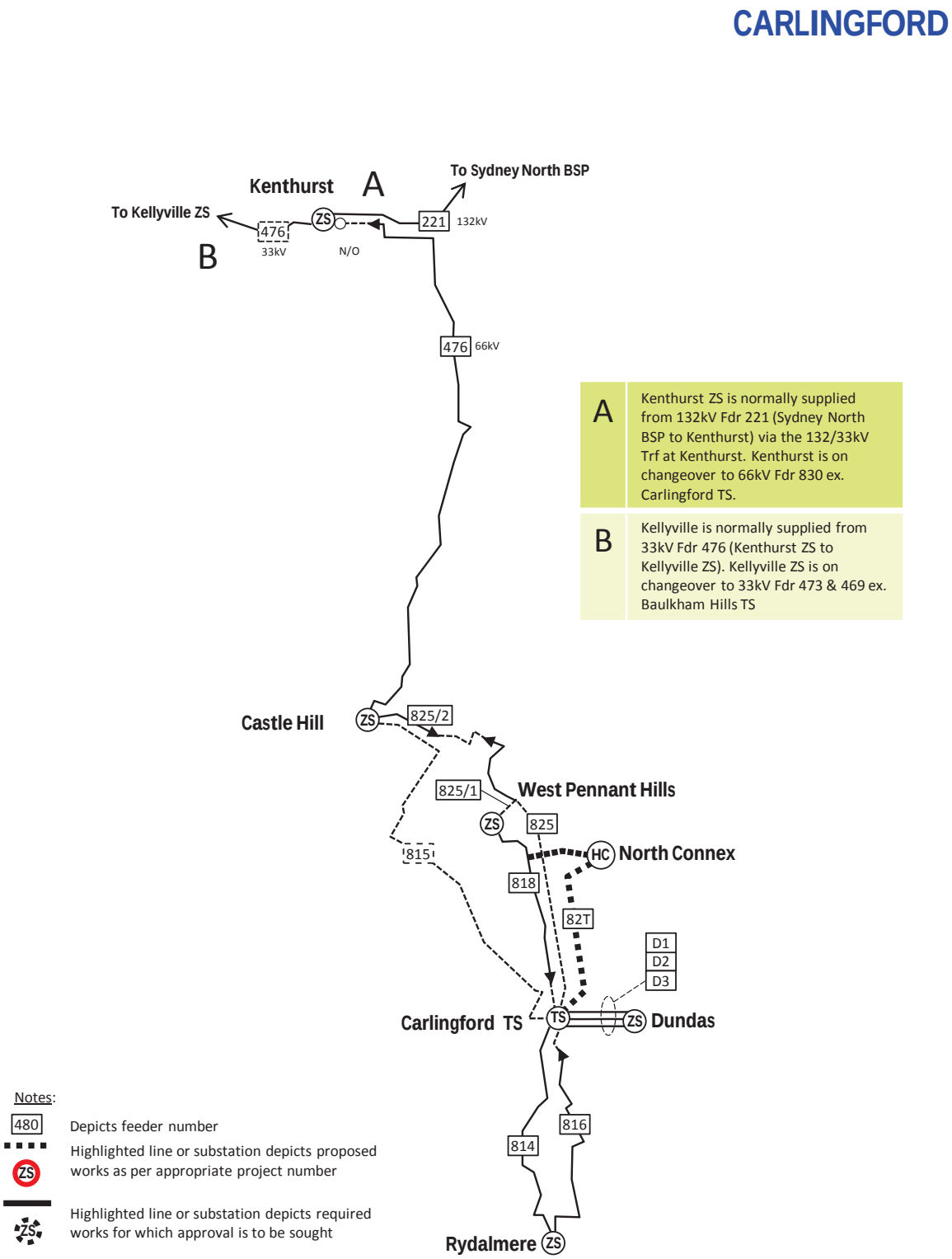
Note 1: Kenthurst ZS normally supplied from Sydney North BSP via feeder 221.

9.4 Analysis Results and Possible Solutions

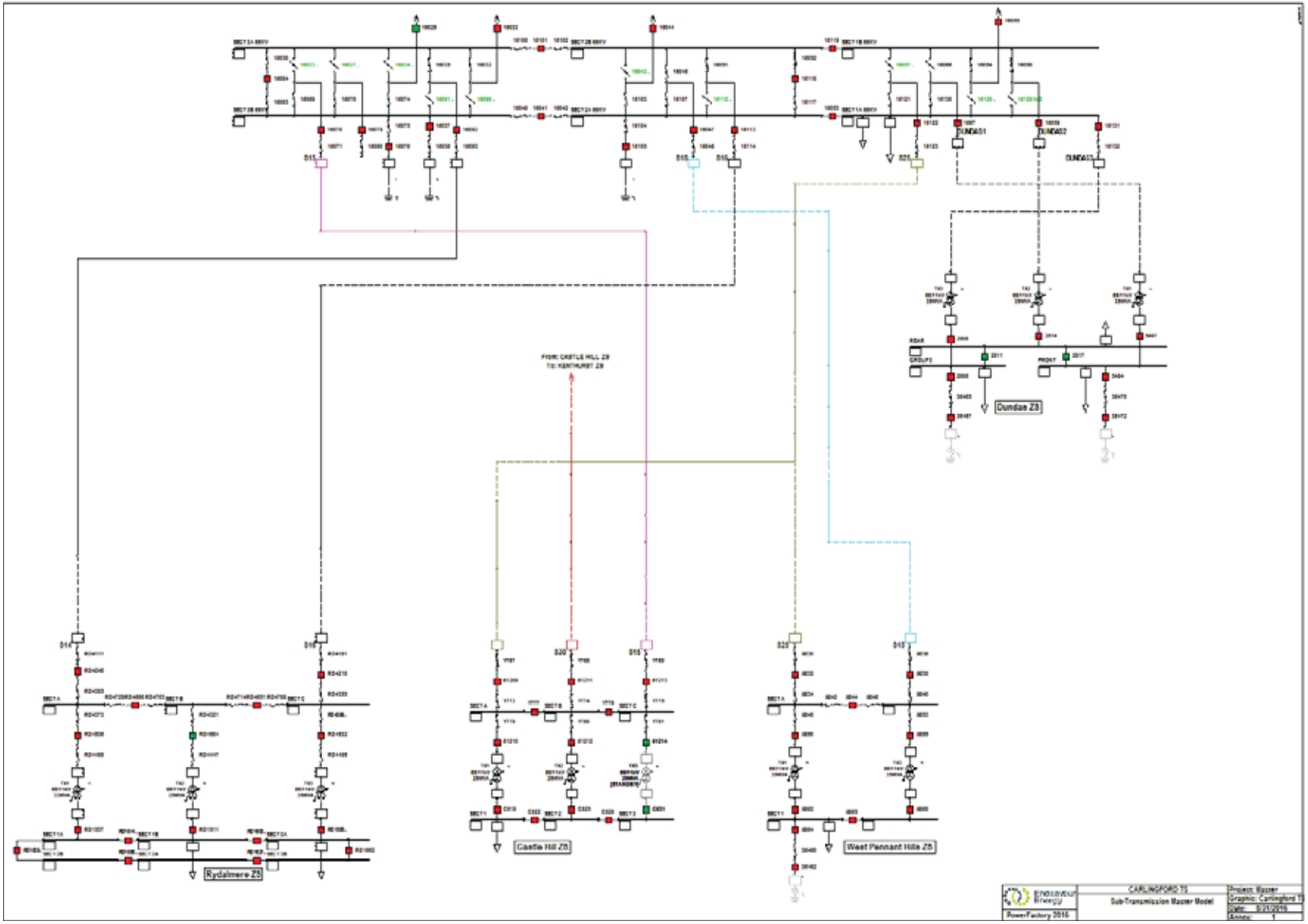
Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges, respectively, for this review period.

Carlingford	Network Constraint	Year	Investigation	Solution
	Nil			

9.5 Carlingford Geographic



9.6 Carlingford Schematic



10 DAPTO BULK SUPPLY POINT

10.1 Dapto Bulk Supply Point Transmission Network Status

Dapto Bulk Supply Point is owned by TransGrid and has four 375 MVA 330/132kV transformers. Only three transformers are in service at any time for fault level reasons. Endeavour Energy is supplied at 132kV from Dapto BSP, which is floated at 138.6kV. There are series line reactors at Dapto BSP, rated at 286MVA on feeders 98Y, 982, 983 & 984. These reactors were installed to limit fault levels on the Springhill TS and BlueScope 33kV switchgear prior to its recent renewal and are still in service.

Dapto BSP supplies 132kV north to Bellambi, Springhill and Outer Harbour TS's; south to Mt Terry TS, Shoalhaven TS and West Tomerong TS as well as Ulladulla ZS; and west to Burrawang Pumping Station then further west providing backup to Fairfax Lane TS. Dapto BSP also supplies 132kV to the Essential Energy network at Bateman's Bay ZS and Moruya North TS. The Essential Energy substations are supplied through the Evans Lane Switching Station which is also the connection point for Endeavour Energy's Ulladulla ZS.

In early 2009 Energy Australia commissioned a 435MW combined cycle gas turbine generator at the former Tallawarra 320MW coal-fired power station site. The generator feeds into the Tallawarra Switching Station which has been cut into feeders 983 and 984 Dapto to Springhill and has a further connection to Dapto via feeder 987. It is planned for feeder 984 adjacent to the foreshore of Lake Illawarra to be removed as part of the environmental approval as part of the generator project, but this has not yet been completed. No line reactors are installed on feeder 987 which is normally open at Dapto BSP. Feeder 987 will need to be integrated into feeder 984 at the Dapto BSP end and utilise its line reactor if the partial removal of feeder 984 proceeds.

The 132kV network south of Dapto BSP, consisting of feeders 98W, 98F, 98L, 98U, 98J, 98P, 28P 98H and 98M connecting Endeavour Energy's Mt Terry TS, Shoalhaven TS and Ulladulla ZS as well as Essential Energy's Batemans Bay and Moruya North substations to Dapto BSP, was subject to both voltage and capacity constraints due to the length of the 132kV feeders.

TransGrid had evaluated alternatives for the establishment of a new Tomerong bulk supply point to provide 132kV injection in this area to resolve voltage and capacity constraints. In 2013, revised 132kV line ratings significantly increased the emergency ratings. The result tables show the rating constraints of previous years on the 132kV lines south of Dapto BSP now do not exist. The only constraints are now voltage related. To overcome the voltage constraints additional reactive support has been approved July 2014 through (PR479) – 132kV Voltage Constraints South Coast, which will defer the establishment of TransGrid's BSP at Tomerong beyond the current forecast period.

Endeavour Energy developed West Tomerong TS, to relieve constraints at Shoalhaven TS as well as the southern catchment of its 33kV subtransmission system.

A report titled "West Lake Illawarra Area Plan" was endorsed by management in May 2016. The West Lake Illawarra release area is proposed to provide up to 25,770 dwellings plus employment lands and commercial activities with an expected demand of up to 128MVA. It is proposed to ultimately service the development with three new zone substations. Two 132/11kV zone

substations are planned, with one northern in the vicinity of West Dapto Road (supplied by feeder 980 – Dapto to Bellambi Creek) and another in the vicinity of Avondale Road (supplied by feeder 988 - Dapto to Fairfax Lane). A potential site for the proposed northern zone substation (Lot 1, DP818199) was acquired in July 2010. The third zone substation is planned to be supplied at 33kV (by feeders 7123 and 7041) in the vicinity of Calderwood Road. Negotiations with the Calderwood Valley developer are proceeding with the likelihood of a zone substation site being acquired near 33kV lines 7123 and 7041 on Calderwood Road Calderwood.

A credible steel lattice tower failure and double circuit outage of 980/981 was desktop simulated prior to a real network switching event on Sunday 4 September 2016, where the entire Bellambi TS 33kV network was supplied (upto 80% of peak load) through three distinct radial 33kV substation groupings fed from Springhill TS.

The analysis has been done on the assumption the following approved projects have been completed:

- *PR479 – 132kV Voltage Constraints South Coast*

10.2 Dapto Bulk Supply Point Network Substation Rating Details

Transmission or Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Dapto BSP	4 x 375*	1125	240	Nil [including Tallawarra]
Bellambi	3 x 60	120	20	Nil
BlueScope Steel #	5 x 60	Not Applicable		Not Applicable
BOC Gases #	1 x 50	Not Applicable		Not Applicable
Burrawang PS #	2 x 30	Not Applicable		Not Applicable
Batemans Bay [Ess. E]	2 x 45	45	6	Not Applicable
Evans Lane SS	Nil	Nil	(2 x 15)	Nil
Mt Terry	2 x 120	120		Nil
Moruya North [Ess. E]	1 x 30 + 1 x 45	30	6	Not Applicable
Outer Harbour	2 x 60	60	20	Nil
Shoalhaven	3 x 60	120	28.9 @ 132kV & 18 @ 33kV	Nil
Springhill	3 x 120	240	80 @ 132kV & 40 @ 33kV	Nil
Tallawarra++	1 x 500	Not Applicable	74	Not Applicable
Ulladulla #	2 x 30	30		Nil
West Tomerong	2 x 60	60	(15 @ 132kV)	Nil
Yatte Yattah ^^	1 x 6.5	Non-Firm		Nil

Notes: # These Substations are supplied directly off the Dapto 132kV busbar, without an intermediate subtransmission busbar. The remaining locations are Transmission Substations with their individual subtransmission networks to each zone substation.

^^ Yatte Yattah is currently supplied by 11/33kV interposing transformer at Ulladulla. From late 2017 normal supply is planned from West Tomerong TS.

++ Tallawarra Switching Station and Tallawarra Gas Fired Generation Station.

* only three transformers in service at any time due to fault level reasons.

10.3 Results tables

10.3.1 Dapto SP (North) Loads and Ratings Summer Summary

Faulty ➔	Nil	980	981	98Y	982	983	984	987[1]	98G	98X	98B	986	985	989	98C	Rating	Result Year
980: DPT BSP to BLLMB TS	36	x	74													163	2027
981: DPT BSP to BLLMB TS	36	74	x													163	2027
98Y: DPT BSP to SPRNGHLL TS	71			x	82	75	75		165	70						344	2027
982: DPT BSP to SPRNGHLL TS	58			71	x	64	63		67	120						344	2027
983: DPT BSP to TLLWRR SS	41			56	57	x	58		55	42						256	2027
984: DPT BSP to TLLWRR SS	38			53	54	56	x		52	40						256	2027
987: DPT BSP to TLLWRR SS[1]	x			x	x	x	x	x	x	x						343	2027
98G: TLLWRR SS to SPRGHLL TS	141			199	145	145	145		x	172						343	2027
98X: TLLWRR SS to SPRGHLL TS	95			107	141	104	104		140	x						343	2027
98B: SPRGHLLTS to HVC93007	27										x	27				69	2027
986: SPRNGHLLTS to HVC93007	x										27	x				69	2027
985: SPRGHLLTS to OUTHRBR TS	17												x	31		165	2027
989: SPRGHLLTS to OUTHRBR TS	13												30	x		165	2027
988: DPT BSP to TEE1	6														82	133	2027

1. Line 987 is normally open at Dapto BSP (no reactors) and not on auto change over.

10.3.2 Dapto SP (North) Voltage Levels (Resultant Tap Position) Summer Summary

Faulty ➔	Nil	980	981	98Y	982	983	984	987	98G	98X	98B	986	985	989	98C	Min. Tap	Max. Tap	Result Year
Bellambi	1	1	1													-12	4	2027
BOC Gasses	N/A																	2027
Burrawang PS	N/A																	2027
Fairfax Lane	3															-12	4	2027
Outer Harbour	2			2	2	2	2		2	2			x	1		-12	4	2027
Springhill	-2			-2	-2	-2	-2		-2	-2						-16	4	2027

10.3.3 Dapto SP (South) Loads and Ratings Winter Summary

Faulty	Nil	98W	98F	98L	98U	98P	28P	98J	28C	28F	98H	98M	98T	Rating	Result Year
98W: DP BSP to MT TRRY TS	152	x	310											354	2026
98F: DP BSP to MT TRRY TS	154	310	x											354	2026
98L: MTTRY TS to SHLVN TS	108			x	219									297	2026
98U: MTTRY TS to SHLVN TS	107			219	x									297	2026
98P: SHLVN TS to WTMRG TS	81					x	50	123						226	2026
28P: WTMRG TS to EVNS LN TS	32					51	X	74						226	2026
98J: SHLHVN TS to EVNS LN SS	42					126	74	x						226	2026
28C: EVN LNE SS to ULDLL ZS	12								x	25				96	2026
28F: EVNS LNE SS to ULDLL ZS	12								25	x				96	2026
98H: EVNS LNE SS to MRY NTH	24										x	47	23	202	2026
98M: EVN LNE SS to BTMNS BY	22										48	x	24	85	2026
98T: BTMNS BY to MRY NTH	5										24	24	x	85	2026

10.3.4 Dapto SP (South) Voltage Levels (Resultant Tap position) Winter Summary

Faulty ➔	Nil	98W	98F	98L	98U	98P	28P	98J	28C	28F	98H	98M	98T	Min. Tap	Max. Tap	Result Year
Mt Terry	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-12	4	2026
Shoalhaven	1	1	1	-1	-1	0	1	1	1	1	1	1	1	-12	4	2026
Ulladulla	0	-2	-2	-4	-4	-4	0	0	-5	x	-2	-1	0	-18	4	2026
West Tomerong	-2	-2	-2	-4	-4	-4	-2	-2	-2	-2	-2	-2	-2	-16	4	2026
Batemans Bay 1	1	0	1	-1	-1	0	1	1	1	1	-3	0	1	-17	5	2026
Moruya North 2	2	1	2	0	0	0	2	1	2	2	-3	1	2	-16	8	2026

10.3.5 Dapto SP (South) Loads and Ratings Summer Summary

Faulty ➔	Nil	98W	98F	98L	98U	98P	28P	98J	28C	28F	98H	98M	98T	Rating	Result Year
98W: DP BSP to MT TRRY TS	155	x	317											343	2027
98F: DP BSP to MT TRRY TS	158	317	x											343	2027
98L: MTTRY TS to SHLVN TS	107			x	222									261	2027
98U: MTTRY TS to SHLVN TS	107			222	x									261	2027
98P: SHLVN TS to WTMRG TS	75					x	38	120						214	2027
28P: WTMRG TS to EVNS LN TS	37					40	x	82						214	2027

98J: SHLHVN TS to EVNS LN SS	44					122	81	x						214	2027
28C: EVN LNE SS to ULDLL ZS	15								x	32				96	2027
28F: EVNS LNE SS to ULDLL ZS	16								32	x				96	2027
98H: EVNS LNE SS to MRY NTH	26										x	50	25	182	2027
98M: EVN LNE SS to BTMNS BY	24										53	x	25	72	2027
98T: BTMNS BY to MRY NTH	5										27	25	x	72	2027

10.3.6 Dapto SP (South) Voltage Levels (Resultant Tap position) Summer Summary

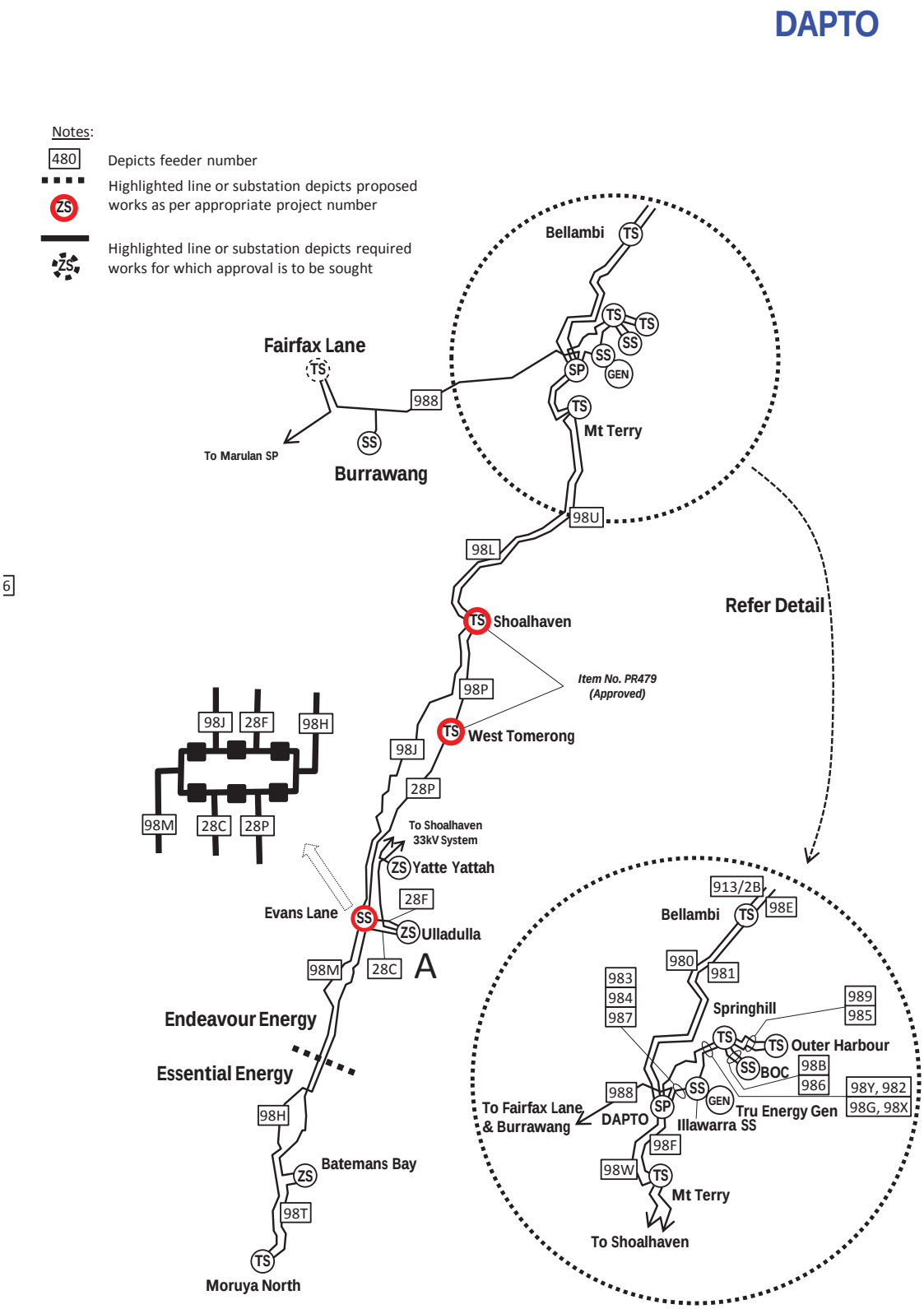
Faulty ➔	**Nil**	**98W**	**98F**	**98L**	**98U**	**98P**	**28P**	**98J**	**28C**	**28F**	**98H**	**98M**	**98T**	**Min. Tap**	**Max. Tap**	**Result Year**
Mt Terry	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-12	4	2027
Shoalhaven	-1	-1	-1	-3	-3	-1	-1	-1	-1	-1	-1	-1	-1	-12	4	2027
Ulladulla	-2	-4	-4	-7	-7	-5	-2	-3	-9	x	-4	-2	-2	-18	4	2027
West Tomerong	-2	-2	-2	-5	-4	-4	-2	-2	-2	-2	-2	-2	-2	-18	4	2027
Batemans Bay1	-1	-1	-1	-2	-2	-4	-1	-2	-1	-1	-5	-2	-1	-16	4	2027
Moruya North2	0	-1	-1	-2	-2	-3	-1	-1	-1	0	-8	-1	0	-16	4	2027

10.4 Analysis Results and Possible Solutions

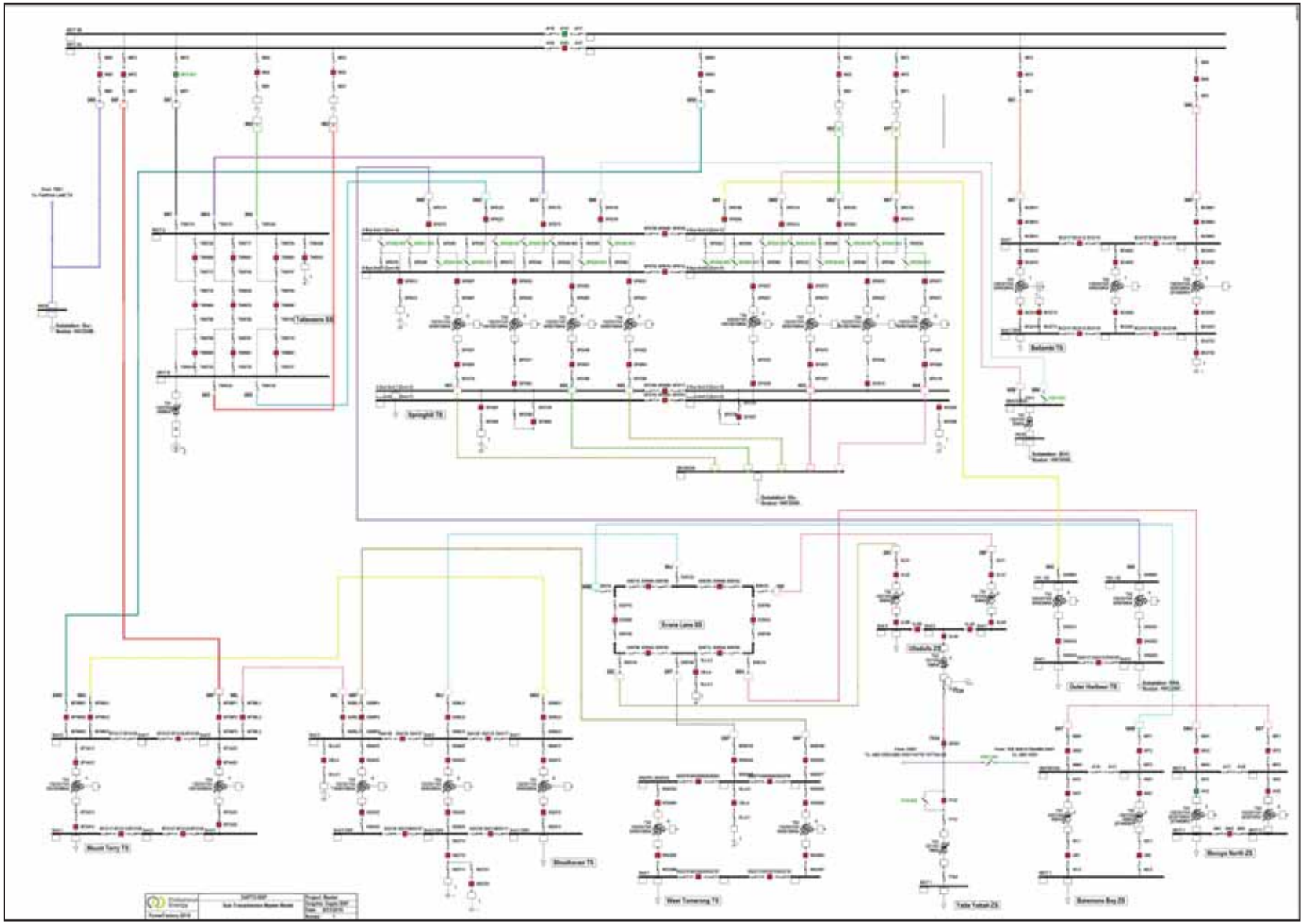
The load demand and voltage levels on all feeders and substations are within their design ratings and ranges, respectively, for this review period.

Dapto	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			

10.5 Dapto BSP Geographic



10.6 Dapto BSP Schematic



11 FAIRFAX LANE TRANSMISSION SUBSTATION

11.1 Fairfax Lane Transmission Network Status

Fairfax Lane Transmission Substation is owned by Endeavour Energy and has three 60MVA 132/33kV transformers providing a firm capacity of 120MVA. The substation is supplied via 132kV feeder 98C from Marulan BSP with an alternative supply from feeder 988 Dapto BSP. Feeder 98C is rated at 168/190 MVA summer/winter with 988 rated at 133/146 MVA summer/winter. The capacity of each of these 132kV feeders is adequate to meet the needs of the area within the forecast period.

Fairfax Lane TS is floated at 33kV with LDC set at 7.5% @ 93MVA. The preferred operating arrangement at Fairfax Lane is to run with all transformers in service whenever available. This is required to improve fault levels on the subtransmission system to assist with large motor starts at a number of test facilities in the area.

Robertson ZS as well as Tycan/Tyree and Sydney Catchment Authority customer substations have no alternate 33kV supply.

33kV spur line 7911/7914/7915 has been augmented to a summer rating of 20MVA. This will allow for the future establishment of a rural ZS in the Hilltop/Yerrinbool areas which is forecast to be driven by a number of enquiries for development in the area. This feeder also supplies the existing Sydney Water Catchment Authority sites at Nepean and Avon dams.

A no-volt change over scheme is in operation at Ringwood ZS. The changeover scheme operates on the 11kV transformer circuit breakers as there are no installed incoming 33kV circuit breakers.

11.2 Fairfax Lane Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Fairfax Lane TS	3 x 60	120	24	Nil
Berrima Junction[1]	1 x 20	Non-Firm		Not Applicable
Bowral	2 x 10 + 1 x 12.5	20	5	Nil
Mittagong	2 x 12.5 + 1 x 15	25	5	Nil
Moss Vale	2 x 25	25		Nil
Ringwood	2 x 12.5	12.5		Nil
Robertson	2 x 3.75	3.75		Existing

11.3 Results tables

11.3.1 Fairfax Lane TS Loads and Ratings Summer Summary

Faulty ➔	Nil	7905	7903	7904	7917	7908	7906	7901	7902	7918	7909	Rating	Result Year
7905: FRFXLN TS to BRM JCTN ZS TEE	12.7	X	14.5	14.5		25.6						34	2026/27
7903: FRFXLN TS to MSS VL ZS	13.1	19.1	X	24.7								35	2026/27
7904: FRFXLN TS to MSS VL ZS	13.2	19.2	24.7	X								32	2026/27
7917: FRFXLN TS to RNGWD ZS	4.4				X		4.4					18	2026/27
7908: MSSVL ZS to TEE BL CRL CMNT	12.1	24.1	10.4	10.4		X						29	2026/27
7906: MSSVL ZS to RNGWD ZS	0.2				4.4		X					14	2026/27
7907: FRFX LN TS to RBRT ZS	3.8											11	2026/27
7901: FRFX LN TS to BWRL ZS	16.2							X	33.5			42	2026/27
7902: FRFX LN TS to BWRL ZS	16.2							33.5	X			42	2026/27
7918: BWRL ZS to MTTGNG ZS	9.1									X	18.5	43	2026/27
7909: BWRL ZS to MTTGNG ZS	9.1									18.5	X	29	2026/27
7910: MTTGNG ZS to TYR TEE	3.3											32	2026/27

11.3.2 Fairfax Lane TS Voltage Levels (Resultant Tap Position) Summer Summary

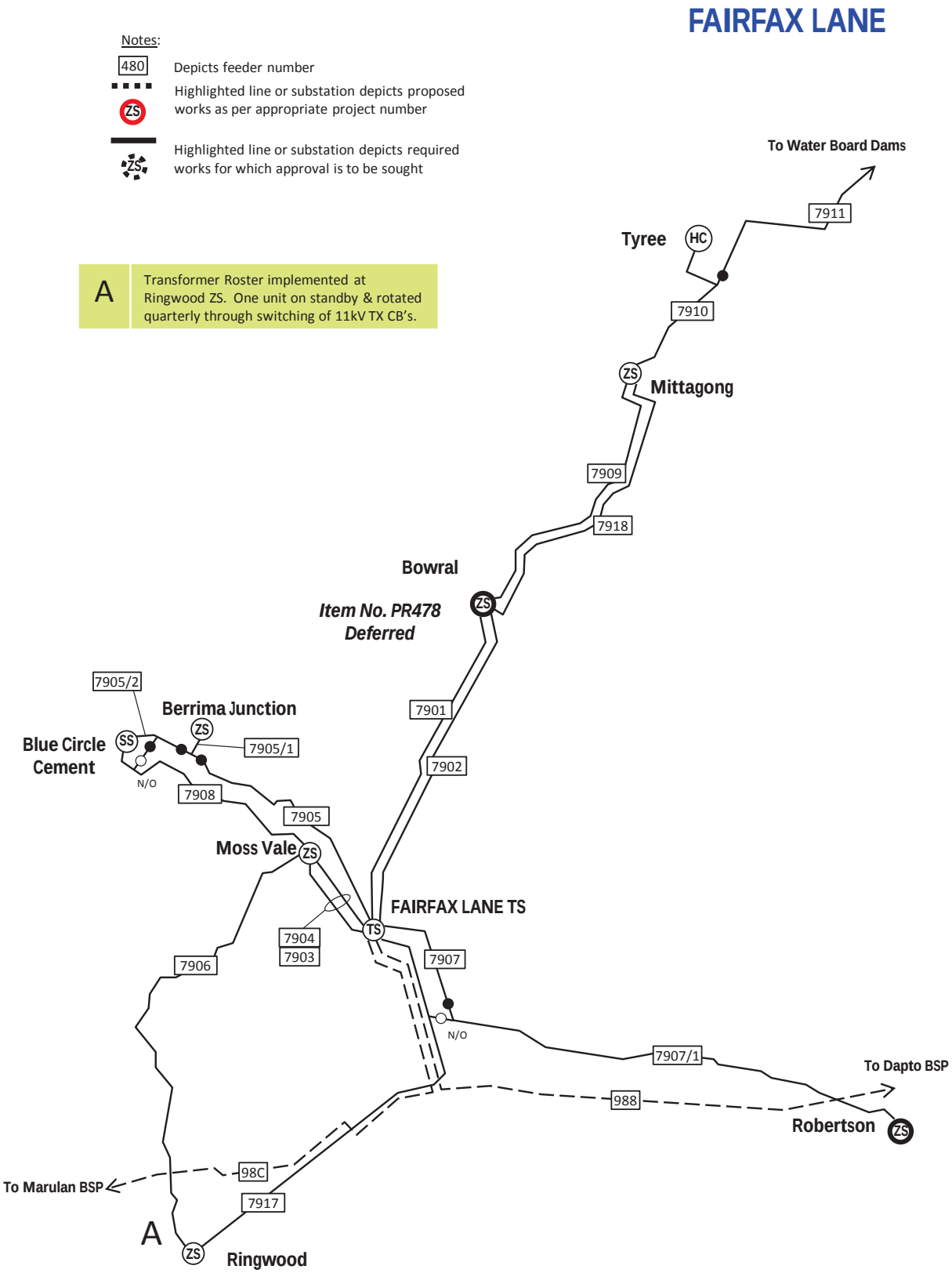
Faulty ➔	Nil	7905	7903	7904	7917	7908	7906	7901	7902	7918	7909	Min Taps	Max Taps	Result Year
Berrima Jun	1					1						-14	7	2026/27
Bowral	0							-2	-2	0	0	-12	4	2026/27
Mittagong 2	-1							-4	-4	-2	-2	-16	4	2026/27
Mittagong 3	-1							-4	-4	-2	-2	-8	14	2026/27
Moss Vale	-1	-1	-1	-1	-1		-1					-12	4	2026/27
Ringwood	-1				-1		-1					-16	4	2026/27
Robertson	0											-12	4	2026/27

The load on the Fairfax Lane transmission network is winter peaking. However, due to the lower summer subtransmission feeder ratings any constraints will occur under summer peak demand conditions.

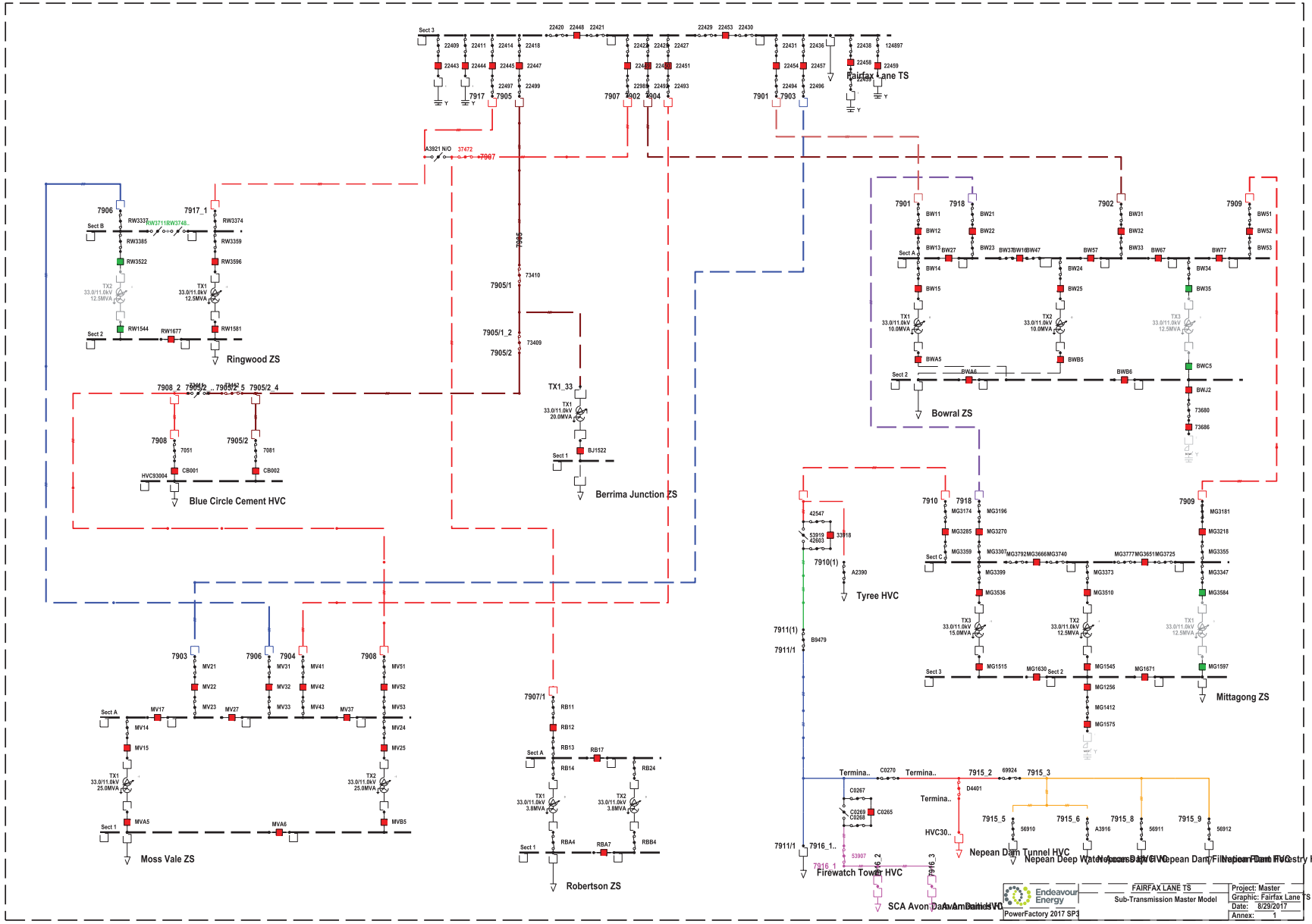
11.4 Analysis Results and Possible Solutions

Fairfax Lane	Network Constraint	Year	Investigation	Solution
	Robertson ZS firm rating exceeded. The load is 31% above the firm rating for a single transformer (3.75MVA)	W2017	The situation will continue to be monitored and options to be investigated in the future. Non-firm rating is 7.5MVA	Continue to Monitor
	The load on Bowral ZS is approaching its firm rating. Each 10MVA transformer is approaching full load for outage of the other 10MVA transformer due to impedance mismatch with the 12.5MVA transformer. As a result, effective firm capacity is approximately 19MVA and not 20MVA.	W2026	PR478 for augmentation of the transformers was deferred due to the installation of capacitors in previous years.	Continue to Monitor PR478

11.5 Fairfax Lane Geographic



11.6 Fairfax Lane Schematic



12 GUILDFORD TRANSMISSION SUBSTATION

12.1 Guildford Transmission Network Status

Guildford Transmission Substation is supplied at 132kV from Holroyd Bulk Supply Point by feeders 93F and 93L and also from Sydney West BSP by feeders 93M (via West Wetherill Park TS) and 93J (via Granville and Camellia). The 132kV busbar is operated split between the two bulk supply sources. The Parramatta CBD Network is supplied from the Guildford 132kV busbar

Guildford TS supplies 33kV to Cabramatta, Carramar, Fairfield, Sherwood, Smithfield, South Granville, Woodpark and Yennora zone substations owned by Endeavour Energy. It also supplies Ausgrid's Leightonfield ZS and the Visy Paper HVC.

Guildford TS has three 120MVA transformers providing a firm capacity of 240MVA. Until mid 2017, Marubeni generating station supplied 160MW and 60MVAr onto the Guildford 33kV busbar. The generating plant consists of three 36MW gas machines and one 77MW steam machine. Proposed new commercial arrangements from mid 2017 will see the generator supply reduced to between 0MW and 108MW provided by the three gas units at intermittent times depending on market need. The normal static support arrangement is for only one capacitor bank in service providing 20MVAr, with Marubeni supplying the remaining reactive power needs. This is required to limit the voltage fluctuations onto the generators, which would otherwise be imposed by repetitive switching of the capacitor banks. The new commercial arrangements for Marubeni will not result in constraints on the sub-transmission network.

Cabramatta ZS is supplied from Homepride ZS by feeder 68C for a contingency on feeder 687 from Guildford TS. Feeder 68C also supplies one bus section of Homepride ZS from Cabramatta ZS during contingencies on either feeder 509 or 517 from West Liverpool TS.

Woodpark ZS is supplied from Blacktown TS by feeder 430 for a contingency on feeder 679 from Guildford TS.

The analysis of the Guildford transmission network has been carried out with the following network configurations:

- Cabramatta ZS normally supplied by feeder 687 from Guildford TS, on changeover to feeder 68C from Homepride ZS.
- Woodpark ZS normally supplied by feeder 679 from Guildford TS, on changeover to feeder 430 from Blacktown TS.
- Feeder 745 West Wetherill Park TS on standby for back-up to Smithfield ZS.

-

12.2 Guildford Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVA)	Transformer Constraint (Year)
Guildford TS	3 x120	240	60	Nil
Cabramatta	2 x 25	25	5	Nil
Carramar	2 x 25	25	5	Nil
Fairfield	3 x 25	50	10	Nil
Sherwood	2 x 25	25	10	Nil
Smithfield	3 x 25	50	10	Nil
South Granville	2 x 25	25	Nil	Nil
Woodpark	2 x 25	25	5	Nil
Yennora	2 x 25	25	5	Nil

12.3 Results Tables

12.3.1 Guildford TS Loads and Ratings - Summer

Faulty →	Nil	679	671	674	673	672	675	677	686	685	688	680	676	678	687	Rating MVA	Year of Result
679 Guildford to Woodpark^	24	X														42	2026/27
671 Guildford to Fairfield	32		X	43	39	27										57	2026/27
674 Guildford to Fairfield	12		36	X	15	10										55	2026/27
673 Guildford to Carramar	10		18	11	X	16										28	2026/27
672 Fairfield to Carramar	7.0		3.0	6.0	16	X										28	2026/27
675 Guildford to Sherwood	13						X	28								42	2026/27
677 Guildford to Sherwood	15						28	X								32	2026/27
686 Guildford to Yennora	14								X	20						42	2026/27
685 Guildford to Yennora	6.0								21	X						24	2026/27
688 Guildford to Tee	10										X	17				42	2026/27
688 Tee to Sth Granville	10										X	18.7				24	2026/27
680 Guildford to Sth Granville	7.0										17	X				24	2026/27
676 Guildford to Tee#	37												X	32		42	2026/27
676/2 Tee to Smithfield*	15												X	11		42	2026/27
676/1 Tee to Visy Paper#	22												X	22		23	2026/27
678 Guildford to Smithfield*	19												11	X		34	2026/27
687 Guildford to Cabramatta	18														X	42	2026/27
68C Homepride to Cabramatta	A/S														18	42	2026/27

^ During outage on feeder 679, feeder 430 supplies Woodpark from Blacktown TS.

* During outage on feeder 676 or 678, feeder 745/1 supplies 2/3 Smithfield from West Wetherill Park TS. Analysis assumes Bossley Park ZS is supplied by feeder 435 from Blacktown TS

Visy Paper will be shed for an outage on feeder 676.

12.3.2 Guildford TS Voltage Regulation & Tap changer Positions - Summer

Faulty →	Nil	687	679	671	674	673	672	675	677	686	685	688	680	676	678	Min Tap	Max Tap	Year of Result
Cabramatta^	-3	-2														-14	7	2026/27
Carramar	-2			-2	-2	-2	-2									-14	7	2026/27
Fairfield	-2			-2	-2	-2	-2									-13	7	2026/27
Sherwood	-1							-1	-2							-14	7	2026/27
Smithfield	-2													1	-2	-14	7	2026/27
(Visy Paper) #	0													X	0	-14	7	2026/27
South Granville	-2											-3	-2			-14	7	2026/27
Woodpark^	-2		-1													-14	7	2026/27
Yennora	-2									-3	-2					-10	5	2026/27

^ Cabramatta ZS is on change-over to West Liverpool TS feeder 68C

^ Woodpark ZS is on change-over to Blacktown TS feeder 430

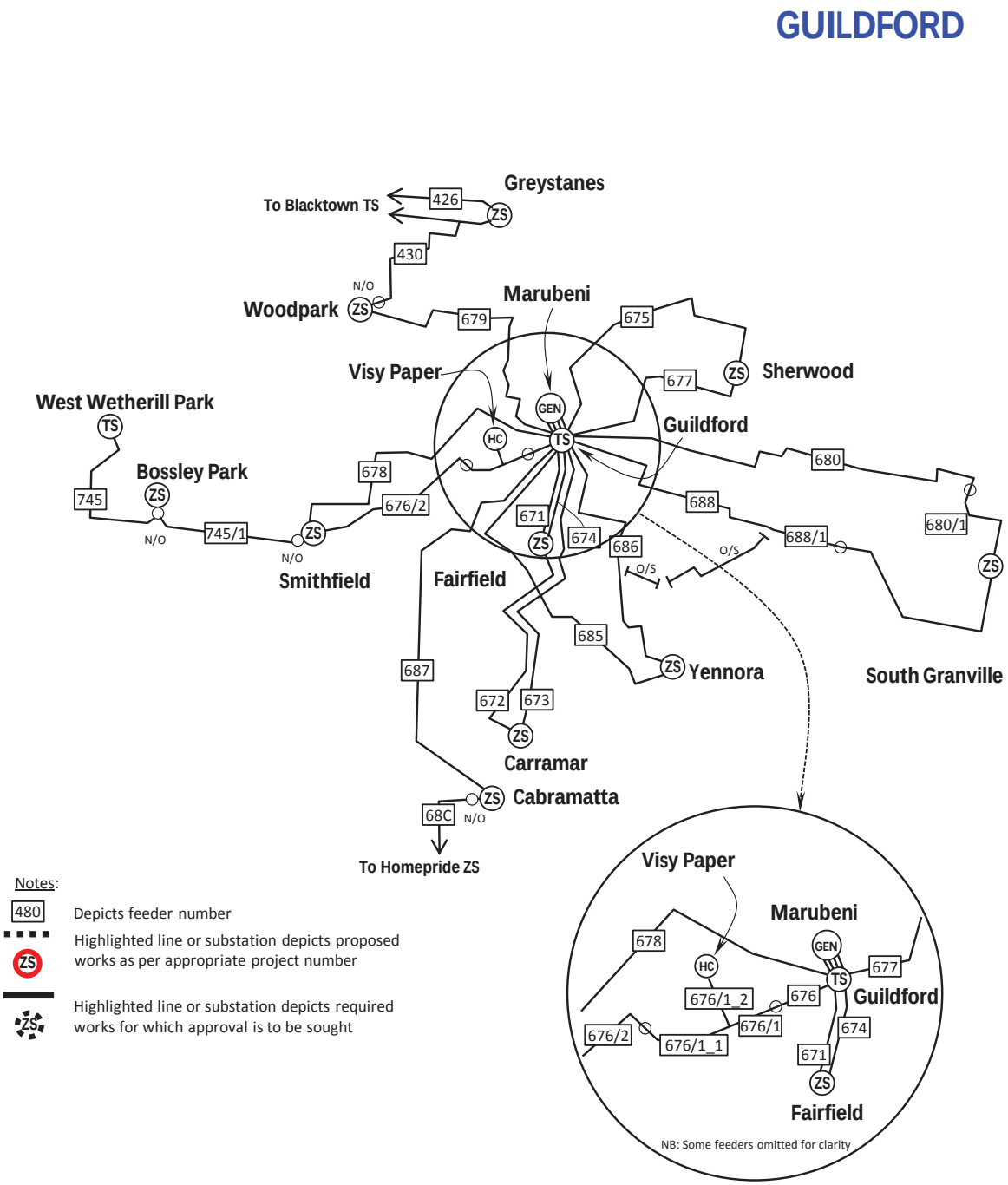
Visy Paper will be shed for an outage on feeder 676

12.4 Analysis Results and Possible Solutions

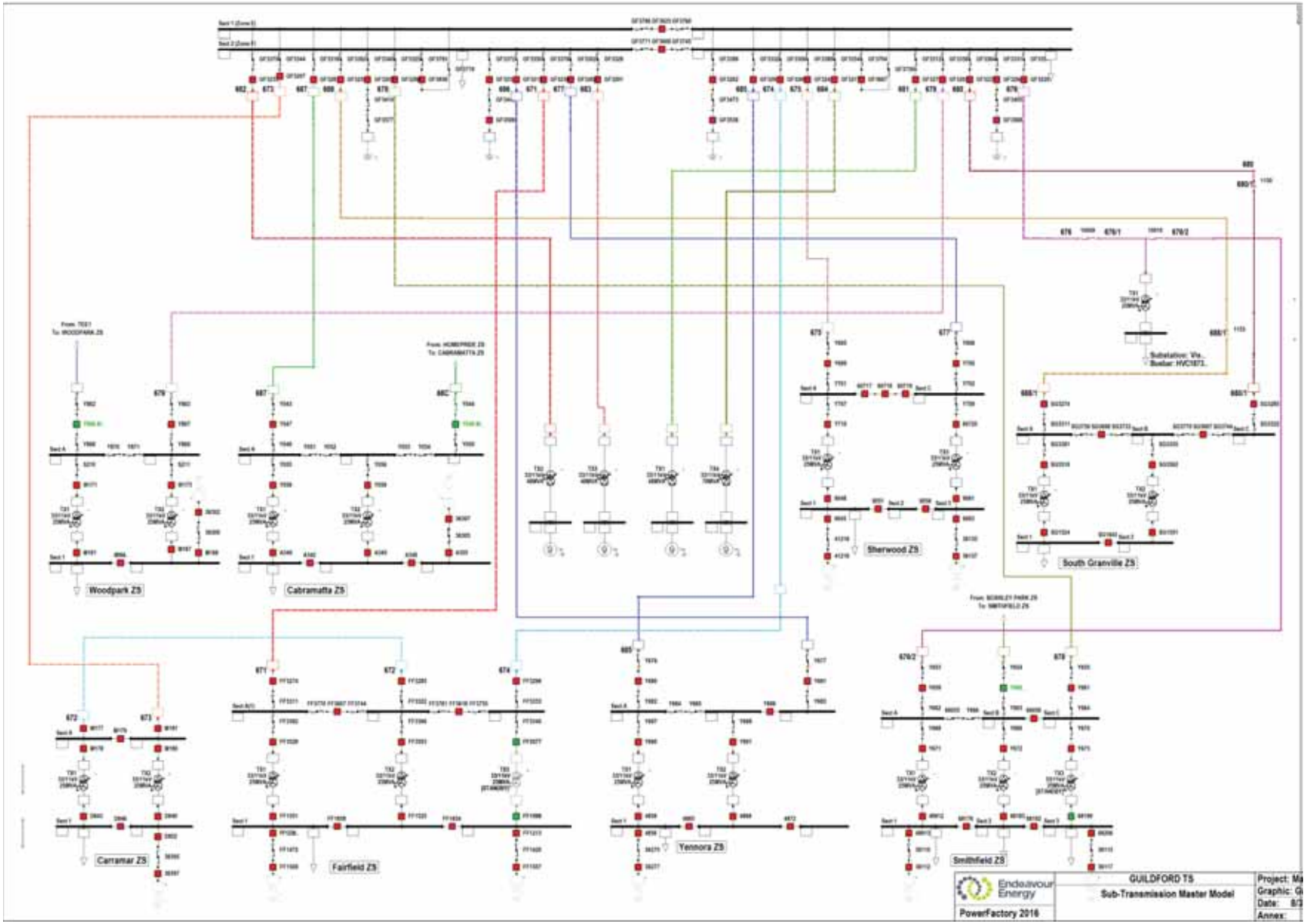
Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges for this review period.

Guildford	Network Constraint	Year	Investigation	Solution
	NIL			

12.5 Guildford Geographic



12.6 Guildford Schematic



13 HAWKESBURY TRANSMISSION SUBSTATION

13.1 Hawkesbury Transmission Network Status

Hawkesbury transmission substation (TS) is supplied at 132kV from Vineyard Bulk Supply Point (BSP) by feeders 227 and 234. Hawkesbury TS has three 120 MVA 132 / 33kV transformers and supplies Cattai, Glossodia, Glenorie, Kurrajong, North Richmond, East Richmond, Riverstone, South Windsor, Windsor and Wisemans zone substations (ZS), owned by Endeavour Energy. It also supplies the Sydney Trains substation at Clarendon. Hawkesbury is a summer demand peaking TS and is floated at 33kV with an LDC setting of 7.5% at 200 MVA, to assist in producing an acceptable voltage profile in the outlying areas.

Endeavour Energy will establish a number of new substations and subtransmission assets that will support development of the North West Sector. The network strategy is to supply these new assets at 132kV from Vineyard BSP.

Kurrajong ZS is currently fed from feeders 453 and 442. The upgrade of protection at Kurrajong ZS has allowed Kurrajong ZS to run solid.

South Windsor is fed directly from the transmission substation on feeders 436, 448 and 449 having tail-ended transformers. One transformer is normally on standby on a rostered basis, to maintain the 11kV busbar fault levels within acceptable limits.

Project PR440 has been completed. It included upgrade of feeders 443 and 458/1 and installation of a motorised isolator to address potential load at risk on feeder 458, under outage of feeder 444. If there is a fault on feeder 444, both Riverstone 33kV and 11kV busbar will split and transformer 2 can be supplied by feeder 441 from Quakers Hill.

There are no incomplete approved projects to consider within the Hawkesbury TS area.

13.2 Hawkesbury Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Limitation (Year)
Hawkesbury TS	3 x 120	240	30	Nil
Cattai	1 x 15 + 1 x 25	15	-	Nil
Glossodia	2 x 25	25	-	Nil
Kurrajong	2 x 15	15	-	Nil
North Richmond	2 x 25	25	5	Nil
East Richmond	2 x 35	35	5	Nil
Riverstone	2 x 25	25	10	Summer 2022
South Windsor	3 x 25	50	5	Nil
Windsor	2 x 35	35	-	Nil
Wisemans	1 x 12.5	Non Firm	-	Nil
Glenorie	1 x 15	Non Firm	-	Nil

13.3 Results tables

13.3.1 Hawkesbury TS Loads and Ratings – Summer Summary

Faulty - >	Nil	[1]444	458	446	447	443	437	420	436	449	439	424	452	453	438	425	442	Rating	Year of Result
[1]441: RIVERSTONE ZS to QUAKERS HILL ZS	S/B	17																16	S 2023/24
444: HAWKESBURY TS to RIVERSTONE ZS	28	X	39	29	28	30	28	28										42	S 2026/27
458: HAWKESBURY TS to TEE	24	33	X	25	25	36	21	21										46	S 2026/27
[1]458: TEE to RIVERSTONE ZS	11	20	X	11	11	9	12	12										19	S 2026/27
458: TEE to CATTAI ZS	13	13	X	15	15	28	10	10										36	S 2026/27
446: HAWKESBURY TS to WINDSOR ZS	20	21	28	X	38	13	18	18										42	S 2026/27
447: HAWKESBURY TS to WINDSOR ZS	19	20	26	38	X	13	17	17										42	S 2026/27
443: WINDSOR ZS to CATTAI ZS	13	14	28	12	12	X	10	10										28.9	S 2025/27
437: WISEMANS ZS to CATTAI ZS	7	7	7	7	7	7	X	7										19	S 2026/27
420: CATTAI ZS to GLENORIE ZS	7	7	8	7	7	8	7	X										17	S 2026/27
[2]436: HAWKESBURY TS to SOUTH WINDSOR ZS	18								X	21								31	S 2026/27
[2]448: HAWKESBURY TS to SOUTH WINDSOR ZS	S/B								17	17								31	S 2026/27
[2]449: HAWKESBURY TS to SOUTH WINDSOR ZS	19								22	X								31	S 2026/27
439: HAWKESBURY TS to GLOSSODIA ZS	16										X	17	18	19	16	16	18	26	S 2026/27
424: NORTH RICHMOND ZS to GLOSSODIA ZS	2										19	X	1	2	1	1	1	26	S 2026/27
452: HAWKESBURY TS to NORTH RICHMOND ZS	10										16	9	X	15	11	11	13	21	S 2026/27
453: HAWKESBURY TS to TEE	11										18	10	15	X	12	12	14	21	S 2026/27
453: TEE to KURRAJONG ZS	25										X	X	X	X	X	X	11	21	S 2026/27
453: TEE to NORTH RICHMOND ZS	9										20	8	16	X	8	7	4	42	S 2026/27
438: HAWKESBURY TS to EAST RICHMOND ZS	14										16	14	16	15	X	30	11	27.4	S 2026/27
425: HAWKESBURY TS to EAST RICHMOND ZS	18										21	18	20	20	31	X	14	27.4	S 2017/18
442: EAST RICHMOND ZS to KURRAJONG ZS	8										13	8	11	10	6	5	X	21	S 2026/27

Notes:

[1] A motorised isolator has been installed to split the 33kV busbar at Riverstone ZS during outage of Feeder 444, as part of PR440.

[2] Feeders 436, 448 and 449 supply tail ended transformers to South Windsor. One feeder will normally be on Standby

13.3.2 Hawkesbury TS Voltage Levels (Resultant Tap Positions)

Faulty - >	Nil	444	458	446	447	443	437	420	436	449	439	424	452	453	438	425	442	Min Tap	Max Tap	Year of Result
Cattai	-1	-3	-5	-2	-2	-5	-2	-2										-14	7	S 2026/27
Glenorie	-1	-3	-5	-2	-2	-5	-1	X										-14	7	S 2026/27
Riverstone TX2	-1	-6	-2	-1	-1	-1	-1	-1										-14	7	S 2026/27
Riverstone TX3	-1	-3	-2	-1	-1	-1	-1	-1										-14	7	S 2026/27
Windsor	0	0	0	0	0	0	0	0										-14	7	S 2026/27
Wisemans	-2	-3	-6	-2	-2	-5	X	-2	-2	-2								-14	7	S 2026/27
South Windsor TX1									X	-2								-14	7	S 2026/27
Glossodia											-9	-3	-3	-3	-2	-2	-3	-14	7	S 2026/27
Kurrajong											-3	-1	-2	-1	-1	-1	-3	-14	7	S 2026/27
East Richmond											1	1	1	1	0	0	1	-14	7	S 2026/27
North Richmond											-3	-1	-2	-3	-1	-1	-2	-14	7	S 2026/27

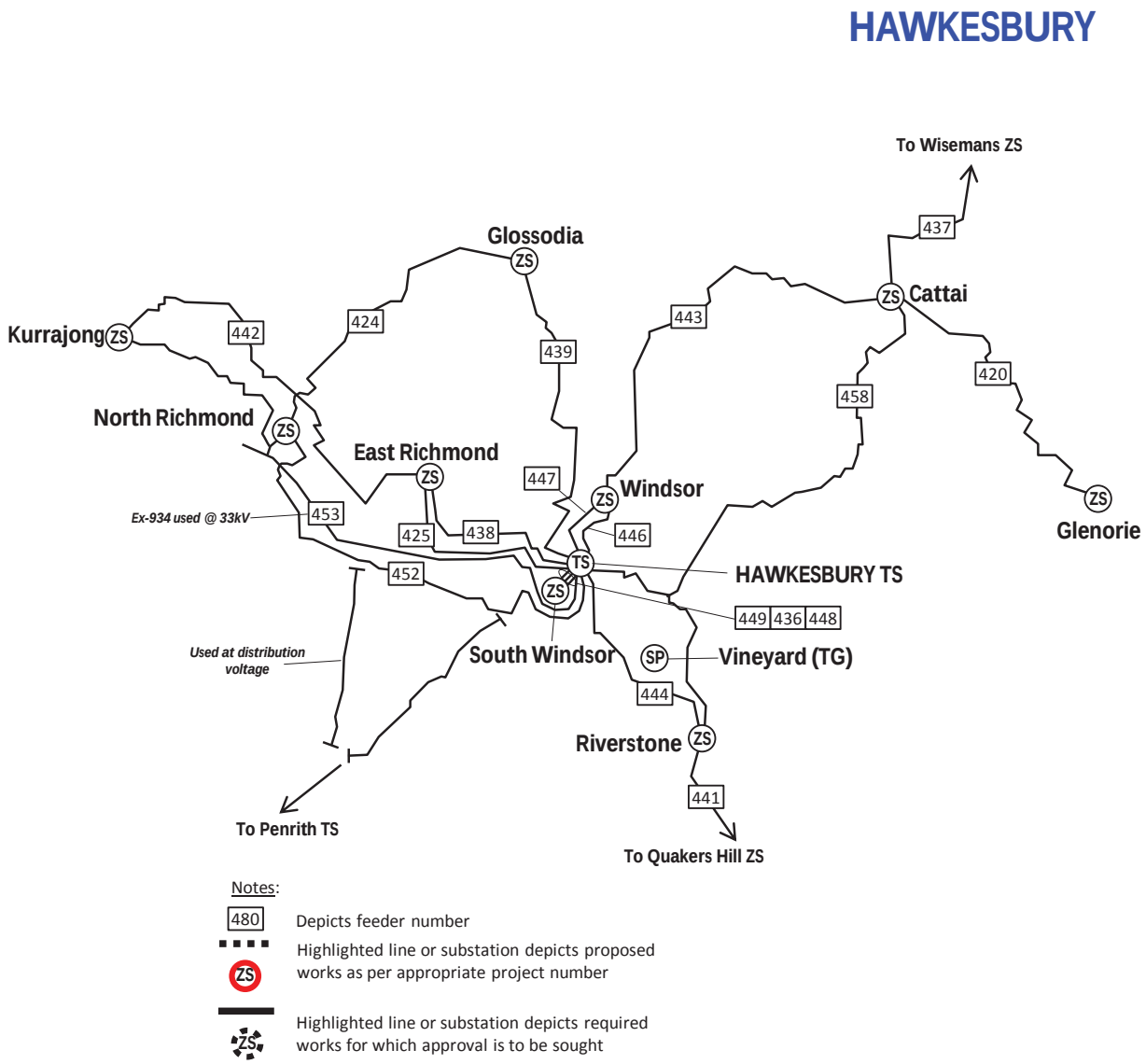
13.4 Analysis Results and Possible Solutions

Hawkesbury	Network Constraint	Year	Investigation	Solution
	The firm rating of Riverstone ZS will be exceeded by S2022.	S2022	Demand management options in the short term.	Long term plan is establishing a new zone substation in the area which will take some load of Riverstone ZS and its feeders.
	On outage of feeder 444, load on feeder 441 will exceed its rating	S2024	Demand management options in the short term.	Long term plan is establishing a new zone substation in the area which will take some load of Riverstone ZS and its feeders.
	On outage of feeder 444, load on feeder 458 will exceed its rating	S2027	Demand management options in the short term.	Long term plan is establishing a new zone substation in the area which will take some load of Riverstone ZS and its feeders.
	Check Ratings for Feeder 425	S2018	Check Ratings	Ratings

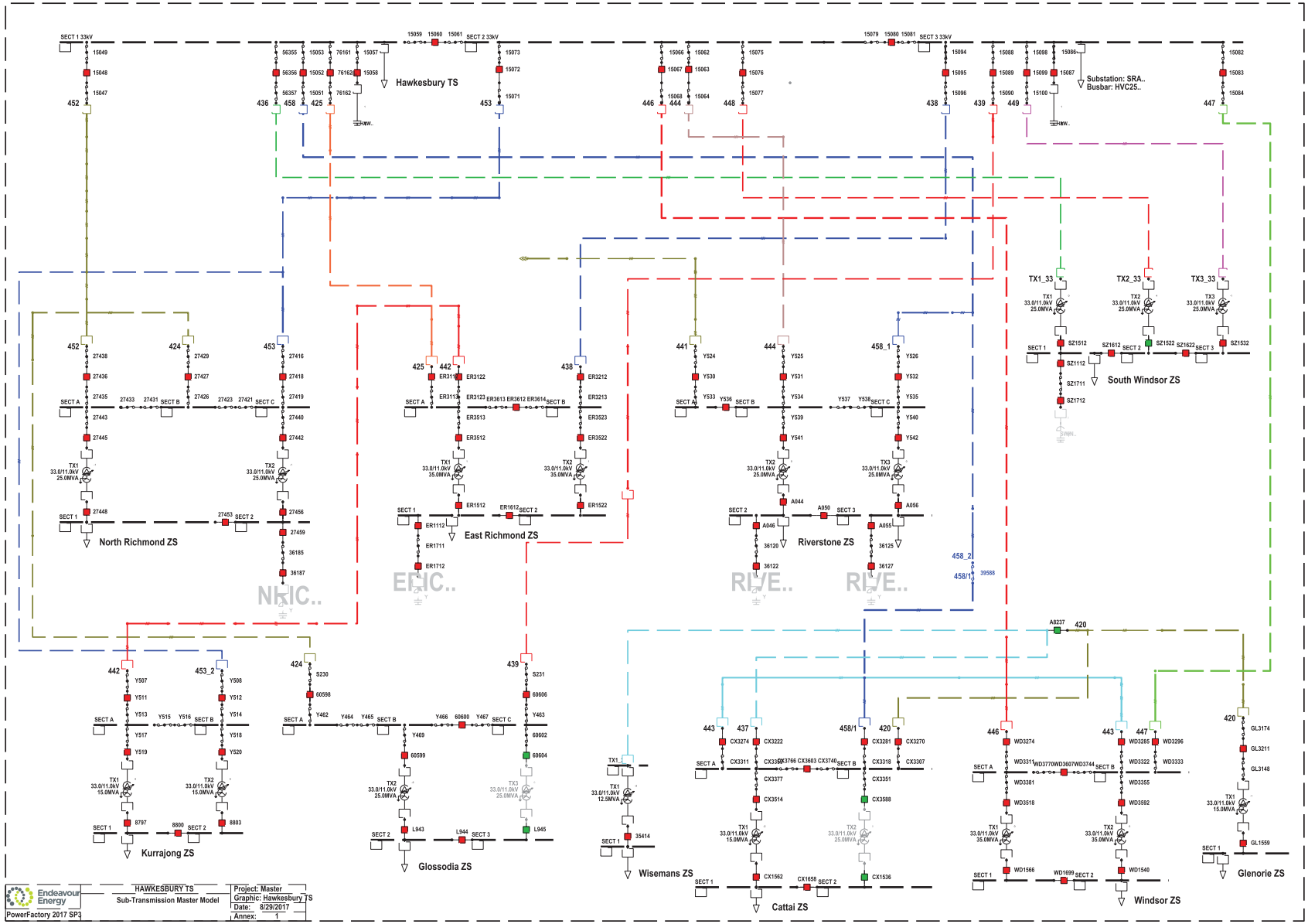
Hawkesbury	Network Constraint	Year	Investigation	Solution
	Check Ratings for Feeder 438	S2018	Check Ratings	Ratings

Voltage levels at all substations are within their design ratings and ranges respectively for this review period.

13.5 Hawkesbury Geographic



13.6 Hawkesbury Schematic



14 HOLROYD BULK SUPPLY POINT

14.1 Holroyd Bulk Supply Point Transmission Network Status

Holroyd Bulk Supply Point is owned by Transgrid and has two tail ended 375 MVA 330/132kV transformers providing a firm capacity of 375MVA to Endeavour Energy.

Holroyd Bulk Supply Point supplies Camellia and Guildford Transmission Substations, Granville, North Parramatta and West Parramatta zone substations and East Parramatta Switching Stattion.

Guildford Transmission Substation operates on a split dual busbar arrangement; normally supplied at 132kV by feeders 93F and 93L on one busbar from Holroyd BSP.

Sydney West BSP backs up supply to Guildford TS via feeders 93J and 93T. These feeders connect onto the alternate Guildford busbar (normally split from the Holroyd source feeders).132kV feeders 93M, 93T and 93J provide a ring supply to West Wetherill Park TS and ZS and Wetherill Park ZS.

Holroyd BSP and Guildford TS operate without fault level restrictions; the split busbar at Guildford can be closed to provide mutual backup between the two load groups for a loss of either Holroyd feeder 93F or 93L or for a loss of either Sydney West feeders 93M,93T or 93J.

The supply strategy for the Guildford / Camellia / Parramatta CBD considers both the growth and renewal needs of this network. The strategy involves conversion of East Parramatta SS to a zone substation and Lennox ZS to service the Parramatta CBD when development dictates. This is additional to the existing West Parramatta, North Parramatta and Granville zone substations.

The strategy also involves Camellia TS to allow the connection of these new zone substations. Refer to the Camellia section of the report and S472-1 “Parramatta CBD – Camellia – Guildford Subtransmission Development Summary Report”.

14.2 Holroyd Bulk Supply Point Rating Details

Transmission or Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Capacity Constraint (Year)
Holroyd BSP	2 x 375	375		Nil
Camellia	3 x 120	240		Nil
Granville ZS**	2 x 45	45	5	Nil
Guildford#	3 x 120	240	60	Nil
North Parramatta **	2 x 55	55		Nil
West Parramatta ZS**	3 x 45	90	10	Nil

Notes:

** These Substations are grouped in the forecast as Holroyd 132kV, as they are supplied directly off the virtual Holroyd 132kV busbar (located at Guildford 132kV), without an intermediate sub-transmission busbar. The remaining locations are Transmission Substations with their individual sub-transmission networks to each zone substation.

Since August 2017, Marubeni Generators will operate on demand only and their input will not be considered for the purpose of these analysis.

14.3 Result Tables

14.3.1 Holroyd SP Loads and Ratings - Summer Summary

Faulty ➔	Nil	93F[1]	93L[1]	93J[2]	93M[2]	93T[2]	22G	225	22W	9J8	228	233	22U	226	224	Rating	Year of Result
93F: HOLROYD BSP to GUILDFORD TS	239	x	387													505	S2026/27
93L: HOLROYD BSP to GUILDFORD TS	229	374	x													505	S2026/27
93J: SYDNEY WEST BSP to TEE1	24	172[3]	171	x	71	31										505	S2026/27
93J: TEE1 to GUILDFORD TS	9	162[3]	162	x	56	x										505	S2026/27
93J: TEE1 to WETHERILL PARK ZS	15			x		31										120	S2026/27
93M: SYD WST BSP to W.WTHRLL PRK TS	44	190[3]	189	69	x	41										505	S2026/27
93T: WEST WETHERILL PARK TS to TEE1	7	156[3]	156	31	42	x										505	S2026/27
93T: TEE1 to WETHERILL PARK ZS	15			31		x										120	S2026/27
93T: TEE1 to GUILDFORD TS	9	147[3]	147	x	56	x										505	S2026/27
22G: GUILDFORD TS to W.PRRMATTA ZS	66						x	90	75	76	90	71	75	69		251	S2026/27
225: W.PRRMATTA ZS to E.PRRMATTA SS	24						90	x	15	14	4	19	15	20		172	S2026/27
22W: GUILDFORD TS to CAMELLIA TS	48						61	44	x	67	59	46	66	55		111	S2026/27
9J8: GUILDFORD TS to CAMELLIA TS	51						64	46	68	x	62	48	69	58		117	S2026/27
228: GUILDFORD TS to EAST PRRMATTA SS	54						83	44	63	64	x	59	63	58		111	S2026/27
233: CAMELLIA TS to EAST PRRMATTA SS	9						45	8	11	12	39	x	11	5		172	S2026/27
22U: GUILDFORD TS to GRANVILLE ZS	54						64	50	69	70	63	55	x	36		117	S2026/27
226: CAMELLIA TS to GRANVILLE ZS	20						31	16	35	36	30	18	35	x		117	S2026/27
224: EAST PRMATTA SS to NTH PRRMATTA ZS	42														x	80	S2026/27
235: EAST PRMATTA SS to NTH PRRMATTA ZS	S/B														43	80	S2026/27

14.3.2 Holroyd SP Voltage Levels - Summer Summary

Faulty ➔	Nil	93F	93L	93J	93M	93T	22G	225	22W	9J8	228	233	22U	226	224	Min Tap	Max Tap	Year of Result
Guildford	0	1	-1	0	-4	-4										-16	4	S2026/27
West Wetherill Park TS	4				x											-16	4	S2026/27
West Wetherill Park ZS	-1	1	-2	1	-7	-7										-17	3	S2026/27
Wetherill Park TX1 (93T)	2	1	1	1	2	x										-14	7	S2026/27
Wetherill Park TX2 (93J)	2	1	1	x	2	-1										-14	7	S2026/27
West Parramatta	-8															-17	3	S2026/27
Camellia	-5															-12	4	S2026/27
Granville	-3															-17	3	S2026/27
North Parramatta TX1	-4															-27	3	S2026/27

Notes: 1. For outage of either 93F or 93L Guildford 132kV busbar was modelled paralleled with Sydney West, all five TSFs in service and the split busbar.
2. Guilford 132kV busbar remains operated split for loss of Sydney West source feeders 93M, 93T and 93J.
3. High load on these feeders is due to increased reactive power flow between Holroyd BSP and Sydney west BSP.

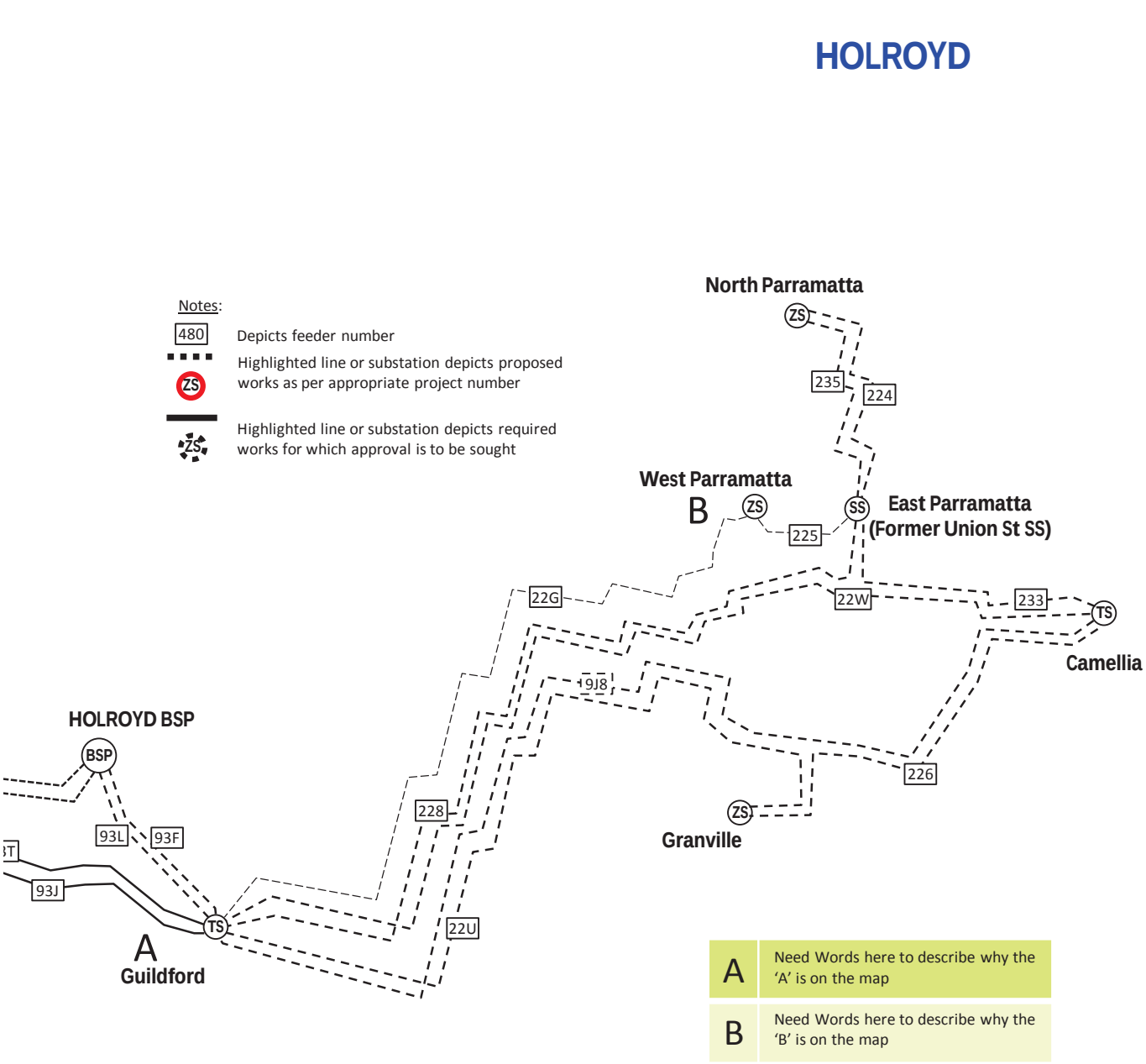
14.4 Analysis Results and Possible Solutions

Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges respectively f

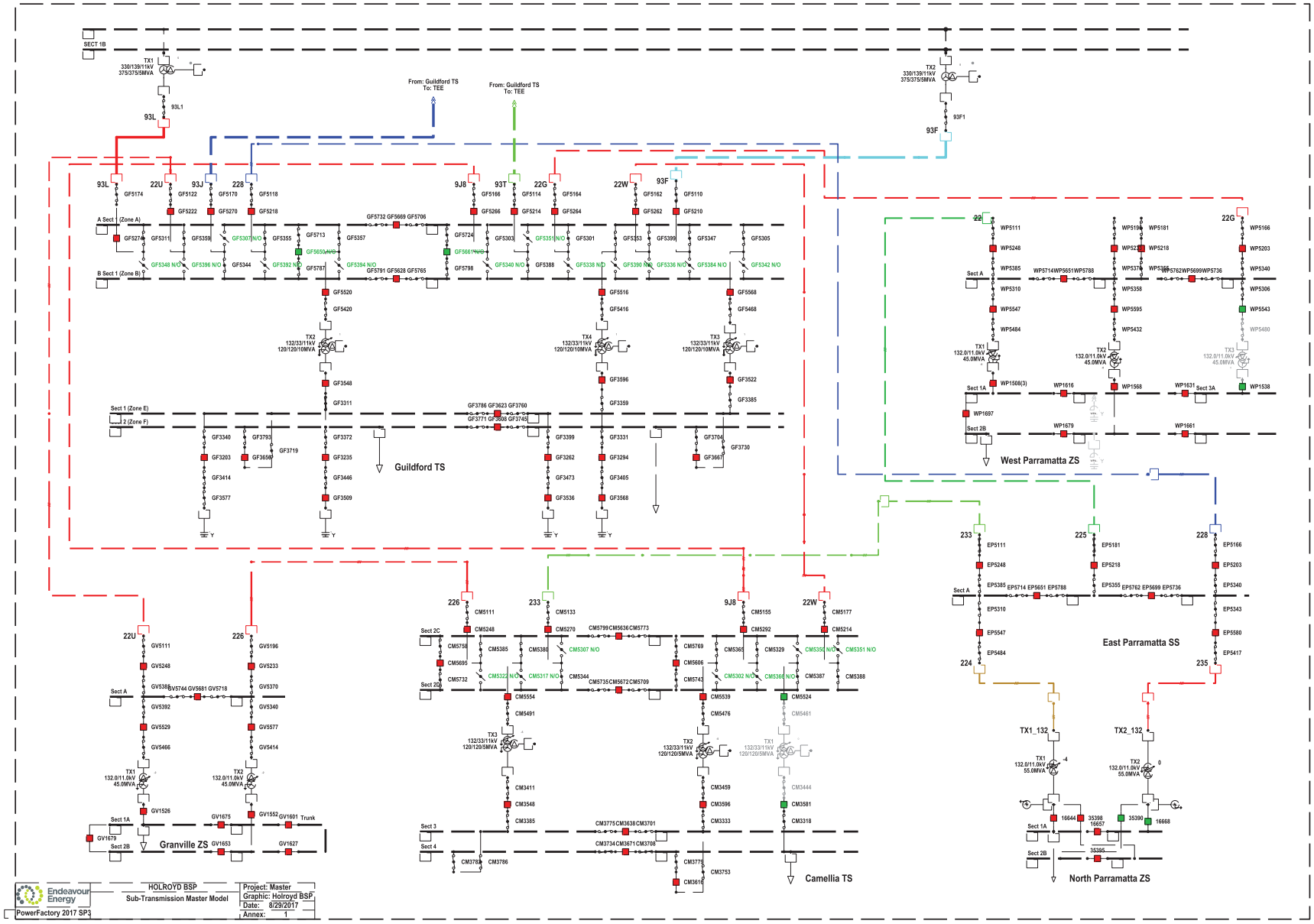
or this review period.

Holroyd SP	Network Constraint	Year	Investigation	Solution
	For an outage of either 132kV Feeder 93L/93F the corresponding Holroyd BSP 375MVA transformer will be overloaded	S2023	Investigate load transfers to Sydney West	Engage Joint Planning with Transgrid

14.5 Holroyd Geographic



14.6 Holroyd Schematic



15 ILFORD BULK SUPPLY POINT

15.1 Ilford BSP Transmission Network Status

Ilford Bulk Supply Point (BSP) is supplied at 132kV from Transgrid's Mt Piper transmission substation (TS), by a single tee off from Transgrid's feeder 94M and a single 60MVA 132/66kV transformer. Mt Piper 66kV BSP provides backup supply to Ilford TS, through the 66kV network.

TransGrid has indicated that the capacity available to Endeavour Energy from line 94M - Mt Piper-Beryl tee Mudgee tee Ilford, can be increased from the 16VMA currently authorised.

There are two significant load applications NIL0208 (Kepco Coal Mine, at 22MVA) and NIL0212 (Bowdens Silver Mine, at 18MVA). Kepco Coal Mine load connection requires 66kV line augmentation from Ilford to Kandos, then onto Bylong. This is currently progressing. Bowdens Silver Mine is proposed to connect at 132kV Ilford BSP, effectively supplied from the Mt Piper 132kV system. Bowdens Silver Mine is not included in this study More information will be available as these two applications progress.

There are no incomplete approved major projects to consider within the Ilford BSP area.

15.2 Ilford BSP Substation Rating Details

There is no Transgrid substation associated with this Bulk Supply Point. The supply point is a tee off from Transrid's Feeder 94M, from Mt Piper TS.

15.3 Results Tables

15.3.1 Ilford TS Loads and Ratings – Summary

Faulty - >	Nil	*94M	Rating	Year of Result
839*: KANDOS ZS to BYLONG ZS	19.6	0.9	114	S 2026/27
841*: ILFORD TS to KANDOS ZS	23.7	0.4	60	S 2026/27

*Load shed of Kepco Coal mine is assumed for loss of Feeder 841 & 94M.

1.1.1 Ilford TS Voltage Levels (Resultant Tap Position) – Summer Summary

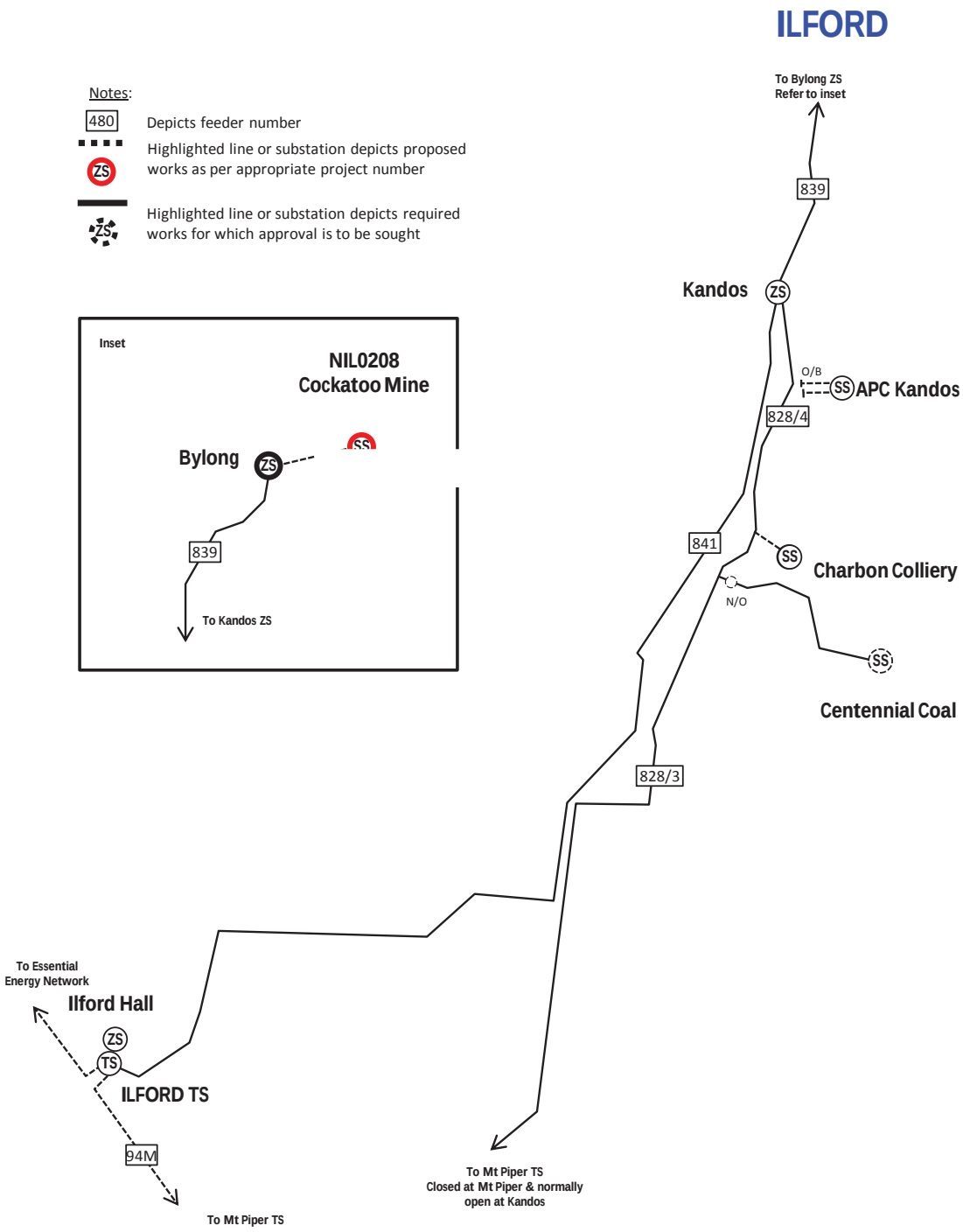
Faulty - >	Nil	94M	Min Tap	Max Tap	Year of Result
Bylong	-4	0	-10	6	S 2026/27
Ilford Hall	0	0	-14	7	S 2026/27
Kandos	4	2	-12	12	S 2026/27

15.4 Analysis Results and Possible Solutions

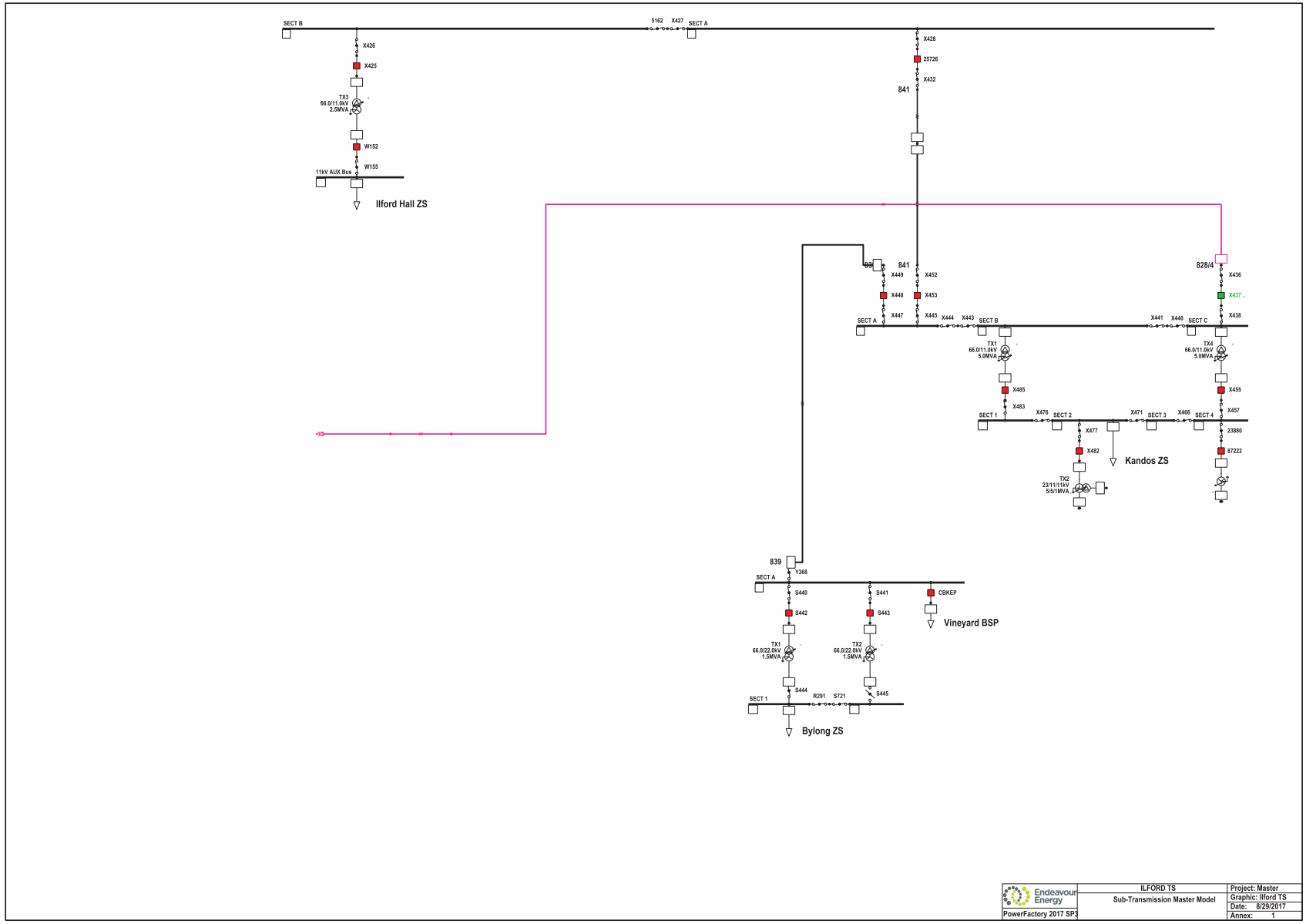
Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges respectively for this review period.

Ilford SP	Network Constraint	Year	Investigation	Solution
	NIL			

15.5 Ilford Geographic



15.6 Ilford Schematic



16 ILFORD TRANSMISSION SUBSTATION

16.1 Ilford Transmission Network Status

Ilford Transmission Substation is supplied at 132kV from Transgrid's Mt Piper substation by a single tee off from Transgrid's feeder 94M and a single 60MVA 132/66kV transformer. Mt Piper 66kV bulk supply point provides backup supply to Ilford TS, through the 66kV network.

Ilford TS is summer demand peaking and is floated at 66kV. It supplies Bylong, Ilford Hall and Kandos zone substations owned by Endeavour Energy.

TransGrid has indicated that the capacity available to Endeavour Energy from line 94M Mt Piper-Beryl tee Mudgee tee Ilford, can be increased from the currently authorised 16MVA.

Feeder 841 from Ilford TS supplies Kandos ZS. Two11kV feeders connect to circuit breakers X482 and 87222 are tail-ended onto 22/11kV auto-transformers.

The 66kV subtransmission system from Ilford TS is radial to Kandos ZS, and is backed up from Mt Piper 66kV BSP on feeder 828. Kandos ZS then supplies Bylong ZS on feeder 839. An outage of either: 132kV feeder 94M, 66kV feeder 841 or the single Ilford TS transformer, requires feeder 828 to supply the Ilford TS load via Kandos ZS.

There are two significant load applications NIL0208 (Kepco Coal Mine) and NIL0212 (Bowdens Silver Mine). Kepco Coal Mine load connection requires 66kV line augmentation from Ilford to Kandos, then onto Bylong.This is currently progressing. Bowdens Silver Mine is currently proposed to connect at 132kV Ilford TS busbar, effectively supplied from the Mt Piper 132kV system. Bowdens Silver Mine is not included in this study, as it only impacts the TransGrid 132kV system (via the Ilford TS 132kV busbar) and they have provided an approval for the additional load. More information will be available as these two applications progress.

There are no incomplete approved major projects to consider within the Ilford TS area.

16.2 Ilford Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Limitation (Year)
Ilford TS	1 x 60	Non Firm		Nil
Bylong	2 x 1.5	1.5		Nil
Ilford Hall	1 x 2.5	Non-firm		Nil
Kandos	2 x 5	5		Nil

16.3 Results Tables

16.3.1 Ilford TS Loads and Ratings – Summer Summary

Faulty - >	Nil	839	*841	*94M	Rating	Year of Result
839: KANDOS ZS to BYLONG ZS	19.6	X	0.9	0.9	114	S 2026/27
841: ILFORD TS to KANDOS ZS	23.7	4.2	X	0.4	60	S 2026/27
828: MT PIPER TS to AIRLY COLLIERY TEE			6.8	7.2	20	S 2026/27
828/1: AIRLY COLLIERY TEE to HYROCK TEE			4.4	4.8	20	S 2026/27
828/4: HYROCK TEE to CENTENNIAL CHARBON TEE			4.4	4.8	20	S 2026/27
828/4: CENTENNIAL CHRBN TEE to KANDOS ZS			4.4	4.8	60	S 2026/27

*Load shed of Kepco Coal mine is assumed for loss of Feeder 841 & 94M

Ilford TS Voltage Levels (Resultant Tap Position) – Summer Summary

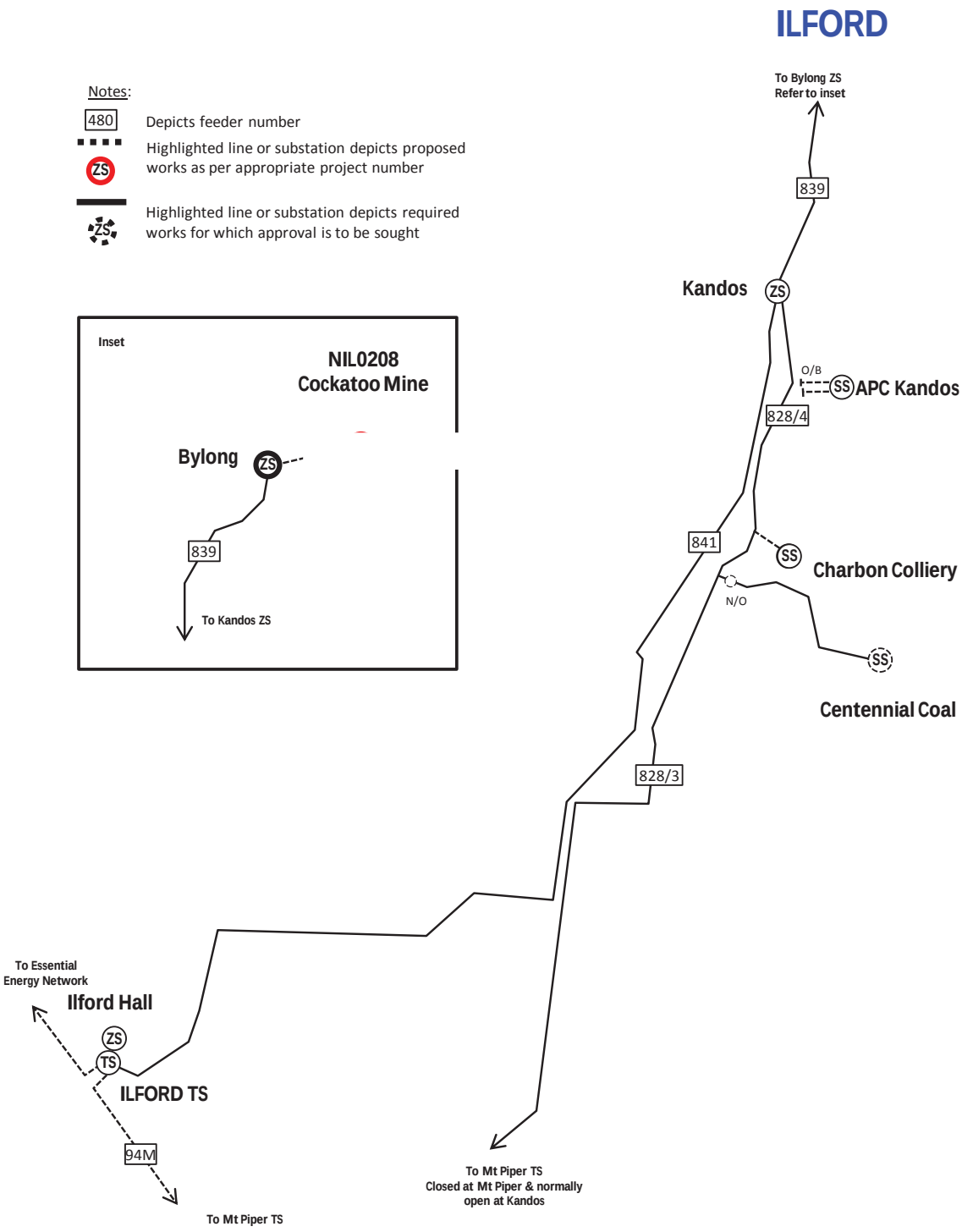
Faulty - >	Nil	839	841	94M	Min Tap	Max Tap	Year of Result
Bylong	-4	x	0	0	-10	6	S 2026/27
Ilford Hall	0	1	0	0	-14	7	S 2026/27
Kandos	4	2	2	2	-12	12	S 2026/27

16.4 Analysis Results and Possible Solutions

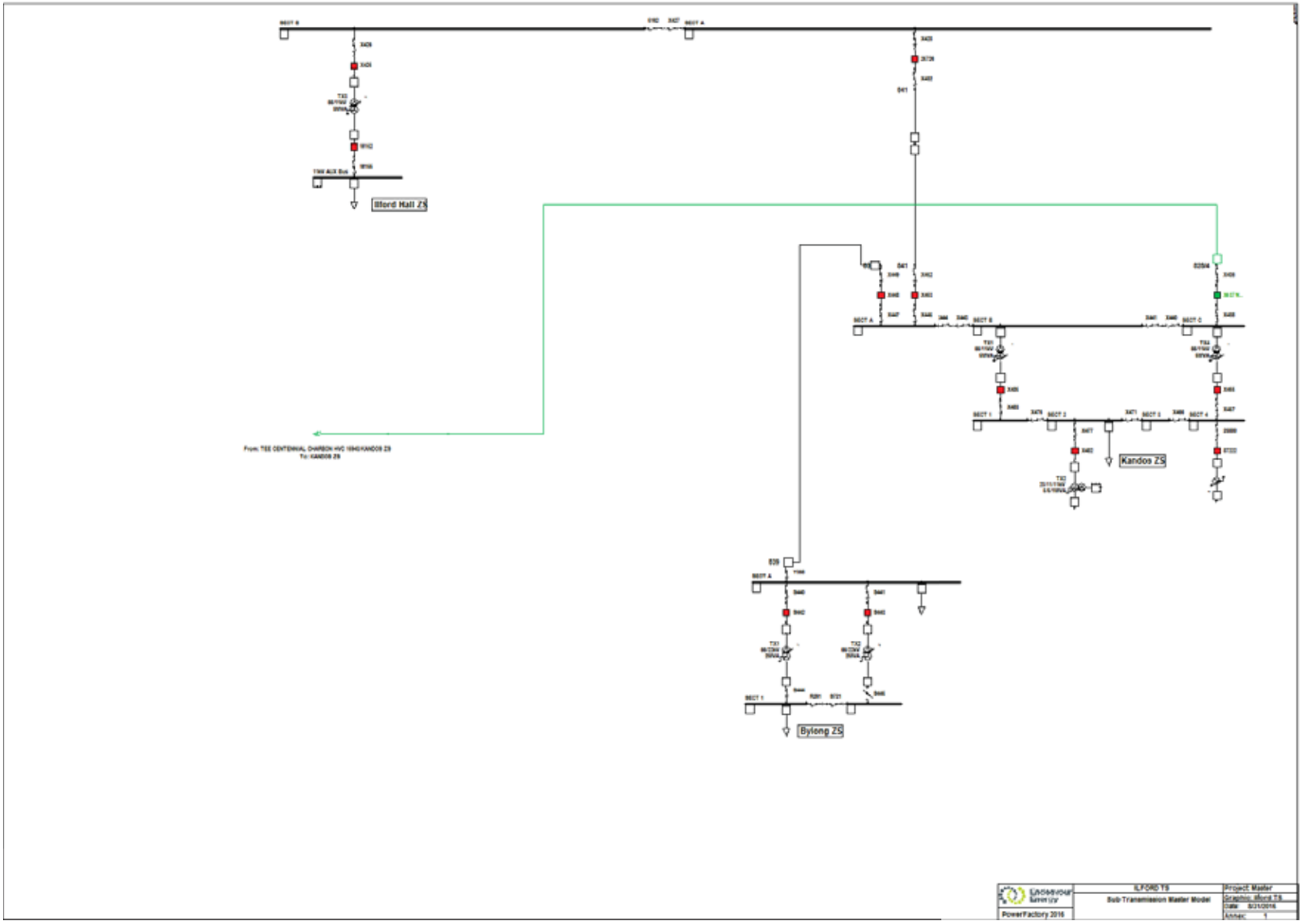
Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges respectively for this review period.

Ilford TS	Network Constraint	Year	Investigation	Solution
	NIL			

16.5 Ilford Geographic



16.6 Ilford Schematic



17 INGLEBURN BULK SUPPLY POINT

17.1 Ingleburn BSP Transmission Network Status

Ingleburn BSP is owned by TransGrid and has two, 250 MVA 330/66kV transformers. There is sufficient capacity at this substation to supply its existing catchment for the medium to long term. Ingleburn BSP is floated at 66kV.

Macarthur BSP has been established in the Mt Annan area to serve as a bulk supply point to the South West Growth Sector and to supply 66kV to Campbelltown, Kentlyn and Ambarvale ZS's.

This allows feeders 862 and 863 from Ingleburn BSP to supply only the Minto ZS load under normal conditions. A change in the 66kV configuration means that the Narellan ZS No 1 66/11kV transformer will now be backed up from Macarthur 66kV BSP using feeder 85T, under high load conditions for a contingency on the normal supply to Narellan. Refer to the geographic and schematic diagrams below and the Macarthur BSP section of the report.

Bow Bowing and Macquarie Fields zone substations share a common feeder 860, which is to be dedicated to Bow Bowing for the loss of its alternate feeder 866. Macquarie Fields has tail-ended transformers which operate on a single transformer roster basis, except for periods of high load, where both transformers are used on a split 11kV busbar. The split busbar arrangement is not usually required due to reduced demand at Macquarie Fields ZS.

The analysis of the Ingleburn BSP transmission network has been carried out with the following network configurations:

- Macquarie Fields ZS is operated as described above so that feeder 860 is not overloaded on an outage of feeder 866.

17.2 Ingleburn BSP Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Ingleburn BSP	2 x 250	250		Nil
Bow Bowing	3 x 35	70	15	Nil
Macquarie Fields	2 x 33	33	5	Nil
Minto	2 x 33 + 1x 35	66	5	Nil

17.3 Results Tables

17.3.1 Ingleburn BSP Loads and Ratings - Summer Summary

Faulty ➔	NIL	860	864	866	*866	862	863	Rating	Year of Result
860: ING BSP to TEE1	23.8	X	39.2	78.2	52.3			64	S201718
860: TEE to BOW BOWING ZS	23.8	X	14.0	52.1	52.1			64	S2026/27
860: TEE to MCQR FLDS ZS	S/B	X	25.4	24.9	S/B			64	S2026/27
864: ING BSP to MCQR FLDS ZS	23.8	29.6	X	S/B	25.1			64	S2026/27
866: ING BSP to BW BWING ZS	29.0	52.9	38.9	X	X			64	S2026/27
862: ING BSP to MINTO ZS	31.5					X	64.2	64	S2017/18
863: ING BSP to MINTO ZS	32.6					64.2	X	64	S2017/18

Notes: Kentlyn & Ambarvale ZSs supplied from Macarthur BSP
* When 866 is out of service, feeder 860 is opened at Macquarie Fields ZS
The three Bow Bowing ZS transformers are operated on a split 11kV busbar.
Two Minto ZS transformers are operated on on a split 11kV busbar with the middle transformer on standby.

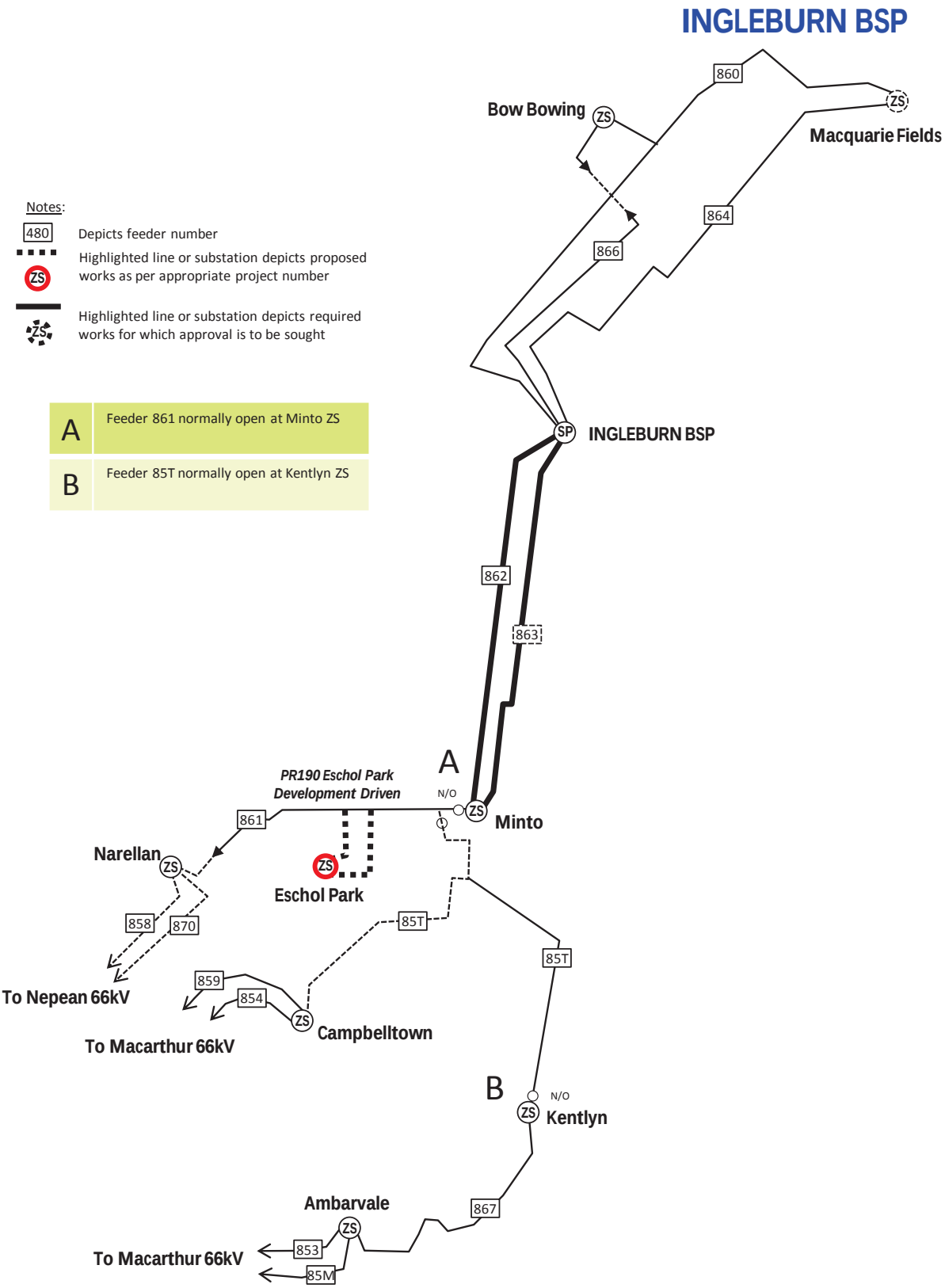
17.3.2 Ingleburn BSP Voltage Levels - Summer Summary

Faulty ➔	Nil	860	864	866	*866	862	863	Min Tap	Max Tap	Year of Result
Mac Fields	-2	-2	-2	-3	-2			-18	3	S2026/27
Bow Bowing TX1&3	-1	-2&-1	-2&-1	-2	-2&-1			-14	7	S2026/27
Bow Bowing TX2	-2	-2	-2	-2	-2			-14	7	S2026/27
Minto TX1	-5					-5	-5	-14	7	S2026/27
Minto TX3	-7					-7	-7	-18	3	S2026/27

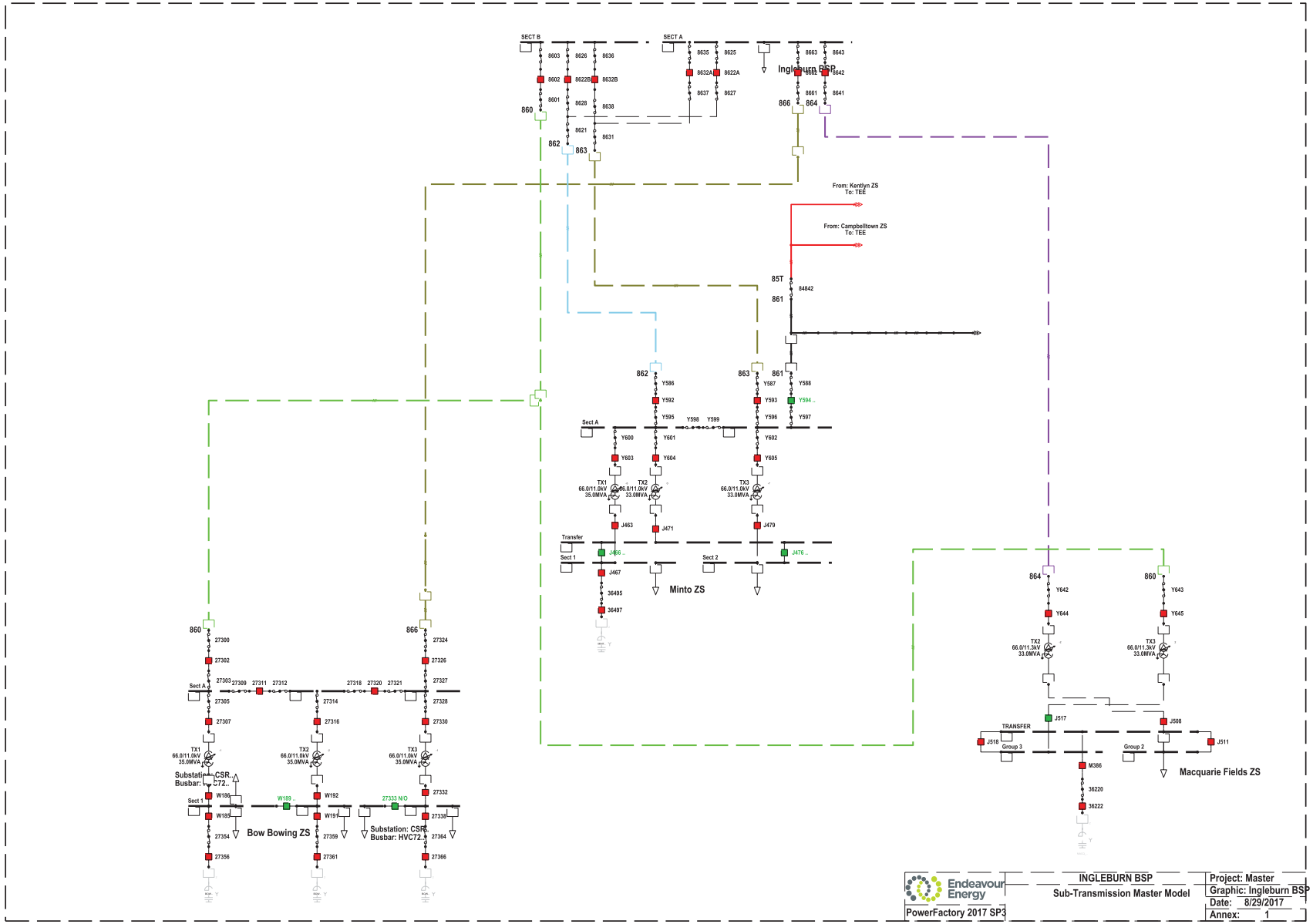
17.4 Analysis Results and Possible Solutions

Ingleburn SP	Network Constraint	Year	Investigation	Solution
	Outage 866 BSP-to Bow Bowing will cause feeder 860 to exceed its line rating.	Existing	Feeder 860 is to be opened at Macquarie Fields when the feeder is supplying Bow Bowing without support from feeder 866.	Transfer Capacity
	Potential greenfield development at Eschol Park cannot be supported from the existing Minto network. This is not included in the demand forecasts and analysis presented here.	Existing	Eschol Park zone substation (PR190) may need to be established if the proposed Blairmount residential development proceeds. The Department of Housing is also redeveloping the Claymore residential area.	Monitor
	Outage of either 862 or 863 BSP-Minto, will cause the respective feeders to exceed their line ratings.	S2018	Probabilistic planning analysis. The load on the feeders requires monitoring.	Monitor

17.5 Ingleburn Geographic



17.6 Ingleburn Schematic



18 KATOOMBA NORTH TRANSMISSION SUBSTATION

18.1 Katoomba North Transmission Substation Status

Wallerawang 132kV Bulk Supply Point supplies Katoomba North Transmission Substation by teed feeders 940 and 941. The two 60MVA 132/66kV transformers are tail ended.

The transformers cannot be operated in parallel due to the distance protection limitations on the feeders (no 132kV busbar). A three monthly in-service / standby roster basis schedule, rotates transformer use.

Limited second contingency backup supply to Katoomba North TS is available at 66kV from Lawson TS. This is achieved via feeder 804 Katoomba tee Wentworth Falls, and Sydney Trains feeder 872. Katoomba North is a winter demand peaking substation and is floated at 67.3kV.

Katoomba North TS supplies Blackheath, Katoomba and Wentworth Falls zone substations.

Blackheath ZS is normally supplied of feeder 805, with limited backup from Sydney Trains feeder 872.

Wentworth Falls ZS is not provided with firm sub-transmission capacity The sub-transmission system consists of a tee from feeder 804, supplying the single tail ended zone substation transformer. As a backup arrangement, manual switching is required to transfer feeder 804 from Katoomba North TS to Lawson TS.

An outage of either feeder 804 tee Wentworth Falls or the single transformer, requires the Wentworth Falls 11kV network to be transferred to Katoomba and Hazelbrook zone substations, through manual switching.

There are no incomplete approved projects to consider within the Katoomba North TS area.

18.2 Katoomba North Transmission Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Katoomba North TS	2 x 60	60		Nil
Blackheath	2 x 7	7		Nil
Katoomba	2 x 25	25		Nil
Wentworth Falls	1 x 10	Non Firm		Nil

18.3 Results Tables

18.3.1 Katoomba North TS Loads and Ratings - Winter Summary

Faulty →	Nil	804	805	Rating	Year of Result
804: KATOOMBA NORTH TS to TEE	7	X	28	126	W 2026
804: KTMB NTH TS TEE to WNTWRTH FLLS ZS TEE	7	X	7	36	W 2026
804: TEE to KATOOMBA ZS	S/B	X	22	36	W 2026
804: WENTWORTH FALLS ZS to TEE	7	7[1]	7	82	W 2026
804: WENTWORTH FALLS ZS TEE to LAWSON TS	S/B	7	S/B	36	W 2026
805: KATOOMBA NORTH TS to TEE	29	29	X	126	W 2026
805: TEE to BLACKHEATH ZS	7	7	X	36	W 2026
805: TEE to KATOOMBA ZS	22	22	X	36	W 2026

Note: 1. Analysis assumes manual switching transfers feeder 804 supply, from Katoomba North TS to Lawson TS

18.3.2 Katoomba North TS Voltage Levels – Winter Summary

Faulty →	Nil	804	805	Min Taps	Max Taps	Year of Result
Blackheath	1	1	X	-12	12	W 2026
Katoomba	-1	-1	0	-14	7	W 2026
Wentworth Falls	1	1	2	-14	7	W 2026

18.4 Analysis Results and Possible Solutions

Load levels on all feeders are within the line ratings for this review period.

Voltage levels at all substations are within the tapping ranges for this review period.

18.5 Katoomba North Geographic

KATOOMBA NORTH TS

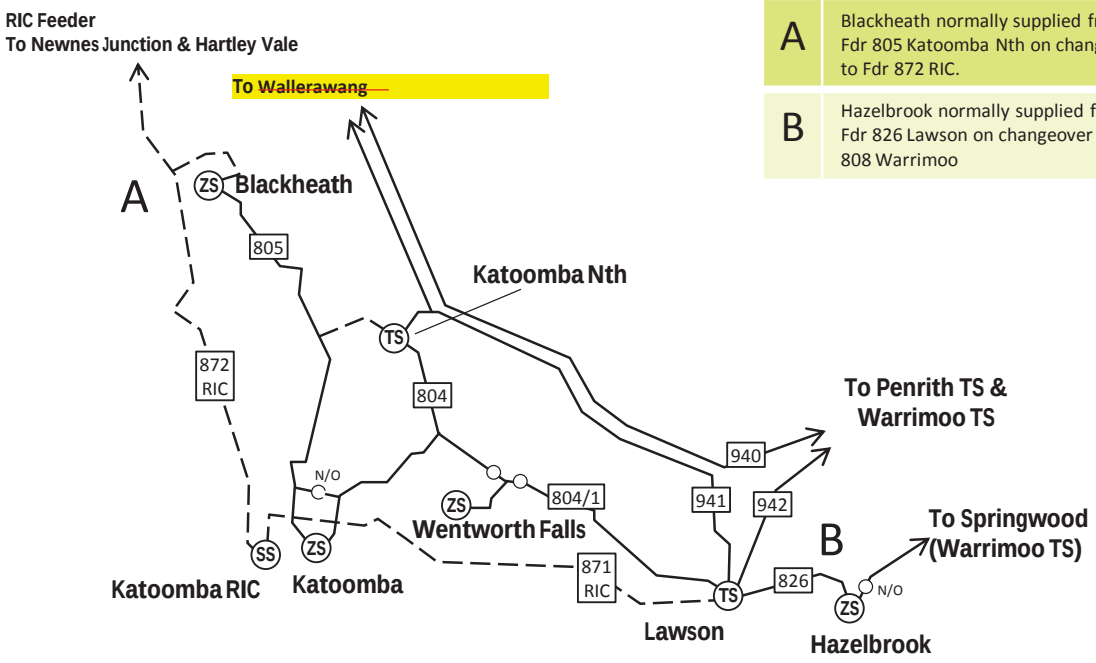
Notes:

480 Depicts feeder number

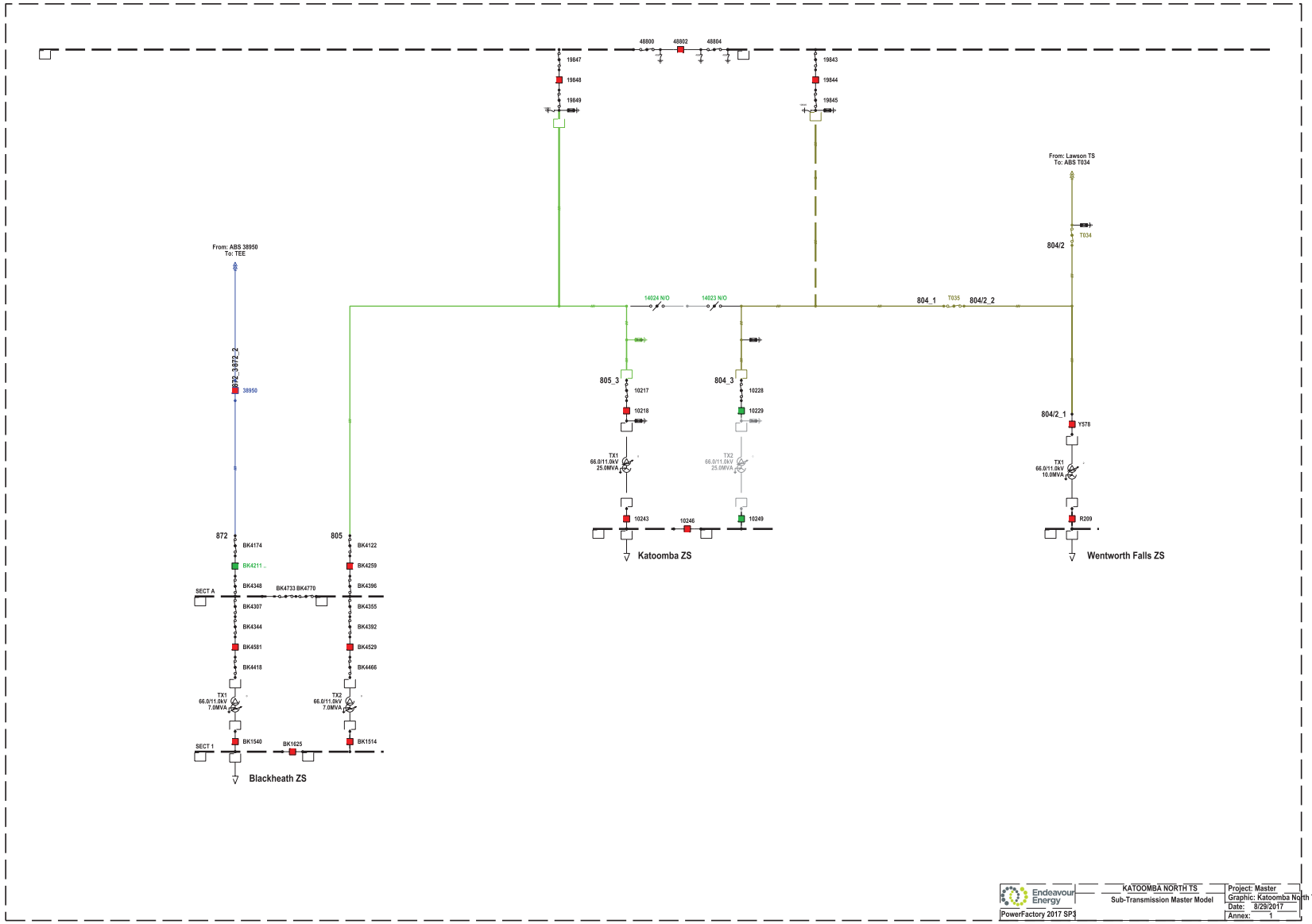
Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

A	Blackheath normally supplied from Fdr 805 Katoomba Nth on changeover to Fdr 872 RIC.
B	Hazelbrook normally supplied from Fdr 826 Lawson on changeover to Fdr 808 Warrimoo



18.6 Katoomba North Schematic



19 LAWSON TRANSMISSION SUBSTATION

19.1 Lawson Transmission Network Status

Lawson 132/66kV Transmission Substation (TS) is supplied at 132kV via feeder 941 from Wallerawang 132kV Bulk Supply Point (BSP), with the alternate supply being feeder 942 from Penrith TS.

The substation supplies Hazelbrook 66/11kV zone substation (ZS) and Sydney Trains, which has a traction substation on the shared site at Lawson. The Sydney Trains 66kV network then supplies a number of traction substations in the mountains region, and the 11kV Sydney Trains signalling supply. Lawson TS is winter and summer demand peaking substation and is floated at 67.3kV.

Limited second contingency backup supply to Katoomba North TS is available at 66kV, from Lawson TS. This is achieved via feeder 804, Katoomba tee Wentworth Falls ZS's, and Sydney Trains feeder 872, which provides a limited backup allocation to Blackheath ZS.

Project PR136 - augmentation of 66kV feeder 808 Stage 1 is complete. Stage 2 has been indefinitely deferred due to lower demand resulting in lower risk levels.

There are no incomplete approved projects to consider within the Lawson TS area.

19.2 Lawson Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Limitation (Year)
Lawson TS	2 x 52	52		Nil
Hazelbrook ZS	2 x 25	25		Nil

19.3 Results Tables

19.3.1 Lawson TS Loads and Ratings – Winter Summary

Faulty - >	Nil	824	804	Rating	Year of Result
826: LAWSON TS to HAZELBROOK ZS	9	33		80	W 2026
808: HAZELBROOK ZS to SPRINGWOOD ZS	S/B	23		36	W 2026
804/1: LAWSON TS to WNTWRTH FLLS TEE	S/B		7	36	W 2026

19.3.2 Lawson TS Voltage Levels (Resultant Tap Position) - Winter Summary

Faulty - >	Nil	824	804	Min Tap	Max Tap	Year of Result
Hazelbrook	1	0		-14	7	W 2026
Springwood		-2		-14	7	W 2026
Wentworth Falls			1	-14	7	W 2026

19.3.3 Lawson TS Loads and Ratings – Summer Summary

Faulty - >	Nil	824	804	Rating	Year of Result
826: LAWSON TS to HAZELBROOK ZS	8.2	31		50	S 2026/27
808: HAZELBROOK ZS to SPRINGWOOD ZS	S/B	23		22	S 2017/18
804/1: LAWSON TS to WNTWRTH FLLS TEE	S/B		5	22	S 2025/26

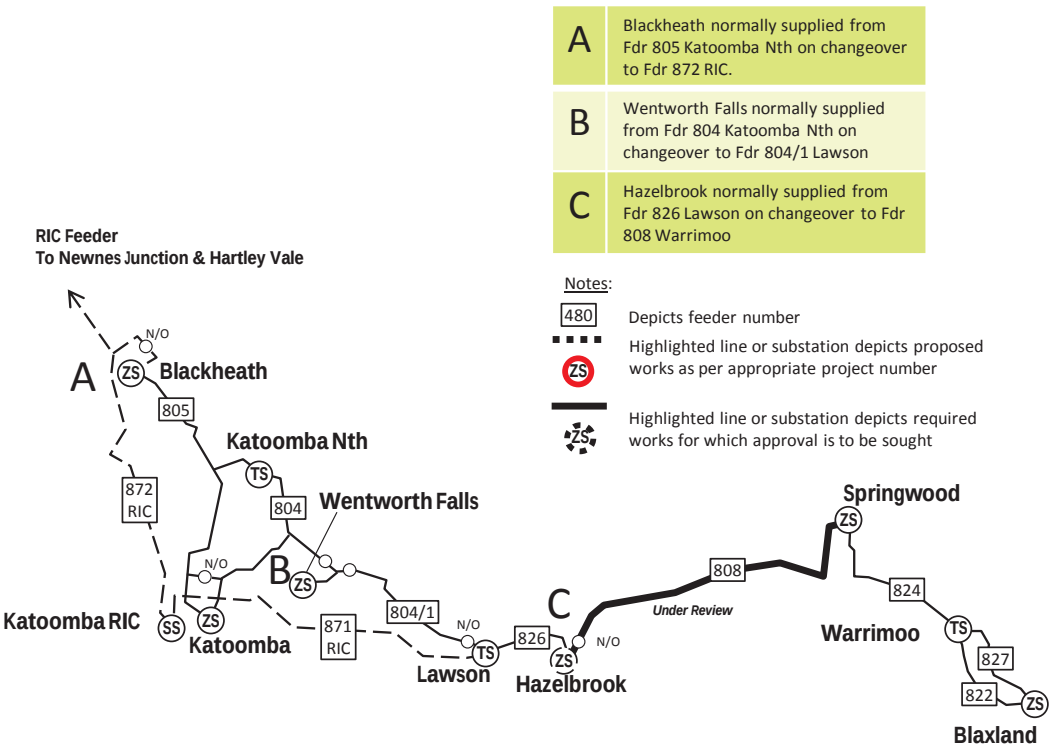
19.3.4 Lawson TS Voltage Levels (Resultant Tap Position) - Summer Summary

Faulty - >	Nil	824	804	Min Tap	Max Tap	Year of Result
Hazelbrook	1	0		-14	7	S 2026/27
Springwood		-2		-14	7	S 2026/27
Wentworth Falls			2	-14	7	S 2026/27

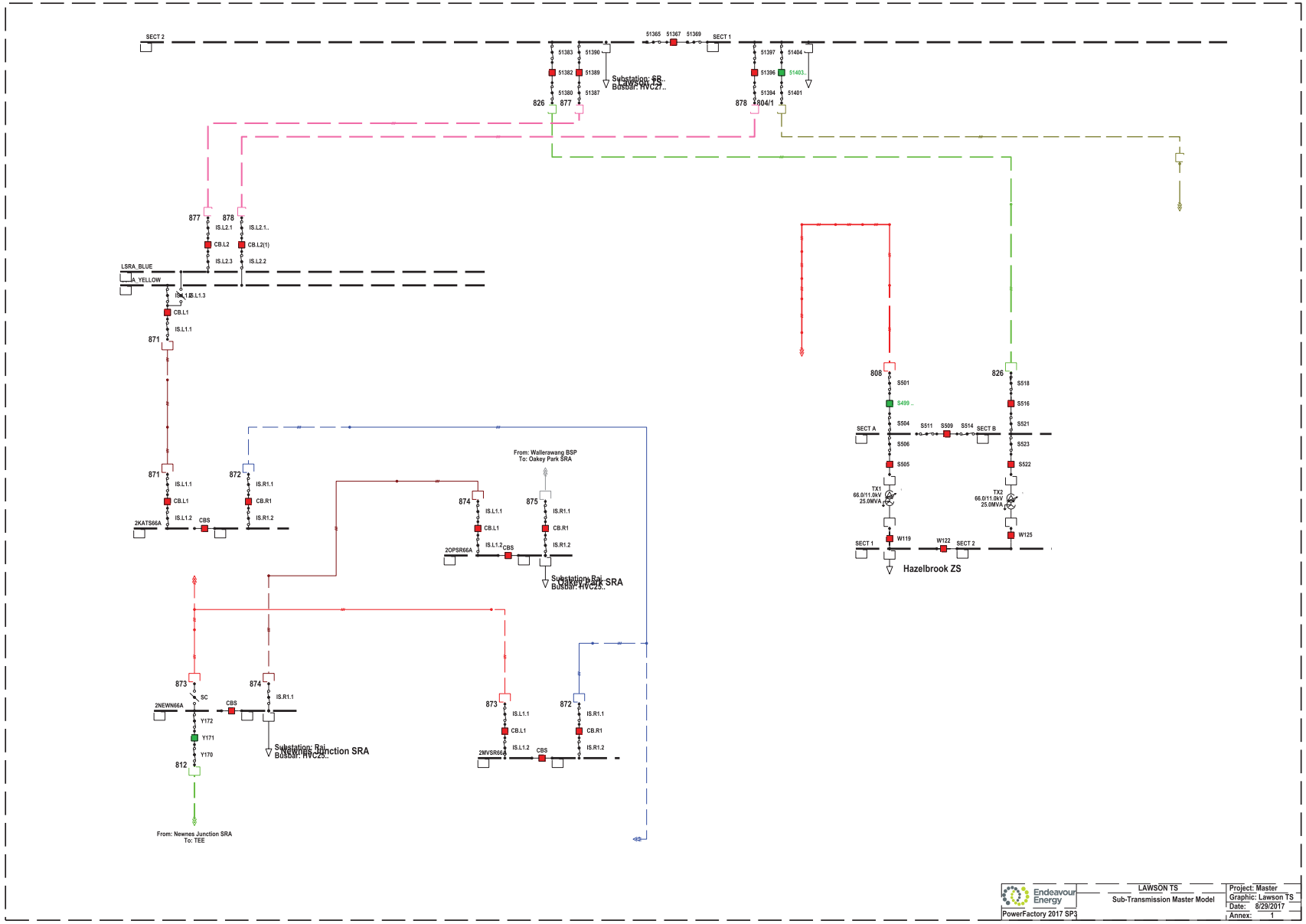
19.4 Analysis Results and Possible solutions

Lawson TS	Network Constraint	Year	Investigation	Solution
	Thermal capacity of standby feeder 808 is exceeded during outage of Feeder 824.	S 2017/18	Project PR136 Stage 2 augmentation of the remainder of Feeder 808 is deferred. This is due to the summer demand reduction at Springwood ZS. The level of network risk is minimal within the forecast period, considering the availability of 11kV emergency transfer capability.	Monitor

19.5 Lawson Geographic



19.6 Lawson Schematic



20 LIVERPOOL BULK SUPPLY POINT

20.1 Liverpool Bulk Supply Point Transmission Network Status

Liverpool Bulk Supply Point is owned by TransGrid and has three tail ended 375MVA 330/132kV transformers providing a firm capacity of 750MVA to Endeavour Energy's West Liverpool TS which is located nearby.

Endeavour Energy is supplied at 132kV by feeders 93B, 93N and 93R. The West Liverpool 132kV busbar then supplies Abbotsbury ZS, Denham Court TS, Liverpool TS, South Leppington ZS and the West Liverpool TS transformers.

Abbotsbury ZS is normally supplied by feeder 93W from West Liverpool TS and is on auto change-over to 93U from Sydney West BSP.

Denham Court TS and South Leppington ZS are supplied by feeder 93Y from West Liverpool TS and on auto change-over to Nepean TS

Liverpool TS (which is located near Liverpool CBD) is supplied by feeders 23L and 93G.

During a contingency at Macarthur BSP, feeders 93Y from West Liverpool and 93X from Sydney West BSP provide back-up to Nepean TS.

This review assumes that all approved projects have been commissioned.

20.2 Liverpool Bulk Supply Point Rating Details

Transmission or Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Capacity Constraint (Year)
Liverpool BSP ^^	3 x 375	750		Nil
Abbotsbury ZS**	2 x 45	45		Nil
Denham Court TS**	1 x 60	Non-Firm		Nil
South Leppington ZS	1 x 45	Non-Firm		2018
Liverpool TS	3 x 120	240	20	Nil
West Liverpool TS	3 x 120	240	62	Nil
Smeaton Grange SS	2 x 60 HVC	60		Nil

Notes:

- ^^ Sydney West BSP is interconnected to Liverpool BSP via Nepean TS. Nepean load is supplied by Macarthur BSP with Liverpool BSP and Sydney West BSP providing contingency backup.
- ** These Substations are supplied directly off the West Liverpool 132kV busbar without an intermediate sub-transmission busbar. The remaining locations are Transmission Substations with their individual sub-transmission networks to each zone substation.

20.3 Results Tables

20.3.1 Liverpool BSP Loads and Ratings - Summer Summary

Faulty ➔	Nil	23L	93G	93B	93N	93R	93W	9L5	Rating (MVA)	Year of Result
23L West Liverpool - Liverpool TS	69	X	223						230^^	2025/26
93G West Liverpool - Liverpool TS	154	223	X						250	2025/26
504 Standby 33kV	S/B								47	2025/26
508 Standby 33kV	S/B								36	2025/26
93B Liverpool TG – West Liverpool	199			X	298	295			375	2025/26
93N Liverpool TG – West Liverpool	199			298	X	296			375	2025/26
93R Liverpool TG – West Liverpool	193			293	294	X			375	2025/26
93U Sydney West – Abbotsbury	A/S						50		400	2025/26
93W West Liverpool – Abbotsbury	48						X		400	2025/26
93Y West Liverpool – Denham Court tee South Leppington ZS	88							122	148	2025/26
9LY Denham Court – Smeaton Grange	36							71	148	2025/26

^^ Contingency rating. Normal continuous rating is 145MVA. Option exists to transfer Casula ZS and Canley Vale ZS to West Liverpool TS for prolonged outage of 93G

20.3.2 Liverpool BSP Voltage Levels (Resultant Tap Position) - Summer Summary

Faulty ➔	Nil	23L	93G	93B	93N	93R	93W	9L5	Min Tap	Max Tap	Year of Result
Abbotsbury ZS	-4			-3	-3	-3	-3		-17	3	2025/26
Denham Court TS	3			5	5	5		6	-16	4	2025/26
Liverpool TS	3	3	3	2	2	2			-16	4	2025/26
West Liverpool TS	2	2	2	1	1	1	2	2	-12	4	2025/26
South Leppington ZS	-6			-4	-4	-4		-5			2025/26

A/S Auto Standby/Changeover, S/B Standby Feeder

20.4 Analysis Results and Possible Solutions

Liverpool SP	Network Constraint	Year	Investigation	Solution
	Feeder 23L has a contingency rating of 230MVA. For outage of 93G West Liverpool TS to Liverpool TS – transfer Casula ZS and Canley Vale ZS to West Liverpool TS with back-up feeders 504 and 508 closed reduces load to 184MVA. *(Monitor and Review)*	2025/26	Possible augment feeder 23L *(Monitor and Review)*	Replace 2750m overhead section of 23L with underground cable to match feeder 93G. This will also result in equal load share of both 23L and 93G during system normal operation. Avoids need to transfer multiple zone substations to West Liverpool TS. *(Monitor and Review)*

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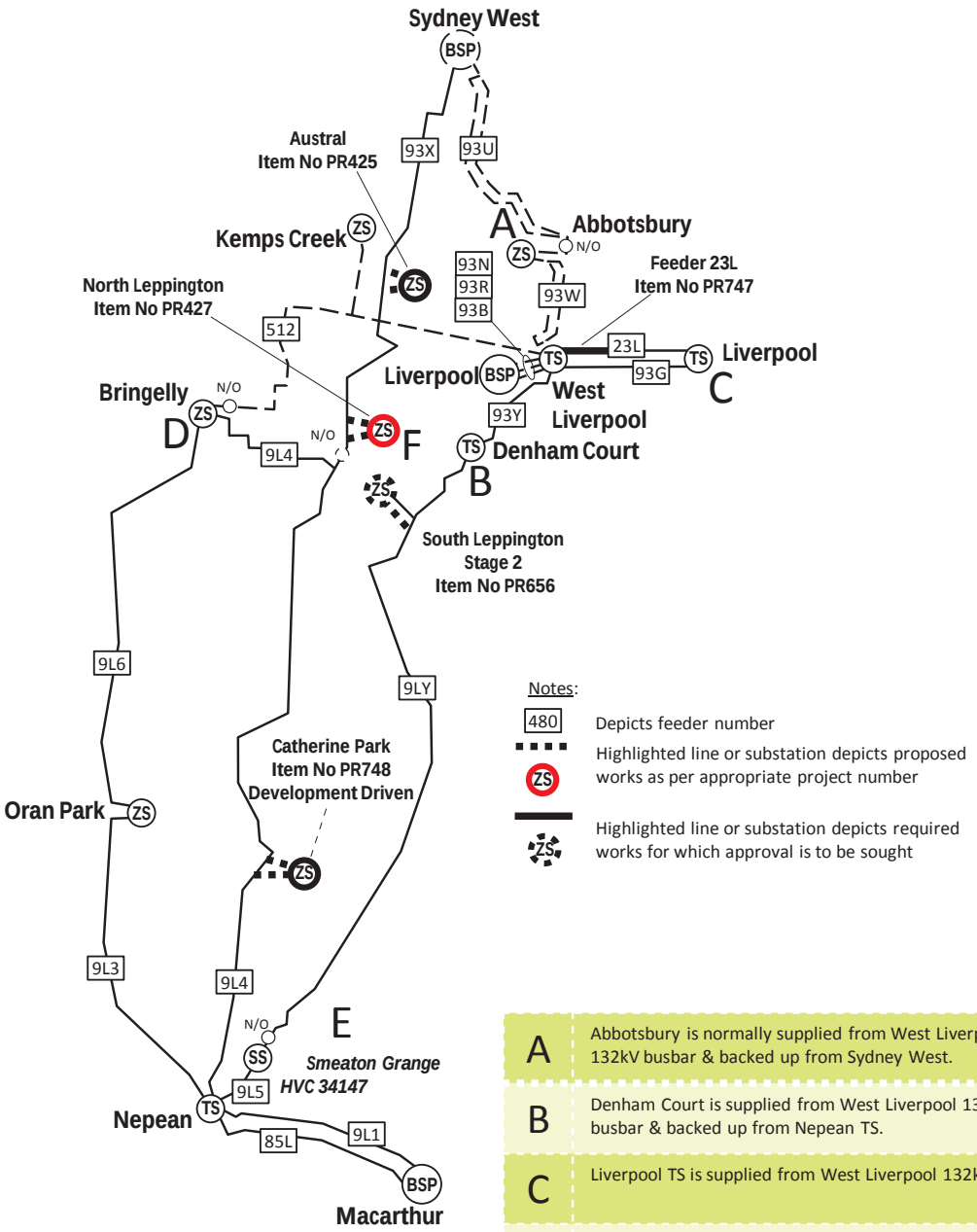
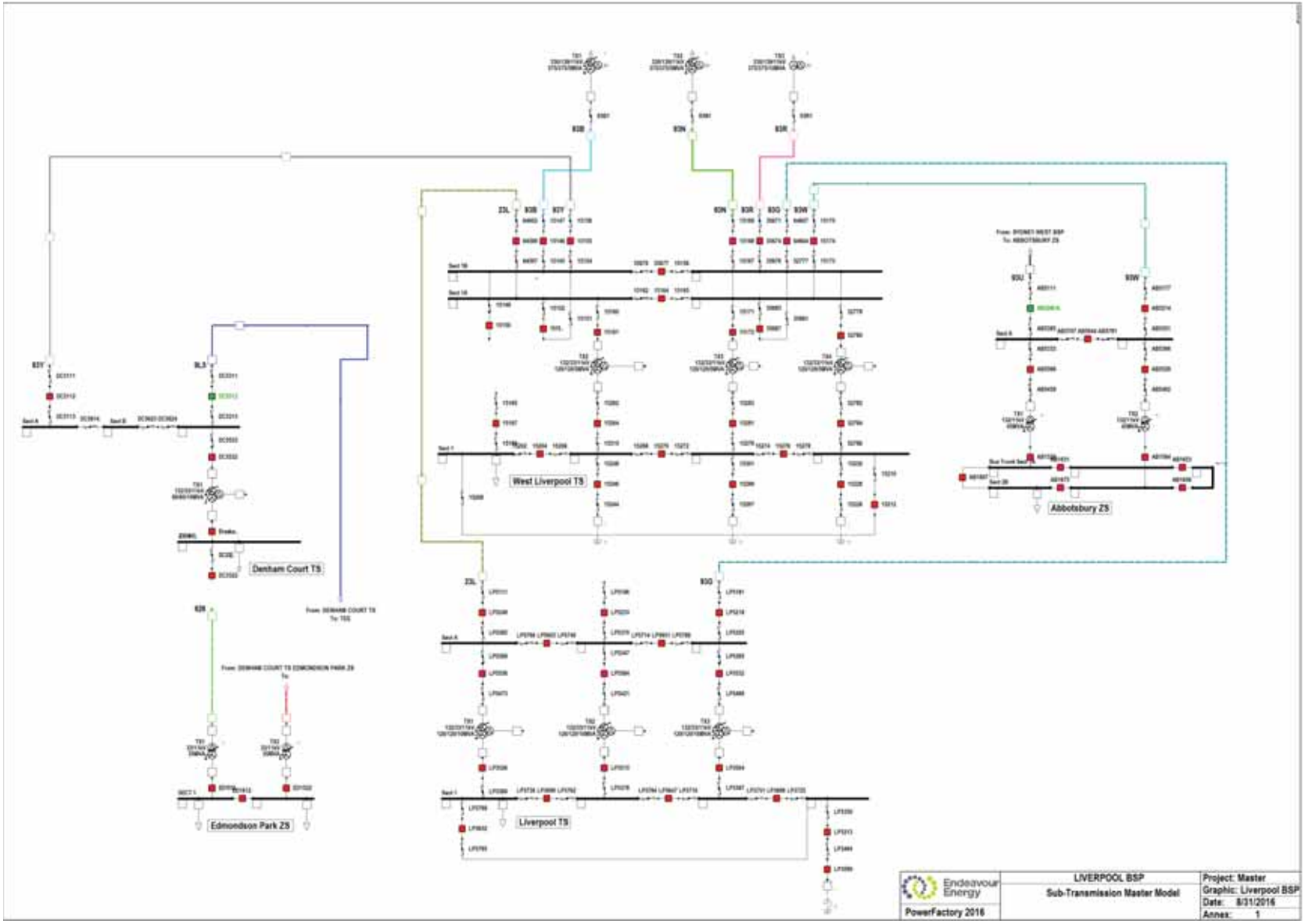
20.5 Liverpool BSP 132kV Geographic



A	Abbotsbury is normally supplied from West Liverpool 132kV busbar & backed up from Sydney West.
B	Denham Court is supplied from West Liverpool 132kV busbar & backed up from Nepean TS.
C	Liverpool TS is supplied from West Liverpool 132kV busbar.
D	Bringelly ZS is supplied from Sydney West & backed up from West Liverpool 33kV. After PR427 Bringelly will be supplied from Macarthur via 9L3 & 9L4. Reliance on 512 is for outage of T1 or when transformer rostering between T1 & T2.
E	Smeaton Grange SS is supplied from Nepean TS & backed up from West Liverpool 132kV busbar.
F	North Leppington ZS is supplied from Sydney West & backed from Nepean TS.

20.6 Liverpool BSP 132kV Schematic



21 LIVERPOOL TRANSMISSION SUBSTATION

21.1 Liverpool Transmission Substation Status

Liverpool TS is supplied by two 132kV feeders, 23L and 93G from the West Liverpool TS 132kV busbar. Mutual back-up is provided between West Liverpool TS and Liverpool TS via two 33kV feeders, 504 and 508. These feeders would be used during the outage of 132kV feeder 93G (the more robust of the two 132kV feeders to Liverpool TS) when the station load exceeds 170MVA.

Liverpool TS has three 120MVA 132/33kV transformers providing a firm capacity of 240MVA at a float voltage of 34kV.

Liverpool TS supplies Anzac Village ZS, Casula ZS, Canley Vale ZS, Chipping Norton ZS, Liverpool ZS, Moorebank ZS, and the Holsworthy Defence Base HVC. Casula ZS is normally supplied by feeder 511 and is on auto change-over to feeder 505 from West Liverpool TS. Canley Vale ZS is normally supplied by feeder 523 and is on auto change-over to feeder 522 from West Liverpool TS via Bonnyrigg ZS.

The transmission network analysis was carried out with all approved major projects within the forecast period assumed to be completed.

21.2 Liverpool Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Substation Capacity Constraint (Year)
Liverpool TS	3 x 120	240	20	Nil
Anzac Village	3 x 25	50	5	Nil
Canley Vale	3 x 25	50	5	Nil
Casula	2 x 35	35	0	Nil
Chipping Norton	2 x 35	35	0	Nil
Defence 33kV HVC	2 x 25 + (6 x 1.5)	Non-firm	0	Nil
Liverpool	3 x 35	70	10	Nil
Moorebank	3 x 35	70	10	Nil

21.3 Results Tables

21.3.1 Liverpool TS Demands and Rating Summary - Summer

Faulty ➔	Nil	516	501	502	530	500	528	520	T4	T5	T6	Rating MVA	Year of Result
523 Liverpool TS to Canley Vale ZS	24.9											42	2026/27
511 Liverpool TS to Casula ZS	34.8											36	2026/27
516 Liverpool TS to Chipping Norton ZS	17.2	X	26.3									38	2026/27
501 Liverpool TS to Chipping Norton ZS	8.9	26.8	X									36	2026/27
502 Liverpool TS to Moorebank ZS	17.1			X	32.4							46	2026/27
530 Liverpool TS to Moorebank ZS	15.2			32.4	X							46	2026/27
500 Liverpool TS to Anzac Village ZS	23.8					X	47.6	17.4				46/52^	2025/26
528 Liverpool TS to Anzac Village ZS	23.8					47.6	X	17.4				46/52^	2025/26
520 Anzac Village ZS to Defence Base HVC 33496	14.4					14.4	14.4	X				57	2026/27
T4 Liverpool TS to Liverpool ZS	25.7								X	25.7	25.7	50	2026/27
T5 Liverpool TS to Liverpool ZS	A/S								25.7	X	25.7	50	2026/27
T6 Liverpool TS to Liverpool ZS	25.7								25.7	25.7	X	50	2026/27

Note: T4, T5 and T6 are feeders to the Liverpool ZS transformers, one being on auto-standby (A/S) mode on a roster basis.

^Feeders 500 and 528 are rated 46MVA when both are in service but rated at 52MVA (contingency rating) when either one of these feeders is out of service

21.3.2 Liverpool TS Voltage Levels Summary - Summer

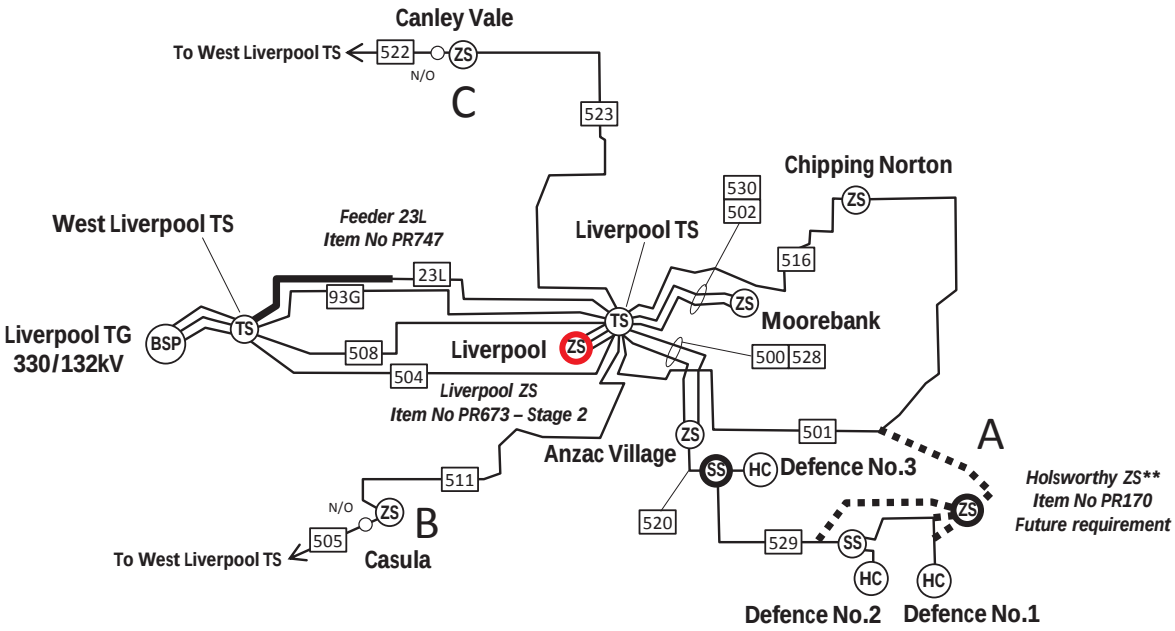
Faulty ➔	Nil	516	501	502	530	500	528	511	T4	T5	T6	Min Tap	Max Tap	Year of Result
Anzac Village ZS	-1					-1	-1					-14	7	2026/27
Canley Vale ZS	-1											-14	7	2026/27
Casula ZS	-2							--2				-14	7	2026/27
Chipping Norton ZS	-1	-2	-1									-14	7	2026/27
Liverpool ZS	0								-1	-1	-1	-14	7	2026/27
Moorebank ZS	-1			1	1							-14	7	2026/27

21.4 Analysis Results with Possible Solutions

Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges, respectively, for this review period.

Liverpool TS	Network Constraint	Year	Investigation	Solution
	NIL			

21.5 Liverpool TS Geographic



** Subject to Developer Activity

A	Future Holsworthy will be normally supplied by Fdr 501 Liverpool & Fdr 520/529 Anzac Village & is subject to demand growth.
B	Casula is normally supplied by Fdr 511 Liverpool & is on changeover to Fdr 505 West Liverpool.
C	Canley Vale is normally supplied by Fdr 523 Liverpool & is on changeover to Fdr 522 Bonnyrigg

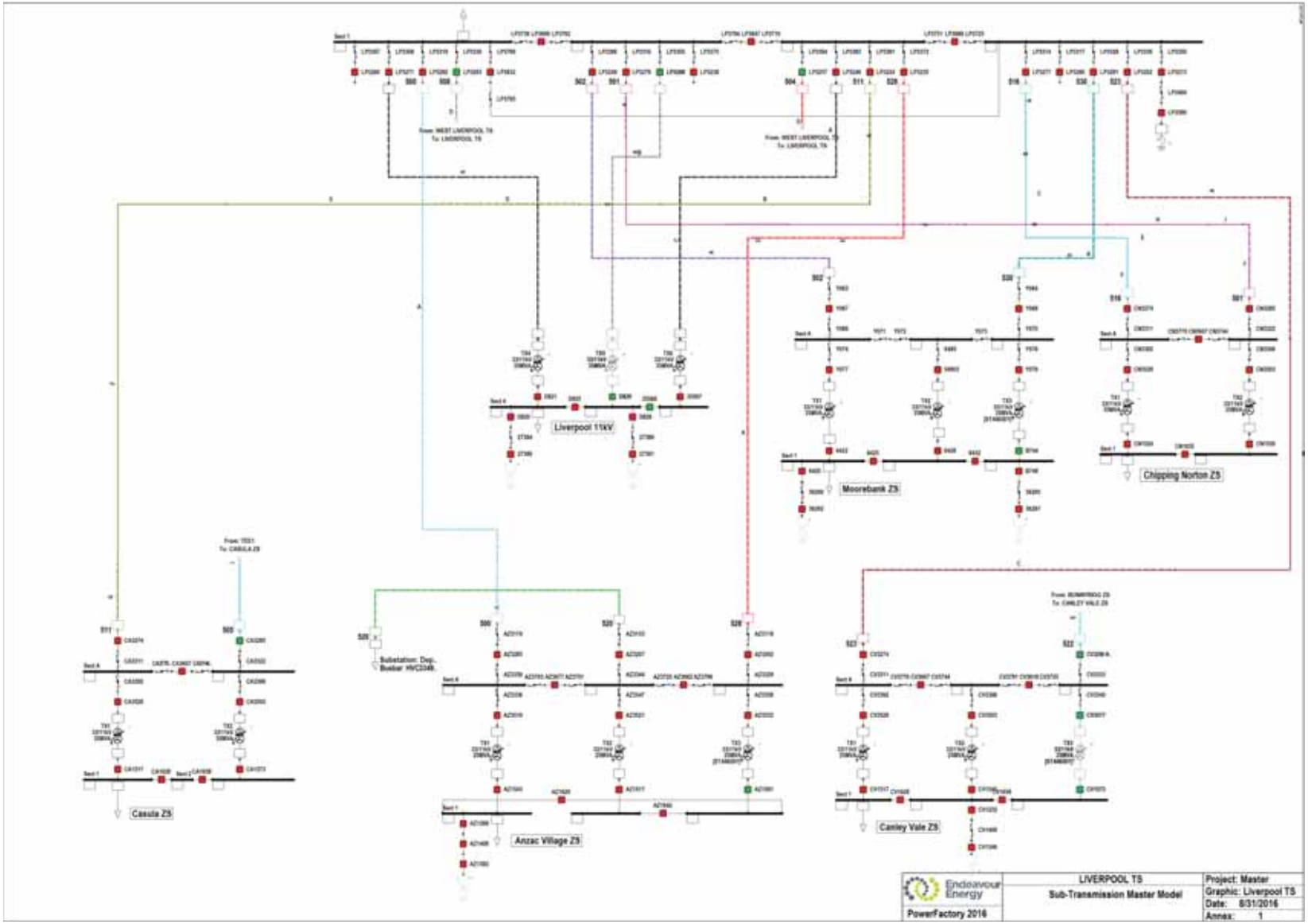
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

21.6 Liverpool TS Schematic



22 MACARTHUR 66KV BULK SUPPLY POINT

22.1 Macarthur BSP 66kV Subtransmission Network Status

Macarthur Substation is owned by TransGrid and is located to the south of the Mt Annan Botanic Garden. It serves as the bulk supply points for the South West Growth Sector at 132kV and the greater Campbelltown area at 66kV. Macarthur Substation supplies power at 66kV through one 250MVA, 330/66kV transformer and 132kV through one 375MVA, 330/132kV transformer initially. Macarthur 132kV BSP will be ultimately configured with two 375MVA 330/132kV and Macarthur 66kV BSP with two 250MVA 330/66kV transformers.

Macarthur Substation supplies Nepean TS at both 132kV and 66kV via two 132kV constructed circuits. One operates at 132kV as feeder 9L1 and the second circuit initially operates at 66kV as feeder 85L. The two circuits will ultimately operate at 132kV into Nepean TS providing capacity to both Nepean TS and into the southern precincts of the South West Growth Sector. The section of the feeder route from the tower to Nepean TS has been built on an interim basis to a lower capacity within the existing easement. The interim ratings will be limited to 233/358MVA Summer continuous/contingency at 132kV and 116/179MVA Summer continuous/contingency at 66kV, which will be adequate for the duration of the current forecast period.

Feeder 93X is set up as normally open at Nepean and on auto changeover for the loss of either 9L1 or 85L. As part of the development of the South West Sector it will be necessary to provide a system whereby either 93X or 9L5 can provide the required backup to Nepean until feeder 85L is converted to 132kV operation. Refer also to the Sydney West, Liverpool, Macarthur 132kV and Nepean 66kV sections of the report.

Macarthur 66kV BSP supplies Ambarvale, Campbelltown and Kentlyn ZS. Macarthur 66kV BSP also supplies the Douglas Park/Appin from feeder 852. A ring arrangement has been formed between Ambarvale and Campbelltown via Kentlyn on feeder 867 and feeder 85T.

The fault level on the Ambarvale 11kV busbar will increase significantly above the allowable 13.1kA level. This will require that only one transformer be operated at a time at Ambarvale with the alternate transformer operated on auto-standby on a roster basis. Alternately both transformers could be operated on a split 11kV busbar arrangement but this would require the replacement of the auxiliary busbar to that of modern standards with a bus section switch and the inclusion of an additional frequency injection cell.

Macarthur 66kV BSP will share the loading of the current Nepean southern catchment area with Nepean 66kV TS. Macarthur 66kV BSP would supply the bulk of the load east of Douglas Park SS through 66kV feeder 852, with Nepean TS supplying the sites west of Douglas Park SS through 66kV feeder 851.

Minimum levels of generation at Appin/Tower is no longer guarenteed to supply into the 66kV network. The average generation level for Summer 2016/17 was approximately 38 MW. This amount of generation was used in the analysis of this report.

The colliery load on the Macarthur/Nepean 66kV network is the subject of ongoing review as the location of activity progressively moves along the various coal seams. A proposal was submitted

for South32 to rearrange their supply in order to change their 66kV HVC connection point. The intent is to enable net metering with their Tower/Appin generation.

22.2 Macarthur 66kV BSP Subtransmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Macarthur BSP	1 x 375 (132kV) & 1 x 250 (66kV)	Non Firm		Nil
Ambarvale	2 x 35	35	5	Nil
Appin	1 x 15	Non Firm		Nil
Campbelltown	3 x 35	70	10	Nil
Kentlyn	2 x 33	33	10	Nil

22.3 Results Tables : Generation – 38MW Continuously

22.3.1 Macarthur 66kV BSP Loads and Ratings - Summer Summary

Faulty ➔	Nil	859	854	853	85M	867	Trnsfr 861 Nar	*852	*^851	850	Rating	Year of Result
859 Mac-C/town	27.5	X	59.2	29.3	29.2	44.0	39.2				67	2026/27
854 Mac-C/town	27.7	59.2	X	29.5	29.5	44.3	39.6				64	2026/27
853 Mac-Amb	28.6	29.3	29.3	X	55.5	14.1	35.2				67	2026/27
85M Mac-Amb	25.6	26.2	26.2	55.6	X	12.6	39.2				86	2026/27
85T Kent-Tee	S/B	S/B	S/B	S/B	S/B	29.4	10.9				72	2026/27
867 Kent-Amb	28.8	28.7	28.7	29.8	28.8	X	39.8				74	2026/27
852 Mac-DP	27.2							X	95.7	46.3	60	2017/18
851 Nep-Mald	32.1							94.2	X	51.8	60	2017/18
850 Mald-DP	23.3							26.7	46.7	X	51	2026/27
*868 DP-Tee	24.4							40.0	39.4	35.6	60	2026/27
*85G DP-BHP	12.4							14.0	13.9	12.6	91	2026/27
*869 DP-Tee	7.0							30.5	18.3	5.6	40	2026/27
*869 Tee- Wilt	17.9							12.9	40.9	28.9	40	2026/27
85C Mald-Wilt	13.9							15.7	27.1	16.7	72	2026/27
861 Tee-Nar	S/B						30.6				50	2026/27

^ Feeder 851 supplied from Nepean 66kV TS
* The analysis was conducted assuming the Appin/Tower Generators were generating at 38MW.

22.3.2 Macarthur 66kV BSP Voltage Levels - Summer Summary

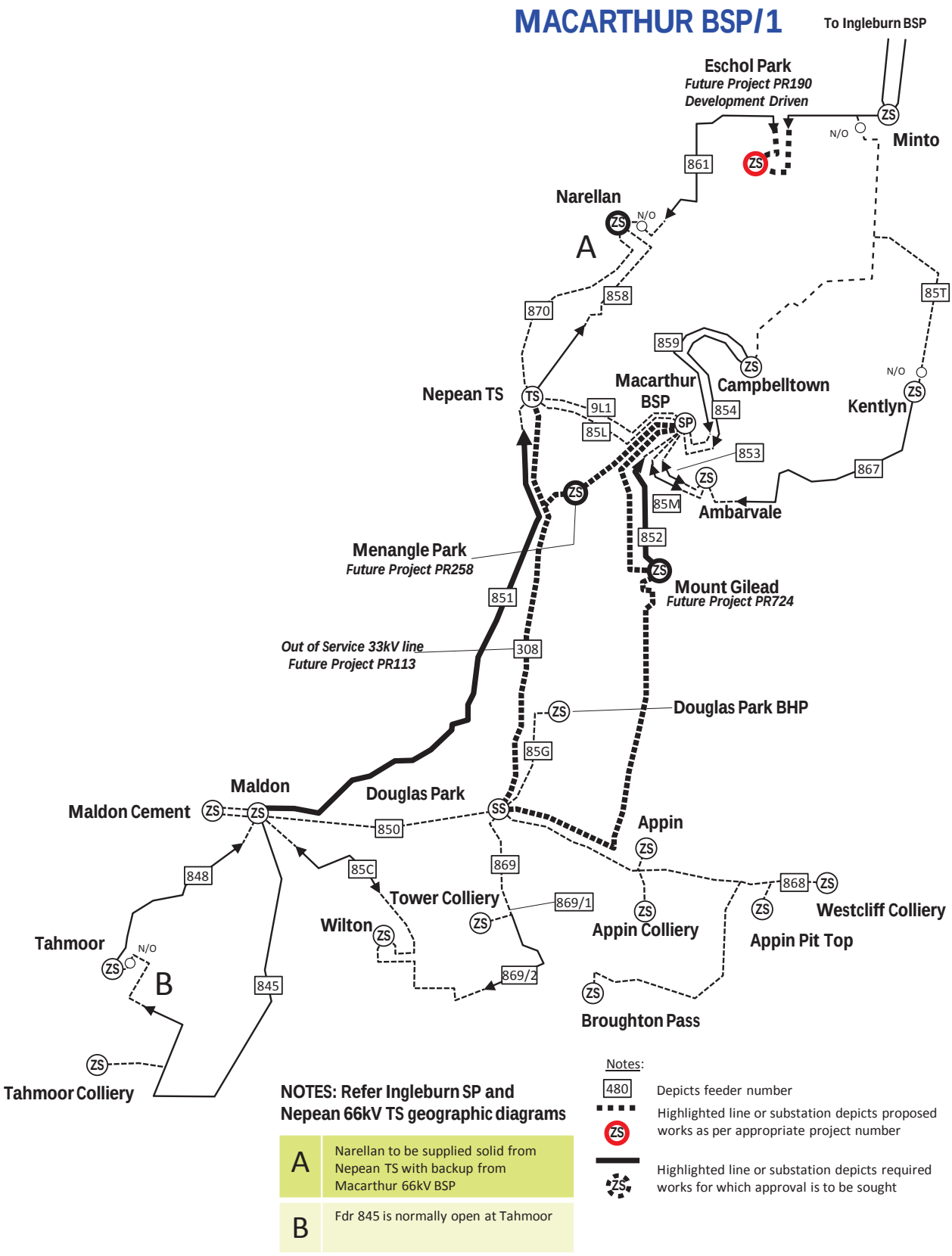
Faulty ➔	Nil	859	854	853	85M	867	Trnsf 861 Nar	852	^851	850	Min Tap	Max Tap	Year of Result
Campbelltown ZS	-2&-3	-2	-2	-2	-3	-2&-3	-2				-14	7	2026/27
Ambarvale ZS	2	-1	-1	-1	-1	-1	-1				-14	7	2026/27
Kentlyn ZS	-3	-4	-4	-4	-4	-3	-4				-18	3	2026/27
Broughton Pass ZS	0							0	0	0	-14	7	2026/27
Appin ZS	-3							-3	-3	-3	-14	7	2026/27
Wilton ZS	-3							-3	-3	-3	-15	8	2026/27
Narellan	S/B						-2&-7				-14	7	2017/18

^ Feeder 851 supplied from Nepean 66kV TS

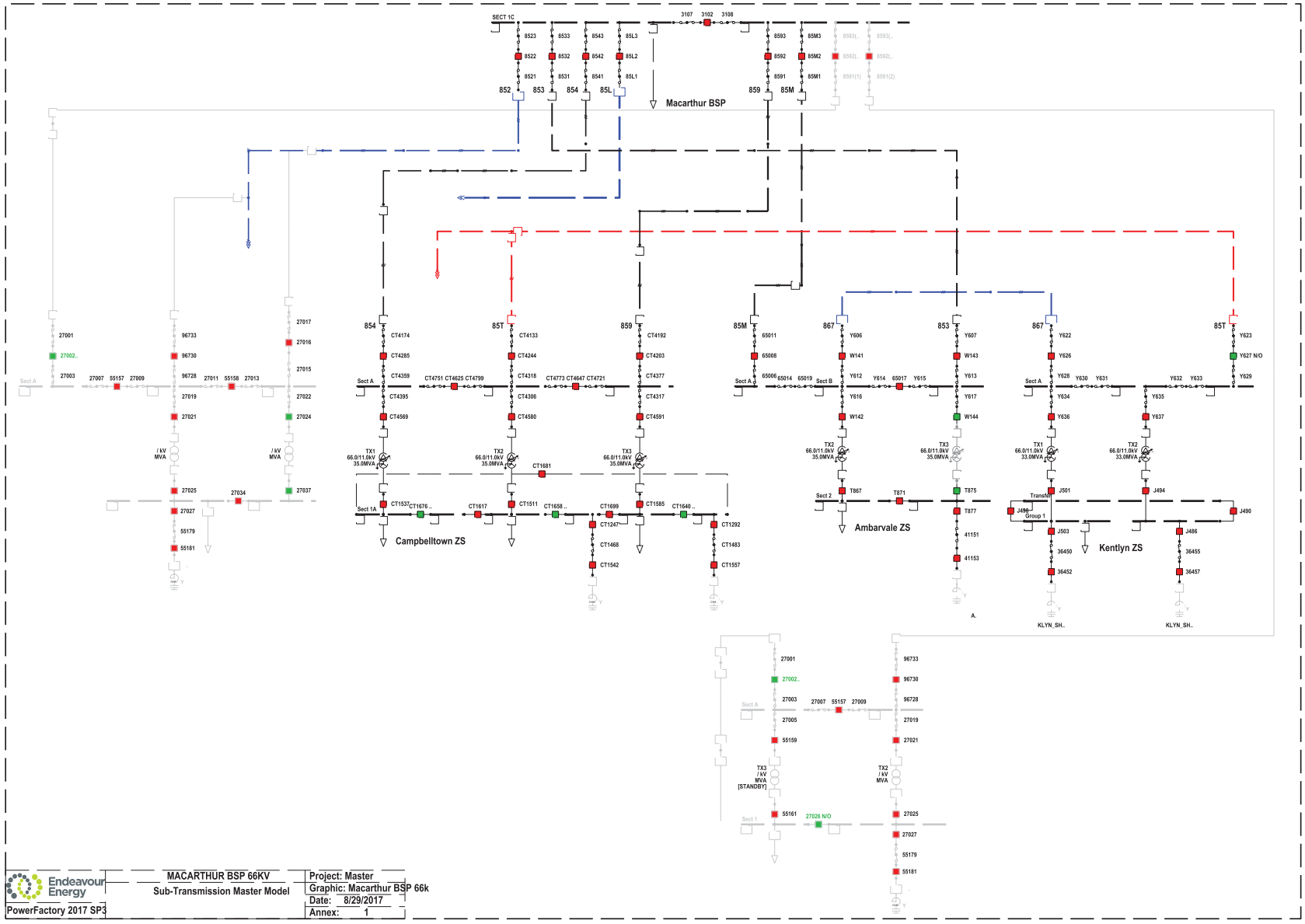
22.4 Analysis Results and Possible Solutions

Macarthur 66kV SP	Network Constraint	Year	Investigation	Solution
	Outage of either feeder 851 or 852 results in an overload on the other feeder. Outage of feeder 851 results in feeder 869 Tower Power Stn Tee to Wilton ZS to be overloaded.	S2018 S2027	There is load at risk with existing generation levels of 38MW. Augment O/S 33kV feeder 308 to 66kV and connect it to Nepean 66kV TS & Douglas Park SS. Augment feeder 869 from the Tower Power Station Tee to Wilton ZS.	Monitor Develop Major project build option
	Tranformer No 2 at Narellan ZS is over loaded when feeder 870 is out & No 1 transformer at Narellan ZS is supplied from Macarthur 66 kV BSP via feeder 861.	S2018	Investigation needs to be carried out to have the three transformers on and a split 11kV busbar at Narellan ZS. Probabilistic planning analysis taking into account actual historical generation.	Monitor

22.5 Macarthur 66kV Geographic



22.6 MACARTHUR - NEPEAN (COMMON) 66kV SCHEMATIC



23 MACARTHUR 132KV BULK SUPPLY POINT

23.1 Macarthur BSP 132kV Transmission Network Status

TransGrid has established Macarthur Substation adjacent to Mt Annan Botanical Garden. The 330/132/66kV substation is the supply source for the South West growth sector through the high capacity feeders between Macarthur and Nepean. Macarthur Substation offloads Liverpool BSP and a share of the Nepean load from Sydney West BSP. Refer to the Ingleburn, Macarthur 66kV, Sydney West and Nepean 66kV sections of this report.

Macarthur Substation supplies power at 66kV through one 250MVA, 330/66kV transformer and 132kV through one 375MVA, 330/132kVtransformer initially. Macarthur 132kV BSP will ultimately be configured with two 375MVA 330/132kV and Macarthur 66kV BSP with two 250MVA 330/66kV transformers. Macarthur Substation supplies Nepean TS at both 132kV and 66kV via two 132kV-constructed 380MVA circuits. Currently one operates at 132kV as feeder 9L1 and the second circuit operates at 66kV as feeder 85L. The two circuits will ultimately operate at 132kV into Nepean TS providing capacity to both Nepean TS and into the southern precincts of the South West Growth Sector. The section of the feeder route from the tower to Nepean TS has been built on an interim basis to a lower capacity within the existing easement. The132kV interim ratings are limited to 233/339 MVA summer/winter, with a summer contingency of 358 MVA. The 66kV ratings are limited to 116/170 MVA summer/winter with a summer contingency of 179 MVA. These ratings will be adequate for the duration of the current forecast period.

The 330/66kV section of the substation supplies 66kV to Campbelltown, Kentlyn and Ambarvale ZS's. Macarthur 66kV BSP supplies the Douglas Park/Appin area through Feeder 852.

Feeder 93X backs up Nepean TS in the short term and has been set up for auto close for loss of either feeder 9L1 or 85L. Alternate backup is available via Feeder 9L5 but parallel operation of this feeder with Feeder 93X will cause fault level exceedances on 66kV equipment. System Operations takes a risk management when paralleling Feeders 93X with 9L5.

Feeder 9L5 provides 132kV supply to a data centre at Smeaton Grange. 9L5 also provides backup to South Leppington ZS which is teed off the main feeder line and to Denham Court TS which is normally supplied from West Liverpool TS on feeder 93Y. Denham Court TS supplies Sydney Trains South West Rail-Link extension and Edmondson Park ZS.

Ultimately feeders 9L5 and 93X from Nepean TS will be outgoing feeders into the South West sector as development proceeds. Feeder 9L3 (uses part of the former feeder 301 corridor from Nepean TS) supplies Oran Park ZS and connects to Bringelly ZS via feeder 9L6.

The NSW Government has announced the potential for 35,000 residential lots to be developed in the Wilton New Town and the Menangle Park/Mt Gilead areas as part of the Greater Macarthur Land Release Area. This will require revision of the 66kV supply strategy for the area. Transgrid's Macarthur Substation does not have the capacity to service the long term needs of the area and joint planning is required as part of the revision of the supply strategy.

23.2 Macarthur BSP 132 kV Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Macarthur BSP	1 x 375 (132kV) & 1 x 250 (66kV)	Non Firm		Nil
Nepean 33kV	2 x 60	60	30	Nil
Nepean 66kV	2 x 120	120	40	Nil

23.3 Results Tables

23.3.1 Macarthur 132kV BSP Loads and Ratings Summary - Summer

Faulty ➔	Nil	9L1	85L	9L3	Transfer 93Y Denham	Macarthur SP Single 330/66kV Transf[3]	Rating	Year of Result
9L1 Mac BSP-Nep TS	213.2	X	236.6		305.8	310.1	358[1]	2026/27
85L Mac BSP-Nep TS 66kV	39.5	74.8	X		57.6	170.7	179[1]	2026/27
93X Syd W-Tee (N/O at Npn)	S/B	103.9	67.5	75.9		86.2	200	2026/27
9L6 Bringelly-Oran Park	S/B			42.3			145	2026/27
9L3 Nepean- Oran Park	43.6	43.6	42.8	X		38.8	145	2026/27
9L5 Npn Tee-Sm Grange SS	32.7				106.9		172	2026/27
93Y West Lvpool-Denham Ct	73.4	196.6	109.7		X	172.2	148	2022/23

Notes 1: Contingency rating

2: Assumed that additional switchgear installed at Bringelly to allow feeder 9L6 to supply Bringelly via Oran Park for outage of feeder 93X

3: Refer to report H:\SPB\Filing\Transgrid\Joint Planning\Macarthur - Nepean contraints – 2016\Report\Macarthur BSP Nepean TS Network Contraints v1.1.

23.3.2 Macarthur 132kV BSP Voltage Levels Summary - Summer

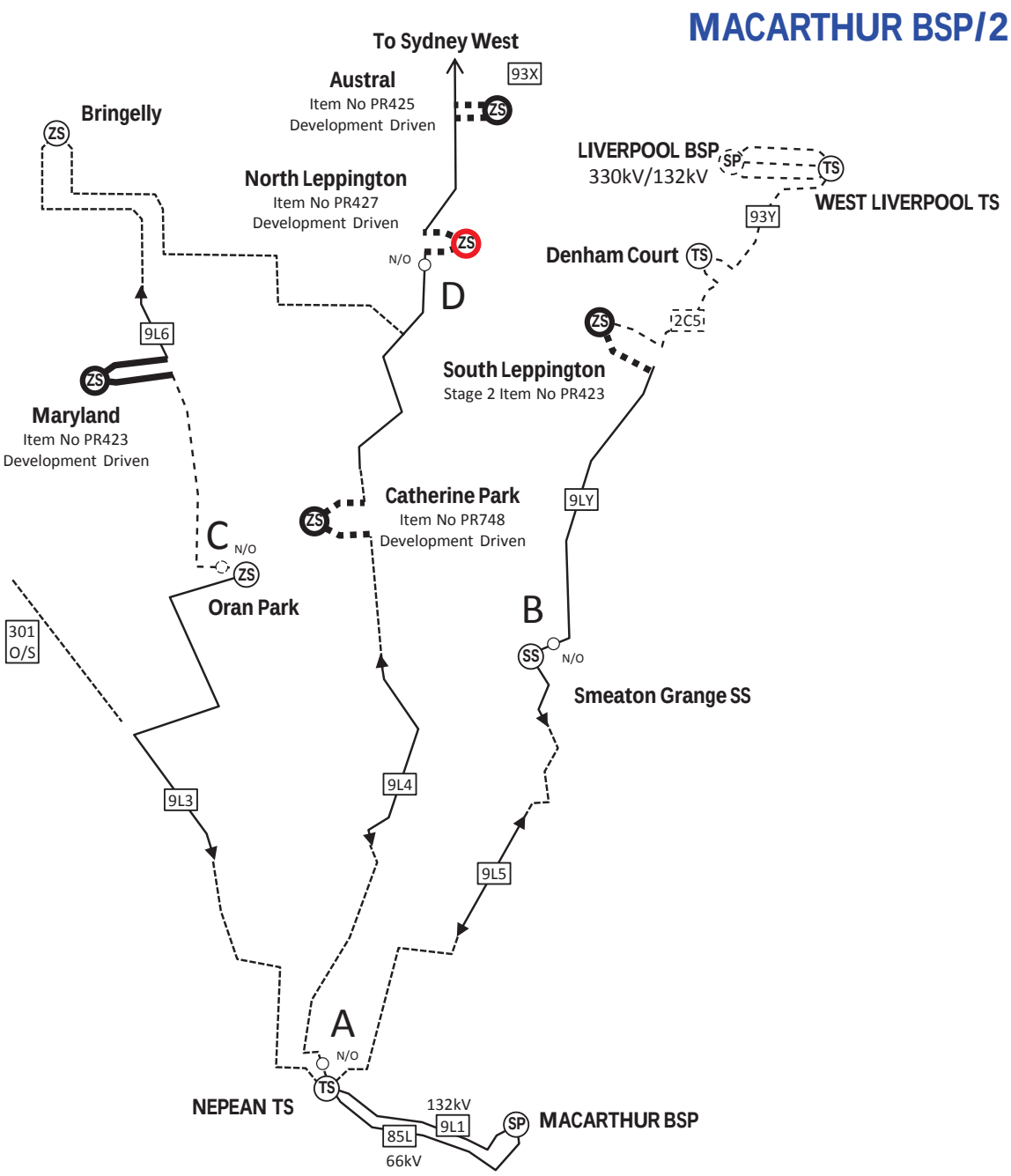
Faulty ➔	Nil	9L1	85L	9L3	Transfer 93Y Denham	Macarthur SP Single 330/66kV Transf	Min Taps	Max Taps	Year of Result
Nepean TS 33kV 1	1	1	1		1	0	-16	4	2026/27
Nepean TS 33kV 2	1	1	1		1	0	-16	4	2026/27
Nepean TS 66kV	0	0	0		0	-6	-12	4	2017/18
Denham Court TS		-6	-6		-6	-5	-16	4	2026/27
Bringelly ZS				2		1	-14	7	2026/27
Oran Park ZS	0	0	0	0		0	-17	3	2026/27
South Leppington		-5	-5		-7	-3	-17	3	2026/27

Notes: 1: Nepean 66kV TS exceeds its firm rating in 2017/18.

23.4 Analysis Results and Possible Solutions

Macarthur 132kV SP	Network Constraint	Year	Investigation	Solution
	When 66kV feeder 85L is out the firm rating of Nepean 66kV is exceed.	S2018	Further investigation is required including load diversity, probabilistic planning analysis and cyclic ratings on the 132/66 kV transformers at Nepean TS.	Monitor
	When 66kV feeder 85L is out 132kV feeder 93Y West Liverpool TS to Denham Court TS is overloaded.	S2023	The second 330/132kV transformer will be required at Macarthur BSP. Feeder 85L will be connected to 132kV and become 9L2. A third 132/66kV transformer and busbar will be required at Nepean TS. Probabilistic planning analysis is required.	Monitor
	The two Nepean TS 132/66kV transformers are overloaded for an outage on the single 330/66 kV transformer at Macarthur BSP.	S2018	Joint planning with Transgrid has resulted in a project for a second 330/66kV transformer at Macarthur.	A second 330/66kV transformer at Macarthur BSP

23.5 Macarthur 132kV Geographic



A	93X normally open at Nepean TS
B	9LY normally open at Smeaton Grange
C	9L6 normally open at Oran Park ZS
D	North Leppington ZS is supplied from Sydney West & backed up from Nepean TS

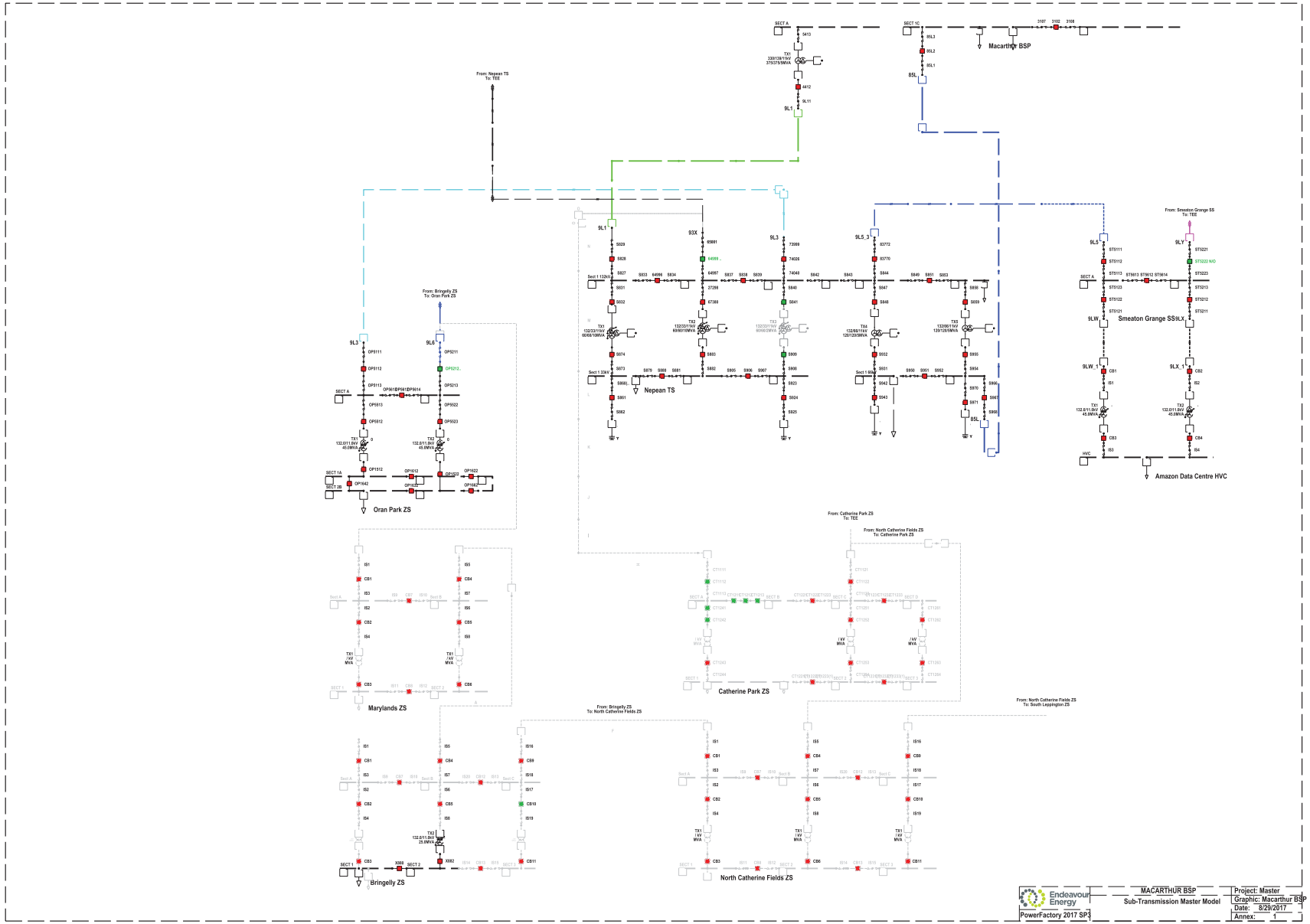
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

23.6 Macarthur 132kV Schematic



24 MARULAN BULK SUPPLY POINT

24.1 Marulan Bulk Supply Point Transmission Network Status

Marulan BSP only has a single 330/132kV, 160MVA transformer supplying both Fairfax Lane and Essential Energy's Goulburn TS. Current contingency arrangements for the loss of the existing single transformer at Marulan, is for Dapto BSP to supply Fairfax Lane TS and for Yass BSP to supply Essential Energy's Goulburn TS.

Fairfax Lane Transmission substation is supplied via 132kV feeder 98C from Marulan BSP with an alternative supply from feeder 988 Dapto BSP. Feeder 98C is rated at 168/190 MVA summer/winter with 988 rated at 133/146 MVA summer/winter. The capacity of each of these 132kV feeders is adequate to meet the needs of the area within the forecast period.

24.2 Fairfax Lane Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Marulan BSP	1 x 160	Non-Firm		
Fairfax Lane TS	3 x 60	120	24	Nil

24.3 Results tables

24.3.1 Fairfax Lane TS Loads and Ratings Summer Summary

Faulty ➔	Nil	98C	Rating	Result Year
98C: MARULAN BSP to FRFXLN TS	74.9	X	168	2026/27
988: DAPTO BSP to TEE	7.0	81.8	133	2026/27

24.3.2 Fairfax Lane TS Voltage Levels (Resultant Tap Position) Summer Summary

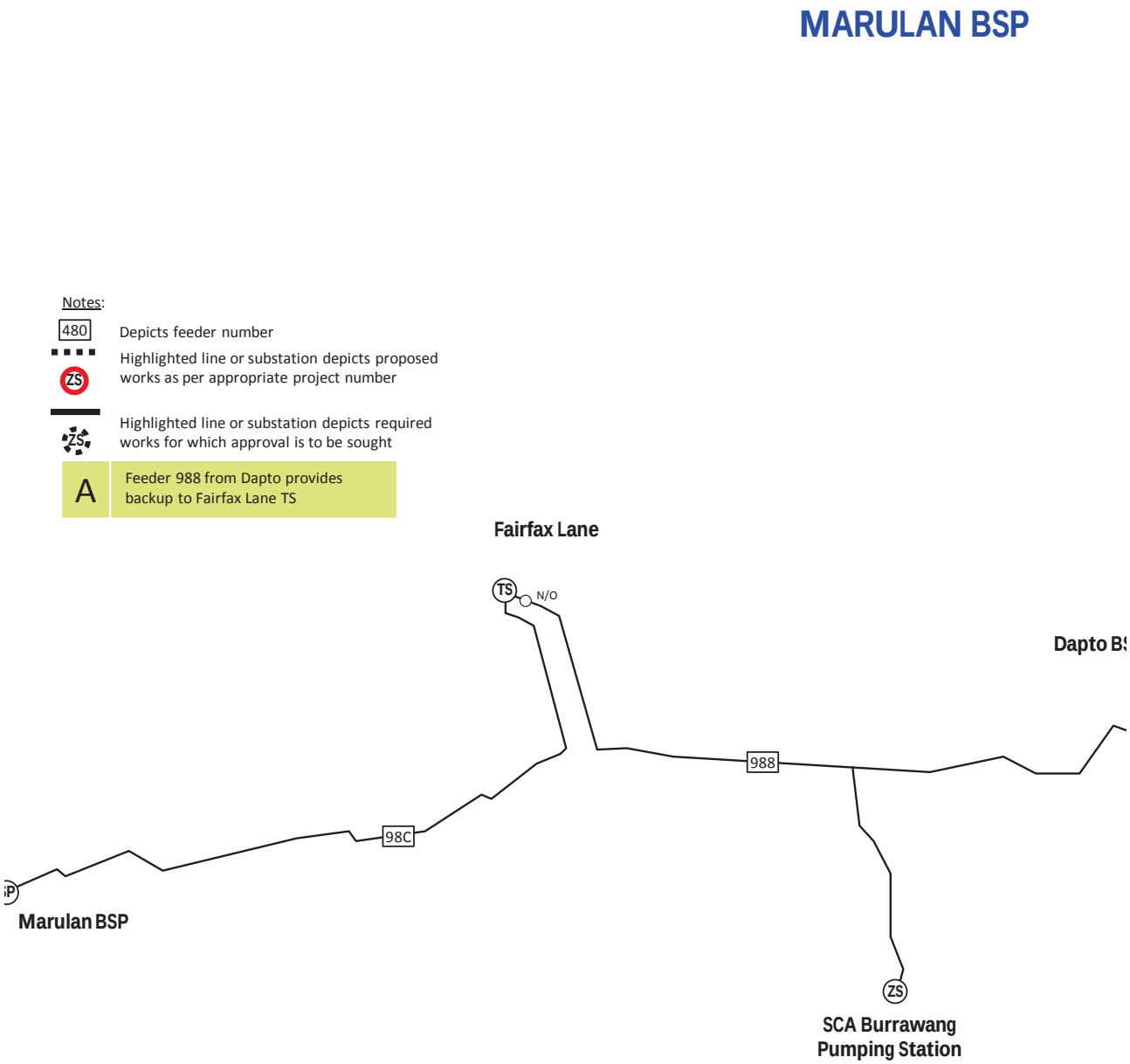
Faulty ➔	Nil	98C	Min Taps	Max Taps	Result Year
Fairfax Ln 1&2	-3	-2	-12	2	2026/27
Fairfax Ln 3	-4	-2	-12	4	2026/27

24.4 Analysis Results and Possible Solutions

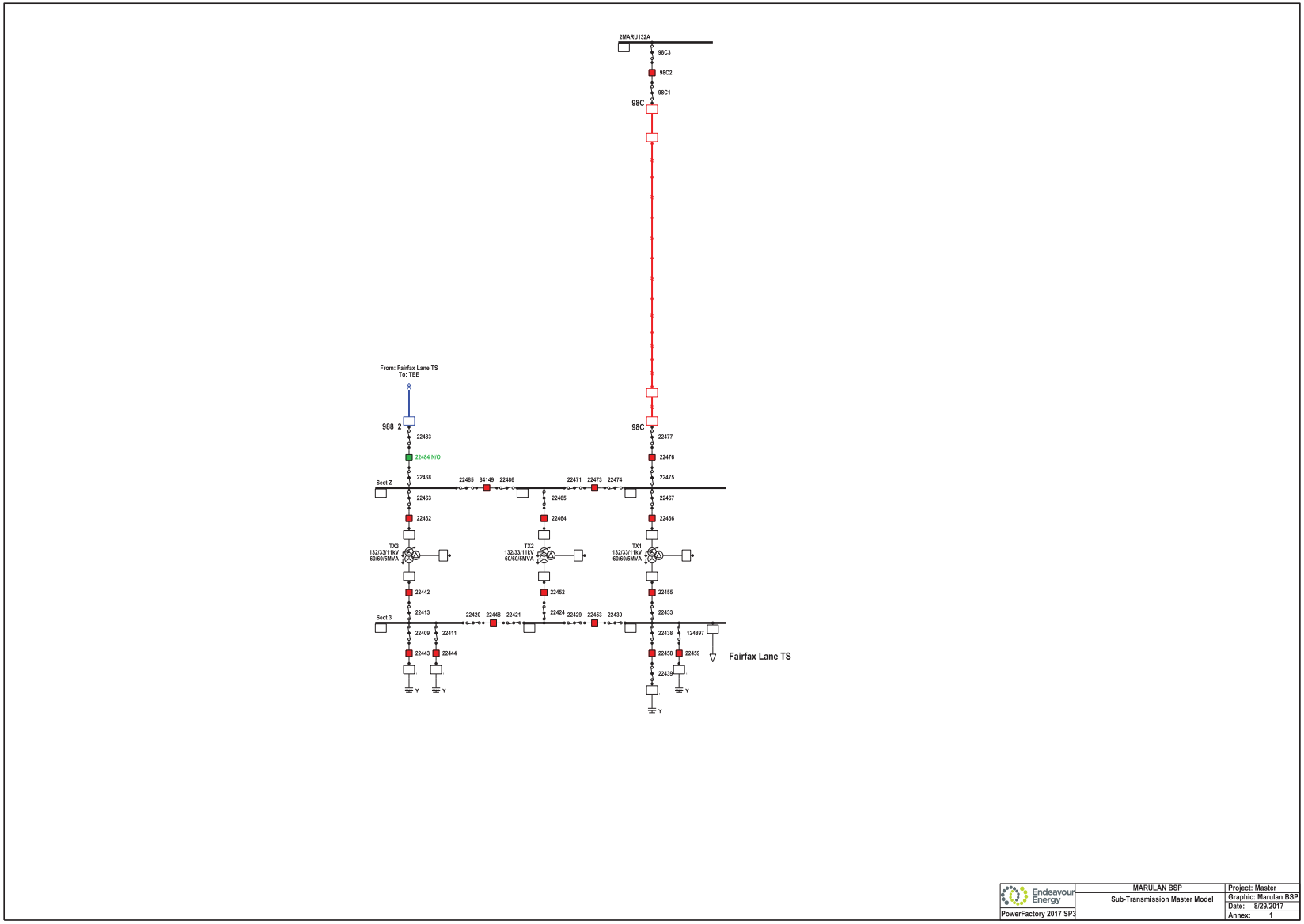
There are no Network Constraints

Marulan SP	Network Constraint	Year	Investigation	Solution
	NIL			

24.5 Marulan BSP Geographic



24.6 Marulan Schematic



Endeavour Energy	MARULAN BSP	Project: Master
	Sub-Transmission Master Model	Graphic: Marulan BSP
		Date: 8/29/2017
PowerFactory 2017 SP3		Annex: 1

25 MOUNT DRUITT TRANSMISSION SUBSTATION

25.1 Mount Druitt Transmission Network Status

Mount Druitt Transmission Substation is supplied from Sydney West Bulk Supply Point via 132kV feeder 932, and feeder 939/219 via Mamre Zone Substation. For a loss of feeder 932, backup supply is available via 132kV feeders 936 and 933 from Regentville BSP via Penrith TS. Mount Druitt TS has three 120 MVA 132/33kV transformers, with provision for a fourth. Mt Druitt is a summer peaking TS and is floated at 33kV with an LDC setting of 3.5% at 200 MVA, to assist in producing an acceptable voltage profile in the outlying areas.

Mount Druitt TS supplies Claremont Meadows, Horsley Park, Plumpton, St Marys ,Werrington and Whalan zone substations. The LMS East Wallgrove generator provides approximately 8MVA to the 33kV busbar at Mt Druitt TS.

Claremont Meadows ZS has offloaded Kingswood ZS and its constrained sub-transmission network. This zone substation supplies the Caddens release area. Claremont Meadows ZS is on changeover to Regentville BSP (Penrith TS) via feeder 457.

Project TS 123 for refurbishment of St Marys ZS has been completed. It included replacement of existing Transformers No 1 and 2 (now Transformers 2 and 3), conversion of 33kV switchgear to indoor and replacement of sections 1 and 2 of the 11kV busbar. Transformer No 3 at St Marys ZS is now on standby. Transformer No 1 (ex No. 3) is the 19MVA unit and has its own section as it has lower impedance than each of the other two.

There are no incomplete approved projects to consider within the Mt Druitt TS area.

25.2 Mt Druitt Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Mt Druitt TS	3 x 120	240	15	Nil
Claremont Meadows	3 x 25	50	5	Nil
Horsley Park	2 x 25	25	5	Nil
Plumpton	3 x 25	50	-	Nil
St Marys	2 x 25 + 1 x 19	44	5	Nil
Werrington	3 x 35	70	10	Nil
Whalan	3 x 25	50	5	Nil
LMS East Wallgrove Generator	8 x 1			

25.3 Results Tables

25.3.1 Mt Druitt TS Loads and Ratings - Summer Summary

Faulty - >	Nil	490	491	456	497	492	493	496	488	495	487	489	48C	Rating	Year of Result
490: MT DRTT TS to ST MRYS ZS[2]	21	X	31											34	S 2026/27
491: MT DRTT TS to ST MRYS ZS[2]	16	32	X											34	S 2026/27
497: TEE to CMBRDG PRK	S/B			18	X									34	S 2026/27
497: WRRNGTN ZS to TEE	7			25	X	7	7	7						34	S 2026/27
497: TEE to SMS MTL HVC	7			7	X	7	7	7						21	S 2026/27
492: MT DRTT TS to WRRNGTN ZS	16			22	13	X	23	25						32	S 2026/27
493: MT DRTT TS to WRRNGTN ZS	14			19	12	21	X	22						34	S 2026/27
496: MT DRTT TS to WRRNGTN ZS	17			24	15	26	25	X						45	S 2026/27
488: MT DRTT TS to PLMPTN ZS	16								X	31	31			42	S 2026/27
495: MT DRTT TS to WHLN ZS	25								31	X	31			42	S 2026/27
487: MNT DRTT TS to TEE	21								31	31	X			42	S 2026/27
487: TEE to WHALAN ZS	6								X*	31	X			42	S 2026/27
487: TEE to PLUMPTON ZS	15								31	X*	X			42	S 2026/27
489: MT DRT TS to E. WLLGRV SS	2											x	9	34	S 2026/27
48C: E WLLGR SS to HRSLY PK ZS	9											9	x	21	S 2026/27
744: HRY PK ZS to W WHRL PK ZS	S/B											2	9	42	S 2026/27
485: MT DRT TS to CLRMT MDW ZS	35													36	S 2026/27

25.3.2 Mt Druitt TS Voltage Levels - Summer Summary

Faulty - >	Nil	490	491	456	497	492	493	496	488*	495*	487	489	48C	Min Tap	Max Tap	Year of Result
St Marys ZS[#]	-2	-2	-2	-2	-2									-14	7	S 2026/27
Cambridge Park	S/B			-1										-14	7	S 2026/27
Werrington ZS	-2			-2	-2	-2	-2	-2						-14	7	S 2026/27
Plumpton ZS	0								-1	-1	-1			-14	7	S 2026/27

Whalan ZS	-1								-1	-1	-1			-14	7	S 2026/27
Horsley Park ZS												2	2	-14	7	S 2026/27
Claremont Meadows ZS	-1													-14	7	S 2026/27

Notes:

* Denotes feeder 487 open at Whalan or Plumpton to dedicate available capacity from feeder 487 on an outage of the alternate feeders 488 or 495

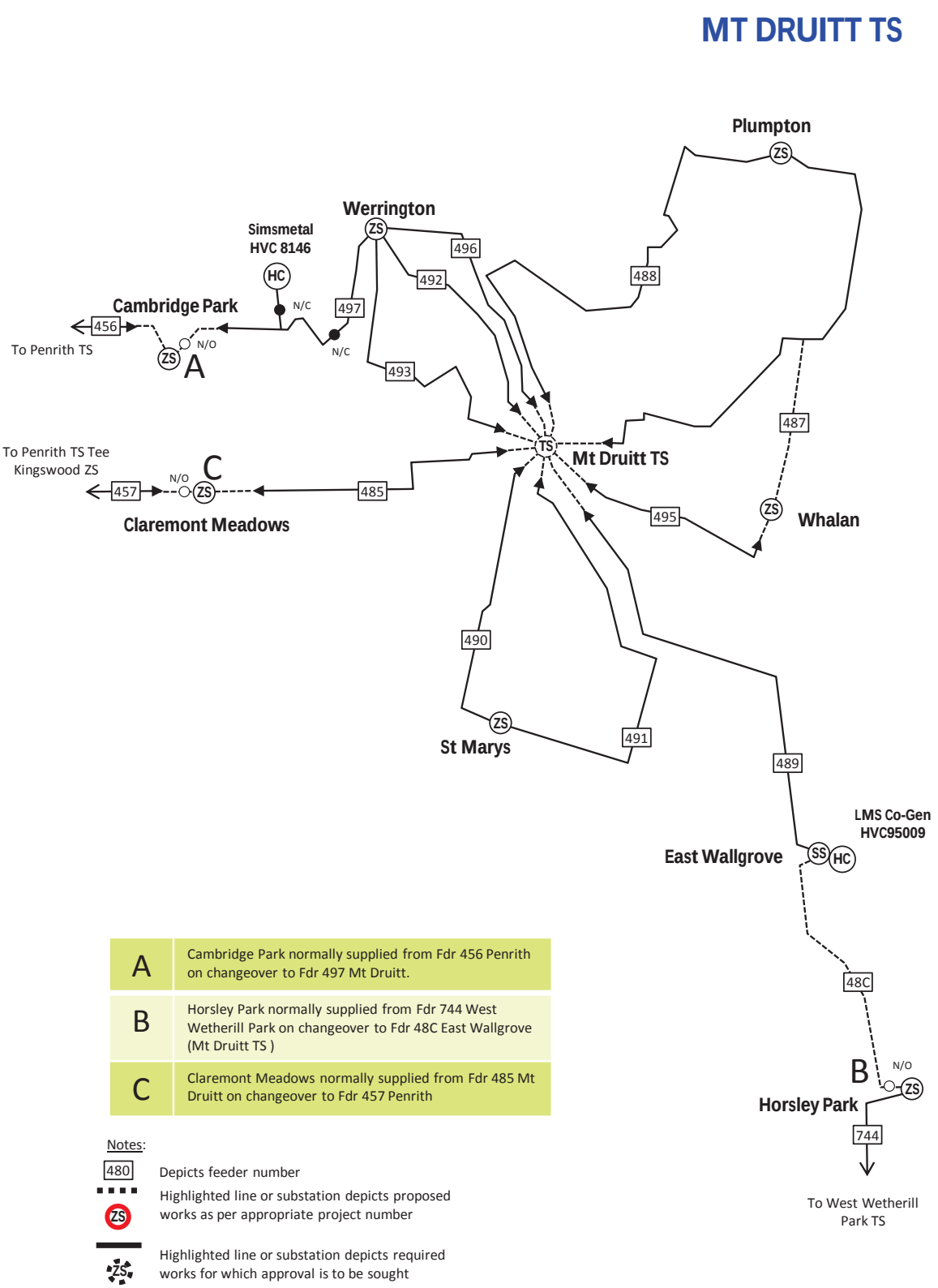
This analysis has been done, as St Marys 33kV and 11kV busbars operated solid. Split arrangement is currently under investigation.

25.4 Analysis Results and Possible Solutions

Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges respectively for this review period.

Mt Druitt	Network Constraint	Year	Investigation	Solution
	NIL			

25.5 Mount Druitt Geographic



A	Cambridge Park normally supplied from Fdr 456 Penrith on changeover to Fdr 497 Mt Druitt.
B	Horsley Park normally supplied from Fdr 744 West Wetherill Park on changeover to Fdr 48C East Wallgrove (Mt Druitt TS)
C	Claremont Meadows normally supplied from Fdr 485 Mt Druitt on changeover to Fdr 457 Penrith

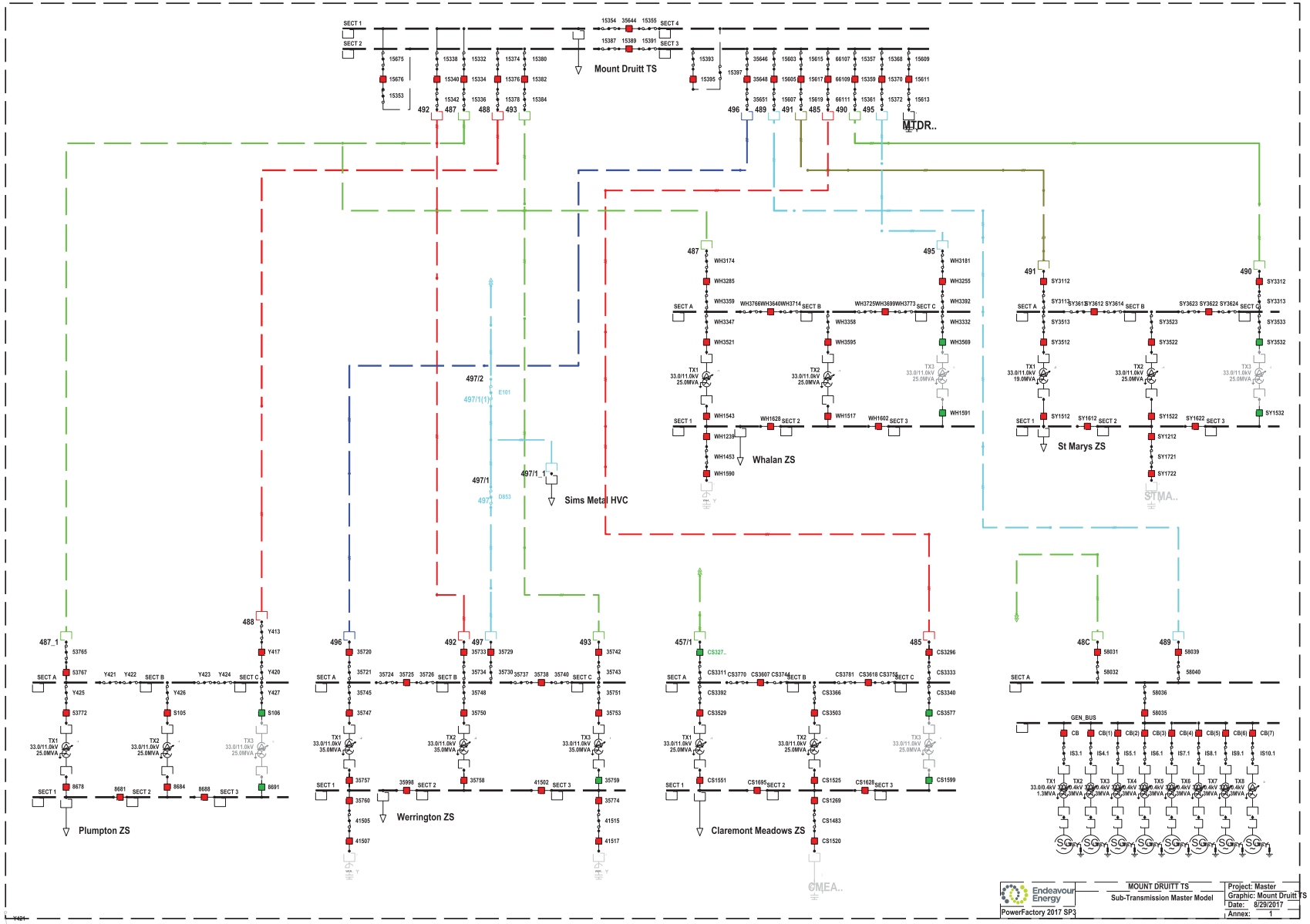
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

25.6 Mount Druitt Schematic



26 MOUNT PIPER BULK 66KV SUPPLY POINT

26.1 Mount Piper Transmission Network Status

Mount Piper 66kV Bulk Supply Point is owned by Transgrid and supplies both Endeavour Energy and Essential Energy. Endeavour Energy's demand is limited to 45MVA on each feeder, being the rating of the metering equipment. Mt Piper 66kV BSP has two 120MVA 132/66/11kV transformers, with no provision for any additional transformers. Each transformer has a cyclic rating of 150MVA. Mt Piper 66kV BSP is winter demand peaking and is floated at 69kV.

Mt Piper supplies Endeavour Energy Blackmans Flat and Hartley Vale zone substations as well as a number of customer substations serving mining operations. The Mt Piper 66kV network also provides backup to Ilford Transmission Substation via feeder 828, for an outage of 132kV feeder 94M or the single transformer at Ilford TS.

Clarence Colliery and Hartley Vale ZS are supplied from Mt. Piper TS, via the Blackmans Flat ZS 66kV busbar on feeder 811. Hartley Vale ZS can be backed up by the Sydney Trains system on feeder 873 (ex-Lawson TS), for an outage of feeders 811 or 812 from Blackmans Flat ZS. However, this requires manual switching and coordination with the Sydney Trains. Springvale Colliery is normally supplied from feeder 85Y, from Wallerawang 66kV BSP. The alternate supply is via feeder 811 from Blackmans Flat ZS (Mt Piper BSP).

Centennial Coal Angus Place East HVC32342 is expanding their mining activity and had applied for a 13MVA load (UIL3870), which is complete. However, the operator has now put the mine in care and maintenance mode. Work at Angus Place Colliery HVC15934 is slowing down, and load has reduced to 3 MVA. Baal Bone colliery HVC16551 is in care and maintenance mode. Invincible Colliery HVC29808 is also slowing down since 2013, and is expected to take minimal load going forward. Charbon Colliery HVC15943 near Kandos, has ceased underground mining activities. . Airly Colliery HVC27401 further south on feeder 828, will re-open and load is expected to grow to about 2.5MVA.

There are no incomplete approved projects to consider within the Mt Piper BSP area.

26.2 Mt Piper Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Limitation (Year)
Mt Piper BSP	2 x 120	120		Nil
Blackmans Flat	1 x 15 + 1 x 10	10		Nil
Hartley Vale	2 x 2.5	2.5		Nil

26.3 Results Tables

26.3.1 Mt Piper BSP Loads and Ratings - Winter Summary

Faulty - >	Nil	811	812	85Y	831	835	840	823	Rating	Year of Result
811: TEE to WLLRWNG 85Y/ SPRNGVLE CLLRY	S/B	S/B	S/B	5					80	W 2026
811: BLCKMNS FLT ZS to TEE	24	X	24	30					80	W 2026
811/2: BLKMNS FLT ZS TEE to SPRGVL CLLRY BH TEE	23		23	25					80	W 2026
811/2: SPRGVL CLLRY BH TEE to SPRNGVL CLLRY BH HVC	2		2	2					45	W 2026
811/2: ANGS PL TEE[1] to SPRNGVL No.3 SHFT TEE	22		21	22					80	W 2026
811/2: SPRNGVL No.3 SHFT TEE to SPRNGVLE NO. 3 HVC	9		9	9					80	W 2026
811/2: SPRNGVL No.3 SHFT TEE to CLRNC CLLRY HVC	13		12	13					80	W 2025
812: CLRNCE CLLRY HVC to HRTLY VL ZS	1.4	X	X	1.6					83	W 2026
835: MT PIPER BSP to TEE	17	4	17	20	34	X	16		80	W 2026
835/1: TEE to INVICIBLE COLLIERY HVC[2]	S/B	0.1	0.1	0.1	0.1	X	0.1		45	W 2026
835/2: TEE to BLACKMANS FLAT ZS	17	4	17	20	34	X	16		79	W 2026
831: MT PIPER BSP to BLACKMANS FLAT ZS	16	4	16	19	X	34	15		79	W 2026
840: BLACKMANS FLAT ZS to TEE	3						X		80	W 2026
840: TEE to ANGUS PLACE COLLIERY HVC	S/B						X		80	W 2026
840: TEE to BAAL BONE COLLIERY HVC	1						X		80	W 2026
***828: MT PIPER BSP to TEE**	2.5							5.4	45	W 2026
***828/1: TEE to PORTLAND ZS**	S/B							2.9	31	W 2026
***828/1: TEE to AIRLY COLLIERY TEE**	2.5							2.5	31	W 2026
828/1: AIRLY COLLIERY TEE to HYROCK TEE	0.6							0.6	31	W 2026
828/2: TEE to HYROCK HVC	0.5							0.5	45	W 2026
828/2: HYROCK TEE to SW35091	0.5							0.5	31	W 2026
828/4: SW35091 to TEE CENTENNIAL CHARBON HVC	2							0.1	79	W 2026
828/4: TEE to CENTENNIAL CHARBON HVC	S/B							S/B	31	W 2026
828/4: TEE to KANDOS ZS	S/B							S/B	31	W 2026

Notes:

* Airly Colliery was in caretaker mode for analysis. Load is expected to increase to 2.5MVA and will be included in future studies.

[1] Angus Place East HVC 32342 is in “care & maintenance” and its load is approx. 800kVA.

[2] Invincible Colliery is in “care & maintenance” and its load is approx. 70kVA.

26.3.2 Mt Piper BSP Summer Voltage Tap Positions and Tapping Steps - Winter Summary

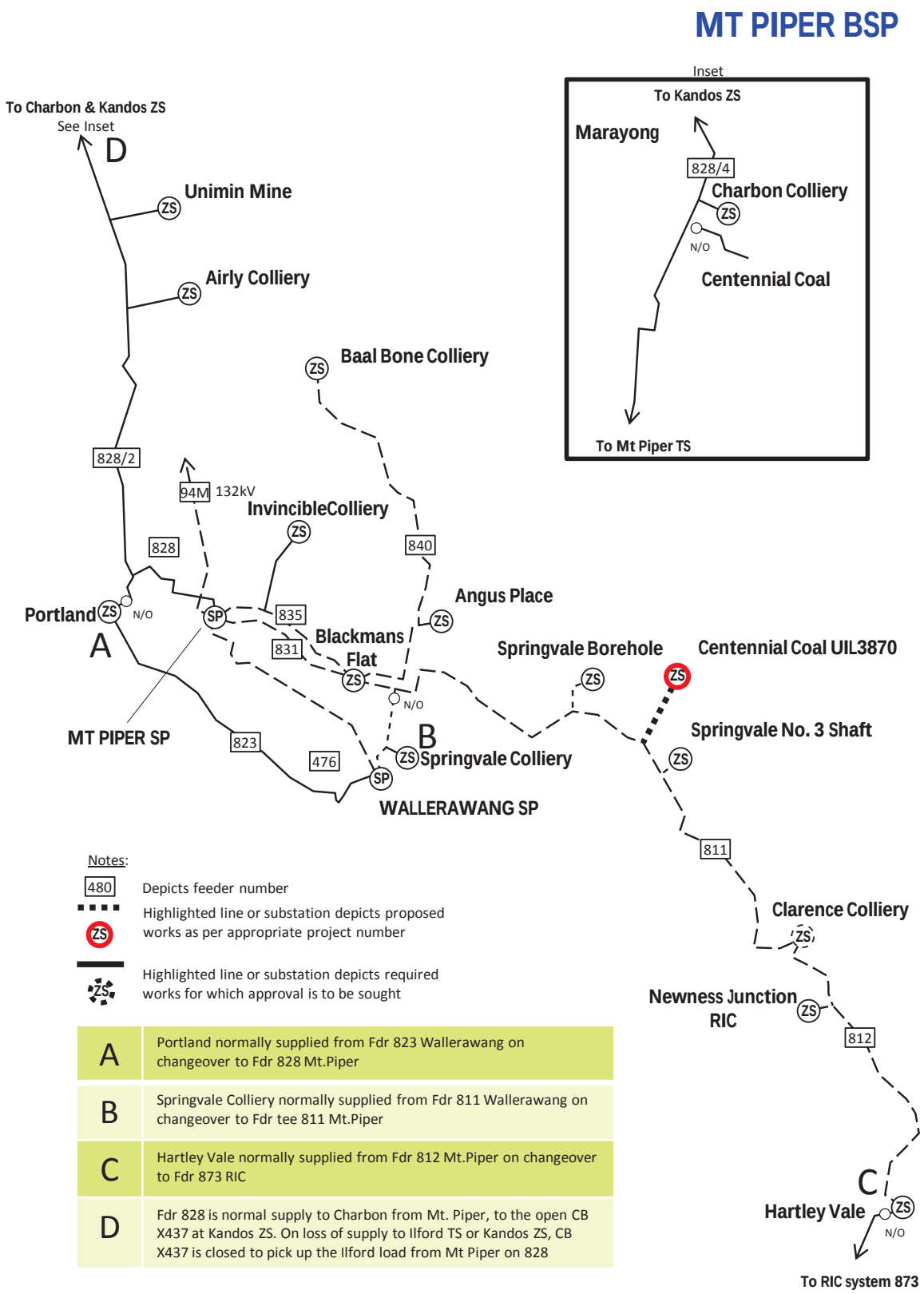
Faulty - >	Nil	811	812	85Y	831	835	840	823	Min Tap	Max Tap	Year of Result
Blackmans Flat ZS	0	0	0	0	0	0	0	0	-14	7	W 2026
Hartley Vale ZS	0	3	x	0	0	0	0	0	-12	12	W 2026
Portland ZS								1	-14	7	W 2026

26.4 Analysis Results and Possible Solutions

Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges respectively for this review period.

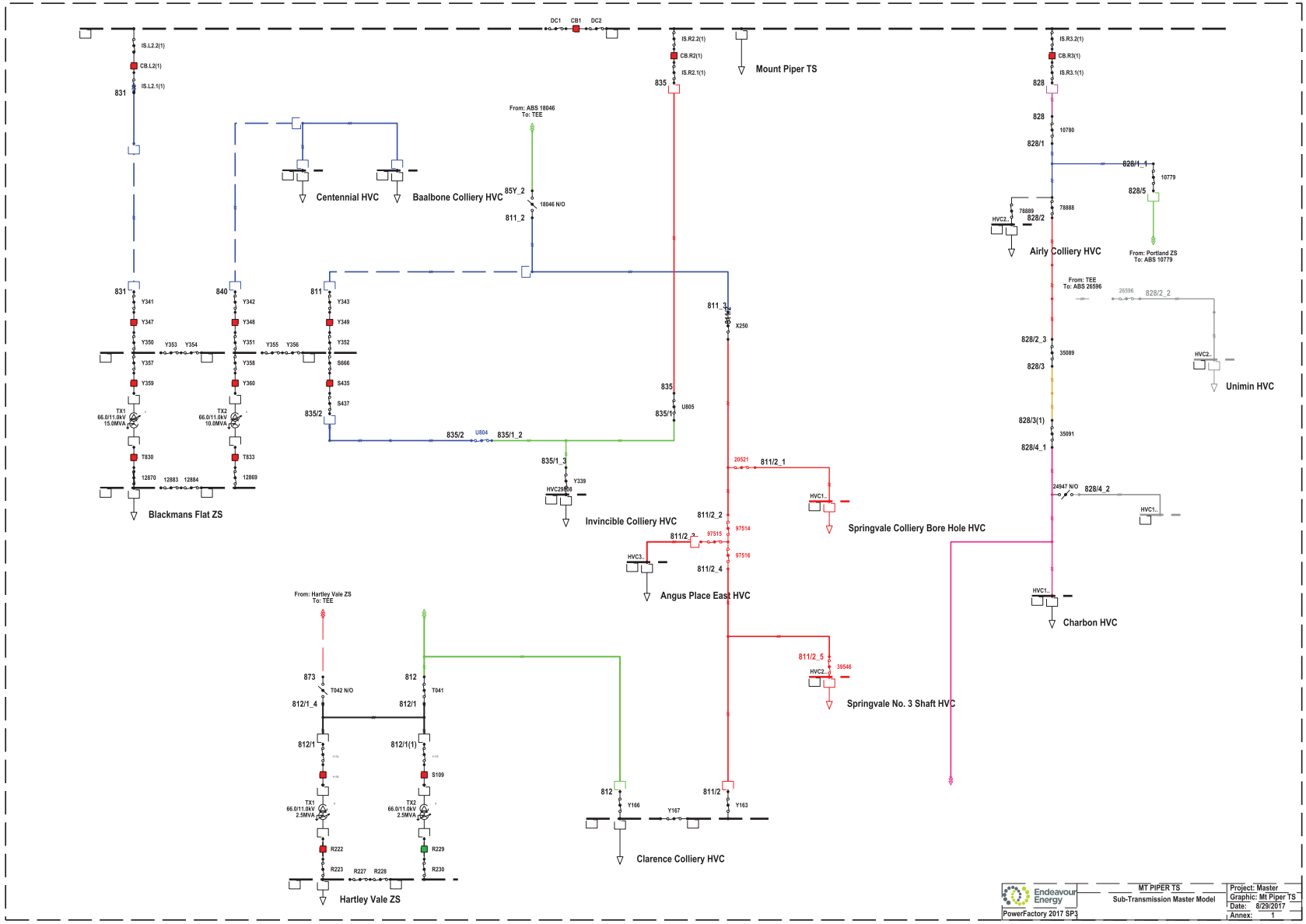
Mt Piper	Network Constraint	Year	Investigation	Solution
	NIL			

26.5 Mount Piper Geographic



A	Portland normally supplied from Fdr 823 Wallerawang on changeover to Fdr 828 Mt.Piper
B	Springvale Colliery normally supplied from Fdr 811 Wallerawang on changeover to Fdr tee 811 Mt.Piper
C	Hartley Vale normally supplied from Fdr 812 Mt.Piper on changeover to Fdr 873 RIC
D	Fdr 828 is normal supply to Charbon from Mt. Piper, to the open CB X437 at Kandos ZS. On loss of supply to Ilford TS or Kandos ZS, CB X437 is closed to pick up the Ilford load from Mt Piper on 828

26.6 Mount Piper Schematic



27 MOUNT TERRY TRANSMISSION SUBSTATION

27.1 Mount Terry Transmission Network Status

Mount Terry Transmission Substation has two 120MVA 132/33kV transformers providing a firm capacity of 120 MVA. The substation is fed from Dapto BSP via 132kV feeders 98F and 98W. Feeders 98L and 98U from Mt Terry provide supply to Shoalhaven TS and onto the south coast substations of West Tomerong, Ulladulla, Moruya North and Batemans Bay. Mt Terry TS is floated at 34kV.

Jerrara SS was over 50 years old with significant corrosion of busbar and switchgear supports. It was configured with manual isolators on feeders 7006, 7050 and the bus section isolator restricted the operation of the network. Project TS178 Jerrara SS Steel Support Structures recommended decommissioning of Jerrara SS as the appropriate level of network security could be maintained without it. Works included redirecting four feeders to outside of the SS and were completed in May 2017. This review includes the new feeder configuration.

The Warilla No. 3 transformer can be remotely transferred onto Outer Harbour TS to relieve constraints under subtransmission contingency conditions (Mt Terry / Shellharbour / Warilla / Albion Park / Mt Terry ring). PR192 was approved in May, 2012, and will increase the ratings of constrained feeders 7158 and 7004. The feeders currently have a continuous summer operating temperature of 50°C, which will be increased to 75°C under PR192.

A report titled “West Lake Illawarra Area Plan” was endorsed by management in May 2016. Part of the West Lake Illawarra release area is located on the fringes of the Albion Park ZS catchment area and is proposed to provide up to 8,770 dwellings plus employment lands and commercial businesses with an expected demand of 43MVA.

The first stages of residential land development in the Calderwood Valley area commenced during late 2016 where up to 4800 lots are expected to produce a demand of 20MVA over the next 20-years. Ultimately, the development area will require a new zone substation. The need for a new zone substation is foreshadowed in the “West Lake Illawarra Area Plan”. Negotiations with the developer are proceeding with the likelihood of a zone substation site being acquired near 33kV lines 7123 and 7041 on Calderwood Road Calderwood.

The analysis has been done with the assumption the following approved projects have been completed:

- *PR192 – Constrained 33kV Feeders 7158 and 7004*

27.2 Mt Terry Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Mt Terry TS	2 x 120	120		Nil
Albion Park	3 x 12.5	23.2[@]		Existing
Gerringong[1]	2 x 5	5		Existing[1]
Jamberoo	1 x 3.75	Non-firm		Nil
Kiama	2 x 12.5 + 1 x 15	25		Nil
Shellharbour	2 x 20 + 1 x 25	40	5	Nil
Warilla	2 x 10 + 1 x 12.5	20		Existing

Notes:

[@] Albion Park firm capacity limited to 23.2MVA due to a mismatch in transformer impedance.

2. Firm capacity exceeded.

27.3 Results Tables

27.3.1 Mt Terry TS Loads and Ratings Summary – Summer

Faulty ➔	Nil	7054	7058	7158	7004	7059	7047	7147	7005	7050	7008	7043	7175	T'fer Berry	T'fer Dapto trf 3	Rating	Result Year
7054: MT TRRY TS to LBN PRK ZS	20.6	x	37.5	10.9	22.4	23.8	24.3	24.3		22.0				20.6	20.5	45.7	2027
7058: MT TRRY TS to LBN PRK ZS	17.8	37.2	x	9.4	19.4	20.5	21.0	21.0		19.0				17.7	17.7	45.7	2027
7158: LBN PRK ZS to WRLL ZS	18.2	16.8	17.1	x	21.6	24.0	25.0	25.0		20.7				18.2	18.1	(32.0)	2027
7123: LBN PRK ZS to ABS 82009	x	x	x	x	x	x	x	x		x	x	x	x	x	x	16.8	2027
7004: SHLLHRBR ZS to WRLL ZS	3.5	4.9	4.5	22.3	x	2.6	3.7	3.7		1.3		2.9	3.1	3.3	3.3	(32.1)	2027
7059: MT TRRY TS to SHLLHRBR ZS	20.6			28.1	19.3	x	32.2	32.2	20.6	24.9		22.0		20.6	20.6	33.2	2027
7047: MT TRRY TS to CRM SS	25.7			**34.9**	24.2	**37.8**	x	x		31.0		27.4		25.8	25.7	33.2	**2018**
7147: CRM SS to SHLLHRBR ZS	21.9			31.0	20.4	**33.9**	x	x		27.1		23.6		21.9	21.8	33.2	**2019**
7005: SHLLHRBR ZS to KM ZS	0.2	0.2	0.2	2.8	0.7	3.7	4.4	4.4	x	11.8	0.9	4.0	2.7	x	0.2	13.4	2027
7050: MT TRRY TS to KM ZS	15.0			17.5		18.2	18.7	18.7	15.0	x		19.9	18.2	20.0	14.9	22.5	2027
7008: KM ZS to GRRNGNG ZS	1.8						2.0	2.0		3.4	x	9.5	6.5	6.2	1.8	20.6	2027
7043: MT TRRY TS to AR E6900	8.1			8.8		9.0	9.2	9.2		**12.5**	9.1	x	2.6	12.5	8.0	11.9	**2019**
7009: AR E6900 to T JMR ZS/AR E6898	2.6											2.8		2.6	2.6	10.0	2027
7175: AR E6898 to GRRNGNG ZS	5.6			6.3		6.5	6.6	6.6		9.8	6.5	2.8	x	9.9	5.5	13.4	2027
7176: GRRNGNG ZS to BRRY ZS	x	x	x	x	x	x	x	x	x	x	x	x	x	9.0	x	16.4	2027
7041: MT TRRY to DPT ZS	0.0													x	12.9	27.4	2027

27.3.2 Mt Terry TS Voltage Levels Summary (Resultant Tap Position) – Summer

Faulty ➔	Nil	7054	7058	7158	7004	7059	7047	7147	7005	7050	7008	7043	7175	T'fer Berry	T'fer Dapto tx 3	Min. Tap	Max. Tap	Result Year
Albion Park 2&3	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	-12	2	2027
Albion Park 1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	-14	7	2027
Gerringong	-1	-1	-1	-2	-1	-2	-2	-2	-2	-4	-3	-4	-3	-4	-2	-12	2	2027
Jamberoo	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	-2	-6	-1	-3	-2	-12	4	2027
Kiama 1&2	-1	-1	-1	-1	-1	-1	-1	-1	0	-4	-1	-1	-1	-1	0	-16	4	2027
Kiama 3	StndBy	x	x	x	x	x	x	x	x	x	x	x	x	x	0	-14	7	2027
Shellharbour 2&3	-1	-1	-1	-2	-1	-3	-3	-3	-1	-2	-1	-1	-1	-1	-1	-12	2	2027
Shellharbour 1	-1	-1	-1	-2	-1	-3	-3	-3	x	-2	-1	-1	-1	x	x	-14	7	2027
Warilla	-1	-1	-1	-4	-1	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-12	2	2027
Berry														-8	x	-13	5	2027
Dapto 3														x	-2	-14	7	2027

27.3.3 Mt Terry TS Voltage Levels Summary (Resultant Tap Position) – Winter

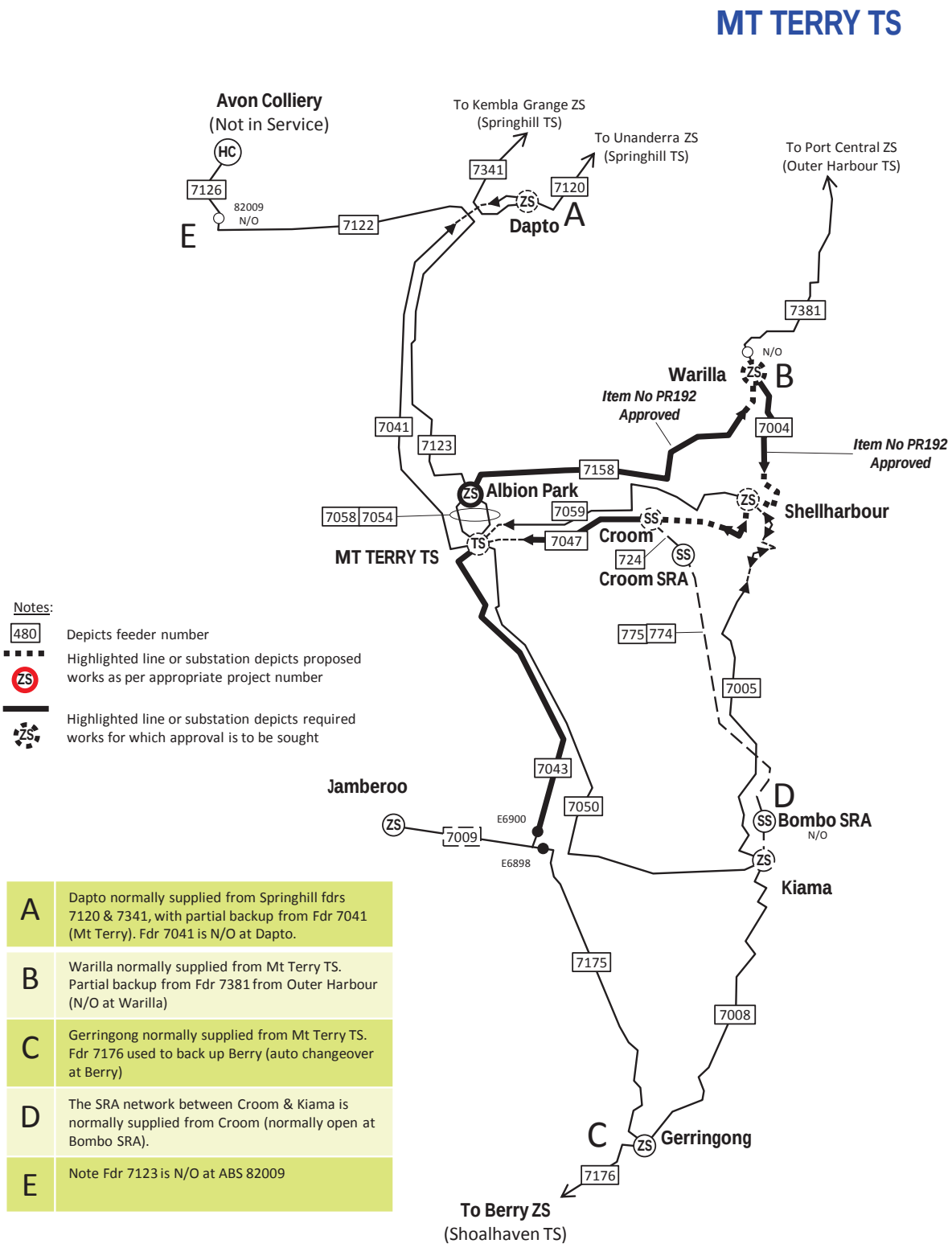
Faulty ➔	Nil	7054	7058	7158	7004	7059	7047	7147	7005	7050	7008	7043	7175	T'fer Berry	T'fer Dapto tx 3	Min. Tap	Max. Tap	Result Year
Albion Park 2&3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-12	2	2026
Albion Park 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-14	7	2026
Gerringong	-1	-1	-1	-2	-1	-2	-2	-2	-2	-4	-2	-4	-3	-4	-2	-12	2	2026
Jamberoo	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	-1	-5	0	-3	-2	-12	4	2026
Kiama 1&2	0	0	0	-1	0	-1	0	0	0	-4	0	-1	0	-1	0	-16	4	2026
Kiama 3	0	x	x	x	x	x	x	x	x	x	x	x	x	x	0	-14	7	2026
Shellharbour 2&3	-1	-1	-1	-1	-1	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-12	2	2026
Shellharbour 1	-1	-1	-1	-1	-1	-2	-2	-2	x	-1	-1	-1	-1	-1	x	-14	7	2026
Warilla	0	0	0	-2	0	-1	-1	-1	-1	0	0	0	0	-1	-1	-12	2	2026
Berry														-8	x	-13	5	2026
Dapto 3															-2	-14	7	2026

27.4 Analysis Results and Possible Solutions

The load demand and voltage levels on all feeders and substations are within their design ratings and ranges, respectively, for this review period.

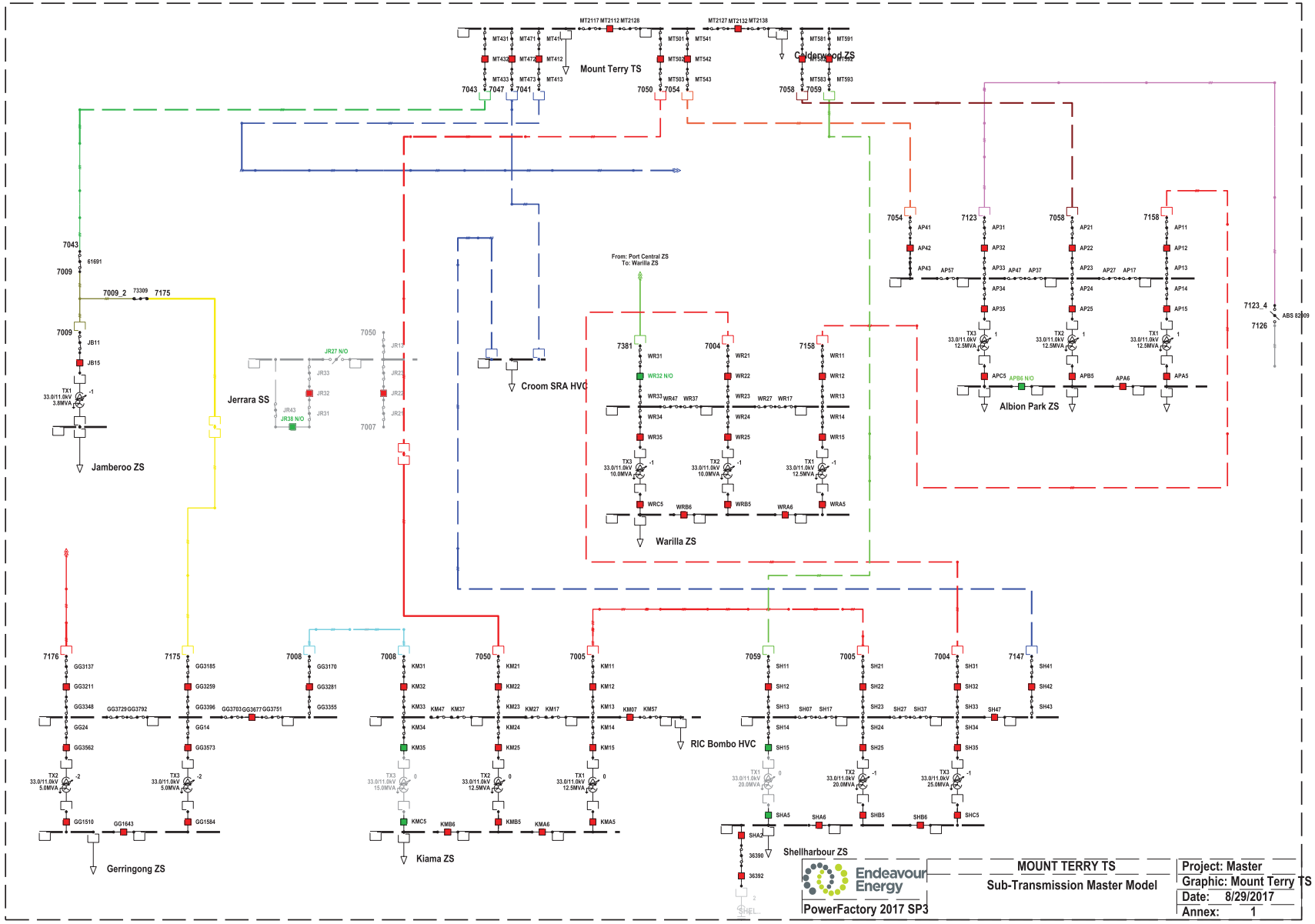
Mt Terry TS	Network Constraint	Year	Investigation	Solution
	Albion Park ZS firm rating is exceeded (derating due to transformer impedance mismatch). The load is 3.5% above the firm rating in S2017 and then below the firm rating at end of the forecast period.	S2017	The proposed Calderwood ZS will ultimately off load Albion Park ZS.	PR657
	Warilla ZS firm rating is exceeded. The load is 6% above the firm rating in W2026.	Existing	The situation will continue to be monitored in accordance with acceptable network capacity planning standards. Investigate additional load transfers and alternate non-network options in the future.	Continue to monitor
	Gerringong ZS	Existing	Refurbish Ex-Russell Vale 10MVA Tx No. 3	TS600
	Feeder 7047 is overloaded for an outage of feeder 7059	S2018	The situation will continue to be monitored and options to re-rate feeder will be studied if required.	PR193
	Feeder 7147 is overloaded for an outage of feeder 7059	S2019	The situation will continue to be monitored and options to re-rate feeder will be studied if required.	Investigate re-rating of feeder
	Feeder 7043 is overloaded for an outage of feeder 7050	S2019	The situation will continue to be monitored and options to re-rate feeder will be studied if required.	Investigate re-rating of feeder

27.5 Mount Terry Geographic



A	Dapto normally supplied from Springhill fdrs 7120 & 7341, with partial backup from Fdr 7041 (Mt Terry). Fdr 7041 is N/O at Dapto.
B	Warilla normally supplied from Mt Terry TS. Partial backup from Fdr 7381 from Outer Harbour (N/O at Warilla)
C	Gerringong normally supplied from Mt Terry TS. Fdr 7176 used to back up Berry (auto changeover at Berry)
D	The SRA network between Croom & Kiama is normally supplied from Croom (normally open at Bombo SRA).
E	Note Fdr 7123 is N/O at ABS 82009

27.6 Mount Terry Schematic



28 NEPEAN 33KV TRANSMISSION SUBSTATION

28.1 Nepean 33kV Subtransmission Network Status

Nepean TS is supplied from Macarthur BSP by 132kV feeder 9L1 & 66kV feeder 85L. Nepean TS has back up supply from Sydney West BSP on feeder 93X and Liverpool BSP via West Liverpool TS on feeder 9L5. It has three 60 MVA 132/33kV transformers, the third older unit will only be used in an emergency and will be removed when the third 66/11kV transformer & third section of 66kV busbar is required. The substation is limited by the 132kV feeder 9L1 with a firm rating of 233/339MVA summer/contingency. 66kV feeder 85L has a rating of 116/170MVA summer/contingency. The 33kV section of Nepean TS is floated at 33kV with an LDC setting of 5% at 70MVA.

The Oaks ZS is teed off feeder 303 Cawdor to Oakdale ZS and only has one 33kV supply to it. Under fault conditions on feeder 303, supply to The Oaks ZS will be temporarily lost until the fault is located and supply is restored with manual switching.

Where practicable, all new major loads are to be connected to the 66kV system, therefore limited growth is expected on the 33kV subtransmission network. Refer also to the Nepean 66kV and Macarthur sections of the report.

28.2 Nepean 33kV Subtransmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraints (Year)
Nepean 33kV TS	2 x 60	60	30	Nil
Cawdor	2 x 25	25		Nil
Oakdale	2 x 10	10		Nil
The Oaks	1 x 15	Non-Firm		Nil

28.3 Results Tables

28.3.1 Nepean 33kV Loads and Ratings Summary – Summer

Faulty ➔	Nil	306	303	309	311	*311	Rating	Year of Result
306 Nep TS-Cawdor	15.9	X	12.7	18.4	34.0	28.7	23	2017/18
303 Cawdor – Tee	7.1	6.0	X	12.5	5.5	X	25	2026/27
303 Tee – Oakdale	1.8	3.0	X	3.6	3.5	8.6	25	2026/27
303 Tee – The Oaks	8.8	8.5	X	8.5	8.5	8.5	22	2026/27
309 Nep TS-Oakdale	5.1	6.3	3.4	X	6.9	12.8	29	2026/27
311 Nep TS-Cawdor	19.1	34.3	15.3	22.1	X	X	29	2017/18

*311 – with feeder 303 open at Cawdor ZS

28.3.2 Nepean 33kV Voltage Levels Summary – Summer

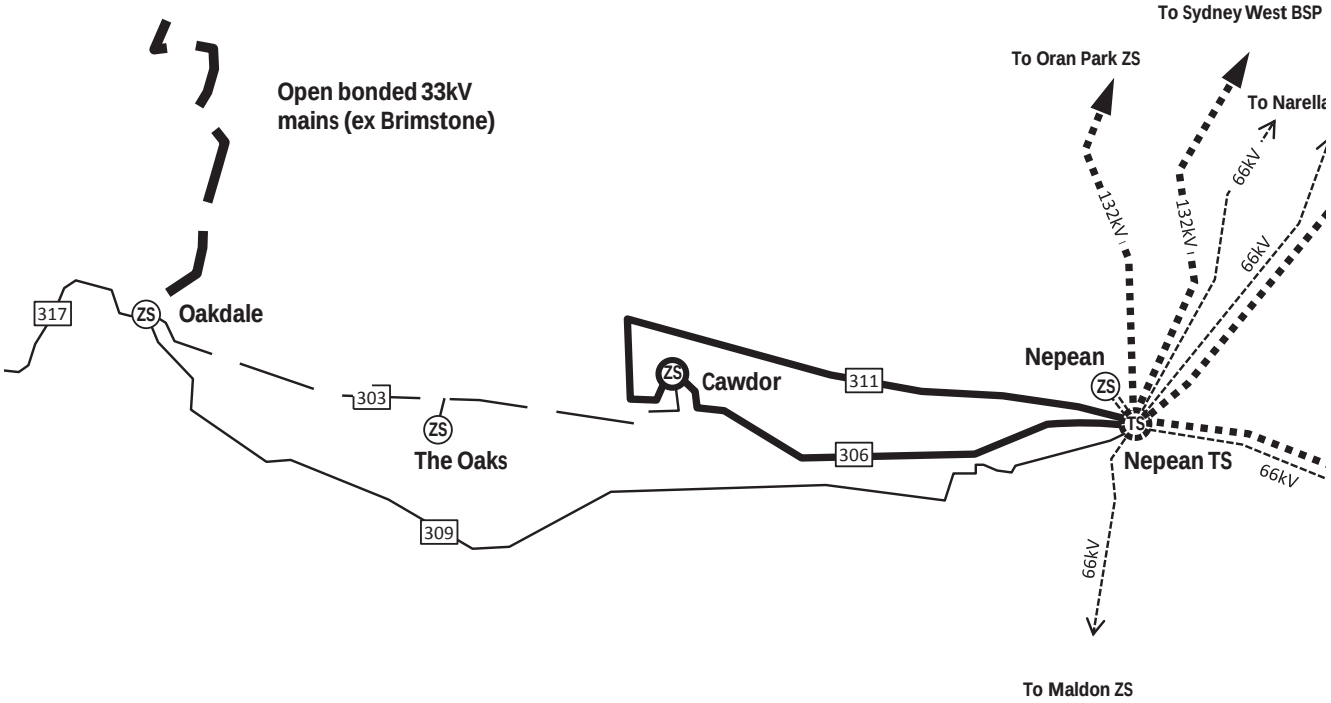
Faulty ➔	Nil	306	303	309	311	*311	Min Tap	Max Tap	Year of Result
Cawdor ZS	-1	-2	-1	-2	-3	-2	-14	7	2026/27
Oakdale ZS	1	0	1	-1	0	-3	-12	4	2026/27
The Oaks	-1	-2	X	-2	-2	-5	-14	7	2026/27

28.4 Analysis Results and Possible solutions

Nepean 33kV TS	Network Constraint	Year	Possible Solution	Solution
	Cawdor ZS has exceeded its firm rating.	S2017	Apply probabilistic planning analysis. May need augmenting with third transformer.	Monitor for next year
	Outage of feeder 306 Nepean TS – Cawdor ZS will cause 311 to exceed its rating.	S2018	Investigate constraint to determine if line augmentation is required. Monitor actual loads for next year. Apply probabilistic planning analysis.	Investigate non-network options. Continue to monitor.
	Outage of feeder 311 Nepean TS – Cawdor ZS will cause 306 to exceed its rating.	S2018	Investigate constraint to determine if line augmentation is required. Monitor actual loads for next year. Apply probabilistic planning analysis.	Investigate non-network options. Continue to monitor.

28.5 Nepean 33kV Geographic

NEPEAN TS/1



11kV mains

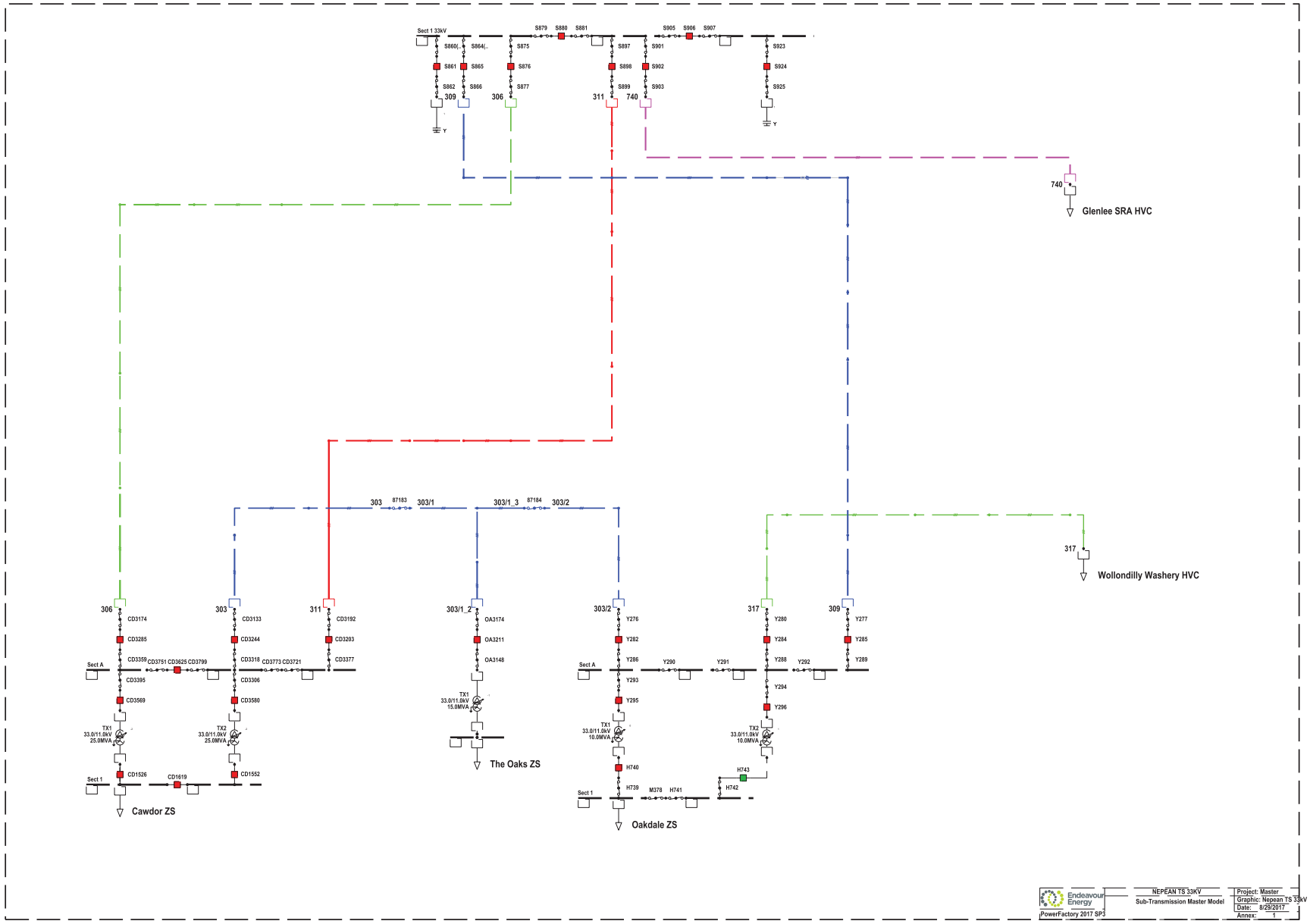
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

28.6 Nepean 33kV Schematic



29 NEPEAN 66KV TRANSMISSION SUBSTATION

29.1 Nepean 66kV Subtransmission Network Substation Status

Nepean TS is supplied from Macarthur Substation by 132kV feeder 9L1 & 66kV feeder 85L. Nepean TS has back up supply from Sydney West BSP on feeder 93X and Liverpool BSP via West Liverpool TS on feeder 9L5. It has two 120MVA 132/66kV auto-transformers providing a firm rating of 120MVA and is floated at 66kV.

Macarthur BSP supplies Nepean TS at both 132kV and 66kV via two 132kV constructed circuits. One operates at 132kV as feeder 9L1 and the second circuit initially operates at 66kV as feeder 85L. The two circuits will ultimately operate at 132kV into Nepean TS providing capacity to both Nepean TS and into the southern precincts of the South West Growth Sector. The section of the feeder route from the tower to Nepean TS has been built on an interim basis to a lower capacity within the existing easement. The interim ratings will be limited to 233/358MVA Summer continuous/contingency at 132kV and 116/179MVA Summer continuous/contingency at 66kV, which will be adequate for the duration of the current forecast period.

There are two 66kV feeders from Macarthur BSP to both Ambarvale and Campbelltown. Refer to the Macarthur section of the report.

Macarthur BSP shares the load of the current Nepean southern catchment area with Nepean 66kV TS. Macarthur BSP supplies the bulk of the load east of Douglas Park SS through 66kV feeder 852, with Nepean TS supplying the sites west of Douglas Park SS through 66kV feeder 851.

Minimum levels of generation at Appin/Tower are no longer guarenteed to supply into the 66kV network. The average generation level during Summer 2016/17 was approximately 38 MW. This level of generation was used in the analysis of this report.

The 66kV feeder configuration from Maldon to Wilton ZS has effectively duplicated feeder 850, relieving the previous constraints on feeders 850 and 851.

The existing overhead section of 66kV feeder 858 from Nepean TS to Narellan ZS is rated at 50MVA. The feeder has been converted to underground from Nepean TS to the edge of the Spring Farm development area, the section between the two underground sections will remain as existing O/H mains. Feeder 870 is the second 66kV feeder from Nepean to Narellan.

Where practicable, all major new loads will be connected to the 66kV system, due to the additional capacity provided by the Macarthur 66kV system.

The 66kV “High Capacity Link” 85L can supply the combined Nepean/ Macarthur 66kV system until approx 2028 based on the expected timetable for lot releases in the South West Sector. The combined Macarthur/Nepean 66kV demand forecast for 2027 is 298MVA (diversified).

29.2 Nepean 66kV Subtransmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraints (Year)
Nepean 66kV TS	2 x 120	120	40	2018 when Mac 66kV TRF is out
Maldon	2 x 35	35	5	Nil
Narellan	3 x 35	70	5	Nil
Nepean	2 x 35	35	5	Firm rating exceeded S2021
Tahmoor	2 x 25	25	5	Nil
Wilton	2 x 20	20		Nil

29.3 Results Tables : With Generation at 38 MW Continuously

29.3.1 Nepean 66kV TS Loads and Ratings - Summer Summary

Faulty ➔	Nil	[1]852	851	850	869	85C	848	845	858	[2]858	870	[2]870	Nep6	Nep 7	Rating	Year of Result
858 Nep-Nar	26.6								X	X	71.9	49.0			50	2017/18
870 Nep-Nar	51.1								74.8	49.4	X	X			72	2018/19
852 Mac-DP	48.8	X	95.7	46.3	61.1	48.0	49.2	39.1							60	2017/18
851-Nep-Mald	49.2	94.2	X	51.8	61.8	50.6	49.7	37.5							60	2017/18
850 Mald-DP	11.5	26.7	46.7	X	14.9	18.3	11.6	7.7							51	2026/27
***868 DP-Tee**	35.7	40.0	39.4	35.6	36.0	35.7	35.7	35.3							60	2026/27
***85G DP-BHP**	12.4	14.0	13.9	12.6	12.7	12.6	12.6	12.4							91	2026/27
***869 DP-Tee**	13.3	30.5	18.3	5.6	X	21.7	13.2	15.3							40	2026/27
***869 Tee-Wilt**	20.6	12.9	40.9	28.9	X	12.7	20.6	17.6							40	2026/27
85C Mald-Wilt	8.4	15.7	27.1	16.7	13.0	X	8.5	6.6							72	2026/27
848 Mald-Tah	14.9	16.0	16.5	14.7	14.8	14.8	X	14.5							60	2026/27
845 Mald-Tah	20.1	16.0	23.0	20.4	20.5	20.5	35.4	X							42	2026/27
Nep6 Nep-Nep	19.0												X	41.4	86	2026/27
Nep7 Nep-Nep	19.0												41.4	X	86	2026/27

Note 1: Feeder 852 supplied from Macarthur 66kV BSP.

Note 2: Outage of feeder 870 or 858 requires Trf No1 at Narellan ZS to be supplied using feeder 861 from Macarthur 66kV BSP.

* The analysis was conducted assuming the Appin/Tower Generators were generating at 38MW.

Narellan Loads need to come down by 8MVA to reflect transfer away of Smeaton Grange Data Centre load to 132kV network. The Smeaton Grange Data Centre load was changed over to 132kV on 23 February 2017.

29.3.2 Nepean 66kV TS Voltage Levels - Summer Summary

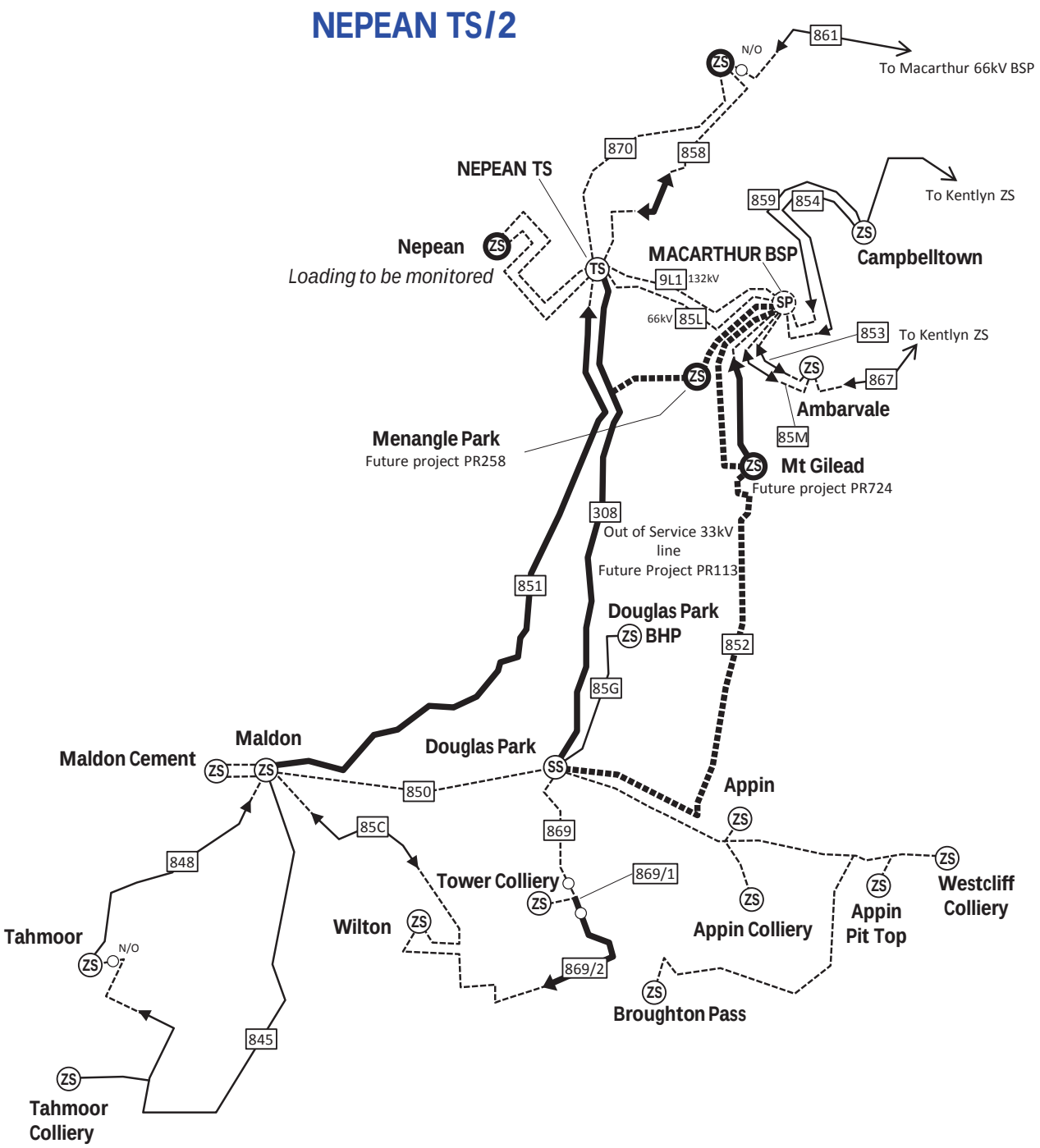
Faulty ➔	Nil	[1]852	851	850	869	85C	848	845	858	[2]858	870	[2]870	Nep 6	Nep 7	Min Taps	Max Taps	Year of Result
Maldon	-4	-4	-4	-4	-4	-4	-4	-4							-14	7	2026/27
Wilton	-3	-3	-3	-3	-3	-3	-3	-3							-15	8	2026/27
Tahmoor	-3	-3	-3	-3	-3	-3	-3	-3							-14	7	2026/27
Narellan	-3&-8								-3&-6	-4&-6	-4&-6	-4&-6			-14	7	2017/18
Nepean ZS	0												0	0	-14	7	2018/19

29.4 Analysis Results and Possible Solutions

Nepean 66kV TS	Network Constraint	Year	Investigation	Solution
	Outage of feeder 870 Nepean TS – Narellan ZS will cause 858 to exceed its rating.	S2018	The network will be operated so that load on Narrellan ZS is split between feeders 858 & 861 from Macarthur 66kV for an outage of feeder 870. Continue to monitor and consider demand management prior to augmentation of feeder 858.	Utilise transfer capacity & monitor
	Outage of feeder 858 Nepean TS – Narellan ZS will cause 870 to exceed its rating.	S2019	When 858 is out the load on feeder 870 will exceed its rating. No 1 transformer at Narellan ZS will be supplied by feeder 861 from Macarthur 66kV. Narellan ZS needs to be off load onto Nepean ZS and onto proposed Catherine Park ZS to keep Narellan ZS within its firm rating.	PR748 will offload Narellan ZS
	Transformer connected to bus sections 2&3 is overloaded when connected as a single transformer.	S2018	Configure the three transformers on a split 11kV busbar arrangement. Proposed Catherine Field ZS can be used to off load bus sections 2&3 at Narellan ZS. Off load Narellan ZS onto Nepean ZS.	Monitor for next year Establish PR748
	Exceed the firm rating of Nepean ZS.	S2019	Investigate constraint to determine, cyclic ratings and if demand management solution is possible. Monitor actual loads for next year. Apply probabilistic planning analysis. Install third 66/11kV transformer as the Spring Farm & Elderslie residential release areas are progressing.	Monitor, assess ratings

Nepean 66kV TS	Network Constraint	Year	Investigation	Solution
	Outage of either feeder 851 or 852 results in an overload on the other feeder. Outage of feeder 851 results in feeder 869 Tower Power Stn Tee to Wilton ZS to be overloaded.	S2018 S2027	There is load at risk with 38MW of generation. Augment O/S 33kV feeder 308 to 66kV and connect it to Nepean 66kV TS & Douglas Park SS. Augment feeder 869 from the Tower Power Station Tee to Wilton ZS.	PR113
	Outage of feeder 869 results in an overload feeders 851 & 852.	S2023	Probabilistic planning analysis also taking into account actual historical generation shows low actual risk and that a do-nothing option is feasible based on current forecast load. Augment O/S 33kV feeder 308 to 66kV and connect it to Nepean 66kV TS & Douglas Park SS.	Investigate non-network options Develop Major project build option

29.5 Nepean 66kV Geographic



NOTES: Refer Ingleburn BSP & Macarthur BSP 66kV Geographic

A	Narellan to be supplied solid from Nepean TS with backup from Macarthur 66kV BSP
B	Fdr 845 is normally open at Tahmoor ZS

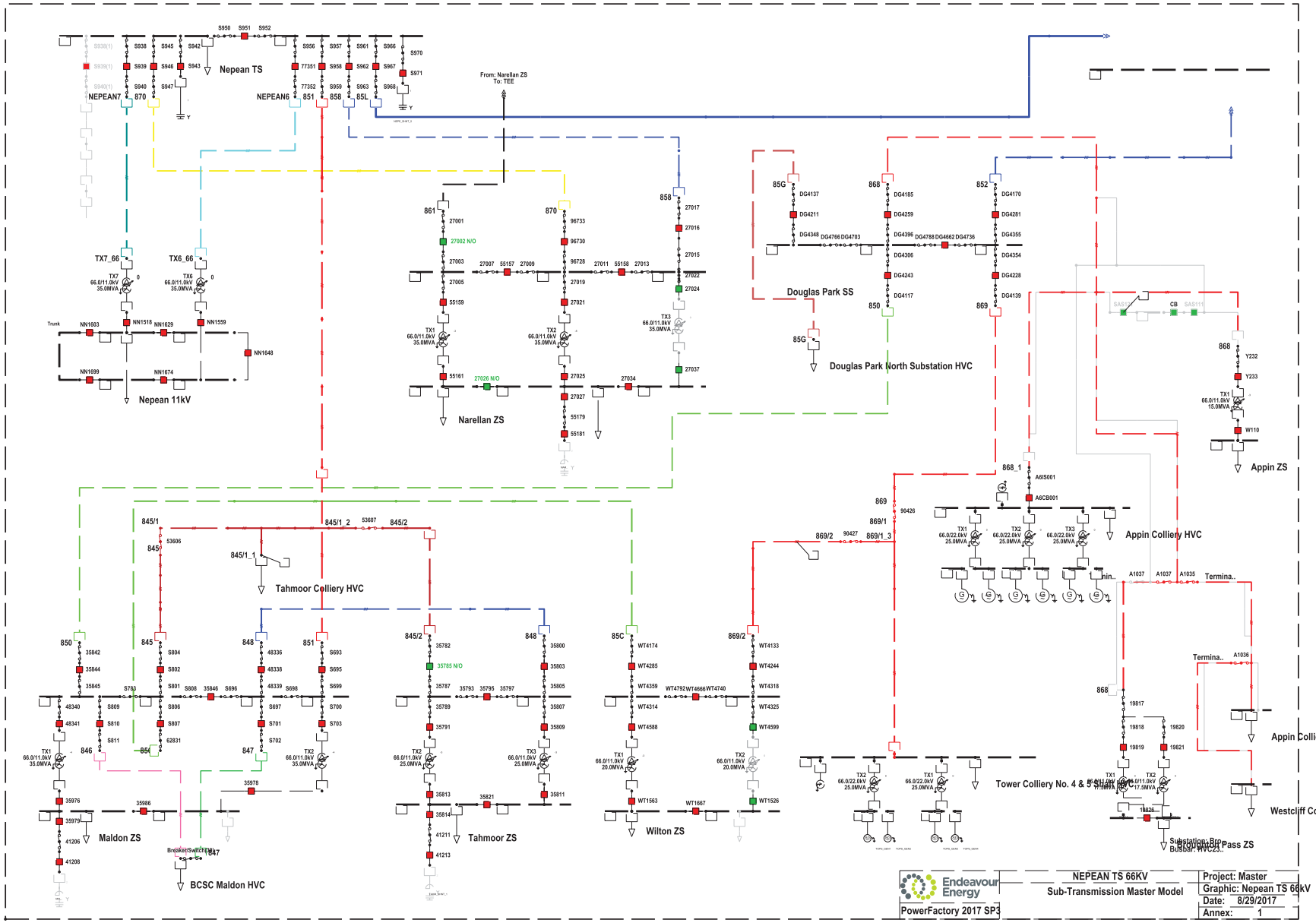
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

29.6 Nepean – Macarthur (Common) 66kV Schematic



30 OUTER HARBOUR TRANSMISSION SUBSTATION

30.1 Outer Harbour Transmission Network Status

Outer Harbour TS is supplied from Dapto Bulk Supply Point via Springhill TS by 132kV feeders 985 & 989. Outer Harbour Transmission Substation has one 30/45/60 MVA and one 30/60 MVA 132/33kV transformer providing a firm rating of 60MVA. Outer Harbour TS is floated at 33.5kV.

Port Kembla ZS is normally supplied from Springhill TS, whilst Port Central ZS is normally supplied from Outer Harbour TS. Mutual back up is provided between the two zones on feeder 7321. Port Central is also linked to the Mount Terry subtransmission network by feeder 7381, which connects (normally open) to Warilla ZS. These ties are, however, only required for second contingency (or greater) conditions. Refer to geographic and schematic diagrams below for more information.

A switching station, named MM Kembla SS9742, has been constructed within the Metal Manufacturers site. MM Kembla SS is supplied by 33kV feeders 7031 and 7036 directly out of Outer Harbour TS.

Renewal project TM014 was completed in February 2017 and this review includes the new configuration. The scope of works completd is as follows:

- Feeder 7032 (oil cable) left in situ.
- Feeders 7033, 7033/1 (gas cables) and 7038 (oil cable) disconnected.
- New XLPE cable laid between Port Central ZS and existing XLPE cable feeder 7033 near Darcy Rd Cable Termination Building forming a new Port Central ZS – MM Kembla Switching Station feeder (Feeder 7036).
- The previously leased Darcy Rd Cable Termination Building was decommissioned and handed back to PKC.
- Feeders 7321 and 7381 (oil cable) sections replaced.

The land to the east of Outer Harbour TS was planned to be developed to allow for the expansion of Port Kembla's Outer Harbour. The proponent advised in October 2013 these plans were deferred indefinitely. One part of the expansion planned for the Outer Harbour, which has proceeded, is Cement Australia's grinding mill. Cement Australia, with an expected ultimate load of 22MVA, has been connected directly to Outer Harbour TS via feeder 7037 as a 33kV customer (HVC 32652).

No major network capacity projects are planned for the current forecast period.

30.2 Outer Harbour Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Outer Harbour TS	2 x 60	60	20	Nil
Port Kembla RIC	Unknown			N/A
Lysaghts CRM	Unknown			N/A
Port Central	2 x 19	19	5	Nil
Metal Manufacturers	2 x 26.5	26.5		N/A
Morgan Cement	10	Non-firm		N/A

30.3 Analysis Results

30.3.1 Outer Harbour TS Loads and Ratings Summary – Summer

Faulty ➔	Nil	7031	7032	7036	7034	T'fer Warilla trf 3*	T'fer half of Port Kembla ZS*	Rating	Result Year
7031: TR HRBR TS to MM KMBL SS	7.3	x	22.2	11.3		8.4	8.7	50.0	2027
7032: TR HRBR TS to PRT CNTRL ZS	15.1	22.2	x	10.9		21.5	20.5	44.3	2027
7036: PRT CNTRL ZS to MM KMBL SS	4.4	11.4	10.9	x		3.9	4.3	47.9	2027
7034: TR HRBR TS to LYSGHTS CRM	0.5				x			15.0	2027
7039: TR HRBR TS to LYSGHTS CRM	0.5				1.0			15.0	2027
7381: PRT CNTRL ZS to WRLL ZS	x	x	x	x	x	7.2	x	19.7	2027
7321: PRT CNTRL ZS to PRT KMBL ZS	x	x	x	x	x	x	7.0	32.1	2027
7035: MM KMBL SS to MRGN CMNT	6.8							30.9	2027
7037: TR HRBR TS to CMNT AUS	9.7							N/A	2027

* Condition only required for second level contingencies

30.3.2 Outer Harbour TS Loads and Ratings Summary – Winter

Faulty ➔	Nil	7031	7032	7036	7034	T'fer Warilla trf 3*	T'fer half - Port Kembla ZS*	Rating	Result Year
7031: TR HRBR TS to MM KMBL SS	7.6	x	21.8	12.3		8.8	8.7	55.0	2026
7032: TR HRBR TS to PRT CNTRL ZS	14.4	21.8	x	9.5		20.8	20.9	45.7	2026
7036: PRT CNTRL ZS to MM KMBL SS	5.0	12.3	9.5	x		4.4	4.3	50.3	2026
7034: TR HRBR TS to LYSGHTS CRM	0.5				x			16.6	2026
7039: TR HRBR TS to LYSGHTS CRM	0.5				0.9			16.6	2026
7381: PRT CNTRL ZS to WRLL ZS	x	x	x	x	x	7.2	x	32.9	2026
7321: PRT CNTRL ZS to PRT KMBL ZS						x	7.5	34.3	2026
7035: MM KMBL SS to MRGN CMNT	4.8							37	2026
7037: TR HRBR TS to CMNT AUS	3.0							N/A	2026

* Condition only required for second level contingencies

30.3.3 Outer Harbour TS Voltage Levels Summary (Resultant Tap Position) – Summer

Faulty ➔	Nil	7031	7032	7036	7034	T'fer Warilla trf 3	T'fer half of Port Kembla ZS	Min. Tap	Max. Tap	Result Year

Port Central	-1	-1	-1	-1	-1	-1	-1	-12	2	2027
Warilla						-2		-12	2	2027
Port Kembla							-1	-14	7	2027

30.3.4 Outer Harbour TS Voltage Levels Summary (Resultant Tap Position) – Winter

Faulty ➔	Nil	7031	7032	7036	7034	T'fer Warilla trf 3	T'fer half of Port Kembla ZS	Min. Tap	Max. Tap	Result Year
Port Central	-1	-1	-1	-1	-1	-1	-1	-12	2	2026
Warilla						-2		-12	2	2026
Port Kembla							-1	-14	7	2026

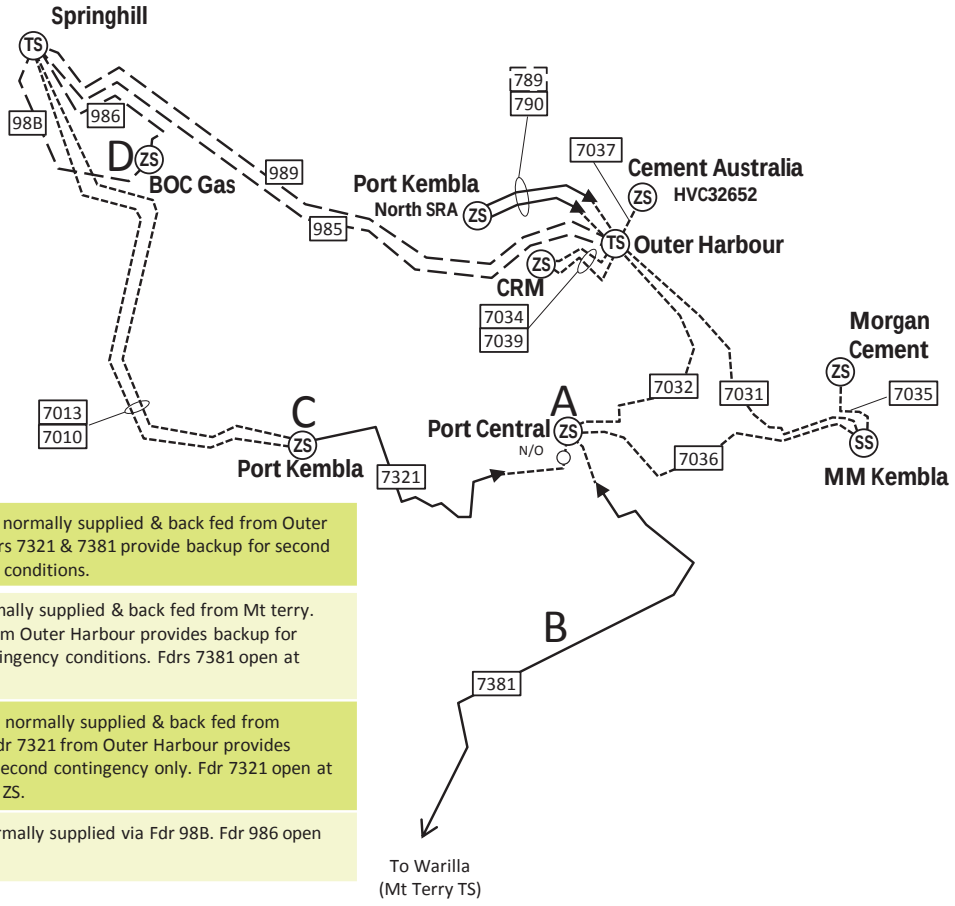
30.4 Analysis Results and Possible Solutions

The load demand and voltage levels on all feeders and substations are within their design ratings and ranges, respectively, for this review period.

Outer Harbour TS	Network Constraint	Year	Investigation	Solution
	NIL			

30.5 Outer Harbour Geographic

OUTER HARBOUR TS



A	Port Central normally supplied & back fed from Outer Harbour. Fdrs 7321 & 7381 provide backup for second contingency conditions.
B	Warilla normally supplied & back fed from Mt terry. Fdr 7381 from Outer Harbour provides backup for second contingency conditions. Fdrs 7381 open at Warilla ZS
C	Port Kembla normally supplied & back fed from Springhill. Fdr 7321 from Outer Harbour provides backup for second contingency only. Fdr 7321 open at Port Central ZS.
D	BOC Gas normally supplied via Fdr 98B. Fdr 986 open at BOC Gas

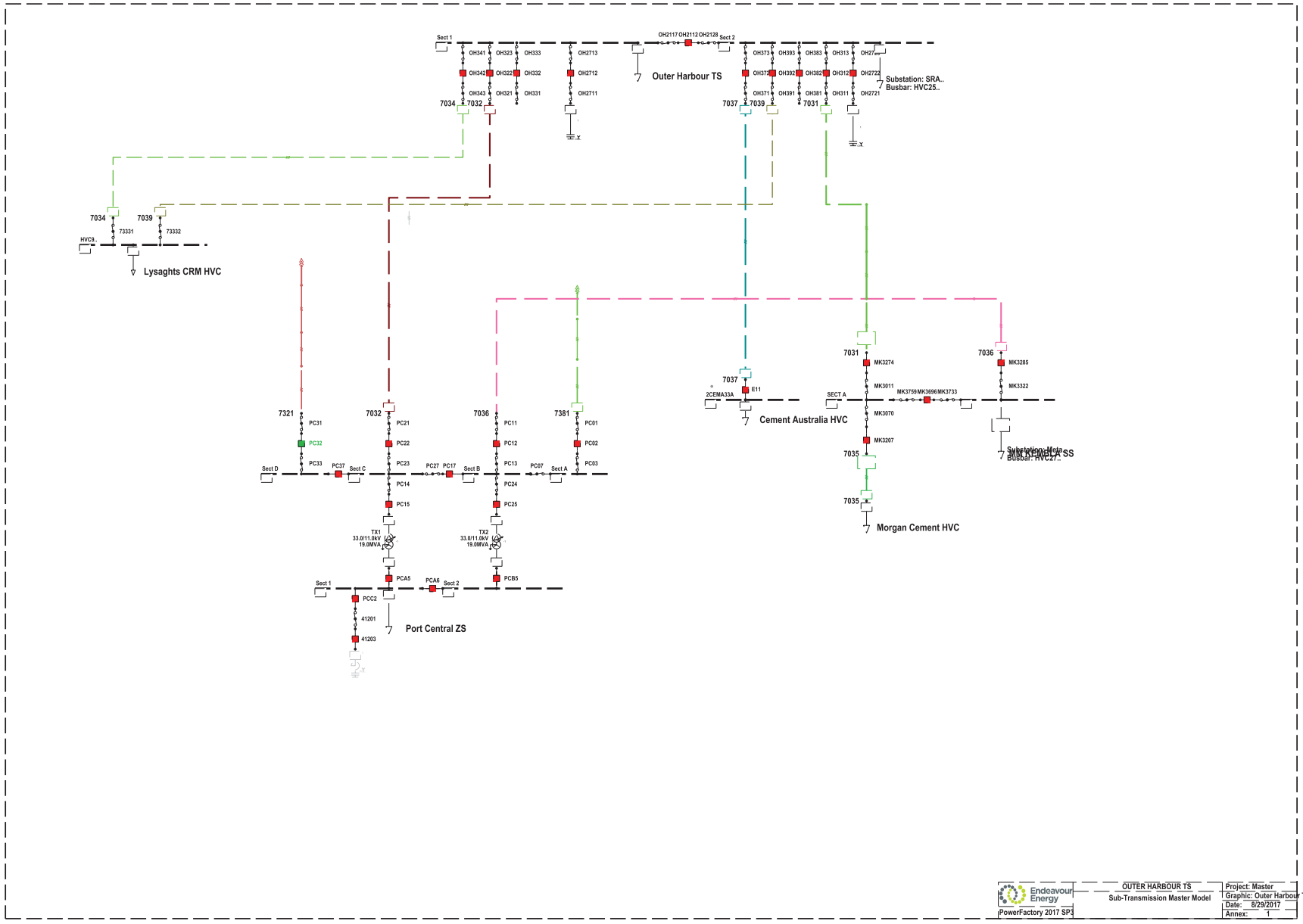
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

30.6 Outer Harbour Schematic



31 PENRITH TRANSMISSION SUBSTATION

31.1 Penrith Transmission Network Status

Penrith Transmission Substation is supplied from Regentville Bulk Supply Point on 132kV feeders 222 and 238. Project PR052 Penrith TS rebuild has been completed. Penrith TS has three 120MVA 132/33kV transformers, providing a firm capacity of 240MVA. It is a summer demand peaking substation and is floated at 34kV. The site also accommodates Penrith 132/11kV Zone Substation with two 52MVA transformers.

Penrith TS supplies Emu Plains ZS via feeders 454 and 462; Cranebrook ZS via feeders 459 and 451 tee Jordan Springs ZS; Cambridge Park ZS via feeder 456 on change over to feeder 497 from Mount Druitt TS; Jordan Springs via feeders 623 and tee off 451, and Kingswood ZS via feeders 461 and 457 tee Claremont Meadows ZS, with partial back up from Regentville BSP on feeder 464 from Glenmore Park ZS.

Penrith ZS is forecast to exceed its firm capacity in 2019. This is discussed in the Regentville BSP section. To help in offloading Penrith ZS, as well as supplying new developments, new South Penrith ZS is proposed in project PR677.This ZS is proposed to be supplied via two new 33kV feeders from Penrith TS.

Transformer No. 3 at Kingswood was replaced in 2013. It is expected that Transformer No.2 and Transformer No. 1 will be replaced in the period from 2020 to 2024 due to their condition. Project PR052 has been completed. This project ensured that Warrimoo TS is normally supplied from Regentville BSP, via Penrith TS, and replaced three existing 60MVA 132/33/11kV transformers with three new 120MVA transformers, catering for future load growth in the area.

There are no incomplete approved projects to consider within Penrith TS area.

31.2 Penrith Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Penrith TS	3 x 120	240	0	Nil
Cambridge Park	2 x 25	25	5	Nil
Cranebrook	3 x 25	50	10	Nil
Emu Plains	3 x 25	50	5	Nil
Jordan Springs ZS	2 x 25	25	0	Nil
Kingswood	3 x 25	50	5	Nil

31.3 Results Tables

31.3.1 Penrith TS Loads and Ratings - Summer Summary

Faulty ➔	Nil	459	451	623	454	462	485 2	457 1	461 1	Rating	Year of Result
459: PNRTH TS to CRNBRK ZS	21	X	29	28						42	S 2026/27
451: PNRTH TS to TEE	22	38	X	30						42	S 2026/27
451: TEE to CRANEBROOK ZS	9	29	X	5						42	S 2026/27
451: TEE to JORDAN SPRINGS ZS	14	9	X	29						42	S 2026/27
623: PNRTH TS to JRDN SPRNGS ZS	15	20	29	X						33.2	S 2026/27
454: PNRTH TS to EMU PLAINS ZS	11				X	30				42	S 2026/27
462: PNRTH TS to EMU PLAINS ZS	19				30	X				42[3]	S 2026/27
457: PNRTH TS to TEE	28						42	X	36	42	S 2026/27
457: TEE to KINGSWOOD ZS	28						7	X	36	42	S 2026/27
457: TEE to CLRMNT MDWS ZS	S/B						35	X	X	38	S 2026/27
461: PNRTH TS to KNGSWD ZS	22						29	36	X	42	S 2026/27
456: PNRTH TS to CMBRDG PRK ZS	17									34	S 2026/27

31.3.2 Penrith TS Voltage Levels - Summer Summary

Faulty	Nil	459	451	623	454	462	485 2	457 1	461 1	Min Tap	Max Tap	Year of Result
Cranebrook 1 & 2	1	1	1	1					1	-14	7	S 2026/27
Cranebrook 3	0	0	0	0					0	-14	7	S 2026/27
Emu Plains	0				0	-1			0	-14	7	S 2026/27
Kingswood 1 & 2	-4				-4	-4	-6	-6	-6/-5	-14	7	S 2026/27
Jordan Springs	0		0				0	0	0	-14	7	S 2026/27
Clrmont Mdows							-2			-14	7	S 2026/27
Cambridge Park	0						0	1	1	-14	7	S 2026/27

Notes: 1. In case for loss of incoming feeders 457 or 461 to Kingswood, or the loss of the normal supply Feeder 485 from Mt Druitt to Claremont Meadows, Kingswood 33kV Bus Sections A to B, and 11kV Bus Sections 1 to 2 operate open with Trf No 1 supplied from Regentville via Glenmore Park.

2. This is also the case for loss of the normal supply to Claremont Meadows (Feeder 485 from Mt Druitt)

3. Under fault on feeder 451 or 459, Jordan Springs ZS will be supplied radially by feeder 623.

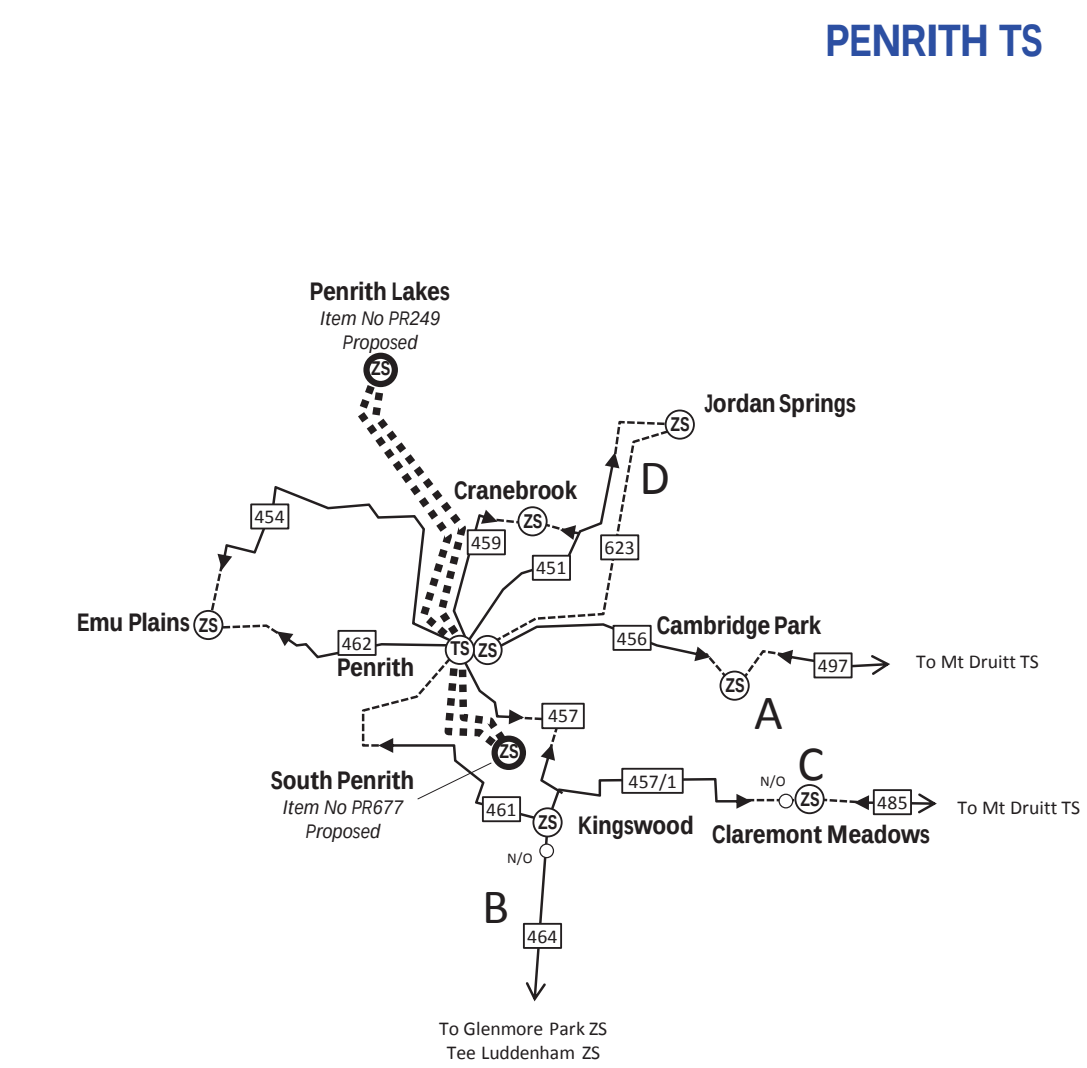
4. Contingency rating

31.4 Analysis Results and Possible Solutions

Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges respectively for this review period

Penrith TS	Network Constraint	Year	Investigation	Solution
	Feeder 623	n/a	Ratings Check	Ratings

31.5 Penrith Geographic



Notes:

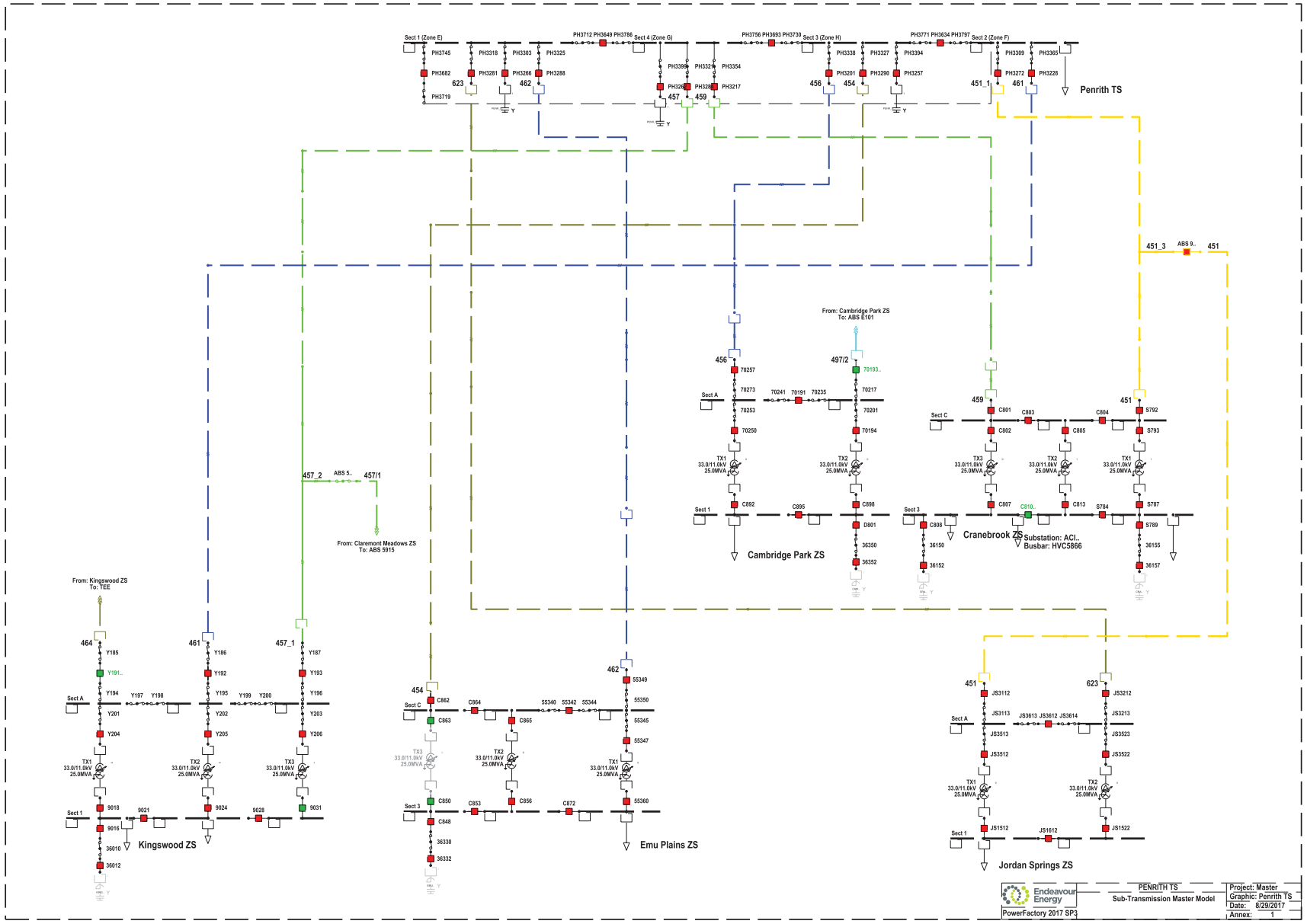
480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

A	Cambridge Park is normally supplied from Fdr 456 Penrith on changeover to Fdr 497 Mt Druitt
B	Kingswood is normally supplied from Fdr's 461 & 457 Penrith on changeover to Fdr 464 Regentville
C	Claremont Meadows is normally supplied from Fdr 485 Mt Druitt on changeover to Fdr 457/1 Penrith
C	Jordan Springs is normally supplied from Fdr 623 & Fdr 451 Penrith

31.6 Penrith Schematic



32 REGENTVILLE BULK SUPPLY POINT

32.1 Regentville Bulk Supply Point Status

Regentville Bulk Supply Point is owned by TransGrid and has two 375 MVA 330/132kV transformers installed, providing a firm capacity of 375MVA. Regentville BSP is floated at 132kV with an LDC setting of 138.5kV at 375MVA.

Regentville BSP supplies Penrith Transmission Substation on feeders 222 and 238. The Penrith 132kV busbar supplies Penrith ZS and Warrimoo TS on feeder 93E. It provides backup supply to Lawson TS on feeder 942 (for an outage of normal supply from Wallerawang BSP, via feeder 941), and back up supply to Mt Druitt TS on feeders 933 and 936.

Regentville BSP also supplies Endeavour Energy's Glenmore Park, Luddenham and North Warragamba zone substations.

The 132/33kV 60MVA transformer at Glenmore Park ZS normally supplies Luddenham ZS; provides backup to North Warragamba ZS and Kemps Creek ZS, and partial backup to Kingswood ZS.

Mt. Druitt TS normally supplies Claremont Meadows ZS via feeder 485, with back up from Penrith TS via feeder 457 tee Kingswood ZS. However on loss of the primary source feeder 485 to Claremont Meadows ZS, or loss of either feeder to Kingswood ZS, Regentville BSP will partly supply Kingswood via the Glenmore Park ZS transformer, on feeder 464 to Luddenham ZS tee to Kingswood ZS.

The Penrith 132/11kV zone substation, incorporated within Penrith TS site, has two 52MVA transformers.

Project PR702 Augment of Penrith ZS 11kV Transformer cables will address the issue of derated transformer cables to match the transformer name plate rating of 52MVA.

The impact of the Deep Water Pump load associated with the SCA (Sydney Catchment Authority) at North Warragamba ZS has been excluded from the analysis, as these pumps operate only infrequently, generally for testing purposes only.

The analysis has been done with the assumption that the following approved project has been completed:

- PR702 – Augment of Penrith ZS 11kV Transformer cables

32.2 Regentville Bulk Supply Point Rating Details

Transmission or Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Regentville BSP	2 x 375	375	160	Nil
Glenmore Park ZS	2 x 45 (132/11) + 1 x 60 (132/33)	45 + 60 Non-Firm	5	Nil
Penrith TS	3 x 120	240		Nil
Penrith 11kV [1] ZS	2 x 52	52	10	Summer 2019
Warrimoo TS	2 x 60	60		Nil
North Warragamba ZS	1 x 25 + 1 x 15	15		Nil
Luddenham ZS	2 x 15	15		Nil

Notes

1 The derated 11kV transformer cables at present limit Penrith 11kV capacity to 40MVA, but upon completion of project PR702 they will match firm transformer rating of 52MVA.

32.3 Results Tables

32.3.1 Regentville 132kV BSP Loads and Ratings Summary - Summer

Faulty - >	Nil	219	932	939	941	238	222	232	231	93E	937	457[1]	512	Rating	Year of Result
222: RGNTVL BSP to PNRTH TS	121	121	166	121	132	243	X			103				448	S 2026/27
238: RGNTVL BSP to PNRTH TS	121	121	166	121	132	X	243			103				448	S 2026/27
231: RGNTVL BSP to GLNM PK ZS	28							56	X		34	35	47	171	S 2026/27
232: RGNTVL BSP to GLNM PK ZS	27							X	56		32	34	45	171	S 2026/27
933: PNRTH TS to MT DRT TS	S/B	S/B	46	S/B										120	S 2026/27
936: PNRTH TS to MT DRT TS	S/B	S/B	47	S/B										120	S 2026/27
942: PNRTH TS to LWSN TS	S/B				23									90	S 2026/27
93E: PNRTH TS to WRRM TS	37					42	42			X				90	S 2026/27
937: RGNTVL BSP to N WRRGMB ZS	10										X			62	S 2026/27

Note: Feeder 933 is set up to supply Mt Druitt TS Transf No 3 after first forecast hot day of each season, to prepare for possible loss of feeder 932. Feeder 936 will supply Mt Druitt TS Transf No 1 on detected overload on feeder 939. However the analysis has been done assuming both feeders 933 and 936 are on standby and will be required on outage of feeder 932.

32.3.2 Regentville 132kV BSP Voltage Levels Summary - Summer

Faulty - >	Nil	219	932	939	941	238	222	232	231	93E	937	457[1]	512	Min Tap	Max Tap	Year of Result
Penrith TS 132/33kV	1										1			-12	4	S 202627
Penrith ZS 132/11kV	-2[#]													-27	3	S 2026/27
Glenmr Park 132/33kV (Fixed Tap)	1											1	-1	-16	4	S 2026/27
Glenmore Park 132/11kV	-1				-1							0	0	-17	3	S 2026/27
Mt Druitt		0	0	0										-12	4	S 2026/27
Lawson					-3									-12	4	S 2026/27
Warrimoo	0										0			-12	4	S 2026/27
North Warragamba 1	-1										x			-14	7	S 2026/27
North Warragamba 2											-10			-14	7	S 2026/27

Notes: **1**: Outage of feeder 457/461 or 485 requires Kingswood Transformer 1 to be supplied from Regentville BSP.

2: Tap changing is on manual setting but can be initiated via SCADA

To enable load flow, transformers TX5 and TX6 at Penrith 11kV were modelled operating in parallel. They cannot operate in parallel due to fault level constraints. Tap on operating transformer under the forecast load would reach its minimum, as the transformer would be constrained due to overload.

32.3.3 Regentville 33kV BSP Loads and Ratings Summary – Summer

Faulty - >	Nil	457/461/485[1]	512	937	464	Rating	Result Year
464: TEE to KINGSWOOD ZS	S/B	16	S/B	S/B	X	17	S2026/27
464: GLENMORE PARK ZS to TEE	15	31	41	27	X	36[2]	S2021/22
464: TEE to LUDDENHAM ZS	15		39	26	X	36[2]	S2021/22
465: LUDDENHAM ZS to TEE	S/B		24	11	15	21	S2021/22
465: TEE to KEMPS CREEK ZS	S/B		24	S/B	15	21	S2021/22
465: TEE to NORTH WARRAGAMBA ZS	S/B		S/B	11	S/B	25	S2026/27

32.3.4 Regentville 33kV Voltage Levels Summary – Summer

Faulty - >	Nil	457/461/485[1]	512	937	464	Min Tap	Max Tap	Result Year
Kingswood 1[1]	-	-6				-14	7	S2026/27
Luddenham	-3	-4	-6	-4	-14	-14	7	S2026/27
Kemps Creek	-		-13[3]	S/B	-11	-14	7	S2021/22
North Warragamba TX1	0			X	0	-14	7	S2026/27
North Warragamba TX2	X			-9	X	-14	7	S2026/27

Notes: 1. In case for loss of incoming feeders 457 or 461 to Kingswood, or the loss of the normal supply Feeder 485 from Mt Druitt to Claremont Meadows, Kingswood 33kV Bus Sections A to B, and 11kV Bus Sections 1 to 2 operate open with Trf No 1 supplied from Regentville via Glenmore Park.

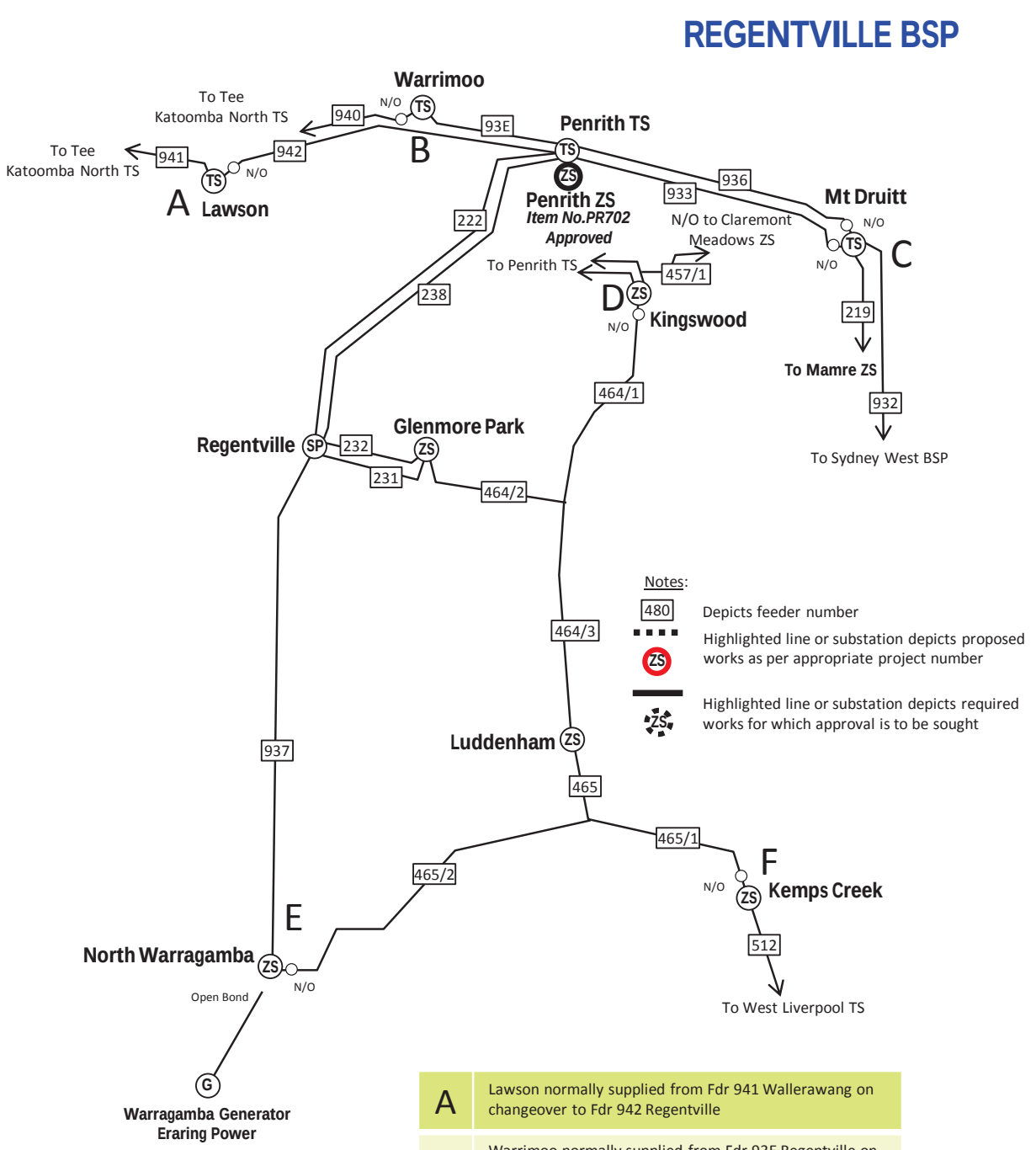
2. Contingency rating of feeder 464 is 57MVA.

3. Tap position was calculated for the first year of constraint under outage of feeder 512.

32.4 Analysis Results and Possible Solutions

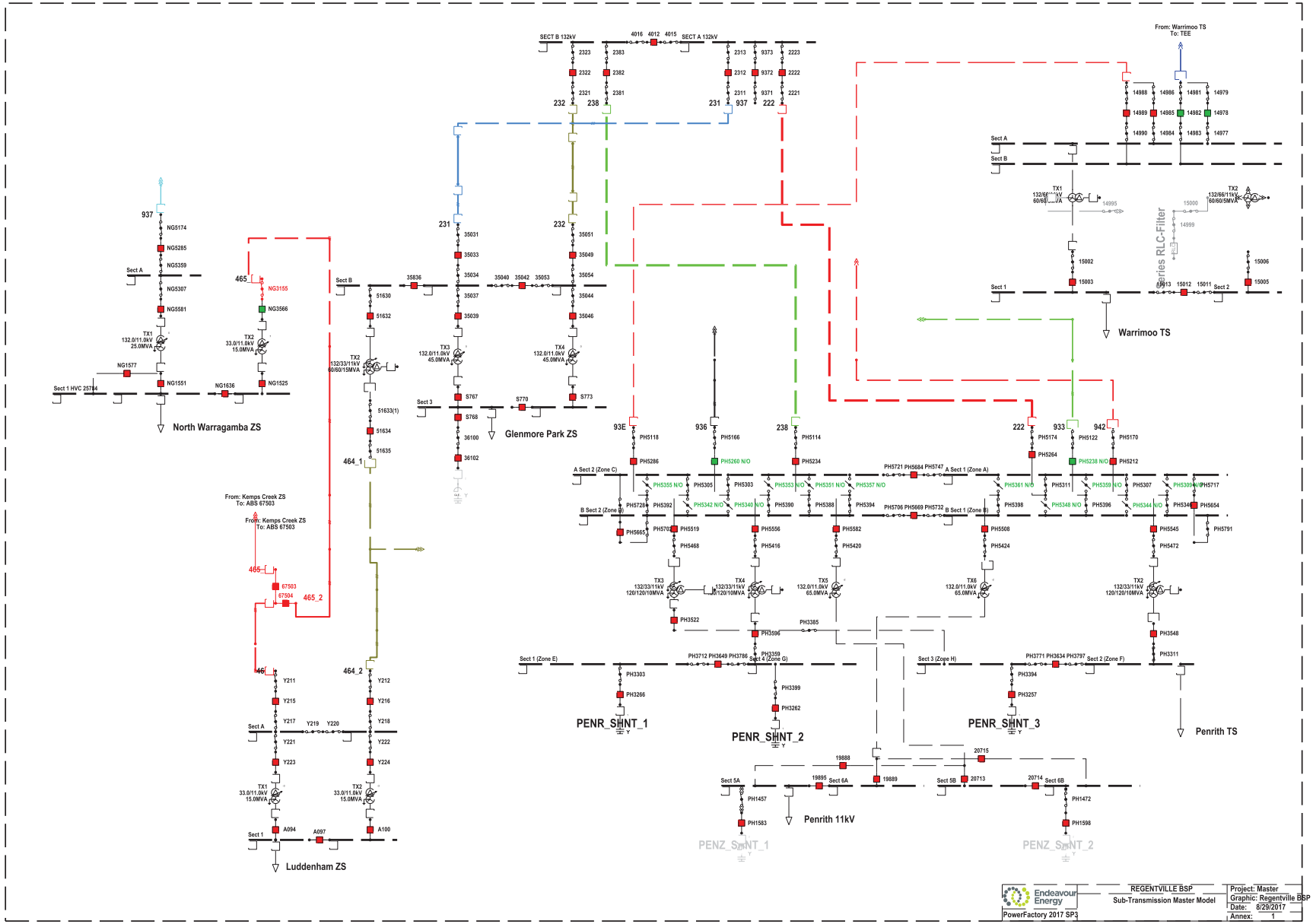
Regentville SP	Network Constraint	Year	Investigation	Solution
	Firm rating of Penrith 11kV ZS (52MVA) will be exceeded in 2019.	S2019	Temporary solution for exceeded firm rating of Penrith 11kV is load transfer of approx. 3MVA to Cranebrook ZS and Emu Plains ZS. Permanent solution includes developing a new zone substation in Penrith area.	PR677 South Penrith ZS
	On outage of feeder 512, rating of feeder 465 is exceeded .	S2022	Feeder 465 needs to be augmented to higher rating. Part of feeder 465 will be augmented as a part of RMS project The Nothern Rd upgrade.	Create a new project to complete upgrade of feeder 465.
	On outage of feeder 464, minimum tap position on Luddenham ZS is reached.	S2027	High voltage drop occurs due to current low rating and high impedance of feeders 512 and 465. Rating of feeder 512 is addressed by project PR750 Augment of 33kV feeder 512.	Create a new project to complete upgrade of feeder 465.

32.5 Regentville Geographic



A	Lawson normally supplied from Fdr 941 Wallerawang on changeover to Fdr 942 Regentville
B	Warrimoo normally supplied from Fdr 93E Regentville on changeover to Fdr 940 Wallerawang
C	Mt Druitt normally supplied from Fdr's 219 & 932 Sydney West on changeover to Fdr's 933 & 936 Regentville.
D	Kingswood normally supplied from Fdr's 461 & 457 Penrith on changeover to Fdr 464 Regentville
E	North Warragamba normally supplied from Fdr 937 Regentville on changeover to Fdr 465 Regentville
F	Kemps Creek normally supplied from Fdr 512 West Liverpool on changeover to Fdr 465 Regentville.

32.6 Regentville Schematic



33 SHOALHAVEN TRANSMISSION SUBSTATION

33.1 Shoalhaven Transmission Network Status

Shoalhaven TS is supplied from the Dapto BSP via Mt Terry TS by 132kV feeders 98L and 98U. The Shoalhaven 132kV busbar supplies West Tomerong TS, Evans Lane and Ulladulla system on feeders 98J and 98P as well as Essential Energy's Batemans Bay and Moruya North substations. Shoalhaven TS has three 60MVA 132/33kV transformers giving it a firm capacity of 120MVA. Shoalhaven TS is floated at 33kV with 3% LDC at 100MVA. Off Peak hot water is controlled by 33kV AFIC equipment at 283Hz.

Shoalhaven TS subtransmission supplies a rural type network with many teed connections. The more critical of these switching points is controlled remotely by the use of field reclosers and additional circuit breakers within ZS sites. These switching points have progressively been installed to improve reliability. Additionally, Berry ZS is normally supplied from feeder 7515 and is on SCADA changeover to feeder 7176 on the Mt Terry TS system. Berry ZS cannot be supplied for long periods from Mt Terry TS as Mt Terry does not have 33kV AFIC equipment for off peak water heater control.

The Australian Paper Mill (HVC 93000) switched off production machines from July 2015. The plants demand has now reduced to 0.3 MVA. It is understood the Manildra Group purchased this site in 2016.

The Manildra site, aka – Shoalhaven Starches (HVC 93018) was offered a increase in capacity for N security from 39MVA to 42MVA in August 2017. The limited 15MVA backup via feeder 7516 remains.

Special Report S453 “Shoalhaven 33kV Subtransmission Network Strategic Plan” was prepared to recommend a preferred network configuration to meet the long term requirements of the 33kV subtransmission system.

Post commissioning of West Tomerong TS in 2014, 3 x 33kV feeder switch bays for feeders 7504, 7508 and 7509 were released at Shoalhaven TS. HMAS Albatross upgraded their 11kV HVC supply to become a 33kV customer (HVC 33361) in 2015 utilising one of the released feeder bays CB SS082 and feeder 7508.

No major network renewal or capacity projects are planned for the current forecast period.

33.2 Shoalhaven Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Shoalhaven TS	3 x 60	120	28.9 @132kV+ 18 @33kV	Nil
Berry	2 x 15	15		Nil
Bolong	1 x 12.5	Non-Firm		Nil
Bomaderry	3 x 15	30		Nil
Kangaroo Valley[1]	1 x 5 + 1 x 2.5	2.5		Existing[1]
Nowra	2 x 35	35	5	Nil

Notes:

1. Firm capacity exceeded in winter.

33.3 Results Tables

33.3.1 Shoalhaven TS Loads and Ratings - Summer Summary

Faulty ➔	Nil	7501, /1 & /2	7505	7539[2]	7510[3]	7502[1,4]	7503	7506	7515	Rating	Result Year
7501: SHLHVN TS to TEE	9.8	x	27.8		9.1					35.2	2027
7501/1: ABS33531 to BMDERY ZS	7.4	x	25.4		6.7					33.5	2027
7540: AR27293 to TEE CLRWTR PMPS HVC 20158	2.2	x								7.1	2027
7505: SHLHVN TS to BMDRRY ZS	16.9	24.8	x		15.3					33.5	2027
7539: SHLHVN TS to MNLDR SS	41.0			x		41.1				44.0	2027
7516: TEE to ABS81719	8.6				11.2				x	13.3	2027
7516: TEE to MNLDR SS	x	x	x	15.0	x	0.0	x	x	x	35.1	2027
7510: BMDRRY ZS to ABS66737	2.4				x					13.6	2027
7511: ABS66737 to TEE1	2.4				x					13.6	2027
7512: AR33539 to 33508	2.4									13.3 / 13.3	2027
7514: TEE ABS 33505/AR27291 to ABS33505	8.6			8.8	11.2				x	13.3 / 13.6	2027
7514/1: ABS33505 to ABS81719	8.6			8.8	11.2				x	13.3	2027
7536: D5332 to ABS A7104/APPM SHLHVN PPR MLL	8.7			24.6	11.3	0.0			x	34.9	2027
7502: SHLHVN TS to 93734 (BLNG ZS)	11.7			27.6	14.3	x			3.1	46.6[5] / 46.6[5]	2027
7503: SHLHVN TS to NWR ZS	x	x	x	x	x		x	23.8	x	56.2	2027
7506: SHLHVN TS to NWR ZS	23.8						23.8	x		56.2	2027
7508: SHLHVN TS to HVC HMS ALBTRSS	14.6									20.7	2027
7176[6]: GRRNGNG ZS to BRRY ZS						8.9				16.4	2027

Notes:

1. N security level.
2. Close circuit breaker SM12 at Shoalhaven Milling (Manildra) to restore agreed backup supply to Manildra. Agreed 'N' supply = 39MVA, 'N-1' security not required. Agreed backup of up to 15MVA via feeder 7516 subject to the discretion of the Systems Operation Manager at the time.
3. Open ABS 66737 close ABS C8339 in field to restore supply to Kangaroo Valley ZS, N-1 security not required. Berry ZS can be transferred to Mt Terry System if required.
4. Berry ZS will change over to Mt Terry System through 11kV no volt change over routine. Open ABS 93734 (was 33503) in field and close circuit breaker SM12 Manildra to restore supply to Bolong ZS and Australian Paper, N-1 Security not required.
5. Feeder rating is restricted by ABS 93734 with a rating of 630A/36MVA.
6. Feeder 7176 is the alternate supply from Mt Terry System to Berry ZS and operates on 11kV no volt change over routine.

33.3.2 Shoalhaven TS Voltage Levels (Resultant Tap Position) - Summer Summary

Faulty ➔	Nil	7501, /1 & /2	7505	7539[2]	7510[3]	7502[1,4]	7503	7506	7515	Min. Tap	Max. Tap	Result Year
Berry 1	-4			-1	-5					-13	5	2027
Berry 2						-8			-8	-13	5	2027
Bolong[1]	-2			-2	-2	-3				-12	4	2027
Bomaderry	-2	-2	-4							-10	6	2027
Kangaroo Valley[1]	-1	-2	-4		-2					-14	7	2027
Nowra 1	0						0			-14	7	2027
Nowra 2								0		-14	7	2027

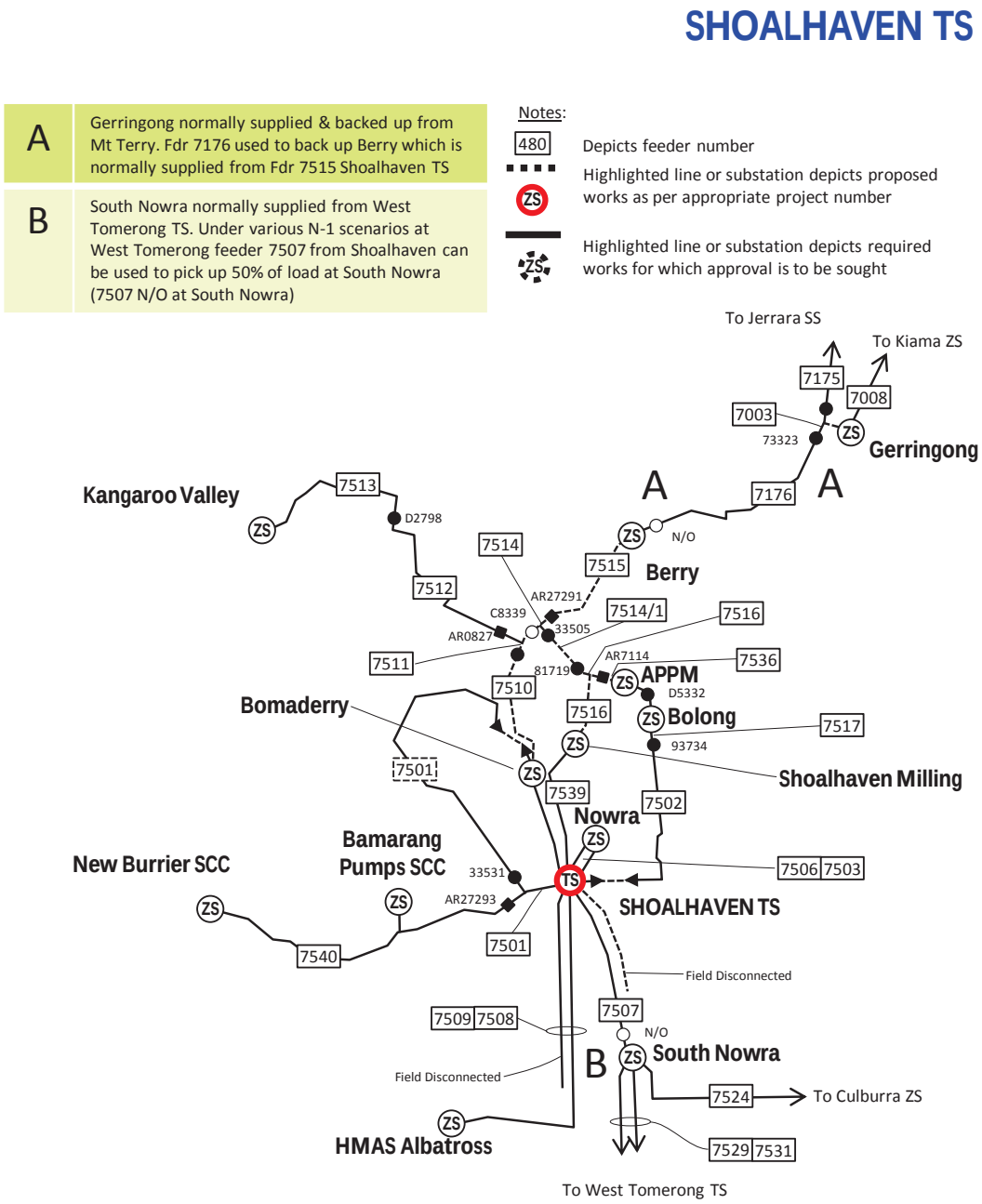
Notes:

1. N security level.
2. Close circuit breaker SM12 at Shoalhaven Milling (Manildra) to restore agreed backup supply to Manildra. Agreed 'N' supply = 39MVA, 'N-1' security not required. Agreed backup of up to 15MVA via feeder 7516 subject to the discretion of the Systems Operation Manager at the time.
3. Open ABS 66737 close ABS C8339 in field to restore supply to Kangaroo Valley ZS, N-1 security not required. Berry ZS can be transferred to Mt Terry System if required.
4. Berry ZS will change over to Mt Terry System through 11kV no volt change over routine. Open ABS 93734 in field and close circuit breaker SM12 Manildra to restore supply to Bolong ZS and Australian Paper, N-1 Security not required.

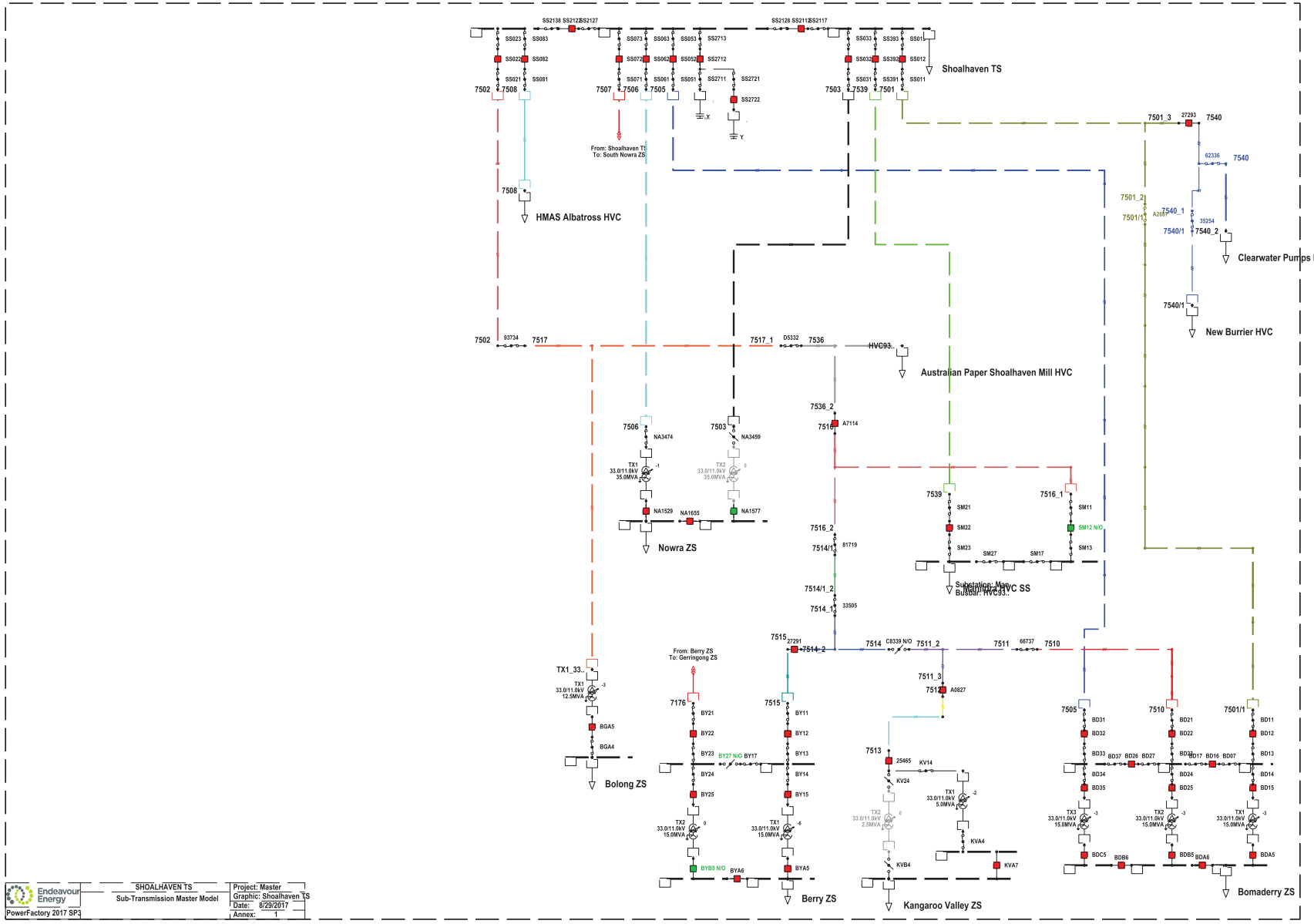
33.4 Analysis Results and Possible Solutions

Shoalhaven	Network Constraint	Year	Investigation	Solution
	Shoalhaven TS	Existing	System Operations advises an outage on 33kV bus section No 2 overloads bus section No 1. The load on bus section No 1 supplies Manildra, Bomaderry, Nowra and Kangaroo Valley at greater than 60MVA.	Swap Feeders PR 712

33.5 Shoalhaven Geographic



33.6 Shoalhaven Schematic



34 SPRINGHILL TRANSMISSION SUBSTATION

34.1 Springhill Transmission Network Status

Springhill Transmission Substation was rebuilt in 2010 and consists of an indoor GIS 132kV busbar as well as indoor 33kV switchgear. There are three 120MVA 132/33kV transformers supplying the Endeavour Energy network with a firm capacity of 240MVA, which is floated at 33.0kV. There are five 60MVA 132/33kV transformers supplying the BlueScope system.

Springhill TS is supplied directly from Dapto Bulk Supply Point by 132kV feeders 982/98Y and is also supplied by feeders 983/984, which have been cut in and out of Tallawarra SS as part of the Tallawarra generation project. Refer to the Dapto section of this report.

A report titled “West Lake Illawarra Area Plan” was endorsed by management in May 2016. Part of the West Lake Illawarra release area is located on the fringes of the Kembla Grange ZS and Dapto ZS catchment area and is proposed to provide up to 17,000 dwellings plus employment lands and commercial businesses with an expected demand of 85MVA.

Initial residential subdivisions commenced in 2012. It is proposed to ultimately supply this development with two new 132/11kV zone substations one northern (West Dapto ZS - supplied from Dapto BSP by cutting in and out of feeder 980 – Dapto to Bellambi Creek) and one southern (Avondale ZS - supplied from Dapto BSP by cutting in and out of feeder 988 - Dapto to Fairfax Lane). A site for the proposed northern (West Dapto) zone substation (Lot 1, DP818199) was acquired in July 2010.

The Springhill TS 33kV busbar supplies a number of subtransmission voltage customers as well as a number of zone substations (as detailed below). South32 (formerly BHP Billiton) operates a private 33kV network in the western Illawarra region, which is currently supplied from BlueScope Steel and is progressively being shut down. In recent years private customer loads have been progressively transferred to the Endeavour 33kV and 11kV networks. This resulted in the requirement for a new dedicated 33kV feeder (7099) to be developed out of Springhill TS in order to supply “Wollongong Coals’ Wongawilli Mine HVC2829. The feeder was commissioned in April 2011. The mine went from production in 2011 to care and maintenance in September 2014. It is now planned for the mine to commence operations again in late 2016.

The Cordeaux Ring is a 33kV network supplying customers such as Dendrobium Mine and Sydney Water. The network is configured in a radial manner and normally supplied by feeder 7091 out of Figtree ZS. The closure of the South32’s private network has meant the load on the ring has increased in recent years, mainly due to the connection of the Wongawilli No. 4 Airshaft. Works to increase the operating temperature of feeder 7091 to 75ºC have been completed and now provides sufficient rating.

Nepean Conveyers was established at the old Orrcon plant HVC 22436 and began taking supply in 2012 using the existing radial 33kV connection which once supplied Orrcon, though their load is significantly less than Orrcon’s.

BlueScope Steel previously expressed concerns with voltage fluctuations on their supply network were causing outages on some of their processes within the “Coated Products” plant (the former Lysaghts plant). Endeavour Energy has offered to give BlueScope Steel a connection point at

Springhill TS by providing them with a transformer bay on a temporary basis, which would allow BlueScope to supply their coated products plant with a dedicated transformer and feeder ex Springhill TS. This arrangement has not been included in the studies as the customer has not yet confirmed their agreement or otherwise.

A credible steel lattice tower failure and double circuit outage of 980/981 was desktop simulated prior to a real network switching event on Sunday 4 September 2016, where the entire Bellambi TS 33kV network was supplied (upto 80% of peak load) through three distinct radial 33kV substation groupings fed from Springhill TS.

No major network capacity projects are planned for the current forecast period.

34.2 Springhill Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Springhill TS	3 x 120	240	40 @ 33kV 100 @ 132kV	Nil
Dapto[@]	3 x 25	50[@]	5	Nil
Figtree	2 x 25	25		S2018
Inner Harbour	2 x 12.5	12.5		Nil
Kenny Street	2 x 25	25		Nil
Kembla Grange	2 x 10	10		S2021
North Wollongong	2 x 20	20	5	Nil
Port Kembla	2 x 25	25		Nil
South Wollongong	2 x 19	19	5	Nil
Unanderra	3 x 12	24	10	S2025
West Wollongong*	10 + 2 x 12.5	20.4*		Nil

Notes:

[@] Dapto firm capacity limited to 45.7MVA by the 11kV transformer circuit breakers.
* West Wollongong firm capacity limited to 20.4MVA due to a mismatch in transformer impedance.
(New Rating) following approved project.

34.3 Results Tables

34.3.1 Springhill TS Loads and Ratings Summary – Summer

Faulty ➔	Nil	7001	7002	7010	7013	7012*	7016*	7120*	7017/ 7117*	7341*	7018	7011	7019	7113	7115	7014	7015	7097	7098	7142	7111	Rating	Result Year
7001: SPRNGHLL TS to LYSGHTS HVC 93013	15.4	x	32.7																			33.3	2027
7002: SPRNGHLL TS to LYSGHTS HVC 93013	16.9	32.6	x																			46.6	2027
7010: SPRNGHLL TS to PRT KMBL ZS	7.1			x	14.2																	19.7	2027
7013: SPRNGHLL TS to PRT KMBL ZS	7.0			14.2	x																	19.7	2027
7012: SPRNGHLL TS to NNDRR ZS	21.3					x	32.0	9.1	23.5	17.9												44.4	2027
7016: SPRNGHLL TS to NNDRR ZS	22.6					32.1	x	9.6	24.9	18.9												33.2	2027
7120: NNDRR ZS to DPT ZS	25.1					13.4	13.3	x	29.7	18.1												33.2	2027
7017: SPRNGHLL TS to 73318	25.4					17.8	17.9	32.2	x	13.0												33.2	2027
7341: KMBL GRNG ZS to DPT ZS	12.5					5.2	5.2	18.8	11.3	x												32.1	2027
7041: MT TRRY TS to DPT ZS	x					18.0	18.0	18.0	18.0	18.0												27.4	2027
7018: SPRNGHLL TS to STH WLLNGNG ZS	27.4										x	**35.1**	**35.3**		20.2	**32.1**				**31.3**	24.6	28.6†	**2018**
7011: SPRNGHLL TS to KNNY STRT ZS	17.1										26.4	x	21.1		22.6	20.5	18.0	18.0	18.0	19.9	15.0	30.9	2027
7019: SPRNGHLL TS to NNR HRBR ZS	15.4										25.1	19.5	x	13.6	11.6	17.9				17.5	13.9	22.9†	2027
7113: NNR HRBR ZS to STH WLLNGNG ZS	3.1										11.5	6.7	13.7	x	3.3	5.0	3.6	3.6	3.4	4.8	2.1	22.9†	2027
7115: STH WLLNGNG ZS to KNNY STRT ZS	11.0										7.6	22.5	4.2	10.4	x	18.1	12.8	12.7	12.9	16.8	7.0	30.9	2027
7014: SPRNGHLL TS to WST WLLNGNG ZS	16.2										21.7	19.6	18.6		19.5	x	18.6	18.5	18.5	11.2	20.1	42.8	2027
7015: FGTR ZS to WST WLLNGNG ZS	5.2										9.1	7.6	6.9		7.4	11.3	x	x	2.3	1.6	8.0	46.3	2027
7097: SPRNGHLL TS to FGTR ZS	24.9										26.9					28.0	22.3	x	44.6	23.1	26.2	42.8	2018
7098: SPRNGHLL TS to FGTR ZS	24.5										26.5					27.6	22.0	44.5	x	22.7	25.9	45.7	2027
7142: WST WLLNGNG ZS to NRTH WLLNGNG ZS	8.6										17.9	14.3	12.6	9.2	14.1	2.3	5.8	6.0	6.2	x	15.2	28.6	2027
7111: KNNY STRT ZS to NRTH WLLNGNG ZS	6.5										3.3	1.0	2.6	6.0	2.6	16.8	9.3	9.2	9.1	15.2	x	34.3†	2027
7091: FGTR ZS to 35057/DNDRBM MN HVC 21436	17.3																					21.3	2027
7099: SPRNG HLL to WNGWLL MN HVC 28295	2.1																					32.9	2027

Notes:

* Pre-emptive or high feeder load alarm triggers manual switching via SCADA which transfers bus section C and Tx No. 3 of Dapto ZS to feeder 7041 from Mt Terry TS. Without a high speed communication link between Unanderra and Dapto ZS's an auto SCADA switching scheme is not possible.

† Feeder ratings limited by current transformers in the switchgear (were confirmed by Southern Region Transmission August 2016). Feeder conductors are rated / restricted as follows:

- 7018: 41.4 / 28.6† MVA; 7019: 46.3 / 22.9† MVA; 7113: 34.9 / 22.9† MVA; and 7111: 50.0 / 34.3† MVA

34.3.2 Springhill TS Voltage Levels Summary (Resultant Tap Position) – Summer

Faulty ➔	Nil	7010	7013	7012*	7016*	7120*	7017/ 7117*	7341*	7018	7011	7019	7113	7115	7014	7015	7097	7098	7142	7111	Min. Tap	Max. Tap	Result Year
Port Kembla	0	-1	-1																	-14	7	2026
Dapto 1	StndBy			x	x	x	x	x												-14	7	2026
Dapto 2 & 3	-3			-3	-3	-5	-3	-2												-14	7	2026
Kembla Grange 1	-2			-2	-2	-2	-3	-1												-12	4	2026
Kembla Grange 2	-2			-2	-2	-2	-3	-1												-12	4	2026
Unanderra 1	StndBy			x	x	x	x	x												-12	2	2026
Unanderra 2 & 3	0			0	0	0	0	0												-12	2	2026
Figtree	-3								-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-14	7	2026
Inner Harbour	-3								-4	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-14	2	2026
Kenny Street	-2								-3	-3	-3	-2	-3	-2	-2	-3	-2	-2	-2	-18	4	2026
North Wollongong	-1								-2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-12	2	2026
South Wollongong	-2								-3	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-12	2	2026
West Wollongong 1	StndBy								x	x	x	x	x	x	x	x	x	x	x	-14	7	2026
West Wollongong 2	-1								-2	-1	-1	-1	-1	-1	-1	-2	-1	-1	-1	-12	2	2026
West Wollongong 3	-1								-2	-1	-1	-1	-1	-1	-1	-2	-1	-1	-1	-16	4	2026

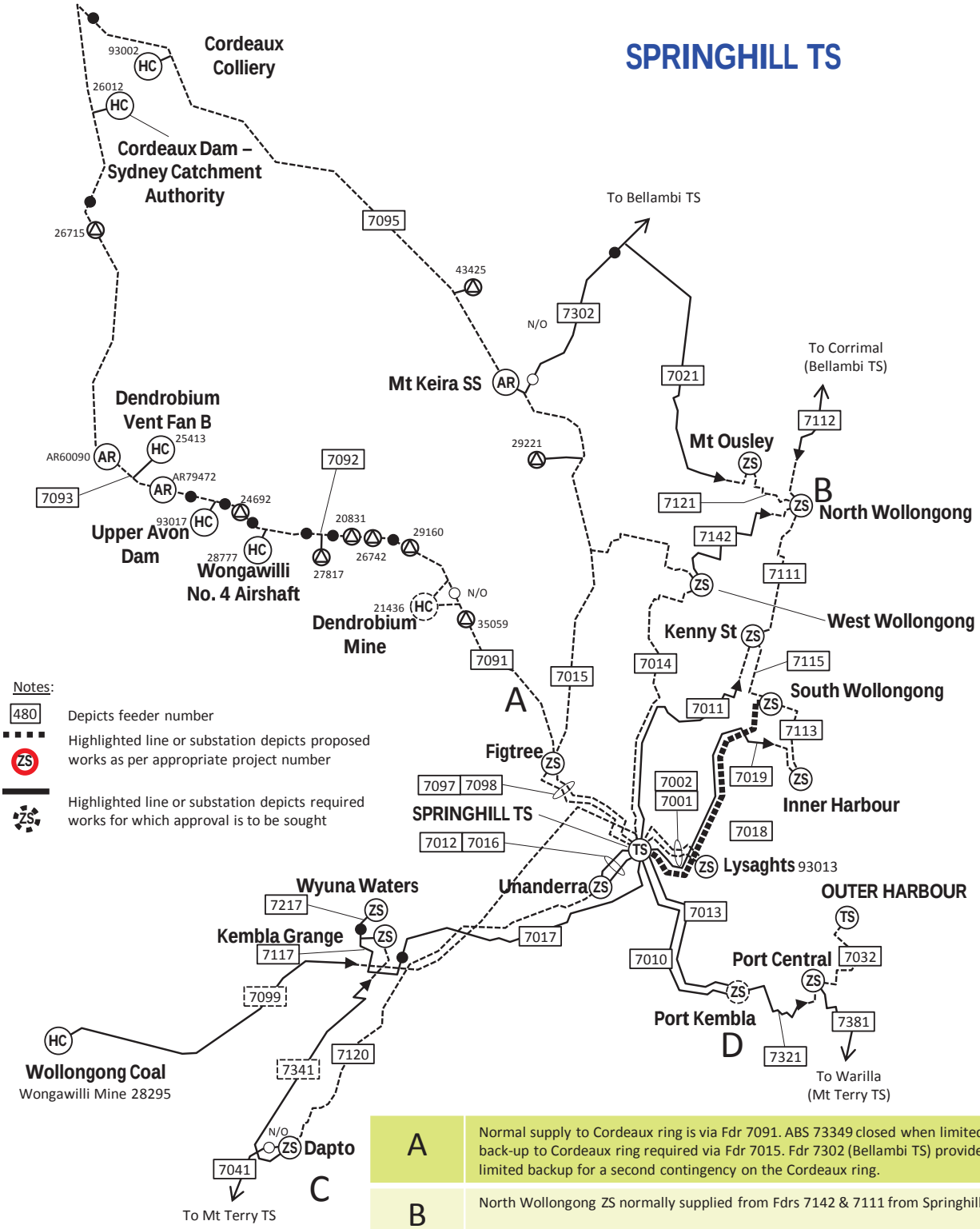
Notes:

* Pre-emptive or high feeder load alarm triggers manual switching via SCADA which transfers bus section C and Tx No. 3 of Dapto ZS to feeder 7041 from Mt Terry TS. Without a high speed communication link between Unanderra and Dapto ZS's an auto SCADA switching scheme is not possible.

34.4 Analysis Results and Possible Solutions

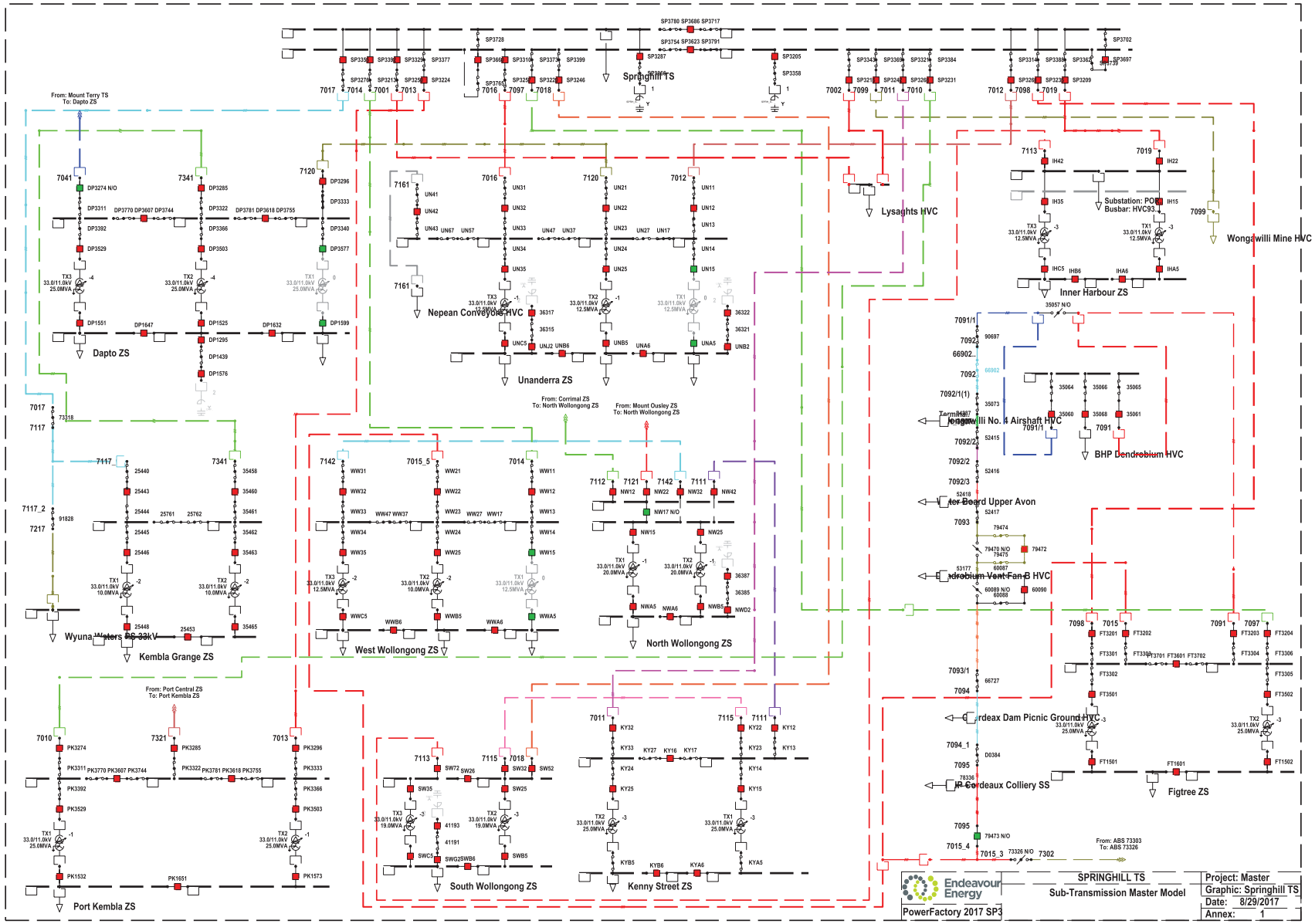
Springhill TS	Network Constraint	Year	Investigation	Solution
	Feeder 7018 is overloaded for an outage of feeders 7011, 7019, 7014 & 7142.	Existing	A 500A CT (C3) at South Wollongong ZS on feeder 7018 is being used by metering. Investigate changing the 500A CT to a 1000A CT.	PR 730
	Feeder 7097 is overloaded for outage of 7098	Existing	Manage LAR	Monitor

34.5 Springhill Geographic



A	Normal supply to Cordeaux ring is via Fdr 7091. ABS 73349 closed when limited back-up to Cordeaux ring required via Fdr 7015. Fdr 7302 (Bellambi TS) provides limited backup for a second contingency on the Cordeaux ring.
B	North Wollongong ZS normally supplied from Fdrs 7142 & 7111 from Springhill TS
C	Dapto normally supplied from Springhill Fdrs 7120 & 7341, with partial additional backup from Fdr 7041 (Mt Terry). Fdr 7041 is N/O at Dapto.
D	Port Kembla normally supplied & backed up from Springhill. Fdr 7321 from Outer Harbour provides backup for second contingency only

34.6 Springhill Schematic



35 SYDNEY NORTH BULK SUPPLY POINT

35.1 Sydney North Bulk Supply Point Transmission Network Status

Sydney North Bulk Supply Point is owned by TransGrid and has five 375 MVA 330/132kV transformers. Both Endeavour Energy and Ausgrid take supply at 132kV from this BSP. Kellyville and Kenthurst zone substations are normally supplied from Sydney North while Carlingford TS is capable of being supplied from Sydney North under contingency conditions, subject to rearrangement of the Ausgrid system.

Kenthurst ZS is a hybrid 132/33kV, 66/11kV and 33/11kV substation with a firm capacity of 25MVA. It is normally supplied from 132kV feeder 221 Sydney North via a 60MVA 132/33kV transformer in series with a 25MVA 33/11kV transformer. The ZS supply is on changeover to 66kV feeder 830 (Castle Hill ZS to Kenthurst ZS). The 132/33kV transformer at Kenthurst also supplies 33kV supply to Kellyville ZS via feeder 476.

Kellyville ZS is a 33/11/22kV substation with a firm capacity of 25MVA. It is normally operated with both transformers in service. On days when high demand is expected at Kellyville ZS, the 33kV busbar can be split via a motorised isolator. This allows the substation to be supplied from Kenthurst ZS via feeder 476 (Sydney North TS), and from Baulkham Hills TS via feeder 473 or feeder 469. For an outage of feeder 221 or feeder 476, Kellyville ZS will be fully supplied from Baulkham Hills TS on feeders 469 and 473.

The line rating of feeder 476 is 19 MVA and would have exceeded this rating in normal operation on peak demand days over the last 5 summers based on actual loads recorded at Kellyville ZS. Refer to summer contingenecy constraint emerging on Feeders 471 and 484 to Jasper Road in Baulkham Hills TS section.

35.2 Sydney North Bulk Supply Point Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Sydney North BSP	5 x 375	1500	360	N/A
Kellyville	2 x 25 (33/11kV) + 2 x 12 (11/22kV)	25	10	Nil
Kenthurst	1 x 60 (132/33kV) + 1 x 25 (33/11kV) + 1 x 25 (66/11kV)	25	5	Nil

35.3 Results tables

35.3.1 Sydney North BSP Loads and Ratings - Summer Summary

Faulty ➔	Nil	221[1]	476	Rating	Year of Result
221 Sydney North to Kenthurst ZS	40	x	18.3	128	S2025/26
476 Kenthurst ZS to Kellyville ZS	18.3*	-	x	19	S2017/18
830 Kenthurst ZS to Castle Hill ZS	S/B	18.3	-	36	S2025/26

Notes:

1. For an outage of 132kV feeder 221, supply to Kenthurst will be via the 66kV feeder 830 from Carlingford TS.
2. For an outage of 132kV feeder 221 or 33kV feeder 476, supply to Kellyville ZS will be via feeders 473 and 469 from Baulkham Hills TS. Refer to Baulkham Hills TS section of the report.
3. * Normal operation result for Feeder 476 indicates that there is no overload for the forecast period 2017-2026. The last 5 years of actual load on Kellyville ZS would overload the 19 MVA rating Feeder 476.

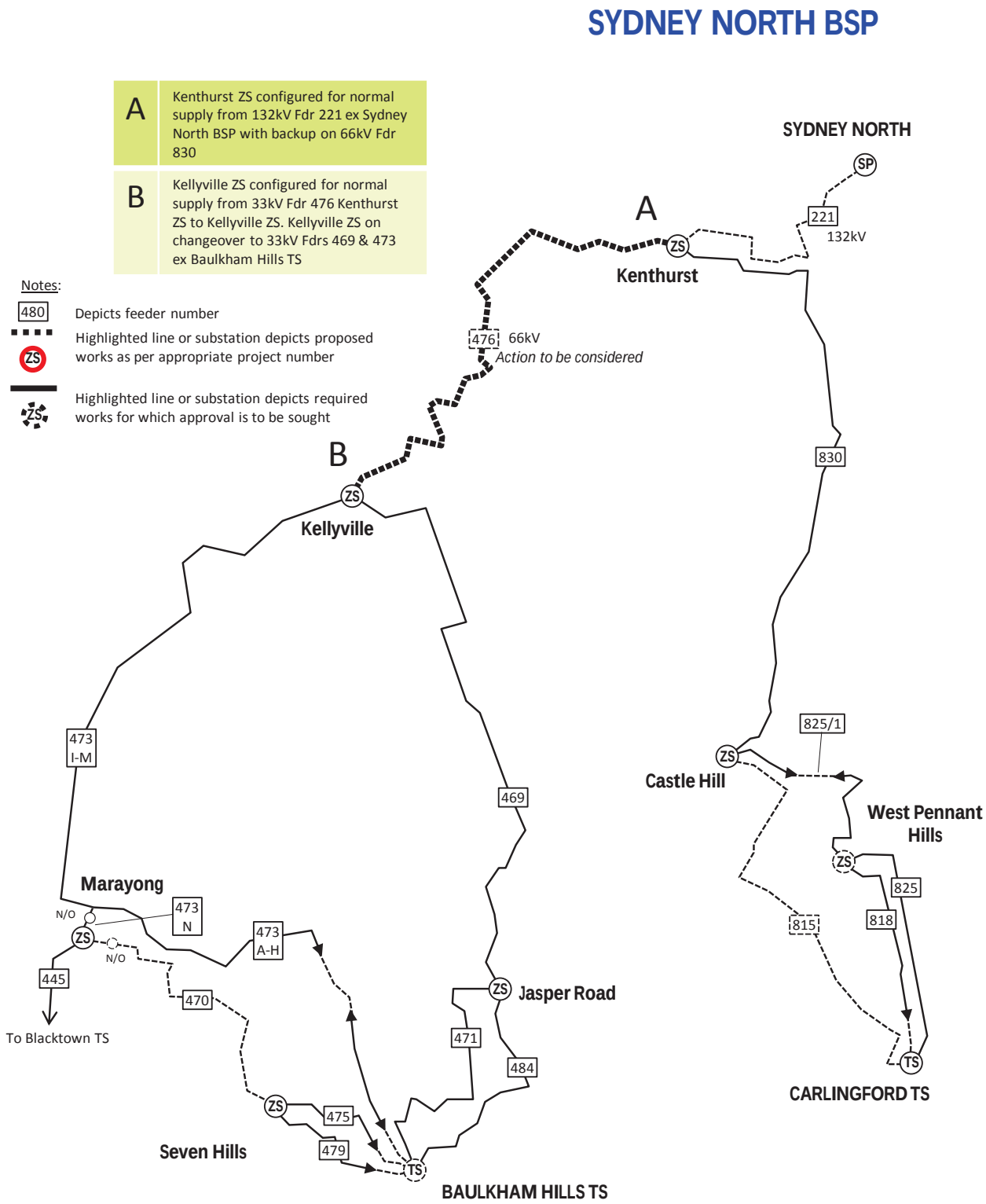
35.3.2 Sydney North BSP Voltage Levels (Resultant Tap Position) - Summer Summary

Faulty ➔	Nil	221	476	Min Tap	Max Tap	Year of Result
Kenthurst 132/33kV Tx	-2	x	-2	-16	4	2025/26
Kenthurst 66/11kV Tx	x	-4	x	-14	7	2025/26
Kenthurst 33/11kV Tx	-2	x	-2	-14	7	2025/26
Kellyville 33/11kV Tx	-4	0	0	-14	7	2025/26

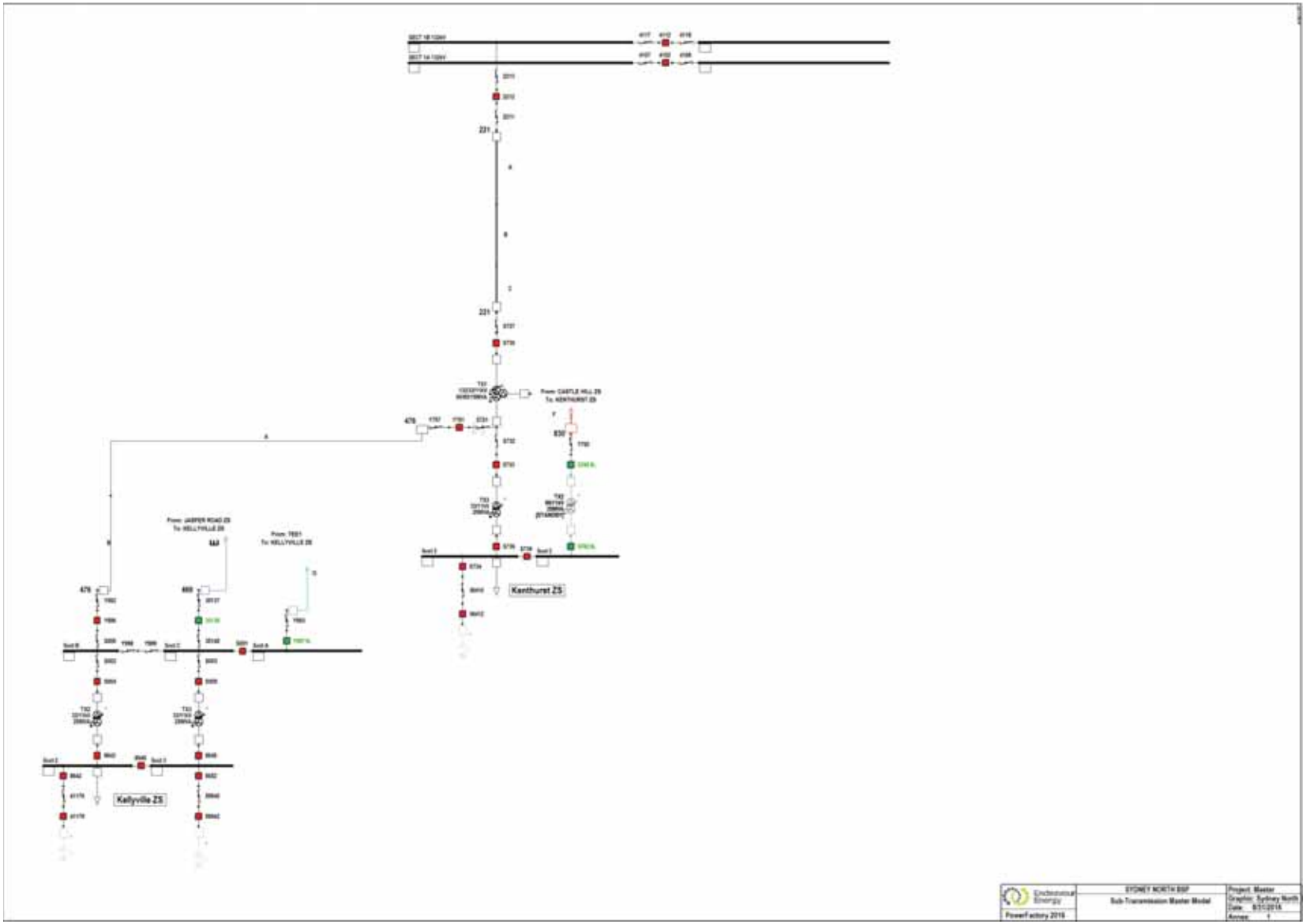
35.4 Analysis Results and Possible Solutions

Sydney North SP	Network Constraint	Year	Investigation	Solution
	The thermal capacity of feeder 476 to Kellyville ZS is close to being exceeded under normal operating conditions for the forecast period. The feeder is derated due to previous trips due to unknown causes. Refer Note 3 from the Loads and Ratings Summer Summary.	2017/18	Summer contingency : Supply half of the Kellyville load from Baulkham Hills to avoid overloads on feeder 476 on peak demand days. Additional load will be transferred to Mungerie Park ZS. Proposal to alleviate summer contingency overload from Jasper Rd ZS is to augment Feeder 476 under loss of Feeder 818 and 825.	Utilise transfer capacity

35.5 Sydney North BSP Geographic



35.6 Sydney North BSP Schematic



36 SYDNEY WEST BULK SUPPLY POINT

36.1 Sydney West Bulk Supply Point Transmission Network Status

Sydney West Bulk Supply Point is owned by TransGrid and has five 375 MVA 330/132kV transformers installed, providing a firm capacity of 1,500MVA. Sydney West BSP supplies Endeavour Energy at 132kV.

The 132kV busbar at Sydney West BSP is normally operated solid. However, in order to reduce fault levels when the Sydney West BSP is paralleled with either: Liverpool, Regentville, Vineyard, Sydney North or Holroyd BSPs, the busbar can be operated split, with two transformers on one busbar section and three transformers on the other section, or with one transformer on one section and four transormers on the other section. This operating configuration is permissible by OM 600.

Feeders 93M and 93T supply West Wetherill Park Transmission Substation at 132kV. This could be utilised to offload the 33kV Blacktown TS and Mt Druitt TS subtransmission network if required. However, West Wetherill Park TS only has a single 132/33kV transformer and therefore has been configured by System Operations to only provide a back up supply to Bossley Park and Horsley Park Zone Substations (ZS) at 33kV. Sydney West BSP feeder 93U backs up Abbotsbury ZS which is normally supplied by West Liverpool TS feeder 93W.

Due to limitations associated with the feeders to Mamre ZS, the Sydney West and Regentville systems can be paralleled at Mt. Druitt if required. Directional overcurrent protection is installed on the Mt Druitt transformers to prevent equipment damage following multiple contingencies on the Transgrid system whilst the Sydney West and Regentville systems are being operated in parallel. Sydney West feeder 939 (de-rated to 145MVA) supplies Mamre ZS. According to present load levels, the Sydney West – Mamre – Mt Druitt 132kV ring is adequate for a single contingency event. However, the system could become constrained in the event of an abnormally switched network where Cambridge Park ZS and Kingswood ZS are being supplied from Mt Druitt TS. To cater for this System Operations may implement a 132kV split arrangement at Mt Druitt TS for the duration of the summer. The Mt Druitt TS busbar is operated split to supply transformer No. 3 from Penrith on feeder 933 and transformers No.1 and No.2 from Sydney West. This makes provision for the possible loss of feeder 932 (Sydney West to Mt Druitt), to initiate closing in feeder 936, to supply transformer No.1 at Mt Druitt from Penrith TS. A double tee off arrangement to Mamre ZS from feeders 932 and 939 to achieve the full rating of these feeders will eliminate these operational difficulties and is to be investigated.

The developments surrounding the Sydney West BSP site is likely to require a number of 132/11kV substations adjacent to Sydney West BSP. The land south of Sydney water pipeline known as the Oakdale Industrial Precinct is part of the Broader Western Sydney Employment Area, and will be supplied by the proposed Southpipe ZS. New development in Luddenham, known as Sydney Science Park, will be supplied by the proposed Science Park ZS. Both substations are proposed to be supplied by new 132kV feeders from Sydney West BSP.

The Sydney West / Rooty Hill / OneSteel / Quakers Hill / Arndell Park / Blacktown interconnection arrangement was subject of a review documented in Special Report S454 – Blacktown Area Study. The 132/11kV 45MVA transformer and 132kV feeder duplication to Quakers Hill ZS has increased

its firm capacity to 50MVA. The 132kV transmission feeder duplication and 11kV distribution transfer to both Schofields and Doonside has deferred the need for additional transformer capacity (project PR312) at Quakers Hill.

Macarthur BSP 330/132/66kV substation is the supply source for the South West growth sector. Macarthur BSP connects to Sydney West BSP via feeder 93X. Refer to the Ingleburn, Macarthur and Nepean 66kV sections of this report. High capacity feeders 9L1 and 85L connect Macarthur BSP and Nepean TS. Sydney West BSP feeder 93X partially backs up Nepean TS.

Feeder 93X from Sydney West to Nepean TS is not normally operated in parallel with Feeder 9L5 (Feeder 93Y from West Liverpool TS) at Nepean TS due to fault level issues with the Nepean 66kV equipment.

North Leppington ZS will loop in and out of feeder 93X, to form feeder 93X Sydney West to North Leppington and feeder 9L4 Nepean TS to North Leppington to tee Bringelly . Feeder 9L4 will be normally open at North Leppington ZS, allowing for a mesh 132kV network to operate between Nepean TS, Oran Park ZS and Bringelly ZS through feeders 9L3, 9L6 and 9L4.

Under normal operation, Vineyard BSP supplies Bella Vista, Cheriton Ave and West Castle Hill zone substations via Parklea ZS. Backup supply is available from Sydney West BSP via feeder 212 from Baulkham Hills TS to Bella Vista ZS, for the loss of either feeder (214/215 Refer to the Vineyard and Baulkham Hills sections of this report.

36.2 Sydney West Bulk Supply Point Rating Details

Transmission or Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Capacity Constraint (Year)
Liverpool BSP ^^	3 x 375	750		Nil
Macarthur BSP ^^#	1 x 375 (330/132) + 1 x 250 (330/66)	Non Firm		Nil (backed up by Sydney West)
Sydney West BSP ^^	5 x 375	1500	560	Nil
Abbotsbury ZS*	2 x 45	45		Nil
Arndell Park	2 x 45	45	10	Nil
Baulkham Hills TS	4 x 60	180	65	Nil
Baulkham Hills ZS	2 x 45	45	5	Nil
Blacktown	4 x 120	360	20	Nil
Bringelly **	1 x 19 + 1 x 25	19	5	Nil
Carlingford	4 x 120	360	40	Nil
Doonside ZS	3 x 45	90		Nil
Eastern Creek	2 x 45	45		Nil
Huntingwood ZS	2 x 45	45		Nil
Liverpool TS*	3 x 120	240	20	Nil
Mt Druitt	3 x 120	240	15	Nil
Mamre	3 x 45	90	5	Nil
Nepean 33kV	2 x 60	60	30	Nil
Nepean 66kV	2 x 120	120 + (Generation)	40	Nil, with Appin / Tower Generation
North Eastern Creek	2 x 45	45		Nil
Onesteel Mini Mill HVC	(1 x 90 + 1 x 45) owned by the customer	N/A	Unknown	Non Firm on Furnace
Quakers Hill	1 x 60 (132/33) + 2 x 25 (33/11) + 1 x 45 (132/11)	50	5	Nil
Rooty Hill	2 x 45	45	10	Nil
West Liverpool*	3 x 120	240	62	Nil
West Wetherill Park TS	1 x 120	Non Firm	20	Nil
West Wetherill Pk ZS	2 x 45	45	5	Nil
Wetherill Park	2 x 45	45	10	Nil

Notes:

- ^^ Sydney West BSP is interconnected to Liverpool BSP via Nepean TS. Interconnection from Sydney West BSP will be N/O at Nepean TS.
- * These Substations are normally supplied of Liverpool BSP, with back up supply from Sydney West BSP.
- #Macarthur BSP supplies Nepean TS, with Sydney West BSP providing contingency backup.

36.3 Results Tables

36.3.1 Sydney West (East) SP Loads and Ratings - Summer Summary

Faulty ➔	Nil	93F[1]	93L[1]	93J[2]	93M[2]	93T[2]	22G	225	22W	9J8	228	233	22U	226	224	Rating	Year of Result
93F: HOLROYD BSP to GUILDFORD TS	239	x	387													505	S2026/27
93L: HOLROYD BSP to GUILDFORD TS	229	374	x													505	S2026/27
93J: SYDNEY WEST BSP to TEE1	24	172[3]	171	x	71	31										505	S2026/27
93J: TEE1 to GUILDFORD TS	9	162[3]	162	x	56	x										505	S2026/27
93J: TEE1 to WETHERILL PARK ZS	15			x		31										120	S2026/27
93M: SYD WST BSP to W.WTHRLL PRK TS	44	190[3]	189	69	x	41										505	S2026/27
93T: WEST WETHERILL PARK TS to TEE1	7	156[3]	156	31	42	x										505	S2026/27
93T: TEE1 to WETHERILL PARK ZS	15			31		x										120	S2026/27
93T: TEE1 to GUILDFORD TS	9	147[3]	147	x	56	x										505	S2026/27
22G: GUILDFORD TS to W.PRRMATTA ZS	66						x	90	75	76	90	71	75	69		251	S2026/27
225: W.PRRMATTA ZS to E.PRRMATTA SS	24						90	x	15	14	4	19	15	20		172	S2026/27
22W: GUILDFORD TS to CAMELLIA TS	48						61	44	x	67	59	46	66	55		111	S2026/27
9J8: GUILDFORD TS to CAMELLIA TS	51						64	46	68	x	62	48	69	58		117	S2026/27
228: GUILDFORD TS to EAST PRRMATTA SS	54						83	44	63	64	x	59	63	58		111	S2026/27
233: CAMELLIA TS to EAST PRRMATTA SS	9						45	8	11	12	39	x	11	5		172	S2026/27
22U: GUILDFORD TS to GRANVILLE ZS	54						64	50	69	70	63	55	x	36		117	S2026/27
226: CAMELLIA TS to GRANVILLE ZS	20						31	16	35	36	30	18	35	x		117	S2026/27
224: EAST PRMATTA SS to NTH PRRMATTA ZS	42														x	80	S2026/27
235: EAST PRMATTA SS to NTH PRRMATTA ZS	S/B														43	80	S2026/27

36.3.2 Sydney West (East) SP Voltage Levels - Summer Summary

Faulty ➔	Nil	93F	93L	93J	93M	93T	22G	225	22W	9J8	228	233	22U	226	224	Min Tap	Max Tap	Year of Result
Guildford	0	1	-1	0	-4	-4										-16	4	S2026/27
West Wetherill Park TS	4				x											-16	4	S2026/27
West Wetherill Park ZS	-1	1	-2	1	-7	-7										-17	3	S2026/27
Wetherill Park TX1 (93T)	2	1	1	1	2	x										-14	7	S2026/27
Wetherill Park TX2 (93J)	2	1	1	x	2	-1										-14	7	S2026/27
West Parramatta	-8															-17	3	S2026/27
Camellia	-5															-12	4	S2026/27
Granville	-3															-17	3	S2026/27
North Parramatta TX1	-4															-27	3	S2026/27

Notes: 1. For outage of either 93F or 93L Guildford 132kV busbar was modelled paralleled with Sydney West, all five TSFs in service and the split busbar.
2. Guilford 132kV busbar remains operated split for loss of Sydney West source feeders 93M, 93T and 93J.
3. High load on these feeders is due to increased reactive power flow between Holroyd BSP and Sydney west BSP. System Operations will need to manage that through change of float voltage on Sydney west BSP.

36.3.3 Sydney West (North) Loads and Ratings - Summer Summary

Faulty ➔	Nil	93A[1]	93Z[1]	9J1[1]	9J2[1]	23G	23J	220	239	23C	23F	223	237	9J3	9J4	930	931	214/215	Rating	Year of Result
93A: SYD W BSP to TEE	247	x	396	310	321								253					284	505	S2026/27
93A: TEE to BLKTWN TS	220	x	319	297	277								255					254	505	S2026/27
93A: TEE to HEALEY CT	25	x	77	12	39								25					26	80[2]	S2026/27
93Z: SYD W BSP to BLKTWN TS	237	376	x	306	305								243					273	505	S2026/27
9J1: SYD W BSP to BLKTWN TS	238	292	296	x	346								245					275	505	S2026/27
9J2: SYD W BSP to TEE	244	308	286	355	x								250					280	505	S2026/27
9J2: TEE to BLKTWN TS	227	264	308	317	x								234					264	505	S2026/27
9J2:TEE to HEALEY CT	14	39	47	32	x								13					13	80[2]	S2026/27
23G: BLCKTWN TS to HNTNGWD ZS	78					x	53	103	105				87						145	S2026/27
23J: HNTNGWD ZS to DNSD ZS	26					53	x	52	52				35						145	S2026/27
220: BLCKTWN TS to TEE1	55					94	68	x	85				62						130	S2026/27
220: TEE1 to ARNDLL PK ZS	18					18	18	x	37				18						80	S2026/27
220: TEE1 to DNSD ZS	37					76	50	x	48				44						120	S2026/27
239: BLCKTWN TS to TEE1	55					94	68	85	x				62						130	S2026/27
239: TEE1 to ARNDLL PK ZS	18					18	18	37	x				18						80	S2026/27
239: TEE1 to DNSD ZS	37					76	50	48	x				44						120	S2026/27
23C: DNSD ZS to TEE 1	37									x	61	56	40						130	S2026/27
23C: TEE1 to QKRS HLL ZS	18									x	41	41	21						130	S2026/27
23C_2: TEE1 to RTY HLL ZS	20									x	20	16	20						76	S2026/27
23F: DOONSIDE ZS to TEE1	23									41	x	25	42						130	S2026/27
23F: TEE1 to ONESTL HVC[3]	S/B									S/B	x	S/B	23						130	S2026/27
23F: TEE1 to QUKRS HLL ZS	23									41	x	26	20						130	S2026/27
223: SYD W BSP to RTY HLL ZS	20									41	20	x	20						120	S2026/27
237: SYD WST BSP to ONESTL	81												x						120	S2026/27
9J3: BLKTWN TS to BLHM HLLS TS	204													x	411	204	204	271	512	S2026/27
9J4: BLKTWN TS to BLKM HLLS TS	204													411	x	204	204	271	512	S2026/27
930: CRLNGFRD TS to BLM HLLS TS	113													114	114	x	227		512	S2026/27
931: CRLNGFRD TS to BLM HLLS TS	113													114	114	227	x		512	S2026/27
212: BLHM HLLS TS to BLLA VST ZS[4]	S/B																	144	172	S2026/27

Notes:

1. Outage of 93A, 93Z, 9J1 or 9J2 has been modelled with a split 132kV busbar at Sydney West.
2. Minimum rating specified in project definition, actual rating may be greater.
3. Onesteel Mini Mill load capped (20MVA) used for outage of preferred supply. This is an agreed supply curtailment.
4. Outage of feeders 214 or 215 (Rouse Hill to Parklea) requires radialising part of the Vineyard system with the remainder transferred to Sydney West. Feeder 212 to supply Bella Vista, Cheriton Ave and West Castle Hill 132kV Busbar SECT 1 via Baulkham Hills, to allow capacity of remaining feeder (214/215) to supply Parklea and West Castle Hill Busbar SECT 2.

36.3.4 Sydney West (North) Voltage Levels (Resultant Tap Position) - Summer Summary

Faulty ➔	Nil	93A	93Z	9J1	9J2	23G	23J	220	239	23C	23F	223	237	9J3	9J4	930	931	214/215	Min Tap	Max Tap	Year of Result
Arndell Park	1					1	1	-1	-1										-27	3	2026/27
Doonside	-1					-1	-1	-1	-1										-17	3	2026/27
Huntingwood	-1					-1	-1	-1	-1										-17	3	2026/27
Quakers Hill 132/11	-3					-3	-3	-3	-3	-3	-3	-3							-17	4	2026/27
Quakers Hill 33/11	-3					-3	-3	-3	-3	-3	-3	-2							-14	7	2026/27
Rooty Hill (23C)	0					0	0	0	0	x	0	-4							-14	7	2026/27
Rooty Hill (223)	1					1	1	1	1	-3	1	x							-14	7	2026/27
Baulkham Hills TS	1	2	2	2	2									1	1	1	1	2	-16	4	2026/27
Baulkham Hills ZS	-4	-4	-4	-4	-4									-5	-5	-4	-4	-4	-17	3	2026/27
Blacktown	-4	-4	-4	-4	-4									-4	-4	-4	-4	-3	-12	4	2026/27
Carlingford	-1	-2	-2	-2	-2									-5	-5	-2	-2	-3	-12	4	2026/27
Bella Vista	-5																	-4	-17	3	2026/27
Cheriton Ave	-3																	-2	-17	3	2026/27
West Castle Hill TX1	-4																	-3	-27	3	2026/27

36.3.5 Sydney West (South) Loads and Ratings - Summer Summary

Faulty ➔	Nil	93W	93X	Rating	Year of Result
93U: SYD WEST BSP to ABBOTSBURY ZS	S/B	48		400[2]	S2026/27
93W: ABBTSBURY ZS to W. LIVERPOOL TS	48	x		400	S2026/27
93X: SYD WST BSP to NTH LEPPINGTON ZS	26		x	200	S2026/27
9L4: NTH LEPPINGTON ZS to TEE	S/B		26	230	S2026/27
9L4: TEE to NEPEAN TS	14		29	172	S2026/27
9L4: TEE to BRINGELLY ZS	14		3	230	S2026/27
9L1 MACARTHUR BSP to NEPEAN TS	223		242	358**	S2026/27

Notes: 1. ** Contingency ratings

2. See Liverpool BSP and Macarthur BSP chapters for full load and ratings result table.

36.3.6 Sydney West (South) Voltage Levels - Summer Summary

Faulty ➔	Nil	93W	93X	Min Tap	Max Tap	Year of Result
Abbotsbury	-4	-2		-17	3	S2026/27
Bringelly TX2	0		0	-14	7	S2026/27
Nepean 33kV	1		0	-16	4	S2026/27
Nepean 66kV	0		0	-12	4	S2026/27
North Leppington	-3		-3	-17	3	S2026/27

36.3.7 Sydney West (West) Loads and Ratings - Summer Summary

Faulty ➔	Nil	217	218	219	932[1]	939	222	238	Rating	Year of Result
217: SYD WEST BSP to NTH EASTERN CREEK ZS	15	x	67						172	S2026/27
218: SYDNEY WEST BSP to EASTERN CREEK ZS	51	67	x						172	S2026/27
22C: ESTRN CREEK ZS to NTH ESTRN CRK ZS	5	20	47						172	S2026/27
219: MOUNT DRUITT TS to MAMRE ZS	27			x	38	71	27	27	230**	S2026/27
932[#]: SYDNEY WEST BSP to MOUNT DRUITT TS	106			132	x	203	105	105	512 (366^^)	S2026/27
939: SYDNEY WEST BSP to MAMRE ZS	96			70	107	x	96	96	230**	S2026/27
222: REGENTVILLE BSP to PENRITH TS	121			121	166	121	x	243	448	S2026/27
238: REGENTVILLE BSP to PENRITH TS	121			121	166	121	243	x	448	S2026/27
933: PENRITH TS to MOUNT DRUITT TS	S/B			S/B	47	S/B			121	S2026/27
936: PENRITH TS to MOUNT DRUITT TS	S/B			S/B	48	S/B			121	S2026/27

Notes:

1. Feeder 933 is set up to supply Mt Druitt TS Transf No 3 after first forecast hot day of each season, to prepare for possible loss of feeder 932. Feeder 936 will supply Mt Druitt TS Transf No 1 on detected overload on feeder 939. The analysis has been done assuming feeder 933 is on load and that feeder 936 will be required on outage of feeder 932.

^^ CT limit at Sydney West Substation (1600Amps)

** Contingency rating

[#] Under outage of 932, Regentville BSP exceeds its firm capacity.

36.3.8 Sydney West (West) Voltage Levels - Summer Summary

Faulty ➔	Nil	217	218	219	932	939	222	238	Min Tap	Max Tap	Year of Result
Penrith TS	1						1	1	-12	4	S2026/27
Penrith 11kV[#]	-2[#]						-3[#]	-3[#]	-27	3	S2026/27
Mt Druitt TX1	0			0	0	0			-12	4	S2026/27
Mt Druitt TX2	0			0	0	0			-12	4	S2026/27
Mt Druitt TX3	0			0	0	0			-12	4	S2026/27
Eastern Creek	0	0	0		0	0			-17	3	S2026/27
North Eastern Creek	0	0	0		0	0			-14	7	S2026/27
Mamre TX2	-3				-3	-4			-17	3	S2026/27

Notes:

[#] To enable load flow, transformers TX5 and TX6 at Penrith 11kV were modelled operating in parallel. They cannot operate in parallel due to fault level constraints. Tap on operating transformer under the forecast load would reach its minimum, as the transformer would be constraint due to overload.

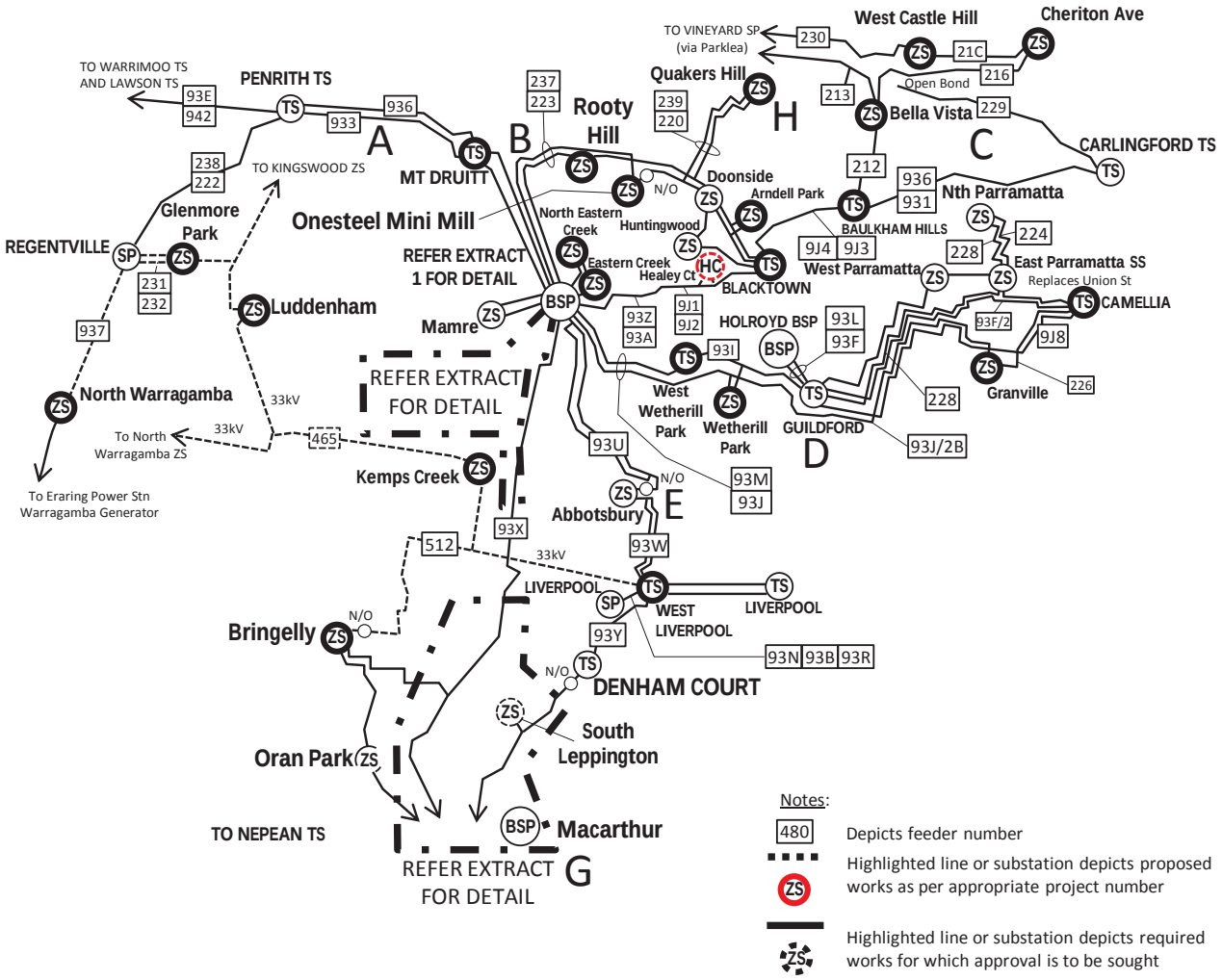
-

36.4 Analysis Results and Possible Solutions

Load levels on all feeders and voltage levels at all substations are within their design ratings and ranges, respectively, for this review period. However, the following operational constraints arise when Mt Druitt network is abnmormally switched to supply Cambridge Park ZS and Kingswood ZS

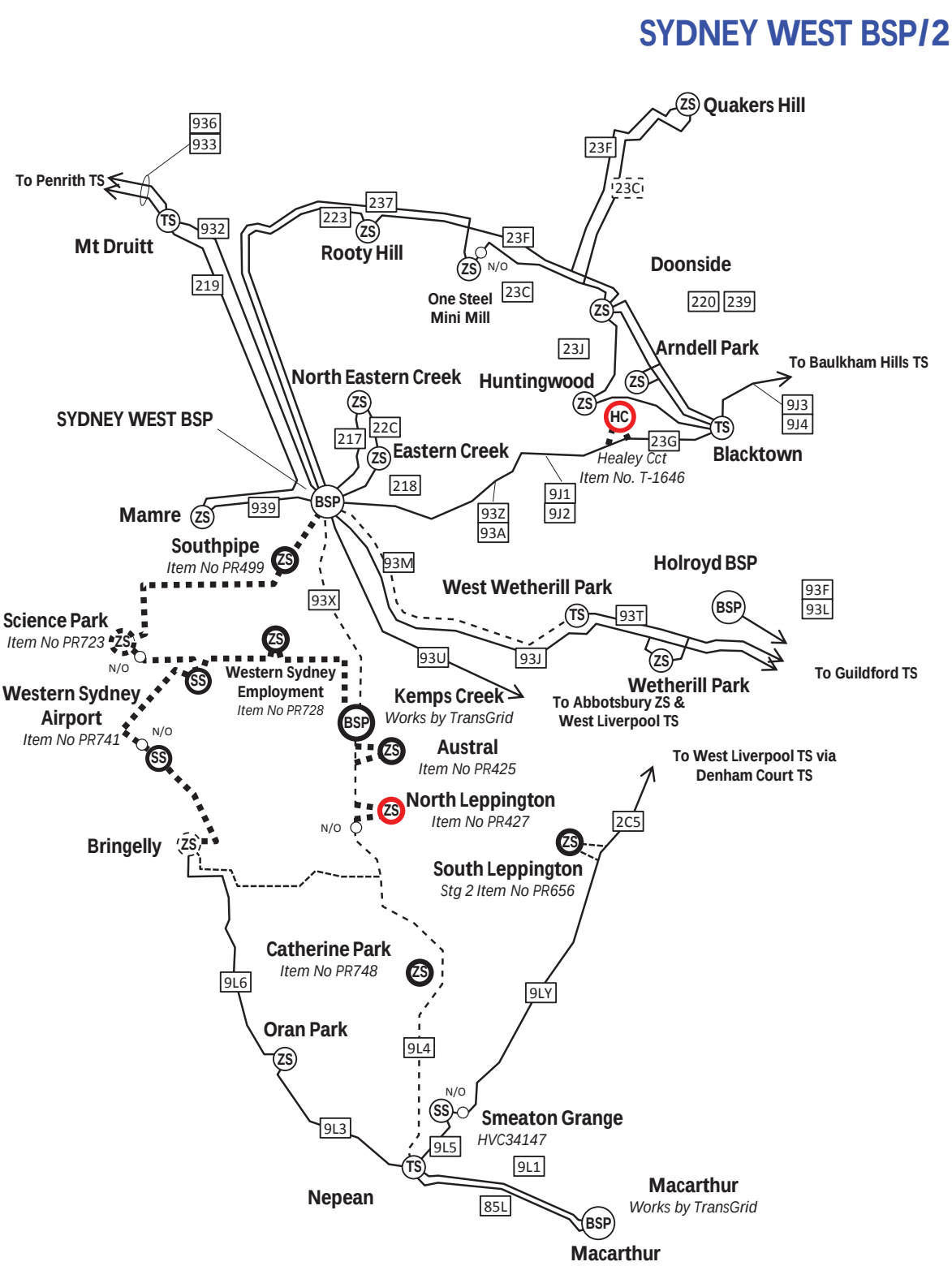
Sydney West BSP	Network Constraint	Year	Investigation	Solution
	Mt Drutt needs to be switched to radial supply with one transformer being supplied from Penrith TS when the Mt Druitt network is abnormally switched to supply Cambridge Park ZS and Kingswood ZS	S2018	When Mt Druitt is supplying Cambridge Park ZS and Kingswood ZS, Mt Druitt needs to be switched to radial supply to make provision for possible loss of Feeder 932	Investigate double tee off arrangement for Mamre ZS to restore feeder 939 to full rating.

36.5 Sydney West Geographic

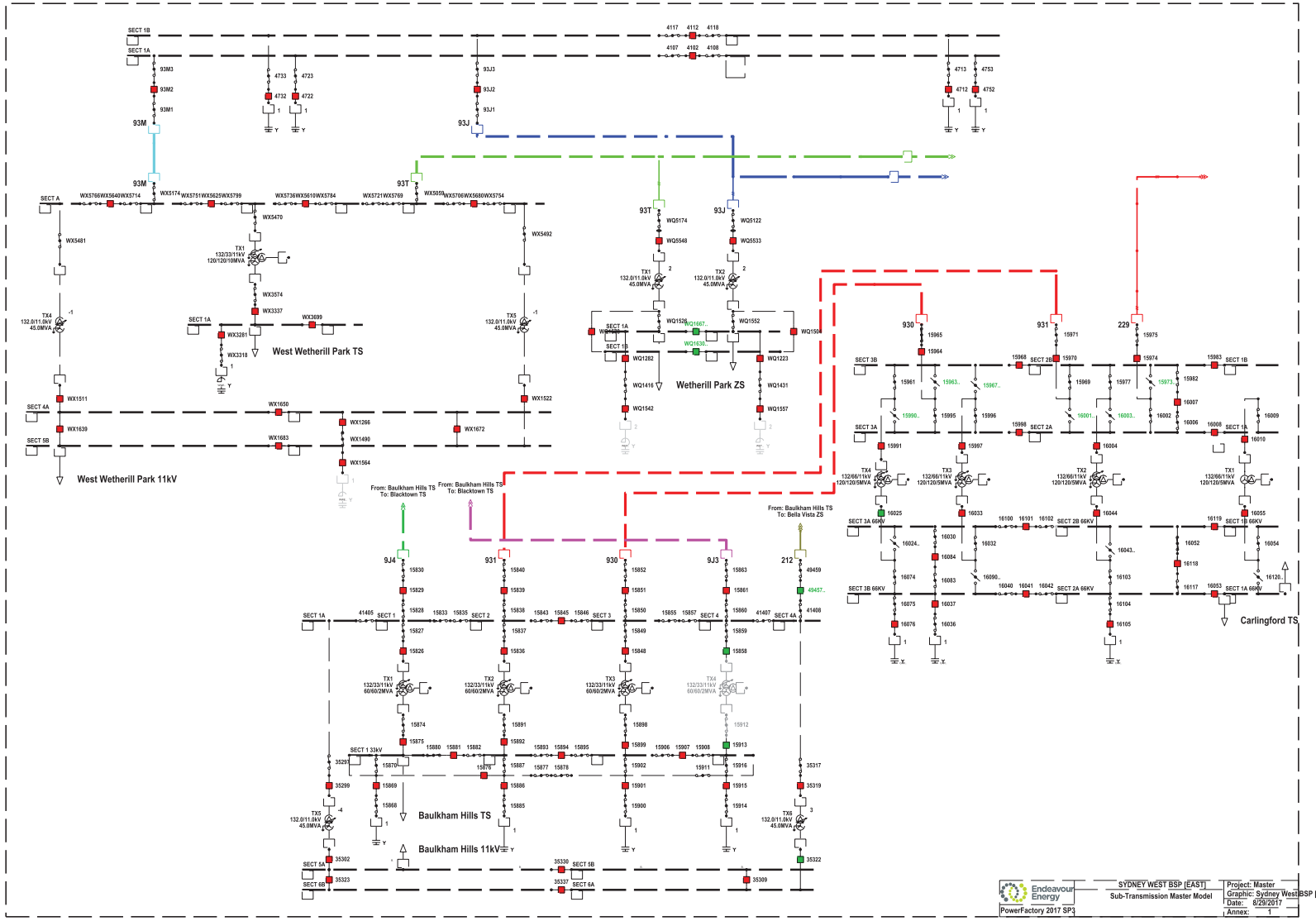


A	Mt Druitt is normally supplied from Sydney West, and is backed up from Regentville.
B	The Blacktown, Onesteel, Rooty Hill ring is operated open. Fdr 237 normally supplies Onesteel. Fdrs 22C & 223 supply Rooty Hill on a split 11kV bus. Arndell Park is operated on fdrs 220 & 239 on a split 11kV bus.
C	Bella Vista, Cheriton Ave & West Castle Hill are supplied from Vineyard SP with backup via Fdr 212 from Baulkham Hills. Fdr 219 from Carlingford is open bonded at WCH pending a future strategy.
D	Guildford is operated on a split arrangement across the Holroyd and Sydney West 132kV source busbars.
E	West Liverpool is normally supplied from Liverpool 330kV SP. Fdr 93U from Sydney West is used as mutual back-up to/from West Liverpool. Fdr 93W will supply Abbotsbury from West Liverpool with backup from Sydney West on Fdr 93U.
F	Bringelly is normally supplied from Fdr 93X Sydney West on changeover to 33kV Fdr 512 West Liverpool.
G	Nepean TS is normally supplied from 132kV feeders 9L1 & 66kV feeder 85L Macarthur BSP. Sydney West & Liverpool BSP provide back up supply from feeders 93X & 93Y respectively. South Leppington will be normally supplied from West Liverpool via Denham Court. Backup is from feeder 9L5 from Nepean via Smeaton Grange.
H	Quakers Hill to be supplied from Fdrs 23C & 23F. 33kV feeder 450 (Blacktown TS) is required for the loss of 132/33kV transformer & will supply one 33/11kV transformer.

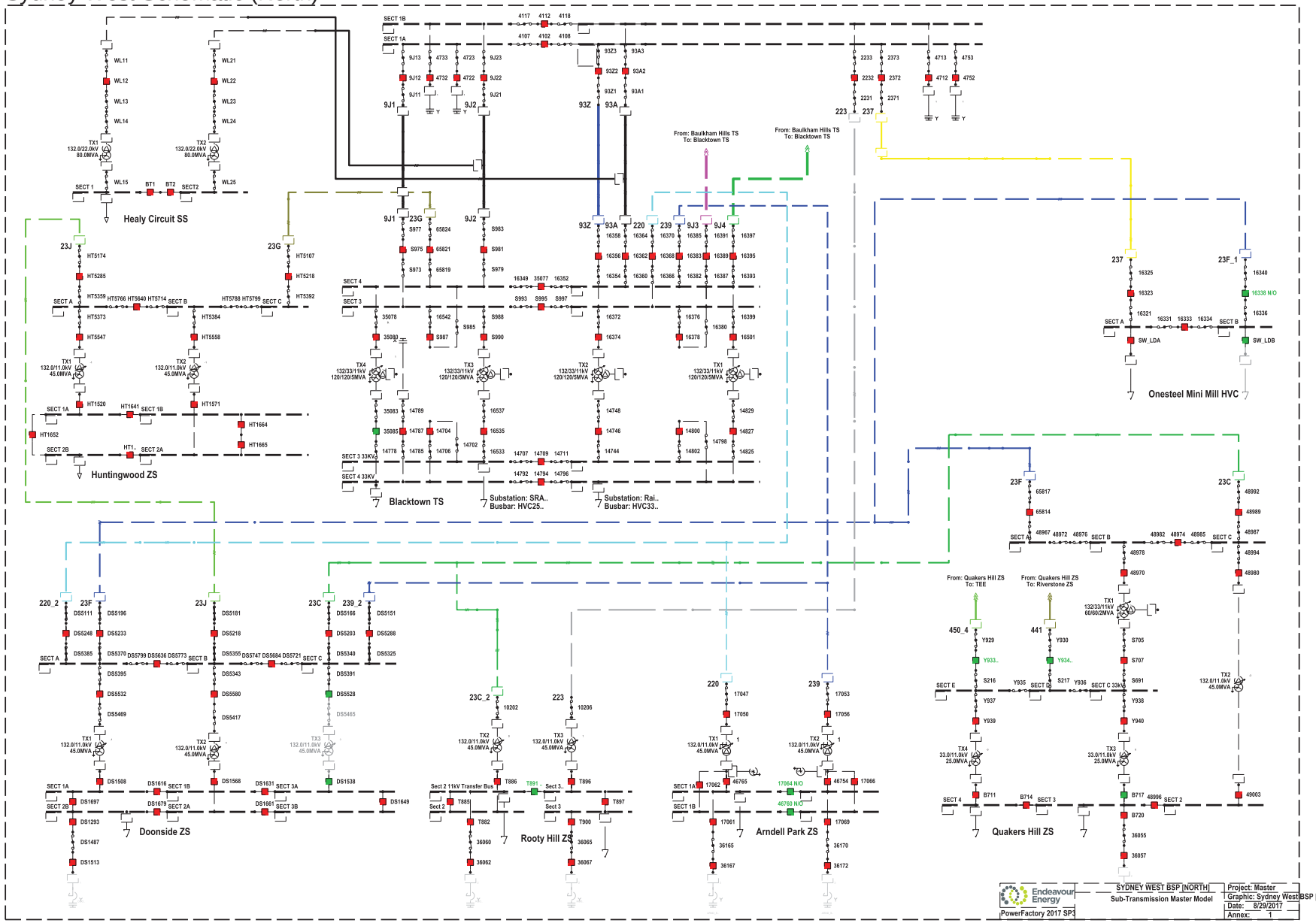
36.6 Sydney West Geographic (Development Extract)



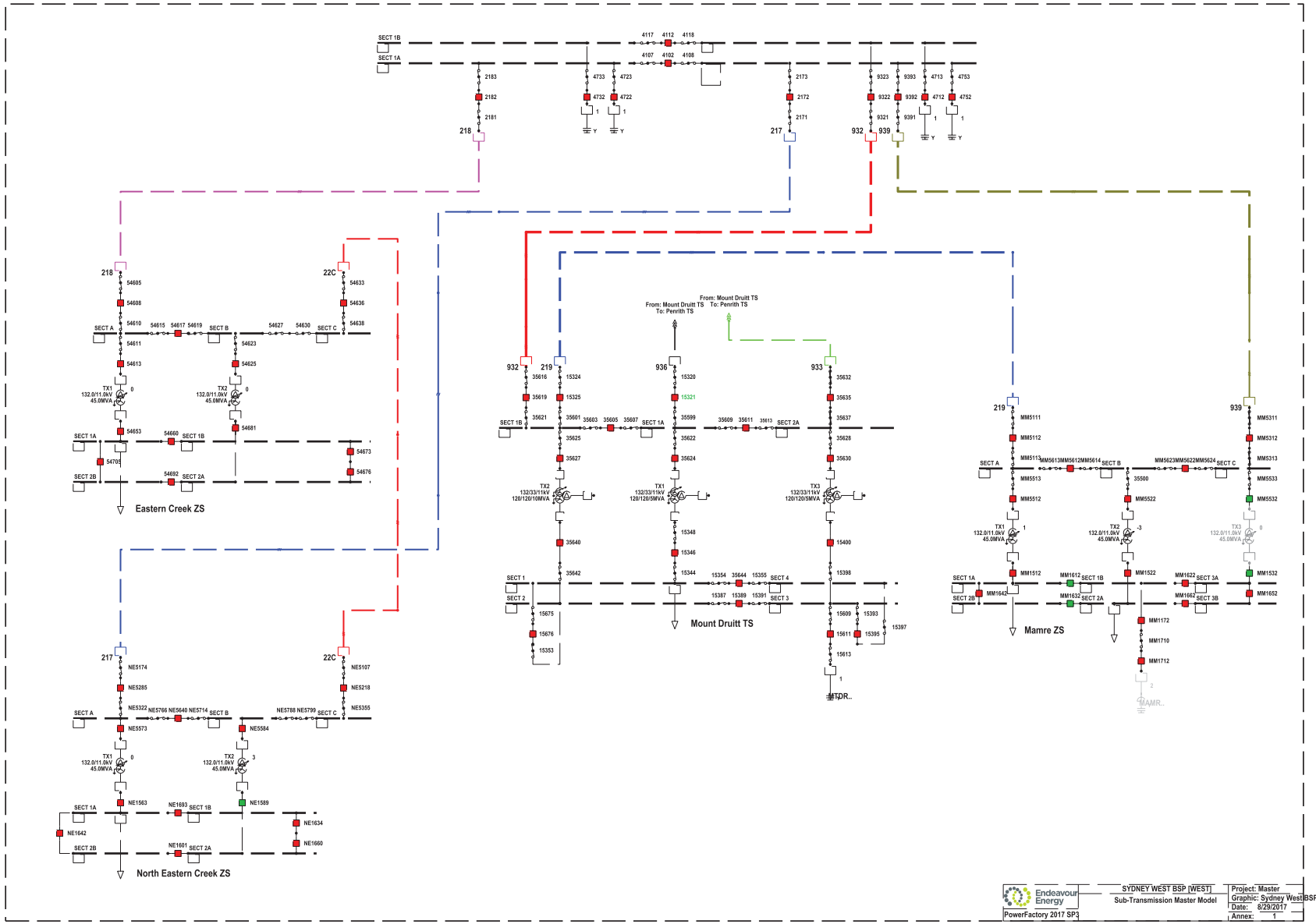
36.7 Sydney West Schematic (East)



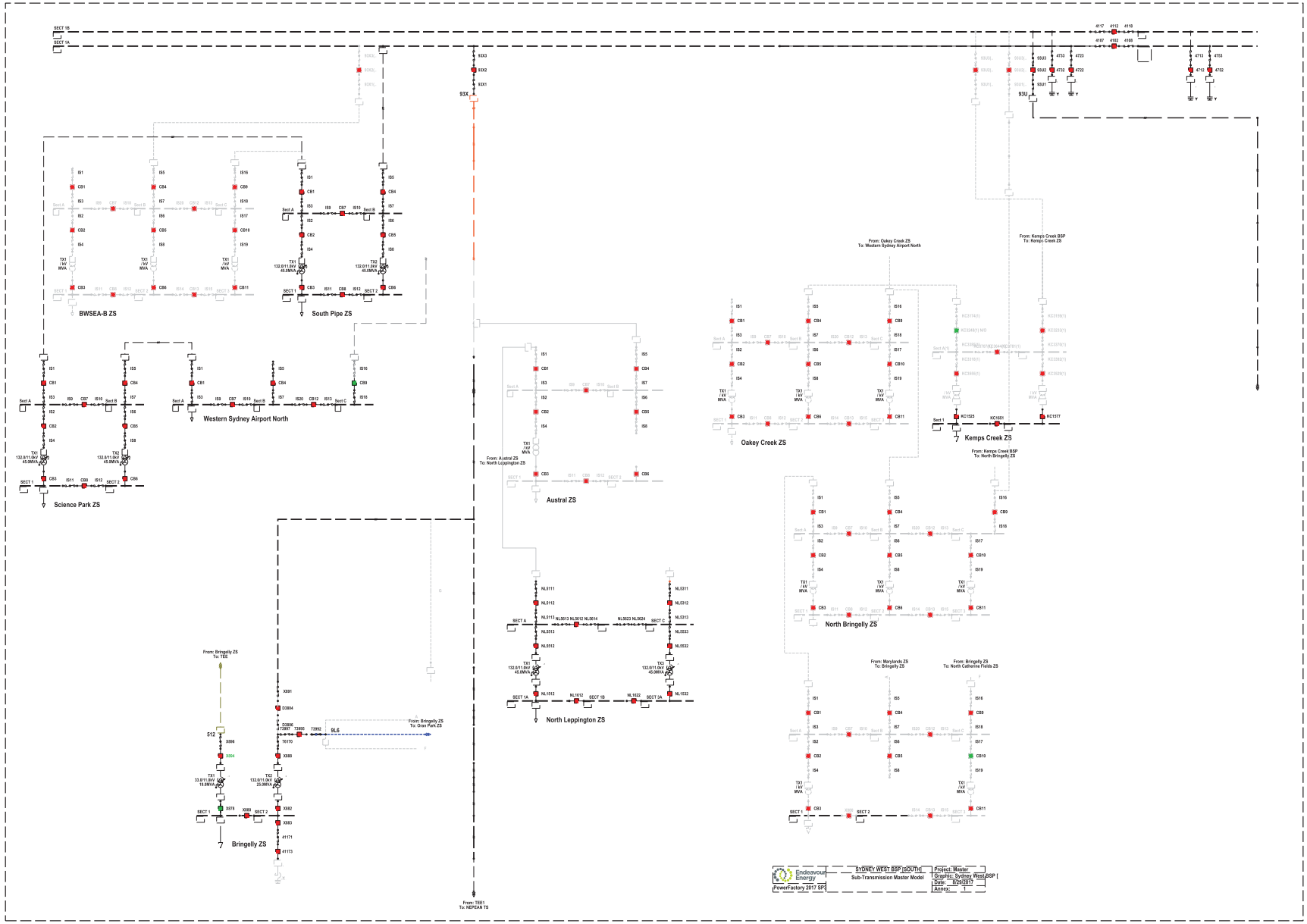
Sydney West Schematic (North)



36.8 Sydney West Schematic (West)



36.9 Sydney West Schematic (South)



37 VINEYARD BULK SUPPLY POINT

37.1 Vineyard Bulk Supply Point Transmission Network Status

Vineyard Bulk Supply Point is owned by TransGrid and has three 375 MVA 330/132kV transformers installed, providing firm capacity of 750MVA. Vineyard BSP supplies Endeavour Energy at 132kV.

The North West Sector Area Plan (April 2014) outlines the long term strategy to supply growth in the North West Growth Centre. The precincts considered in the Area Plan include Riverstone, Riverstone West, Riverstone East, Box Hill, Box Hill Industrial, Box Hill North and Vineyard. These new land release areas will require approximately 160MVA of capacity and necessitate the need for two additional zone substations. The report recommends additional zone substations in the Riverstone East and Box Hill precincts.

Vineyard BSP supplies Hawkesbury Transmission Substation via feeders 227 and 234. Hawkesbury TS has three 132/33kV 120MVA transformers. Additionally, Vineyard supplies 495MVA firm capacity to Rouse Hill switching station (SS) via high capacity feeders 9JA and 938. Rouse Hill SS supplies Bella Vista, Cheriton Avenue and West Castle Hill ZS's via Parklea ZS. Rouse Hill SS also directly supplies Mungerie Park ZS and Schofields ZS. Kellyville ZS 132/11/22kV conversion works have been deferred indefinitely as Mungerie Park ZS has significantly offloaded Kellyville ZS.

The 132kV feeder 212 from Baulkham Hills TS to Bella Vista is normally open and provides backup for a loss of 132kV feeders 214 or 215. The establishment of Cheriton Avenue ZS has offloaded West Castle Hill ZS and Castle Hill ZS. Schofields ZS has offloaded Riverstone ZS.

Recent asset relocation works have also been implemented on 132kV Feeder 230 between Parklea ZS and West Castle Hill ZS. The feeder was previously limited by the overhead sections to a summer rating of 84MVA. The majority of these sections have now been relocated underground with the exception of two spans passing over the new light rail, however, this section has been augmented to achieve a continuous summer rating of 145MVA and a contingency rating of 230MVA. Transmission ducts will be laid to facilitate the future relocation of the remaining section of overhead, should it be deemed cost effective. The resultant rating of a completely underground Feeder 230 would be 172MVA continuous.

Two 132kV feeders have been established in the greater Marsden Park area in recent times. Feeder 21L was established in 2016 providing radial supply via Schofields ZS to the temporary South Marsden Park ZS. 132kV feeder 21R has also recently been established, providing radial supply from Vineyard BSP to Marsden Park ZS Stage 1. Load at risk will be present at both new zone substations until PR292 South Marsden Park ZS Stage 2 is completed, establishing 132kV feeder 21J between Marsden Park ZS and South Marsden Park ZS. This project will also establish the permanent South Marsden Park ZS with a firm rating of 45MVA. These works are expected to be completed in 2020.

Major Project PR184 was originally earmarked for the establishment of an interim zone substation at Box Hill. However, due to the availability of capacity at Mungerie Park Zone Substation, it was deemed to be cost effective to defer the zone substation by extending the 22kV network into Box

Hill and converting the existing rural 11kV network in the area to 22kV. These conversion works were completed in early 2017. Options for the future 132kV feeder from Vineyard BSP to the proposed Box Hill ZS are being investigated.

The transmission analysis assumes that the following projects will be established by the associated completion date.

PR292 Establishment of South Marsden Park Stage 2 – 2020

Box Hill ZS has been included in the analysis as a spot load supplied directly from the Vineyard BSP 132kV busbar. The model will be refined in the coming years as the scope of the project materialises.

37.2 Vineyard Bulk Supply Point Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
Vineyard BSP	3 x 375 (330/132kV)	750	60	Nil
Hawkesbury TS	3 x 60/80/120 (132/33kV)	240	30	Nil
Parklea	3 x 30/35/45 (132/22kV)	90	5	2019
West Castle Hill	2 x 35/44/52 (132/11kV)	52	15	2024
Bella Vista	3 x 30/34/45 (132/11kV)	90	10	Nil
Mungerie Park	3 x 45 (132/22kV)	90	5	2026
Cheriton Ave	2 x 45 (132/11kV)	45	5	2026
Schofields	2 x 45 (132/11kV)	45	10	2021
Marsden Park	1 x 45 (132/11kV)	45 (non-firm)	0	Nil
South Marsden Park	2 x 45 (132/11kV)	45	0	Nil

37.3 Results Tables

37.3.1 Vineyard BSP Loads and Ratings Summary – Summer

Faulty ➔	Nil	213	214	215	216	21C	230	21F	21G	21M	21P	21R	21L	227	234	938	9JA	Rating	Year of Result
212: BAULKHAM HILLS TS to BELLA VISTA ZS	S/B																	172	S2026/27
213: PARKLEA ZS to BELLA VISTA ZS	101	x			63	113	172											172	S2026/27
214: PARKLEA ZS to ROUSE HILL SS	152		x	304														172	S2026/27
215: PARKLEA ZS to ROUSE HILL SS	152		304	x														172	S2026/27
216: BELLA VISTA ZS to CHERITON AVENUE ZS	38	65			x	50	108											172	S2026/27
21C: WEST CASTLE HILL ZS to CHERITON AVENUE ZS	14	112			50	x	59											172	S2026/27
230: PARKLEA ZS to WEST CASTLE HILL ZS	73	173			111	61	x											172[1]	S2026/27
21F: ROUSE HILL SS to SCHOFIELDS ZS	42							x	85			80	58					172	S2026/27
21G: ROUSE HILL SS to SCHOFIELDS ZS	42							85	x			80	58					172	S2026/27
21M: MUNGERIE PARK ZS to ROUSE HILL SS	53									x	105							172	S2026/27
21P: MUNGERIE PARK ZS to ROUSE HILL SS	53									105	x							172	S2026/27
21R: VINEYARD BSP to MARSDEN PARK ZS	72											x	40					145	S2026/27
21L: MARSDEN PARK ZS to STH MARSDEN PARK ZS	32											43	x					145	S2026/27
21J: SCHOFIELDS ZS to STH MARSDEN PARK ZS	S/B											71	30					145	S2026/27
227: VINEYARD BSP to HAWKESBURY TS	95													x	189			230[2]	S2026/27
234: VINEYARD BSP to HAWKESBURY TS	94													189	x			230[2]	S2026/27
938: VINEYARD BSP to ROUSE HILL SS	261											301	278			x	540	495	S2026/27
9JA: VINEYARD BSP to ROUSE HILL SS	261											301	278			540	x	495	S2026/27

Notes:

1. Contingency rating
2. Emergency rating

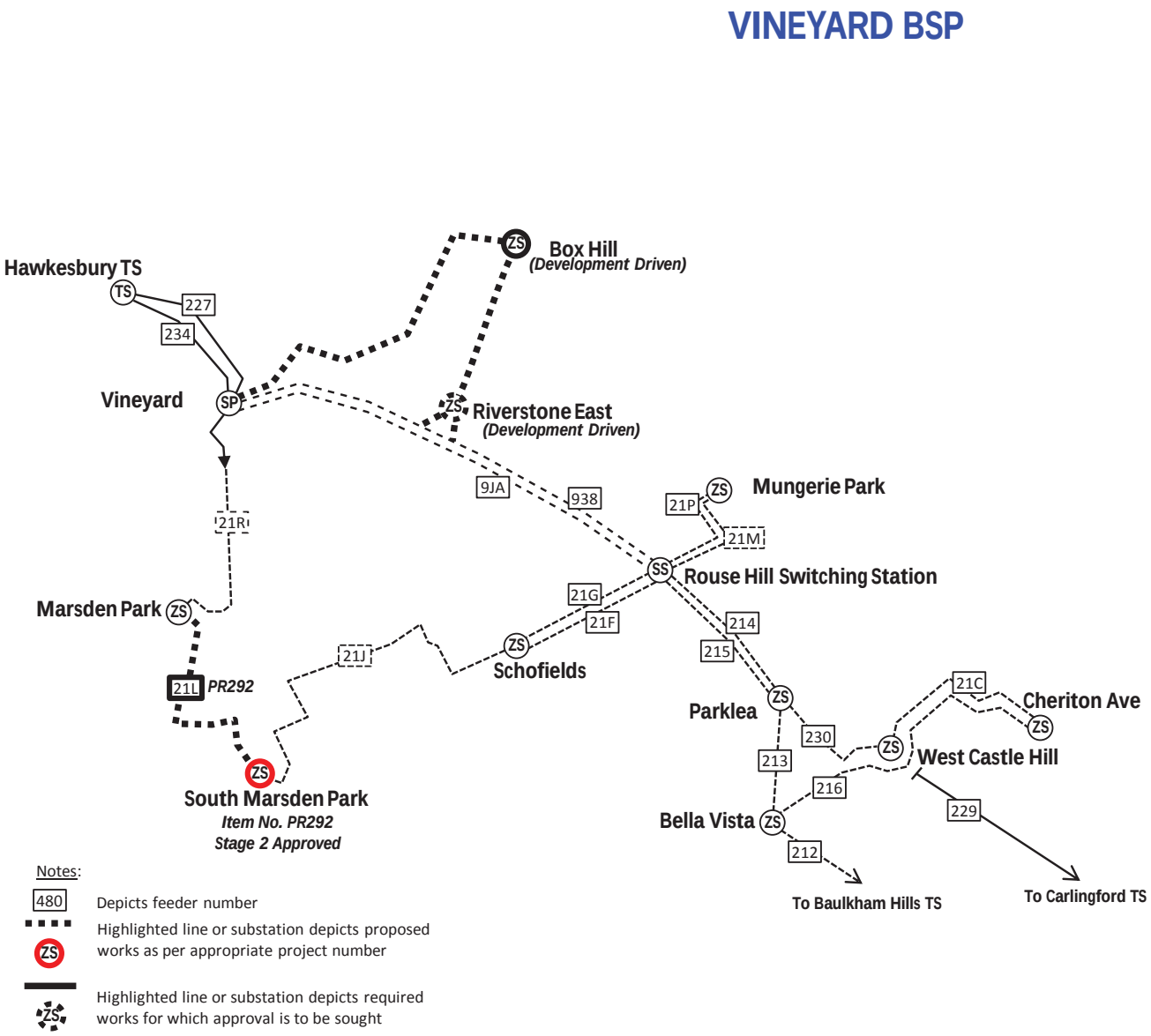
37.3.2 Vineyard Voltage Levels (Resultant Tap Position) Summary - Summer

Faulty -->	Nil	213	214	215	216	21C	230	21F	21G	21M	21P	21R	21L	234	227	9JA	938	Min Tap	Max Tap	Year of Result
Bella Vista	-5	-7	-6	-6	-6	-6	-5									-8	-8	-17	3	S2026/27
Parklea	-5	-5	-5	-5	-5	-5	-6									-7	-7	-19	5	S2026/27
Cheriton Ave	-3	-4	-3	-3	-3	-3	-3									-5	-5	-17	3	S2026/27
West Castle Hill	-4	-5	-4	-4	-4	-4	-4									-6	-6	-27	3	S2026/27
Schofields	-9							-10	-10							-12	-12	-17	3	S2026/27
Mungerie Park	-6									-6	-6					-8	-8	-17	3	S2026/27
Hawkesbury	-2													-2	-2	-2	-2	-12	4	S2026/27
South Marsden Park	1											-2	-1					-17	3	S2026/27
Marsden Park	0											-4	-2					-17	3	S2026/27

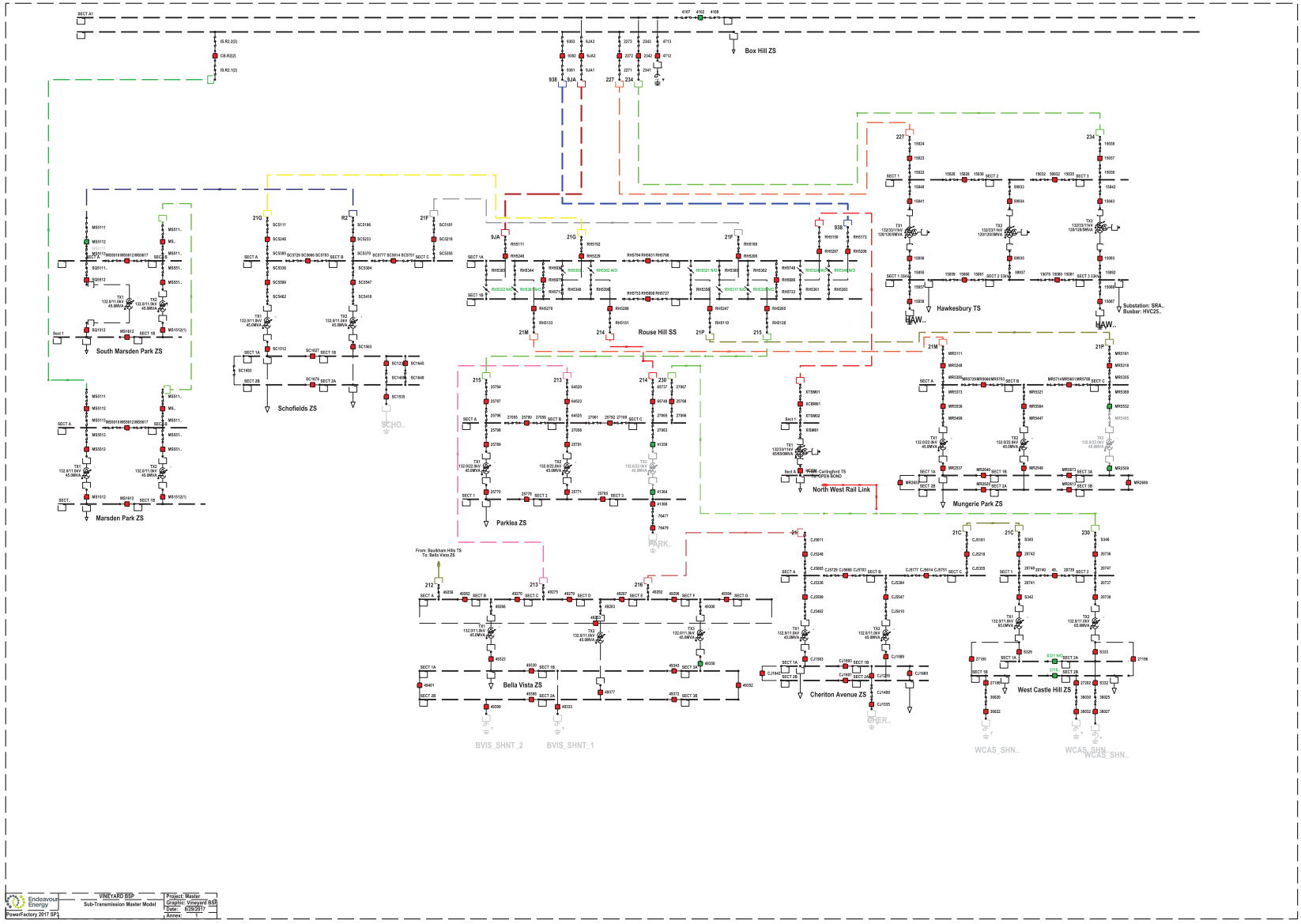
37.4 Analysis Results and Possible Solutions

Vineyard SP	Network Constraint	Year	Investigation	Solution
	Exceed firm rating of Parklea ZS	S2019	Conduct non-network option investigation. Investigate options to utilise available capacity at Bella Vista ZS.	Begin Investigation PR751
	Exceed firm rating of Schofields ZS	S2021	Continue to monitor lot releases uptake and load growth. Conduct non-network option investigation when required. Third power transformer may be required.	Continue to monitor
	Exceed firm rating of West Castle Hill ZS	S2024	Continue to monitor, conduct load transfer to Bells Vista ZS when required	Continue to monitor
	Exceed firm rating of Cheriton Avenue ZS	S2026	Continue to monitor, conduct load transfer to Castle Hill ZS when required	Continue to monitor PR729
	Exceed firm rating of Mungerie Park ZS	S2026	Continue to monitor, new zone substation in Riverstone East may allow for load transfer	Proposed Box Hill ZS
	Outage of either feeder 214 or 215 will result in overload of the other	Existing	Investigate schemes to allow overloading of remaining feeder during manual switching or implement automation scheme to offload remaining feeder. Investigate reinstatement of feeder 229 to increase contingency capacity from Sydney West via Baulkham Hills.	PR732
	Outage of either feeder 9JA or 938 will result in overload of the other	S2025	Solution to previous constraint will mitigate this	PR732
	Outage of either feeder 213 or 230 will result in overload of the other	S2027	Solution to previous constraint will mitigate this	PR732

37.5 Vineyard Geographic



37.6 Vineyard Schematic



38 WALLERAWANG 66KV BULK SUPPLY POINT

38.1 Wallerawang BSP 66kV Subtransmission Network Status

Wallerawang 66kV Bulk Supply Point is owned by TransGrid and provides supply to both Endeavour Energy and Essential Energy at 66kV, as well as at 132kV via the 132kV bulk supply point. The 132kV busbar at Wallerawang is supplied via two 330/132kV 375MVA transformers, which in turn supply the 66kV busbar through two 132/66kV 60MVA transformers. The Transgrid owned Wallerawang 66kV busbar is floated at 66kV.

Wallerawang 66kV BSP supplies Portland Zone Substation via feeder 823. Portland ZS is on changeover to Mt Piper 66kV BSP via feeder 828. It also supplies Lithgow ZS and Meadow Flat ZS.

Springvale Colliery is normally supplied from Wallerawang 66kV BSP on feeder 85Y. The alternate supply is from Mt Piper 66kV BSP via Blackmans Flat ZS, on feeder 811. Feeder 85Y from Wallerawang 66kV BSP was formerly part of feeder 811, which used to supply out to the collieries and Hartley Vale ZS, prior to establishment of Mt Piper 66kV BSP.

Clarence Colliery and Hartley Vale ZS are normally supplied from MtPiper 66kV BSP, via the Blackmans Flat ZS 66kV busbar on feeder 811. Hartley Vale ZS can be backed up by the Sydney Trains system on feeder 873 (ex - Lawson TS), for an outage of feeders 811 or 812 from Blackmans Flat. However, this requires manual switching and coordination with Sydney Trains.

An outage of feeder 817 Wallerawang 66kV BSP to Meadow Flat ZS, requires Meadow Flat ZS to be supplied on the 11kV network from Portland ZS and Lithgow ZS.

38.2 Wallerawang BSP 66kV Network Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Limitation (Year)
Wallerawang BSP (66kV)	2 x 60	60		Nil
Lithgow	2 x 30	30		Nil
Meadow Flat	1 x 2.5	Non-firm		Nil
Portland	2 x 10	10		Nil

38.3 Results Tables

38.3.1 Wallerawang TS Loads and Ratings – Winter Summary

Faulty ➔	Nil	857	85X	*811	85Y	823	Rating	Year of Result
857: WALLERAWANG TS to LITHGOW ZS	10	X	17				45	W 2026
85X: WALLERAWANG TS to LITHGOW ZS	8	17	X				40	W 2026
85Y: WALLERAWANG TS to TEE	6			32	X		80	W 2026
85Y: TEE to SPRINGVALE COLLIERY HVC	6			6	6		80	W 2026
85Y: SPRGVL CLLRY TEE to BLCKMNS FLT TEE	S/B			26	6		80	W 2026
817: WALLERAWANG TS to MEADOW FLAT ZS	1						29	W 2026
823: WALLERAWANG TS to PORTLAND ZS	3					X	27	W 2026

* Fault condition assumes Blackmans Flat ZS cannot supply feeder 811, and feeder 811 is operational from Wallerawang TS

38.3.2 Wallerawang TS Voltage Tap Positions and Tapping Steps – Winter Summary

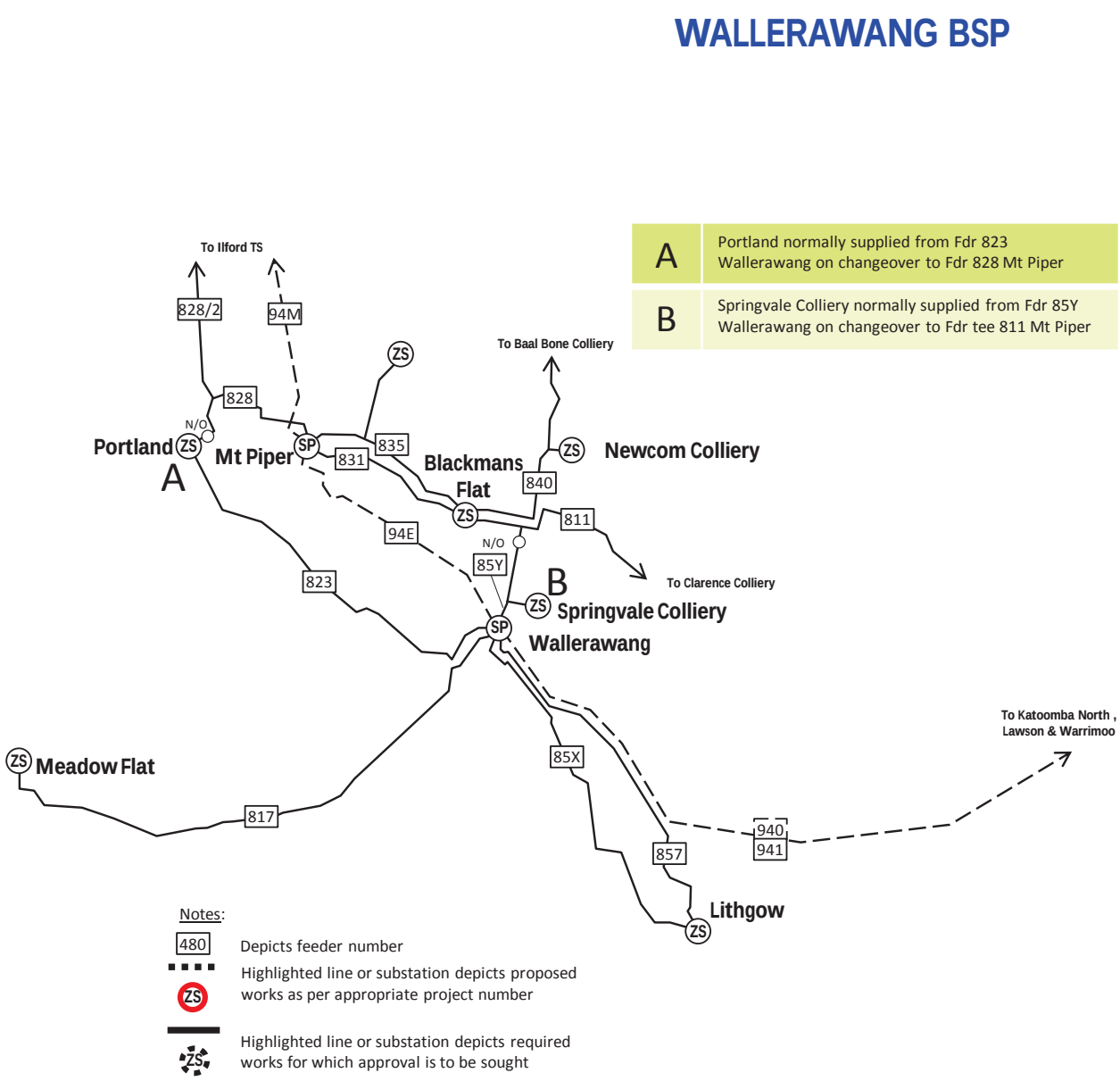
Faulty ➔	Nil	857	85X	811	85Y	823	Min Tap	Max Tap	Year of Result
Lithgow	-2	-3	--3	-3	-2	-2	-14	7	W 2026
Meadow Flat	---1						-14	7	W 2026
Portland	-2					1	-14	7	W 2026

38.4 Analysis Results

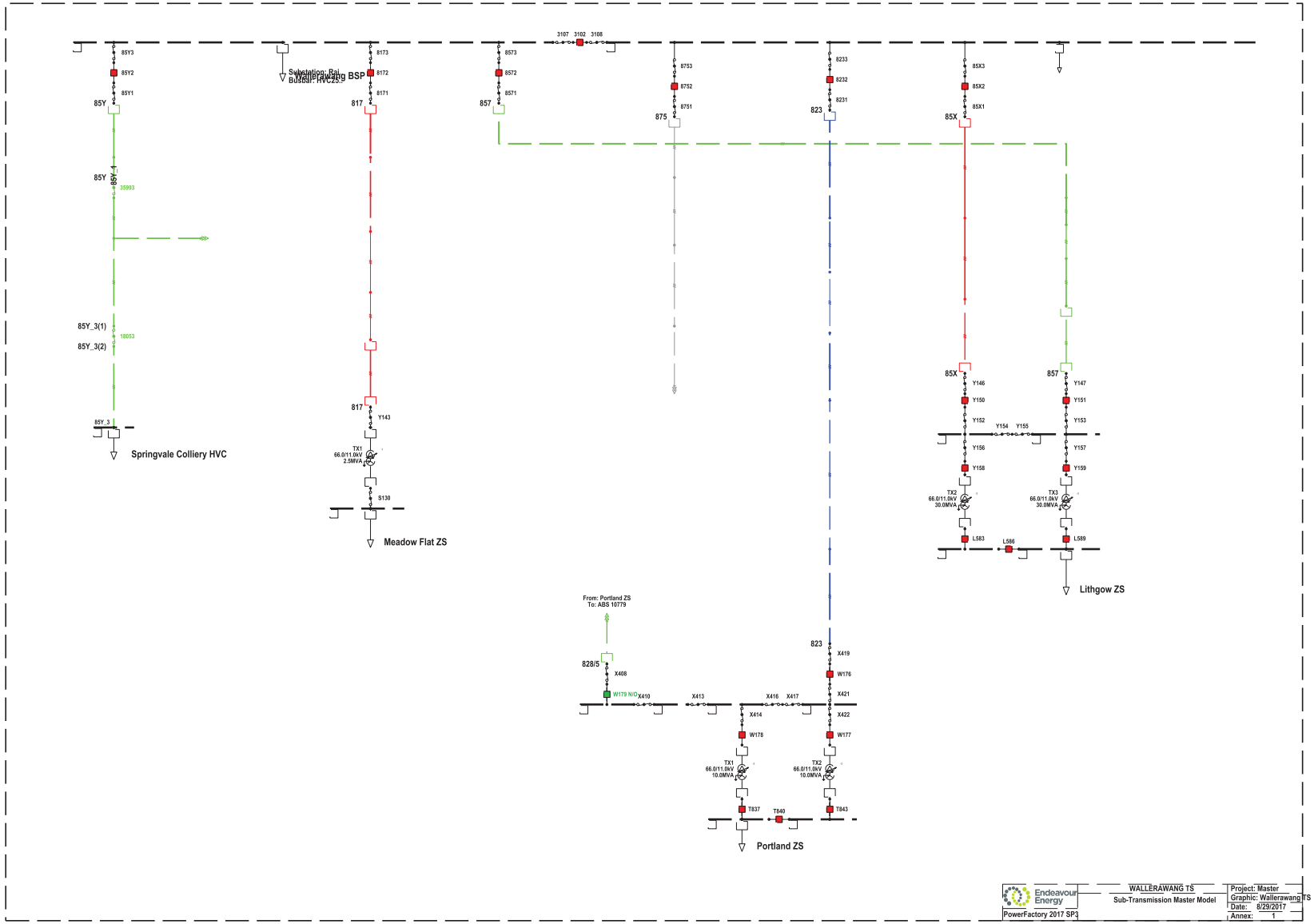
- The Wallerawang 66kV system is winter peaking.
- Load levels on all feeders are within the line ratings for this review period.
- Voltage levels at all substations are within the tapping ranges for this review period.

Wallerawang 66 SP	Network Constraint	Year	Investigation	Solution
	NIL			

38.5 Wallerawang 66kV Geographic



38.6 Wallerawang 66kV Schematic



39 WALLERAWANG 132KV BULK SUPPLY POINT

39.1 Wallerawang BSP 132kV Subtransmission Network Status

Wallerawang 132kV Bulk Supply Point (BSP) is owned by TransGrid and provides supply to both Endeavour Energy and Essential Energy, at both 66kV and 132kV. The 132kV busbar is supplied via two 330/132kV 375MVA transformers, which in turn supply the 66kV busbar through two 132/66kV 60MVA transformers. The Wallerawang 132kV system is winter demand peaking and is floated at 132kV.

Wallerawang 132kV BSP supplies Lawson Transmission Substation (TS) on feeder 941 and is on changeover to Regentville BSP, via feeder 942 from Penrith TS. It also supplies Katoomba North TS, Mt Piper 66kV BSP and Ilford 66kV TS. Katoomba North TS is supplied from Wallerawang 132kV BSP on feeders 940 and 941. Both feeders are teed off and tail ended to two 60MVA 132/66kV transformers.

Regentville BSP supplies Warrimoo TS via feeder 93E from Penrith TS. Warrimoo is on changeover to feeder 940 from Wallerawang BSP. The 132kV network cannot be run solid between Wallerawang and Regentville, via either Lawson or Warrimoo, as a possible abnormal operational contingency on TransGrid 330kV network could overload the 132kV network.

39.2 Wallerawang BSP 132kV Network Substation Rating Details

Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Limitation (Year)
Wallerawang BSP	2 x 375	375		Nil
Katoomba North	2 x 60	60		Nil
Lawson	2 x 52	52		Nil
Wallerawang 66kV	2 x 60	60		Nil

39.3 Results Tables

39.3.1 Wallerawang BSP Load and Ratings – Winter Summary

Faulty ➔	^^ Nil	940	93E	**93E	*Rating	Year of Result
940: WALLERAWANG BSP to TEE	32	X	76	42	148	W 2026
940: TEE to KATOOMBA NORTH TS	33	X	34	S/B	184	W 2026
940: TEE to WARRIMOO TS	S/B	X	44	42	119	W 2026
941: WALLERAWANG BSP to TEE	25	58	25	58	148	W 2026
941: TEE to LAWSON TS	25	26	25	26	161	W 2026
941: TEE to KATOOMBA NORTH TS	S/B	32	S/B	32	161	W 2026

Notes:

* Feeders 940 & 941 are limited by rating of CT 110MVA.

**Feeder 940 is supplying Warrimoo TS, feeder 941 is supplying Katoomba North TS and Lawson TS.

^^Refer to Regentville BSP section of report for outage of 941 (Lawson TS supplied via 942 from Penrith TS and Katoomba North TS supplied as above).

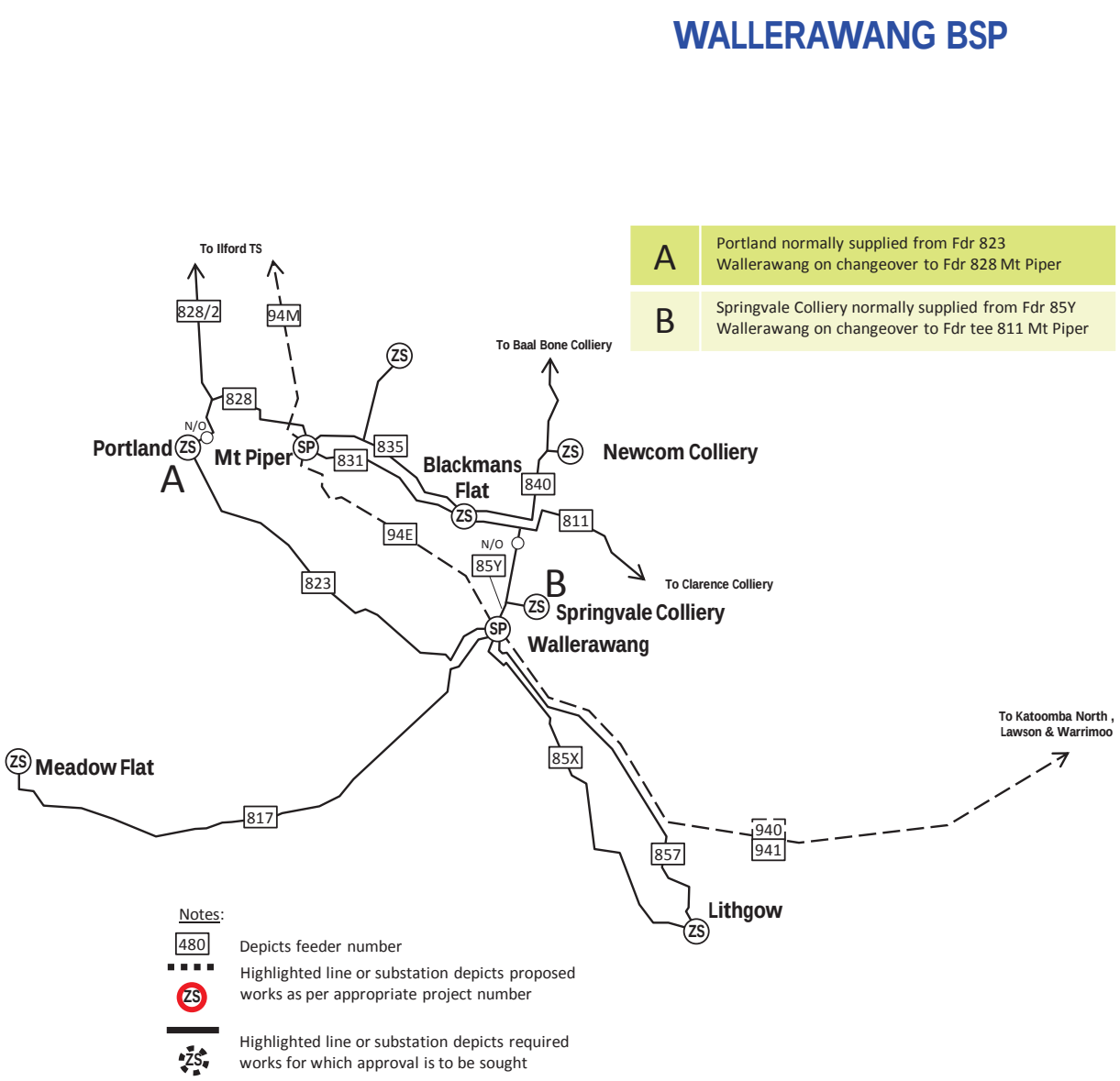
39.3.2 Wallerawang BSP Voltage Levels (Resultant Tap Position) – Winter Summary

Faulty ➔	Nil	940	93E	**93E	Min Tap	Max Tap	Year of Result
Katoomba North 1	-4	x	-4	x	-12	4	W 2026
Katoomba North 2	S/B	-4	x	-2	-16	4	W 2026
Lawson	-2	-3	-3	-3	-12	4	W 2026
Warrimoo			0	0	-12	4	W 2026

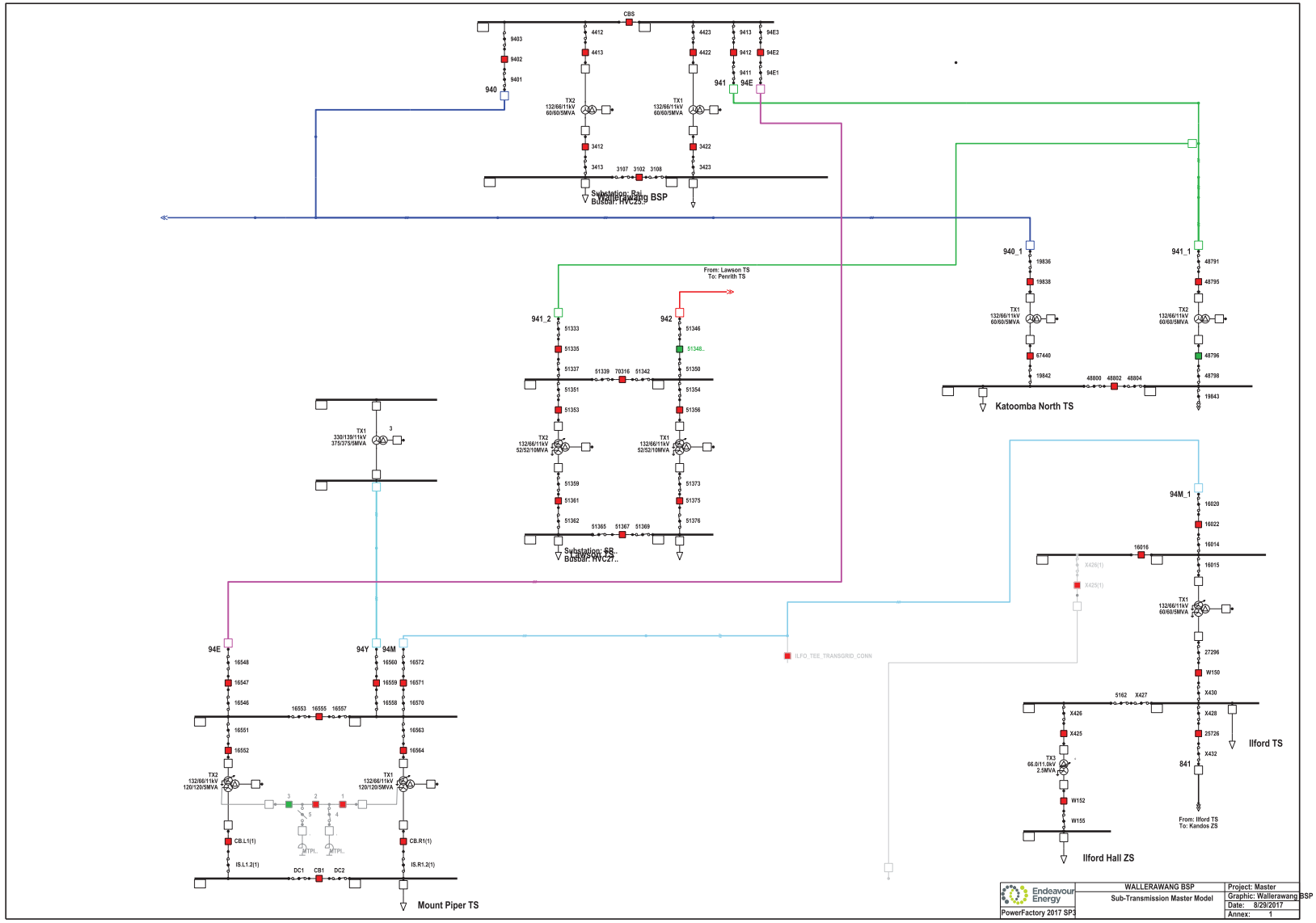
39.4 Analysis Results and Possible solutions

Wallerawang 66 SP	Network Constraint	Year	Investigation	Solution
	NIL			

39.5 Wallerawang 132kV Geographic



39.6 Wallerawang 132kV Schematic



40 WARRIMOO TRANSMISSION SUBSTATION

40.1 Warrimoo Transmission Network Status

Regentville Bulk Supply Point supplies Warrimoo Transmission Substation via 132kV feeder 93E from Penrith TS. The substation back up is via feeder 940 tee from Wallerawang BSP (Katoomba North TS).

Warrimoo TS has two 60MVA 132/66/kV auto-transformers, providing a firm capacity of 60MVA. There is no provision for additional transformers. Warrimoo TS is floated at 67kV. The Warrimoo 66kV transmission network supplies Blaxland Zone Substation (ZS) on tail-ended transformers via feeders 822 and 827, which are operated on no-volt change over, on a roster basis; it also supplies Springwood ZS via feeder 824.

Warrimoo TS provides backup to Lawson TS via feeders 824 and 808. Feeder 826 from Lawson TS normally supplies Hazelbrook ZS. Lawson TS provides backup to Springwood ZS via feeders 826 and 808 from Hazelbrook ZS.

Stage 1 of project PR136, the augmentation of 66kV feeder 808 has been completed and Stage 2 has been indefinitely deferred due to lower demand. If Stage 2 is completed, feeder 808 will have the capacity to provide mutual backup between Lawson and Warrimoo and supply the forecast load of both Hazelbrook and Springwood, from either transmission substation. Otherwise the existing feeder 808 capacity will still allow for this arrangement, but there will be a small load at risk over summer when supplying Springwood from Lawson TS.

There are no incomplete approved projects to consider within the Warrimoo TS area.

40.2 Warrimoo Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVA)	Transformer Limitation (Year)
Warrimoo TS	2 x 60	60		Nil
Blaxland	2 x 35	35	5	Nil
Springwood	2 x 35	35		Nil

40.3 Results Tables

40.3.1 Warrimoo TS Loads and Ratings – Summer Summary

Faulty ➔	Nil	827	824	826	Rating	Year of Result
827: WARRIMOO TS to BLAXLAND ZS	21	X			42	S 2026/27
822: WARRIMOO TS to BLAXLAND ZS	S/B	21			30	S 2026/27
824: WARRIMOO TS to SPRINGWOOD ZS	23		X	32	45	S 2026/27
808: SPRINGWOOD ZS to HAZELBOOK ZS	S/B		24	9	22	S 2017/18

40.3.2 Warrimoo TS Voltage Levels (Resultant Tap Position) –Summer Summary

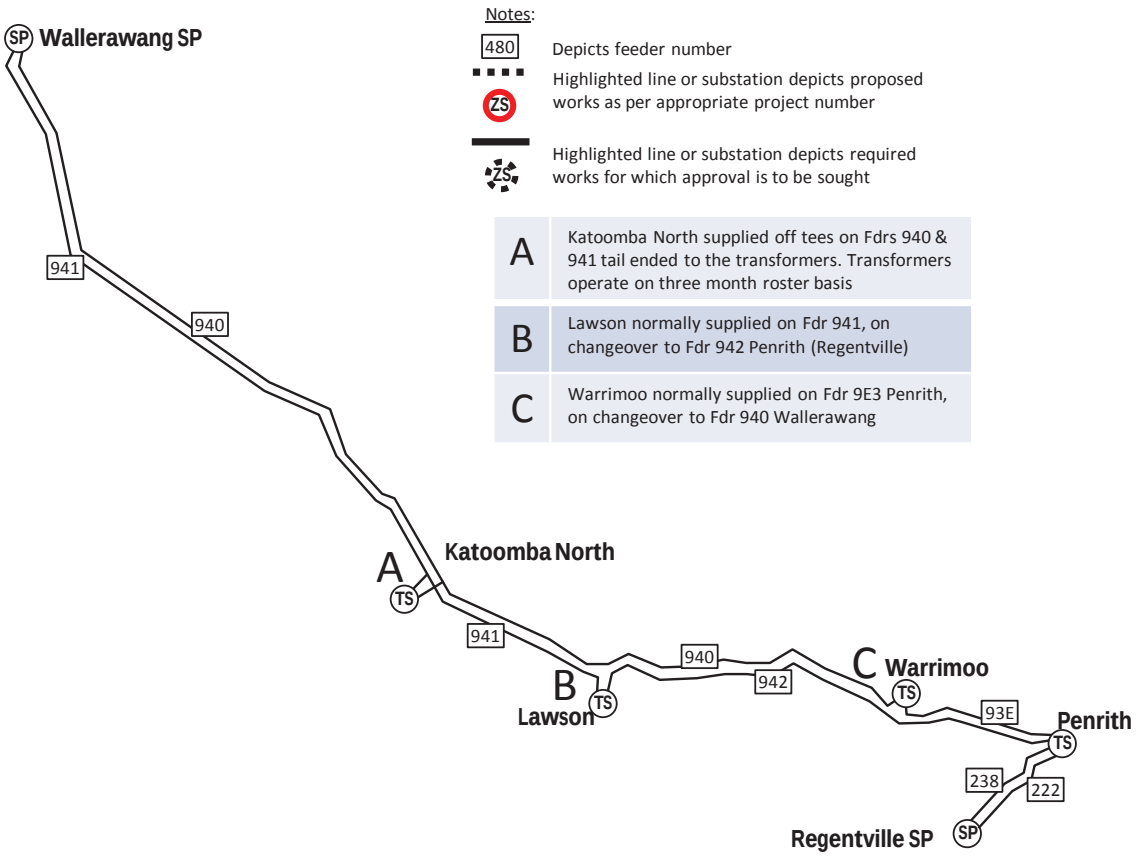
Faulty ➔	Nil	827	824	826	Min Tap	Max Tap	Year of Result
Blaxland 2	1	0	x	x	-14	7	S 2026/27
Blaxland 3	-2	x	-2	-2	-14	7	S 2026/27
Springwood	-1	-1	-2	-1	-14	7	S 2026/27
Hazelbrook				0	-14	7	S 2026/27

40.4 Analysis Results and Possible solutions

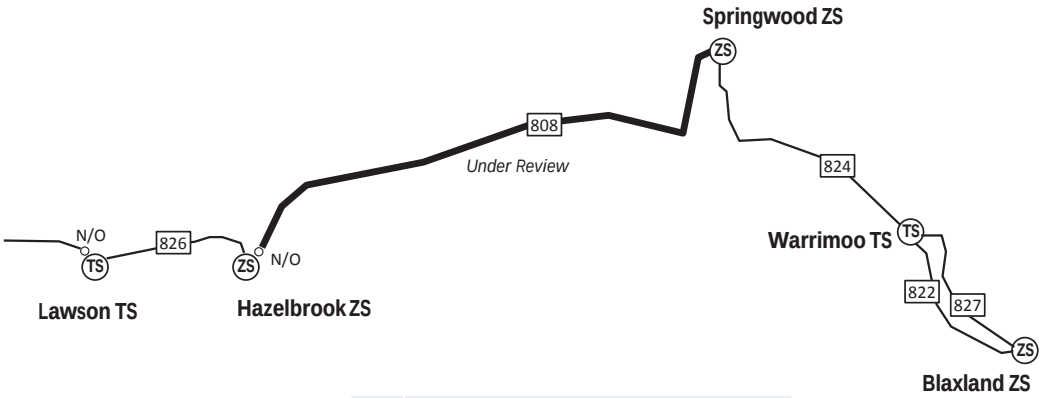
Warrimoo	Network Constraint	Year	Possible Solution	Solution
	Thermal capacity of standby feeder 808 is exceeded during outage of Feeder 824.	S 2017/18	Project PR136 Stage 2 augmentation of the remainder of Feeder 808 had been deferred. This was due to the summer demand reduction at Springwood ZS. Actual load data show the risk has increased since last year's analysis; There is some 11kV emergency transfer capability available.	Investigate activating Stage 2 of PR136.

40.5 Warrimoo Geographic

WARRIMOO TS/1



WARRIMOO TS/2



A	Hazelbrook normally supplied from Fdr 826 Lawson on changeover to Fdr 808 Warrimoo

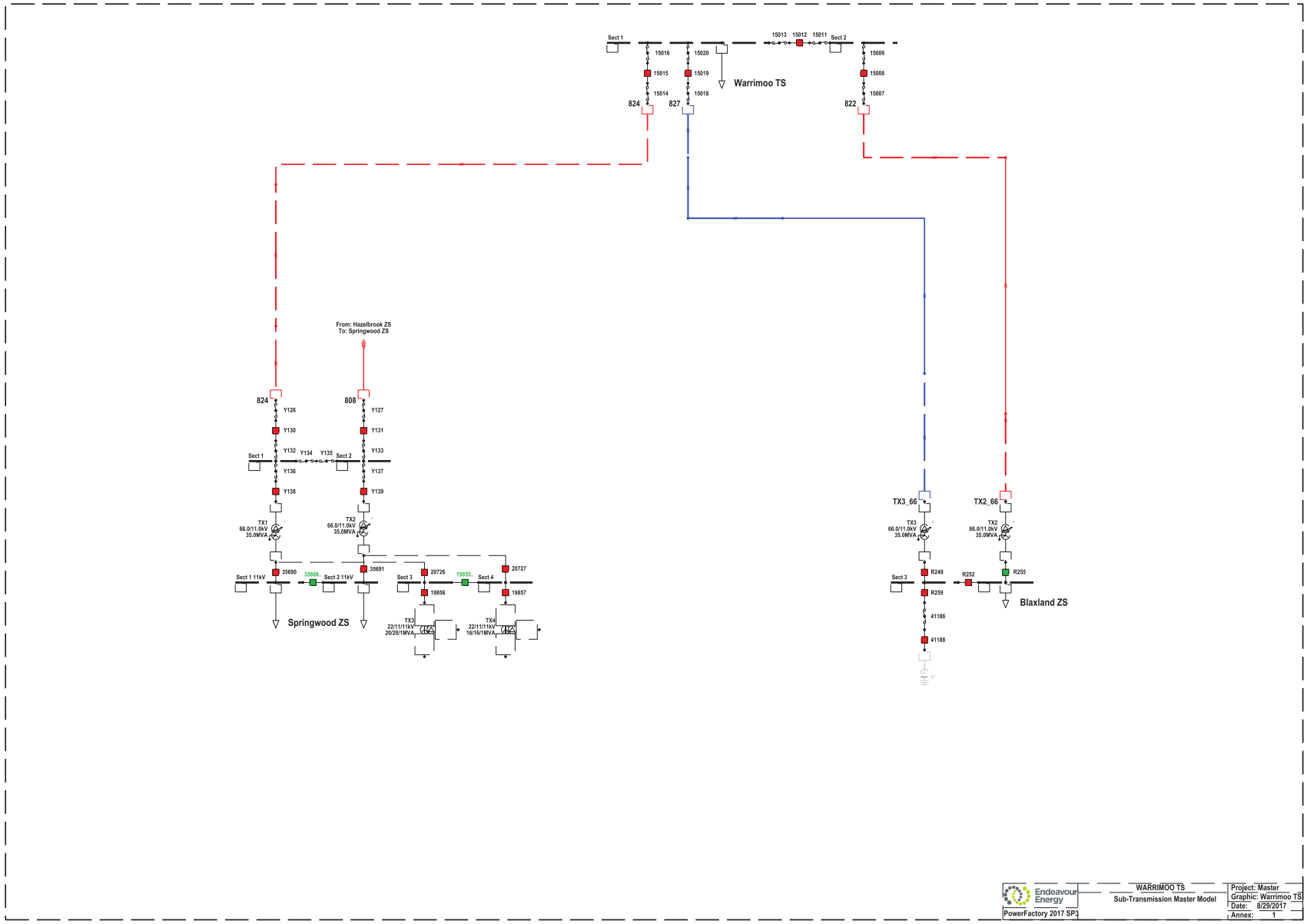
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

40.6 Warrimoo Schematic



41 WEST LIVERPOOL TRANSMISSION SUBSTATION

41.1 West Liverpool Transmission Substation Status

West Liverpool TS is supplied from TransGrid's Liverpool Bulk Supply Point at 132kV by three 375MVA tail-ended transformers and feeders 93B, 93N and 93R. Mutual backup is provided between Sydney West BSP and West Liverpool TS by 132kV feeders 93U and 93W via Abbotsbury ZS.

There are three 120MVA 132/33kV transformers providing a firm capacity of 240MVA at a float voltage of 34kV. West Liverpool TS and Liverpool TS provide mutual back-up to each other via two 33kV standby feeders 504 & 508.

Since Macarthur BSP was commissioned in 2014, 132kV feeder 93Y from West Liverpool TS provides back-up to Nepean TS via Denham Court TS.

Bringelly ZS is normally supplied by 132kV feeder 93X from Sydney West and is on auto-changeover to 33kV feeder 512 from West Liverpool TS. Luddenham ZS is normally supplied by feeder 464 from Glenmore Park ZS and is on auto-changeover to feeders 465 and 512 from West Liverpool TS via Kemps Creek ZS. Kemps Creek ZS is normally supplied by feeder 512 from West Liverpool TS and is on auto-changeover to feeder 465 from Glenmore Park ZS via Luddenham ZS. Cabramatta ZS is normally supplied by feeder 687 from Guildford TS and is on auto-changeover to feeder 68C from West Liverpool TS via Homepride ZS.

Edmondson Park ZS will be seasonally supplied from West Liverpool TS via Prestons ZS with back-up from Denham Court TS or from Denahm Court TS with back-up from West Liverpool via Prestons ZS.

The transmission network analysis was carried out with all approved major projects within the forecast period assumed to be completed.

41.2 West Liverpool Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Substation Capacity Constraint (Year)
West Liverpool TS	3 x 120	360	62	Nil
Bonnyrigg	3 x 35	70	10	Nil
Canley Vale	3 x 25	50	5	Nil
Casula	2 x 35	35	0	Nil
Hinchinbrook	3 x 25	50	0	Nil
Edmondson Park	2 x 35	35	0	Nil
Homepride	3 x 25	50	5	Nil
Kemps Creek	2 x 25	25	5	Nil
Prestons	3 x 25	50	5	Nil
West Liverpool 11kV	3 x 35	70	5	Nil

41.3 Results Tables

41.3.1 West Liverpool TS Demands and Rating Summary – Summer

Faulty ➔	Nil	T5	T6	T7	525	527	524	505	511	626	503	514	523	509	517	687	93G	464	T2 Bringelly	Rating	Year of Result
T5 West Liverpool TS to West Liverpool ZS	22	X	22	22																50	2026/27
T6 West Liverpool TS to West Liverpool ZS	A/S	22	X	22																50	2026/27
T7 West Liverpool TS to West Liverpool ZS	22	22	22	X																50	2026/27
525 West Liverpool TS to Hinchinbrook	26				X	51														68	2026/27
527 West Liverpool TS to Hinchinbrook	26				51	X														68	2026/27
524 West Liverpool TS to Prestons	18						X	32	31	31										68	2026/27
505 West Liverpool TS to Tee	13						32	X	36	23										42	2026/27
505 Tee to Prestons	13						32	X	2	23										68	2026/27
505 Tee to Casula	A/S						S/B	X	35	S/B										42	2026/27
625 Prestons to Edmondson Park	A/S						A/S	A/S	X	23										50	2026/27
626 Denham Court to Edmondson Park	23						23	23	23	X										50	2026/27
503 West Liverpool TS to Bonnyrigg	20										X	36	34							42	2026/27
514 West Liverpool TS to Bonnyrigg	16										36	X	28							42	2026/27
522 Bonnyrigg to Canley Vale	A/S												26							34	2026/27
509 West Liverpool TS to Homepride	25													X	28	36				42	2026/27
517 West Liverpool TS to Homepride	17													28	X	25				36	2026/27
68C Homepride to Cabramatta	A/S													15	15	18				42	2026/27
512 West Liverpool TS to Kemps Creek Tee Bringelly	25																	43	39	36/45^	2026/27
512 Tee to Kemps Creek	25																	**26**	**25**	21	2019/20
512 Tee to Bringelly	A/S																		12	42	2026/27
504 West Liverpool TS to Liverpool TS	S/B																40			42	2026/27
508 West Liverpool TS to Liverpool TS	S/B																40			42	2026/27

^ Contingency rating

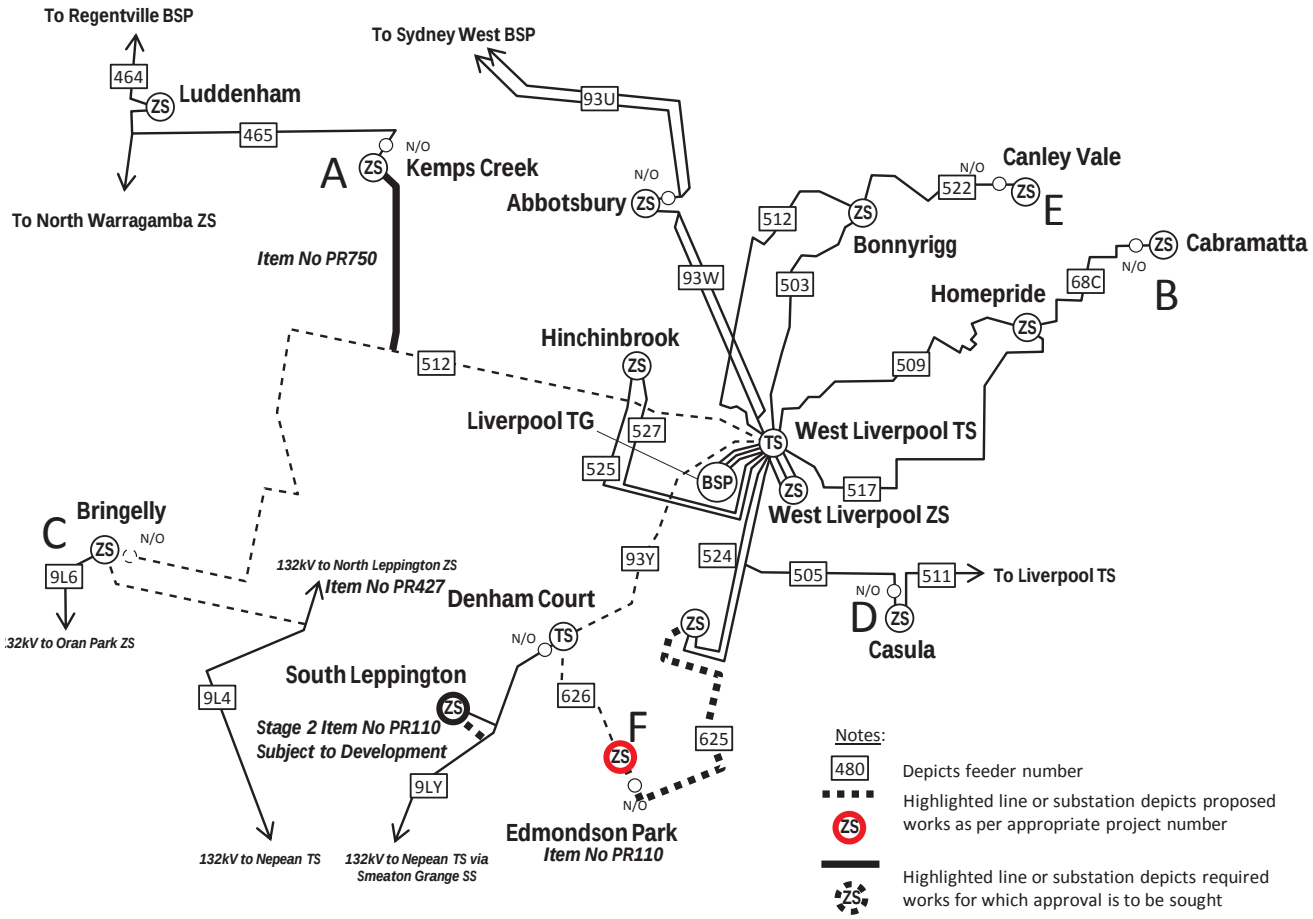
41.3.2 West Liverpool TS Voltage Levels Summary - Summer

Faulty ➔	Nil	T5	T6	T7	525	527	524	505	511	503	514	523	509	517	687	626	93X	Min Tap	Max Tap	Year of Result
Bonnyrigg	1									1	1	1						-14	7	2025/26
Bringelly	0																-1	-14	7	2025/26
Cabramatta	-3														-2			-14	7	2025/26
Canley Vale	0											-2						-14	7	2025/26
Casula	-2								-1									-14	7	2025/26
Edmondson Park	-3															-3		-14	7	2025/26
Hinchinbrook	-1				-1	-1												-14	7	2025/26
Homepride	-2												-2	-1	-2			-14	7	2025/26
Kemps Creek	0																-2	-14	7	2025/26
Prestons	0						-1	-1	1							0		-14	7	2025/26
West Liverpool ZS	-1	-1	-1	-1														-14	7	2025/26

41.4 Analysis Results with Possible Solutions

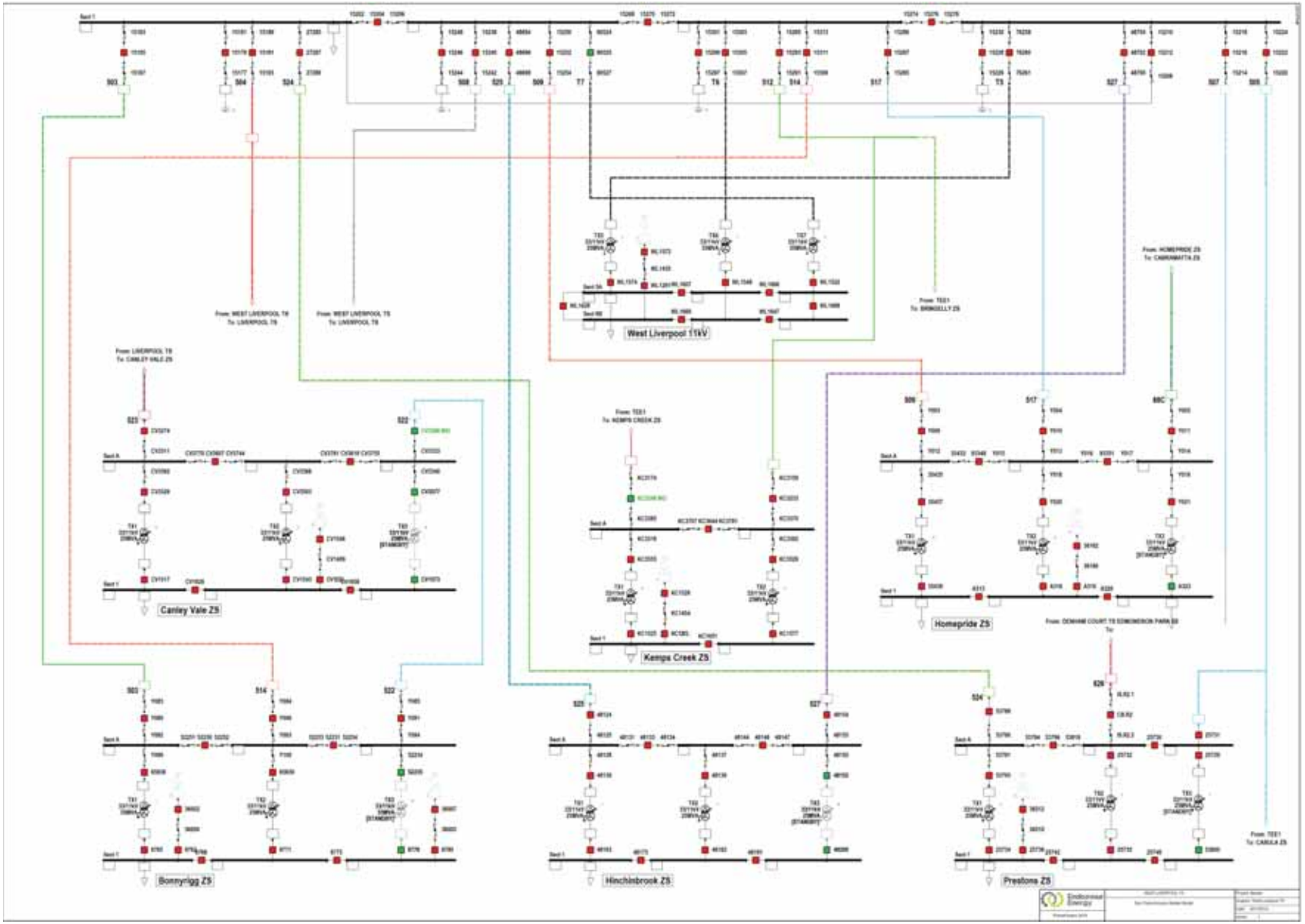
West Liverpool	Network Constraint	Year	Investigation	Solution
	Outage of 464 to Luddenham ZS overloads 512 tee to Kemps Creek ZS	2019/20	Augment 512 tee to Kemps Creek ZS	Augment 3500m of OH conductor along Devonshire Rd from tee-off to Kemps Creek ZS
	512 Tee to Kemps Creek is overloaded under system normal conditions	2022/23		PR750

41.5 West Liverpool Geographic



A	Kemps Creek is normally supplied by Fdr 512 West Liverpool on changeover to Fdr 465 Luddenham
B	Cabramatta is normally supplied by Fdr 687 Guildford on changeover to Fdr 68C Homepride
C	Bringelly is normally supplied by Fdr 9L4 (132kV) on changeover to Fdr 512 (33kV) West Liverpool
D	Casula is normally supplied by Fdr 511 Liverpool on changeover to Fdr 505 West Liverpool
E	Canley Vale is normally supplied by Fdr 523 Liverpool on changeover to Fdr 522 Bonnyrigg.
F	Edmondson Park is normally supplied by Fdr 626 Denham Court TS on changeover to Fdr 625 Prestons

West Liverpool Schematic



42 WEST TOMERONG TRANSMISSION SUBSTATION

42.1 West Tomerong Transmission Network Status

West Tomerong TS is located off Blackbutt Range Road Tomerong within the easement of 132kV line 98P (formerly 98M/1) and was commissioned in various stages throughout 2014. It is supplied from Dapto BSP via Mount Terry TS 132kV feeders 98L and 98U and subsequently supplied via Shoalhaven TS feeder 98P. A 132kV closed loop is provided through line 28P (West Tomerong to Evans Lane) and 98J (Shoalhaven to Evans Lane). Refer to the Dapto BSP chapter and Geographic drawing for details. West Tomerong TS has two 60MVA 132/33kV transformers providing a firm rating of 60MVA. The substation is floated at 33kV with 6.5% LDC at 60MVA. Off Peak hot water is controlled by 33kV AFIC equipment at 283Hz.

The West Tomerong 132kV busbar also forms part of the supply chain through Evans Lane Switching Station to Ulladulla as well as Essential Energy's Batemans Bay and Moruya North substations. The West Tomerong TS subtransmission system supplies a substantially rural network with a few teed connections; the more critical of these switching points will be controlled remotely by field reclosers and circuit breakers within ZS's.

Tomerong ZS provides the 33kV subtransmission connectivity to form the required network to Huskisson, Sussex Inlet and Yatte Yattah Zone Substations. The project has off loaded Huskisson's distribution network.

If the need arises it is possible to transfer approximately 50% of the load at South Nowra ZS to the Shoalhaven system via feeder 7507. Additionally, under certain contingency conditions Yatte Yattah ZS may be off loaded to the Dapto 132kV system and supplied from feeder 7534 ex-Ulladulla ZS. The planned transfer of Yatte Yattah to the West Tomerong system remains outstanding. The transfer relies on the installation of two field reclosers on feeders 7523 and 7534 plus the implementation of new protection settings which is planned to be completed in late 2017. Refer to the results tables and geographic diagram below for the teed arrangements and changeover schemes.

Future load growth within the southern Shoalhaven City Council area is anticipated in the release areas around Culburra, Huskisson and Sussex Inlet. Special Report S585 "Culburra Area Development" was prepared to promote an alternative solution to the provision of permanent zone substation facilities. The report recommends the use of two smaller modular zone substations up to 10MVA closer to the north and south load centres plus the use of 33kV covered conductor (CCT).

The analysis has been done with the assumption that the following approved projects have been completed:

- *PR479 – 132kV Voltage Constraints South Coast*
- *PR123 – Establishment of West Tomerong TS*

42.2 West Tomerong Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Transformer Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
West Tomerong TS	2 x 60	60	(15 @ 132kV)	Nil
Culburra	2 x 10	10		Existing
Huskisson	2 x 20	20		Nil
South Nowra	2 x 25	25		Nil
Sussex Inlet	2 x 15	15		Nil
Tomerong	2 x 15	15		Nil
Yatte Yattah^^	1 x 6.5	Non-Firm		Nil

Notes:

^^ Yatte Yattah proposed to be supplied from West Tomerong TS from late 2015. An alternate supply will still be available from the 11/33kV interposing transformer at Ulladulla ZS.

(New Rating) following approved project.

42.3 Results Tables

42.3.1 West Tomerong TS Loads and Ratings - Summer Summary

Faulty ➔	Nil	7529	7531	7533&/1	7524	7519	7521	7520[1]	7518[2]	7535	7541	Rating	Result Year
7529: WST TMRNG TS to STH NWR ZS	7.6	x	14.1	11.2	5.5							20.7	2027
7531: WST TMRNG TS to STH NWR ZS	8.5	14.4	x	12.5	6.1							14.0	2020
7533: WST TMRNG TS to CLBRR ZS	7.0	9.1	9.5	x	11.4							14.5	2027
7524: STH NWR ZS to BRND T & CLBRR ZS	4.4	2.6	2.2	11.9	x							14.5	2027
7519: WST TMRNG TS to HSKSSN ZS	7.9					x	15.7	8.5	8.6	9.6	9.6	20.7	2027
7521: TMRNG ZS to HSKSSN ZS	7.5					15.6	x	8.3	8.4	5.9	5.9	20.7	2027
7520: TMRNG ZS to ABS 65840	3.3							x	7.8			14.1	2027
7535: WST TMRNG TS to TMRNG ZS	12.7					16.8	9.0	13.0	13.2	x	23.9	53.4	2027
7541: WST TMRNG TS to TMRNG ZS	12.7					16.8	9.0	13.0	13.1	23.9	x	44.6	2027
7518: TMRNG ZS to ABS 33525	4.4							8.0	x			20.7	2027
7522: ABS33525 to AR 35174/ABS 33526	4.4							8.0				14.1	2027
7523: ABS33526 to AR A8325	0.0											13.3	2027
7530: ABS1791 to ABS33516 to AR35172	3.3							0.7	7.9			14.1	2027
7525/7526[1]: AR35172 to AR35174 to SX IN ZS	7.7							7.7	7.9			14.1	2027
7532: ABS516 to ABS33521	0.7											14.1	2027
7542: BRND T to ABS 33536	0.4											14.5	2027
7507[3]: SHLHVN TS to STH NWR ZS	Standby											35.1	
7534: LLDLL ZS to AR A8324												8.9	

Notes:

1. Outage of feeder 7520 may require switching (via recloser A8324 and A8325) of Yatte Yattah to feeder 7534 feed from Dapto 132kV system. Limits overload on feeder 7522.
2. Outage of feeder 7518 may require switching (via recloser A8324 and A8325) of Yatte Yattah to feeder 7534 feed from Dapto 132kV system. Limits overload on feeder 7530.
3. Feeder 7507 is only required to supply South Nowra for a second level contingency due to easing of forecast demand.

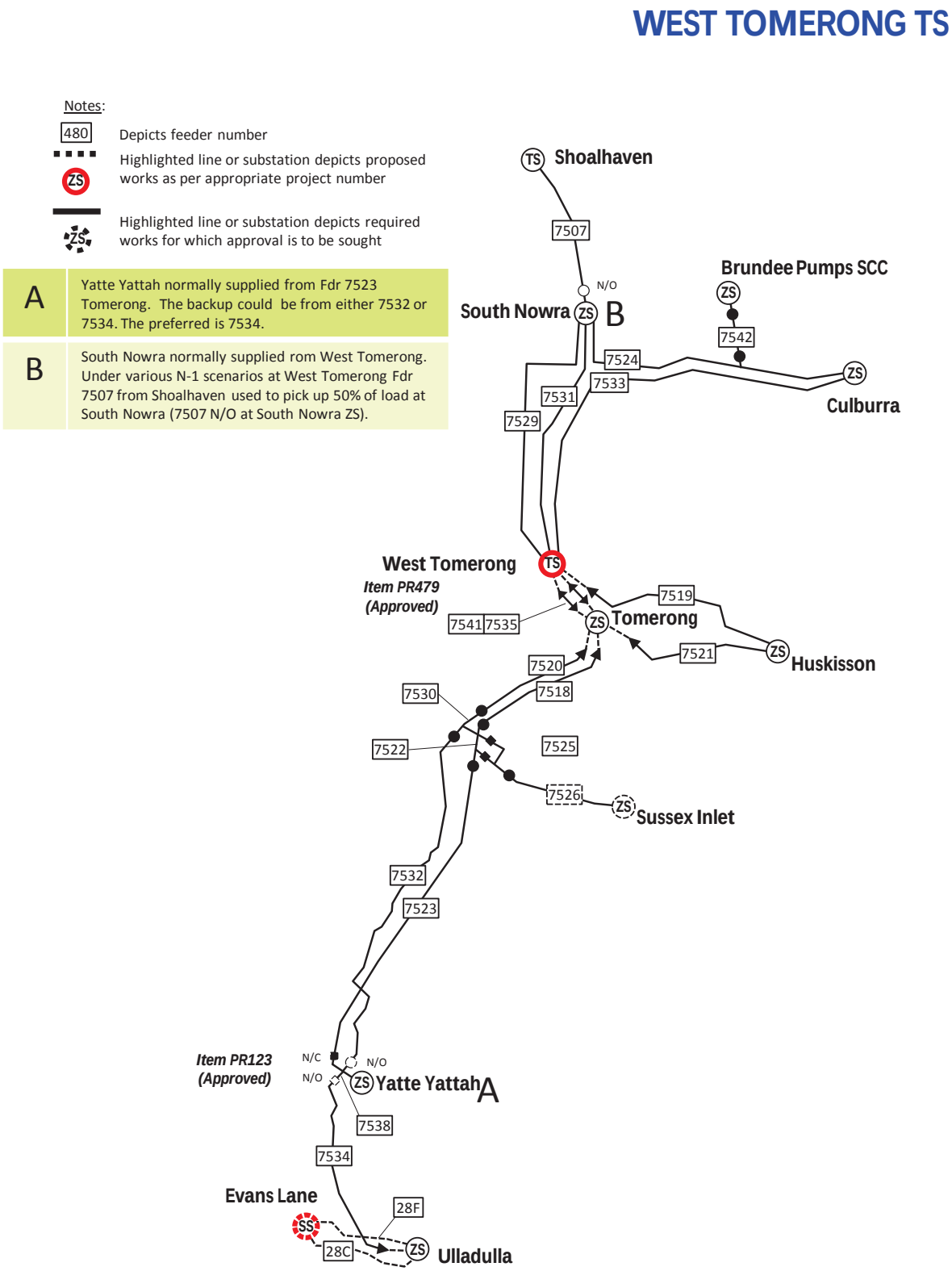
42.3.2 West Tomerong TS Voltage Levels (Resultant Tap Position) - Summary

Faulty ➔	Nil	7529	7531	7533	7524	7519	7521	7520[1]	7518[2]	7535	7541	Min. Tap	Max. Tap	Result Year
South Nowra	0	-1	-1	-1	0							-16	4	2027
Culburra 1	-2			-4	-3							-10	6	2027
Culburra 2	-2			-4	-3							-10	6	2027
Tomerong	2					2	2			2	2	-14	7	2027
Huskisson	3					2	2			3	3	-16	4	2027
Sussex Inlet 1	1							1	0	1	1	-10	6	2027
Sussex Inlet 2	1							1	1	1	1	-10	6	2027
Yatte Yattah	-5							-7	-7	-7	-7	-10	5	2027

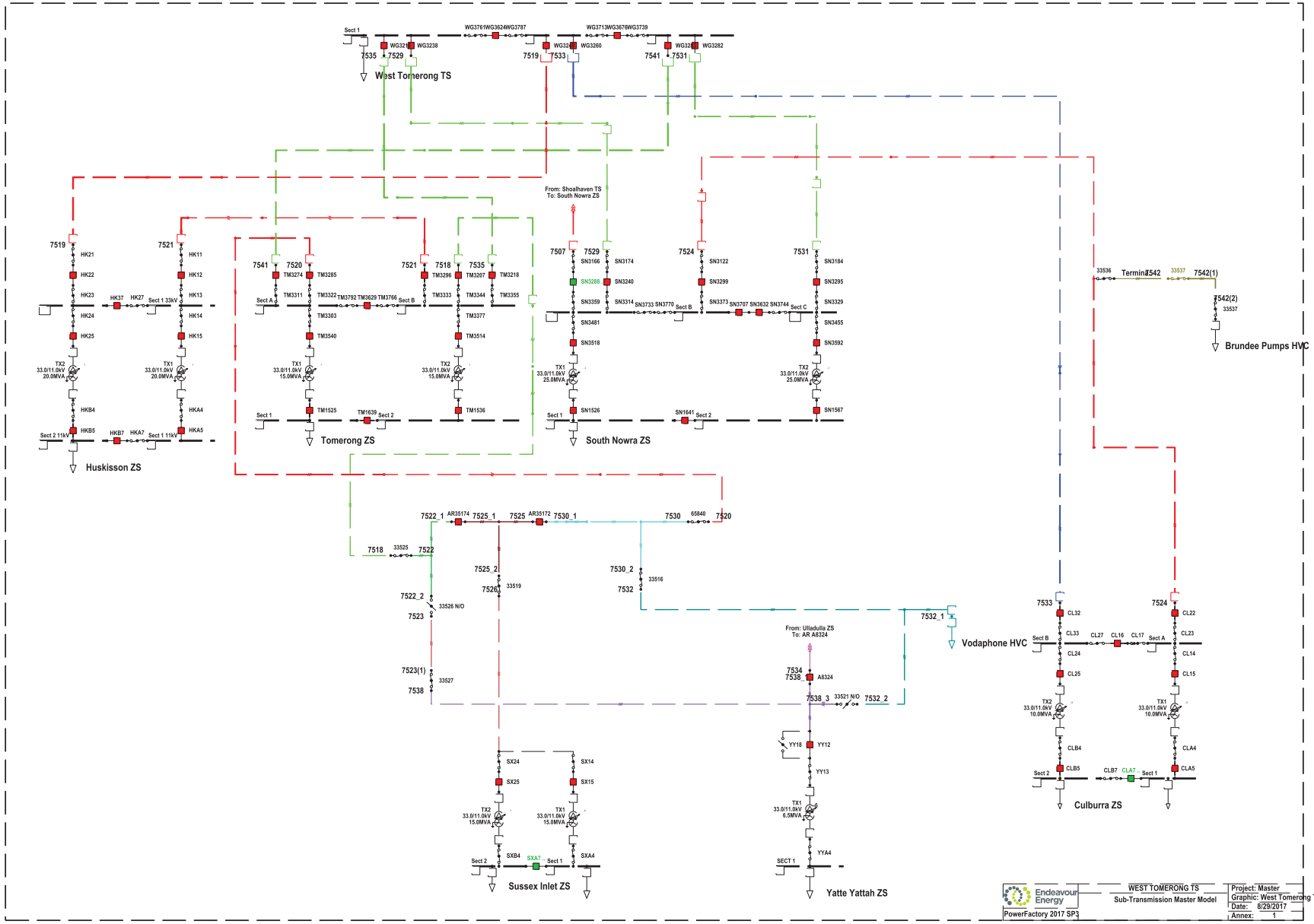
42.4 Analysis Results and Possible Solutions

West Tomerong TS	Network Constraint	Year	Investigation	Solution
	Culburra ZS firm rating is exceeded in summer 2017. The LAR is 15% over firm.	Existing	The situation will continue to be monitored in accordance with acceptable network capacity planning standards. Investigate additional load transfers and alternate non-network options in the future.	Continue to monitor
	Fdr 7531 is overloaded for outage of Fdr 7529		The situation will continue to be monitored in accordance with acceptable network capacity planning standards.	Continue to monitor

42.5 West Tomerong Geographic (Upon Commissioning)



42.6 West Tomerong Schematic



43 WEST WETHERILL PARK TRANSMISSION SUBSTATION

43.1 West Wetherill Park Transmission Network Status

West Wetherill Park Transmission and Zone Substations are supplied at 132kV from Sydney West Bulk Supply Point by feeder 93M with alternate supply provided by feeder 93T from Guilford TS which is supplied from Holroyd BSP. West Wetherill Park TS has one 120MVA 132/33kV transformer providing a 33kV non-firm capacity of 120MVA and West Wetherill Park ZS situated on the same site with two 45MVA 132/11kV transformers providing an 11kV firm capacity of 45MVA.

West Wetherill Park TS was proposed to normally supply Horsley Park ZS on feeder 744 and Bossley Park ZS on feeder 745 on changeover to Mt Druitt and Blacktown TS's respectively. For operational reliability preference, West Wetherill Park TS provides standby back-up to Horsley Park ZS, Bossley Park ZS, Smithfield ZS and normal supply to West Wetherill Park ZS. This arrangement provides higher security of supply until such time that West Wetherill Park TS is augmented with a second transformer to provide a firm 33kV capacity of 120MVA. However based on present loading this is not expected to occur within the current 10 year forecast period.

Smithfield ZS is normally supplied by feeders 676 and 678 from Guildford TS with feeder 745 from West Wetherill Park TS providing partial back-up.

The analysis of the West Wetherill Park transmission network was carried out with the following network configurations:

- Bossley Park ZS normally supplied by feeder 435 Blacktown TS, on change over to feeder 745 West Wetherill Park TS.
- Horsley Park ZS normally supplied by feeder 48C Mount Druitt TS via Eastern Creek LMS co-generation on change over to feeder 744 West Wetherill Park TS.
- Smithfield ZS normally supplied by feeders 676 and 678 Guildford TS with partial change over to feeder 745 West Wetherill Park TS.

43.2 West Wetherill Park Transmission Network Substation Rating Details

Zone Substation	Transformer Description (MVA)	Firm Capacity (MVA)	Installed Reactive Capacity (MVAr)	Transformer Constraint (Year)
West Wetherill Park TS	1 x 120	Non-Firm	20	Nil
West Wetherill Park ZS	2 x 45	45	5	Nil
Bossley Park	2 x 35	35	10	Nil
Horsley Park	2 x 25	25	5	Nil
Smithfield	3 x 25	50	10	Nil

Note: Bossley Park, Horsley Park and Smithfield zone substations are on change-over supply to West Wetherill Park TS.

43.3 Results Tables

43.3.1 West Wetherill Park TS Loads and Ratings – Summer Summary

Faulty ➔	Nil	435	48C	678*	676*	T4	T5	Rating MVA	Year of Result
744 West Wetherill Park to Horsley Park	A/S		9.0					21	2026/27
745 West Wetherill Park to Bossley Park*	A/S	29						45	2026/27
745 Bossley Park to Smithfield*	A/S			22	22			38	2026/27
T4 West Wetherill Park 11kV	18.7					X	37	50	2026/27
T5 West Wetherill Park 11kV	18.7					37	X	50	2026/27

A/S = Transformer or sub-transmission feeder which is in auto-standby mode.

* During outage on feeder 676 or 678, feeder 745/1 supplies 2/3 Smithfield from West Wetherill Park TS. Analysis assumes Bossley Park is supplied by feeder 435 from Blacktown TS.

43.3.2 West Wetherill Park TS Voltage Regulation & Tap-changer Positions - Summer Summary

Faulty ➔	Nil	435	48C	678	676	T4	T5	Min Tap	Max Tap	Year of Result
Bossley Park	-1	0						-15	7	2026/27
Horsley Park	0		2					-14	7	2026/27
Smithfield	-1			2	1			-14	7	2026/27
T1 West Wetherill Park 33kV	0	4	4	4	4					2026/27
T4 West Wetherill Park 11kV	-1					X	-8	-17	3	2026/27
T5 West Wetherill Park 11kV	-1					-8	X	-17	3	2026/27

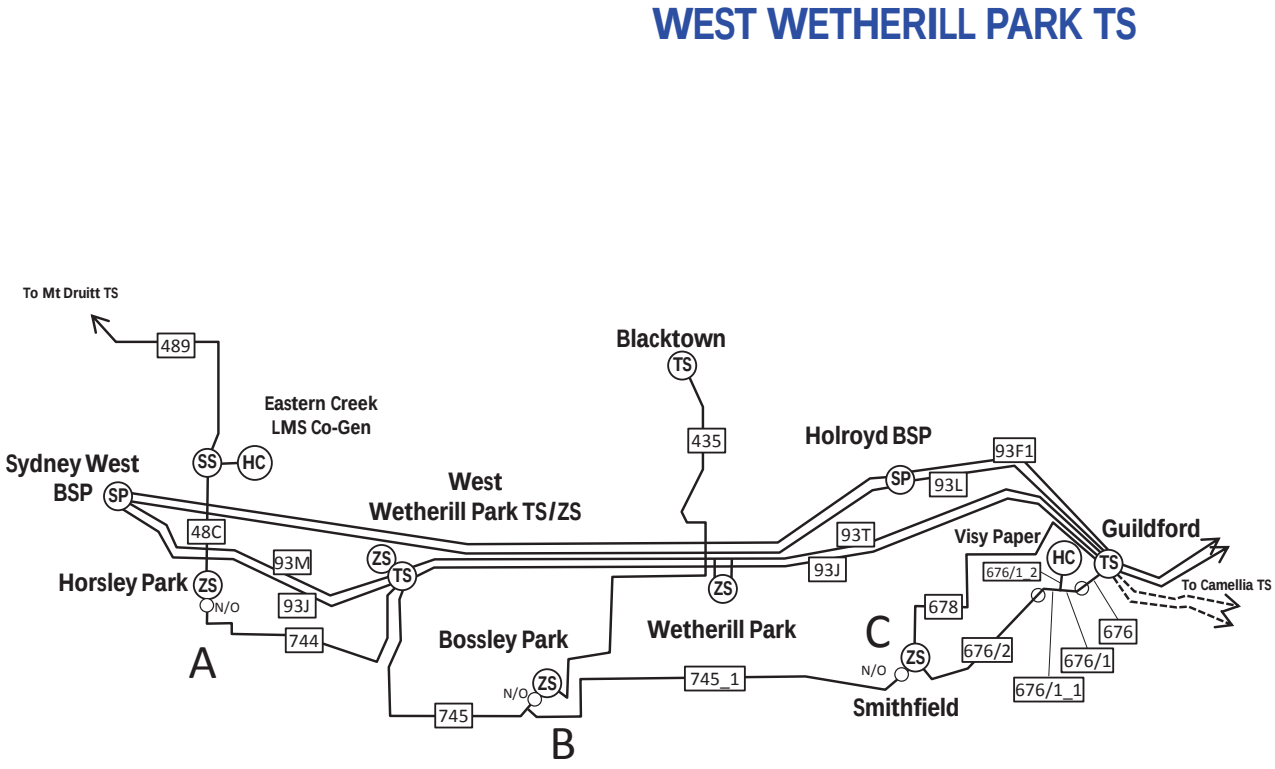
43.4 Analysis Results

Load levels on all feeders are within the line ratings for this review period.

Voltage levels at all substations are within the tapping ranges for this review period.

West Wetherill Park	Network Constraint	Year	Investigation	Solution
	NIL			

43.5 West Wetherill Park Geographic



A	Horsley Park ZS normally supplied by Fdr 48C/489 from Mt Druitt & is on change-over to Fdr 744 from West Wetherill Park
B	Bossley Park ZS is normally supplied by Fdr 435 from Blacktown & is on changeover to Fdr 745 from West Wetherill Park
C	Smithfield ZS is normally supplied by Fdr 676 & 678 from Guildford with backup by Fdr 745 from West Wetherill Park.

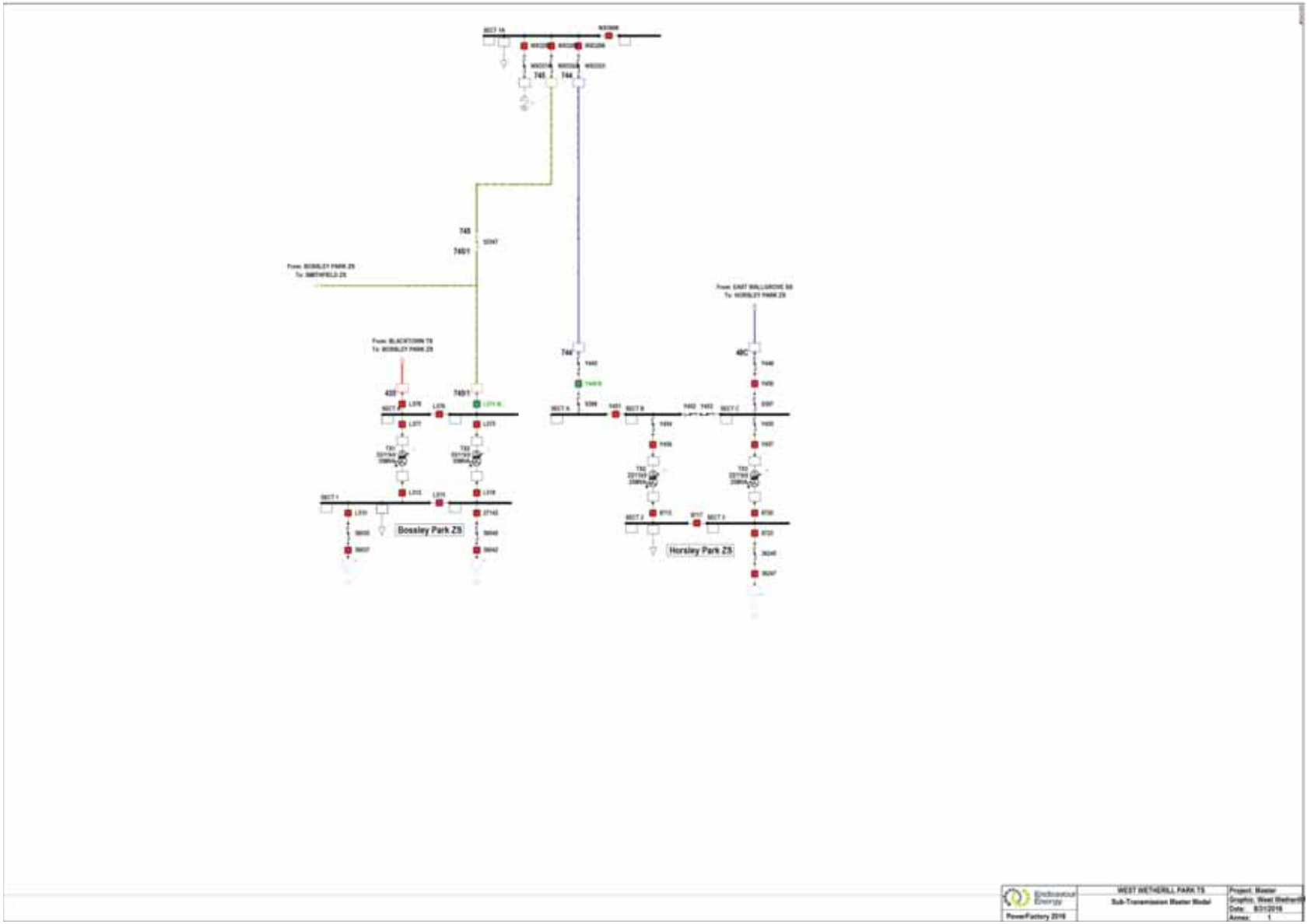
Notes:

480 Depicts feeder number

Highlighted line or substation depicts proposed works as per appropriate project number

Highlighted line or substation depicts required works for which approval is to be sought

43.6 West Wetherill Park Schematic



44 LOAD AT RISK SUMMARY

The load at risk summary chapter summarises the overall situation of capacity constraints affecting both zone and transmission substations for the period from 1 July 2016 to 30 June 2017.

The calculation of zone substation load at risk is the difference in actual load and firm capacity at the zone substation. The real risk requires the consideration of the duration of the exceedance.

The Design, Reliability and Performance licence conditions schedule 1 has been repealed by the Minister for Energy and the changes have taken effect from 1 July 2014. In the absence of mandated security standard, Endeavour Energy self-determines supply security standards for different levels of the network. This is based on internal company polices and standards including:

- 9.1.8 Network Configuration Policy
- 9.2.1 Network Planning
- SDI 501 Network Configuration

Endeavour Energy now applies probabilistic planning principles to assess investment requirements. In determining load at risk, by incorporating probabilistic planning principles, Endeavour Energy also determines the energy at risk and the value customers place on the risk of losing supply. The following factors determine this value:

- outage risks associated with various asset classes,
- energy at risk (energy when demand exceeds firm capacity)
- expected unserved energy
- VCR (value of customer reliability)

Generally, investments are only considered economic if the value of the expected unserved energy exceeds the investment costs on a present value basis (net present value).

Section 44.3 lists subtransmission feeder constraints identified within the forecast period, load at risk is shown at the end of the 10 year forecast. As stated in Section 3 Methodology and Assumptions:

Endeavour Energy operates its transmission and subtransmission overhead system so as not to exceed a continuous conductor temperature of 75°C. Under contingency conditions, a feeder may be operated above 75°C only where it has been designed to maintain statutory clearances at these temperatures. Typically these are ACSR circuits but also include AAC and AAAC circuits constructed since the mid 1990’s. The use of contingency ratings at elevated temperatures is likely to only be required for up to 30 event days per year, over the life of the asset. Of these event days it assumes that the peak load cycle would not exceed 10 hours.

Endeavour Energy also has a limited number of XTACIR circuits, which are designed for continuous elevated temperature operation.

In cases where operational remedial actions may not be enough to address load at risk and the availability of emergency ratings are unclear, an improved understanding of line rating will be required. This will involve carrying out field surveys on actual clearances.

44.1 Transmission Substation Capacity Constraints Summary for Summer 2016/17

TRANSMISSION SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
BAULKHAM HILLS	4 x 60	180	141.4	Summer		
BELLAMBI	3 x 60	120	87.9	Winter		
BLACKTOWN	4 x 120	360	279.6	Summer		
CAMELLIA	3 x 120	240	61.9	Summer		
CARLINGFORD	4 x 120	360	231.8	Summer		
DENHAM COURT TS	1 x 60	Non-Firm	14.9	Winter	Non-Firm	
FAIRFAX LANE	3 x 60	120	85.6	Winter		
GUILDFORD	3 x 120	240	211.0	Summer		
HAWKESBURY	3 x 120	240	181.0	Summer		
ILFORD	1 x 60	Non-Firm	6.2	Winter	Non-Firm	Supported by Mt. Piper on 66kV
KATOOMBA NORTH	2 x 60	60	32.9	Winter		
LAWSON	2 x 52	52	27.3	Summer		
LIVERPOOL TS	3 x 120	240	177.6	Summer		
MOUNT DRUITT	3 x 120	240	150.7	Summer		
MOUNT TERRY	2 x 120	120	110.4	Summer		
NEPEAN 33kV	2 x 60	60	52.9	Summer		
NEPEAN 66kV	2 x 120	120	129.8	Summer	9.8	Supported by Macarthur 66kV and Appin/Tower Generation
OUTER HARBOUR	2 x 60	60	33.2	Winter		
PENRITH	3 x 120	240	148.9	Summer		
SHOALHAVEN	3 x 60	120	92.9	Summer		
SPRINGHILL	3 x 120	240	179.8	Summer		
WARRIMOO	2 x 60	60	61.1	Summer	1.1	
WEST LIVERPOOL	3 x 120	240	194.0	Summer		
WEST TOMERONG TS	2 x 60	60	50.4	Summer		
WEST WETHERILL	1 x 120	Non-Firm	0			Backup for Horsley Park and Bossley Park ZSs

44.2 Zone Substation Capacity Constraints Summary for Summer 2016/17

ZONE SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
ABBOTSBURY	2 x 45	45	42.7	Summer		
ALBION PARK	3 x 12.5	25	24.0	Summer		
AMBARVALE	2 x 35	35	26.4	Summer		
ANZAC VILLAGE	3 x 25	50	27.3	Summer		
APPIN	1 x 15	Non-Firm	6.7	Summer	Non-Firm	
ARNDELL PARK	2 x 45	45	32.1	Summer		
BAULKHAM HILLS 11KV	2 x 45	45	35.7	Summer		
BELLA VISTA	3 x 45	90	52.7	Summer		
BERRIMA JUNCTION	1 x 20	Non-Firm	1.6	Winter	Non-Firm	
BERRY	2 x 15	15	9.0	Summer		
BLACKHEATH	2 x 7	7	7.2	Winter	0.2	
BLACKMANS FLAT	2 x 10	10	6.3	Winter		
BLAXLAND	2 x 35	35	29.7	Summer		
BOLONG ROAD	1 x 12.5	Non-Firm	3.0	Summer	Non-Firm	
BOMADERRY	3 x 15	30	21.0	Summer		
BONNYRIGG	3 x 35	70	38.2	Summer		
BOSSLEY PARK	2 x 35	35	31.6	Summer		
BOW BOWING	3 x 35	70	46.7	Summer		
BOWRAL	2 x 10 + 1 x 12.5	20	18.2	Summer		Impedance mismatch limits firm capacity to 19MVA
BRINGELLY	1 x 19 + 1 x 25	19	14.6	Summer		
BULLI	2 x 15	15	12.2	Winter		
BYLONG	2 x 1.5	1.5	0.4	Summer		
CABRAMATTA	2 x 25	25	19.9	Summer		

ZONE SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
CAMBRIDGE PARK	2 x 25	25	21.8	Summer		
CAMPBELLTOWN	3 x 35	70	54.4	Summer		
CANLEY VALE	3 x 25	50	32.9	Summer		
CARRAMAR	2 x 25	25	16.4	Summer		
CASTLE HILL	3 x 25	50	25.6	Summer		
CASULA	2 x 35	35	33.1	Summer		
CATTAI	1 x 25 + 1 x 15	15	14.2	Summer		
CAWDOR	2 x 25	25	27.7	Summer	2.7	
CHERITON AVENUE	2 x 45	45	33.8	Summer		
CHIPPING NORTON	2 x 35	35	21.2	Summer		
CLAREMONT MEADOWS	3 x 25	50	30.3	Summer		
CORRIMAL	2 x 19	19	18.7	Summer		
CRANEBROOK	3 x 25	50	26.5	Summer		
CULBURRA	2 x 10	10	11.5	Summer	1.5	
DAPTO	3 x 25	50	34.7	Summer		
DARKES FOREST	2 x 5	5	0.9	Summer		
DOONSIDE	3 x 45	90	49.4	Summer		
DUNDAS	3 x 35	70	49.0	Summer		
EAST RICHMOND	2 x 35	35	29.5	Summer		
EASTERN CREEK	2 x 45	45	19.7	Summer		
EDMONDSON PARK	2 x 35	35	3.8	Summer		
EMU PLAINS	3 x 25	50	35.5	Summer		
FAIRFIELD	3 x 25	50	26.8	Summer		
FIGTREE	2 x 25	25	24.8	Summer		
GERRINGONG	2 x 5	5	6.5	Winter	1.5	
GLENMORE PARK	2 x 45	45	44.8	Summer		

ZONE SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
GLENORIE	1 x 15	Non-Firm	7.1	Summer	Non-Firm	
GLOSSODIA	2 x 25	25	21.3	Summer		
GRANVILLE 132KV	2 x 45	45	28.4	Summer		
GREYSTANES	2 x 25	25	24.0	Summer		
HARTLEY VALE	2 x 2.5	2.5	1.4	Winter		
HAZELBROOK	2 x 25	25	9.6	Winter		
HELENSBURGH	2 x 12.5	12.5	10.3	Winter		
HINCHINBROOK	3 x 25	50	50.2	Summer	0.2	
HOLROYD	1 x 17.25 + 2 x 25	42.25	37.0	Summer		
HOMEPRIDE	3 x 25	50	36.6	Summer		
HORSLEY PARK	2 x 25	25	10.3	Summer		
HUNTINGWOOD	2 x 45	45	27.0	Summer		
HUSKISSON	2 x 20	20	15.5	Summer		
ILFORD HALL	1 x 2.5	Non-Firm	0.5	Winter	Non-Firm	
INNER HARBOUR	2 x 12.5	12.5	10.3	Winter		
JAMBEROO	1 x 3.75	Non-Firm	3.2	Summer	Non-Firm	
JASPER ROAD	3 x 25	50	41.3	Summer		
JORDAN SPRINGS	2 x 25	25	23.4	Summer		
KANDOS	2 x 5	5	4.3	Summer		
KANGAROO VALLEY	1 x 5 + 1 x 2.5	2.5	3.1	Summer	0.6	
KATOOMBA	2 x 25	25	20.7	Winter		
KELLYVILLE	2 x 25	25	20.0	Summer		
KEMBLA GRANGE	2 x 10	10	4.4	Summer		

ZONE SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
KEMPS CREEK	2 x 25	25	14.2	Summer		
KENNY STREET	2 x 25	25	19.4	Summer		
KENTHURST	2 x 25	25	23.3	Summer		
KENTLYN	2 x 33	33	38.8	Summer	5.8	
KIAMA	2 x 12.5 + 1 x 15	25	14.7	Winter		
KINGSWOOD	3 x 25	50	47.0	Summer		
KURRAJONG	2 x 15	15	15.2	Summer	0.2	
LEABONS LANE	2 x 25	25	22.6	Summer		
LENNOX	3 x 25	50	20.8	Summer		
LITHGOW	2 x 30	30	17.4	Winter		
LIVERPOOL	3 x 35	70	38.0	Summer		
LUDDENHAM	2 x 15	15	10.9	Summer		
MACQUARIE FIELDS	2 x 33	33	28.3	Summer		
MALDON	2 x 35	35	22.9	Summer		
MAMRE	3 x 45	90	57.2	Summer		
MARAYONG	3 x 25	50	40.1	Summer		
MARSDEN PARK	Approved (1 x 45)	Non-Firm	.	Summer	Non-Firm	
MEADOW FLAT	1 x 2.5	Non-Firm	1.2	Winter	Non-Firm	
MINTO	2 x 33 + 1 x 35	66	68.4	Summer	2.4	
MITTAGONG	2 x 12.5 + 1 x 15	25	19.5	Winter		
MOOREBANK	3 x 35	70	30.5	Summer		
MOSS VALE	2 x 25	25	18.2	Winter		
MT OUSLEY	2 x 35	35	20.8	Summer		
MUNGERIE PARK	3 x 45	90	58.5	Summer		

ZONE SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
NARELLAN	3 x 35	70	75.8	Summer	5.8	
NEPEAN ZS	2 x 35	35	42.8	Summer	7.8	
NEWTON	3 x 25	50	34.1	Summer		
NORTH EASTERN CREEK	2 x 45	45	10.6	Summer		
NORTH PARRAMATTA	2 x 55	55	32.6	Summer		
NORTH RICHMOND	2 x 25	25	16.6	Summer		
NORTH ROCKS	2 x 25	25	21.6	Summer		
NORTH WARRAGAMBA	1 x 25 + 1 x 15	15	12.0	Summer		
NORTH WOLLONGONG	2 x 19	19	13.5	Winter		
NORTHMEAD	2 x 35	35	24.7	Summer		
NOWRA	2 x 35	35	26.2	Summer		
OAKDALE	2 x 10	10	2.5	Summer		
ORAN PARK	2 x 45	45	11.9	Summer		
PARKLEA	3 x 45	90	106.8	Summer	16.8	
PENRITH 11KV	2 x 52	52	46.7	Summer		
PLUMPTON	3 x 25	50	36.1	Summer		
PORT CENTRAL	2 x 19	19	10.4	Summer		
PORT KEMBLA	3 x 10	20	14.0	Winter		
PORTLAND	2 x 10	10	3.0	Winter		
PRESTONS	3 x 25	50	30.8	Summer		
PROSPECT	3 x 15	30	31.7	Summer	1.7	
QUAKERS HILL	2 x 25 + 1 x 45	50	44.2	Summer		
QUARRIES	2 x 35	35	30.1	Summer		
RINGWOOD	2 x 12.5	12.5	6.6	Winter		

ZONE SUBSTATION	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
RIVERSTONE	2 x 25	25	21.2	Summer		
ROBERTSON	2 x 3.75	3.75	4.9	Winter	1.2	
ROOTY HILL	2 x 45	45	42.6	Summer		
ROSEHILL	3 x 25	50	21.0	Summer		
RUSSELL VALE	2 x 10 + 1 x 25	20	16.3	Winter		
RYDALMERE	1 x 25 + 1 x 33 + 1 x 35	58	40.2	Summer		
SCHOFIELDS	2 X 45	45	19.6	Summer		
SEVEN HILLS	3 x 25	50	27.2	Summer		
SHELLHARBOUR	2 x 20 + 1 x 25	40	29.6	Summer		
SHERWOOD	2 x 25	25	30.4	Summer	5.4	
SMITHFIELD	3 x 25	50	39.3	Summer		
SOUTH GRANVILLE	2 x 25	25	19.6	Summer		
SOUTH LEPPINGTON	1 x 45	Non-Firm	6.0	Summer	Non-Firm	
SOUTH MARSDEN PARK	Approved (1 x 15)	Non-Firm	.	Winter	Non-Firm	New ZS commissioned 2017
SOUTH NOWRA	2 x 25	25	10.5	Summer		
SOUTH WINDSOR	3 x 25	50	36.1	Summer		
SOUTH WOLLONGONG	2 x 19	19	15.0	Summer		
SPRINGWOOD	2 x 35	35	33.3	Summer		
ST MARYS	2 x 25 + 1 x 19	44	35.7	Summer		
SUSSEX INLET	2 x 15	15	7.5	Summer		
TAHMOOR	2 x 25	25	18.2	Summer		
THE OAKS	1 x 15	Non-Firm	8.7	Summer	Non-Firm	
TOMERONG ZS	2 x 15	45	11.0	Summer		
ULLADULLA	2 x 30	30	28.6	Summer		

CAMBRIDGE PARK	Installed Transformer Capacity (No. x MVA)	Firm Transformer Capacity (MVA)	Peak Demand 2016/17 (MVA)	Season Peak	Load at Risk	Notes
UNANDERRA	3 x 12	24	17.1	Summer		
WARILLA	2 x 10 + 1 x 12.5	20	20.5	Winter	0.5	
WENTWORTH FALLS	1 x 10	Non-Firm	6.8	Winter	Non-Firm	
WERRINGTON	3 x 35	70	37.1	Summer		
WEST CASTLE HILL	2 x 65	65	47.5	Summer		
WEST LIVERPOOL ZS	3 x 35	70	37.9	Summer		
WEST PARRAMATTA	3 x 45	90	53.1	Summer		
WEST PENNANT HILLS	2 x 35	35	27.2	Summer		
WEST WETHERILL PK	2 x 45	45	32.7	Summer		
WEST WOLLONGONG	1 x 10 + 2 x 12.5	22.5	13.9	Summer		
WESTMEAD	2 x 35	35	25.1	Summer		
WETHERILL PARK	2 x 45	45	29.1	Summer		
WHALAN	3 x 25	50	32.8	Summer		
WILTON	2 x 20	20	2.8	Winter		
WINDSOR	2 x 35	35	23.4	Summer		
WISEMANS	1 x 12.5	Non-Firm	6.4	Summer	Non-Firm	
WOMBARRA	2 x 5	5	5.8	Winter	0.8	
WOODPARK	2 x 25	25	22.6	Summer		
YATTE YATTAH	1 x 6.5	Non-Firm	5.1	Summer	Non-Firm	
YENNORA	2 x 25	25	20.6	Summer		

44.3 Subtransmission Capacity Constraints Summary (over forecast period)

FEEDER No & DESTINATION	Forecast Maximum Loading (N or N-1)	Continuous Peak Season Rating	Contingency Rating	LAR over Maximum Rating	Notes
478 Baulkham Hills to Northmead ZS	41.4	42	Not available	Nil	Monitor/Manage LAR
477 Baulkham Hills to Westmead ZS	45.2	45	Not available	0.2	Monitor/Manage LAR
480 Baulkham Hills to TEE (Northmead ZS)	41.3	42	Not available	Nil	Monitor/Manage LAR
482 Blacktown to Fujistsu HVC	29	27.4	TBC	2.4	Check Ratings
483 Blacktown to Fujitsu HVC	29	27.4	TBC	2.4	Check Ratings
458 Hawkesbury TS – Riverstone ZS Tee	20	19	Not available	1.0	Monitor/Manage LAR
425 Hawkesbury TS – East Richmond ZS	31	27.4	TBC	3.6	Check Ratings
438 Hawkesbury TS – East Richmond ZS	30	27.4	TBC	2.6	Check Ratings
441 Riverstone ZS to Quakers Hill ZS	17	16	Not available	1.0	Standby feeder. Monitor/Manage LAR
860 Ingleburn SP to Tee (Macquarie Fields ZS)	78.2	64	Not available	14.2	Roster Macquarie Fields transformers to avoid LAR on Teed feeder 866
862 Ingleburn SP to Minto	64.2	64	Not available	0.2	LDC may be implemented to manage LAR
863 Ingleburn SP to Minto	64.2	64	Not available	0.2	LDC may be implemented to manage LAR
23L West Liverpool TS to Liverpool TS	223	145	230	Nil	Use contingency rating
852 Macarthur to Douglas Park	95.7	60	Not available	35.7	LAR based on 38MW of generation
851 Nepean to Maldon	94.2	60	Not available	34.2	LAR based on 38 MW of generation
869 Macarthur – Wilton Tee	40.9	40	Not available	0.9	Monitor/Manage LAR
93Y West Liverpool – Denham Court	196.6	145	148	48.6	Investigate second 330/132kV trf at Macarthur BSP
490 Mt Druitt TS to St Marys ZS	31.0	34	Not available	Nil	load transfers to manage LAR
491 Mt Druitt TS to St Marys ZS	32.0	34	Not availa ble	Nil	load transfers to manage LAR
7047 Mt Terry to Croom	37.8	33.2	Not available	4.6	Monitor/Manage LAR; Investigate rerating of feeder
7147 Croom to Shellharbour ZS	33.9	33.2	Not available	0.7	Monitor/Manage LAR; Investigate rerating of feeder

FEEDER No & DESTINATION	Forecast Maximum Loading (N or N-1)	Continuous Peak Season Rating	Contingency Rating	LAR over Maximum Rating	Notes
7043 Mt Terry TS to AE E6900	12.5	11.9	Not available	0.6	Monitor/Manage LAR; Investigate rerating of feeder
306 Nepean TS to Cawdor ZS	34.0	23	Not available	11.0	Investigate non-network options
311 Nepean TS to Cawdor ZS	34.3	29	Not available	5.3	Investigate non-network options
858 Nepean TS to Narellan ZS	71.9	50	Not available	21.9	Re-switch system to manage LAR
870 Nepean TS to Narellan ZS	74.8	72	Not available	2.8	PR748
7018 Springhill TS to South W'gong ZS	35.3	28.6	Not available	6.7	PR730 to change limiting CT
476 Kenthurst ZS to Kellyville ZS	18.3	19	Not available	Nil	Pre-emptive switch system to avoid LAR on peak days
623 Penrith TS to Jordan Springs ZS	29	33.2	TBC	Nil	Ratings Check Required
213 Parklea ZS to Bella Vista ZS	172	172	Not available	Nil	PR732
465 Luddenham ZS to Tee	24	21	Not available	3.0	Upgrade Feeder 465
465 Tee to Kemps Creek ZS	24	21	Not available	3.0	Upgrade Feeder 465
230 Parklea ZS to West Castle Hill ZS	173	172	172	1.0	PR732
214 Rouse Hill SS to Parklea ZS	304	172	Not available	132.0	PR732
215 Rouse Hill SS to Parklea ZS	304	172	Not available	132.0	PR732
227 Vineyard SP to Hawkesbury TS	189	145	230	Nil	Use contingency rating
234 Vineyard SP to Hawkesbury TS	189	145	230	Nil	Use contingency rating
938 Vineyead SP to Rouse Hill SS	540	495	Not available	45.0	PR732
9JA Vineyeard SP to Rouse Hill SS	540	495	Not available	45.0	PR732
808 Springwood ZS to Hazelbrook ZS	24	22	Not available	2.0	Investigate Stage 2 of PR136
512 West Liverpool TS to Kemps Creek Tee	26.0	21	Not available	5.0	Augment 3500m overhead on feeder 512 PR750
509 West Liverpool TS to Homepride	36	42	Not available	Nil	Monitor/Manage LAR
7531 West Tomerong TS to South Nowra ZS	14.4	14	Not available	0.4	Monitor/Manage LAR

44.4 Consolidated Table of Constraints

Baulkham Hills TS	Network Constraint	Year	Investigation	Solution
	Capacity of feeders 477 is reached during outage of feeder 466	S2026/27	Continue to monitor development in area. Conduct non-network investigation when necessary	Continue to monitor
	Westmead ZS exceeds its firm capacity – Transformer capacity and 11kV busbar rating Transformer in 2021/22 and 11kV busbar in 2022/23	S2021/22	Monitor the loading yearly prior to this time and if Westmead UWS and the Westmead Hospital complex proceeds as forecast, then develop Options to provide capacity at Westmead ZS	Continue to monitor
	Under Note 1 of the Loads and Ratings summary for Summer, the Summer contingency of splitting the bar at Kellyville ZS to allow supply from Sydney North and Baulkham Hills, it was found that an overload of Feeder 471 by 0.25 MVA under loss of Feeder 484 and a overload of Feeder 484 by 0.7 MVA under loss of Feeder 471 occurred in 2022/23	S2022/23	Continue to monitor loading of Kellyville ZS.	Augment Feeder 476 to cater for: (a) Kellyville ZS normal summer load and (b) Eliminate potential emerging constraint on Jasper Rd ZS feeders 471 an 484 in S2022/2023 under summer contingency configuration.
Bellambi TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Blacktown TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Feeder 482 Ratings Check Required	2022	Check Ratings	Ratings

	Feeder 483 Ratings Check Required	2022	Check Ratings	Ratings
Camellia TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Carlingford TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Fairfax Lane TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Robertson ZS firm rating exceeded. The load is 31% above the firm rating for a single transformer (3.75MVA)	W2017	The situation will continue to be monitored and options to be investigated in the future. Non-firm rating is 7.5MVA	Continue to Monitor
	The load on Bowral ZS is approaching its firm rating. Each 10MVA transformer is approaching full load for outage of the other 10MVA transformer due to impedance mismatch with the 12.5MVA transformer. As a result, effective firm capacity is approximately 19MVA and not 20MVA.	W2026	PR478 for augmentation of the transformers was deferred due to the installation of capacitors in previous years.	Continue to Monitor PR478
Guildford TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Hawkesbury TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	The firm rating of Riverstone ZS will be exceeded by	S2022	Demand management options in the short term.	Long term plan is establishing a new zone substation in

	S2022.			the area which will take some load of Riverstone ZS and its feeders.
	On outage of feeder 444, load on feeder 441 will exceed its rating	S2024	Demand management options in the short term.	Long term plan is establishing a new zone substation in the area which will take some load of Riverstone ZS and its feeders.
	On outage of feeder 444, load on feeder 458 will exceed its rating	S2027	Demand management options in the short term.	Long term plan is establishing a new zone substation in the area which will take some load of Riverstone ZS and its feeders.
	Check Ratings for Feeder 425	S2018	Check Ratings	Ratings
	Check Ratings for Feeder 438	S2018	Check Ratings	Ratings
Holroyd SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	For an outage of either 132kV Feeder 93L/93F the corresponding Holroyd BSP 375MVA transformer will be overloaded	S2023	Investigate load transfers to Sydney West	Engage Joint Planning with Transgrid
Ilford SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Ilford TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Ingleburn SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Outage 866 BSP-to Bow	Existing	Feeder 860 is to be opened at Macquarie	Transfer Capacity

	Bowing will cause feeder 860 to exceed its line rating.		Fields when the feeder is supplying Bow Bowing without support from feeder 866.	
	Potential greenfield development at Eschol Park cannot be supported from the existing Minto network. This is not included in the demand forecasts and analysis presented here.	Existing	Eschol Park zone substation (PR190) may need to be established if the proposed Blairmount residential development proceeds. The Department of Housing is also redeveloping the Claymore residential area.	Monitor
	Outage of either 862 or 863 BSP-Minto, will cause the respective feeders to exceed their line ratings.	S2018	Probabilistic planning analysis. The load on the feeders requires monitoring.	Monitor
Katoomba North TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Lawson TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Thermal capacity of standby feeder 808 is exceeded during outage of Feeder 824.	S 2017/18	Project PR136 Stage 2 augmentation of the remainder of Feeder 808 is deferred. This is due to the summer demand reduction at Springwood ZS. The level of network risk is minimal within the forecast period, considering the availability of 11kV emergency transfer capability.	Monitor
Liverpool SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Feeder 23L has a contingency rating of 230MVA. For outage of 93G West Liverpool TS to Liverpool TS – transfer Casula ZS and Canley Vale ZS to West Liverpool TS with back-up feeders 504 and 508 closed reduces load to 184MVA.	2025/26	Possible augment feeder 23L *(Monitor and Review)*	Replace 2750m overhead section of 23L with underground cable to match feeder 93G. This will also result in equal load share of both 23L and 93G during system normal operation. Avoids need to transfer multiple zone

	(Monitor and Review)			substations to West Liverpool TS. *(Monitor and Review)*
Macarthur 66kV SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Outage of either feeder 851 or 852 results in an overload on the other feeder. Outage of feeder 851 results in feeder 869 Tower Power Stn Tee to Wilton ZS to be overloaded.	S2018 S2027	There is load at risk with existing generation levels of 38MW. Augment O/S 33kV feeder 308 to 66kV and connect it to Nepean 66kV TS & Douglas Park SS. Augment feeder 869 from the Tower Power Station Tee to Wilton ZS.	Monitor Develop Major project build option
Macarthur 132kV SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	When 66kV feeder 85L is out the firm rating of Nepean 66kV is exceed.	S2018	Further investigation is required including load diversity, probabilistic planning analysis and cyclic ratings on the 132/66 kV transformers at Nepean TS.	Monitor
	When 66kV feeder 85L is out 132kV feeder 93Y West Liverpool TS to Denham Court TS is overloaded.	S2023	The second 330/132kV transformer will be required at Macarthur BSP. Feeder 85L will be connected to 132kV and become 9L2. A third 132/66kV transformer and busbar will be required at Nepean TS. Probabilistic planning analysis will be required.	Monitor
	The two Nepean TS 132/66kV transformers are overloaded for an outage on the single 330/66 kV transformer at Macarthur BSP.	S2018	Further investigation is required including load diversity, probabilistic planning analysis and cyclic ratings. Joint planning may be required with Transgrid to discuss options including a second 330/66kV transformer at Macarthur.	Joint Planning with Transgrid

			Off load onto Ingleburn BSP under contingency.	
Marulan SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Mt Druitt TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Mt Piper TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Mt Terry TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Albion Park ZS firm rating is exceeded. The load is 3.5% above the firm rating in S2017 and then below the firm rating at end of the forecast period.	S2017	The proposed Calderwood ZS will ultimately off load Albion Park ZS.	PR657
	Warilla ZS firm rating is exceeded. The load is 6% above the firm rating in W2026.	Existing	The situation will continue to be monitored in accordance with acceptable network capacity planning standards. Investigate additional load transfers and alternate non-network options in the future.	Continue to monitor
	Gerringong ZS	Existing	Refurbish Ex-Russell Vale 10MVA Tx No. 3	TS600
	Feeder 7047 is overloaded for an outage of feeder 7059	S2018	The situation will continue to be monitored and options to re-rate feeder will be studied if required.	PR193
	Feeder 7147 is overloaded for an outage of feeder 7059	S2019	The situation will continue to be monitored and options to re-rate feeder will be studied if required.	Investigate re-rating of feeder

	Feeder 7043 is overloaded for an outage of feeder 7050	S2019	The situation will continue to be monitored and options to re-rate feeder will be studied if required.	Investigate re-rating of feeder
Nepean 33kV TS	**Network Constraint**	**Year**	**Possible Solution**	**Solution**
	Cawdor ZS has exceeded its firm rating.	S2017	Apply probabilistic planning analysis. May need augmenting with third transformer.	Monitor for next year
	Outage of feeder 306 Nepean TS – Cawdor ZS will cause 311 to exceed its rating.	S2018	Investigate constraint to determine if line augmentation is required. Monitor actual loads for next year. Apply probabilistic planning analysis.	Investigate non-network options. Continue to monitor.
	Outage of feeder 311 Nepean TS – Cawdor ZS will cause 306 to exceed its rating.	S2018	Investigate constraint to determine if line augmentation is required. Monitor actual loads for next year. Apply probabilistic planning analysis.	Investigate non-network options. Continue to monitor.
Nepean 66kV TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Outage of feeder 870 Nepean TS – Narellan ZS will cause 858 to exceed its rating.	S2018	The network will be operated so that load on Narrellan ZS is split between feeders 858 & 861 from Macarthur 66kV for an outage of feeder 870. Continue to monitor and consider demand management prior to augmentation of feeder 858.	Utilise transfer capacity & monitor
	Outage of feeder 858 Nepean TS – Narellan ZS will cause 870 to exceed its rating.	S2019	When 858 is out the load on feeder 870 will exceed its rating. No 1 transformer at Narellan ZS will be supplied by feeder 861 from Macarthur 66kV. Narellan ZS needs to be off load onto Nepean ZS and onto proposed Catherine Park ZS to keep Narellan ZS within its firm rating.	PR748 will offload Narellan ZS

	Transformer connected to bus sections 2&3 is overloaded when connected as a single transformer.	S2018	Configure the three transformers on a split 11kV busbar arrangement. Proposed Catherine Field ZS can be used to off load bus sections 2&3 at Narellan ZS. Off load Narellan ZS onto Nepean ZS.	Monitor for next year Establish PR748
	Exceed the firm rating of Nepean ZS.	S2019	Investigate constraint to determine, cyclic ratings and if demand management solution is possible. Monitor actual loads for next year. Apply probabilistic planning analysis. Install third 66/11kV transformer as the Spring Farm & Elderslie residential release areas are progressing.	Monitor, assess ratings
	Outage of either feeder 851 or 852 results in an overload on the other feeder. Outage of feeder 851 results in feeder 869 Tower Power Stn Tee to Wilton ZS to be overloaded.	S2018 S2027	There is load at risk with 38MW of generation. Augment O/S 33kV feeder 308 to 66kV and connect it to Nepean 66kV TS & Douglas Park SS. Augment feeder 869 from the Tower Power Station Tee to Wilton ZS.	
	Outage of feeder 869 results in an overload feeders 851 & 852.	S2023	Probabilistic planning analysis also taking into account actual historical generation shows low actual risk and that a do-nothing option is feasible based on current forecast load. Augment O/S 33kV feeder 308 to 66kV and connect it to Nepean 66kV TS & Douglas Park SS.	Investigate non-network options Develop Major project build option
Outer Harbour TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			

Penrith TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Feeder 623	n/a	Ratings Check	Ratings
Regentville SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Firm rating of Penrith 11kV ZS (52MVA) will be exceeded in 2019.	S2019	Temporary solution for exceeded firm rating of Penrith 11kV is load transfer of approx. 3MVA to Cranebrook ZS and Emu Plains ZS. Permanent solution includes developing a new zone substation in Penrith area.	PR677 South Penrith ZS
	On outage of feeder 512, rating of feeders 464 and 465 are exceeded .	S2022	Emergency rating of feeder 464, confirmed with Transmission Mains is 57MVA. Feeder 465 needs to be augmented to higher rating. Part of feeder 465 will be augmented as a part of RMS project The Nothern Rd upgrade.	Create a new project to complete upgrade of feeder 465.
	On outage of feeder 464, minimum tap position on Luddenham ZS is reached.	S2027	High voltage drop occurs due to current low rating and high impedance of feeders 512 and 465. Rating of feeder 512 is addressed by project PR750 Augment of 33kV feeder 512.	Create a new project to complete upgrade of feeder 465.
Shoalhaven TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Shoalhaven TS	Existing	System Operations advises an outage on 33kV bus section No 2 overloads bus section No 1. The load on bus section No	Swap Feeders PR 712

			1 supplies Manildra, Bomaderry, Nowra and Kangaroo Valley at greater than 60MVA.	
Springhill TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Feeder 7018 is overloaded for an outage of feeders 7011, 7019, 7014 & 7142.	Existing	A 500A CT (C3) at South Wollongong ZS on feeder 7018 is being used by metering. Investigate changing the 500A CT to a 1000A CT.	PR 730
Sydney North SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	The thermal capacity of feeder 476 to Kellyville ZS is not exceeded under normal operating conditions for the forecast period. Refer Note 3 from the Loads and Ratings Summer Summary.	2017/18	Summer contingency : Supply half of the Kellyville load from Baulkham Hills to avoid overloads on feeder 476 on peak demand days. Additional load will be transferred to Mungerie Park ZS. Proposal to alleviate summer contingency overload from Jasper Rd ZS is to augment Feeder 476 under loss of Feeder 818 and 825.	Utilise transfer capacity
Sydney West SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Mt Drutt needs to be switched to radial supply with one transformer being supplied from Penrith TS when the Mt Druitt network is abnormally switched to supply Cambridge Park ZS and Kingswood ZS	S2018	When Mt Druitt is supplying Cambridge Park ZS and Kingswood ZS, Mt Druitt needs to be switched to radial supply to make provision for possible loss of Feeder 932	Investigate double tee off arrangement for Mamre ZS to restore feeder 939 to full rating.
Vineyard SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Exceed firm rating of Parklea	S2019	Conduct non-network option investigation.	Begin Investigation

	ZS		Investigate options to utilise available capacity at Bella Vista ZS.	PR751
	Exceed firm rating of Schofields ZS	S2021	Continue to monitor lot releases uptake and load growth. Conduct non-network option investigation when required. Third power transformer may be required.	Continue to monitor
	Exceed firm rating of West Castle Hill ZS	S2024	Continue to monitor, conduct load transfer to Bells Vista ZS when required	Continue to monitor
	Exceed firm rating of Cheriton Avenue ZS	S2026	Continue to monitor, conduct load transfer to Castle Hill ZS when required	Continue to monitor PR729
	Exceed firm rating of Mungerie Park ZS	S2026	Continue to monitor, new zone substation in Riverstone East may allow for load transfer	Proposed Box Hill ZS
	Outage of either feeder 214 or 215 will result in overload of the other	Existing	Investigate schemes to allow overloading of remaining feeder during manual switching or implement automation scheme to offload remaining feeder. Investigate reinstatement of feeder 229 to increase contingency capacity from Sydney West via Baulkham Hills.	PR732
	Outage of either feeder 9JA or 938 will result in overload of the other	S2025	Solution to previous constraint will mitigate this	PR732
	Outage of either feeder 213 or 230 will result in overload of the other	S2027	Solution to previous constraint will mitigate this	PR732
Wallerawang 132kV SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Wallerawang 66kV SP	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			
Warrimoo TS	**Network Constraint**	**Year**	**Possible Solution**	**Solution**
	Thermal capacity of standby feeder 808 is exceeded during outage of Feeder 824.	S 2017/18	Project PR136 Stage 2 augmentation of the remainder of Feeder 808 has been deferred. This is due to the summer demand reduction at Springwood ZS. Actual load data show the risk has increased since last year analysis; The level of network risk is minimal within the	Investigate activating Stage 2 of PR136.

			forecast period, considering the availability of 11kV emergency transfer capability.	
West Liverpool TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Outage of 464 to Luddenham ZS overloads 512 tee to Kemps Creek ZS 512 Tee to Kemps Creek is overloaded under system normal conditions	2019/20 2022/23	Augment 512 tee to Kemps Creek ZS	Augment 3500m of OH conductor along Devonshire Rd from tee-off to Kemps Creek ZS PR750
West Tomerong TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	Culburra ZS firm rating is exceeded in summer 2017. The LAR is 15% over firm.	Existing	The situation will continue to be monitored in accordance with acceptable network capacity planning standards. Investigate additional load transfers and alternate non-network options in the future.	Continue to monitor
	Fdr 7531 is overloaded for outage of Fdr 7529	2020	The situation will continue to be monitored in accordance with acceptable network capacity planning standards.	Continue to monitor
West Wetherill Park TS	**Network Constraint**	**Year**	**Investigation**	**Solution**
	NIL			

45 NETWORK MAPS

A set of network maps shows the relationship between the various parts of the network and the geographic maps shown within each Bulk Supply Point and Transmission Substation network section.

Refer to the hyperlinks below or turn the page where you have a paper copy:

Endeavour Area Geographic Maps - 6 pages