PowerWater

Power and Water Corporation
Preliminary Business Case – Category A

PRD33001
Construct Wishart Zone Substation

Proposed:

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A/Chief Engineer
Power Networks
Date: 6/2/2018

Approved:

Michael Thomson
Chief Executive & Chair
Investment Review Committee
Date: 23/02/2018

Endorsed:

Djuna Pollard
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Date: 15/2/2018

Refer to email
D2018/72353

Finance Review
Date: 06/02/2018

Refer to email
D2018/61666

PMO QA
Date: 9/02/2018

1 RECOMMENDATION

It is recommended that the Chief Executive approve project PRD33001 – Construct Wishart Zone Substation (ZSS), to construct a new Wishart 66/11kV zone substation located adjacent to the current Wishart Modular Substation for an estimated capital cost of [redacted] and a corresponding completion date of June 2024.

Approval is sought for expenditure of up to $0.5 million of the total forecast expenditure to undertake the necessary work to proceed to the next approval gateway (Business Case Approval), including:

- site selection, site survey, geotechnical investigation and earth grid assessment for the new ZSS;
- detailed design; and
- a competitive tender with a detailed cost estimate and a construction price offer from external contractors.
- The project has a 95% likelihood of being delivered between [redacted]

The project has been included in the SCI forecast.

The estimated cost does not include decommissioning and relocation of the existing Wishart Modular Substation.

2 PROJECT SUMMARY

Project Title:	Construct Wishart Zone Substation		
Project No./Ref No:	PRD33001	**SAP Ref:**	
Anticipated Delivery Start Date:	Jul 2021	**Anticipated Delivery End Date:**	Jun 2024
Business Unit:	Power Networks		
Project Owner (GM):	Djuna Pollard	**Phone No:**	8985 8431
Contact Officer:	Peter Kwong	**Phone No:**	8924 5060
Date of Submission:	23/02/18	**File Ref No:**	D2017/394282
Submission Number:		**Priority Score:**	
Primary Driver:	Growth/Demand	**Secondary Driver:**	Service Delivery/Compliance
Project Classification:	Capital Category A		

2.1 Prior Approvals

Document Type	Sub Number	Approved By	Date	Capex Value
BNI	10111	Michael Thomson	20/09/2017	[redacted]

3 INVESTMENT NEED

3.1 Background

Peak demand in the areas surrounding the existing Berrimah ZSS has been increasing steadily over the last ten years due to the connection of customers in new and existing commercial and industrial estates. Load demand supplied from Berrimah ZSS is expected to increase through to the wet season of 2021. In addition, new developments in the Berrimah, Wishart and East Arm areas (Wishart load area) will potentially draw an additional 45 MVA over the next 10-15 years.

In 2015 a mobile 'NOMAD' 12MVA substation[1] (Figure 1) was established at Wishart to support load growth in the Wishart and East Arm (Port) areas. This installation provided much needed voltage support to the long Port feeders, additional supply capacity in normal condition and in the event of a transformer failure at Berrimah ZSS.

The mobile substation has prudently deferred installation of a new substation at Wishart or a third transformer at Berrimah ZSS.

Figure 1: NOMAD Modular substation located at Wishart

[1] NOMAD 1 x 66/11kV 12MVA mobile substation

Figure 2 shows the network topology and proximity of the substations to one another[2] as well as load development. Demand growth is forecast to be strongest in areas close to the current Wishart modular substation. There is limited transfer capacity to contiguous substations via the distribution network (such as Palmerston, Casuarina, Woolner and Leanyer ZSSs) due to the voltage regulation limitations on 11kV feeders.

The combined firm supply capacity in the load area of Wishart and Berrimah[3] is forecast to be exceeded as early as the wet season of 2021/22. To meet the required Class 'C' supply criteria,[4] additional firm capacity is required in the area.

As discussed in a separate Preliminary Business Case (PBC),[5] Berrimah ZSS has reached the end of its serviceable life due to asset condition and is scheduled to be replaced by June 2021. The plan for the Berrimah ZSS replacement and the plan for supplying forecast load growth in the Wishart load area are interdependent projects.

[2] The Wishart modular substation is currently located adjacent to Hudson Creek 132kV Terminal Station

[3] Incorporating the current supply areas of Berrimah ZSS and the Wishart Modular substation

[4] Network Technical Code and Planning Criteria, clause 14.6 – supply must be restored to Class C customers within 60 minutes of a single network component failure

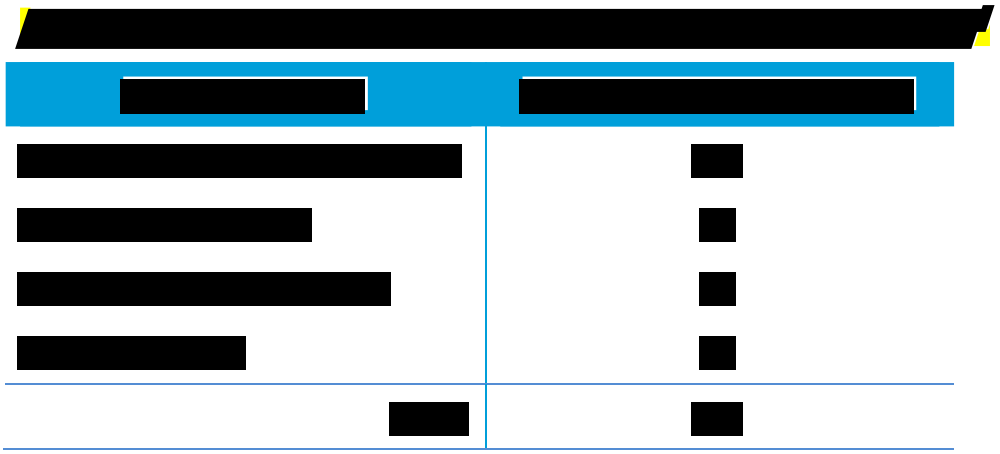
[5] PRD30402 – Preliminary Business Case PBC – Replace Berrimah Zone Substation

3.2 Peak demand and capacity forecasts

This section provides a summary of the peak demand and firm capacity forecasts for Wishart load area. Further details are included in the planning report. The demand forecasts for the area are based on Australian Energy market Operator's (AEMO's) forecasts undertaken on behalf of Power and Water.[6]

3.2.1 New load developments in the region

New developments in the Berrimah, Wishart and East Arm areas and the maximum demand that they are expected to draw over the next 10-15 years are listed in Table 1. The total area maximum demand would then be approximately 75MVA.



3.2.2 Berrimah ZSS

Berrimah ZSS's firm capacity is currently 41.7MVA.[8] As shown in Figure 3, load at Berrimah ZSS is forecast to increase through to 2021/22 before declining slightly due to the impact of distributed energy sources (such as roof top PV installations), energy efficient appliances, and other energy conservation measures.

Despite the slight forecast reduction in peak demand from 2021/22 onwards, Power and Water considers Berrimah substation is required on an ongoing basis to supply customers in the area.

As discussed in the Berrimah ZSS replacement preliminary business case, the plan is to replace the existing substation with a new substation initially configured with 2 x 20/27MVA 66/11kV transformers with provision for a third

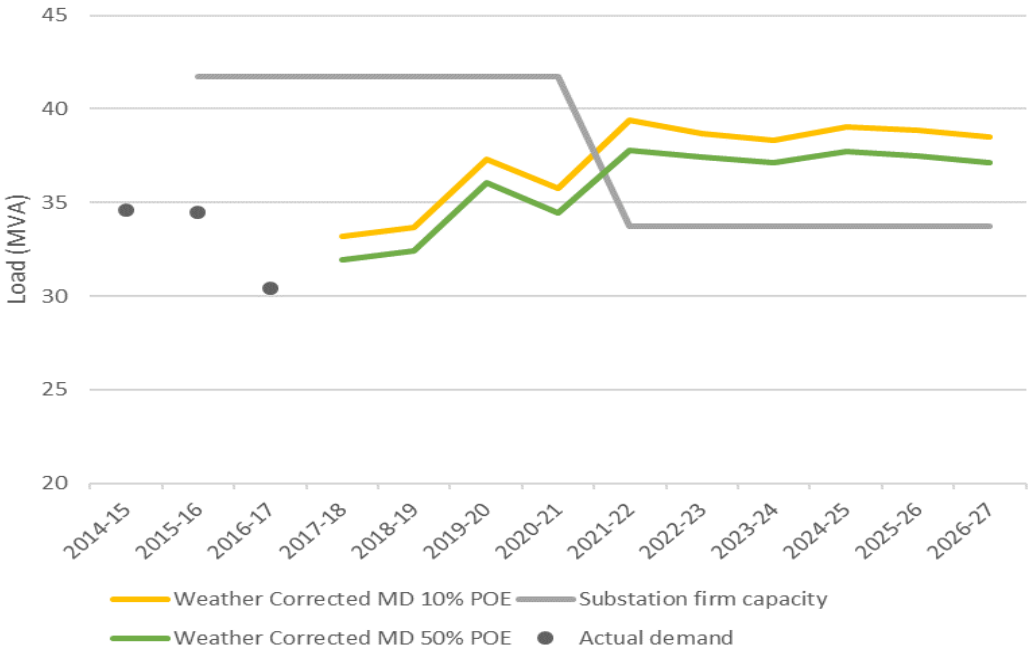
[6] AERReportForPWC_V3

[7] Based on Power and Water's appraisal of development plans and the recent history of take up of vacant land in similar residential, commercial and industrial estates

[8] The current configuration is 2 x 25/31.5/38.1 MVA 66/11 kV transformers, with distribution transfer capacity of 3.6MVA to Wishart modular substation (i.e. provided the 12MVA long term emergency rating of the modular substation transformer is not exceeded)

transformer circuit.[9] Figure 3 shows that the firm capacity will reduce to 33.7MVA once the new substation is commissioned.[10]

Figure 3: Berrimah ZSS peak load AEMO forecast and firm capacity



If Berrimah substation is established as planned in 2021 the load on Berrimah ZSS must be reduced by up to 5.7MVA (i.e. according to AEMO's Berrimah ZSS demand forecast.

3.2.3 Wishart Modular substation

The NOMAD modular substation located at Wishart adjacent to the Hudson Creek 132/66kV Terminal has a single transformer with a firm capacity of 10MVA.[11] As shown in Figure 4, the peak demand supplied from Wishart Modular substation is forecast to increase steadily before increasing at a faster rate from 2023/24, even after accounting for the impact of PV installations and other mitigating factors.

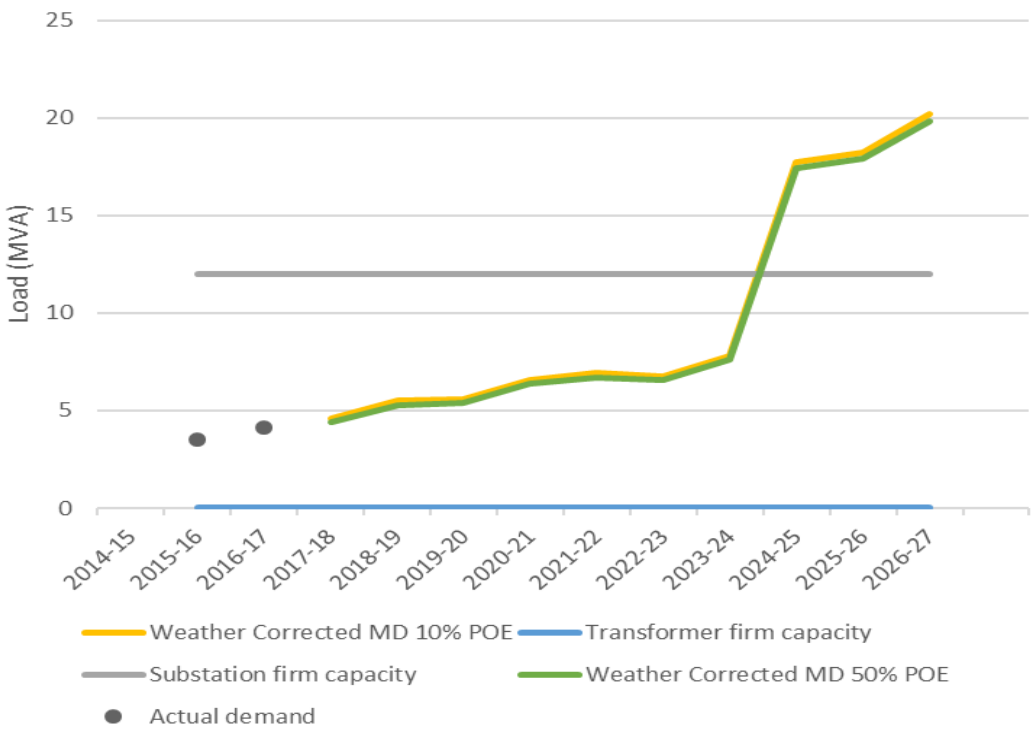
It is evident from Figure 4 that Wishart Modular substation single transformer would be overloaded at peak times if the excess demand of up to 5.7MVA at Berrimah ZSS (from 2021/22) was supplied from Wishart Modular substation.

Figure 4: Wishart Modular substation peak demand forecast and firm capacity

[9] This is Power and Water's standard 66/11kV ZSS configuration

[10] N-1 capacity (i.e. one transformer, which has a long-term emergency rating of 30.1MVA) plus distribution load transfer of 3.6MVA able to be enacted within 60 minutes

[11] The firm capacity is assumed to be equal to the maximum load that can be supplied from the NOMAD substation (10MVA) and transferred back to Berrimah ZSS in event of the NOMAD substation failing



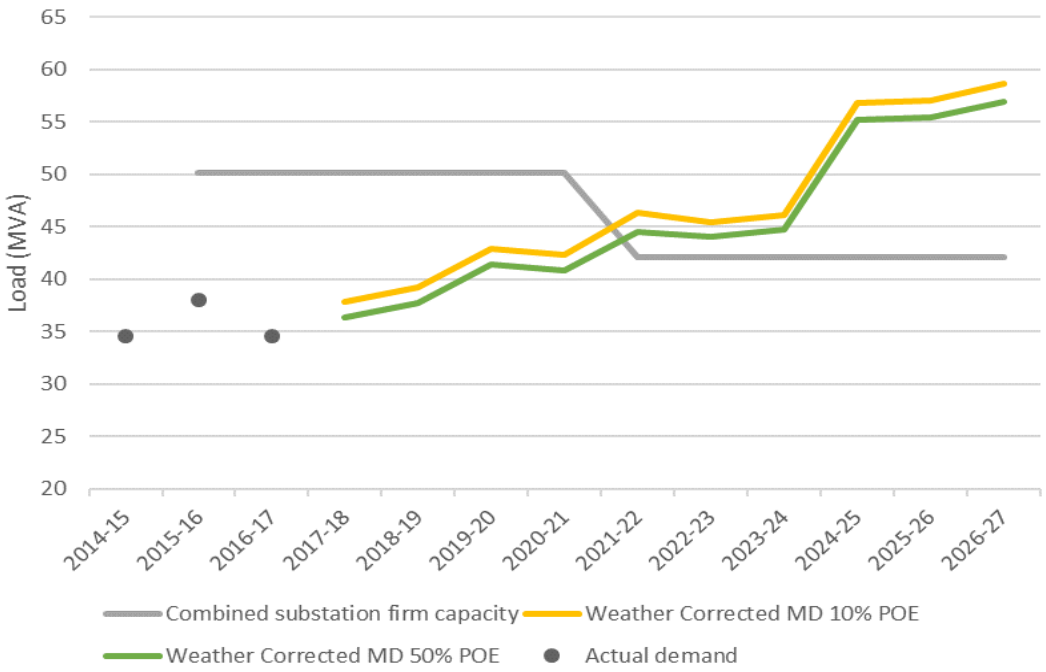
3.2.4 Berrimah and Wishart substations combined

Figure 5 also shows the combined current and forecast peak demand supplied from Berrimah ZSS and the Wishart modular substation. It clearly shows that there is insufficient firm capacity to meet forecast peak load growth beyond the time that the new Berrimah ZSS is commissioned.[12] This conclusion is the same for the higher [P10] and lower [P90] load growth cases.

If Berrimah ZSS did not need to be replaced, there would only be sufficient firm capacity until 2024/25.

[12] The replacement project proposes 2 x 20/27MVA transformers

Figure 5 Combined Wishart and Berrimah substation firm capacity and AEMO load forecast



3.2.5 Risk analysis

Figure 6 shows the current rating, inherent rating in 2024, (i.e. if no action is taken in the interim), and the residual (post-treatment) risk ratings associated with the current supply capacity in the Berrimah/Wishart/East Arm area.

(i) *Current rating:* The Current rating (2017) is assessed to be 'Medium' because in the 'Unlikely' event there is a single transformer outage at Berrimah ZSS, there should be sufficient supply capacity in the area to restore loads to all customers. However, there is some risk that the restoration time will not meet the Class C supply criteria. This consequence is classed as 'Moderate'.

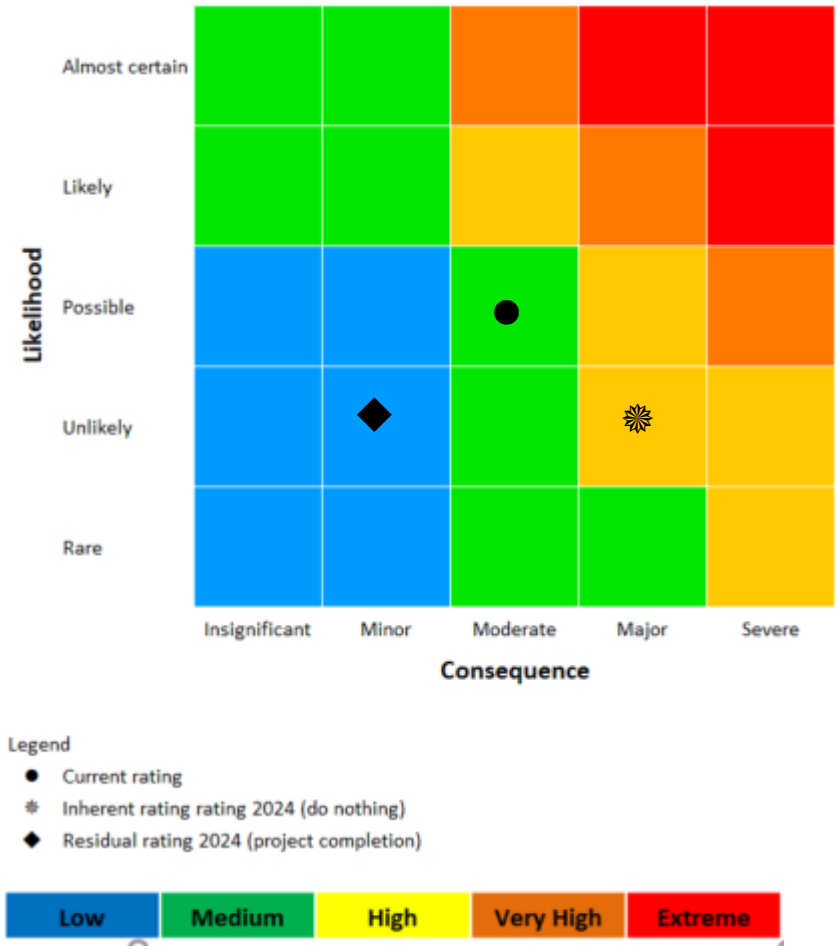
In the case of the 'Rare' event of complete loss of Berrimah ZSS for a prolonged period, there would be insufficient capacity to meet all the load growth for an extended period, even with the deployment of the second NOMAD mobile substation to supply load in the East Arm area. Customers' supply will be interrupted for many hours, if not days (on a rotational basis) whilst load is progressively transferred to contiguous adjacent substations and the second modular substation is commissioned. This consequence is classified as 'Major'. The risk rating is therefore 'Medium'.

(ii) *Inherent rating:* As discussed in sections 3.1-3.2.3, once the planned reduction in firm capacity into the load area associated with the replacement of the Berrimah ZSS, there will be insufficient firm capacity to supply the forecast peak demand in the load area

for the ‘Unlikely’ failure of a transformer at Berrimah ZSS. From 2021/22 – 2023/24 up to 4.2MVA of load will be interrupted until supply from Berrimah can be restored or the second NOMAD mobile substation can be commissioned in the region. From 2024/25, this amount increases to approximately 15MVA (and increasing). Whilst the consequence of rotational load shedding of 4MVA every day for at least several days could be considered ‘Moderate’ impact, the consequence of shedding up to 15MVA or more for many days is rated as ‘Major’. The risk rating by 2023/24 is therefore ‘High’ if no action is taken.

(iii) *Residual rating:* The proposed project will increase the firm capacity and the supply diversity in the Berrimah/Wishart/East Arm area, so that in the ‘Unlikely’ event of a single transformer failure at Berrimah ZSS or the proposed new Wishart substation, it is unlikely there will be any loss of supply to customers for more than the 60 minutes required under the Supply criteria. A ‘Minor’ consequence classification is attributed to the possibility that there may be significant number of commercial and industrial customers interrupted for a short period. The risk rating is therefore ‘Low’.

Figure 6: Berrimah/Wishart load area supply risk assessment[13]



It is Power and Water's current practice to take action on risks that have an inherent rating of 'HIGH' or above. The PBC summarises the proposed response to this impending risk.

4 STRATEGIC ALIGNMENT

This project aligns with the Corporation's key result areas of operational performance and customer centricity, where the goals are to be an efficient provider of services and delivering on customers' expectations.

This project will allow Power and Water to safely and reliably meet current and future demands for the Berrimah, Wishart and East Arm areas.

[13] Based on Power and Water's Risk Assessment Guide

5 TIMING CONSTRAINTS

This project is required to be completed by June 2024 to provide sufficient firm capacity to cater for forecast load growth in the Berrimah, Wishart and East Arm areas. It is expected that there will be a significant increase in demand from 2024.

While there is a slight deficit in firm capacity from 2021, the risk can be carefully managed until the new zone substation is commissioned. It is expected that the rebuild of Berrimah Zone Substation will not be commissioned until 2021, and there would be significant risk to the success of the both projects to construct both concurrently due to Power and Water's limited resources.

6 EXPECTED BENEFITS

Driver/Objective	Benefit	Current State	Future State
Growth / Demand	Sufficient capacity to supply forecast load growth in the East Arm and Wishart areas with provisions to meet future load growth.	It is forecast that the load in the East Arm, Wishart and Berrimah areas will exceed the firm capacity of the Berrimah ZSS and Wishart Modular substation. The Wishart substation is a temporary facility based on a NOMAD modular substation – it is not designed for long-term fixed operation.	New Wishart zone substation designed to cater for forecast load growth in East Arm, Wishart and Berrimah areas and provide feeders for (N-1) firm capacity. New Berrimah ZSS configuration optimised to supply forecast horizon load. NOMAD modular substation released to fulfil its planned purpose.
Compliance	Compliant power quality and reliability of service.	There is increased risk of prolonged outages due to complexity in transferring load	Ensure compliant long term security of supply to the East Arm, Wishart and Berrimah industrial areas. Improved operational capbility to restore load during emergencies or to preserve supply continuity during planned outages by deployment of the (released) NOMAD modular substation.

7 REQUIREMENTS

The solution selected must resolve the need to cater for the projected growth in the East Arm, Wishart and Berrimah areas and still satisfy the required

supply contingency criteria for Class C Supply. In addition, all power quality requirements must be met, especially supply voltage levels during periods of peak demand to the East Arm area.

Power and Water will also require compliance with the following:

- Northern Territory Electricity Reform Act
- Power and Water's Network Licence as issued by the Utilities Commission
- Network Technical Code and Network Planning Criteria

8 OPTIONS

The options considered in section 8.1 include options also considered in the Berrimah ZSS Replacement PBC because the two projects are interdependent.

8.1 Options identification

8.1.1 Option 1: Do nothing (retain the Nomad mobile substation at Wishart)

This option requires Berrimah substation to continue to operate in its present configuration and to retain the NOMAD Modular substation at Wishart.

In the event of a single transformer failure at Berrimah, distribution network switching will be required to transfer up to the available 10 MVA capacity of the Wishart Modular substation.

In the event of failure of the Wishart Modular substation, the load can be supplied from Berrimah substation, but supply on some 11kV feeders will be non-compliant with voltage limits.[14]

The advantage of this approach is the deferment of capital expenditure for Wishart and Berrimah substations.

The disadvantages of this option are:

(i) Given the age and condition of the primary plant assets at Berrimah zone substation, there is a high risk that a transformer circuit at Berrimah ZSS will be unavailable due to asset failure within the next five years (i.e. by 2022/23).[15] The planned replacement of Berrimah takes this into account;

(ii) It is unlikely that the quality and reliability of supply criteria will be able to be met in the case of a forced outage of a transformer circuit at Berrimah substation or a forced outage of the Wishart NOMAD mobile substation beyond 2021;

[14] Depending on the loading of particular feeders during the outage of the Wishart Modular substation, excessive under-voltage will be experienced

[15] Refer to PRD30402 – PBC – Replace Berrimah Zone Substation

(iii) The NOMAD substation will continue to be unavailable to provide emergency response or to maintain network reliability during planned outages;

(iv) The NOMAD substation is currently operated at Wishart with oil containment but it does not fully satisfy Australian Standards requirements.

8.1.2 Option 2 – Install additional transformer capacity at Berrimah Zone Substation

The existing Berrimah ZSS is planned to be replaced with a new Berrimah ZSS by 2020/21 due to the poor condition of its primary assets. The current plan is to establish the substation with Power and Water's standard 2 x 20/27MVA 66/11kV transformers, providing an expected cyclic firm capacity of 33.7MVA, which will not be sufficient to firmly supply the forecast load in accordance with the Supply Criteria from 2021 onwards.

Two options for increasing the firm supply capacity from the new Berrimah ZSS and potentially removing the requirement for the Wishart Modular substation are:

Option 2a: Establish the substation with (non-standard) 2 x 50MVA transformers at an approximate incremental[16] cost of [redacted], to provide firm capacity of approximately 54MVA, which is forecast to be sufficient until 2024/25; and

Option 2b: Establish the substation with 3 x 20/27MVA transformers at an approximate incremental[17] cost of [redacted] to provide firm capacity of approximately 54MVA, which is forecast to be sufficient until about 2030/31. The single line diagram and layout for this option is option is shown in Appendix B.

Supplying forecast load growth in the Wishart and East Arm areas from Berrimah substation requires additional feeders, which will be very expensive due to comparably long routes being along/across major roads with significant congestion of infrastructure. Along Berrimah Road there is inadequate room for overhead power poles and underground cabling will be required.

The advantages of Option 2 are:

(i) The incremental cost of providing the additional firm capacity at Berrimah substation, even allowing for the additional cost of work in the 11kV network;

(ii) It releases the NOMAD mobile substation for its intended purpose.

The disadvantages of Option 2 are:

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[16] The additional cost when compared to the 'base case' of establishing the new Berrimah substation as a 2 x 20/27MVA transformer substation and any augmentation necessary to the 11kV network to allow the load in the area to be supplied from Berrimah ZSS

[17] *ibid*

(i) Option 2a requires a non-standard transformer size (50MVA) and non-standard substation design, which will limit operational flexibility, reduce asset utilisation over time, and increase operational costs (such as Power Transformer spare holdings);

(ii) There are limitations in the practical ability to distribute from high capacity site due to localised congestion of underground and overhead circuits. Equally, this provides an additional 'point load' to the transmission system. These issues have resulted in PWC's current standard transformer size being the more practical size of 20/27MVA.

(iii) Full reliance is placed on a single zone substation for supply to approximately 60MVA (peak) of residential, commercial and industrial load;

(iv) If load grows beyond the firm capacity of Berrimah substation or the quality of supply criteria cannot be met, a two-transformer substation at Wishart is likely to be required. The overall net present cost (NPC) is likely to exceed the NPC of Option 4 (see analysis below);

(v) Even with new feeders, in the absence of a Wishart substation, it is likely that undervoltage limits will be not be able to be maintained in the East Arm area; and

(vi) Given the transfer limits of 11kV, and notwithstanding the above point, Berrimah substation is a lot further from the forecast new load growth, increasing distribution losses significantly.

8.1.3 Option 3 – Install a second NOMAD mobile substation in the area

Power and Water has a second NOMAD mobile substation which could be deployed to provide additional firm capacity in the area, assuming the new Berrimah ZSS is established, as planned, with 2 x 27MVA transformers and the Wishart Modular substation is retained.

This would add up to 12MVA of firm capacity in the area (a total of 52.1MVA), which, based on the current P50 demand forecast, would only be sufficient until 2024/25. If peak demand continues to grow, as expected, additional firm capacity will be required in the area (i.e. at Berrimah or by establishing the Wishart zone substation).

The estimated initial capital cost of this option is [redacted] and would be required in-service to coincide with commissioning of the new Berrimah substation (i.e. 2021).

The advantage of this option is the relatively low cost as it defers the capital expenditure for a third transformer at Berrimah ZSS or the establishment of Wishart ZSS.

The disadvantages of Option 3 are:

(i) The installation does not meet the long-term requirements of the area - based on the current load forecast, additional supply capacity will be required by 2024/25;

(ii) Oil containment and general installation standards are suitable for short term installation but have not been design with long term operation in mind.

(iii) It removes the only other NOMAD mobile substation from availability; and

(iv) It does not lead to the release of the NOMAD at the Wishart Modular substation for intended purpose.

Currently and in addition to emergency response needs, the NOMADs units are specifically planned for use the longer term mitigation of demand (and subsequent capital deferral) at Archer ZSS and Strangways ZSS's as well as risk mitigation and supply continuity during the construction of Humpty Doo and Centre Yard construction.

The opportunity cost of this option (i.e. inability to provide emergency response or planned outage support) has not been costed. However, the cost of a new Nomad substation is about [redacted], and it will be likely that a replacement will be required.

The technical limitations of Option 3 render it technically unviable as a medium-term solution to augmenting the firm capacity in the Berrimah/Wishart/East Arm area.

8.1.4 Option 4 – Establish a new AIS Zone Substation in Wishart (Preferred Option)

This option involves returning the NOMAD mobile substation to operational duty and establishing a permanent 'Wishart' zone substation adjacent to the Hudson Creek Terminal Substation, at an estimated base cost of [redacted]

The proposed configuration of the permanent Wishart ZSS is a standard Power and Water AIS design,[18] comprising an outdoor 66kV switchyard with two 20/27MVA 66/11kV transformers initially, with an allowance for an ultimate third transformer. It will be similar in layout to Leanyer Zone Substation. The preliminary concept single line diagram and layout of Option 4 is presented in Appendix C.

As shown in Figure 6, with the addition of two 27MVA transformers (each with long-term cyclic rating of 30.1MVA) at the proposed Wishart ZSS, the firm capacity in the area increases to 93MVA[19] which will be adequate for

[18] A GIS substation was not considered as it is more expensive than the AIS alternative considered here and there are no material impediments to establishing an AIS substation on the preferred location.

[19] 3 x 30.1MVA transformer capacity and 3.6MVA distribution transfer capacity

foreseeable peak demand, as well as supporting local and developing areas supply voltages

Figure 6 – Berrimah/Wishart area load forecast and firm capacity with and without the proposed new Wishart ZSS (option 4)

The advantages of Option 4 are:

(i) It provides a technically compliant, long term basis for supplying the existing and forecast load growth in the Wishart/East Arm area;

(ii) The design is based on Power and Water's standard 66/11kV substation design, reducing development, implementation, and operational costs compared to non-standard options;

(iii) It is consistent with good industry practice;

(iv) It will be located close to the load centre, reducing distribution losses and helping to meet both Class C Supply criteria in the event of an unplanned outage at either Berrimah ZSS or the proposed Wishart ZSS;

(v) It provides supply diversity in the (unlikely) event of catastrophic failure at Berrimah substation, noting the limited distribution transfer capacity to contiguous substations; and

(vi) It provides flexibility for responding to growth by adding a third transformer circuit, if required.

(vii) It is consistent with Power and Water's planning strategy of building standardised zone substations in preference to fewer very large ones (except where the load density is high, e.g. Darwin CBD). Power Networks has determined that 20/27MVA transformers are most appropriate, as opposed to the 38MVA units installed in the existing Berrimah ZSS.

(viii) It provides additional diversity in the 66kV transmission system by linking the Palmerston transmission 66kV loop (including the Weddell Power Station) into the city transmission loop.

The proposed location of the new substation is ideally located in the middle of the current and forecasted loads. This will allow the assets to be utilised efficiently and effectively in delivering power to East Arm and Wishart areas.

Power and Water currently owns the land, so no further acquisition is required and it is surrounded by industrial customers. This will minimise the likelihood of public opposition to the project.

The design of the substation will be to the existing PWC Substation Standards and will be similar in layout to current zone substations. This will maximise constructability and reduce design risk.

There will be minimal clearing of the site as it is currently within the boundaries of Hudson Creek Terminal Substation. As with other zone substations, power transformers will be installed with appropriate standard oil containment systems that will prevent hydrocarbons to be released into the environment.

The disadvantage of Option 4 is that it provides 'lumpy' capacity investment, together with the new Berrimah ZSS; it will result in 108MVA of installed capacity by 2023/24 to supply a forecast load of approximately 60MVA. However, the 46MVA forecast demand increase from the new developments in the area[20] over the next 10-15 years will progressively require the increased firm supply capacity.

8.1.5 Option 5 – Demand Management

Two demand management options are considered, Option 5a, which is based on delaying capital expenditure on extra firm capacity in the area (i.e. via options 2, 3 or 4) until at least 2024/25 and Option 5b, which is based on releasing the NOMAD modular substation for its intended purpose. Both options are predicated on the new Berrimah substation being commissioned in 2021 with a firm capacity of 33.7MVA.

Based on Power and Water's research, the most likely source of demand management is via curtailment contracts with large commercial and with industrial customers in the area.[21] Power and Water does not have access to

[20] North Crest, Truck Central, Berrimah Business Park Stage 3 and Robertson Barracks

[21] Typically, this is arranged through a third party 'aggregator'

other forms of demand management such as through ripple control or smart meter activated control of customer loads (such as air conditioners).[22]

To comply with the Class C Supply requirements, the load curtailment would have to be achieved within 60 minutes, which is relatively short notice.[23]

Option 5a – defer extra firm capacity until 2024/25 (NOMAD)

Referring to Figure 4, this option requires approximately 2-4MVA[24] of reliable peak demand reduction to be available in the event of a significant unplanned outage of a Berrimah ZSS transformer circuit through to 2023/24 and at least 13MVA (increasing) from 2024/25 onwards.

The estimated cost of this option (if it is technically achievable) is [redacted] over the five years of the next RCP.[25]

The major advantage of Option 5a is that it delays the need to commit to capital expenditure to provide more firm capacity into the area, providing more time to assess the actual load growth and update demand forecasts.

The disadvantages of Option 5a are:

(i) Power and Water has no experience with securing reliable load curtailment and the community is not familiar with these arrangements;

(ii) The option is unlikely to be technically (or commercially) viable:

- A projected 13MVA of interruptible load is required in 2024/25 (and beyond) which is a large amount of distribution-connected load in absolute terms, and it represents a significant proportion of the total demand in the area; and
- The required load may not be able to be curtailed within the required 60 minutes to satisfy the Class C Supply requirements

(iii) It requires ongoing operation of the Wishart Modular substation, which has the technical disadvantages outlined under Option 1.

Power and Water will continue to explore the technical and commercial viability of this option by engaging with experienced load aggregators prior to submitting the Business Case for approval.

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[22] It is unlikely that turning off air conditioner compressors, even for as little as 15 minutes at a time will be accepted as a demand management initiative in the Northern Territory due to the prevailing climatic conditions

[23] Based on PWC's research, advance notice of at least several hours is typically required to arrange the necessary arrangements within the business' premises

[24] Based on a combined firm capacity of (30.1 + 12) MVA = 42.1 MVA from the Berrimah ZSS and Wishart Modular substation and the forecast combined peak load

[25] If it is available, interruptible load can be assumed to cost between $75-$350/kVA, depending on the technology deployed (refer to AusGrid, Regulatory Proposal, 2014-19, Attachment 6.12, page 13, and Oakely Greenwood, Advice on the DMIS, pages 15-17)

In the interim, Option 5a is not considered to be technically or commercially viable.

Option 5b – defer extra firm capacity (NOMAD released)

To release the Wishart Modular substation for its intended purpose as a mobile substation, up to an estimated 21MVA of peak load reduction is required in the Berrimah/Wishart/East Arm region. More peak demand reduction may be required from 2026/27 onwards.

The main advantages of Option 5b are the same as Option 5a, with the additional advantage of releasing the NOMAD substation for its intended purpose.

Option 5b is much less likely to be technically (or commercially) viable than Option 5a and a cost estimate has not been derived for it.

8.2 Comparative cost analysis (including sensitivity analysis)

Power and Water is currently developing a probabilistic risk-cost methodology which, when completed will be used to compare options and confirm the economically optimum time for investment.

Table 2 summarises the results of a comparative cost analysis, the details of which are included in Appendix D. Only options 2a, 2b, and 4 are technically viable, for the reasons provided in section 8.1. Of the technically viable options, Option 4 – Build Wishart ZSS – has the lowest NPC. Costs shown in the table below are base project costs and do not include the risk-adjusted costs (ie. P_{50}).

Table 2: Summary of comparative capital cost analysis

Option	Base capital cost ($M)	Net Present Cost ($M)	Comments
1 – Do nothing	[redacted]	[redacted]	Not technically viable
2a – 2 x 50MVA transformer 66/11kV Berrimah ZSS	[redacted]	[redacted]	The assumed capital cost is the incremental cost of establishing this configuration rather than the planned 2 x 20/27MVA substation plus the work required in the 11kV network. NPC includes establishing permanent Wishart Zone Substation on 2027/28.
2b – 3 x 20/27MVA transformer 66/11kV Berrimah ZSS	[redacted]	[redacted]	The assumed capital cost is the incremental cost of establishing this configuration rather than the planned 2 x 20/27MVA substation plus the work required in the 11kV network. NPC includes establishing permanent Wishart Zone

			Substation on 2030/31.
3 – Install 2nd NOMAD substation	[redacted]	[redacted]	Not technically viable
4 – Build Wishart ZSS	[redacted]	[redacted]	Lowest NPC option
5 – Demand management	[redacted]	[redacted]	Not technically viable (pending further research)

8.3 Non-cost attributes

An analysis of the non-cost attributes for each option has been completed using the multi-criteria analysis method. The attributes are selected considering major risks and priorities to achieve Project Objectives. A weighting is allocated to each, totalling 100%. Each attribute is given a score out of 5 (from 1 – Fails to satisfy, to 5 – exceeds requirements); the score is then multiplied by the relevant weighting to give the weighted score that is summarised in the table below.

8.3.1 Evaluation Summary

Table 2: Non-cost attributes analysis – weighted scores

	Project Objectives			Technical & System Risk			Stakeholder Risk			Env. Risk		Commercial
Criteria	**Cater for Project Load Demand**	**Maintain System Security**	**40 Year Design Life**	**Standard Assets**	**Constructability**	**Continuity of Supply**	**Safety**	**Community Impact**	**Approvals**	**Oil Contamination**	**Land Clearing**	**NPV/C**
Weighting (%)	10	10	10	5	5	10	10	5	5	5	5	20
Option 1	0.1	0.2	0.1	0.05	0.2	0.2	0.2	0.1	0.2	0.1	0.2	1.0
Option 2a	0.2	0.2	0.4	0.1	0.1	0.2	0.2	0.3	0.15	0.15	0.2	0.4
Option 2b	0.3	0.3	0.4	0.2	0.15	0.2	0.2	0.3	0.15	0.15	0.2	0.6
Option 3	0.2	0.2	0.4	0.1	0.1	0.2	0.2	0.3	0.15	0.15	0.2	0.6
Option 4	0.4	0.4	0.4	0.2	0.15	0.2	0.2	0.3	0.15	0.15	0.15	0.8

Weighted Scores:

Option 1: Deferral	2.65
Option 2a: 2 x 50MVA TX at Berrimah ZSS	2.60
Option 2b: 3 x 20/27MVA TX at Berrimah ZSS	3.15
Option 3: 2nd Nomad at Wishart	2.80
Option 4: 2 x 27MVA ZSS at Wishart	3.50

8.4 Preferred option

The preferred option (option 4) is to establish a permanent Wishart ZSS, initially with 2 x 20/27MVA 66/11 kV transformers to coincide with the commissioning of the new Berrimah ZSS (2021).

This is the preferred option for the following reasons:

(i) It has the lowest NPC over the 15-year study period of the technically acceptable options, although it has the highest initial capital cost of the options considered,;

(ii) It provides for diversity of supply in the area, providing additional security and reliability compared to the other options, including through transmission diversity;

(iii) It provides the maximum flexibility to expand network capacity to meet projected load growth in the region;

(iv) It is based on Power and Water's standard substation design, which helps keep design, maintenance and strategic spares costs to a practical minimum

(v) It releases the NOMAD substation from the location in Wishart for its intended purpose, providing other operational and capital deferral benefits; and

(vi) It has the highest weighted score from the assessment of non-cost attributes.

The proposed solution and timing does not change with either high case [P10] or low case [P90] load growth assumptions.

8.5 Other Considerations

Power and Water will continue to monitor the actual load and updated peak demand forecast to determine the optimal timing of the proposed solution.

Power and Water will also continue to investigate the technical viability and cost of securing sufficient demand reduction (e.g. from curtailed loads). The updated information will be included in the approval documentation at the next gate.

9 PROJECT OUTLINE

9.1 Project Description

This project is to construct the permanent 66/11kV zone substation at Wishart.

Work includes a new 66kV AIS (air insulated switchyard) with two 66/11kV 20/27MVA power transformers, 11kV switchboard, along with the associated protection and control equipment.

9.1.1 Scope Inclusions

The scope of the project includes:

- Construct a new 66kV AIS switchyard allowing for three incoming 66kV transmission lines and three 66/11kV transformers;
- Install associated 66kV outdoor switchgear and equipment;
- Install two 20/27MVA 66/11kV ONAN/ONAF power transformers;
- Construct building for the 11kV switchboard and secondary control systems;
- Install 11kV switchboard (two bus sections with an allowance for a third) with arc containment and ducting;
- Install associated control and protection equipment in the new control building;
- Install two 11kV capacitor banks with an allowance for a third;
- Minor transmission and distribution line works to turn existing feeders into the new switchyard;
- Minor remote end control and protection equipment upgrades.

9.1.2 Scope Exclusions

- Decommissioning of the existing Nomad substation used for the Wishart Modular Substation.

9.1.3 Assumptions

The cost estimate is within ±20% accuracy. It is based on the recently completed Leanyer Zone Substation. The detailed design, costing, site selection, site survey, geotechnical investigation and earth grid assessment for the new ZSS has not yet been undertaken.

9.1.4 Dependencies

The new Wishart ZSS is assumed to be required after the completion of the new Berrimah Zone substation.

The NOMAD Modular substation is required to remain in situ until the new Wishart ZSS is commissioned.

9.1.5 Key Stakeholders

Name	Title / Business Unit
Internal – Governance Stakeholders	Chief Executive
	Investment Review Committee
	Executive General Manager Power Networks
	Chief Engineer
	Group Manager Service Delivery
Internal – Design Stakeholders	Senior Manager Networks Development and Planning
	Manager Major Projects
	Senior Manager Network Assets
	Manager Protection
	Manager Zone Substations
External – Authorities	City of Darwin
	Environmental Protection Authority
	Aboriginal Areas Protection Authority
External - Other	Local Residents
	Ministers
	Utilities Commission
	Australian Energy Regulator

9.2 Capital Cost

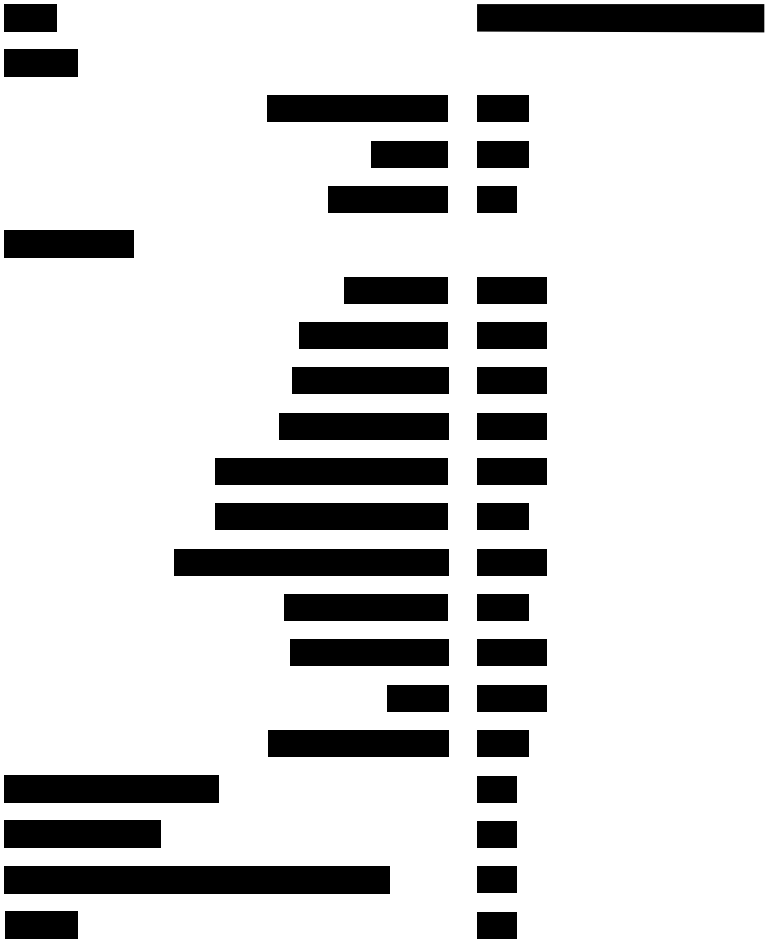
A preliminary cost estimate for the proposed Wishart ZSS has been prepared based on information provided by consultants.[26] A risk adjusted cost estimate (RACE) was conducted on the preferred option based on latest design, scope and cost information.

Based on the analysis, the project has a 90% likelihood of being delivered between [redacted] The calculated P_{50} risk-adjusted cost is the estimated cost of the project.

[26] GHD, *Power and Water Corporation, Wishart Modular Substation Options Study, Options Study Report,* October 2017

[redacted]

9.2.1 Base Capital Cost



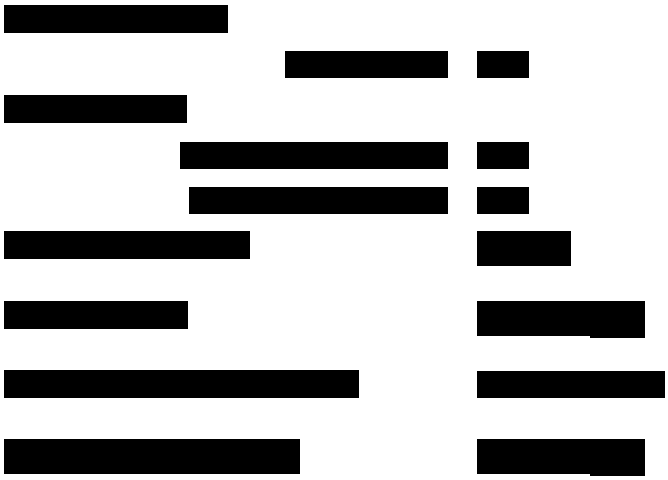


Table 1 – Base Capital Cost Estimate

9.2.2 Risk and Contingency

The current estimate has been developed largely based on Power and Water and consultant estimates considering previous experience with similar works. In addition, the RACE process integrates risk into cost estimates based on a monte-carlo simulation of expected pricing and risk realisation.

The contingency amount, calculated as the P95 value minus the expected P50 value, is currently $ 2.2 million.

9.3 Estimated Operating Cost Impact

The expected maintenance cost for a new AIS zone substation is expected to be approximately $142,677. This is based on the recently commissioned AIS Zone Substation in Leanyer. The new Wishart Zone Substation will have a similar configuration with an AIS 66kV switchyard, two 66/11kV transformers, and a 11kV switchboard with two bus sections. The existing operating cost of the Nomad portable substation is currently about $40,000, so there will be an increase when the permanent substation is constructed. Potential additional operating costs of the current arrangement, due to the unavailability of the NOMAD have not been considered.

Item	Annual Incremental Cost
Planned Maintenance	57,533
Preventative Maintenance	78,844
Unplanned Maintenance	6,299
TOTAL	**142,677**

Table 2 – Estimated Operating Cost Impact

9.4 Project Milestones

Project Phase (end)	Investment Planning	Project Development	Commitment	Implementation	Review
Original Plan (BNI)	05/2017	03/2021	06/2021	06/2024	09/2024
Current Forecast		03/2021	06/2021	06/2024	09/2024
Actual Completion	05/2017				

10 RISK MANAGEMENT AND COMPLIANCE

A preliminary risk register has been established to address project risk. This is included in Appendix E. This register will form the basis of the Project Risk Register and Safety in Design process into the project delivery phase. The register will be regularly reviewed and updated as required to ensure all identified risks are managed as the project progresses.

10.1 Technical and System Issues

The existing Wishart Modular Zone Substation will remain in service whilst the new substation is under construction.

As the site is adjacent to Hudson Creek Terminal Station and in close proximity to existing 66kV transmission lines, Power and Water AAR (Access to Apparatus Rules) will need to be adhered to during the construction period, although the impact will be minimal during most stages.. Security and access concerns will need to be addressed as well.

Change over from existing to the new 66kV switchyard will involve a short term line outage to affect the transfer. These outages will be scheduled away from peak periods and in close consultation with System Control to minimise system security risks.

11 PROJECT IMPLEMENTATION

This project is to be managed by the Power Networks' Project Management group. At this stage it is planned that the project will be delivered using the "Design and Construct" (D&C) methodology through an external contractor.

- This project will follow the requirements of the Power and Water investment planning framework (gating process);
- This project will follow the requirements of the Power Networks delivery framework; and
- The project will comply with Power and Water designs.

Testing and commissioning will be managed by Power Networks' Test and Protection group.

To ensure efficient costs are achieved, the majority of the electrical equipment and construction will be procured through the D&C contract, with detailed specifications prepared by Power and Water.

11.1.1 Resourcing Requirements (to next gateway)

The estimated resource requirements to finalise the Business Case for final gate approval is shown in the table below.

Resource Type/Role	How Many?	Internal/ External?	Anticipated Start Date	Duration Required	Allocation (% time or # hrs/days/ wks/mths)
Project Manager	1	Internal	Aug 2020	6 months	10%
Planning Engineer	1	Internal	Aug 2020	6 months	10%
Design Engineer	1	External	Aug 2020	6 months	50%

12 FINANCIAL IMPACT

12.1 Funding Arrangements

This project will be part of the augmentation capital works 2019-24 Network Price Determination to the AER, which is recovered through standard control network tariffs.

Based on the most up to date information, the project cost estimate has been revised to [redacted] The revised cost is based on the estimated costs provided in the concept design and additional estimates for internal Power and Water expenditure.

12.2 Capital Expenditure

The capex in the table below is in $2017-18, and is excluding capitalised overheads and cost escalation.

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]	[redacted]	[redacted]	[redacted]

12.3 Incremental Operating Expenditure

An operating expenditure of approximately $142,677 per annum is expected for the maintenance of the new switchyard. However, this cost will be offset by savings obtained from the redeployment of the NOMAD Modular substation from its temporary location in Wishart, resulting in a reduction of $40,000 per annum. Upon completion of the project, the operational cost of the new switchyard will be included in the operational budget and forecasted in regulatory processes.

APPENDIX A

Summary of Financial Analysis

Introduction

The purpose of this Appendix is to provide details of the options analysis for Construct Wishart Zone Substation.

Table A1 below outlines the estimated capital expenditure for each option. This is reflected in the operational cash flows below.

Commercial analysis of Option 1 (deferral) was not undertaken as it is not considered to be a viable alternative due to the risk of major outages as a result of significant load increases in the Wishart and East Arm area.

Table A1 – Estimated Capital & Operating Expenditure

Option	Capex – Base Costs ($M)	Opex – Base Costs ($000's)
Option 2a – 2 x 50MVA transformer 66/11kV Berrimah ZSS	[redacted]	$143 (from 2027/28)
Option 2b – 3 x 20/27MVA transformer 66/11kV Berrimah ZSS	[redacted]	$143 (from 2033/34)
Option 3 – 2nd Nomad Substation at Wishart	[redacted]	$143 (from 2027/28) $40 (annually from 2023 to 2027)
Option 4 – 2 x 27MVA 66/11kV Wishart ZSS	[redacted]	$143 (from 2024/25)

Assumptions

In modelling the options, technical, economic and cost parameters were included. The technical and cost data was provided by Power Networks and the economic data was sourced from Pricing and Economic Analysis (PEA). Base cost capital expenditure was sourced from the consultant's feasibility study.

In the assumptions, all costs exclude GST or other government charges.

The common variables employed in the Discounted Cash Flow (DCF) model are presented in Table A2 below.

These variables are consistent with the 2019-24 Regulatory Proposal to the AER and are considered appropriate for use in the detailed commercial analysis.

Table A2 – Common Variables

Variables	
Nominal Pre-Tax WACC	6.96%
CPI – 2017/18	2.42%

CPI after 2017/18	2.42%
Time Horizon of Project	40 years

Option 1 - Deferral

Commercial analysis of Option 1 (deferral) was not undertaken as it is not considered to be a viable alternative due to the risk of major outages as a result of significant load increases in the Wishart and East Arm area.

Option 2a – 2 x 50MVA transformer 66/11kV Berrimah ZSS

The analysis for this option includes capital expenditure of [redacted]

Option 2b – 3 x 20/27MVA transformer 66/11kV Berrimah ZSS

The analysis for this option includes capital expenditure of [redacted]

Option 3 – 2nd Nomad Substation at Wishart

The analysis for this option includes capital expenditure of [redacted]

Option 4 – 2 x 27MVA 66/11KV Wishart ZSS

The analysis for this option includes capital expenditure of [redacted]

Least cost analysis

Based on the DCF analysis undertaken, the least cost option is Option 4. This option is $9.5 million less in Net Present Cost (NPC) terms than Option 2a, $5.3 million less than Option 2b and $2.3 million less than Option 3. This is summarised in Table A3 below.

Table A3 – Net Present Cost of Options

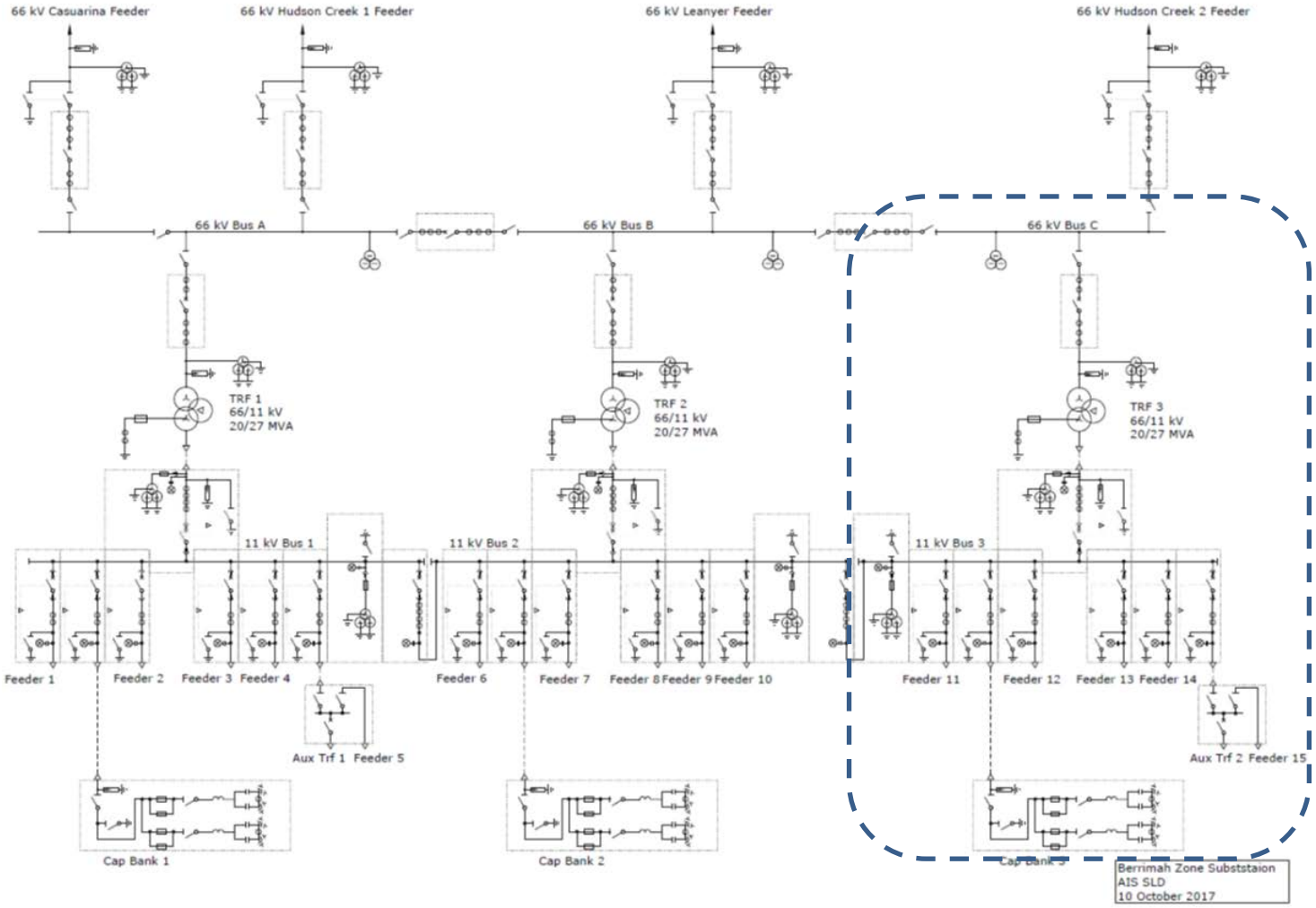
Option	NPC ($M)
Option 2a – 2 x 50MVA transformer 66/11kV Berrimah ZSS	[redacted]
Option 2b – 3 x 20/27MVA transformer 66/11kV Berrimah ZSS	[redacted]
Option 2 – 2nd Nomad Substation	[redacted]
Option 4 – 2 x 27MVA 66/11kV Wishart ZSS	[redacted]

Tariff cover

A portion of this project capex (2021/22, 2022/23, and 2023/24 expenditure) will be submitted as part of the 2019 Regulatory Proposal to the AER. The AER's Final Determination will provide the approved level of net capital expenditure for the 2019-24 period. In so far as the Regulated Networks annual capital expenditure program remains at this level (or lower), Networks will earn a guaranteed rate of return through standard control service charges until the commencement of the next regulatory control period in 2024-25.

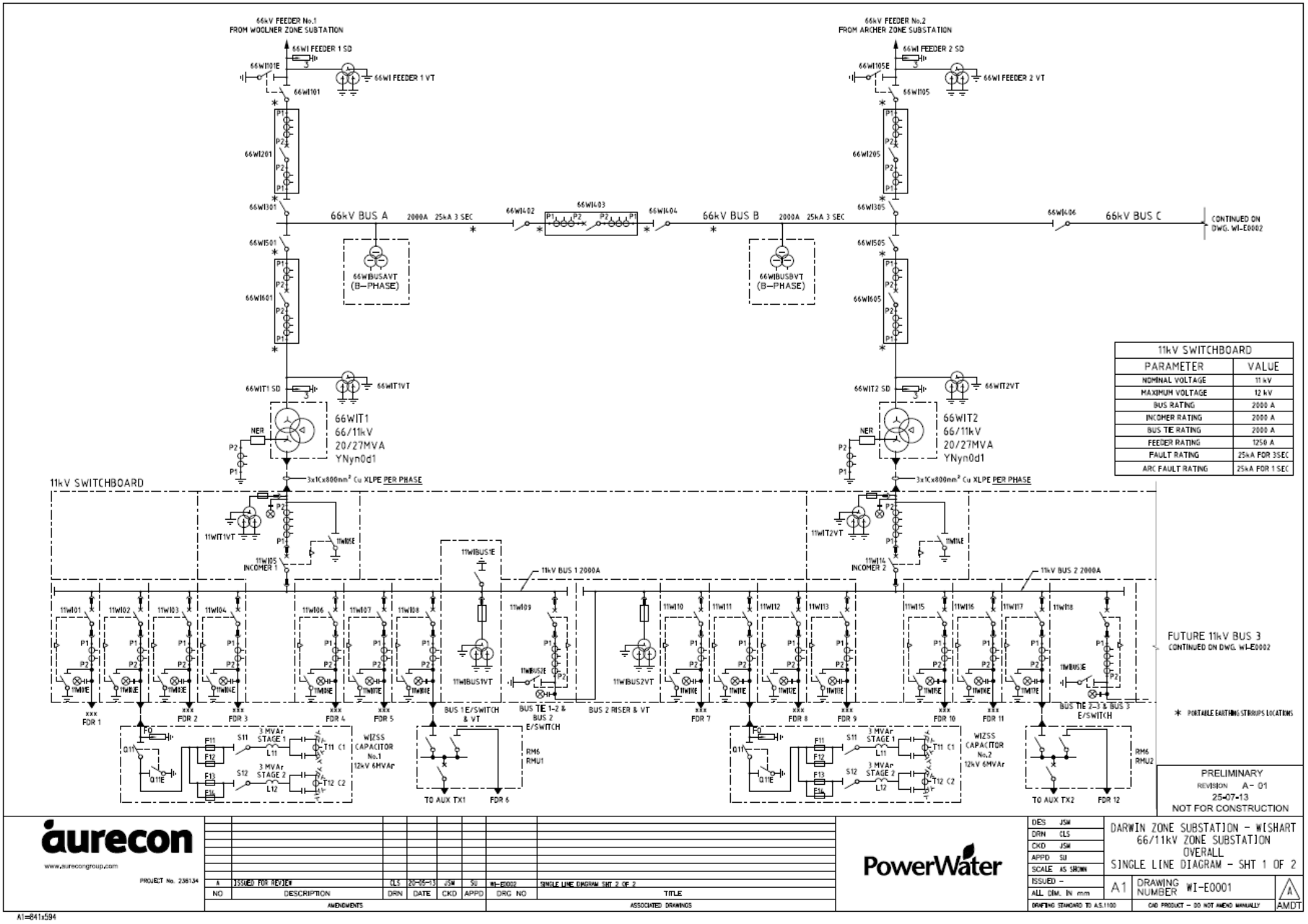
APPENDIX B

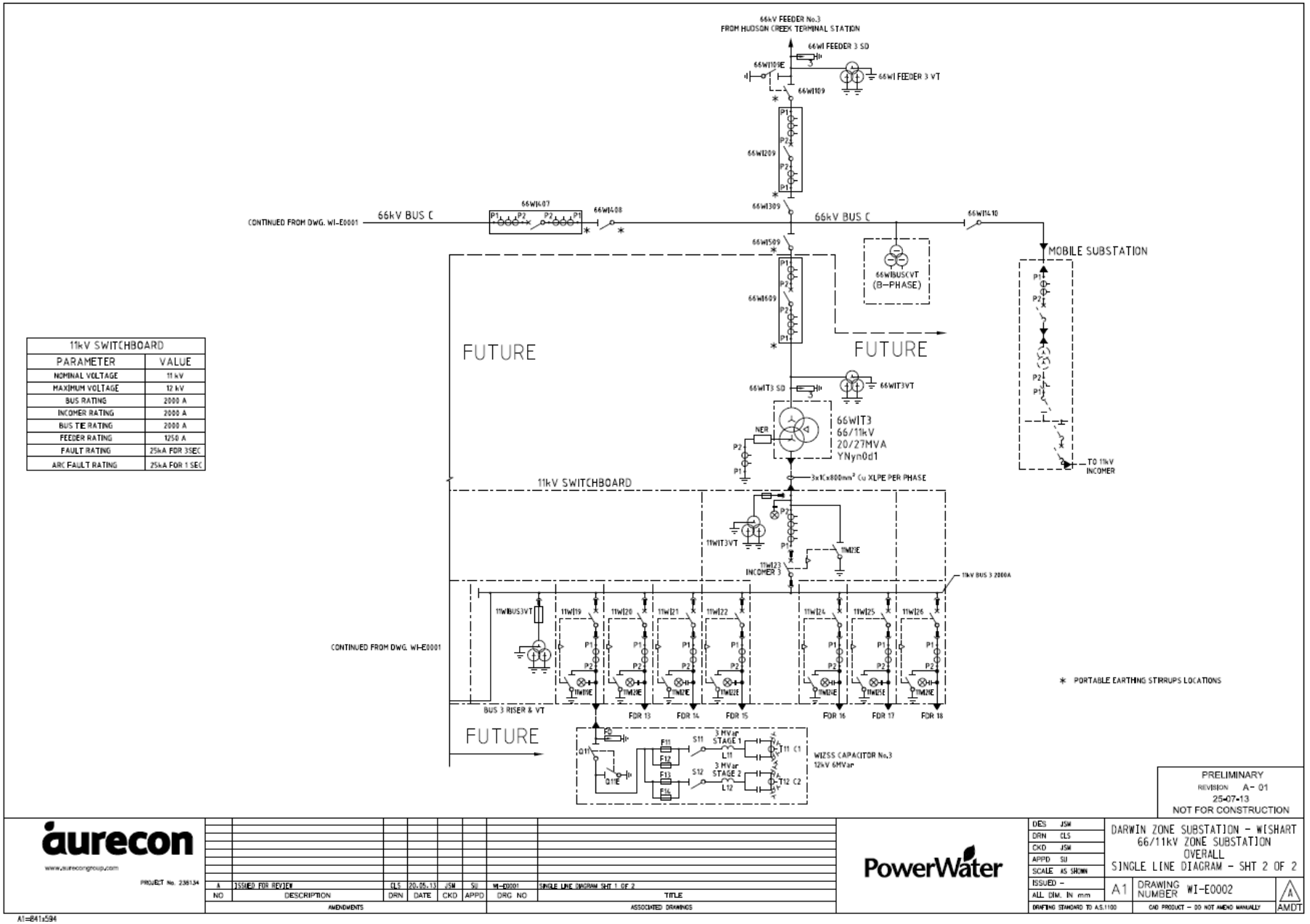
SLD of Option 2 – Third Transformer at Berrimah Zone Substation


66 kV Casuarina Feeder
66 kV Hudson Creek 1 Feeder
66 kV Leanyer Feeder
66 kV Hudson Creek 2 Feeder
66 kV Bus A
66 kV Bus B
66 kV Bus C
TRF 1
66/11 kV
20/27 MVA
TRF 2
66/11 kV
20/27 MVA
TRF 3
66/11 kV
20/27 MVA
11 kV Bus 1
11 kV Bus 2
11 kV Bus 3
Feeder 1
Feeder 2
Feeder 3
Feeder 4
Aux Trf 1
Feeder 5
Feeder 6
Feeder 7
Feeder 8
Feeder 9
Feeder 10
Feeder 11
Feeder 12
Feeder 13
Feeder 14
Aux Trf 2
Feeder 15
Cap Bank 1
Cap Bank 2
Berrimah Zone Subststaion
AIS SLD
10 October 2017

APPENDIX C

SLD and Layout of Option 3 – New AIS Zone Substation at Wishart


66kV FEEDER No.1
FROM WOOLNER ZONE SUBSTATION
66kV FEEDER No.2
FROM ARCHER ZONE SUBSTATION
66kV BUS A
66kV BUS B
66kV BUS C
2000A 25kA 3 SEC
CONTINUED ON DWG. WI-E0002
66WIT1
66/11kV
20/27MVA
YNyn0d1
66WIT2
66/11kV
20/27MVA
YNyn0d1
11kV SWITCHBOARD
11kV BUS 1 2000A
11kV BUS 2 2000A
FUTURE 11kV BUS 3
CONTINUED ON DWG. WI-E0002
* PORTABLE EARTHING STRIPS LOCATIONS
11kV SWITCHBOARD
PARAMETER | VALUE
NOMINAL VOLTAGE | 11 kV
MAXIMUM VOLTAGE | 12 kV
BUS RATING | 2000 A
INCOMER RATING | 2000 A
BUS TIE RATING | 2000 A
FEEDER RATING | 1250 A
FAULT RATING | 25kA FOR 3SEC
ARC FAULT RATING | 25kA FOR 1 SEC
PRELIMINARY
REVISION A- 01
25-07-13
NOT FOR CONSTRUCTION
aurecon
www.aurecongroup.com
PROJECT No. 236134
A ISSUED FOR REVIEW CLS 20-05-13 JSW SU WI-E0002 SINGLE LINE DIAGRAM SHT 2 OF 2
NO DESCRIPTION DRN DATE CKD APPD DRG NO TITLE
AMENDMENTS ASSOCIATED DRAWINGS
PowerWater
DES JSW
DRN CLS
CKD JSW
APPD SU
SCALE AS SHOWN
ISSUED –
ALL DIM. IN mm
DRAFTING STANDARD TO AS.1100
DARWIN ZONE SUBSTATION - WISHART
66/11kV ZONE SUBSTATION
OVERALL
SINGLE LINE DIAGRAM - SHT 1 OF 2
A1
DRAWING NUMBER WI-E0001
A
AMDT
CAD PRODUCT – DO NOT AMEND MANUALLY
A1=841x594



11kV SWITCHBOARD	
PARAMETER	VALUE
NOMINAL VOLTAGE	11 kV
MAXIMUM VOLTAGE	12 kV
BUS RATING	2000 A
INCOMER RATING	2000 A
BUS TIE RATING	2000 A
FEEDER RATING	1250 A
FAULT RATING	25kA FOR 3SEC
ARC FAULT RATING	25kA FOR 1 SEC

PRELIMINARY
REVISION A- 01
25-07-13
NOT FOR CONSTRUCTION

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PROJECT No. 236134

NO	DESCRIPTION	DRN	DATE	CKD	APPD
A	ISSUED FOR REVIEW	CLS	20.05.13	JSM	SU

AMENDMENTS

DRG NO	TITLE
WI-E0001	SINGLE LINE DIAGRAM SHT 1 OF 2

ASSOCIATED DRAWINGS

PowerWater

DES	JSM
DRN	CLS
CKD	JSM
APPD	SU
SCALE	AS SHOWN
ISSUED -	
ALL DIM. IN mm	

DRAFTING STANDARD TO A.S.1100

DARWIN ZONE SUBSTATION - WISHART
66/11kV ZONE SUBSTATION
OVERALL
SINGLE LINE DIAGRAM - SHT 2 OF 2

A1 DRAWING NUMBER WI-E0002 A AMDT

CAD PRODUCT - DO NOT AMEND MANUALLY

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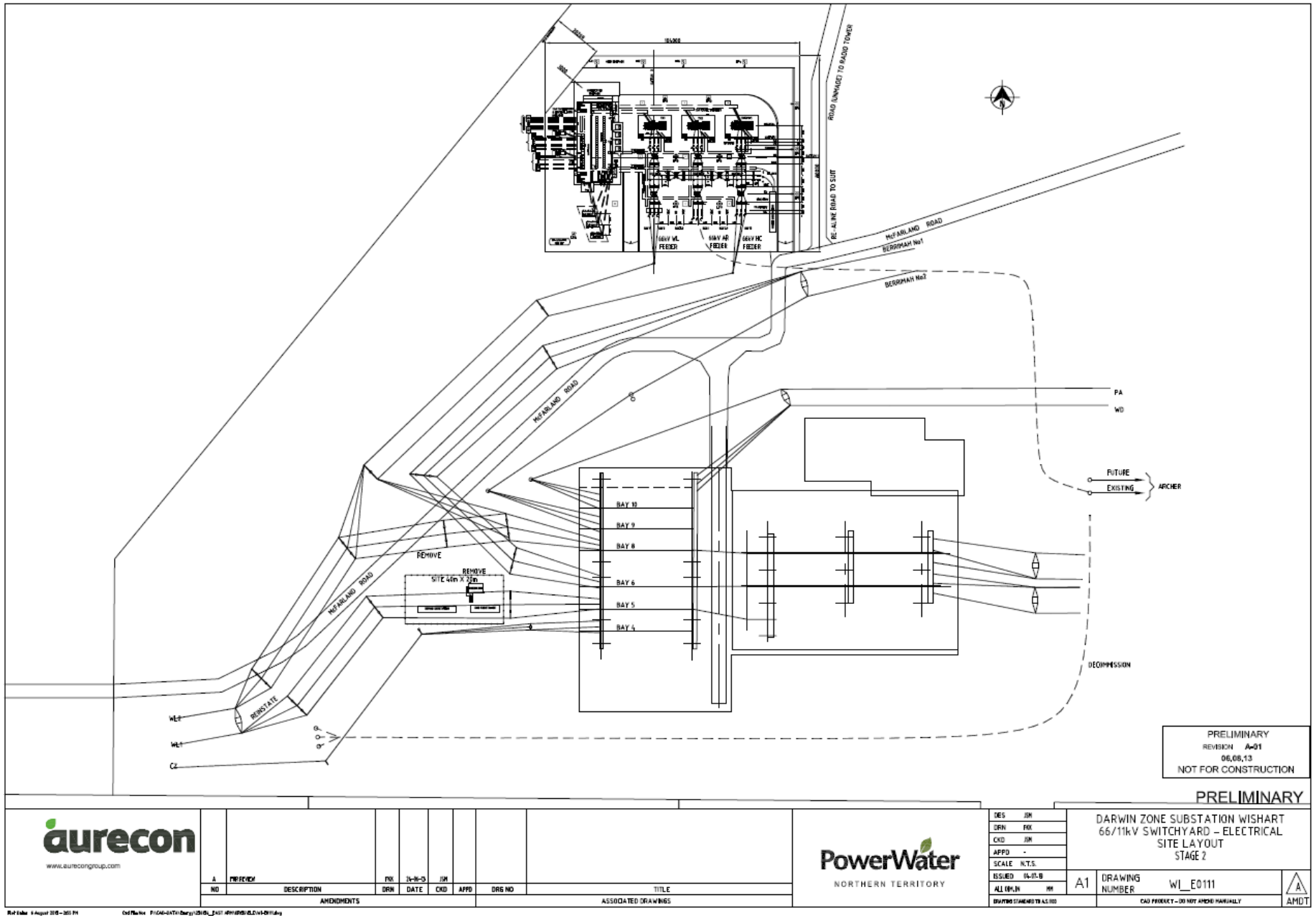
ROAD (UNMADE) TO RADIO TOWER
RE-ALIGN ROAD TO SUIT
66kV WL FEEDER
66kV AR FEEDER
66kV HC FEEDER
McFARLAND ROAD
BERRIMAH No1
BERRIMAH No2
McFARLAND ROAD
PA
WD
FUTURE
EXISTING
ARCHER
BAY 10
BAY 9
BAY 8
BAY 6
BAY 5
BAY 4
REMOVE
REMOVE
SITE 46m X 20m
McFARLAND ROAD
REINSTATE
DECOMMISSION
WL2
WL1
CZ
PRELIMINARY
REVISION A-01
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A PRELIMINARY JSH 14-08-13
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NORTHERN TERRITORY
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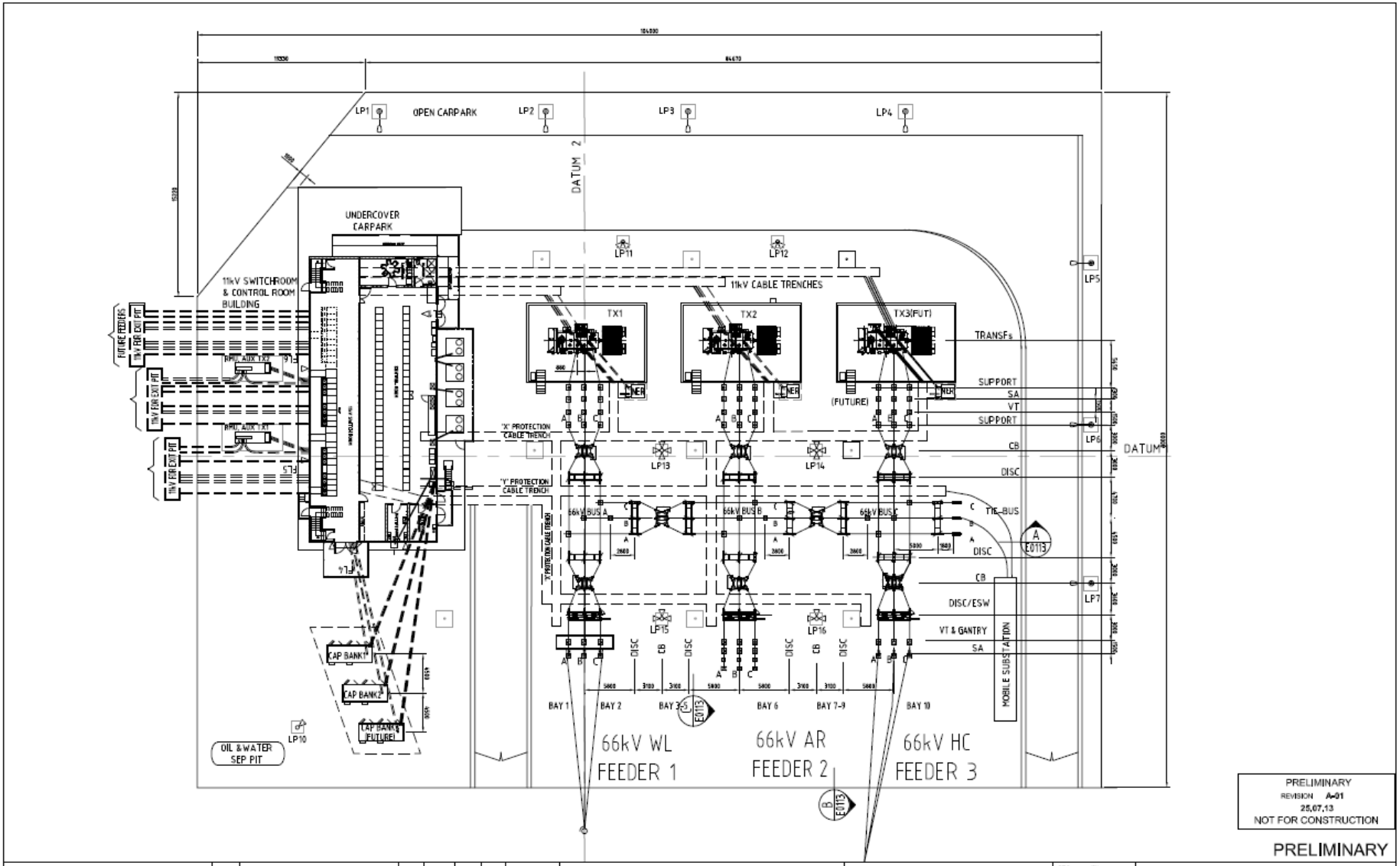
CKD JSH
APPD -
SCALE N.T.S.
ISSUED 14-08-13
ALL DIM.IN MM
DRAWING STANDARD TO A.S.1100
DARWIN ZONE SUBSTATION WISHART
66/11kV SWITCHYARD – ELECTRICAL
SITE LAYOUT
STAGE 2
A1
DRAWING NUMBER WI_E0111
A AMDT
CAD PRODUCT – DO NOT AMEND MANUALLY



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AMENDMENTS

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ASSOCIATED DRAWINGS

PowerWater
NORTHERN TERRITORY

DES	JSH
DRN	PIX
CKD	JSH
APPD	-
SCALE	1:200
ISSUED	04-07-13
ALL DIMS	MM

DRAWING STANDARD TO AS1100

DARWIN ZONE SUBSTATION WISHART
66/11kV SWITCHYARD – ELECTRICAL
SUBSTATION LAYOUT
STAGE 2

A1

DRAWING NUMBER WI_E0100

A AMDT

CAD PRIVACY – DO NOT AMEND MANUALLY

APPENDIX D

PROJECT RISK ANALYSIS

Refer:

PRD30402 Risk Analysis Wishart Zone Substation

Power and Water Ref: D2017/468839

APPENDIX E

SUMMARY PROJECT PROGRAM

Task	*Baseline*			*2020*		*2021*				*2022*				*2023*				*2024*	
	Plan Start	*Plan Duration*	*Percent Complete*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*
Options Study	Jul 17	12 wks	100%																
Concept Design	Aug 20	12 wks	50%																
Planning and Permits	Jan 21	20 wks	20%																
Detailed Design	Jun 21	28 wks																	
Procurement	Jan 22	44 wks																	
Civil Construction	Jan 22	24 wks																	
Primary Electrical Construction	Jun 22	40 wks																	
Secondary Electrical Construction	Jan 23	40 wks																	
Commissioning and Energisation	Oct 23	20 wks																	
Cutover Existing Services	Apr 24	8 wks																	

APPENDIX F

Planning Report

Refer:

NPR1608 Planning Report – Wishart Zone Substation

PWC Ref: D2017/298126

PowerWater

Report No:	NPR1608	**File No:**	D2017/298126
Revision	Final	**Container No:**	F2005/13996
Date:	13th February 2018		
Author:	Craig Owens		
Approved by:	Tat Au-Yeung – Senior Manager Network Development and Planning		
Title:	**Wishart Area Demand Growth**		

Report Circulation:

The following staff members are on the circulation list for this report:

Goutham Maddirala	Peter Kwong	Christina Camilleri

1. Executive Summary

The combined firm capacity of Berrimah Zone Substation (ZSS) and the Wishart Modular Substation is forecast to be exceeded during 2021/2022.

Wishart, Berrimah, East Arm and the surrounding areas have significant development opportunities, with a total of 28.4 MVA[27] of additional committed maximum demand expected to be connected to the two substations in the period 2017/18 to 2023/24.

[27] APPENDIX B Load Forecasts: Sum of Permanent Changes (MVA) for the 2017/18 to 2023/24

–Wishart Area Demand Growth

Many of the assets at Berrimah Zone Substation are in poor condition and near the end of their useful life. The existing power two 25/31.5/38 MVA transformers are planned to be replaced as part of a rebuild of the Zone Substation which will see two new smaller, standard sized 20/27 MVA transformers installed.

Projections indicate feeders from the rebuilt Berrimah ZSS and Wishart Modular Substation cannot meet N-1 criteria in this area.

It is recommended that development work to meet demand for new loads in the Wishart area be started.

2. Network Planning Criteria

The relevant clauses in the Power Networks Network Technical Code and Network Planning Criteria, December 2013 that apply to this study are:

Part A – Legislative Requirements

Part B – Network Technical Code

1.7 Obligations

2.3 Power frequency voltage levels

4.2 Power system security principles

4.3 Power system security obligations and responsibilities

4.5 Control of network voltages

8 Disconnection and reconnection of plant and equipment

Part C – Network Planning Criteria

The purpose of Network Planning Criteria is to strike a balance between each User's need for a safe, secure, reliable, high quality electricity supply and the desire for this service to be provided at minimal cost. At the same time, environmental and social considerations shall be taken into account.

13 Introduction

14 Supply contingency criteria

15 Steady state criteria

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3. Contents

4. List of Tables

5. Introduction

5.1. Background

The area of East Arm (EA) was developed into a new Port in the year 2000 with the addition of the Adelaide to Darwin rail in 2003. This has significantly increased the loading in the East Arm area and it is expected to continue with growth projected [redacted]

Berrimah Zone Substation is a 66/11kV Zone Substation located on Vanderlin Drive, Berrimah. It supplies between Berrimah and surrounding Zone Substations Palmerston, Casuarina, Woolner, Wishart Modular and the Leanyer ZSS.

The Wishart Modular Substation is located near the corner of Berrimah and Wishart Roads, adjacent to the Hudson Creek Transmission Terminal substation. It was commissioned in November 2015 in order to defer the construction of a new Zone Substation at that site.

This report details the capacity of the existing infrastructure to meet the forecast growth in Berrimah, Wishart and East Arm areas and works required to meet growth.

5.2. Existing network

The area to be considered is as shown in APPENDIX A Existing Area of Development on page 56. As can be seen there is Berrimah ZSS, Palmerston ZSS, Wishart Modular ZSS and Hudson Creek Terminal Station in the area.

Berrimah ZSS, Palmerston ZSS and Wishart Modular Substation provide supply to the 11 kV network in the area. There is limited interconnection capacity to Palmerston Zone Substation. It is reasonable to consider the combined firm capacity of the Berrimah and Wishart Modular substation. The normal cyclic firm capacity of 50.1 MVA shown in APPENDIX B Load Forecasts on page 57 considers that one of the existing Berrimah transformers is out of service.

The chart at APPENDIX B Load Forecasts shows the updated forecast produced by AEMO in 2017 for the combined Berrimah and Wishart maximum demands.

The combined firm rating of the two substations was increased by 12 MVA in 2014/2015 when the Wishart Modular Substation was installed. The reduction in firm rating shown in 2020/2021 reflects the fact that the proposed replacement transformers at Berrimah have lower cyclic rating than the existing units. As can be seen from the chart at Appendix B, forecast maximum demand exceeds firm capacity of the two substations in 2021/2022.

Significant proposed new developments in the area are shown in APPENDIX C Geographical Map of new Subdivisions on page 59.

5.3. Scope of study

The scope of study is to determine the required actions to be able to meet current load and future growth of East Arm, Hudson Creek, Wishart and Berrimah suburbs.

The study will consider possible options to delay capital expenditure and interim arrangements for meeting expected load forecasts.

5.4. Existing works

Berrimah ZSS is planned for rebuild due to advanced asset age and poor condition. This project is planned to be commissioned by 2020/2021.

Wishart Modular ZSS was established towards a long term solution to develop the entire load area gradually, in tune with development demand but also maintain compliant supply security and power quality to the entire area that continues to grow away from historical load centres. Further development at the Wishart site will provide this broader capability and defer additional, less effective development at the more distant Berrimah ZSS site.

6. Overview of works and rationale for the network investment

6.1. Existing system

The existing system will not meet the required supply contingency criteria for class of supply C[28], once Berrimah Zone Substation is rebuilt and the total load on Berrimah and Wishart exceeds 42.1 MVA in 2021/2022. In addition

[28] Network Technical Code and Network Planning Criteria - Table 13 - Supply contingency criteria - CBD and Urban areas

there will be voltage issues in the East Arm area for the loss of the transformer at the existing Wishart Modular Substation.

There is difficulty moving loads to adjacent feeders with long switching programs required. This means that is unlikely that the 60 minute restoration time required for class C supply could be met. This is considered critical as the Port and industrial areas are productive industrial areas with the NT economy.

6.2. New developments

Identified new developments in the Berrimah, Wishart, East Arm area and the maximum demand that they are expected to draw are listed in Table 1 below.

Table 1 - Proposed additional loads

Description	Load (MVA)[29]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

This represents a total notional additional maximum demand of 45.8 MVA. These loads are expected to be connected over several years meaning that it is not necessary to provide for the total additional load immediately.

APPENDIX B Load Forecasts on page 57 shows graphically the AEMO forecast increase in load on Berrimah and Wishart Modular Substations over the period to 2026/2027.

In APPENDIX C Geographical Map of new Subdivisions, shows the location of the significant developments.

[29] Committed developments as at 19 July 2017 recorded in D2016/269280 - 2016/17 Load log for forecasting All Regions created 16 June 2016

6.3. Identification of network limitations

As can be seen from the chart in APPENDIX B Load Forecasts on page 57, forecast load in the Berrimah and Wishart area is expected to exceed the combined substations' cyclic firm capacity in 2021/2022.

6.4. Material inter network impact

No material inter network impacts have been considered in this study. This study has only considered the 11kV network in the Berrimah, Wishart and East Arm areas of Darwin and does not consider interactions on the 66/132kV transmission network.

6.5. Consideration of demand management and/or local generation

Where applications are being made for solar in the area they are being approved/encouraged. This is because the daily load profile and PV daily generation profile are compatible. There are also more distribution transformers than in residential areas reducing the possibility of voltage drop/rise issues on the LV.

As growth is new load of residential and small commercial nature as opposed to underlying growth there are limited opportunities seen for demand management.

7. Options considered

7.1. Do nothing

This option is not considered reasonable since the forecast maximum demand on Wishart and Berrimah Zone Substations is expected to exceed their combined cyclic firm capacity in the 2021/2022 financial year or sooner. This exceedance would be contrary to the supply contingency requirement of the Network Planning Criteria.[30] The installation of Wishart Modular Substation has to date, provide deferral of more significant investment.

[30] Network Technical Code and Network Planning Criteria - Table 13 - Supply contingency criteria - CBD and Urban areas – Class of Supply C

7.2. New Wishart Zone Substation

This is the most technically suitable option given the forecast loading of both Wishart Modular and Berrimah Zone Substations and expected growth of areas surrounding. A site is available for the new Zone Substation adjacent to the existing Wishart Modular Substation and the Hudson Creek Transmission Terminal Substation.

Following the commissioning of the new Wishart Zone Substation, the existing Wishart Modular Substation should be removed and made available again for emergency deployment.

Installation at this site requires minimal transmission line works, no additional land acquisition and is central to the developing load.

7.3. Install 3rd transformer at Berrimah

This is a possible short term solution which would include a new 66/11kV transformer, new 11kV switchboard extension, if installed with additional feeders would meet the needs of East Arm in the short term and new breakers to provide feeders to Pinelands or Robertson Barracks would also be available.

Additional feeders from Berrimah ZSS towards East Arm will be very expensive due to routes being along/across major roads with significant traffic. Along Berrimah Road there is very limited room for overhead power poles and underground will bring higher costs. As subdivisions continue to be developed around Hidden Valley, Berrimah and Wishart there will be additional feeders required. The distance to the load and associated voltage regulation concerns also will limit the effectiveness of the investment. This option does not cater for the expected longer term growth in this area.

Another disadvantage of this option is that the Nomad from Wishart Modular Substation, intended as an interim solution is not available for emergency service and demand management options throughout the network.

In addition, as load grows, particularly in the East Arm area, it is expected that there would be low steady state voltage in the case of a failure of the Wishart Modular Substation transformer.

7.4. Demand Management

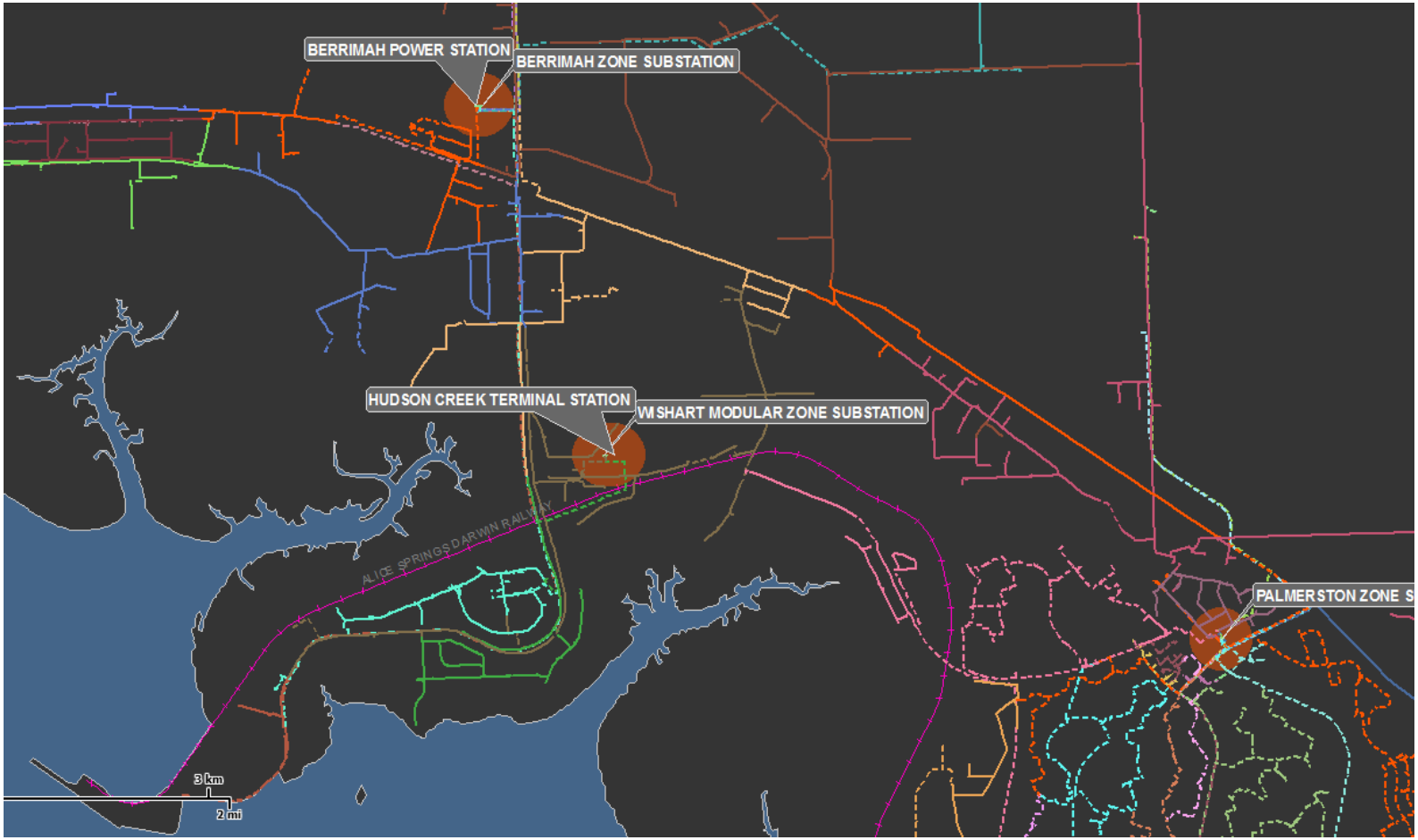
Demand management as considered in the section 6.5.

8. Conclusions and recommendations

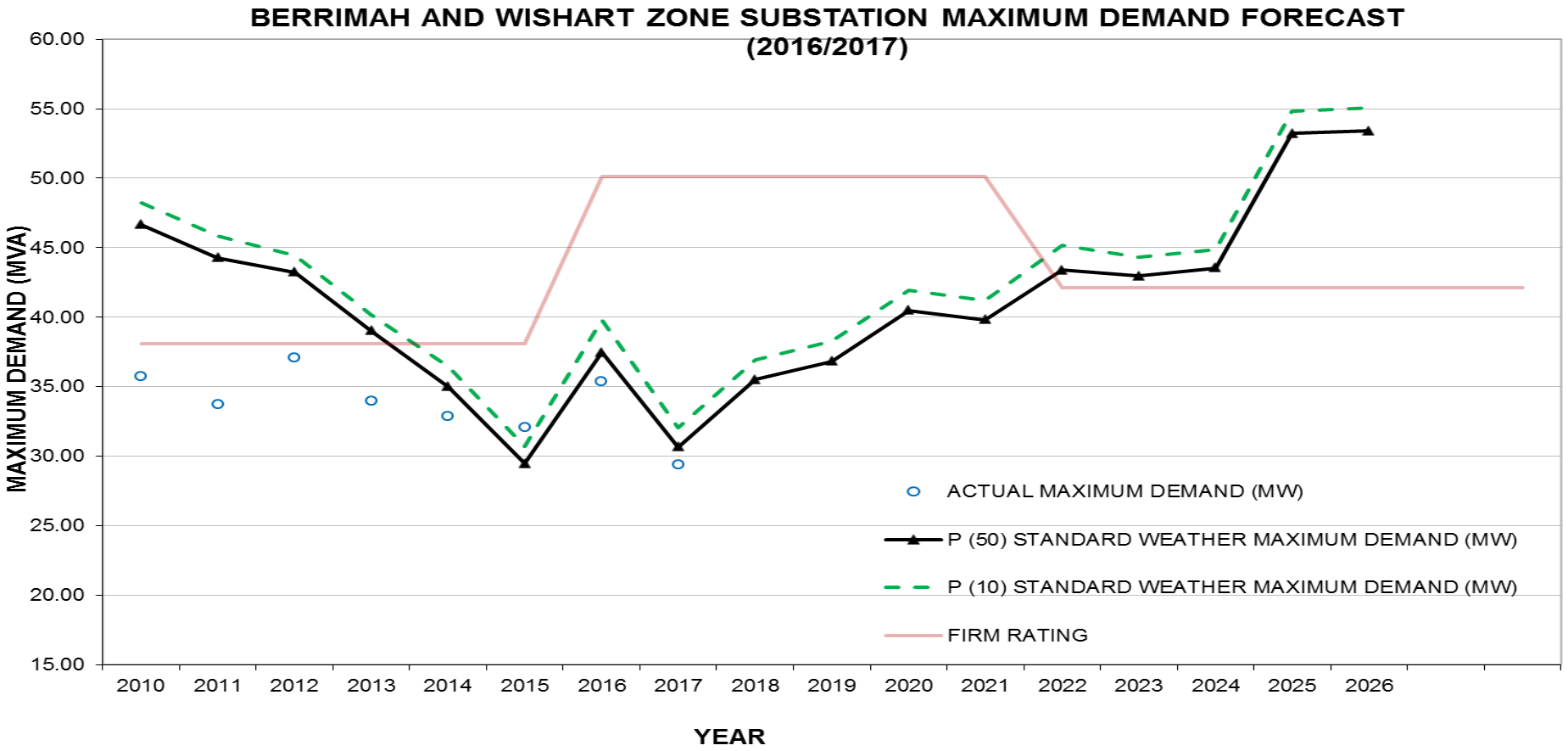
A business case should be prepared for determining the options to further the design and construction of a new, two transformer Zone Substation built adjacent to the existing Wishart Modular Substation. The substation is expected to be required by 2020/2021, depending on actual load on the network.

Berrimah and Wishart actual and forecast loads should be closely monitored to determine when the new Zone Substation is required.

9. APPENDIX A Existing Area of Development



10. APPENDIX B Load Forecasts



BERRIMAH AND WISHART ZONE SUBSTATION MAXIMUM DEMAND FORECAST (2016/2017)[31]

Note: P10 and P50 Values from AEMO are used which includes all adjustment for load transfers and block loads

YEAR	ACTUAL MAXIMUM DEMAND (MW)	P (50) STANDARD WEATHER MAXIMUM DEMAND (MW)	P (10) STANDARD WEATHER MAXIMUM DEMAND (MW)	NORMAL RATING OF THE TRANSFORMERS (MVA)	CYLCIC RATING OF THE TRANSFORMERS (MVA)	FIRM RATING (MVA)
2009	36.31	46.31	47.82	76.00	76.20	38.10
2010	35.76	46.65	48.22	76.00	76.20	38.10
2011	33.73	44.26	45.85	76.00	76.20	38.10
2012	37.07	43.23	44.43	76.00	76.20	38.10
2013	33.99	39.01	40.16	76.00	76.20	38.10
2014	32.89	35.01	36.43	76.00	76.20	38.10
2015	32.09	29.48	30.70	88.00	88.20	50.10
2016	35.38	37.48	39.80	88.00	88.20	50.10
2017	29.41	30.66	32.05	88.00	88.20	50.10
2018		35.53	36.92	88.00	88.20	50.10
2019		36.84	38.25	88.00	88.20	50.10
2020		40.48	41.93	88.00	88.20	50.10
2021		39.82	41.24	66.00	72.20	42.10
2022		43.40	45.17	66.00	72.20	42.10
2023		42.96	44.33	66.00	72.20	42.10
2024		43.55	44.90	66.00	72.20	42.10
2025		53.22	54.80	66.00	72.20	42.10
2026		53.40	55.05	66.00	72.20	42.10
2027		54.84	56.50	66.00	72.20	42.10

[31] D2017/446904 - NPR1608 Supporting Document - Berrimah and Wishart Zone Substation Maximum Demand Forecast (2016-2017)

–Wishart Area Demand Growth

[redacted]