PB ASSOCIATES

TRANSFER CAPABILITY REVIEW

Of Murraylink Application to ACCC

Prepared for

AUSTRALIAN COMPETITION AND CONSUMER COMMISSION

***PB Associates** Quality System:*

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EXECUTIVE SUMMARY

This report presents the results of a review of the Murraylink transfer capability assessments provided in the Murraylink Transmission Company (MTC) *Application for Conversion to a Prescribed Service and a Maximum Allowable Revenue for 2003-12 of 18 October 2002* (MTC Application). The review was undertaken by PB Associates for the Australian Competition and Consumer Commission.

This review and ensuing report is based on the information contained in the revenue cap application and additional supporting information provided to PB Associates by MTC. This report has been prepared on the basis that this information is accurate and PB Associates has not undertaken any audit of the accuracy or validity of the power system studies or underlying models on which this information was based.

During the course of this review, MTC provided a presentation to PB Associates on the TransEnergie Australia (TEA) and Power Technologies International (PTI) reports. Further clarifications and information were provided by MTC in responding to information requests and questions from PB Associates. Formal discussions with transmission network service providers (TNSPs) or other stakeholders have not been held, although some informal discussion took place with VENCorp.

The review included a detailed study of a previous Interconnector Options Working Group (IOWG) assessment of Murraylink published in August 2001 and a brief appraisal of the IOWG assessments for SNOVIC and SNI as these documents are all considered relevant to any assessment of the Murraylink transfer capability. The main documents from the Murraylink revenue cap application to the Commission reviewed for this report were the TEA Murraylink Transfer Capability Assessment (Appendix A of application) and the PTI Due Diligence on Power Transfer Studies (Appendix B of application).

The main findings and recommendations of the review are as follows:

Murraylink Transfer Capability

Under the assumption that the findings of original IOWG assessments of Murraylink, SNOVIC and SNI were correct, and noting the findings of the PTI due diligence, PB Associates believes that the following Murraylink transfer capabilities should be achievable:

- 2003/04 Peak summer demand, high import (1900 MW) to Victoria from Snowy / NSW, incremental generation in Victoria – Murraylink transfer capability Victoria to South Australia (SA) is **180 MW.** This is lower than the capability proposed by TEA and is discussed further below.

- 2003/04 Peak summer demand, high import (2010 MW) to Victoria from Snowy / NSW, incremental generation in NSW – Murraylink transfer capability Victoria to SA is **110 MW**

- 2003/04 Peak Riverland demand – Murraylink transfer capability SA to Victoria is **95 – 100 MW**

This assumes that the existing and additional augmentations defined in the TEA report are in service.

The 180 MW transfer capacity from Victoria to SA with incremental generation in Victoria is less than the 220 MW transfer capacity given in the MTC application for these conditions. This difference is due to uncertainty on whether unacceptable voltage depression or collapse in the state grid region of Victoria might occur for transfers greater than 180 MW under these conditions. PB Associates recommends that further dynamic studies are performed, in consultation with VENCorp, to determine whether the full 220 MW transfer capability claimed by TEA is achievable, considering the additional augmentations proposed in the TEA report or similar.

PB Associates notes the following with respect to its review of the transfer capability of Murraylink:

- TEA and PTI have demonstrated that they had used the best available information (including PSS/E data files provided by NEMMCO), conventional assumptions, and accepted methodology as the basis of their analysis;
- This information, assumptions and methodology had been used in the recent past by the IOWG to assess the transfer capability of Murraylink and other proposed network augmentations;
- A number of augmentations, which alleviate some of Murraylink's constraints, have been undertaken at the expense of the Murraylink Transmission Partners since the initial IOWG assessment of Murraylink; and
- PB Associates examined the data files and the nature of TEA's analysis, sought extensive additional explanation from TEA, and found no evidence that the power system studies on which the TEA Report is based are invalid.

Other Issues

1. At the time of the IOWG study TEA, after consultation with TransGrid, were proposing a number of minor network augmentations and run-back schemes to alleviate the most limiting constraints arising from the operation of the NSW grid. These schemes have still to be implemented, even though they are assumed in service for this assessment. MTC have advised that these augmentations are at an advanced stage and the latest estimated in service date is May 2003.
2. MTC have included a capped augmentation expenditure clause in the revenue cap application and are proposing only to fund additional augmentation up to a $8.97 million limit. PB Associates recommends that consultation is held with the affected TNSPs to confirm that the additional augmentations are achievable below this cap.
3. The PTI due diligence confirmed the requirements for the additional augmentations and runback schemes proposed in the TEA report to achieve the following Murraylink transfer capabilities stated above.

1. INTRODUCTION

On 18 October 2002, the Australian Competition and Consumer Commission (Commission) received an application from the Murraylink Transmission Company (MTC), on behalf of the Murraylink Transmission Partnership (MTP), requesting the Commission determine that:

1. the network service provided by the Murraylink interconnector be classified as a prescribed service for the purposes of the National Electricity Code (Code); and

2. for the provision of this prescribed service, MTC be eligible to receive the maximum allowable revenue from transmission customers (through a coordinating network service provider) for a regulatory period commencing from the date of the Commission's final decision to 31 December 2012.

PB Associates has been engaged by the Commission to review the assessment of the Murraylink interconnector's transfer capability included in the application. The power transfer capability of Murraylink is a critical input into the calculation of the market benefits of the interconnector. The greater the transfer capability of Murraylink then the greater its potential market benefits as assessed under the regulatory test. Therefore, it is essential to accurately assess the transfer capability so that the economic value of Murraylink can be estimated from a market benefit analysis, and hence, the regulated revenue of Murraylink can be set.

In the MTC application, additional AC network augmentations have been proposed to increase the Murraylink transfer capability from existing levels.

This report documents PB Associates' review and findings.

1.1 TERMS OF REFERENCE

The Terms of Reference provided by the Commission required this review to analyse and comment on the following matters in relation to the transfer capability of Murraylink proposed in the application:

1. The assumptions, methodology and findings of TransEnergie Australia's (TEA) Power Transfer Capability Report (Appendix A of MTC's application).
2. The due diligence of TEA's Power Transfer Capability Report, undertaken by Power Technologies International (PTI) (Appendix B of MTC's application).

1.2 REVIEW

PB Associates notes that this review and ensuing report is based on the information in the application and provided to PB Associates by MTC. This report relies on the said information and PB Associates has not undertaken any form of audit of the power system studies or underlying models on which this information was based.

During the course of this review, MTC provided a presentation to PB Associates on the TEA and PTI reports. Further clarifications and information were provided by MTC in response to information requests and questions by PB Associates. Formal discussions with transmission network service providers (TNSPs) or other stakeholders have not been held, although some informal discussion took place with VENCorp.

This report is structured such that in Section 2 we provide the background and history of the Murraylink interconnector. Public reports related to the assessment of the transfer capability of Murraylink are summarised in this section together with an overview of the technical issues relating to potential constraints on power transfer on an interconnector.

Section 3 details the findings of an earlier assessment of the transfer capability of Murraylink published in 2001. A review of this report was not covered explicitly in the Commission's terms of reference. However, studies associated with this assessment were performed by the relevant TNSPs, and the findings are important as a foundation for this review.

Sections 4 and 5 detail the PB Associates' review of the TEA assessment of Murraylink transfer capability and the PTI due diligence respectively. The main findings of this review are summarised in Section 6 of this report.

1.3 ACKNOWLEDGEMENTS

PB Associates acknowledges the assistance from the Commission and MTC in carrying out this review.

2. BACKGROUND AND HISTORY

2.1 INTERCONNECTOR POWER TRANSFER CONSTRAINTS

To understand the PB Associates review, it is important to understand the difference between the rated capacity and the transfer capability of the Murraylink interconnector, and the factors that impact these capabilities.

The rated capacity of Murraylink is 220 MW and is likely to be determined by the thermal capacity of the individual Murraylink components. The power transfer capability of an interconnector is limited not only by the rated capacity of the interconnector itself, but also the capability of the interconnected transmission and distribution systems that it connects into. As the power flow through an interconnector will impact power flows on the transmission network, the flows through an interconnector may need to be reduced to below the interconnector rated capacity to ensure that:

- the alternating current (AC) transmission and distribution equipment is not, and will not following a credible contingency[1], be overloaded[2] and network voltages are within and would remain within acceptable limits; and
- under credible contingency or fault situations the AC transmission and distribution systems would remain stable and unnecessary loss of supply to customers would be avoided.

From the above it can be seen that an interconnector power flow that is acceptable under steady state operation may cause unacceptable overloads or voltage deviations in the event of a credible contingency, and it may be necessary to operate at lower power flow levels in anticipation of a contingency event. This is consistent with standard operating practice for a transmission grid, where loads under normal operation are not permitted to exceed load levels that could not be accommodated in the event of a credible contingency occurring. However, unlike most AC transmission network lines, it is possible to directly control the level of power flow through a direct current (DC) interconnector such as Murraylink. Therefore it is often possible to operate the interconnector at higher steady state operating levels provided that control and communications equipment is in place to automatically reduce interconnector power flows in the event of a contingency situation arising on the AC power system.

The power transfer capability of an interconnector will therefore be dependent not only on the rated capacity of the interconnection, but also on the design of its associated controls, the state of the power system at each end of the interconnection including the system load at a particular time[3], and the direction of power flow. It may be lower than the interconnector's rated capacity and may change with time in accordance with changes in the operating state of the transmission network at each end.

[1] A "contingency event" is defined in the NEC 4.2.3(A): *as an event affecting the power system which NEMMCO expects would be likely to involve the failure or removal from operational service of a generating unit or transmission element.*

[2] Overloads relate to the thermal rating of equipment – continuous ratings apply under long term steady state conditions, shorter term rating can apply following contingent events. Short terms ratings should be higher than continuous ratings. Short term ratings are achievable due to thermal inertia effects. However, where secondary plant such as protection, wave traps, droppers, etc. define the limiting rating, a higher shorter term rating can not be applied.

[3] As the power flow on the network increases as load increases, then generally worst case conditions for constraints occur at times of peak demand. This is not always the case however if the network is operated differently at lower load. It is also important to note that the thermal ratings of lines in winter should be higher than in summer and this may impact worst case conditions particularly in winter peaking regions.

2.2 METHODS OF INCREASING TRANSFER CAPABILITY

The following table summarises the main methods for increasing an interconnector's transfer capability when it is constrained by potential network overloads or voltage control violations.

Potential Network Violation[4]	**Solutions**	**Comments**
Voltage	Reactive plant (e.g. shunt reactors, capacitor banks)	Voltage control issues relate very much to reactive power flows on a network. The location and capacity of reactive plant, and switching requirements, must be determined from system studies.
	Run-back scheme[5]	Run-Back schemes can be used to remove voltage control violations following a contingency event. If the required speed of response is not achievable then a reactive plant solution may be required.
	Tripping scheme[6]	Tripping schemes can be used to remove post-contingent voltage control violations. If the required speed of response is not achievable then a reactive plant solution may be required.
Thermal Overload	Primary plant upgrade	Primary plant is the main load carrying equipment (e.g. conductors and transformers). The cost of upgrades associated with these items may be prohibitive.
	Secondary plant upgrade	Secondary plant such as protection, wave traps, etc. may be limiting equipment. These can normally be upgraded at a much lower cost than primary plant. For existing augmentations funded by the MTP, and for TEA's proposed additional augmentations, generally secondary equipment has been upgraded until the rating is limited by primary plant.

[4] A power network must be operated so that voltages across the network remain within acceptable levels and so that power flow remains within the thermal capacity of individual components. Hence both voltage and overload violations can occur.

[5] A run-back scheme automatically reduces the power flow of Murraylink on detection of a specific event. This allows Murraylink to operate at a higher transfer capability as it removes the violation for the limiting contingencies. This is an example of an automatic control scheme. Suitable monitoring, control and communication equipment is required to operate a run-back scheme.

[6] A tripping scheme is similar in intention to the run-back scheme, however, for a tripping scheme either the interconnector may be tripped or the network re-configured automatically on detection of a specific contingency to remove the voltage violation. Tripping schemes are presently in operation in the NEM (e.g. Yass-Wagga 132 kV tripping scheme).

	Slow run-back scheme	A slow run-back scheme will automatically run-back Murraylink flow within 5 minutes. This would allow a 5 minute rating to be used on constraining network equipment. For this to be of use a 5 minute rating must be able to be applied.
	Fast run-back scheme	A fast run-back scheme can be used to remove post-contingent overloads. If the required speed of response is not achievable then a plant upgrade solution may be required.
	Tripping scheme	Tripping schemes can be used to remove post-contingent overloads. If the required speed of response is not achievable then a plant upgrade solution may be required.

2.3 HISTORY

A map and schematic of the relevant parts of transmission networks of SA, Victoria and NSW is included in Appendix A.

Murraylink is a DC interconnector[7] between the transmission networks of Victoria and SA. The Victoria terminal is situated at Red Cliffs. The SA terminal is situated at the new Monash substation in the Riverland region. The Murraylink interconnector uses DC Light technology. The DC nature of the interconnector allows rapid controllability of the power through the interconnector. Control of an AC interconnector, in the form of an AC line, is not achievable, and power will flow as a function of impedances within the electrical network, which are not controllable to any great degree. The convertor stations at each end of Murraylink also allow independent and flexible control of reactive power at each terminal station[8].

In March 2000, NEMMCO was notified by GPU PowerNet[9] that a connection application had been received from TEA in respect to the Murraylink interconnector. Murraylink at that stage was to be a market network service, and as such, would be an unregulated transmission asset. The Inter-regional Planning Committee (IRPC) requested the Interconnection Options Working Group (IOWG) asses the Murraylink interconnector proposal in accordance with (the then) clause 5.6.6(b) of the NEC.

This assessment was published in August 2001 and is available on the NEMMCO website. The principle aims of this assessment were to:

1. Assess the capability of existing networks to support Murraylink (i.e. identify any limitations in the existing networks that may require power flow through the interconnector to be limited to below the thermal rating);

2. Determine the impact on other regions including impacts on interconnector flows;

[7] An interconnector is defined within the Code as a transmission line or group of transmission lines that connects the transmission networks in adjacent NEM regions.

[8] Reactive power and the control thereof, are important with respect to the voltage profile of transmission network as the voltage magnitude is most sensitive to reactive power flows in the network.

[9] Now SPI PowerNet.

3. Determine the performance requirements of Murraylink which would be necessary for it to operate; and

4. Determine the cost of any augmentations to the existing network which would be necessary to support Murraylink.

This IOWG report provided an assessment of the Murraylink transfer capability at that time. Included in the Murraylink proposal at that time were a number of network augmentations to increase the Murraylink transfer capability. As this assessment discussed many of the issues that may constrain Murraylink transfers, this assessment is an important starting point for the PB Associates' review. This assessment is discussed in more detail in Section 3.

2.4 SNOVIC AND SNI INTERCONNECTORS

Other IOWG 5.6.6(b) assessments relevant to Murraylink power transfers that have been performed in the intervening period are those for the SNI and SNOVIC interconnectors.

SNI (previously SANI) is the name of a project proposed by TransGrid. This project includes:

- a new AC interconnector between Buronga in NSW and Robertstown in SA;
- network augmentations to remove certain constraints on SNI, and hence increase SNI transfer capability; and
- automatic tripping schemes and automatic switching of capacitors to remove certain constraints on SNI transfer capability.

The 5.6.6(b) assessment of SNI was performed by the IOWG. This assessment was published in September 2001 (Ver. 4.0). This assessment included the impact of and on the Murraylink interconnector.

SNOVIC is the name of the project proposed by VENCorp to increase the capability of the existing Snowy to Victoria interconnector. The intention of the project was to raise the notional transfer capability of the existing Snowy to Victoria interconnector from 1500 MW to 1900 MW (import into Victoria from Snowy – summer peak conditions). Project works included:

- a number of network augmentations;
- an automatic switching scheme at the Dederang terminal station; and
- an automatic tripping scheme at Darlington Point.

The original 1500 MW transfer capability of the Snowy-Victoria interconnector was assumed for the IOWG assessment of Murraylink.

The 5.6.6(b) assessment of SNOVIC was performed by the IOWG. This assessment was published in October 2001. Also at the time, the IOWG produced an assessment of the combined impact of SNOVIC and SNI. These assessments included the impact of and on the Murraylink interconnector.

The base year for the SNOVIC and SNI assessments by the IOWG was assumed to be 2003/04. Included in the assessments of SNOVIC and SNI were the impacts on the constraint equations that defined the Murraylink transfer capability at that time.

NEMMCO have approved the SNOVIC and SNI projects, based upon recommendations by the IRPC. Many of the SNOVIC works have now been completed. The decision by the National Electricity Tribunal ("NET") upholding the SNI approval decision by NEMMCO under clause 5.6.6 of the NEC is under appeal, and as such, PB Associates does not believe that it is appropriate for it to comment on the probability of this project proceeding or the possible form this project may take.

The Murraylink transfer capability proposed in the recent MTC application is a revised transfer capability from the original IOWG assessment. MTC propose that the transfer capability can be raised provided a number of additional network augmentations and run-back schemes are implemented. The assumed base year for this revised assessment is 2003/04. MTC have assumed SNOVIC is in service for this assessment, but have assumed SNI is not in service at this time.

The IOWG SNOVIC and SNI assessment reports have been included in the documents that have been considered in the PB Associates review. Details of the review of these reports are not included in this report. However, where it is considered relevant, reference is made to particular findings and assumptions in the IOWG SNOVIC and SNI assessments, particularly where they impact Murraylink transfer capability.

3. ORIGINAL IOWG TECHNICAL ASSESSMENT

3.1 INTRODUCTION

This section summarises the IOWG assessment of the Murraylink transfer capability published in 2001. The findings of this original assessment are not under review in this report. However, the issues and constraints assessed and reported by the IOWG are an important starting point for the PB Associates review of the updated Murraylink transfer capability as set out in the MTC application.

The IOWG performed an assessment of Murraylink in accordance with (then) clause 5.6.6(b) of the NEC. This assessment was published in August 2001 and is available on the NEMMCO website. The principle aims of this assessment were to:

1. Assess the capability of existing networks to support Murraylink (i.e. identify any limitations in the existing networks that may require power flow through the interconnector to be limited to below the thermal rating);
2. Determine the impact on other regions including impacts on interconnector flows;
3. Determine the performance requirements of Murraylink which are necessary for it to operate; and
4. Determine the cost of any augmentations to existing network which are necessary to support Murraylink.

In order to perform this assessment the relevant planning bodies for the Victoria, South Australia and New South Wales transmission grids undertook planning studies of the impact of Murraylink on their respective grids, based on an agreed model and set of load flow cases. Individual study reports produced for each region were included as appendices to the IOWG report.

3.2 IOWG STUDY PARAMETERS

All studies used agreed base case conditions, including load, generation dispatch levels, and inter-regional flows. The base cases covered forecast summer peak and summer light load operating conditions for 2000/01 and 2001/02 and forecast winter peak and winter light load operating conditions for 2001 and 2002.

The criteria for thermal overload and voltage control violations were the same for all studies. Hence the definition of a network violation was consistent for all studies.

Full details of the base case system loads and inter-regional power flows, as well as the overload and voltage control criteria are given in Appendix A of the IOWG study report.

3.3 MURRAYLINK TRANSFER CAPABILITY ASSESSED IN IOWG STUDY

3.3.1 South Australia Region

The original assessment of transfer limits in South Australia was performed by ElectraNet SA[10]. Since then, the Electricity Supply Industry Planning Council (ESIPC) has become the jurisdictional planning body for the South Australian network and further assessments have been performed by the ESIPC. The following sections summarise the transfer

[10] Appendix B of IOWG 5.6.6(b) Assessment of Murraylink (V 2.0) August 2001 – NEMMCO website

capability of Murraylink due to limitations in the SA grid and augmentations proposed in the IOWG assessment to achieve this capability.

3.3.1.1 Murraylink power transfers into SA

The study indicated that there would not be voltage control limitations in the SA region for Murraylink transfers up to 220 MW provided suitable control of the 132 kV voltage at Berri was possible under peak load conditions. This should be achievable using the voltage control capability of the Murraylink converter station at Monash. The worst case contingency for this voltage control limitation is the loss of Murraylink.

Murraylink transfer capability could also be constrained due to post contingency overloading of the Monash to North West Bend line following a single outage of a number of circuits between Monash and Robertstown. TEA negotiated with ElectraNet SA on a number of minor plant upgrades in the Riverland region[11] and the implementation of a fast runback scheme (both plant upgrades and run-back scheme funded by MTP) to remove this constraint.

The augmentations and runback scheme allow Murraylink to operate at its thermal design capacity of 220 MW for power import into SA without causing network violation in SA.

3.3.1.2 Murraylink power transfers out of SA

The study indicated that voltage control limitations in the SA region limit the capability of Murraylink transfers out of SA. The worst case contingency was the loss of the Robertstown to North West Bend No 2 132 kV line. However this constraint was not quantified, as thermal limitations on Murraylink transfers were much more limiting. It should be noted that the removal of the thermal limitations could result in this voltage control issue becoming problematic.

Murraylink transfer capability could be constrained due to post contingent overloading of the Monash to North West Bend line following a single outage of a number of circuits between Monash and Robertstown. These thermal limitations are similar in nature to those for import into SA by Murraylink as discussed above.

The minor plant upgrades in the Riverland region and the implementation of the fast runback scheme negotiated with ElectraNet SA improve the transfer capability, but transfer capability would still be limited for power transfers out of SA under high Riverland load conditions.

The following constraint equations apply, where ML is the interconnector power flow limit from SA to Victoria:

ML <= 220(MW) – Riverland load (MW)   Summer ratings

ML <= 280(MW) – Riverland load (MW)   Winter ratings

At the time of the IOWG assessment, the Riverland demand was considered to be between 50 MVA to 128 MVA for summer months and 33 MVA to 80 MVA for winter months. This indicated that Murraylink would be constrained to around 95~100 MW during peak summer conditions and around 200 MW during peak winter conditions.

[11] See Table 4 of IOWG 5.6.6(b) Assessment of Murraylink (V 2.0) August 2001 – NEMMCO website

3.3.2 Victoria Region

The assessment of transfer limits in Victoria was performed by VENCorp[12]. The following sections summarise the transfer capability of Murraylink due to limitations in the Victoria region, and augmentations in the Victoria region proposed in the IOWG assessment to achieve this capability.

3.3.2.1 Murraylink power transfers into SA

For high import conditions into VIC from Snowy/NSW, maintenance of sufficient reactive margin was a critical factor in determining voltage control limitations for Murraylink transfers to SA. The critical contingency was the loss of the Bendigo to Kerang 220 KV line. This constraint on Murraylink transfer is very much a function of the Victoria state grid load (SGL)[13].

The IOWG assessment produced the following Murraylink constraint equations relating to this reactive margin limitation:

ML <= 220 – 0.33 x SGL Summer ratings (V1)

ML <= 220 – 0.29 x SGL Winter ratings (V2)

For the IOWG assessment, the SGL was considered to be between 400 MVA and 1000 MVA. This indicated that Murraylink would be constrained to around 120 MW during peak summer conditions with high import into Victoria from Snowy/NSW.

Under conditions of export from VIC to Snowy/NSW, Murraylink transfer could be limited by a requirement to maintain the instantaneous voltage change on the 66 kV network around Ararat to 10%[14]. The critical contingency for this limitation was the loss of the Ballarat to Horsham 220 kV line. This constraint is a function of SGL, VIC export through Snowy, and VIC hydro dispatch, and was defined in the IOWG assessment as:

ML <= 468 – 0.32 x SGL – 0.086 x Vic export to Snowy + 0.05 x Vic hydro (V3)

Based upon maximum Vic to Snowy export level (~730 MW) and minimum Vic hydro dispatch levels (-46 MW) at the time of the IOWG assessment, Murraylink could be constrained to around 145 MW during probable high SGL (820 MW) times.

VENCorp determined that a number of different thermal overload limitations were possible for Murraylink transfers from Vic to SA. These overloads related to a number of circuits, particularly in the state grid region, for a range of single contingencies. Some of these potential overloads could be particularly constraining on the transfer capability of Murraylink, and as such, TEA, through consultation with VENCorp and SPI PowerNet, were proposing a number of minor network augmentation and run-back schemes to alleviate the most limiting constraints. The proposed work covered:

- **A fast run-back scheme for the outage of Ballarat to Horsham 220 kV line**. This contingency was assessed by VENCorp to be a particularly constraining contingency on Murraylink transfers. Murraylink transfers to SA without fast run back could result in a significant thermal overload of the 66 kV network that runs parallel to the 220 kV line during an outage of the 220 kV line.

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12 Appendix C of IOWG 5.6.6(b) Assessment of Murraylink (V 2.0) August 2001 – NEMMCO website

13 The Victoria 'state grid' refers to the transmission network in the North-West of Victoria, fed from Moorabool, Dederang and Buronga: including terminal stations at Ballarat, Bendigo, Glenrowan, Horsham, Kerang, Red Cliffs, Shepparton and Terang.

14 This is the 66 kV sub-transmission network that runs parallel with the 220 kV network from Ballarat to Horsham. The 66 kV network is owned by Powercor.

- **Slow run back schemes to allow 5 minute rating to be applied on a number of state grid 220 kV lines**. The slow run back schemes would monitor outages of certain plant such that 5 minute ratings could be applied to certain 220 kV lines. This effectively raises the constraint on Murraylink transfers due to potential overload on the lines protected by the slow run back[15]. The circuits that could have 5 minute ratings applied due to the slow run-back schemes included:
    - Keilor to Geelong Nos. 1, 2, & 3 220 kV lines
    - Dederang – Glenrowan No. 3 220 kV line
    - Moorabool – Ballarat No. 1 220 kV line
    - Kerang to Red Cliffs 220 kV line
- **Upgrades of minor plant** to increase rating of Ballarat to Moorabool No. 2 220 kV line and Kerang to Red Cliffs 220 kV line.

With above upgrades and run-back schemes in place, VENCorp assessed the potential thermal overloads and associated contingencies summarised in Table 3-1 to be the limiting constraints on Murraylink transfers from Vic to SA.

Table 3-1 Thermal overload constraints on Murraylink Transfer

Limit Ref ID	Constraining Element [16]	Associated Transmission Outage
VT1	Dederang-Glenrowan No 1 220kV	Dederang-Glenrowan No 3 220kV
VT2	Dederang-Glenrowan No 3 220kV	Dederang-Glenrowan No1 220kV
VT3	Glen rowan-Shepparton No 1 220kV	Glen rowan-Shepparton No 3 220kV
VT4	Glen rowan-Shepparton No 3 220kV	Glen rowan-Shepparton No1 220kV
VT5	Dederang No 1 & 2 330/220kV transformers	Dederang No 3 330/220kV transformer
VT6	Ballarat -Moorabool No 1 220kV	Ballarat -Moorabool No 2 220kV
VT7	Ballarat -Moorabool No 2 220kV	Ballarat -Moorabool No 1 220kV
VT8	Ballarat - Moorabool No 2 220kV	Bendigo - Shepparton 220kV
VT9	Ballarat - Bendigo 220kV	Bendigo - Shepparton 220kV
VT10	Bendigo - Kerang 220kV	Ballarat - Horsham 220kV
VT11	Bendigo - Kerang 220kV	Darlington Point - Balranald 220kV
VT12	Kerang - Red Cliffs 220kV	Darlington Point - Balranald 220kV

[15] Without slow run-back of Murraylink, the existing 30 minute or continuous rating (depending on limiting plant) would apply. This rating is lower than the 5 minute rating, and therefore, more constraining.

[16] Applicable ratings are defined in Attachments 3 and 4 of Appendix C of IOWG .

VT13	Kerang - Red Cliffs 220kV	Ballarat - Horsham 220kV
VT14	Darlington Point - Balranald 220kV	Bendigo - Kerang 220kV
VT15	Keilor - Geelong No 1, 2 & 3 lines	Moorabool 500/220kV transformer
VT18	Ballarat – Bendigo 220kV	Ballarat – Horsham 220kV

The above constraints become more limiting as SGL increases, and are also related to Vic / Snowy import levels and Vic hydro generation dispatch levels. These constraints on Murraylink transfers from Vic to SA are shown graphically in Figures 8 to 13 of Appendix C of the IOWG report.

These diagrams indicate the following:

- at times of peak summer SGL, high Victoria import from Snowy/NSW (~1500 MW), and high Victoria hydro generation dispatch (450 MW), then the potential overloads in the Glenrowan to Shepparton and Dederang to Glenrowan 220 kV lines (VT 1-4) reduce the transfer capability of Murraylink to levels below 100 MW;

- for lower SGL, the reactive and voltage limitations (equation V1, V2 and V3 above) and potential overloads of the Darlington Point to Balranald 220 kV line (VT 14) can become more constraining, limiting Murraylink to transfers between 120 to 200 MW; and

- the potential Dederang transformer overload (VT5) can be a significant constraint under very low Victoria generation dispatch levels but high SGL load and Victoria imports from Snowy/NSW.

Other less significant constraints on Murraylink transfers relate to potential overloads on the following 220 kV lines:

- Ballarat to Bendigo (VT 9);
- Bendigo to Kerang (VT 10-11);
- Ballarat to Moorabool No1 (VT6); and
- Keilor to Geelong (VT 15) 220 kV lines.

The VENCorp assessment also determined that the transient stability limit may be reduced for transfers from Victoria to Snowy/NSW when Murraylink is transferring power to SA. Although this is not a constraint on Murraylink, it is assumed that this change in the constraint on Victoria to Snowy/NSW would have to be incorporated in the market modelling for the economic assessment of Murraylink.

3.3.2.2 Murraylink power transfers out of SA

The IOWG assessment found no limitation on Murraylink transfers into Victoria up to the 220 MW rating of Murraylink due to violations in the Victorian region.

3.3.3 New South Wales Region

The assessment of transfer limits in NSW was performed by TransGrid[17]. The following sections summarise the transfer capability of Murraylink due to limitations in the NSW region, and augmentations in the NSW region proposed in the IOWG assessment to achieve this capability.

It is clear from the IOWG report that negotiations between TEA and TransGrid at the time of the release of the report were not at an advanced stage in terms of defining the Murraylink transfer capability. Due to this, the Murraylink transfer capability and associated assumed run-back schemes are not as clearly defined as for the SA and Vic regions in the IOWG report.

3.3.3.1 Murraylink power transfers into SA

The TransGrid assessment determined that overvoltages on the SW-NSW 220 kV network[18] following particular line outages could limit the Murraylink transfers to SA during times of high Vic import from Snowy/NSW. The loss of the Red Cliffs to Buronga 220 kV line, or opening at one end of the Darlington Point to Buronga 220 kV line, were considered the worst case contingencies. Initial TransGrid studies indicated that this voltage control limitation could constrain Murraylink transfers to below 150 MW into SA with high Vic import from Snowy/NSW conditions. TEA were proposing further investigations into the possibility of fast switching a reactor at Buronga to alleviate the overvoltage constraint[19].

TransGrid also determined that inadequate reactive margin and possible voltage instability in the SW-NSW region following single contingencies could limit Murraylink's transfers to SA. The following are the most significant contingencies determined in the TransGrid studies:

- The most critical contingency for this condition was the loss of the Wagga-Darlington Pt 330 kV line, which results in inadequate reactive margin around Darlington Pt, even with zero flow on Murraylink, under high summer load conditions. TransGrid noted that the existing system (2000) was known to be voltage stable. TEA were proposing a fast run-back scheme for this contingency and the TEA assessment indicated a worst case Murraylink transfer limitation of 150 MW for this contingency;

- Loss of either Bendigo – Kerang 220 kV line or Ballarat – Horsham 220 kV line in Victoria state grid requires reduced Murraylink transfers (120-140 MW) to maintain adequate post contingency reactive margin. This is in line with the TEA assessment;

- Loss of the Lower Tumut – Wagga 330 kV line indicated Murraylink transfers up to 215 MW were acceptable to maintain adequate post contingency reactive margin. The TEA assessment indicated a limit of 155 MW at times of peak summer demand; and

- Loss of Darlington Point – Buronga 220 kV line require reduced Murraylink transfers (160 MW) to maintain adequate post contingent reactive margin. The TEA assessment indicated a limit of 130 MW at times of peak summer demand.

TransGrid determined that a number of different thermal overload limitations were possible for Murraylink transfers from Victoria to SA. These overloads related to a

[17] Appendix D of IOWG 5.6.6(b) Assessment of Murraylink (V 2.0) August 2001 – NEMMCO website

[18] SW-NSW 220 kV network covers 220 kV substation at Buronga, Balranald, Darlington Point and Broken Hill.

[19] Indicated in section 10 of TEA report 1/8/2001 accompanying IOWG Assessment – NEMMCO website

number of circuits for a range of single contingencies. Some of these potential overloads could be particularly constraining on the transfer capability of Murraylink, and as such, TEA, through consultation with TransGrid, were proposing a number of minor network augmentation and run-back schemes to alleviate the most limiting constraints. It is clear from the IOWG assessment that the exact specification for the augmentations and run-back schemes had not been finalised at that time.

The following table summarises the TransGrid initial findings and the TEA proposals to alleviate constraints:

Constraining Element [20]	**Associated Transmission Outage**	**Murraylink transfer and associated run-back scheme**
Lower Tumut to Wagga 330 kV	Bendigo to Kerang line or Ballarat to Horsham 220 kV lines	The slow run-back schemes for these contingencies in Victoria allows a 10 minute rating to be applied for this line. TransGrid state that this overload is insensitive to Murraylink transfer level.
Darlington Pt to Balranald 220 kV line	Bendigo to Kerang line or Ballarat to Horsham 220 kV lines	A short term rating is not appropriate for this line[21] and as such the slow run-back will not increase Murraylink transfer capability for this contingency. Murraylink transfer may be limited to 170 MW.
Yass 330/132 kV transformer	Yass 330/132 transformer or Lower Tumut to Wagga 330 kV line.	Yass-Wagga 132 kV tripping scheme (see below) is applied to relieve loading on Yass transformer. TransGrid state that this overload is relatively insensitive to Murraylink transfer level.
Wagga to Yanco 132 kV line	Wagga to Darlington Pt 330 kV line	A run-back for outage of Wagga to Darlington Point line proposed by TEA would allow the use of the 10 minute rating for this line. Murraylink transfer may be limited to 90 MW. Fast run-back may allow full 220 MW transfer capability.
Wagga to Finley 132 kV line	Wagga to Darlington Pt 330 kV line.	A short term rating is not appropriate for this line[22] and as such a fast run back would be required for this contingency. Murraylink transfer may be limited to 195 MW. Fast run-back may allow full 220 MW transfer capability.
Finley to Denilliquin 132 kV line	Wagga to Darlington Pt 330 kV line	A run-back for outage of Wagga to Darlington Point line proposed by TEA would allow the 10 minute rating for this line. This allows full 220 MW transfer capability.

[20] Applicable ratings are defined in Appendix 2 and Section 8 of Appendix D of IOWG .

[21] The IOWG report indicates that this line's limiting rating is due to protection equipment and as such a short term rating is not appropriate.

[22] The IOWG report indicates that this line's limiting rating is due to protection equipment and as such a short term rating is not appropriate.

Constraining Element [20]	Associated Transmission Outage	Murraylink transfer and associated run-back scheme
Yass-Burrinjuck 132 kV line	Lower Tumut to Wagga 330 kV line.	Yass-Wagga 132 kV tripping scheme (see below) is normally applied to relieve overloads for this contingency. TEA was also proposing a run-back scheme to allow 10 minute rating to apply (see comment below).
Yass-Murrumburrah 132 kV line	Lower Tumut to Wagga 330 kV line.	Yass-Wagga 132 kV tripping scheme (see below) is normally applied to relieve overloads for this contingency. TEA was also proposing a run-back scheme to allow 10 minute rating to apply (see comment below).
Yass-Wagga 132 kV line	Lower Tumut to Wagga 330 kV line.	Yass-Wagga 132 kV tripping scheme (see below) is normally applied to relieve overloads for this contingency. TEA was also proposing a run-back scheme to allow a 10 minute rating to apply (see comment below).

TransGrid presently operates an automatic tripping scheme that opens the Yass – Wagga 132 kV system to relieve overloads in the 132 kV system in that region following particular contingencies.

TransGrid considered that Murraylink's transfers to SA would increase the loading on the Yass-Wagga 132 kV system which would result in the need to arm the existing 132 kV tripping scheme more often. This may reduce the security of the 132 kV system. TEA have proposed a runback scheme following the outage of the Lower Tumut to Wagga 330 kV line such that the requirement to arm the 132 kV tripping scheme is not increased.

3.3.3.2 Murraylink power transfers out of SA

The IOWG assessment found no limitation on Murraylink transfers into Victoria up to the 220 MW rating of Murraylink due to violations in the NSW region.

3.4 SUMMARY OF MURRAYLINK TRANSFER CAPABILITY IN IOWG ASSESSMENT

Table 3-2 summarises the transfer capability of Murraylink in the IOWG assessment for worst case conditions. It would be expected that more favourable conditions would allow the transfer capability to be increased up to the 220 MW rating of Murraylink.

It should also be noted that table relates to normal network conditions pre-contingency and single network outage contingencies. Other particular non-normal network conditions (e.g. certain plant out of service) or load and generation profiles may impose more onerous constraints. These operational constraints were not considered relevant for the IOWG assessment.

Table 3-2 IOWG Assessed Murraylink Transfer Capability

Murraylink Transfer	**Worst case condition**	**Limits in SA**	**Limits in Vic**	**Limits in NSW**	**Overall**
Vic to SA	Peak summer demand – high import to Vic from Snowy/NSW	220 MW	80-150 MW	100–120 MW	**80-150 MW**
SA to Vic	Peak Riverland demand	95-100 MW	220 MW	220 MW	**95-100 MW**

4. REVIEW OF TEA TRANSFER CAPABILITY ASSESSMENT

4.1 INTRODUCTION

TransEnergie Australia (TEA) has performed an assessment of Murraylink's transfer capability with the additional augmentations and run-back schemes proposed in the revenue cap application. A report by TEA discussing the additional augmentations and their impact on Murraylink transfer capability was included as Appendix A of MTC's application to the Commission.

Part of the PB Associates' scope of work for the Transfer Capability Review was to review this TEA report. The broad terms of reference for this review were:

- to undertake a review which analyses and comments on the assumptions, methodology and findings of TEA's Power Transfer Capability Report (Appendix A of MTC's application).

The findings of the PB Associates review of the TEA study are discussed in this section of our report.

It is important to note that it is not within the scope or timing of this review to perform an audit of the power system studies performed by TEA or its consultants. That said, the potential constraints on Murraylink have been publicly documented in the previous IOWG assessment, and as such, the proposed additional augmentations and their impact on Murraylink transfers can be assessed to a reasonable degree.

The TEA report and its underlying analysis is based upon previous public IOWG assessments of Murraylink, SNOVIC and SNI, and further studies performed by TEA. The report discusses the additional augmentations proposed in the application, and the impact these have on increasing Murraylink's transfer capability. The augmentations and budgetary cost are also summarised. The report does not provide any detail of the power system studies supporting the report, and as such, PB Associates would not consider it as detailed or comprehensive as previous IOWG assessments. In our review we have used information in existing IOWG reports and the PTI due diligence results to assess the TEA claims. In addition to this, PB Associates requested additional information and explanations from TEA to assist in the review of the power system studies that TEA undertook. TEA has responded to all requests from PB Associates.

4.2 STUDY PARAMETERS FOR FURTHER ASSESSMENT

PB Associates requested clarification of the Power System Model used for the TEA and PTI assessment. TEA provided notes relating to the model and assumptions relating to load levels, network augmentation, and network operational assumptions. The following summarises the salient points relating to the model:

- the file was that provided by the IOWG to TEA for its recent assessment of combined SNI and SNOVIC (note: components related to SNI were switched out);

- the model is based upon a 3 state network model covering the NSW, Snowy, Victoria and SA NEM regions;

- the peak summer forecast related to 2003/04. This represented an increase from the original IOWG assessment. TEA has stated that the summer peak condition related to a sum of peak conditions in each region rather than a coincident system peak. The following table compares the model loads with those in the NEMMCO SOO-2001 (provided by TEA).

Region	**SOO-2001 M10 03/04 Load*** (Generator terminal basis)	***Base Case Study***** (PSS/E Area Report = Load + Losses)	**Approx. Difference**
Victoria	9331 MW	9360 MW	+30
South Australia	3183 MW	3450 MW	+260
SW-NSW	Not provided	610 MW	N/A
* Refer to NEMMCO SOO-2001 Tables 3.25 and 3.29 ** Refer to PSS/E load flow file Area Totals Report			

- model assumes the SNOVIC 400 components are in service;
- reactive plant as specified in Vencorp Victorian reactive tender; and
- reactive plant in SW-NSW as advised by TransGrid – matches that assumed in IOWG SNI assessment (not including that specifically for the SNI project).

As this model is based upon the IOWG model accepted and used for the SNOVIC/SNI assessment, PB Associates have confirmed the advised network augmentation and consider this model reasonable for the further assessment performed by MTC in its application.

The decision by the "NET" upholding the SNI approval decision by NEMMCO under clause 5.6.6 of the National Electricity Code is under appeal, and as such, PB Associates cannot comment on the probability of this project or the possible form this project may take.

It is important to note that in the IOWG assessments it is assumed network augmentations occur following the base year to maintain transfer capability. As such, a single year for the assessment is appropriate, rather than an assessment of transfer capability through a range of years. The 2003/04 date has been chosen by MTC to represent the appropriate worst case time from when Murraylink will receive regulated status.

TEA has advised that the design criteria, in terms of thermal overload and voltage control, is the same as that previously applied in the IOWG assessment[23]. PB Associates considers that these criteria have been broadly adhered to in the TEA assessment. However, it is impossible in a review of this type to confirm this with certainty for all contingencies and conditions. There does appear to be a requirement for fast switching of reactive support to alleviate some voltage drop violations[24]. This appears to violate the IOWG criteria which limits the immediate post contingent voltage drop to 10%. However, automatic fast switching and tripping schemes have been accepted by the IOWG in its previous assessments of SNI and SNOVIC, presumably on the basis that a voltage dip prior to system switching could be considered a dynamic or transient condition provided that switching is fast enough.

4.3 REVIEW OF EXISTING CONSTRAINTS AND AUGMENTATIONS TO INCREASE TRANSFER CAPACITY

The following section is based upon the potential network violations and resulting constraints on Murraylink transfers discussed in the original IOWG Assessment. The

23 Appendix A of IOWG Murraylink Assessment August 2001 – NEMMCO website

24 TEA have advised that they may be required to fast switch reactive plant to reduce overvoltages at Dederang. VENCorp have indicated that they may allow this, but it would have to be assessed whether this is possible.

additional augmentations proposed by MTC in its application to the Commission to alleviate each constraint are discussed below.

4.3.1 South Australia Region

4.3.1.1 Murraylink power transfers into SA

The IOWG assessment found no limitation on Murraylink transfers into SA up to the 220 MW rating of Murraylink due to violations in the SA region with the proposed minor augmentations and run-back schemes in the SA region in place. These augmentations have already been implemented and TEA has not proposed any further augmentations in the SA region.

4.3.1.2 Murraylink power transfers out of SA

The transfer capability of Murraylink for power transfers out of SA is not proposed to be increased in the application. The constraint equations that were determined in the original IOWG assessments are assumed to still apply in the application, namely:

ML <= 222(MW) – Riverland Load (MW) Summer ratings

ML <= 280(MW) – Riverland Load (MW) Winter ratings

The above Murraylink transfers are capped at 150 MW for voltage control limitations.

4.3.1.3 Comment on TEA Assessment

Network loadings in SA have increased since the original IOWG assessment. It may be that new constraints on Murraylink transfers due to violation in the SA region (not specifically in the Riverland region) resulting from these load increases may have arisen. It should also be noted that the PTI due diligence did not examine contingencies in the SA region or transfers from SA to Vic, and as such, the PTI work did not examine this issue.

Although it would appear reasonable, based upon the original IOWG study, to assume that the transfer capability of Murraylink should not change due to new violations in the SA region under the new network model and loadings, PB Associates have not specifically examined this issue within the course of this review.

4.3.2 Victoria Region

4.3.2.1 Murraylink power transfers into SA

State Grid Reactive Margin

The original IOWG assessment considered Murraylink's transfer would be constrained at a time of high SGL to achieve acceptable reactive margins in the state grid region (see constraint equations V1 and V2 in Section 3.3.2.1). In the TEA study, the SGL forecast for 2003/04 is more onerous than that used in the IOWG assessment (maximum SGL of 1000 MW for IOWG, 1100 MW in the TEA study), and therefore, Murraylink's transfers could be reduced further.

To increase Murraylink's transfer capability, TEA is proposing to add additional reactive support in the state grid region. The reactive support is in the form of 50 MVAr and 25 MVAr capacitor banks at Kerang and Horsham, increasing the dynamic range of the existing SVCs at these locations, and an 80 MVAr capacitor bank at Red Cliffs.

The load flow studies performed in the PTI due diligence did not converge for certain contingencies, indicating that voltage depression or collapse could occur for Murraylink transfers above 180 MW at the time of summer peak. TEA is proposing the use of fast run-back schemes to increase post contingent reactive margins, removing the possibility of voltage collapse, and permit a Murraylink transfer capability to 220 MW. TEA has performed dynamic studies to examine the voltage collapse issue in SW-NSW and provided details of these studies to PB Associates. These studies use dynamic load modelling in the SW-NSW and have been performed in consultation with TransGrid. TEA advised that these studies indicate voltage collapse does not occur. PB Associates have not reviewed actual study results.

In discussions between VENCorp and PB Associates, held during the course of this review, VENCorp stated that voltage collapse could also be centred in the state grid region, and as such, dynamic studies would need to be performed with suitable load modelling of the state grid region to confirm that the fast run-back schemes were sufficient to allow Murraylink transfers up to 220 MW.

In light of the uncertainty surrounding voltage collapse in the state grid region for Murraylink transfer greater than 180 MW, PB Associates recommends that further dynamic studies are undertaken, in consultation with VENCorp, to ensure that the full 220 MW transfer capability is achievable with the additional augmentations proposed without voltage control limitations.

Voltage Step Change

The IOWG assessment determined that under conditions of export from Victoria to Snowy/NSW, Murraylink transfer could be limited by a requirement to maintain the instantaneous voltage change on the 66 kV network around Ararat to 10% (see constraint equation V3 in Section 3.3.2.1). The critical contingency for this limitation was the loss of the Ballarat to Horsham 220 kV line.

TEA is proposing to improve the speed of response of the existing fast run-back scheme that monitors the Ballarat to Horsham 220 kV line to a 200 ms scheme or to implement a protection grade tripping scheme for the 66 kV line. This would remove this voltage violation and allow Murraylink transfers to increase to the 220 MW rating.

PB Associates considers this an acceptable solution provided it is technically and economically feasible.

Thermal limitations

The IOWG assessment determined that a number of different thermal overload limitations were possible for Murraylink transfers from Vic to SA. These overloads related to a number of circuits, particularly in the state grid region, for a range of single contingencies. Some of these potential overloads could significantly limit the transfer capability of Murraylink, and as such, TEA, after consultation with VENCorp and SPI PowerNet, was proposing a number of minor network augmentations and run-back schemes to alleviate the most limiting constraints. These augmentations have been implemented and are considered in service for the assessment in the study.

VENCorp assessed the potential thermal overloads and associated contingencies summarised in Table 3-1 to be the limiting constraints on Murraylink transfers from Vic to SA, after implementation of the above minor augmentations. In its study TEA has proposed a number of additional augmentations to remove these remaining constraints. The constraining elements in the IOWG assessment and associated contingencies are summarised in Table 4-1 with the additional augmentation proposed by TEA in its report to remove each constraint.

Table 4-1 Thermal overload constraints on Murraylink Transfer

Limit Ref ID	Constraining Element	Associated Transmission Outage	Removal augmentation
VT1	Dederang-Glenrowan No 1 220kV	Dederang-Glenrowan No 3 220kV	Assumed removed by SNOVIC 400 project
VT2	Dederang-Glenrowan No 3 220kV	Dederang-Glenrowan No 1 220kV	Assumed removed by SNOVIC 400 project
VT3	Glenrowan-Shepparton No 1 220kV	Glenrowan-Shepparton No 3 220kV	Assumed removed by SNOVIC 400 project
VT4	Glenrowan-Shepparton No 3 220kV	Glenrowan-Shepparton No 1 220kV	Assumed removed by SNOVIC 400 project
VT5	Dederang No 1 & 2 330/220kV transformers	Dederang No3 330/220kV transformer	TEA proposing slow run-back scheme to allow Murraylink transfers to 220 MW
VT6	Ballarat - Moorabool No 1 220kV	Ballarat -Moorabool No 2 220kV	Slow run-back scheme allows Murraylink transfers to 180 MW (existing run-back scheme). Fast run-back scheme allows Murraylink transfers up to 220 MW rating
VT7	Ballarat - Moorabool No 2 220kV	Ballarat -Moorabool No 1 220kV	TEA propose slow run-back scheme to allow Murraylink transfers to 220 MW[25]
VT8	Ballarat - Moorabool No 2 220kV	Bendigo - Shepparton 220kV	Fast run-back scheme to allow transfers to 220 MW
VT9	Ballarat - Bendigo 220kV	Bendigo - Shepparton 220kV	Fast run-back scheme to allow transfers to 220 MW
VT10	Bendigo - Kerang 220kV	Ballarat - Horsham 220kV	Fast run-back scheme to allow transfers to 220 MW
VT11	Bendigo - Kerang 220kV	Darlington Point - Balranald 220kV	Fast run-back scheme to allow transfers to 220 MW
VT12	Kerang - Red Cliffs 220kV	Darlington Point - Balranald 220kV	Fast run-back scheme to allow transfers to 220 MW
VT13	Kerang - Red Cliffs 220kV	Ballarat - Horsham 220kV	Fast run-back scheme to allow transfers to 220 MW

[25] Following discussion with VENCorp and TEA, the 35C continuous rating of the Ballarat to Moorabool No. 2 220 kV line is that assumed to be the 5 minute rating in the TEA studies, and as such the proposed slow run-back may not be required.

Limit Ref ID	Constraining Element	Associated Transmission Outage	Removal augmentation
VT14	Darlington Point - Balranald 220kV	Bendigo - Kerang 220kV	Fast run-back scheme to allow transfers to 220 MW
VT15	Keilor-Geelong No 1, 2 & 3 lines	Moorabool 500/220kV transformer	Fast run-back scheme to allow transfers to 220 MW
VT18	Ballarat - Bendigo220kV	Ballarat –Horsham 220kV	Fast run-back scheme to allow transfers to 220 MW

It is important to note that the PTI due diligence confirmed the majority of the above constraining elements. Notable exceptions were VT 10, VT 13 and VT 18 for the Ballarat to Horsham outage. It is not clear why these overloads did not appear in the PTI analysis.

The PTI study also found a number of other potential constraining elements, the most significant being the Bendigo to Shepparton 220 kV line. In its report, TEA is proposing a number of additional fast run-back schemes to allow Murraylink's transfers up to the 220 MW rating for these further contingencies.

Based upon the constraints on Murraylink and line ratings provided in the IOWG assessments, and the possible overloads indicated in the PTI due diligence, PB Associated considers that the additional run-back schemes defined in the application, if technically and economically feasible, would allow Murraylink transfers up to the 220 MW rating.

4.3.2.2 Murraylink power transfers out of SA

The IOWG assessment found no limitation on Murraylink transfers out of SA up to the 220 MW rating of Murraylink due to violations in the Victoria region. As such, TEA is not proposing any further augmentations in the Victoria region to achieve the increased transfer capability of Murraylink.

4.3.3 New South Wales Region

4.3.3.1 Murraylink power transfers into SA

Overvoltage limitations

The IOWG assessment determined that overvoltages on the SW-NSW 220 kV network following particular line outages could limit the Murraylink transfers to SA during times of high Vic import from Snowy/NSW. The loss of the Red Cliffs to Buronga 220 kV line, or opening at one end of the Darlington Point to Buronga 220 kV line, was considered the worst case contingencies. Initial TransGrid studies indicated that this voltage control limitation could constrain Murraylink transfers to below 150 MW into SA with high Victoria import from Snowy/NSW conditions.

In order to alleviate this constraint, TEA studies indicated that at least one of the reactors at Buronga must be in service during times of peak load. TEA stated in its report that this is the case for normal system operation as advised by TransGrid. TEA also considers that the proposed new capacitor bank at Red Cliffs will maintain an acceptable pre-contingent voltage profile.

It is difficult without performing load flow studies to confirm that, with the proposed new capacitor bank at Red Cliffs, the transfer capability limitation due to this issue would be removed. The PTI due diligence does not appear to have checked overvoltage violations. The TEA solution would seem reasonable, but the specific transfer capability due to this issue is not clearly defined in the TEA report.

Reactive Margin Limitations

The IOWG assessment determined that inadequate reactive margin and possible voltage instability in SW-NSW region following single contingencies could limit Murraylink transfer to SA. This is a particular issue when incremental generation for Murraylink dispatch is sourced from NSW. The most significant contingencies determined in the TransGrid studies were:

- Wagga - Darlington Pt 330 kV line;
- Bendigo – Kerang 220 kV line;
- Ballarat – Horsham 220 kV line;
- Lower Tumut – Wagga 330 kV line; and
- Darlington Point – Buronga 220 kV line.

TEA is proposing additional reactive support in the Wagga region to improve reactive margins, namely 160 MVAr and 10 MVAr capacitor banks at Wagga 330 kV and Darlington Point 132 kV busbars respectively. TEA is also proposing a 160 MVAr capacitor bank at Dederang 330 kV to improve post contingent voltages in that area.

The SNOVIC 400 assessment also indicated voltage depression in the 132 kV network between Wagga and Darlington Point for an outage of the parallel Wagga to Darlington Point 330 kV line under high Vic import from Snowy/NSW. The SNOVIC project included an automatic tripping scheme to alleviate this violation. TEA is proposing a fast run-back for this contingency to remove any constraints on Murraylink transfers.

The SNOVIC assessment also indicated possible thermal overloads and voltage depression in the state grid region of Victoria for an outage of the Wagga to Darlington Point 330 kV line and Darlington Point to Buronga 220 kV line. The PTI due diligence confirmed these overloads. The proposed fast run back scheme for the Wagga to Darlington Point 330 kV line contingency and the fast run-back proposed for the Darlington Point to Buronga 220 kV line will also remove the Murraylink transfer constraint due to these overloads and voltage control issues.

Provided the fast run back schemes are technically and economically feasible, PB Associates considers them sufficient to achieve the transfer capabilities indicated by TEA. The PTI due diligence report did not examine contingency analysis with the reactive plant proposed by TEA in its report and as such it is difficult to confirm acceptable voltage profiles under all single contingencies. The limited amount and location of additional reactive support suggested in the PTI studies would however indicate that the levels and locations of additional reactive support in the TEA report should be sufficient to achieve the 110 MW Murraylink transfer capability when incremental generation is in NSW.

Thermal limitations

The IOWG assessment determined that a number of different thermal overload limitations were possible for Murraylink transfers from Victoria to SA. These overloads related to a number of circuits for a range of single contingencies. Some of these potential overloads could significantly limit the transfer capability of Murraylink, and as such, TEA, after consultation with TransGrid, was proposing a number of minor network augmentations and run-back schemes to alleviate the most limiting constraints. At the time of the IOWG assessment, the exact specification for the run-back schemes had not been finalised. At the present time these schemes are not implemented. However they are assumed to be in service in the TEA study. TEA has advised that the current estimated in service date for the augmentations is May 2003.

TEA is also proposing in its report to increase the 5 minute rating of the Wagga to Lower Tumut 330 kV line to 1160 MVA. TEA states that if the cost for this is prohibitive then an additional run-back scheme could be used to control post contingent power flow on this line.

The following table summarises overloads indicated in the IOWG assessment and PTI studies, and the TEA proposals to alleviate constraints:

Constraining Element	**Associated Transmission Outage**	**Murraylink transfer and associated run-back scheme**
Lower Tumut to Wagga 330 kV line	Bendigo to Kerang line or Ballarat to Horsham 220 kV lines	The slow run-back schemes for these contingencies in Victoria would allow the proposed increased 5 minute rating to be applied for this line.
Darlington Pt to Balranald 220 kV line	Bendigo to Kerang line, Ballarat to Horsham, Bendigo to Shepparton, Kerang to Red Cliffs and Horsham to Red Cliffs 220 kV lines	The fast run-back schemes for these contingencies in Victoria would remove constraints on Murraylink transfers due to these contingencies. TEA has also advised that uprating of this line may be an option. However, slow run-back schemes would still be required.
Yass 330/132 kV transformer	Yass 330/132 kV transformer or Lower Tumut to Wagga 330 kV line.	Yass-Wagga 132 kV tripping scheme[26] is applied to relieve loading on Yass transformer. Existing slow run-back for Lower Tumut to Wagga 330 kV outage also removes the constraint for that contingency.
Wagga to Yanco 132 kV line	Wagga to Darlington Pt 330 kV line	The fast run-back for outage of Wagga to Darlington Point line would remove constraints on Murraylink transfers due to this contingency.
Wagga to Finley 132 kV line	Wagga to Darlington Pt 330 kV line.	The fast run-back for outage of Wagga to Darlington Point line would remove constraints on Murraylink transfers due to this contingency.
Finley to Denilliquin 132 kV line	Wagga to Darlington Pt 330 kV line	The fast run-back for outage of Wagga to Darlington Point line would remove constraints on Murraylink transfers due to this contingency.
Yass-Burrinjuck 132 kV line	Lower Tumut to Wagga 330 kV line.	Existing run-back scheme allows 10 minute ratings to apply. PTI studies indicate overloading does not occur for the increased Murraylink transfer

[26] TransGrid presently operates a tripping scheme that opens the Yass – Wagga 132 kV system to relieve overloads in the 132 kV system in that region, following a loss of one of the parallel 330 kV circuits.

		capability in the application.
Yass-Murrumburrah 132 kV line	Lower Tumut to Wagga 330 kV line.	Existing run-back scheme allows 10 minute ratings to apply. PTI studies indicate overloading does not occur for the increased Murraylink transfer capability in the application.
Yass-Wagga 132 kV line	Lower Tumut to Wagga 330 kV line.	Existing run-back scheme allows 10 minute ratings to apply. PTI studies indicate overloading does not occur for the increased Murraylink transfer capability in the application.

Based upon the thermal constraints on Murraylink and line ratings provided in the IOWG assessments, and the possible thermal overloads indicated in the PTI due diligence, PB Associates considers that the additional run-back schemes and Lower Tumut to Wagga 330 kV line uprating defined in the application, if technically and economically feasible, would allow Murraylink transfers up to the capability defined in the revenue cap application.

4.3.3.2 Murraylink power transfers out of SA

The IOWG assessment found no limitation on Murraylink transfers out of SA up to the 220 MW rating of Murraylink due to violations in the NSW region. As such, TEA is not proposing any other augmentations in the NSW region to achieve the increased transfer capability of Murraylink in MTC's application to the Commission.

4.4 SUMMARY OF TRANSFER CAPABILITY OF MURRAYLINK

Table 4-2 summarises the transfer capability of Murraylink in the MTC application for worst case conditions. It would be expected that more favourable conditions would allow the transfer capability to be increased up to the 220 MW rating of Murraylink.

It should also be noted that the table relates to normal network conditions pre-contingent and single network outage contingencies. Other particular non-normal network conditions (e.g. certain plant out of service) or load and generation profiles may impose more onerous constraints. These operational constraints are not considered relevant for this assessment.

Table 4-2 TEA Report Murraylink Transfer Capability

Murraylink Transfer	Worst case condition	Incremental generation	Limits in SA	Limits in Vic	Limits in NSW	Overall
Vic to SA	Peak summer demand – high import to Vic from Snowy / NSW	Vic	220 MW	220 MW	220 MW	**220 MW**
		NSW	220 MW	220 MW	110 MW	**110 MW**
SA to Vic	Peak Riverland demand	Not applicable	95-100 MW	220 MW	220 MW	**95-100 MW**

4.5 PB COMMENTS ON TRANSFER CAPABILITY ASSESSMENT

Under the assumption that the findings of original IOWG assessments of Murraylink, SNOVIC and SNI are correct, and noting the findings of the PTI due diligence, PB Associates believes that the following Murraylink transfer capabilities should be achievable:

- 2003/04 Peak summer demand, high import (1900 MW) to Vic from Snowy / NSW, incremental generation in Victoria – Murraylink transfer capability Victoria to SA is **180 MW.** This is lower than the capability proposed by TEA and is discussed further below;

- 2003/04 Peak summer demand, high import (2010 MW) to Vic from Snowy / NSW, incremental generation in NSW – Murraylink transfer capability Victoria to SA is **110 MW**; and

- 2003/04 Peak Riverland demand – Murraylink transfer capability SA to Victoria is **95 – 100 MW**.

This assumes that the existing and additional augmentations defined in the TEA report are in service. During the course of this review, PB Associates have not attempted to determine whether the additional augmentations are technically and economically achievable, as this would require detailed consultations between MTC and relevant TNSPs. However, based upon the additional augmentation proposed and possible alternatives, we consider that it is reasonable to assume they are achievable.

It is also important to note that MTC have included a capped augmentation expenditure clause in the application. MTC is proposing only to fund additional augmentation up to a $8.97 million limit.

PB Associates' proposed 180 MW transfer constraint on Murraylink defined above is due to possible unacceptable voltage depression or collapse at higher transfer levels during peak summer demand, with high import to Victoria from Snowy/NSW. TEA has proposed fast run-back schemes in its report to remove the voltage issue and increase Murraylink transfer capability to 220 MW rating under similar conditions.

TEA has performed dynamic studies to examine the voltage issue in SW-NSW. However, in discussions with VENCorp, held during the course of this review, VENCorp stated that voltage collapse could also be centred in the state grid region, and as such, dynamic studies would need to be performed with suitable load modelling of the state grid region to confirm that the fast run-back schemes were acceptable to allow Murraylink transfers up to 220 MW.

In light of the uncertainty surrounding the voltage issue in the Victoria state grid region for Murraylink transfer greater than 180 MW, PB Associates consider that further dynamic studies, in consultation with VENCorp, are necessary before TEA's proposed 220 MW transfer capability can be confirmed.

Of particular note for Murraylink transfers with incremental generation in NSW (considered the most onerous for the SW-NSW network), TEA has proposed that the Snowy-Victoria interconnector transfer capability can be raised to 2010 MW by using Murraylink power flows and an altered dispatch of Snowy hydro to skew existing power flows across the Snowy/Vic interconnector. This removes a potential overload of the Murray to Dederang 330 kV line. This requirement on the dispatch of Snowy hydro in order to utilise the full rated capacity of Murraylink under these conditions should be further examined in the context of the impact on the market benefits analysis.

It is important to note the transfer capability discussed above relates to normal network conditions pre-contingency and single network outage contingencies. Other particular non-normal network conditions (e.g. certain plant out of service) or load and generation profiles may impose more onerous constraints. These operational constraints are not considered relevant for this assessment.

PB Associates' review of the Murraylink transfer capability in the application assumes that the power systems studies on which the TEA report is based are valid and complete. A rigorous audit of these studies would be needed to confirm this. Such an audit is not within the scope or timeframe of this review.

5. REVIEW OF PTI DUE DILIGENCE OF TEA TRANSFER CAPABILITY STUDIES

5.1 INTRODUCTION

Power Technologies International (PTI) has performed a due diligence on the Murraylink transfer capability assessment. A report by PTI detailing this due diligence was included as Appendix B of MTC's application to the Commission.

Part of the PB Associates' scope of work for this review was to review the PTI due diligence report. The review conducted by PB Associates and findings are discussed in this section of our report.

The due diligence by PTI included a review of the TEA study findings. However the main due diligence analysis performed by PTI involved independent power system studies to confirm the general findings of TEA on Murraylink transfer capabilities. PTI undertook power flow contingency analysis to ascertain potential network thermal overloads and voltage control violations.

It is important to note, that although PTI undertook independent power system studies, the power system model, loading and generation dispatch scenarios were provided and defined by TEA.

TEA has confirmed that the power system model provided to PTI for the studies was that agreed and used by the IOWG in the SNOVIC/SNI assessment with SNI components switched out. This is also the model used by TEA for the assessment in the application. PB Associates agrees that this is a reasonable model to be using for the PTI studies.

The PTI study only considered the 2003/04 summer peak condition as used in the TEA assessment, with 1900 MW import to Vic from Snowy/NSW, and 500 MW transfer to SA via the Heywood interconnector. Two generation dispatch cases were examined:

- **Vic swing bus case**. Murraylink transfers were picked up by incremental generation in the Latrobe Valley region of Victoria. This condition should be the most onerous for voltage control and overloads in the Victoria state grid region.
- **NSW swing bus case**. Murraylink transfers picked up by incremental generation in the Hunter Valley region of NSW. This condition should be the most onerous for voltage control and overloads in the SW-NSW region. This case also increases flows on the SNOVIC interconnector due to Murraylink transfers. The base case for zero Murraylink transfer is 1900 MW on SNOVIC.

The design criteria adopted for the IOWG assessment[27] for thermal overload and voltage drop and step were applied in the PTI studies.

PTI did not examine whether the two cases represented a reasonable set of limiting conditions for the assessment of the Murraylink transfer capability. However, based upon its discussions with PTI and TEA, and the findings in the original IOWG assessment, PB Associates consider these conditions to be the most material for the market benefits assessments as they represent the most onerous conditions when maximum Murraylink transfers into SA may be required.

TEA provided a list of the most onerous contingencies to PTI (seeTable 5-1). However, the analysis performed by PTI also covered all single contingencies in Victoria. TEA has

[27] Appendix A of IOWG Assessment of Murraylink – NEMMCO website

advised that this list is based upon findings of previous IOWG studies. PB Associates have confirmed these contingencies to be considered important in the previous IOWG assessments.

Table 5-1 Contingencies considered most onerous by TEA

Contingency Description	Specific Contingency Tested
Loss of large Victorian generator	LYA 540 MW unit
	NPS 500 MW unit
Loss of major SNOVIC component	MSS- DDTS 330 kV line (either)
	SMTS – DDTS 330kV line (either)
Loss of major Victorian transmission component	HWTS – ROTS 500 kV line
	SMTS – ROTS 500 kV line
	HWTS – SMTS 500 kV line
Loss of SW-NSW transmission component	BURO – RCTS 220 kV line
	DLPT – BLND – BURO 220 kV line
	WAGG – DLPT 330 kV line
	LTSS – WAGG 330 kV line
Loss of Victorian state grid transmission component	BATS - HOTS 220kV line
	HOTS – RCTS 220kV line
	BETS – KGTS 220kV line
	KGTS – RCTS 220kV line
	MLTS – BATS 220kV line (both)
	BETS – SHTS 220kV line
	BETS – BATS 220kV line
	MLTS 500/220kV transformer
	DDTS 330/220kV transformer

5.2 VIC SWING BUS CASE

TEA provided two case files for the PTI Victoria swing bus studies. One case contained the proposed TEA additional reactive support and one case (base case) did not include this support.

PTI performed automatic contingency power flow studies on the base case (without additional reactive support) to assess voltage issues and thermal overloads for 0 MW, 180 MW and 220 MW Murraylink transfer levels. This analysis automatically cycles through all contingencies and reports voltage and rating violation based upon defined criteria. The load flow studies did not converge for high Murraylink transfers, particularly without additional reactive support, indicating that severe voltage problems could occur for certain contingencies. This results in a situation when a power flow solution cannot be obtained, and as such it was not possible to precisely determine the cause of the voltage issue.

The PTI load flow studies with a Murraylink transfer of 180 MW and the TEA proposed additional reactive support converged successfully for all studied single contingency events.

Where load flow non-convergence did occur during automatic contingency analysis, PTI performed individual power flow studies for the contingency to assess the level of reactive support required to remove the voltage violations and the thermal overloads.

The studies confirmed the need for TEA's proposed additional reactive support to remove voltage control violations for Murraylink transfers up to 180 MW. The thermal overloads assessed in the PTI studies also confirmed the need for the slow and fast run-back schemes proposed by TEA for Murraylink transfers up to 220 MW. The table in Appendix B summarised the thermal overload predicted from the PTI studies for particular contingencies and indicates the run-back scheme proposed by TEA to alleviate this overload to allow Murraylink transfers up the 220 MW rating.

The PTI studies and the Table in Appendix B confirm the findings of the Murraylink transfer capability defined in the previous Section. In particular:

- Assuming 2003/04 peak summer demand, high import (1900 MW) to Vic from Snowy / NSW, incremental generation in Victoria – Murraylink transfer capability Victoria to SA is **180 MW;**

provided additional reactive augmentations and the TEA proposed run-back schemes are in place.

PTI in its report also stated that dynamic studies would be required to confirm that voltage collapse would not occur for higher transfers up to the 220 MW limits. This is consistent with PB Associates' view that TEA's proposed transfer capability of 220 MW from Victoria to SA with incremental generation in Victoria should not be accepted without further dynamic studies.

It is noted that the PTI studies did not appear to examine voltage rise issues, and as such, the PTI report does not validate certain voltage rise solutions in the SW-NSW networks proposed by TEA.

5.3 NSW SWING CASE

TEA provided three case files for the PTI NSW swing bus studies:

- Base case – No additional augmentations;
- Case 2 – additional reactive support in SW-NSW, adjustments to Snowy hydro generation to increase SNOVIC capability; and
- Case 3 – as above but higher levels of reactive support in SW-NSW and assumed higher 5 minute rating on Lower Tumut to Wagga 330 kV line (increased from 1100 MVA to 1160 MVA) – this case is most representative of the MTC application.

PTI performed automatic contingency power flow studies on the base case (without additional reactive support) to assess voltage issues and thermal overloads for 0 MW and 110 MW Murraylink transfer levels. This analysis automatically cycles through all contingencies and reports voltage and rating violation based upon a defined criteria. The studies indicated that for high Murraylink transfers, particularly without additional reactive support, voltage collapse could occur for certain contingencies. This results in a situation when a power flow solution cannot be obtained.

Where voltage collapse did occur, PTI performed individual power flow studies for the contingency to assess the level of reactive support required to remove the voltage violations and obtain the thermal overloads for these contingencies.

The studies confirmed the need for additional reactive support to remove voltage control violations for Murraylink transfers up to 110 MW. The PTI study did not however perform confirming studies with the TEA proposed reactive support. That said, due to the levels and location of reactive support assessed by PTI as being necessary to remove the constraint, it can be expected that the reactive support proposed by TEA would be sufficient.

The thermal overloads assessed in the PTI studies also confirmed the need for the slow and fast run-back schemes proposed by TEA for Murraylink transfer up to 110 MW and the altered dispatch of Snowy hydro to remove an overload of the Murray to Dederang 330 kV line. This requirement on the dispatch of Snowy hydro should be examined in the context of the impact on the market benefits analysis.

The table in Appendix B summarised the thermal overloads predicted from the PTI studies for particular contingencies and indicates the run-back scheme proposed by TEA to alleviate these overloads to allow Murraylink transfers up the 110 MW.

The PTI studies and the Table in Appendix B confirm the findings of the Murraylink transfer capability defined in the previous Section. In particular:

- assuming 2003/04 peak summer demand, high import (2010 MW) to Vic from Snowy / NSW, incremental generation in NSW – Murraylink transfer capability Victoria to SA is **110 MW;**

provided additional augmentations and run-back schemes are in place, and noting dispatch requirements on Snowy hydro discussed in the previous section.

It is noted that the PTI studies did not appear to examine voltage rise issues, and as such, the PTI report does not validate certain voltage rise solutions in the SW-NSW networks proposed by TEA.

5.4 OVERVIEW OF PTI DUE DILIGENCE

The PTI due diligence confirms the requirements for the additional augmentations and runback schemes proposed in the application. The Table of overloads in Appendix B summarises the overloads determined in the PTI studies and the TEA proposed additional run-back schemes to remove the overloads for the following Murraylink transfer capabilities:

- 2003/04 Peak summer demand, high import (1900 MW) to Vic from Snowy / NSW, incremental generation in Victoria – Murraylink transfer capability Victoria to SA is **180 MW;**

- 2003/04 Peak summer demand, high import (2010 MW) to Vic from Snowy / NSW, incremental generation in NSW – Murraylink transfer capability Victoria to SA is **110 MW;**

The PTI studies indicate that the additional reactive support in the application is adequate to achieve the above Murraylink transfer levels without causing voltage control violations. However, TEA's proposed additional reactive support in the SW-NSW region does not appear to have been confirmed by PTI studies, and voltage rise studies do not appear to have been reported. PB Associates consider that the results would be more conclusive with a contingency study with the TEA additional reactive support indicating no voltage control issues, including the overvoltage criteria.

It is also important to note that the TEA proposed additional reactive support indicated to PTI at the time of the studies had changed slightly from that proposed in the TEA report. TEA has informed that these changes are due to minor adjustments during the design phase resulting from new information on the configuration or operation of the network. TEA also point out that exact specification of reactive support will only be achieved during more detailed design phases and as such is likely to result in minor changes. These changes, whilst maintaining transfer capability, should not materially impact budgetary cost. PB Associates agree with the TEA comments.

6. CONCLUSIONS AND RECOMMENDATIONS

The following section summarises the main finding of the PB Associates review of the Murraylink transfer capability and additional augmentations proposed in the MTC application.

6.1 MURRAYLINK TRANSFER CAPABILITY

Under the assumption that the findings of original IOWG assessments of Murraylink, SNOVIC and SNI were correct, and noting the findings of the PTI due diligence, PB Associates believes that the following Murraylink transfer capabilities should be achievable:

- 2003/04 Peak summer demand, high import (1900 MW) to Victoria from Snowy / NSW, incremental generation in Victoria – Murraylink transfer capability Victoria to SA is **180 MW.** This is lower than the capability proposed by TEA and is discussed further below.

- 2003/04 Peak summer demand, high import (2010 MW) to Victoria from Snowy / NSW, incremental generation in NSW – Murraylink transfer capability Victoria to SA is **110 MW**

- 2003/04 Peak Riverland demand – Murraylink transfer capability SA to Victoria is **95 – 100 MW**

This assumes that the existing and additional augmentations defined in the TEA report are in service.

The 180 MW transfer capacity from Victoria to South Australia with incremental generation in Victoria is less than the 220 MW transfer capacity given in the MTC application for these conditions. This difference is due to uncertainty on whether unacceptable voltage depression or collapse in the state grid region of Victoria might occur for transfers greater than 180 MW under these conditions. PB Associates recommends that further dynamic studies are performed, in consultation with VENCorp, to determine whether the full 220 MW transfer capability claimed by TEA is achievable, considering the additional augmentations proposed in the TEA report or similar.

6.2 GENERAL FINDING AND RECOMMENDATIONS

The following are general findings of particular importance, unresolved issues and findings of the PB Associates review.

- For Murraylink transfers with incremental generation in NSW (considered the most onerous for the SW-NSW network), TEA has proposed that the SNOVIC interconnector transfer capability can be raised to 2010 MW by using Murraylink power flows and an altered dispatch of Snowy hydro to skew existing power flows across the interconnector. This removes a potential overload of the Murray to Dederang 330 kV line. This requirement on the dispatch of Snowy hydro should be examined in the context of the impact on the market benefits analysis.

- TEA, after consultation with TransGrid, was proposing a number of minor network augmentations and run-back schemes to alleviate the most limiting constraints. At the time of the IOWG assessment, the exact specification for the run-back schemes had not been finalised. At the present time these schemes are not implemented, although they are assumed in service for the TEA assessment. TEA has advised that the current estimated in service date for these augmentations is May 2003.

- MTC have included a capped augmentation expenditure clause in the revenue cap application and are proposing only to fund additional augmentation up to a $8.97 million limit. PB Associates recommend that consultation is held with the affected TNSPs to confirm that the additional augmentations are achievable below this cap.

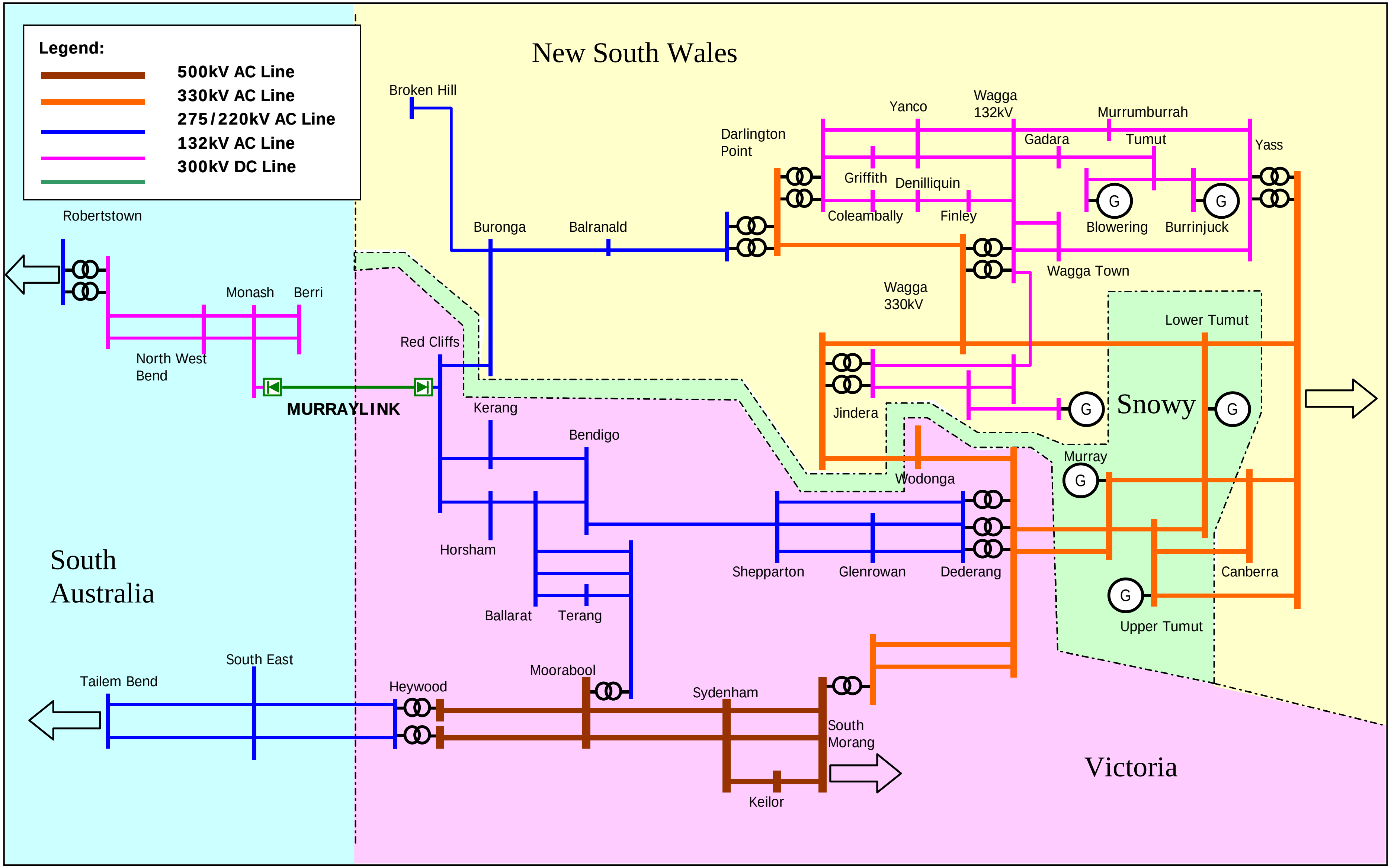
- The PTI due diligence confirmed the requirements for the additional augmentations and runback schemes proposed in the application to achieve the following Murraylink transfer capabilities stated above.

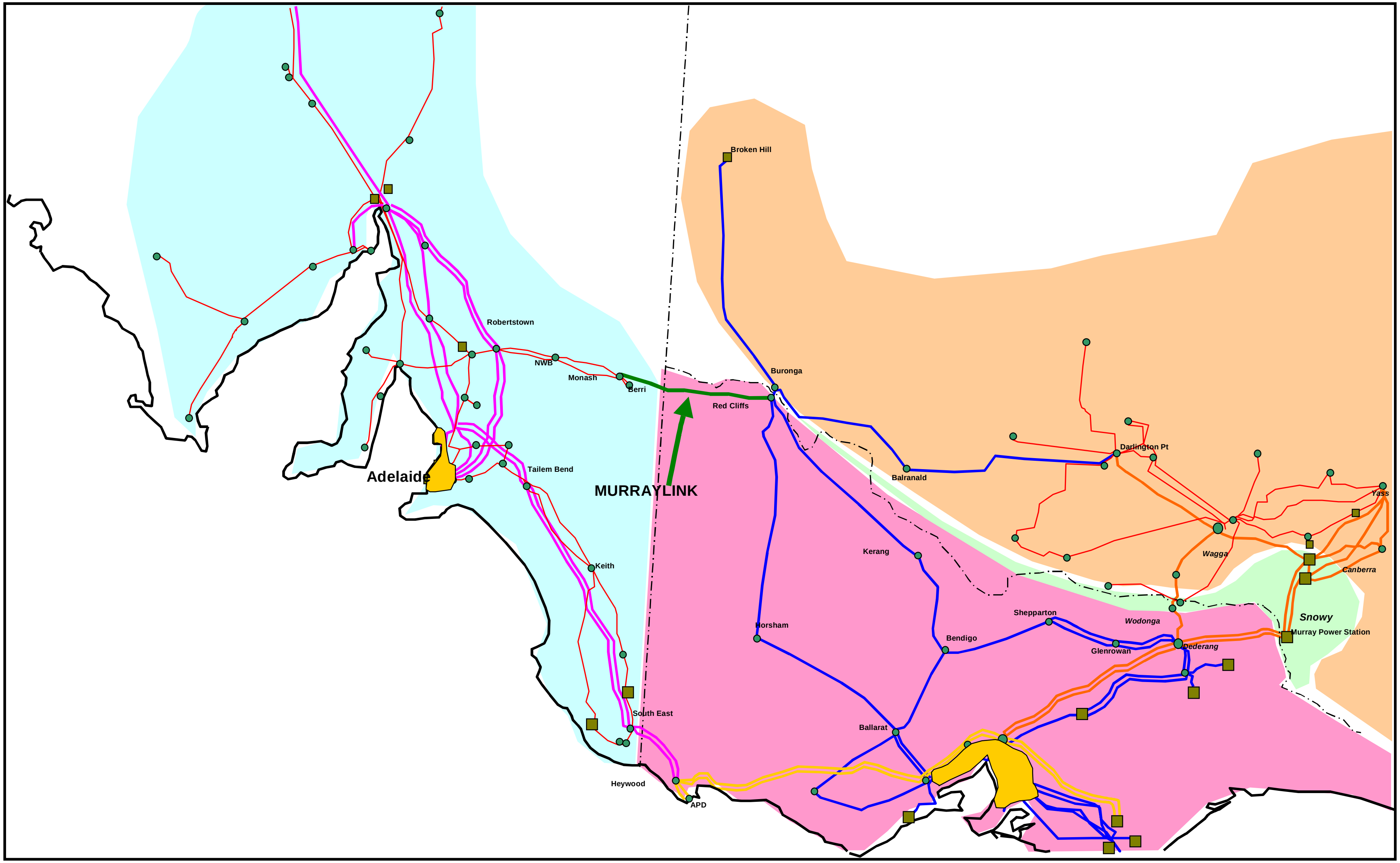
  The PTI studies also indicate that the additional reactive support in the revenue cap application is adequate to achieve the above Murraylink transfer levels without causing voltage control violations. However, the TEA proposed additional reactive support in the SW-NSW region does not appear to have been confirmed by PTI studies, and voltage rise studies do not appear to have been reported. PB Associates consider that the results would be more conclusive with a contingency study with the TEA additional reactive support indicating no voltage control issues, including the overvoltage criteria.

7. GLOSSARY OF TERMS AND ABBREVIATIONS

AC	Alternating Current
ACCC	Australian Competition and Consumer Commission
CAPEX	Capital Expenditure
DC	Direct Current
HVDC	High Voltage Direct Current
IOWG	Interconnector Options Working Group
IRPC	Inter-regional Planning Council
MTC	Murraylink Transmission Company
MTP	Murraylink Transmission Partnership
MVAr	Mega Volts Amps Reactive
MWh	Mega watt hour (1,000 kWh)
MW	Mega watt
NEC	National Electricity Code
NET	National Electricity Tribunal
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company
PTI	Power Technologies International
TEA	TransEnergie Australia
TNSP	Transmission Network Service Provider
VNSC	Victorian Network Switching Centre

APPENDIX A
Schematic of relevant SA, VIC and NSW transmission networks


Legend:
500kV AC Line
330kV AC Line
275/220kV AC Line
132kV AC Line
300kV DC Line
New South Wales
South Australia
Victoria
Snowy
Broken Hill
Robertstown
Monash
Berri
North West Bend
MURRAYLINK
Red Cliffs
Buronga
Balranald
Darlington Point
Yanco
Wagga 132kV
Murrumburrah
Gadara
Tumut
Yass
Griffith
Denilliquin
Coleambally
Finley
Blowering
Burrinjuck
Wagga Town
Wagga 330kV
Lower Tumut
Jindera
Kerang
Bendigo
Wodonga
Murray
Horsham
Shepparton
Glenrowan
Dederang
Canberra
Ballarat
Terang
Upper Tumut
South East
Tailem Bend
Heywood
Moorabool
Sydenham
South Morang
Keilor
G


Broken Hill
Buronga
Red Cliffs
Balranald
Darlington Pt
Robertstown
NWB
Monash
Berri
Tailem Bend
Adelaide
MURRAYLINK
Keith
South East
Heywood
APD
Kerang
Horsham
Bendigo
Ballarat
Shepparton
Wodonga
Glenrowan
Dederang
Wagga
Yass
Canberra
Snowy
Murray Power Station

APPENDIX B
Overview of overloads and run-back schemes

Monitor		**To Protect:**
Slow Runback		
S1	Ballarat to Moorabool #1	Ballarat to Moorabool #2 Bendigo to Shepparton
S2	Ballarat to Moorabool #2	Ballarat to Moorabool #1 Bendigo to Shepparton
S3	Ballarat to Bendigo	Bendigo to Shepparton
S4	DDTS TX #3	DDTS TX #1 & #2
S5	Buronga to Red Cliffs	Various
Fast Runback		
F1	Bendigo to Kerang	Darlington Point to Balranald
F2	Moorabool TX	Geelong to Keilor #1, 2, 3
F3	Bendigo to Shepparton	Ballarat to Bendigo Darlington Point to Balranald
F4	Ballarat to Horsham	BAN to ART 66 Darlington Point to Balranald
F5	Darlington Point to Balranald	Bendigo to Shepparton (includes voltage control)
F5	Balranald to Buronga	Bendigo to Shepparton (includes voltage control)
F6	Wagga to Darlington Point	Voltage control Wagga to DLPT 132 kV network

Note

Shading of specific schemes in the table indicates network elements where it may be more economic to pursue a network upgrade, rather than a fast runback scheme. Specific network elements for which secondary plant upgrade paths exist include:

- *Darlington Point to Balranald to Buronga transmission line (protection upgrade)*
- *Bendigo to Ballarat 220 kV transmission line (protection upgrade)*
- *Bendigo to Kerang 220 kV transmission line (protection upgrade)*
- *Other upgrade paths may also be identified during detailed design.*

Runback Schemes for 180 MW Transfer Capability

Monitor		**To Protect:**
Fast Runback		
F7	Ballarat to Moorabool #2	Ballarat to Moorabool #1
F8	Kerang to Red Cliffs	Darlington Point to Balranald
F9	Horsham to Red Cliffs	Darlington Point to Balranald
F10	Buronga to Red Cliffs	Bendigo to Shepparton Bendigo to Kerang

Note

Shading of specific schemes in the table indicates network elements where it may be more economic to pursue a network upgrade, rather than a fast runback scheme. Specific network elements for which secondary plant upgrade paths exist include:

- *Darlington Point to Balranald to Buronga transmission line (protection upgrade)*
- *Other upgrade paths may also be identified during detailed design.*

Additional Runback Schemes Required for 220 MW Transfer Capability

		Overloaded circuits (from PTI study) / TEA augmentations										
Specific Contingency Tested	**PTI ID**	**Bendigo to Shepparton 220 kV line**	**Geelong to Keilor 220 kV line**	**Darlington Point to Balranald 220 kV line**	**BAN to ART 66 kV line (Powercor)**	**Ballarat to Moorabool 220 kV line**	**Buronga to Balranald 220 kV line**	**Ballarat to Bendigo 220 kV line**	**Bendigo to Kerang 220 kV line**	**Kerang to Red Cliffs 220 kV line**	**Yass 330/132 kV transformer**	**Murray to Dederang 330 kV line**
Murray to Dederang 330 kV line	SNOVIC 2.1											See comment [2]
South Morang to Dederang 330 kV line	SNOVIC 2.2											
Hazelwood to Rowville 500 kV line	3.1											
South Morang to Rowville 500 kV line	3.2											
Hazelwood to South Morang 500 kV line	3.3											
Buronga to Red Cliffs 220 kV line	NSW 4.1	S5 for 180MW, F10 for 220 MW								S5 for 180 MW, F10 for 220 MW		
Balranald to Buronga 220 kV line	NSW 4.2											
Darlington Point to Balranald 220 kV line	NSW 4.3	F5 for 220 MW				F5 for 220 MW			F5 for 220 MW	F5 for 220 MW		
Wagga to Darlington Point 330 kV line*	NSW 4.4	F6 for 220 MW								F6 for 220 MW		
Low Tumut to Wagga 330 kV line	NSW 4.5										See comment [1]	
Ballarat to Horsham 220 kV line	VIC 5.1			F4 for 220 MW	F4 for 220 MW							
Horsham to Red Cliffs 220 kV line	VIC 5.2											
Bendigo to Kerang 220 kV line	VIC 5.3			F1 for 220 MW			F1 for 220 MW					
Kerang to Red Cliffs 220 kV line	VIC 5.4			F8 for 220 MW								

Specific Contingency Tested	**PTI ID**	**Bendigo to Shepparton 220 kV line**	**Geelong to Keilor 220 kV line**	**Darlington Point to Balranald 220 kV line**	**BAN to ART 66 kV line (Powercor)**	**Ballarat to Moorabool 220 kV line**	**Buronga to Balranald 220 kV line**	**Ballarat to Bendigo 220 kV line**	**Bendigo to Kerang 220 kV line**	**Kerang to Red Cliffs 220 kV line**	**Yass 330/132 kV transformer**	**Murray to Dederang 330 kV line**
Moorabool to Ballarat 220 kV line	VIC 5.5					S1 & S2 for 180 MW, F7 for 220 MW						
Bendigo to Shepparton 220 kV line	VIC 5.6			F3 for 220 MW		F3 for 220 MW	F3 for 220 MW	F3 for 220 MW				
Bendigo to Ballarat 220 kV line	7											
Moorabool 500/220 kV transformer	VIC 5.8	F2 for 220 MW	F2 for 220 MW									
Dederang 330/220 kV transformer [3]												

VIC swing bus overloads
NSW swing bus ovreloads
VIC and NSW swing bus overloads

* 220 kV line from Darlington Point to Balranald is tripped under contingency of loss of Wagga to Darlington Point line.

1. Existing Murraylink NSW runback scheme currently being implemented is sufficient to manage Murraylink related overloads on this transformer. For SNOVIC related overloads it will be possible to integrate this outage with the existing Yass-Wagga tripping scheme which presently operates for loss of Lower Tumut - Wagga 330kV line and is armed when SNOVIC exceeds approx. 900MW import into VIC. TransGrid and Vencorp have shown that it is possible to use this tripping scheme for SNOVIC imports up to 2100MW (Refer IRPC Combined SNOVIC and SNI documentation November 2001).
2. SNOVIC 400 permits 1900MW import into VIC without overloading this line (for the critical contingency). In this present proposal TEA use directed Snowy Hydro dispatch to off-load the MSS-DDTS lines (pre-contingent) and additional reactive support at Wagga and Dederang (on the Murray-Sth Morang side of the bus split) to keep post-contingent voltage high enough to maintain current below the critical flow limit. With these strategies and the upgrading of the LTSS-Wagga 330kV line to 1160MVA it is possible to import 2010MW into VIC without exceeding the 5 minute rating of the intact MSS-DDTS line. Murraylink runback is not effective in off-loading SNOVIC since reductions in Murraylink transfer (in the short-term at least) result in increases in Heywood transfer to SA, which leave post-contingent loading on MSS-DDTS at about the same level.
3. The Dederang transformer outage can constrain Murraylink for low levels of Victorian Hydro dispatch at times of summer peak (see IOWG Assessment). These conditions were not studies as part of the PTI assessment. TEA do have a slow run-back scheme for this contingency.