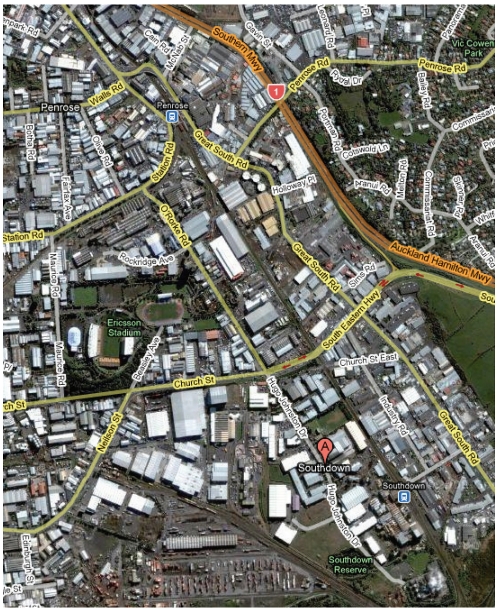
SINCLAIR KNIGHT MERZ

SKM

MIGHTY RIVER POWER

Southdown: Feasibility Study of Direct Embedment at Penrose GXP



- Version 2

- August 2010

Southdown: Feasibility Study of Direct Embedment at Penrose GXP

- Version 2
- August 2010

Sinclair Knight Merz
Level 1, 70 Forth Street
Invercargill
New Zealand
Tel: +64 3 218 7102
Fax: +64 3 214 4843
Web: www.skmconsulting.com

Contents

Executive Summary 4

1. Introduction 5

2. Existing Power System Details 6

3. Cable/Line Route 8

3.1. Overhead Line 10
3.2. 33kV vs. 220kV vs. 110kV Interconnection 10
3.3. Southern Motorway Crossing 11
3.3.1. Existing Underground Services 11
3.4. KiwiRail Conditions 12
3.5. Final Route Selection 13

4. Basis of Design 14

4.1. Powerflow Calculations 14
4.2. Fault Level Calculations 16

5. Penrose Connection Details 20

5.1. Primary Plant 20
5.1.1. 220 kV Rigid Bus 20
5.1.2. 220 kV Flexible Connections between Equipment 20
5.1.3. 220 kV Post Insulators 21
5.1.4. 220 kV Outdoor Circuit Breakers 21
5.1.5. 220 kV Disconnectors 21
5.1.6. 220 kV Earth Switches 21
5.1.7. 220 kV Capacitor Voltage Transformers 21
5.1.8. 220 kV Current Transformers 21
5.1.9. 220 kV Cable Sealing End Terminations 22
Refer to section 7 of this report. 22
5.2. Earthing 22
5.3. Protection & Control 22
5.4. Acoustics/Noise 22

6. Southdown Connection Details 23
6.1. Primary Plant 23
6.1.1. 220 kV Rigid Bus 23
6.1.2. 220 kV Flexible Connections between Equipment 24
6.1.3. 220 kV Post Insulators 24
6.1.4. 220 kV Outdoor Circuit Breakers 24
6.1.5. 220 kV Disconnectors 24
6.1.6. 220 kV Earth Switches 24
6.1.7. 220 kV Capacitor Voltage Transformers 24

SKM

6.1.8. 220 kV Current Transformers 24
6.1.9. 220 kV Cable Sealing End Terminations 24
6.2. Earthing 25
6.3. Protection & Control 25
6.4. Revenue Metering 26
6.5. Acoustics/Noise 26
6.6. Reconnection of the HEN-OTA Overhead Line Circuit 26
7. 220kV Cable Details 27
7.1. Cable System 27
7.1.1. Cable selection 28
7.1.2. Extra Low Frequency (ELF) Fields 28
7.1.3. Earthing 29
7.1.4. Interference Due to the Underground 220kV Cable 30
7.2. Civil works Associated with Cable Installation 31
7.2.1. Geotechnical Information 31
7.2.2. Trenching Constraints 32
7.2.3. Railway Crossings 32
7.2.4. Great South Rd and Southern Motorway Crossing 33
7.2.5. Watercare Services Watermains 34
7.2.6. ARTA Fibre Optic Cable 34
7.2.7. Contaminated Land 34
7.2.8. Comprehensive Survey of Cable Route 35
8. Network Losses 36
9. EGR Compliance 37
10. Project Time-Line 43
11. Estimated Project Construction Costs 44
11.1. Summary of Cost Estimates 45
11.2. Assumptions/Exclusions 46
11.3. Potential Variances to Cost Estimates 46
Appendix A Project Price Breakdown 48
Appendix B Calculation Sheets 49
Appendix C Substation Drawing Mark-Ups 52
Appendix D Typical Cable Design Drawings & Proposed Cable Info 55
Appendix E Civil Cable Route Drawings 56
Appendix F Project Programme 57
Appendix G Background Information 58

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
0	25/06/10	R A McDougall	Richard Fairbairn	25/06/10	Draft for issue to Client
1	02/07/10	R A McDougall	Richard Fairbairn	02/07/10	FINAL subsequent to client comment
2	25/08/10	R A McDougall	Richard Fairbairn	25/08/10	FINAL subsequent to client requested modifications

Distribution of copies

Revision	Copy no	Quantity	Issued to
0	1	1 (pdf)	Nick Murray
1	1	1 (pdf)	Nick Murray
2	1	1 (pdf)	Nick Murray

Printed:	25 August 2010
Last saved:	25 August 2010 04:19 PM
File name:	I:\ZPINA\Projects\ZP00777\DELIVERABLES\Design Reports\ZP00777 - MRP Southdown to Penrose 220kV Costing - Rev 2 .docx
Author:	David de Bruyn/S Houghton/A Williams
Project manager:	Richard Fairbairn
Name of organisation:	Mighty River Power
Name of project:	Southdown to Penrose 220kV Cable : Cost Estimate
Name of document:	Southdown to Penrose 220kV Cable : Cost Estimate
Document version:	2
Project number:	ZP00777

Executive Summary

Sinclair Knight Merz (SKM) have been contracted by Mighty River power (MRP) to complete a technical feasibility and capital cost estimate to connect the Southdown power station to the Penrose substation. The Southdown power station is an existing co-generating station located in South Auckland that injects into one circuit of Transpower's existing Henderson-Otahuhu 220kV transmission line.

Vector takes supply from Transpower at the Penrose substation and constitutes a significant load centre that is located approximately 3km from the Southdown station. The connection of Southdown generation directly to the Penrose substation has the potential to significantly reduce transmission charges that are paid by Vector to Transpower.

The overall intention of SKM's report is to establish a cost effective and credible "alternative connection option", and for the project cost estimate to be used in a Prudent Discount Agreement (PDA) that involves Transpower, Mighty River Power and Vector. If a PDA can be negotiated then the project does not need to proceed.

As a result of the work SKM have investigated various connection and transmission options at 220kV, 110kV and 33kV. These investigations have included review of previous detailed connection options considered during the original construction of the Southdown Plant. In consultation with MRP and Vector, SKM have then proceeded to select a preferred option that employs a single circuit underground 220kV cable between Southdown and Penrose. The 220kV cable follows a route that effectively traverses along an existing railway corridor and then under the motorway (SH1).

It is anticipated that the installation can be achieved within the timescales required by MRP.

The cost to MRP for the complete installation is anticipated to be in the order of **$32 million**. SKM notes that the accuracy of the estimate is +/-20%, which is commensurate with the project development stage.

1. Introduction

Southdown is a 175MW Co-generation facility located to the south of Penrose in Auckland. Southdown, whilst not directly embedded, is presently treated as embedded generation (via Otahuhu and Henderson Substations) at Penrose GXP substation approximately 3km away, in a series of agreements involving Mighty River Power, Vector and Transpower that SKM understands will expire on December 31st 2011. MRP has two options to re-secure transmission benefits beyond December 31st 2011:

- Apply for a new agreement under the Prudent Discount Policy (PDA) outlined in the Electricity Governance Rules.
- Directly embed Southdown at the Penrose substation.

Both options require detailed analysis of the feasibility of a direct Southdown-Penrose connection. The objective of this study is to provide MRP with an assessment of the technical requirements, electrical loss benefits and capital costs associated with establishing an embedded connection. MRP can use this report to either (i) support a Prudent Discount Application (PDA), or (ii) as costing to justify physically embedding Southdown at Penrose.

2. Existing Power System Details

Currently, Southdown injects into one circuit of the Henderson to Otahuhu 220kV line, via an in-out connection as shown in Figure 1. The power station contains the following generation:

- Three LM6000 gas turbine generators with the following ratings:
  - 2 x 42MW, (61.375MVA)
  - 1 x 47MW, (61.375MVA)
- One steam turbine generator rated at 37.8MW (42MVA)

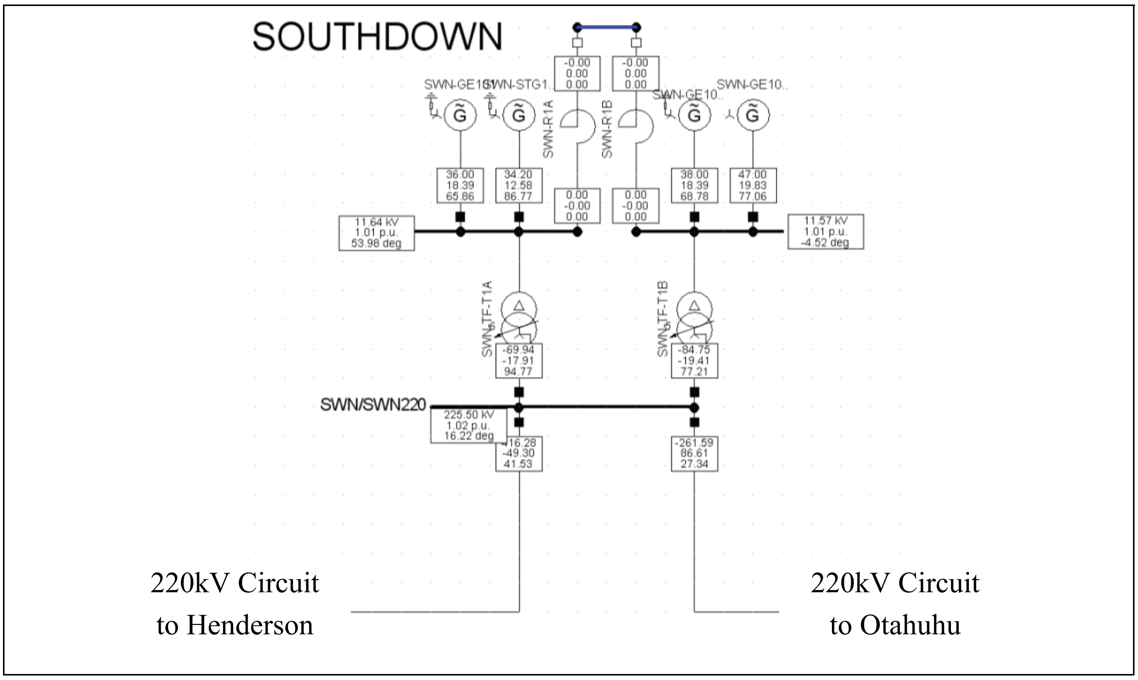
All of which are linked to the 220kV system via two 11.5 / 220kV transformers, one rated at 100MVA and the other rated at 120MVA.

SKM has been informed by MRP that there are plans to expand and include a fourth 50MW gas turbine generator, which would increase the total Southdown generation to 225MW and would necessitate the replacement of at least one of the existing Southdown 11.5 / 220 kV transformers. The proposed alternative direct connection to Penrose is to cater for the future maximum station rating of 225MW.

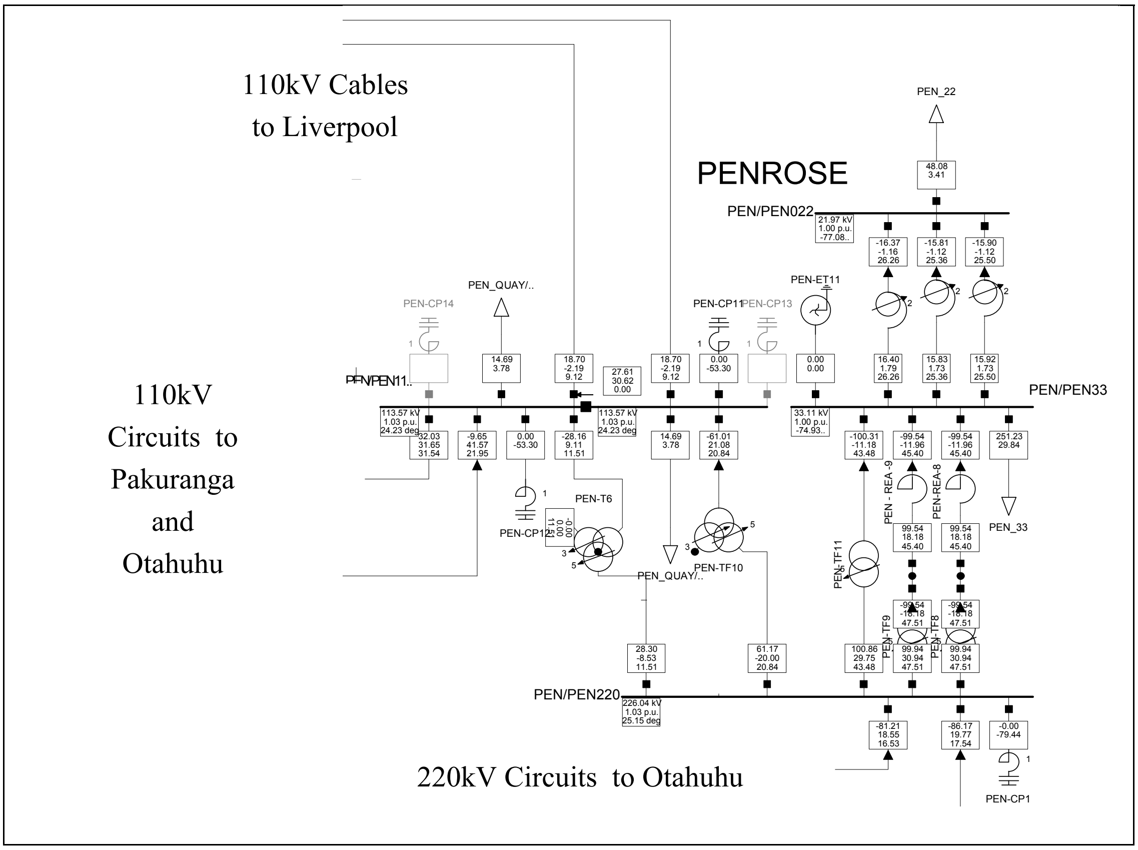
MRP's expectation is that the alternative connection to Penrose could utilise these transformers, with the potential to use a cable/line route along a nearby railway reserve. This route would have to cross the SH1 motorway at a suitable location, and inject into either the 220kV, 110kV or 33kV systems at Penrose substation.

Penrose substation has 33kV, 110kV and 220kV systems as shown in Figure 2. Vector takes supply at 33kV for supply of consumers in the Penrose and surrounding area and also at 110kV, via 2 x 110kV cable circuits, to supply demand at Liverpool substation (Auckland CBD consumers). The peak demand due to Vector on the 33kV and 110kV Penrose substation systems is approximately 330MW and 120MW respectively.

SKM



■ **Figure 1 Southdown Power Station: One-Line Powerflow Diagram**



■ **Figure 2 Penrose Substation: One-Line Powerflow Diagram**

3. Cable/Line Route

At the beginning of the project SKM reviewed the potential line/cable route options. This review included consideration of previous investigations that had been undertaken[1] and resulted in the identification of three potential cable routes from Southdown to Penrose which are described in Table 7 and shown geographically in Figure 3. These routes were chosen based on the following considerations:

- route distance,
- options for crossing the southern motorway (SH1),
- a preference to avoid private land, which has the potential for protracted discussions and negotiate to gain cable/line easements.

- **Table 1 Potential Cable Routes[2]**

Route	Reference Name	Route Description	Distance (km)
A (blue)	Railway	Along NIMT Railway to McNab St, along McNab St, under SH1 to Penrose Substation	2.9
B (red)	Hugo Johnston Dr	Along Hugo Johnston Dr, O'Rorke St, Station Rd, KiwiRail land, McNab St, under SH1 to Penrose substation	3.3
C (yellow)	Gavin St	Along NIMT Railway, Southdown Lane, Industry Rd, Church St East, Great South Rd, Sims Rd, Under SH1, Commissariat Rd, Aranui Rd, Portman Rd, Gavin St to Penrose substation	3.6

Vector, MRP and SKM then met for a one-day workshop, on 19th May 2010, during which the three routes were discussed in detail and the routes were driven. The following sections outline:

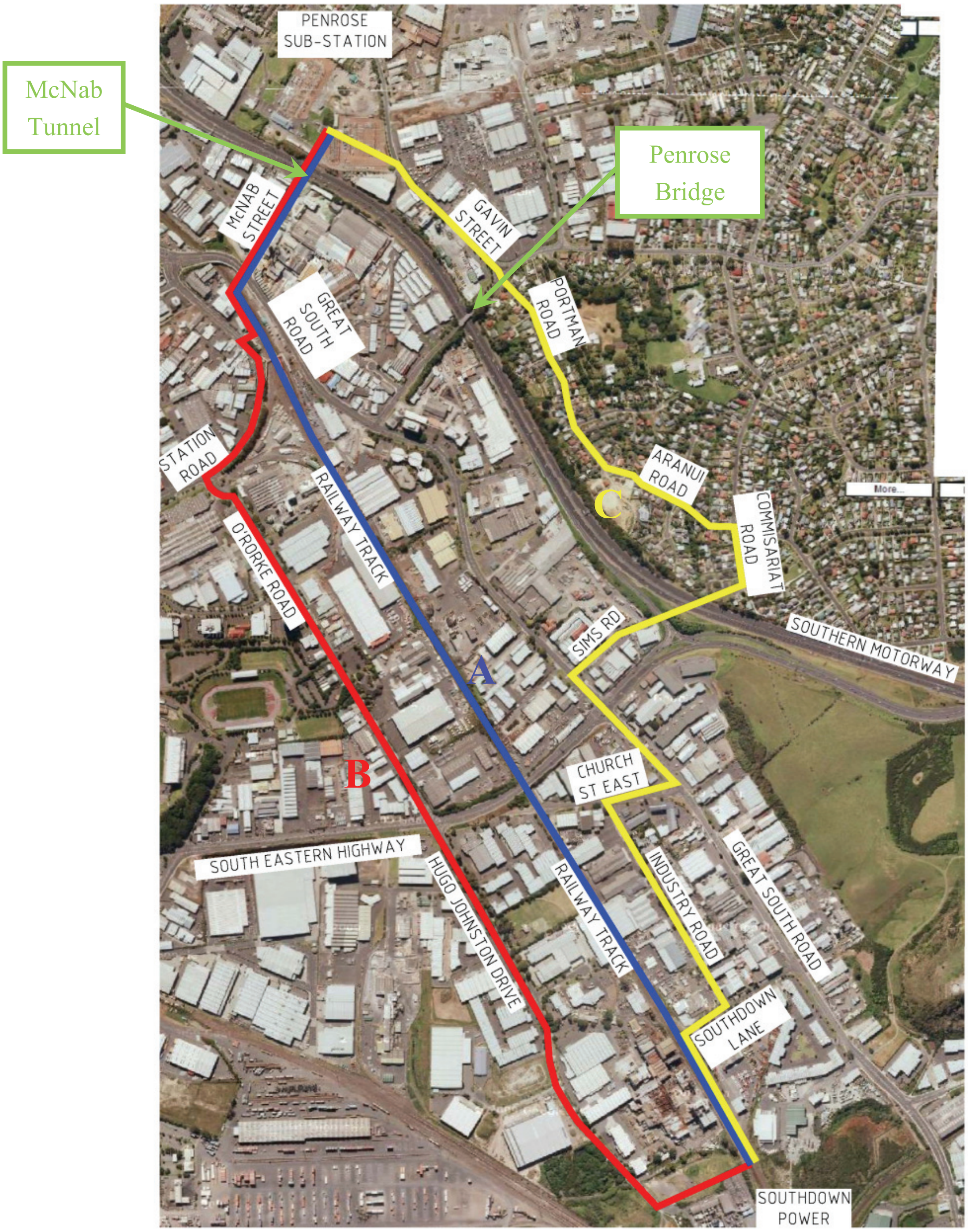
- the key decisions that were made during the workshop,
- documentation that was reviewed during and subsequent to the workshop,

---

[1] "Southdown Cable Interconnection Options", Tonkin & Taylor/Leyland Consultants, 1995. This investigation considered 6 different route options.

[2] Route lengths are substation boundary to substation boundary.

- the determination of the preferred route



- **Figure 3 Potential Cable/Line Routes**

3.1. Overhead Line

Vector/MRP/SKM considered it to be highly unlikely that resource consent could be gained for an overhead 220kV or 110kV line, even for a portion of the route, within the project time constraints.

This overhead line connection was discarded at the workshop as being impractical.

3.2. 33kV vs. 220kV vs. 110kV Interconnection

As outlined in Section 2 connection to the Penrose substation is possible at 33kV, 110kV and 220kV. The use of 33kV cables to interconnect Southdown with Penrose was discounted as impractical due to the large amount of Southdown generation. The 250MVA capacity would mean the installation of 10 cables per phase at 33kV (≈7,576Amps).

The interconnection using both 110kV and 220kV cables was considered and discussed at length. A decision was made to interconnect using a single 220kV cable for the following reasons:

- MRP indicated that connection at 220kV at Penrose would be sufficient to satisfy the requirements of a PDA.
- SKM sought prices for both 110kV and 220kV cables based on the transfer of 250MVA[3]. This translates to a cable rating of ≈650Amps at 220kV and ≈1,300Amps at 110kV. SKM was advised by cable manufacturers that for the 110kV option two 110kV cables per phase (i.e. 6 cables) would be required. Furthermore the costs quoted for the supply of 2 x 110kV cables were almost twice that associated with a single 220kV cable per phase.
- MRP indicated no desire for circuit redundancy (i.e. N-1).
- The use of a 220kV circuit would make connection to the existing 220kV systems at Southdown simple and cost effective. Photographs in Appendix C illustrate the space available for cable termination and connection.
- A single 220kV cable circuit was expected to result in a relatively small corridor width.
- Interconnection to the 110kV busbar at Penrose would necessitate the addition of a new 220kV/110kV, 250MVA Interconnecting Transformer. The cost of this and the associated, additional, protection schemes were deemed prohibitive.
- The 33kV system at Penrose is complex and has significant engineering challenges which effectively discounted it as a credible connection option. The loading on the 33kV system is

[3] Section III of Part C of the EGRs requires generation plant to have a lagging and leading reactive power capability of 50% and 33%, respectively, of the maximum active/MW plant output. This means a maximum output from the Southdown Station of 250MVA.

extremely high (highest in the country) and the fault levels are managed via the use of high impedance transformers. The addition of the Southdown generation at this point at Penrose, is likely to have increased the fault levels above the capability of the existing switchgear.

- Space was identified for connection at 220kV. The Photo in Appendix C illustrates the proposed location for connection to the 220kV busbar at Penrose

3.3. Southern Motorway Crossing

Three potential locations for crossing SH1 were considered, McNab Street, Sims Road and Penrose Road over-bridge.

The Penrose Rd over-bridge was discounted on the basis that it had a high risk of being damaged. SKM understands that it is the lowest bridge on the Auckland motorway network and subject to vehicle strikes several times a year. Whilst most of these are minor and quickly resolved, the bridge would represent a risk to cable security, particularly given that only a single 220kV cable circuit is proposed.

The information reviewed indicated that McNab Street is very congested with underground services and would be difficult to open trench. In addition, the McNab tunnel (a pedestrian tunnel which presently crosses underneath the motorway) was also deemed to have little room for large cables and also presented a consenting issue (magnetic and electric fields close to pedestrians).

As a result of the above, a new motorway crossing was considered to be required at either McNab Street or Sims Road, with the new SH1 crossing constructed by trenchless construction methods.

Trenchless construction along the full length of McNab St and under SH1 is considered to be feasible, but expensive, due to the ground conditions which include hard basalt.

Sims Rd represents a new crossing under SH1. Whilst the SH1 crossing appears attractive due to ground conditions at the highway crossing, this route is considerably longer than the other routes, and would have a complicated pull due to the high numbers of bends which would be required. In addition, the approach to Penrose along Gavin Street is heavily congested with existing services and utilities, and as such offers no real incentive when compared with the McNab Street approach. Lastly, when compared with Route A, this route has considerably more land owners who would be affected by the works, and which could affect the consenting process.

3.3.1. Existing Underground Services

For all routes, underground services plans along public roads were obtained from the following service providers:

- Chorus (Telecom)

- Vector Power
- Vector Gas
- Vector Communications
- Watercare
- Auckland City Council (incl. Metrowater)
- TelstraClear
- Nova Energy
- KiwiRail
- Transpower
- Auckland Motorway Alliance (maintenance contractor for NZTA)

KiwiRail also provided drawings for the proposed electrification project between Southdown and Penrose. This information shows which railway track will be electrified and gantry foundation locations. The electrification gantries are 3 to 4 metres away from the track centreline.

Transpower provided advice regarding their overhead and underground services outside of Penrose Substation, but no details of services inside the substation property.

After reviewing the services SKM were of the view that the most unencumbered route was along the existing railway corridor (blue route in Figure 3), provided KiwiRail gave permission and the conditions were not significant.

3.4. KiwiRail Conditions

MRP had discussions with KiwiRail, who were supportive of the proposed Southdown cable project and indicated the following specific conditions:

- The cables must be ducted along the corridor and would require more than nominal cover to ensure future cross track service can be easily laid above them.
- The nearest edge of the cable trench must be 5 metres from the track centre line.
- The cable route would need to cross under the tracks at least three times between Southdown and Penrose. The cables should be ducted and the cover to the top of the duct shall be a minimum of 1,500mm.
- Construction could be undertaken under Level B protection when excavations are 5 metres from the track centre line and would involve temporary fencing and could be undertaken during normal working hours. However, for under track crossings and work within the 5 metre perimeter a weekend line closure would be required and bus replacement services would be required.

- The cable route would require MRP to enter into a Deed of Grant with NZRC and there would be an associated lease cost for access.

Appendix G contains relevant KiwiRail correspondence.

3.5. Final Route Selection

As a result of the information reviewed/available Route A (blue line), along the North Island Main Trunk Railway (NIMTR), was selected as the preferred option and deemed to constitute a credible route based on the following facts:

- It constituted the most direct available option.
- The majority of the proposed corridor contains relatively few existing services to navigate around.
- KiwiRail has indicated their conditional agreement.
- The collocation of the cables and the railway corridor would likely meet approval with the Auckland City Council and likely present less opposition during consenting.
- The installation of cable ducts underneath the North Shore Busway is an existing equivalent example which demonstrates the possible collocation of transportation and power transmission routes.
- In the event that Route A is not possible, then, the less preferable, Route B (red route) along the road should be achievable. Furthermore the installation costs are not likely to be significantly different given that (i) the route lengths are relatively similar and (ii) the final SH1 crossing is identical for both Route A and Route B.

4. Basis of Design

4.1. Powerflow Calculations

SKM undertook an investigative review of the power flow expected subsequent to the connection of proposed Southdown to Penrose 220kV cable. The prime objective being to confirm (i) the proposed connection does not have any fatal flaws, (ii) satisfactory network voltages and (iii) determine the network losses at system peak. The model used was sourced from the Electricity Commission[4]. A DIgSILENT diagram of the proposed connection, which outlines the expected peak powerflow results, is illustrated in Figure 4 which shows the following:

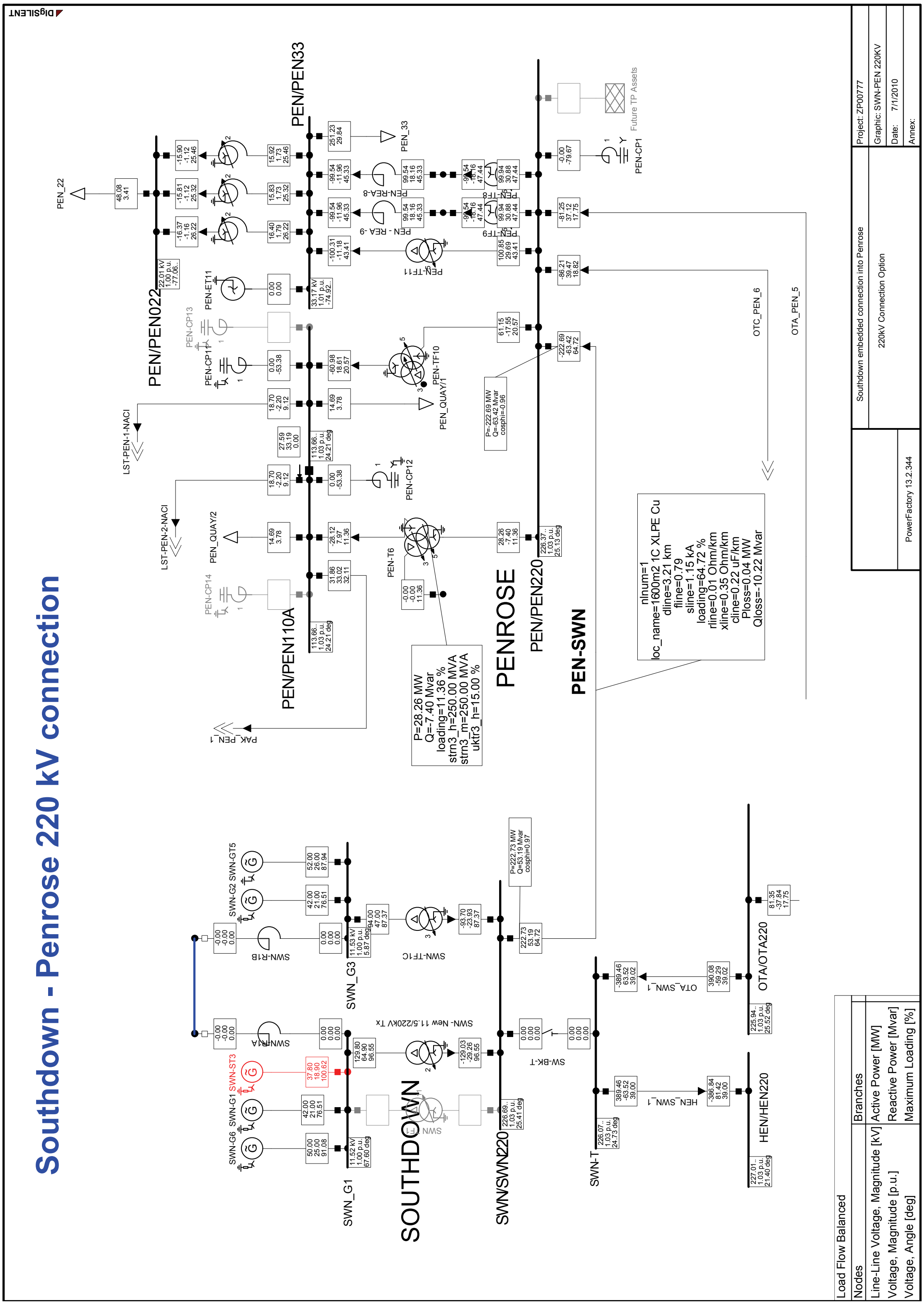
- The addition of a future 50MW generator (G6) connecting to the same 11.5kV bus as G1. G6 has been assumed to have a capacity or 55.9MVA, 0.9 power factor.
- The existing 100MVA, 11.5/220kV generator transformer has been upgraded to a 150MVA 11.5/220kV transformer to cater for the additional generator. The new generator transformer has been assumed to be YNd11, OLTC with an impedance of 22.8% similar to that of the existing generator transformers at Southdown.
- Typical 220kV cable parameters
- Acceptable network voltages at both Penrose and Southdown.

SKM has used the model to determine the peak network losses for (i) the existing and future Southdown power station capacities and (ii) the existing OTA-HEN line connection and the proposed direct cable connection to Penrose. The results of SKM's calculations are outlined in Table 2 which shows that the resistive loss reductions, at system peak, are predicted to be approximately 0.13MW, for both the existing and expanded Southdown Station.

- **Table 2 North Island Network Losses: Peak Loading Conditions**

Southdown Capacity	Network Losses					
	Existing OTA-HEN OHL Connection		Proposed PEN Cable Connection		Difference	
	MW	MVAr	MW	MVAr	MW	MVAr
175MW	126.21	403.50	126.08	395.06	-0.13	-8.44
225MW	124.72	410.68	124.59	403.38	-0.13	-7.3

[4] Year 2010 Peak Loading Case, Centralised Data Set (CDS), Electricity Commission, dated April 2010.



■ **Figure 4 – Load flow model for the proposed Southdown - Penrose 220kV connection**

SKM

4.2. Fault Level Calculations

SKM has also used the model outlined in Section 4.1 to estimate the likely future network fault levels. As expected the investigations indicate that the proposed 220kV cable connection at Penrose will change the 220kV three phase fault levels at both Southdown and Penrose substations.

Table 3 summarises the fault calculation results for the existing Southdown power station (capacity of 175MW) with (i) the HEN-OTA 220kV connection and (ii) the proposed PEN-SWN 220kV cable connection. It shows that the proposed 220kV cable connection to Penrose will result in the following:

- The Penrose 220kV fault levels increasing from the existing 17.0kA to 17.6kA.
- The Penrose 110kV fault levels marginally increasing from 25.2kA to 25.5kA.
- The Penrose 33kV fault levels marginally increasing from 24.1kA to 24.2kA.
- The 220kV fault level at Southdown decreasing from the existing 17.6kA to 15.8kA. This decrease is primarily due to the fact that subsequent to connection to Penrose the Southdown station becomes more electrically distant from Otahuhu, which has significant generation and contributes a significant amount of the fault current at Southdown.

Table 3 Penrose and Southdown Subs: 3-phase fault levels: Existing Generation

Substation	HEN-OTA Connection		PEN-SWN 220kV Connection		
	Electricity Commission[5] (kA)	Complete Method[6] (kA)	Complete Method[6] (kA)	IEC method[6] Pre-fault bus voltage of 1pu	IEC method[6] Pre-fault 1.1pu bus voltage
PEN 220kV	16.5	17.03	17.63	17.09	18.79
PEN 110kV	23.2	25.19	25.48	24.26	26.69
PEN 33kV	24.6	24.05	24.24	24.33	26.76
PEN 22kV	-	17.59	17.67	17.61	19.37
SWN 220kV	17.3	17.57	15.76	15.18	16.70
SWN 11.5kV bus G1	-	64.21	64.31	55.67	61.23
SWN 11.5kV bus G3	-	59.67	59.63	53.56	58.91

Table 4 summarises the fault calculation results for the existing and new Southdown power station generation (prospective capacity of 225MW) with (i) the HEN-OTA 220kV line connection and

[5] Based on Electricity Commissions CDS fault level data sheets. SKM understands these values were calculated using DIgSILENT complete method of fault calculation.

[6] SKM fault calculations using DIgSILENT.

(ii) the proposed PEN-SWN connection. It shows that the proposed 220kV cable connection to Penrose will result in the following:

- The Penrose 220kV fault levels increase from the existing 17.1kA to 17.8kA.
- The Penrose 110kV fault levels marginally increase from 25.3kA to 25.6kA.
- The Penrose 33kV fault levels marginally increase from 24.1kA to 24.3kA.
- The 220kV fault level at Southdown decreases from the existing 17.8kA to 15.9kA. As outlined earlier this is primarily due to the fact that subsequent to connection to Penrose the Southdown station becomes more electrically distant from Otahuhu.

Table 4 Penrose and Southdown Subs: 3-phase fault levels: Prospective Generation

Substation	HEN-OTA Connection	PEN-SWN 220kV Connection		
	Complete method[6] (kA)	Complete method[6] (kA)	IEC method[6] Pre-fault bus voltage of 1pu (kA)	IEC method[6] Pre-fault 1.1pu bus voltage (kA)
PEN 220kV	17.13	17.78	17.23	18.95
PEN 110kV	25.29	25.59	24.37	26.80
PEN 33kV	24.07	24.28	24.37	26.81
PEN 22kV	17.6	17.68	17.62	19.38
SWN 220kV	17.75	15.91	15.32	16.86
SWN 11.5kV bus G1	85.06	84.81	70.72	77.79
SWN 11.5kV bus G3	59.84	59.53	53.58	58.94

Table 5 illustrates the breaker/switchboard/equipment ratings at the Penrose and Southdown substations.

Table 5 Penrose and Southdown Subs: Equipment Ratings

Busbar	Existing Breaker rating (kA)	Maximum Design Fault Levels to be assumed (kA)[7]
PEN 220 kV	40	-
PEN 110 kV	31.5 and 40	26.3
PEN 33 kV	40, 31.5, 26.3 and 26.2	26.3
PEN 22 kV	25	-
SWN 220 kV	40	-

[7] Vector have indicated that the 110kV and 33kV systems at Penrose are designed to meet these levels. (Discussions with Tim Chatterton).

SKM have then proceeded to determine the sensitivity of the 110kV and 33kV busbar fault levels when the 220kV fault levels are increased, the objective being to determine the extent to which the 220kV fault level can increase before equipment ratings are exceeded, and also consider the possible effects of the proposed Pakuranga-Penrose 220kV cable connection.

Table 6 illustrates the following fault level calculations:

Case A: The connection of Southdown to Penrose with the proposed increase in generation capacity (as per that outlined in Table 4).

Case B: Identical to Case A except with the injection of an additional 22kA of fault current. This shows the fault ratings of the 110kV and 33kV equipment will be exceeded.

Case C: Identical to Case A except with the injection of an additional 11kA of fault current. This shows the 110kV fault levels are equal to the fault rating the 110kV equipment.

Case D: Identical to Case A except with (i) the upgrade of T10 (110/220kV, 250MVA interconnector) and (ii) the injection of an additional 13kA of fault current. This shows that the 110kV and 33kV fault levels are within equipment fault ratings.

- **Table 6 Fault Level Sensitivity Review: PEN-SWN 220kV Connection: Prospective Southdown Generation**

Busbar	Existing Breaker/Equipment rating (kA)	Three-phase fault levels (kA): Complete Method[6]			
		Case A	Case B	Case C	Case D
		Existing Penrose substation and associated grid assets	Existing plus additional 22kA	Existing plus additional 11kA	Existing plus 110/220kV Tx Upgrade & additional 13kA
PEN 220kV	40	17.78	40	28.71	30.48
PEN 110kV	26.3	25.59	35.29*	31.5	28.57
PEN 33kV	26.3	24.28	26.95*	26.02	26.2
PEN 22kV	25	17.68	18.49	18.22	18.27
SWN 220kV	40	15.91	30.58	23.7	24.85

*Fault level exceeds equipment capability

Given the above analysis and the information currently available SKM has concluded the following in the relation to the proposed Southdown-Penrose 220kV cable connection:

- On balance the changes in network fault levels are relatively small.
- The 220kV and 110kV equipment ratings at the Penrose substation will be well within the marginal fault level increases outlined in Table 3 and Table 4.
- The 220kV equipment ratings at the Southdown substation are well within the fault levels outlined in Table 3 and Table 4.
- The 33kV equipment ratings at Penrose are close to the fault levels outlined in Table 3 and Table 4. However, this is an existing issue faced by Vector/Transpower and SKM's calculations predict that the fault levels on the 33kV network, due to the 220kV cable connection to Penrose, would increase fault levels by only 200Amps (an increase of approximately 0.8%). This small increase is due to the high impedance of the existing 220/33kV supply transformers and associated reactors, which are significant in comparison to the proposed 220kV line/cable impedance.
- The fault level on the Penrose 220kV busbar needs to increase by 11kA before the fault rating of the 110kV equipment is exceeded. SKM expects that the fault contribution of the proposed Pakuranga-Penrose 220kV cable connection will be less than this.

5. Penrose Connection Details

It is envisaged that a new 220 kV bay– Bay 792 will be established. Access to this bay is partially inhibited by the existing incoming connection for the OTA 5 220kV circuit. However, it is anticipated that the OTA 5 connection could be modified to make the unused bay more accessible. For the purposes of costing the works involved in establishing a new 220 kV cable feeder to Southdown, it has been assumed that:

a) Bay 792 can be used by MRP.
b) Modification to the Bus Zone Protection & CB Trip at Penrose will be required.
c) Modification to the SCADA at Penrose will be required.
d) Dual protection of the proposed 220 kV cable will be required
e) Surge arrestors will not be required, as existing substation will have adequate lightning protection. This will be confirmed at detailed design stage.
f) Outages on the Penrose 220kV busbar B will be accommodated.

5.1. Primary Plant

All equipment will be rated at a minimum of 2500 A, with a 3 second fault current rating of 40 kA. All equipment shall have a creepage of 25mm/kV. Creepage should be confirmed at the detailed design phase

5.1.1. 220 kV Rigid Bus

Connection to the existing 220kV Rigid bus at Penrose will be required opposite Bay 782 (refer to the hand marked-up drawing TX25607/1 in Appendix C).

An appropriate outage will be required to connect to the 220kV busbar (for a short duration), but no major issues are anticipated. A full assessment of the required outage should be made at the detailed design phase.

5.1.2. 220 kV Flexible Connections between Equipment

Flexible connections should be sized to accommodate the equipment rating of 2500 A. Note this exceeds the requirements for the Southdown connection (≈650Amps), but it is considered good practice for the connections to match the capability of the existing equipment. These connections can be made up of single and twin Cicada arrangements.

SKM

5.1.3. 220 kV Post Insulators

It is proposed that standard solid-core post insulators be used for the 220 kV bus supports, along with composite 220 kV tension insulators for the overhead strung bus.

5.1.4. 220 kV Outdoor Circuit Breakers

3-phase 2500A outdoor circuit breakers will be required. These will be live tank design.

Transpower standard 245 kV circuit breakers as specified in TP.PS 13.01 with 40 kA/3s rated short circuit breaking current and 1.3 first pole to clear factor will be suitable for this installation.

5.1.5. 220 kV Disconnectors

A single 3-phase 2500 A disconnector will be required for busbar selection and a single 3-phase 2500 A disconnector with one earthing switch will be required for 220 kV cable isolation and earthing.

It is proposed to use horizontal break, centre-rotate disconnectors for all disconnectors. Each disconnector will require an operator earth mat designed and installed in accordance with TP.DS 52.01.

All disconnectors shall be motorised

5.1.6. 220 kV Earth Switches

220 kV earthing switches, if required, will be mounted on disconnectors. These earthing switches should be rated to 40 kA/3 sec short time current. All earth switches shall be manual operation only.

5.1.7. 220 kV Capacitor Voltage Transformers

220 kV Capacitor Voltage Transformers will be required. Transpower standard 220 kV CVT as per TP.PS 23.01 will apply.

5.1.8. 220 kV Current Transformers

A 3-phase set of 2500 A, 40kA/3s current transformers will be required. Transpower, 5-core CT with a multi-ratio of 2400/1600/1000/400:1, could be used. The indication core on these CT shall be dual class as specified in TP.PS.22.01.

5.1.9. 220 kV Cable Sealing End Terminations

Refer to section 7 of this report.

5.2. Earthing

SKM has not undertaken a detailed earthing investigation to identify EPR, touch/step voltages and transferred potential issues.

However, as outlined in Section 4.2, subsequent to the cable connection, the network fault levels are predicted to only marginally change, with the fault levels at the Penrose station marginally increasing.

A detailed review of the earthing systems at Penrose would be required but given that it is an operational substation SKM has assumed that it presently complies with relevant standards (i.e. Transpower Standards, AS/NZS 3835.1, IEEE80 and EEA Guide to Risk Based Earthing System Design).

5.3. Protection & Control

Extensions will be required to the existing busbar protection and CB fail protection schemes.

Circuit Protection will take the form of a feeder management relay providing back-up protection, and two forms of Main protection.

The main protection schemes will need to be finalised at detail design phase, but current expectations are that each main protection scheme should have a different operating principle. With this in mind, it is anticipated that one will be a Line Differential protection and the other will be a Distance Protection operating a blocking scheme. The use of a distance protection scheme requires the inclusion of line CVT units. Both these schemes will require protection signalling. Fibres will be installed as part of the HV cable installation, for this purpose. A marked up version of TX38926/3, in Appendix C shows the proposed R&I diagram for the new circuit.

SCADA systems will need to be extended to accommodate the new extension. It is anticipated that Transpower will control equipment up to and including the circuit breaker, and may require status and indications from other equipment. Similarly, MRP will require an element of control and/or status indications. However, the final details concerning the control of the bay and associated interfaces will be finalised during the detailed design phase.

5.4. Acoustics/Noise

Increased levels of noise will not be an issue given that the terminal equipment is located in an existing substation and the equipment to be installed will not increase noise levels above those that presently exist.

SKM

6. Southdown Connection Details

It is envisaged that one of the two existing 220 kV bays at Southdown will be used for the cable connection. For purposes of costing, the works involved in reconfiguring the Henderson – Otahuhu 220 kV connection (i.e. removing the existing 220kV Southdown tee) and establishing a new cable feeder, it has been assumed that:

a) Transpower owned equipment will be replaced. SKM notes that it should be feasible for MRP to purchase the existing equipment from Transpower rather than requesting that the equipment be removed, and some cost benefits could be achieved from this. However, costing this section of the scheme based upon replacement equipment provides a conservative assessment.

b) The cost of the foundations has been included in the costing. Again these already exist and should not result in any cost to MRP, however the inclusion of new foundations for project costing purposes, provides a conservative assessment.

c) Modification to the busbar protection & SCADA at Southdown will be required.

d) Unit protection of the proposed 220 kV cable will be required.

e) Surge arrestors will not be required, as the existing substation will have adequate lightning protection. This will be confirmed at detailed design stage.

f) CVT's will be required.

g) Power Station outages will be accommodated.

6.1. Primary Plant

All equipment will be rated at 2500A, with a 3 second fault current rating of 40 kA. All equipment shall have a creepage of 25mm/kV. Creepage should be confirmed at the detailed design phase

6.1.1. 220 kV Rigid Bus

The existing 220kV Rigid bus at Southdown will be maintained.

Appropriate outages will be required to the Power Station for the duration of the works, should existing equipment need to be replaced.

In the likely event that arrangement is made with Transpower to retain existing equipment outages should be able to be minimised during the construction period.

A full assessment of the required outages should be made at the detailed design phase.

6.1.2. 220 kV Flexible Connections between Equipment

Flexible connections should be sized to accommodate the equipment rating of 2500 A. Note this exceeds the requirements for the Southdown connection, but it is considered good practice for the connections to match the capability of the equipment. These connections can be made up of single and twin Cicada arrangements.

6.1.3. 220 kV Post Insulators

It is proposed that standard solid-core post insulators be used for the 220 kV bus supports.

6.1.4. 220 kV Outdoor Circuit Breakers

Three 3-phase 2500 A outdoor circuit breakers will be required. These will be live tank design. Transpower standard 245 kV circuit breakers as specified in TP.PS 13.01 with 40 kA/3s rated short circuit breaking current and 1.3 first pole to clear factor will be suitable for this installation.

6.1.5. 220 kV Disconnectors

Three phase 2500 A disconnectors will be required for busbar selection and a 3-phase, 2500A, disconnector with one earthing switch will be required for 220 kV cable isolation and earthing.
It is proposed to use horizontal break, centre-rotate disconnectors for all disconnectors. Each disconnector will require an operator earth mat designed and installed in accordance with TP.DS 52.01. All disconnectors shall be motorised.

6.1.6. 220 kV Earth Switches

220 kV earthing switches, where required, will be mounted on disconnectors. These earthing switches should be rated to 40 kA/3 sec short time current. All earth switches shall be manual operation only.

6.1.7. 220 kV Capacitor Voltage Transformers

220 kV Capacitor Voltage Transformers will be required. Transpower standard 220 kV CVT as per TP.PS 23.01 will apply.

6.1.8. 220 kV Current Transformers

A 3-phase set of 2500 A, 40kA/3s current transformers will be required. Transpower standard, 5-core CT with a multi-ratio of 2400/1600/1000/400:1, could be used. The indication core on these CT shall be dual class as specified in TP.PS.22.01.

6.1.9. 220 kV Cable Sealing End Terminations

Refer to section 7 of this report.

6.2. Earthing

SKM has not undertaken a detailed earthing investigation to identify EPR, touch/step voltages and transferred potential issues.

However, as outlined in Section 4.2, subsequent to the cable connection, the network fault levels are predicted to only marginally change, with the fault levels at the Southdown station marginally decreasing.

A detailed review of the earthing systems at Southdown would be required but given that it is an operational substation SKM has assumed that it presently complies with relevant standards (i.e. Transpower Standards, AS/NZS 3835.1, IEEE80 and EEA Guide to Risk Based Earthing System Design).

6.3. Protection & Control

As it is unknown whether the existing equipment will be transferred to MRP, SKM have assumed new protection and control schemes will be required, which is in keeping with the conservative approach taken to the costing exercise.

New busbar protection and CB fail protection schemes will be required.

Circuit Protection will take the form of a feeder management relay providing back-up protection, and two forms of Main protection.

The main protection schemes will need to be finalised at detail design phase, but current expectations are that each main protection scheme should have a different operating principle. With this in mind, it is anticipated that one will be a Line Differential protection and the other will be a Distance Protection operating a blocking scheme. The use of a distance protection scheme requires the inclusion of line CVT units. Both these schemes will require protection signalling. Fibres will be installed as part of the HV cable installation, for this purpose. A marked up version of TX35516, in Appendix C shows the proposed R&I diagram for the new circuit.

A new SCADA system will be required for the site. It may be possible to extend the Power Station control system to cover the substation, but this can be determined at the detailed design phase. It is anticipated that Transpower will require status and indications from certain equipment. However, the final details concerning the control of the substation and associated interfaces will be finalised during the detailed design phase.

6.4. Revenue Metering

The existing revenue metering scheme, including the bushing mounted metering CT's, will be retained and located at Southdown. The Meter settings will be modified to take account of the new cable connection.

6.5. Acoustics/Noise

Increased levels of noise will not be an issue that the terminal equipment is located in an existing substation and the equipment to be installed will not increase noise levels above those that presently exist.

6.6. Reconnection of the HEN-OTA Overhead Line Circuit

It is recommended that the OTA-HEN line currently turned into Southdown substation, has its jumpers restored, in order to bypass the site, and any necessary protection/comms modifications are undertaken by Transpower at Henderson and Otahuhu substations. The cost associated with this work is excluded from the scope of this report.

7. 220kV Cable Details

The following sections outline the details associated with the installation of a single circuit 220kV cable along a route that is substantially within the rail corridor (blue route in Figure 3).

7.1. Cable System

The cable system proposed will consist of Outdoor Cable Terminations at each substation, dropping into a 1.5m wide concrete cable trench within the substation fence line in trefoil arrangement to ease identification/location. On leaving the substations, the cables will migrate into a direct buried duct system. This shows a typical trefoil arrangement, however cable/duct spacings will need to be confirmed by the cable designer at detailed design stage of the works. In addition, a new micro-tunnel is proposed between Great South Road and the perimeter of Penrose substation, underneath all existing utilities and services. Refer to drawings in Appendix E for details.

The cables will be cross bonded, and a draft design for this can be seen on drawing ZP00777-002 in Appendix D.

Due to the length of the route, three jointing bays will be required. A typical arrangement, based on a Transpower design can be found in drawing ZP00777 - 003 in Appendix D.

During the cable duct installation, independent ducts will be installed for fibre optic protection signalling cables and ECC cable, for the single point bonded section.

It is proposed that a DTS system be installed as part of the installation, in order to monitor for cable hotspots. The DTS will be located in the Southdown Relay Room.

In addition equipment will be installed to accommodate future PD monitoring. Due to the ongoing costs of such monitoring (engaging a sub-contractor to take and analyse results etc), a full system is not recommended to be installed at this stage, however, the fibres/sensors will be installed to ease implementation at a later stage should MRP wish.

All cable installation drawings are typical examples. It is recommended that a full study and design is carried out by the HV Cable supplier and that this design includes the following studies, as a minimum, to ensure the suitability of the design:

- Cable Rating Study.
- Induced Voltage Study.
- Sheath Bonding Study.
- Magnetic Field Study.
- Thermo-mechanical Study.

SKM

7.1.1. Cable selection

SKM selected a 1600 mm^2 Cu cable (3x1-core in trefoil in ducts and/or direct buried) to cater for the expected load of 250 MVA. The cable sizing choice is conservative given that the thermal constraints/conditions along the cable route have not been investigated in detail.

It is estimated that the total route length of 220kV cable required will be ≈3 km and that three joint bays will be required (typical drum lengths indicated to be 913m) with cable terminations required at Southdown and Penrose substations.

Table 7 outlines the major cable details/parameters, and fuller details can be found in the Olex quotation in Appendix D.

- **Table 7 - 220kV Southdown- Penrose cable parameters**

Parameter	Value	Unit
Route Length	3.2	km
Voltage	220	kV
Conductor material	Copper	
Conductor Area	1600	mm^2
No of cores	1	Per phase
Insulation	XLPE	
Current capacity in air	1652	Amps
Current capacity in ground	1214	Amps
Laying arrangement	Trefoil	
Max short circuit current of the metallic sheath	40	kAmps for 1 second
Bending radius:		
Pulling	3.3	m
Set	2.0	m

7.1.2. Extra Low Frequency (ELF) Fields

ELF field thresholds are prescribed by the National Radiation Laboratory as follows:

- **Table 7 – ELF Field Thresholds**

Exposure characteristics	Basic restriction	Reference Levels		
	Induced current density	Electric field strength	Magnetic flux density	
	(mA/m^2)	(kV/m)	(microtesla)	(Milligauss)
Occupational	10	10	500	5000
General public	2	5	100	1000

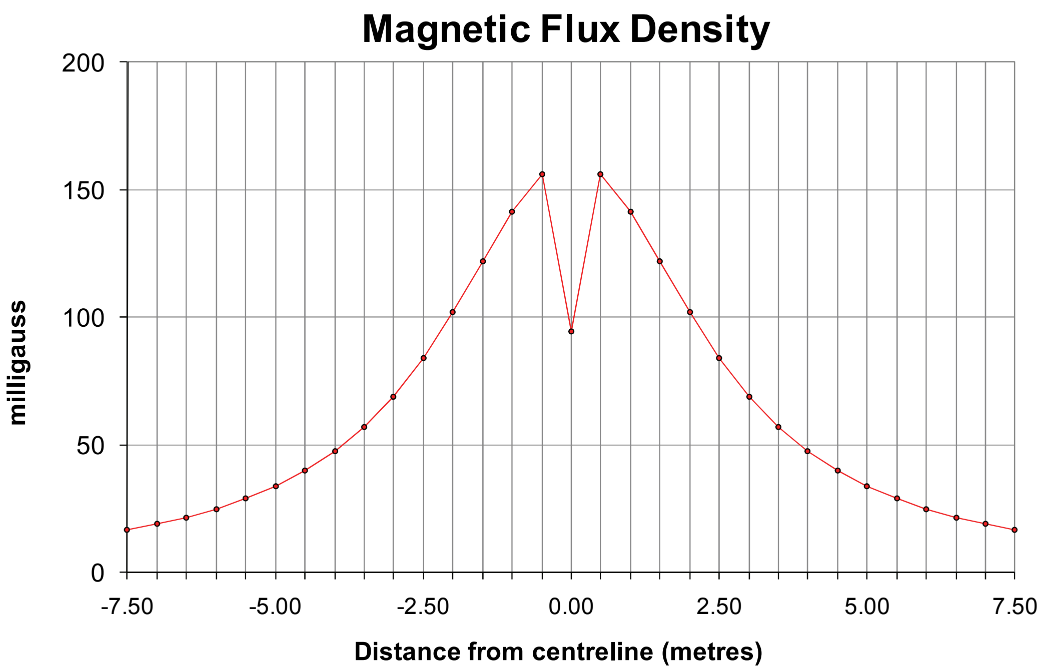
Source: http://www.nrl.moh.govt.nz/publications/emfbooklet.pdf

There will be no electrical fields associated with the proposed 220kV cable.

Figure 5 outlines a prediction of the magnetic fields at a location one metre above ground and at a location of up to 7.5metres away from the cable. The calculation is conservative in that it assumes a flat laid cable configuration at a depth of 1.5 metres below the surface with individual phases 0.5 metres apart and carrying a current of 650amps. SKM has chosen this configuration on the basis that the cables are expected to be laid in this configuration at some locations along the route (i.e. joint bays) and this configuration is expected to deliver the highest levels of magnetic field of approximately 150 milligauss.

Given the above, SKM believes that there will no issues associated with consenting the proposed 220kV cable. We also note that:

- It is likely that passive loop shielding would be employed above joint bays. This involves the use of a series of conductive loops that are place above the 220kV cable joints (in the ground) and passively oppose, hence reduce, the cable's magnetic fields.
- It would not be unusual for a 33kV cable to carry a current of 650amps and there are many of these cables in service in Auckland, some of which are buried along roads and footpaths.



- **Figure 5 Predicted magnetic flux density 1metre above ground**

7.1.3. Earthing

An investigation of the EPR and touch/step voltages associated with the 220kV cable would be required. However, as SKM's experience is that the majority of fault current associated with a cable will flow along the cable sheath and/or screen (as opposed to the ground). Accordingly the EPR and touch/step voltages with a cable can be managed relatively easily using standard cable designs that include earthing systems at locations where the cables are cross bonded. These issues will be dealt with during the detailed design stage.

7.1.4. Interference Due to the Underground 220kV Cable

Railways sharing a right-of-way with power circuits may be subject to electric or magnetic field coupling. The principal coupling mechanisms are:

Conductive: Conductive coupling due to currents flowing in the soil is of particular concern at locations where railways are close to overhead power line structures, which may inject large amount of currents into the soil during power line fault conditions. Such structures include power line towers and substation grounding systems. This coupling can result in touch and step voltages, especially when the ballast (usually crushed rock) is dry. This is because the soil potential rises due to the injected current. Railways located near the faulted structure, however, will remain at a relatively low potential since the dry ballast has a high resistance and offers poor grounding. The magnitude of the conductive coupling is strongly influenced by the soil structure. It decreases with increasing distance away from the faulted structure, but the rate of decrease depends upon the soil structure. Earth-fault currents on overhead lines tend to result in significantly more conductive coupling due to the higher levels of fault current that follow an earth return path to local substations.

Inductive: Railway tracks and circuits can exhibit mutual inductive coupling with parallel power circuits due to the long length of exposure. This level of interference increases with decreasing separation and angle between the railways and the power lines/cables, with increasing soil resistivity, as well as with increasing current magnitude and frequency in the power lines. It can result in rail-to-earth and rail-to-rail voltages, which represent a possible direct electrical shock hazard and can jeopardize the proper operation of the signal and protection system of the railway systems.

Capacitive: The capacitive coupling results from the electric gradient established between energized conductors and poorly grounded parallel metallic paths, which can include above ground pipelines and railways. If a metallic path, such as a pipeline, is buried, the capacitive coupling is negligible. The capacitive coupling associated with an underground cable would be zero.

In the case of the proposed 220kV cable circuit there would be no conductive coupling during normal operation (i.e. no leakage current). During 220kV cable faults a significant portion of the fault current would take a path along the 220kV cable screens back to the Penrose or Southdown sub-stations.

The three cable phases of the proposed 220kV cable circuit would be physically laid in close proximity to one another and there would be significant magnetic field cancelling. The cables would also be located at least five metres from the rails and would only be parallel with the rails for a relatively short distance of 2.5kms. As a result SKM expects that the inductive coupling on the railway line will be minimal for both normal operation and during fault conditions.

There would be no capacitive coupling associated with the proposed 220kV cable circuit.

Having said the above, SKM is of the view that an interference study would be mandatory, and would be carried out during the detailed design phase. This type of study is typically done using a software tool, for example, like CDEGS (http://www.sestech.com/), and given the health and safety issues, it would be usual to verify the work via an independent calculation.

Whilst SKM expects that the outcome of the study will establish that there are no significant issues SKM has made a small cost allowance for the study and to provide mitigation against interference during the detailed design stage of the project. Typical mitigation issues would include the inclusion of additional earth rods/conductors that are connected to the railway lines.

7.2. Civil works Associated with Cable Installation

All the following sections relate to the selected route along the railway easement. For route details, refer to drawings in Appendix E.

7.2.1. Geotechnical Information

No geotechnical investigations have been undertaken for this report. Previously, consultants from Tonkin and Taylor assessed the ground conditions in the project area, based on geological maps and their knowledge of the local soils. This desktop study identified the following groups of soils.

- **Table 8 – Summary of Desktop Geotechnical Study**

Soil Type	Distribution along cable route	Description
BASALT	50%	Very hard, very strong, massive vesicular to non-vesicular grey to black volcanic rock usually divided by rough sub-vertical fractures spaced at 0.2-1.0m intervals, and form blocks with similar dimensions
RUBBLE	25%	Hard to very hard, very strong, highly vesicular to non-vesicular grey to black boulder to gravel sized basalt with

		minor silt and sand. Includes fill consisting of similar material but included debris. Basalt rock is expected to closely underlie the rubble in most cases.
SOILS	25%	Stiff to very stiff silts and clays with occasional minor gravel. Includes fine grained fill. Incorporated tuff, Tauranga Group sediments and residual East Coast Bays Formation soils

Tonkin and Taylor advised that basalt rock can be expected at shallow depth throughout much of the project area. Due to the nature of basaltic flows, the surface geology along the route is highly variable; any estimates of distribution are approximate only. A geotechnical investigation of the route is the only way to confidently determine the soils within the project area. Costs associated with this investigation have been included in the cost estimate.

7.2.2. Trenching Constraints

Construction activities within the rail corridor will be subject to Kiwirail requirements. These include Type B protection along the trench, consisting of solid barriers that prevent the digger arm from swinging into the path of oncoming trains.

Access along the rail corridor to undertake the trenching operation, dispose of excavated soil and deliver the thermal surround is likely to be restricted at certain places along the route. Truck movements may be suspended at times and co-ordination with railway services will be required. Construction progress is likely to be slow within the restricted areas of operation.

The cable route along the rail corridor includes sections where buildings on adjacent properties are built on the boundary. It is assumed that the cable trench can be excavated without affecting the building foundations. This is likely to involve having short lengths of trench open over these sections of the route. The exact nature of building foundations will require research as part of the detailed design phase.

7.2.3. Railway Crossings

Three circuit crossings of the railway tracks will be required, one adjacent to the Southdown power station and two in the vicinity of the Penrose railway station. These will be undertaken by trenchless construction methods. KiwiRail will require the contractor to take possession of the railway tracks during these operations, suspend rail operations in the area and provide an alternative transport service for disrupted public transport.

The construction of this element of the work will not be permitted while KiwiRail has also shut the Eastern line through Panmure, so that freight services in and out of Auckland can be maintained. KiwiRail have advised that possession of the rail tracks would not be possible during the 2010 and 2011 Christmas periods, when works are programmed for the NIMTR line through Panmure.

The costs associated with closing the railway and providing bus services to replace rail passenger services have not been assessed. Any special track protection required by KiwiRail during this period, such as having KiwiRail staff on site, control of signals and switches and liaison with the urban rail operator, have also not been assessed.

7.2.4. Great South Rd and Southern Motorway Crossing

Crossing Great South Rd at McNab St will require the construction of a tunnel, as will State Highway 1 (SH1). The likely presence of basalt will require a micro-tunnel operation, rather than directional drilling.

Trenching along McNab St is considered to be significantly constrained by the congestion of existing underground services. Potholing and detailed route planning would be required, and it is likely that the only possible way to open trench along McNab St is to relocate other services to make room for the proposed power circuit. There is also doubt about whether enough room could be cleared to excavate receiving and drilling pits in McNab St.

In view of this, the option to construct two short tunnels has been adopted for the purpose of this study, which effectively bypasses the congestion in McNab St. The first tunnel is from the railway, under Great South Road, to private property on the north side of McNab St. This involves a tunnel length of approximately 60m. The circuit would then the laid in an open trench along the frontage of the McNab St properties up until the existing Vector substation. A second tunnel, approximately 110m long, would be constructed under State Highway 1 to the Penrose substation. Discussions with Harker Underground Construction Ltd, identified two options

1. 600mm diameter steel-lined tunnels. Installation equipment would have to be brought into the country to construct this.
2. 1800mm diameter concrete-lined tunnels. The size is dependent on the equipment the contractor has available to install a concrete lining.

SKM are not in favour of steel lined tunnels because of the potential of corrosion of the steel casings, which is likely to be promoted by the presence of the power cables inducing currents along the tunnel. SKM could see that there is no possibility of guaranteeing the integrity of any pipe protection (i.e. wrapping) when is it installed by trenchless construction and there is a high likelihood groundwater will be present from McNab St soakholes. Overall, there are too many uncertainties in the long-term performance of steel lined tunnels. Hence the proposal for the concrete-lined tunnels was adopted. Harker Underground have confirmed they have the machinery and personnel to construct the two tunnels concurrently to meet the project programme.

Whilst 1800mm diameter tunnels are larger than required to carry a single 220kV circuit, there may be future interest in sharing the tunnel from Vector and/or other parties with whom a cost sharing, or lease, agreement could be negotiated.

The basalt flows in the area are known to vary from 10-35m thick. A possible alternative would be to construct a tunnel at a depth below the basalt, which may cost less than a single tunnel through the basalt. This option will be more expensive than the two short tunnels and its feasibility will only become apparent following the results of part of the geotechnical investigation, which will involve drilling of boreholes along the tunnel route. Therefore, the cost estimate prescribed in this study includes the full cost for two short tunnels. This provides the most reliable and feasible option for the project.

7.2.5. Watercare Services Watermains

Watercare Services have two bulk water supply mains running along Church St East that would need to be crossed. These are the Hunua No1 watermain (700mm dia) and the Hunua No 3 watermain (1700mm dia).

The size of these watermains would require the 220kV cable path to be lowered to around 3.5m depth, requiring significant excavation and trenchless construction of a duct underneath the Watercare watermains. Consideration of installing the cables at this depth would have to be undertaken at detailed design stage to ensure no impact on current rating.

7.2.6. ARTA Fibre Optic Cable

The ARTA fibre optic cable inside the rail corridor will need to be crossed at several locations. Fibre optic cables are not sensitive to vibration, for example from normal trenching operations.

Relocating the cables may be required to make room for the 220kV circuit over a length of approximately 1000m. No discussion has been held with ARTA regarding their requirements for protecting and maintaining the fibre optic cable during construction.

7.2.7. Contaminated Land

The top 600mm of soil within the rail corridor is considered to be potentially contaminated due to railway activities and those of the neighbouring properties, particularly at the Southdown end of the project area. Contaminants can be expected to include hydrocarbons, asbestos, lead and arsenic.

An environmental management plan for the project will be required which details a sampling and testing regime, plus a contingency plan in the case where contaminants are discovered on the site. The management plan will require the approval of the ARC or Auckland Council (super city).

In the case of contaminants being found, a suggested management plan would be to separate gravel sized particles, or smaller, and send them to a licensed landfill for disposal. Rock of cobble size, or larger, (>60mm diameter) may be retained on site and used to backfill the top level of the trench.

A management plan, as suggested above, has been included in the costing.

7.2.8. Comprehensive Survey of Cable Route

A cadastral and topographical survey by a registered surveyor of the proposed circuit route is recommended at the outset of the detailed design phase. This will definitively establish the legal boundaries, the available envelope for the 220kV circuit within the rail corridor and the field location of all underground services.

The current study has gathered information from a range of sources, including CAD drawings, GIS databases and paper records of underground services locations. These have been amalgamated to gain an overall picture of the proposed route, but assembling records in this manner is not a guarantee of where services are actually located.

A site survey involving cadastral, topographical survey, "potholing' selected locations and marking out of underground services is necessary to provide certainty of other services along route. SKM understands that MRP have undertaken and completed a title search to uncover all easements and land grants along the proposed route.

Similarly, the as-built position and depth of the constructed cables and any relocated services should be recorded by a registered surveyor.

8. Network Losses

As outlined in Section 4.1 SKM has estimated that during peak network loading conditions (and maximum Southdown station output) the alternative supply option via connection to Penrose would result in a network loss reduction of 0.13MW. If one assumes that these conditions occur for the entire year (an unlikely scenario) the annual network losses can be calculated as 0.13MW x 8760hours ≈ 1.1GWhr which translates to an annual loss reduction cost of ≈NZ$77k based on NZ$70/MWhr[8].

If one considers that the network loading varies from hour to hour and from season to season it is possible to estimate the network losses based on the use of a classical formulae called the Load Loss Factor (LLF) which is as follows:

$$LLF = a \times LF + b \times LF^2$$

Where: LF = Load Factor which is typically 0.5 for the loads North of the Auckland Isthmus.

Constants a and b are selected based on the load profile but are typically 0.3 and 0.7 respectively.

If one uses the above factor one arrives at an annual cost of losses of:

$$(0.3 \times 0.5 + 0.7 \times 0.5^2) \times 1{,}100 MWhr \times \$70 \approx NZ\$25k$$

Appendix B outlines what is potentially a more accurate estimate (undertaken by MRP) of the expected cost of network losses associated with the existing Southdown station capacity (175MW) as follows:

- Existing OTA-HEN 220kV line connection: $65/annum
- Proposed PEN 220kV cable connection: $9k/annum

This delivers a potential reduction in network losses of $56k/annum resulting from the PEN 220kV cable connection alternative option.

Given the above calculations SKM has concluded that cost savings due to network loss reduction would be of the order of $50k/annum subsequent to the proposed alternative PEN 220kV cable connection. This loss reduction is primarily due to the Southdown generation being electrically closer to off-take loads.

[8] Appendix B outlines MRP's estimate of the average price of energy over the period 2007-2009.

9. EGR Compliance

SKM understands that the Southdown station presently has the following eight EGR dispensations:

1) **ID 2015:** T1 is not equipped with OLTC. SKM understands that this transformer is no longer in service and held as a spare. Both in service transformers, T1A and T1B, are equipped with OLTC.
2) **ID2343**: G1, G2 & G3 (GE-101, GE-102, GE-103) do not comply with EGR frequency capability requirements
3) **ID 2344**: G1, G2 & G3 (GE-101, GE-102, GE-103) do not comply with EGR reactive power export requirements
4) **ID 2345**: G1, G2 & G3 (GE-101, GE-102, GE-103) do not comply with EGR reactive power import requirements
5) **ID 2346**: G1, G2 & G3 (GE-101, GE-102, GE-103) are connected to a step up transformer that does not have sufficient tap range to comply with the EGR requirements
6) **ID 2404**: GE-105 does not comply with EGR frequency capability requirements
7) **ID 2524**: GE-105 does not comply with EGR reactive power export requirements
8) **ID 2525**: GE-105 does not comply with EGR reactive power import requirements

The proposed Penrose connection would not affect items (2) and (6) and these dispensations would need to be rolled over. SKM believes that item (1) could be relinquished (i.e. not necessary).

SKM have re-examined the remaining items consisting of (3)-(5) and (7)-(8) which are dispensations associated with reactive power capability. The key AOPO requirements in relation to reactive power capability are outlined in Figure 6. The results of SKM's investigations are in the paragraphs that follow.

We note that for the investigations SKM has assumed that the Grid Injection Point (GIP) is the 220kV busbar at Penrose.

SKM have reviewed MRP's Southdown ACS information and discussed with MRP the station's maximum active outputs and the generator OEL and UEL settings[9]. As a result SKM/MRP have determined the following maximum active/reactive power generator capabilities:

[9] Note that UEL/OEL settings primarily govern the export/import capabilities of the generators. SKM was supplied a comprehensive document outlining the OEL/UEL settings on GE-105. However, SKM has relied on MRP to supply the reactive power (OEL/UEL) limits for GE-101 through GE-103.

Generator	Active Output (MW)	Reactive Output (MVAr)	
		Export	Import
GE-101	46.00	24.00	-9.00
GE-102	46.00	24.00	-9.00
GE-103	37.80	18.31	-8.40
GE-105	52.00	18.00	-7.00

SKM have then used the above reactive power capabilities, together with a DIgSILENT station model, to review Southdown's compliance with the EGRs subsequent to the proposed Penrose connection.

This review has determined that the station will fall short in terms of reactive export and import for all units/transformers. There is one exception and that relates to the T1A/GE-101/GE-103 combination which marginally exceeds the reactive power export requirements.

The following diagrams demonstrate the station's capability:

Figure 7 This figure illustrates the reactive power capability of the generator/T1A-transformer combination. Export requirements are met but import requirements are not met.

Figure 8 This figure illustrates the reactive power capability of the generator/T1A-transformer combination. Both export and import requirements are not met.

Figure 9 This figure illustrates in tabular form the results presented in Figure 7 and Figure 8.

Figure 10 This figure illustrates the maximum Southdown reactive export capability with the Penrose 220kV busbar operating at 110%. Both T1A & T1B transformers have reached minimum tap and the terminal voltages on the generators have just reached their capability of 12kV.

Figure 11 This figure illustrates the maximum Southdown reactive import capability with the Penrose 220kV busbar operating at 95%. Both T1A & T1B transformers have reached maximum tap and the terminal voltages on the generators have not reached their minimum capability of 11kV.

SKM

3.2 Voltage Support AOPOs

Each **generator** with a **point of connection** to the **grid** will at all times ensure its **assets**:

3.2.1 Exporting net reactive power at full load

When the voltage at its **grid injection point** is within the applicable range of nominal voltage, are capable of exporting (over excited) when **synchronised** and made available for dispatch by the **system operator**, a minimum net **reactive power** which is 50% of the maximum continuous megawatt (**MW**) output power as measured at the **generating unit** terminals as set out below:

Nominal grid voltage (kV)	Voltage range for which reactive power is required			
	Minimum (kV)		Maximum (kV)	
220	198	-10.0%	242	10.0%
110	99	-10.0%	121	10.0%
66	62.7	-5.0%	69.3	5.0%
50	47.5	-5.0%	52.5	5.0%
33	31.35	-5.0%	34.65	5.0%
22	21.45	-2.5%	22.55	2.5%
11	10.725	-2.5%	11.275	2.5%

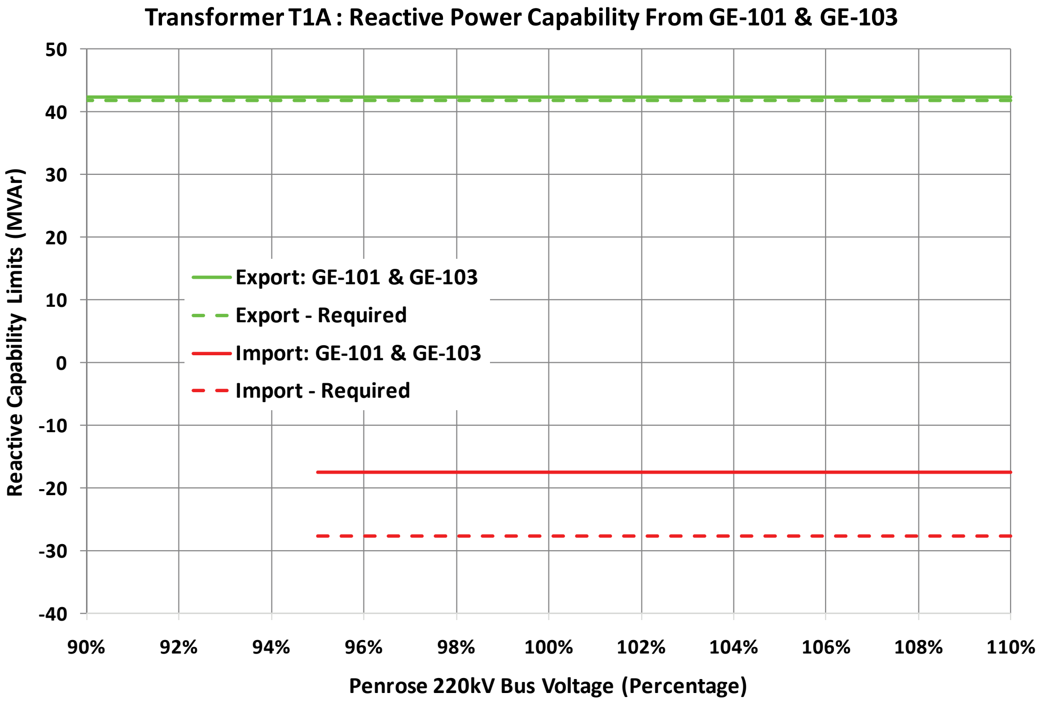
3.2.2 Importing net reactive power at full load

When the voltage at its **grid injection point** is within the applicable range of nominal voltage, are capable of importing (under excited) when synchronised and made available for dispatch by the **system operator**, a minimum net reactive power which is 33% of the maximum continuous megawatt (**MW**) output power as measured at the **generating unit** terminals as set out below:

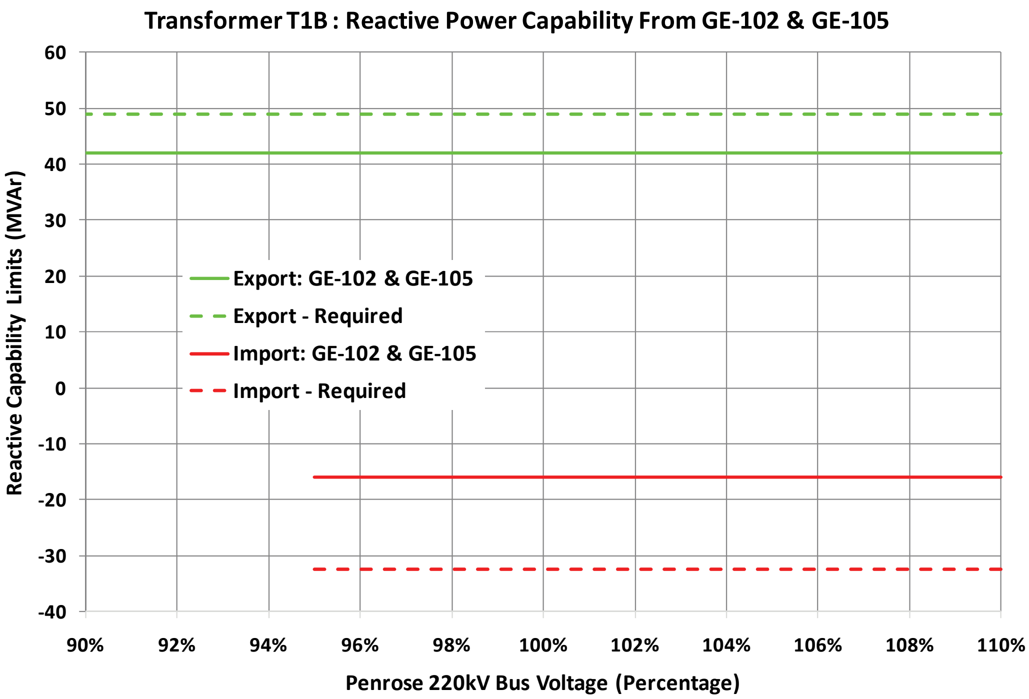
Nominal grid voltage (kV)	Voltage range for which reactive power is required			
	Minimum (kV)		Maximum (kV)	
220	209	-5.0%	242	10.0%
110	104.5	-5.0%	121	10.0%
66	62.7	-5.0%	69.3	5.0%
50	47.5	-5.0%	52.5	5.0%
33	31.35	-5.0%	34.65	5.0%
22	21.45	-2.5%	22.55	2.5%
11	10.725	-2.5%	11.275	2.5%

grid injection point and **GIP** mean any **point of connection** on the **grid** where **electricity** predominantly flows into the **grid**. For clarity, such a **point of connection** may, from time to time, constitute either a **grid injection point** or a **grid exit point**, but not both at the same time

- **Figure 6 EGRs: Part C – Section III Asset Owner Performance Obligations and Technical Standards**



- **Figure 7 VAR Capability: GE-101 & GE-103 Supplying T1A**



- **Figure 8 VAR Capability: GE-102 & GE-105 Supplying T1B**

SKM

T1A

EXPORT

220kV	220kV	GE-101	GE-101	GE-103	GE-103	Export: GE-101 & GE-103		Export -
PEN	PEN	MW	MVAr	MW	MVAr	MW	MVAR	Required
110%	1.10	46.00	24.00	37.80	18.31	83.80	42.31	41.90
109%	1.09	46.00	24.00	37.80	18.31	83.80	42.31	41.90
108%	1.08	46.00	24.00	37.80	18.31	83.80	42.31	41.90
107%	1.07	46.00	24.00	37.80	18.31	83.80	42.31	41.90
106%	1.06	46.00	24.00	37.80	18.31	83.80	42.31	41.90
105%	1.05	46.00	24.00	37.80	18.31	83.80	42.31	41.90
104%	1.04	46.00	24.00	37.80	18.31	83.80	42.31	41.90
103%	1.03	46.00	24.00	37.80	18.31	83.80	42.31	41.90
102%	1.02	46.00	24.00	37.80	18.31	83.80	42.31	41.90
101%	1.01	46.00	24.00	37.80	18.31	83.80	42.31	41.90
100%	1.00	46.00	24.00	37.80	18.31	83.80	42.31	41.90
99%	0.99	46.00	24.00	37.80	18.31	83.80	42.31	41.90
98%	0.98	46.00	24.00	37.80	18.31	83.80	42.31	41.90
97%	0.97	46.00	24.00	37.80	18.31	83.80	42.31	41.90
96%	0.96	46.00	24.00	37.80	18.31	83.80	42.31	41.90
95%	0.95	46.00	24.00	37.80	18.31	83.80	42.31	41.90
94%	0.94	46.00	24.00	37.80	18.31	83.80	42.31	41.90
93%	0.93	46.00	24.00	37.80	18.31	83.80	42.31	41.90
92%	0.92	46.00	24.00	37.80	18.31	83.80	42.31	41.90
91%	0.91	46.00	24.00	37.80	18.31	83.80	42.31	41.90
90%	0.90	46.00	24.00	37.80	18.31	83.80	42.31	41.90

IMPORT

220kV	220kV	GE-101	GE-101	GE-103	GE-103	Import: GE-101 & GE-103		Import -
PEN	PEN	MW	MVAr	MW	MVAr	MW	MVAR	Required
110%	1.10	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
109%	1.09	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
108%	1.08	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
107%	1.07	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
106%	1.06	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
105%	1.05	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
104%	1.04	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
103%	1.03	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
102%	1.02	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
101%	1.01	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
100%	1.00	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
99%	0.99	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
98%	0.98	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
97%	0.97	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
96%	0.96	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
95%	0.95	46.00	-9.00	37.80	-8.40	83.80	-17.40	-27.65
94%	0.94	46.00	-9.00	37.80	-8.40	83.80		
93%	0.93	46.00	-9.00	37.80	-8.40	83.80		
92%	0.92	46.00	-9.00	37.80	-8.40	83.80		
91%	0.91	46.00	-9.00	37.80	-8.40	83.80		
90%	0.90	46.00	-9.00	37.80	-8.40	83.80		

T1B

EXPORT

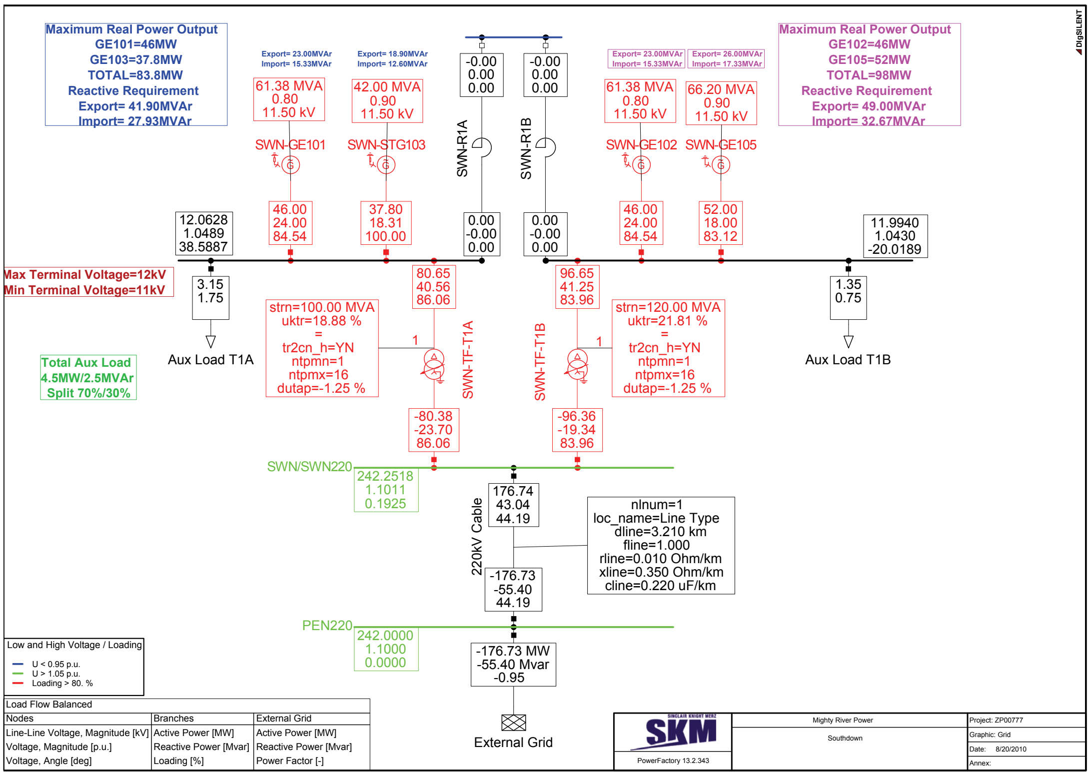
220kV	220kV	GE-102	GE-102	GE-105	GE-105	Export: GE-102 & GE-105		Export -
PEN	PEN	MW	MVAr	MW	MVAr	MW	MVAR	Required
110%	1.10	46.00	24.00	52.00	18.00	98.00	42.00	49.00
109%	1.09	46.00	24.00	52.00	18.00	98.00	42.00	49.00
108%	1.08	46.00	24.00	52.00	18.00	98.00	42.00	49.00
107%	1.07	46.00	24.00	52.00	18.00	98.00	42.00	49.00
106%	1.06	46.00	24.00	52.00	18.00	98.00	42.00	49.00
105%	1.05	46.00	24.00	52.00	18.00	98.00	42.00	49.00
104%	1.04	46.00	24.00	52.00	18.00	98.00	42.00	49.00
103%	1.03	46.00	24.00	52.00	18.00	98.00	42.00	49.00
102%	1.02	46.00	24.00	52.00	18.00	98.00	42.00	49.00
101%	1.01	46.00	24.00	52.00	18.00	98.00	42.00	49.00
100%	1.00	46.00	24.00	52.00	18.00	98.00	42.00	49.00
99%	0.99	46.00	24.00	52.00	18.00	98.00	42.00	49.00
98%	0.98	46.00	24.00	52.00	18.00	98.00	42.00	49.00
97%	0.97	46.00	24.00	52.00	18.00	98.00	42.00	49.00
96%	0.96	46.00	24.00	52.00	18.00	98.00	42.00	49.00
95%	0.95	46.00	24.00	52.00	18.00	98.00	42.00	49.00
94%	0.94	46.00	24.00	52.00	18.00	98.00	42.00	49.00
93%	0.93	46.00	24.00	52.00	18.00	98.00	42.00	49.00
92%	0.92	46.00	24.00	52.00	18.00	98.00	42.00	49.00
91%	0.91	46.00	24.00	52.00	18.00	98.00	42.00	49.00
90%	0.90	46.00	24.00	52.00	18.00	98.00	42.00	49.00

IMPORT

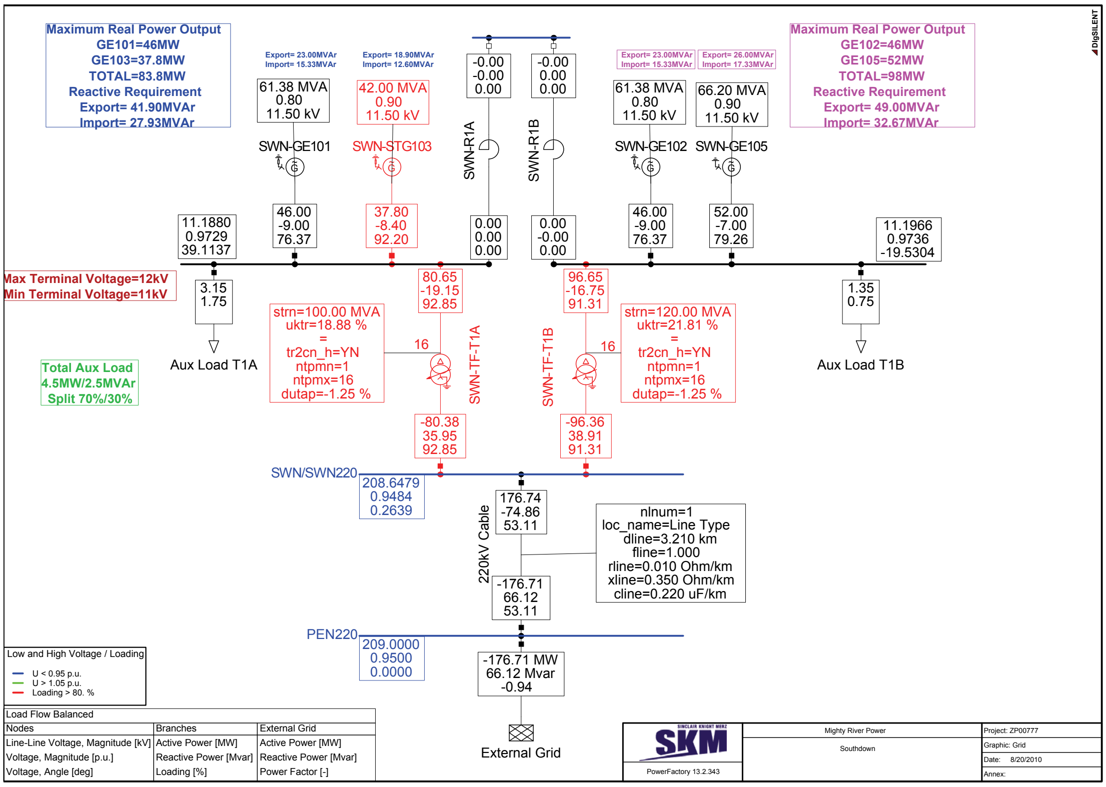
220kV	220kV	GE-102	GE-102	GE-105	GE-105	Import: GE-102 & GE-105		Import -
PEN	PEN	MW	MVAr	MW	MVAr	MW	MVAR	Required
110%	1.10	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
109%	1.09	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
108%	1.08	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
107%	1.07	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
106%	1.06	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
105%	1.05	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
104%	1.04	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
103%	1.03	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
102%	1.02	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
101%	1.01	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
100%	1.00	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
99%	0.99	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
98%	0.98	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
97%	0.97	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
96%	0.96	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
95%	0.95	46.00	-9.00	52.00	-7.00	98.00	-16.00	-32.34
94%	0.94	46.00	-9.00	52.00	-7.00	98.00		
93%	0.93	46.00	-9.00	52.00	-7.00	98.00		
92%	0.92	46.00	-9.00	52.00	-7.00	98.00		
91%	0.91	46.00	-9.00	52.00	-7.00	98.00		
90%	0.90	46.00	-9.00	52.00	-7.00	98.00		

Notes:	Active	Reactive Output		
	Output	Export	Import	
GE-101	46.00	24.00	-9.00	Instructed by MRP to assume same as GE-105
GE-102	46.00	24.00	-9.00	Instructed by MRP to assume same as GE-105
GE-103	37.80	18.31	-8.40	Instructed by MRP to assume same as capability curve
GE-105	52.00	18.00	-7.00	MRP Document titled "Southdown GE-105 ACS Excitation Control System"

- **Figure 9 Max Southdown Active Out: Reactive Capability: Penrose 220kV 90%-110%**



■ **Figure 10 Max Southdown Active Output: Max Reactive Export: Penrose 220kV at 110%**



■ **Figure 11 Max Southdown Active Output: Max Reactive Import: Penrose 220kV at 95%**

10. Project Time-Line

Appendix F, contains a proposed programme of works. This programme has been prepared in conjunction with MRP, and takes into account feedback from Vector and Kiwirail. SKM have produced the design and construction estimates based on recent engineering experience.

Whilst the programme meets MRP's requirements, SKM considers it to be tight, especially due to the extensive underground works in a project of this nature, as described in section 7.2. This said, mitigation by way of splitting contracts (Cable procurement & Cable Design), has assisted in achieving MRP's target dates. In addition it should be noted that in order to achieve the target dates, MRP will have to commit resources to the project in advance of obtaining resource consent. The advance resources required will be as follows:

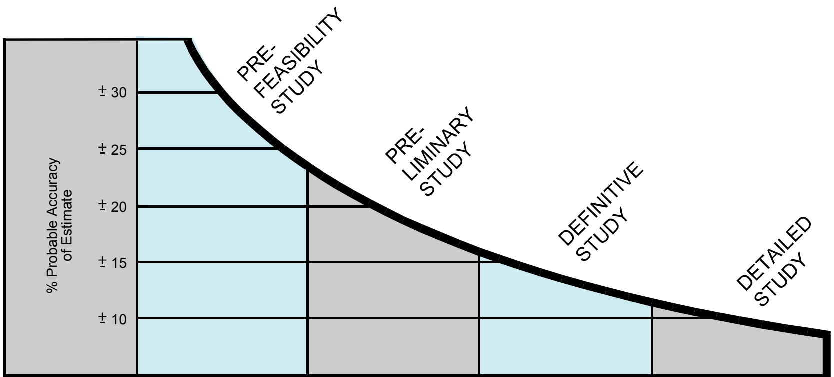
- Electrical Substation Design including associated civil works design.
- Cable Route Design including associated civil works design.
- Field Geotechnical Study, including drilling contractor and lab work.
- Cable Route Survey by Registered Surveyor.
- Physical confirmation of Underground Services and Utilities.

11. Estimated Project Construction Costs

Cost estimates for projects are prepared at various stages of development of a project from the feasibility stage through to detailed estimates prior to construction. In general there are four stages in project development:

- Investigation and Planning Report stage.
- Pre-design (Concept Report) stage.
- Pre-tender stage.
- Throughout the construction stage to monitor and control costs.

The level of accuracy of these estimates depends on the amount of detail available. Figure 1 shows a chart that is used by SKM to indicate the level of accuracy that can be expected at the various stages of the development of a project.



Type of Estimate	Order of Magnitude	Preliminary	Definitive	Detailed
Provided Documentation	• Product capacity and Location • Cost Data on Similar Projects • Major Equipment List	• Preliminary Equipment List • Engineering Line Diagram • Plant Outline General Arrangement • Maps and Surveys • Bench Test Results • Nature of Facilities	• Equipment Specifications and Vendor Quotations • Construction Schedule • Electrical One Lines • Piping and Instrumentation Flow Diagrams • Soil Data and Architect Features • Site Survey and Labour Complete	• Bulk Material Specifications and Vendor Quotes • Construction Specification and Sub Contractor Quotations • Engineering Advanced Approximately 10%
Definition of Scope of Work	Conceptual	Approximate	Clearly Described Essentially Complete	Complete. Well Detailed
Estimating Procedure	Factoring	Combination of Factoring and Quantity Take-Off	Most Quantity Take-Off. Very little Factoring	Complete Quantity Take-Off
Use of Study	Comparison/ Rejection	Final Feasibility	Budget	Funding

Figure 6 Definition chart for engineering estimates

In relation to SKM's involvement, and the time available to complete the study, the costing is in effect in the preliminary study stage of development with a probable accuracy of estimate of +/- 20%. A greater accuracy could be achieved; however, this would require firm quotations to be received for all equipment and a level of more detailed engineering, especially in terms of cable route design and confirmation of ground conditions.

Civil works have been estimated based upon SKM's recent experience. However, SKM notes that the cost of the civil component is relatively high, and has the potential to vary significantly. We specifically note that geotechnical investigations have not been undertaken.

Electrical costs have been based upon SKM's experience, and internal databases. In addition, to achieve added confidence in the figures used, budget equipment costs were requested from OLEX, ABB, AREVA and Siemens.

Prices in our database are in various currencies and the rates of the day were used to convert costs.

11.1. Summary of Cost Estimates

The cost for the provision of a 220 kV cable connection between Southdown and Penrose will be approximately **$32 million**. A detailed breakdown is provided in Appendix A and a summary in Table 9.

- **Table 9 – Project Construction Costs Breakdown**

Item	Description	Total Installation Cost ($)
1	Project Management and Design	$901,465
2	Substation Civil and Structural Works	$260,667
3	Substation Primary Works	$917,665
4	Substation Protection & Control Works	$420,468
5	Substation Auxiliary & Supplementary Works	$71,200
6	220 kV Cable Supply & Installation[10]	$9,471,747
7	Cable Civil Installation Works	$16,891,386
8	Contingency allowance 10%	$2,893,460
	Contract Total	**$31,828,057**

[10] Cable length costed totals 9600m, which includes the route length as defined in Table 1, additional route length within the substation fences and jointing and termination allowances.

11.2. Assumptions/Exclusions

SKM notes the following in relation to the cost estimate.

- The costs associated with railway shutdowns and the provision of bus services to replace rail have not been included, as we understand these costs will be estimated by MRP.
- No rock blasting will be necessary.
- The costs associated with land lease agreements have not been included, as we understand these costs will be estimated by MRP.
- The costs associated with consents and approvals have not been included, as we understand these costs will be estimated by MRP.
- Special Track Protection measures that KiwiRail might require when the railway is shutdown or any other time, such as having KiwiRail staff on site, programming of railway switching and signals, and liaison with Viola as the suburban rail operator have not been costed.
- Fluctuations in metal costs have not been assessed.
- Fluctuations in exchange rates have not been assessed.
- A total re-build of Southdown connection assets will be required.
- Bay 792 will be made available at Penrose Substation by Transpower.
- Reconnection costs associated with the OTA-HEN Circuit at Southdown. SKM do not believe these costs should be included as part of the connection costs, and should be borne by Transpower as part of a separate project.

11.3. Potential Variances to Cost Estimates

SKM points out that, as mentioned in the previous sections, the costing has been carried out in a relatively conservative manner, and as such there may be possible savings dependent upon the result of detailed investigations to be carried out during the detailed design stage. Some possible savings are as follows:

SKM

- **Table 10 – Potential Variances to Cost Estimates**

Item	Description	Estimated Saving ($)	Basis for Reduction
1	Purchase/ Transfer of existing assets at Southdown from Transpower to MRP	188,000	Based on Paying TP 80% of build Cost
2	Reduction in Cable Size Following Detailed Design	1,000,000	Based on Cable Size reduced from 1600mm2 to 1200mm2
3	Rental of DTS Measuring Unit Rather than Purchase	250,000	Based on assumption that rental costs over the life of cable will be $50,000

Appendix A Project Price Breakdown

Item	Description	Install	Materials	Sub-Contractor ($)	Total Installation Cost ($)
1	**Project Management**				
1.1	**General**				
1.1.1	Management & Site Supervision (Substation Work)	$29,443.38		$6,450.00	$35,893.38
1.1.2	Contract Administration	$3,607.50			$3,607.50
1.1.3	Insurances		$11,011.00		$11,011.00
1.1.4	Site Establishment		$18,700.00		$18,700.00
1.1.5	Site Disestablishment	$2,245.20	$550.00		$2,795.20
1.1.6	Design inc Studies, civils, electrical	$800,000.00			$800,000.00
		$835,296.08	**$30,261.00**	**$6,450.00**	**$872,007.08**
1.2	**Reporting & Meetings**				
1.2.1	Weekly & Monthly Progress Reporting	$3,968.25			$3,968.25
1.2.2	Technical Meetings	$2,566.92			$2,566.92
		$6,535.17	**$0.00**	**$0.00**	**$6,535.17**
1.3	**Contract Deliverables**				
1.3.1	MMS Requirements	$5,384.40			$5,384.40
1.3.2	Commissioning Plans	$3,230.64			$3,230.64
1.3.3	Test Reports	$4,307.52			$4,307.52
1.3.4	As Built Drawings	$10,000.00			$10,000.00
		$22,922.56	**$0.00**	**$0.00**	**$22,922.56**
		$864,753.81	**$30,261.00**	**$6,450.00**	**$901,464.81**
2.2	**220 kV Bay at Penrose**				
2.2.1	Install CB712/CT712 foundation	$17,415.00			$17,415.00
2.2.2	Install JB712 foundation	$2,365.00			$2,365.00
2.2.3	Install DIS714 foundation	$10,927.38			$10,927.38
2.2.4	Install DIS716/ES719 foundation	$10,927.38			$10,927.38
2.2.5	Install CVT712 foundation	$10,927.38			$10,927.38
2.2.6	Install Cable termination stand foundation	$17,415.00			$17,415.00
2.2.7	Install bus support stands and foundations	$43,709.52			$43,709.52
2.2.8	Extend existing cable trench to new ODJB location.	$3,846.35			$3,846.35
2.2.10	Supply and install conduits for ODJB field cabling	$1,272.47	$918.40		$2,190.87
		$118,805.48	**$918.40**	**$0.00**	**$119,723.88**
2.3	**220 kV Bay at Southdown**				
2.3.1	Install DIS214 foundation	$10,927.38			$10,927.38
2.3.2	Install DIS234 foundation	$10,927.38			$10,927.38
2.3.3	Install bus support stands and foundations	$45,265.03			$45,265.03
2.3.4	Install DIS224 foundation	$10,927.38			$10,927.38
2.3.5	Install CB222/CT222 foundation	$17,415.00			$17,415.00
2.3.6	Install JB foundation	$2,365.00			$2,365.00
2.3.7	Install DIS226/ES229 foundation	$10,927.38			$10,927.38
2.3.8	Extend existing cable trench to new ODJB location.	$3,846.35			$3,846.35
2.3.10	Install CVT222 foundation	$10,927.38			$10,927.38
2.3.11	Install Cable termination stand foundation	$17,415.00			$17,415.00
		$140,943.28	**$0.00**	**$0.00**	**$140,943.28**
		$259,748.76	**$918.40**	**$0.00**	**$260,667.16**
3.2	**220 kV Bay at Penrose**				
3.2.1	Install CB712	$12,600.00	$95,000.00		$107,600.00
3.2.2	Install CT712	$27,384.00	$52,500.00		$79,884.00
3.2.3	Install JB712	$1,000.00	$5,300.00		$6,300.00
3.2.4	Install DIS714	$19,200.00	$21,750.00		$40,950.00
3.2.5	Install new DIS716/ES719	$19,200.00	$29,250.00		$48,450.00
3.2.6	Install new rigid bus for bay 712	$10,260.00	$31,860.00		$42,120.00
3.2.7	Install bay 712 switchyard hardware and flexible connections	$6,170.00	$5,630.00		$11,800.00
3.2.8	Install CVT712	$36,300.00	$46,200.00		$82,500.00
3.2.9	Extension of Earthing	$10,000.00	$5,000.00		$15,000.00
		$142,114.00	**$292,490.00**	**$0.00**	**$434,604.00**
3.3	**220 kV Bay at Southdown**				
3.3.1	Install DIS214	$19,200.00	$21,750.00		$40,950.00
3.3.2	Install DIS234	$19,200.00	$21,750.00		$40,950.00
3.3.3	Install rigid bus for bays	$3,367.80	$20,000.00		$23,367.80
3.3.4	Install switchyard hardware and flexible connections	$3,059.09	$20,000.00		$23,059.09
3.3.5	Install CB222	$12,600.00	$95,000.00		$107,600.00
3.3.6	Install CT222	$27,384.00	$52,500.00		$79,884.00
3.3.7	Install JB	$1,000.00	$5,300.00		$6,300.00
3.3.8	Install new DIS226/ES229	$19,200.00	$29,250.00		$48,450.00
3.3.9	Install CVT222	$36,300.00	$46,200.00		$82,500.00
3.3.10	Extension of Earthing	$20,000.00	$10,000.00		$30,000.00
		$161,310.89	**$321,750.00**	**$0.00**	**$483,060.89**
		$303,424.89	**$614,240.00**	**$0.00**	**$917,664.89**

Item	Description		Install	Materials	Sub-Contractor ($)	Total Installation Cost ($)
4	**Protection & Control Works**					
4.1	**Penrose**					
4.1.1	Bus Zone Selection & CB Trip at Penrose		$3,095.40	$7,610.00		$10,705.40
4.1.2	CB Management		$2,200.00	$4,800.00		$7,000.00
4.1.3	Main 1 Protection		$11,700.00	$24,300.00		$36,000.00
4.1.4	Main 2 Protection		$11,700.00	$24,300.00		$36,000.00
4.1.5	Protection Cabinets		$400.00	$22,000.00		$22,400.00
4.1.6	Comms Modifications		$12,994.00	$29,223.60		$42,217.60
4.1.7	SCADA Modification		$11,040.00	$23,460.00		$34,500.00
			$53,129.40	$135,693.60	$0.00	$188,823.00
4.2	Southdown					
4.2.1	Bus Zone Selection & CB Trip at Penrose		$15,477.00	$38,050.00		$53,527.00
4.2.2	CB Management		$2,200.00	$4,800.00		$7,000.00
4.2.3	Main 1 Protection		$11,700.00	$24,300.00		$36,000.00
4.2.4	Main 2 Protection		$11,700.00	$24,300.00		$36,000.00
4.2.5	Protection Cabinets		$400.00	$22,000.00		$22,400.00
4.2.6	Comms Modifications		$12,994.00	$29,223.60		$42,217.60
4.2.7	SCADA Modification		$11,040.00	$23,460.00		$34,500.00
			$65,511.00	$166,133.60	$0.00	$231,644.60
			$118,640.40	**$301,827.20**	**$0.00**	**$420,467.60**
5	**Auxiliary & Supplementary Works**					
5.1	**Penrose**					
5.1.1	New ODJB secondary cabling		$3,400.00	$10,000.00		$13,400.00
5.1.2	415V powerCables		$1,000.00	$12,000.00		$13,000.00
5.1.3	DC Distribution		$5,000.00	$4,200.00		$9,200.00
			$9,400.00	$26,200.00	$0.00	$35,600.00
5.2	**Southdown**					
5.2.1	New ODJB secondary cabling		$3,400.00	$10,000.00		$13,400.00
5.2.2	415V powerCables		$1,000.00	$12,000.00		$13,000.00
5.2.3	DC Distribution		$5,000.00	$4,200.00		$9,200.00
			$9,400.00	$26,200.00	$0.00	$35,600.00
			$18,800.00	**$52,400.00**	**$0.00**	**$71,200.00**
	TOTAL SUBSTATION		**$1,565,367.86**	**$999,646.60**	**$6,450.00**	**$2,571,464.46**
6	**220 kV Cable Supply**					
6.1	9.6km of 1600 mm2 cable (3200 route length) @$54k/100m		$1,777,293.86	$5,217,341.40		$6,994,635.26
6.2	Cross Bond Cable joints (3 bays, 9 Joints)		$62,181.60	$292,488.00		$354,669.60
6.2	Cable Terminations (6 off)		$52,790.89	$223,806.00		$276,596.89
6.2	Link Boxes (1 per Joint position)		$667.94	$37,200.00		$37,867.94
6.2	Link Boxes (terminations)		$667.94	$18,000.00		$18,667.94
6.2	DTS Fibre (1 off)/ PD Sensor Fibre		$114,407.32	$77,040.00		$191,447.32
6.2	DTS System		$3,000.00	$300,000.00		$303,000.00
6.2	Protection Comms Fibres (2 off)		$114,407.32	$77,040.00		$191,447.32
6.2	Cable Supplier Supervision and Jointing				$600,000.00	$600,000.00
6.2	Hire of HV Test Kit		$3,414.47		$500,000.00	$503,414.47
	TOTAL Cable Supply		**$2,128,831.34**	**$6,242,915.40**	**$1,100,000.00**	**$9,471,746.74**
7	**220 kV Cable Installation Civil Works**					
7.1	Prelim & General		$519,750.00			$519,750.00
7.2	Site Survey inc Geotech		$126,000.00			$126,000.00
7.2	Excavate Trench		$5,837,081.25			$5,837,081.25
7.4	Dispose of trench spoil off-site		$641,134.15			$641,134.15
7.5	Cable Ducts		$3,509,100.00			$3,509,100.00
7.6	Joint Bays		$336,000.00			$336,000.00
7.7	Backfill		$1,723,387.05			$1,723,387.05
7.8	McNab St & SH1 Microtunnel		$2,992,500.00			$2,992,500.00
7.9	Railway Crossing		$787,500.00			$787,500.00
7.10	Church Road Crossing		$208,933.44			$208,933.44
7.11	Relocate Existing Services		$157,500.00			$157,500.00
7.12	As Builts		$52,500.00			$52,500.00
	TOTAL Cable Civil Works Installation		**$16,891,385.88**	**$0.00**	**$0.00**	**$16,891,385.88**

SUMMARY

Item	Description	Installation Labour ($)	Major equipment ($)	SubContractor ($)	Total Installation Cost ($)
1	Project Management and Design	$864,753.81	$30,261.00	$6,450.00	$901,464.81
2	Substation Civil and Structural Works	$259,748.76	$918.40	$0.00	$260,667.16
3	Substation Primary Works	$303,424.89	$614,240.00	$0.00	$917,664.89
4	Substation Protection & Control Works	$118,640.40	$301,827.20	$0.00	$420,467.60
5	Substation Auxiliary & Supplementary Works	$18,800.00	$52,400.00	$0.00	$71,200.00
6	220 kV Cable Supply & Installation	$2,128,831.34	$6,242,915.40	$1,100,000.00	$9,471,746.74
7	Cable Civil Installation Works	$16,891,385.88	$0.00	$0.00	$16,891,385.88
8	Contingency allowance 10%			$2,893,459.71	$2,893,459.71
	Contract Total	**$20,585,585.09**	**$7,242,562.00**	**$3,999,909.71**	**$31,828,056.79**

Appendix B Calculation Sheets

SKM

Network Loss Calculations
Source: Mighty River Power

Existing Losses: Southdown to Penrose Connection

The actual losses in MWh that would be expected from Southdown (175MW plant) when connected to Penrose via cable have been calculated, based on the actual Southdown generation profile (by trading period) 2007 – 2009 (and using SKM's cable parameters). Annual cable losses SWN-PEN (220kV):

Year	MWh	
2007	80.13	MWh
2008	102.68	MWh
2009	38.25	MWh

Cost of Losses: Southdown to Penrose Connection

The PDA also requires the estimated average price of energy in $/MWh (presumably to calculate the cost above, and thus assuming base generation). However, this won't provide the correct price coincident with peaking generation. While not expected to be material, a potentially more accurate method to calculate losses on the proposed Southdown to Penrose 220kV cable connection coincident with Southdown spot price should be:

$$\text{Annual cost}_{\text{(underground cable losses)}} = \sum_{1}^{365}\left(\sum_{1}^{TP=48}\frac{\left(3\left(\frac{SWNGen_{TP}}{\sqrt{3}\cdot 220kV}\right)^{2}\cdot Cable(\Omega/\text{km})\cdot km\right)\times SWNPrice_{TP}}{2}\right)$$

which results in the following estimate for the annual cost of cable losses SWN-PEN (220kV):

Year	Cost of losses (SWN-PEN)
2007	$ 5,169.14
2008	$ 17,186.24
2009	$ 3,386.41
Average	**≈$9,000**

Page 1 of 2

Cost of Losses: Southdown to Otahuhu/Henderson Line Connection

The PDA requires additional losses, which are assume are compared to the existing Southdown grid connection. The following are the losses for Southdown (175MW capacity) to OTA based on actual generation and pricing data (2007 – 2009). The annual cost of losses SWN-OTA (220kV) for the existing Southdown connection are predicted to be:

Year	Cost of losses (SWN-OTA/HEN)
2007	$ 66,593.43
2008	$ 91,346.22
2009	$ 32,645.56
Average	**≈$65,000**

The above annual losses have been calculated using the following:

The Annual cost $_{\text{(SWN to OTA line losses)}} = \sum_{1}^{365}\left(\sum_{1}^{TP=48}\frac{(SWNPrice_{TP}-OTAPrice_{TP})\times SWNGen_{TP}}{2}\right)$

Note that Penrose 220kV is not a pricing node and no pricing data is available. OTA2201 has been used instead, on the basis that it is electrically closer to PEN2201 than PEN1101.

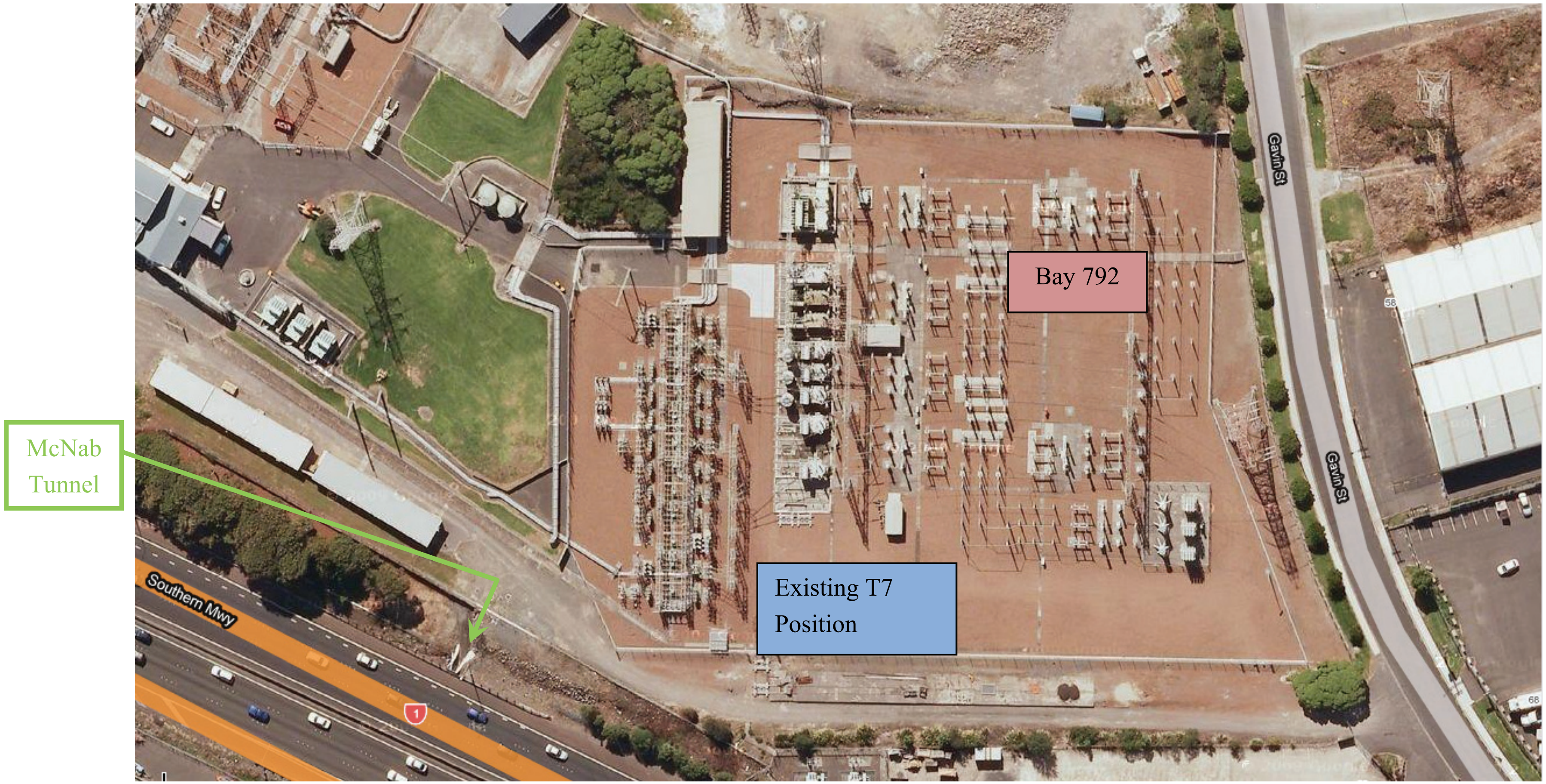
Average Electrical Prices: Southdown: Otahuhu: Penrose

The following are the average prices at Southdown over the period 2007 to 2009:

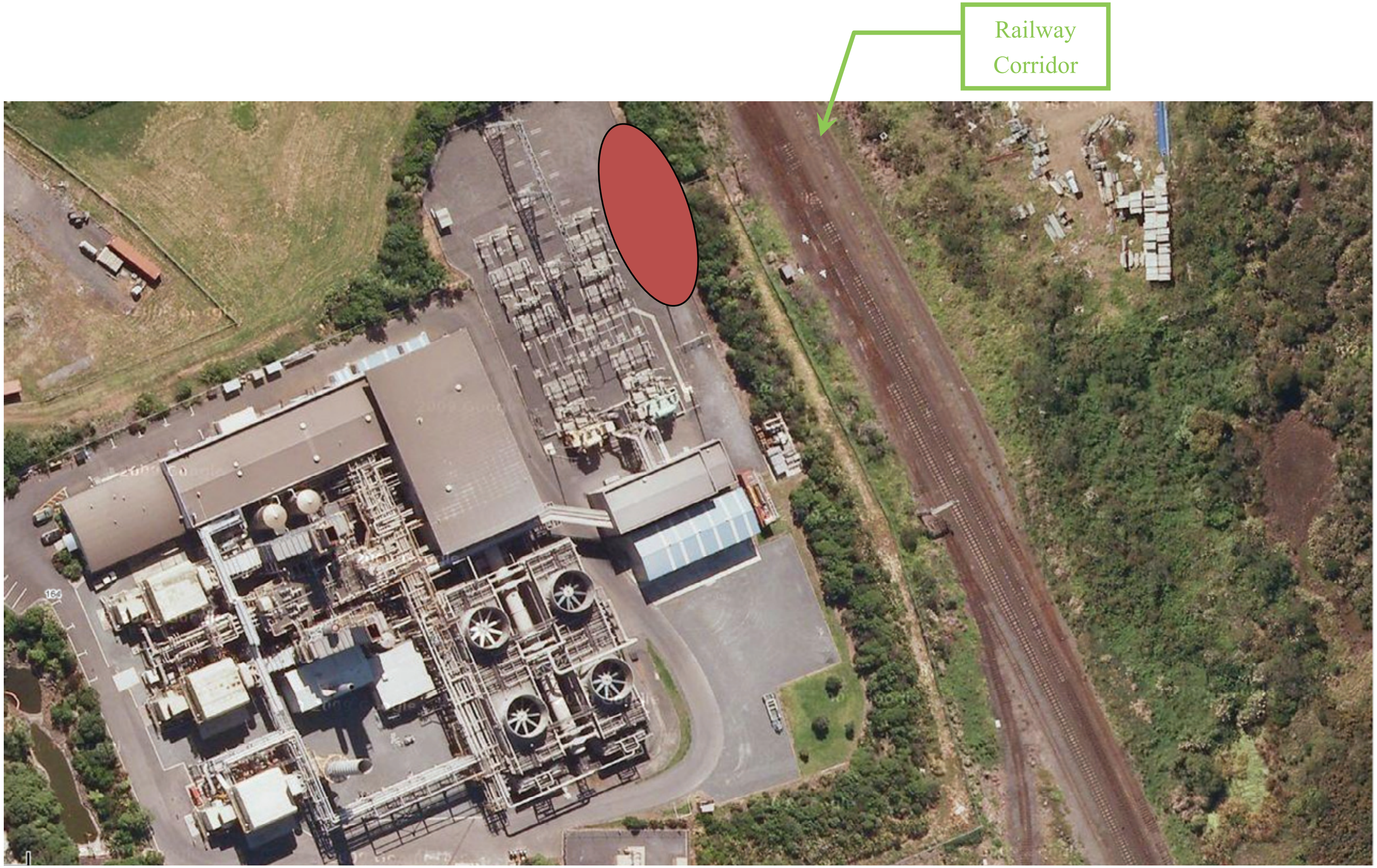
Year	SWN2201	OTA2201	PEN1101
2007	$52.21	$52.27	$52.54
2008	$113.30	$113.22	$113.90
2009	$48.63	$48.66	$49.08
Average	**$71.38**	**$71.38**	**$71.84**

Page 2 of 2

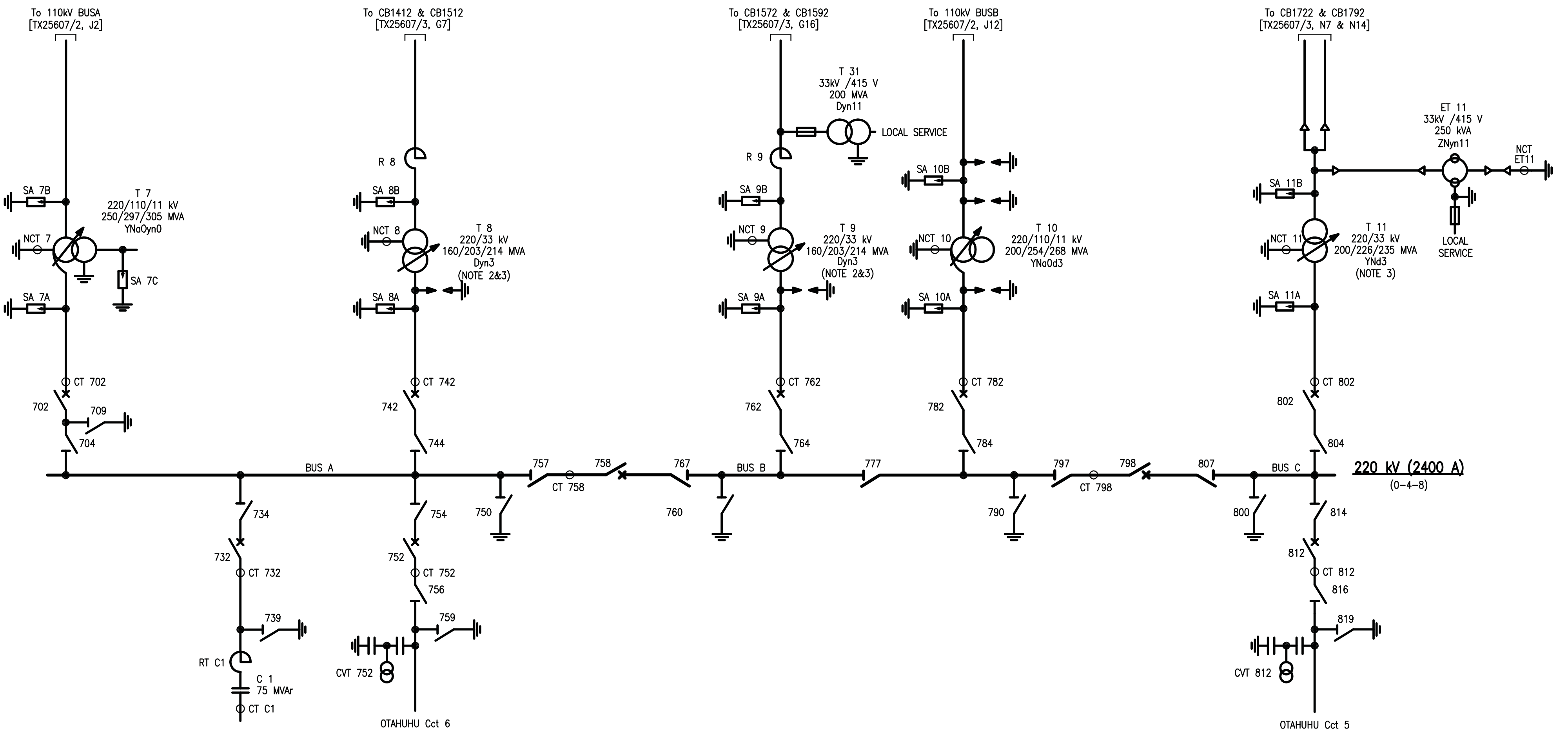
Appendix C Substation Drawing Mark-Ups



- **Penrose Substation: Aerial Photo of 220kV Switchyard: Blue rectangle is recent expansion.**



- **Southdown Power Station: Aerial Photo: Red oval shows potential space for 220kV connection**



NOTES

1. TRANSFORMER RATINGS **/**/** MVA ARE FOR CONTINUOUS/SUMMER/WINTER RESPECTIVELY.
2. TRANSFORMER RATING IS LIMITED TO 131 MVA IF ONE OF T8 OR T9 INCOMERS IS REMOVED FROM SERVICE.
3. PENROSE T8 TAPS ARE HARD WIRED ON TAP6.
   PENROSE T9 IS NOT TO BE TAPPED.
   PENROSE T11 IS NOT TO BE TAPPED UNLESS REQUESTED BY VECTOR AND APPROVED BY PIETER DE BRUIN.

REFERENCE DRAWINGS:

TX25607/2 (P5/2C1.1) 110 kV SINGLE LINE DIAGRAM (OPERATING)
TX25607/3 (P5/2C1.1) 33 kV SINGLE LINE DIAGRAM (OPERATING)
TX25607/4 (P5/2C1.1) 22 kV SINGLE LINE DIAGRAM (OPERATING)
TX38926/1 (P5/2C1.1) RELAY & INSTRUMENT DWG LIST & EQUIPMENT LEGENDS (OPERATING)

THIS DRAWING SUPERSEDES TX25607

REV	DESCRIPTION	NAME	DSN	DATE	DRN	DATE	CHK	DATE	QC	DATE	APP	DATE	APP	DATE
U	AS BUILT: T7 ADDED, DRAWING REFERENCES & NOTE3 AMENDED	EDISON			IAT	01/10	ML	01/10	ML	01/10	MN	01/10	JH	01/10
V	AS BUILT: SA7C ADDED TO T7	EDISON			IAT	04/10	ML	04/10	ML	04/10	MN	04/10	JH	04/10
P	AS BUILT: T8, T9 & T11 RATINGS UPDATED	EDISON			IAT	02/09	ML	02/09	ML	02/09	MN	02/09	JH	03/09
R	AS BUILT: TRANSFORMER T10 RATINGS UPDATED, T11 11kV CABLES CORRECTED	EDISON			IAT	04/09	ML	04/09	ML	04/09	MN	04/09	JH	04/09
S	AS BUILT: NOTE 3 ADDED	EDISON			IAT	05/09	ML	05/09	ML	05/09	MN	05/09	JH	05/09
T	AS BUILT: ET11 CONFIGURATION UPDATED	EDISON			IAT	11/09	ML	11/09	ML	11/09	MN	11/09	JH	12/09

DESIGNED	S.ZARKOVIC	22.09.99
DRAWN	V.MITIC	22.09.99
CHECKED	S.SALMON	22.09.99
QC CHECKED	H.KAY	09.99
APPROVED	S.SALMON	09.99
TP APPROVED	M.SCHOO	09.99

PREPARED BY:
Beca Carter Hollings & Ferner
132 Vincent St Auckland Ph3009000

TRANSPOWER

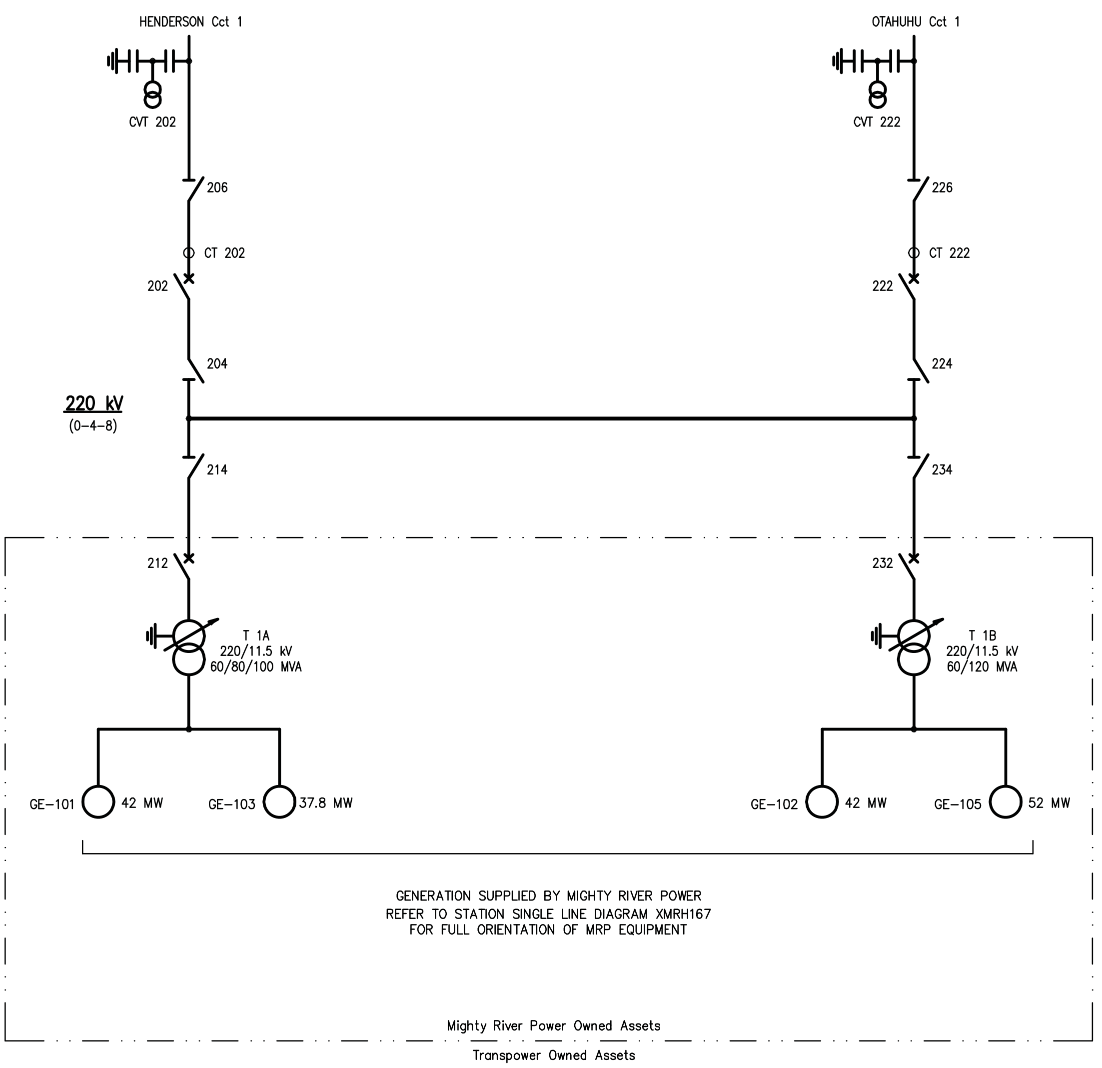
PENROSE SUBSTATION

220 kV SINGLE LINE DIAGRAM (OPERATING)

SCALE N.T.S. | FOLDER P5/2C1.1
DRAWING NUMBER TX25607/1 | REVISION V
CAD FILE NAME TX25607_1_0.dwg

A1

DRAWING NUMBER TX25607/1



REFERENCE DRAWINGS

XMRH167 (S30/2C1.1) (S60/7c.1) SINGLE LINE DIAGRAM
TX35516 (S30/2C1.1) (S60/7c.1) 220kV RELAY & INSTRUMENTATION DIAGRAM (OPERATING)

CATEGORY 4
MUTUAL INTEREST DRAWING
MIGHTYRIVERPOWER FOLDER REF : S60/7c.1
SUPPLEMENTARY DISTRIBUTION FILE TO : MIGHTYRIVERPOWER

REV	DESCRIPTION	NAME	DSN	DATE	DRN	DATE	CHK	DATE	QC	DATE	APP	DATE	TP APP	TP DATE
A	CTs & BUS RATING ADDED	EDISON			ML	4/03	CB	4/03	CB	4/03	MN	4/03	JH	5/03
B	TRANSFORMER NAMES CORRECTED	EDISON			JM	3/04	ML	3/04	CB	3/04	MN	3/04	JH	4/04
C	AS BUILT - HEN Cct1 LT REMOVED	EDISON			JM	7/04	ML	7/04	CB	7/04	MN	7/04	BO	7/04
D	AS BUILT: DRAWING NOW CAT 4	EDISON			JB	11.06	ML	11.06	ML	11.06	MN	11.06	JH	11/06
E	AS BUILT: GENERATORS ADDED	EDISON			IAT	09/07	ML	09/07	ML	09/07	MN	09/07	JH	09/07
F	AS BUILT: GENERATION DETAILS CORRECTED	EDISON			IAT	11/07	ML	11/07	ML	11/07	MN	11/07	JH	11/07

DESIGNED		
DRAWN	C. BOGGISS	7/99
CHECKED	M. NICHOLSON	7/99
QC CHECKED	M. NICHOLSON	7/99
APPROVED		
TP APPROVED	R BRIGHT	7/99

PREPARED BY:
EDISON LOGIC
34 MATUA RD, TAURANGA. PH 07 5768340

TRANSPOWER

SOUTHDOWN SUBSTATION

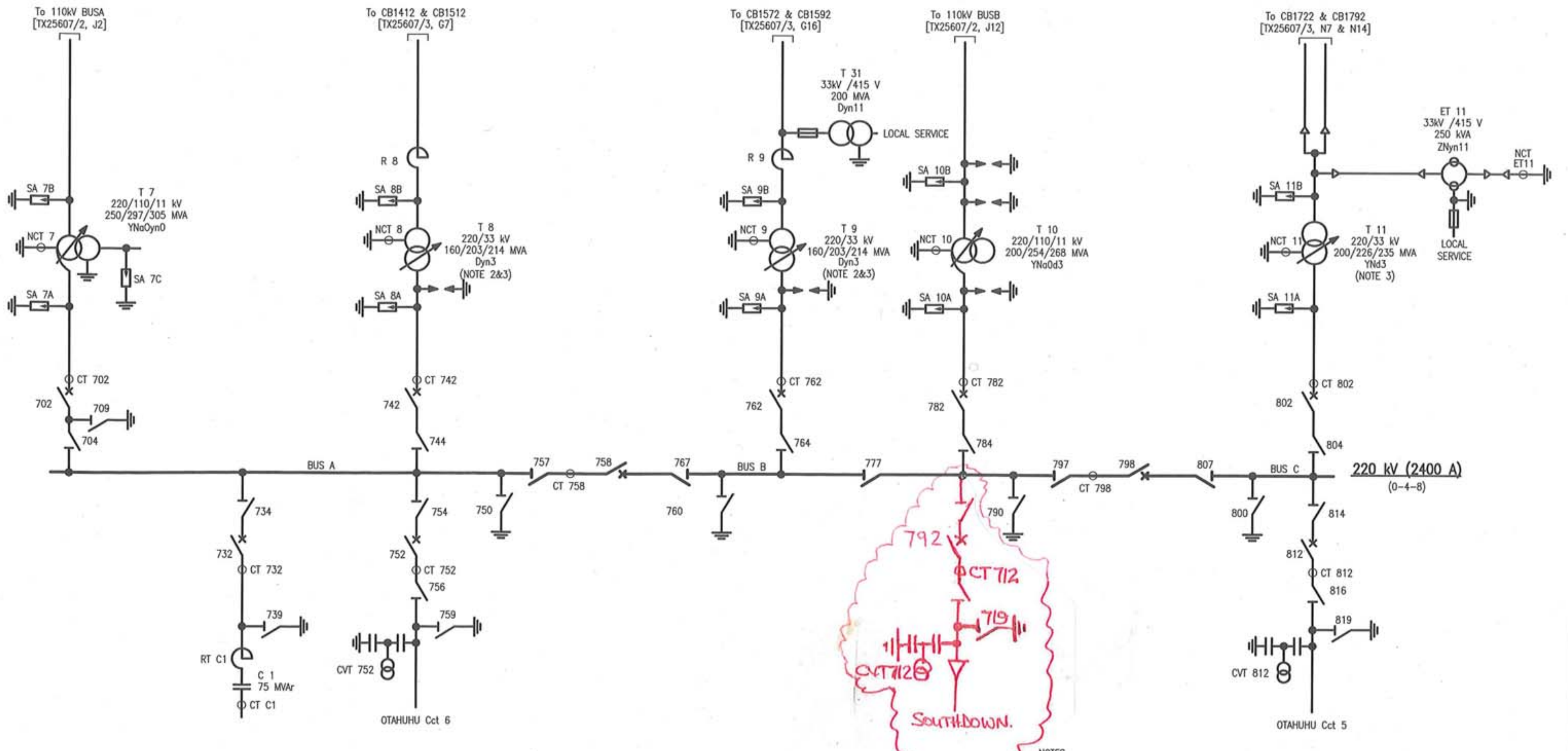
220kV SINGLE LINE DIAGRAM (OPERATING)

SCALE N.T.S.
FOLDER S30/2C1.1
DRAWING NUMBER TX39568
REVISION F
CAD FILE NAME TX39568

A1

DRAWING NUMBER TX39568

DRAWING NUMBER TX25607/1



NOTES

1. TRANSFORMER RATINGS **/**/** MVA ARE FOR CONTINUOUS/SUMMER/WINTER RESPECTIVELY.
2. TRANSFORMER RATING IS LIMITED TO 131 MVA IF ONE OF T8 OR T9 INCOMERS IS REMOVED FROM SERVICE.
3. PENROSE T8 TAPS ARE HARD WIRED ON TAP6.
   PENROSE T9 IS NOT TO BE TAPPED.
   PENROSE T11 IS NOT TO BE TAPPED UNLESS REQUESTED BY VECTOR AND APPROVED BY PIETER DE BRUIN.

REFERENCE DRAWINGS:

TX25607/2 (P5/2C1.1) 110 kV SINGLE LINE DIAGRAM (OPERATING)
TX25607/3 (P5/2C1.1) 33 kV SINGLE LINE DIAGRAM (OPERATING)
TX25607/4 (P5/2C1.1) 22 kV SINGLE LINE DIAGRAM (OPERATING)
TX38926/1 (P5/2C1.1) RELAY & INSTRUMENT DWG LIST & EQUIPMENT LEGENDS (OPERATING)

THIS DRAWING SUPERSEDES TX25607

REV	DESCRIPTION	NAME	DSN	DATE	DRN	DATE	CHK	DATE	QC	DATE	APP	DATE	TP APP	DATE
U	AS BUILT: T7 ADDED, DRAWING REFERENCES & NOTE3 AMENDED	EDISON			IAT	01/10	ML	01/10	ML	01/10	MN	01/10	JH	01/10
V	AS BUILT: SA7C ADDED TO T7	EDISON			IAT	04/10	ML	04/10	ML	04/10	MN	04/10	JH	04/10
P	AS BUILT: T8, T9 & T11 RATINGS UPDATED	EDISON			IAT	02/09	ML	02/09	ML	02/09	MN	02/09	JH	03/09
R	AS BUILT: TRANSFORMER T10 RATINGS UPDATED, T11 11kV CABLES CORRECTED	EDISON			IAT	04/09	ML	04/09	ML	04/09	MN	04/09	JH	04/09
S	AS BUILT: NOTE 3 ADDED	EDISON			IAT	05/09	ML	05/09	ML	05/09	MN	05/09	JH	05/09
T	AS BUILT: ET11 CONFIGURATION UPDATED	EDISON			IAT	11/09	ML	11/09	ML	11/09	MN	11/09	JH	12/09

DESIGNED	S.ZARKOVIC	22.09.99
DRAWN	V.MITIC	22.09.99
CHECKED	S.SALMON	22.09.99
QC CHECKED	H.KAY	09.99
APPROVED	S.SALMON	09.99
TP APPROVED	M.SCHOO	09.99

PREPARED BY: Beca Carter Hollings & Ferner 132 Vincent St Auckland Ph3009000

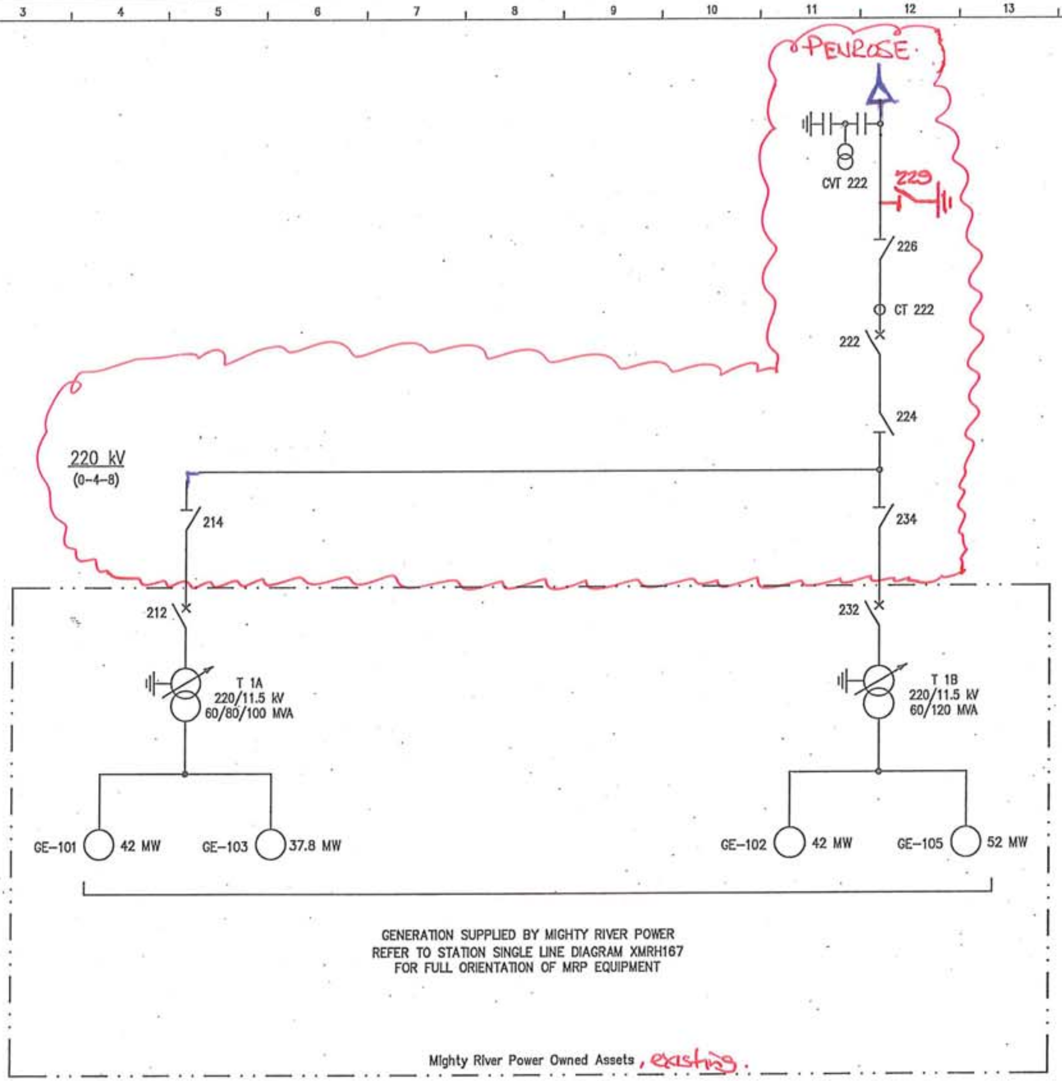
TRANSPOWER

PENROSE SUBSTATION

220 kV SINGLE LINE DIAGRAM (OPERATING)

SCALE N.T.S.
FOLDER P5/2C1.1
DRAWING NUMBER TX25607/1
REVISION V
CAD FILE NAME TX25607_1_0.dwg

A1



REFERENCE DRAWINGS

XMRH167 (S30/2C1.1) (S60/7c.1) SINGLE LINE DIAGRAM
TX35516 (S30/2C1.1) (S60/7c.1) 220kV RELAY & INSTRUMENTATION DIAGRAM (OPERATING)

CATEGORY 4
MUTUAL INTEREST DRAWING
MIGHTYRIVERPOWER FOLDER REF : S60/7c.1
SUPPLEMENTARY DISTRIBUTION FILE TO : MIGHTYRIVERPOWER

REV	DESCRIPTION	NAME	DSN	DATE	DRN	DATE	CHK	DATE	QC	DATE	APP	DATE	TP APP	TP DATE
A	CTs & BUS RATING ADDED	EDISON			ML	4/03	CB	4/03	CB	4/03	MN	4/03	JH	5/03
B	TRANSFORMER NAMES CORRECTED	EDISON			JM	3/04	ML	3/04	CB	3/04	MN	3/04	JH	4/04
C	AS BUILT – HEN Cct1 LT REMOVED	EDISON			JM	7/04	ML	7/04	CB	7/04	MN	7/04	BO	7/04
D	AS BUILT: DRAWING NOW CAT 4	EDISON			JB	11.06	ML	11.06	ML	11.06	MN	11.06	JH	11/06
E	AS BUILT: GENERATORS ADDED	EDISON			IAT	09/07	ML	09/07	ML	09/07	MN	09/07	JH	09/07
F	AS BUILT: GENERATION DETAILS CORRECTED	EDISON			IAT	11/07	ML	11/07	ML	11/07	MN	11/07	JH	11/07

DESIGNED		
DRAWN	C. BOGGISS	7/99
CHECKED	M. NICHOLSON	7/99
QC CHECKED	M. NICHOLSON	7/99
APPROVED		
TP APPROVED	R BRIGHT	7/99

PREPARED BY:
EDISON LOGIC
34 MATUA RD, TAURANGA, PH 07 5768340

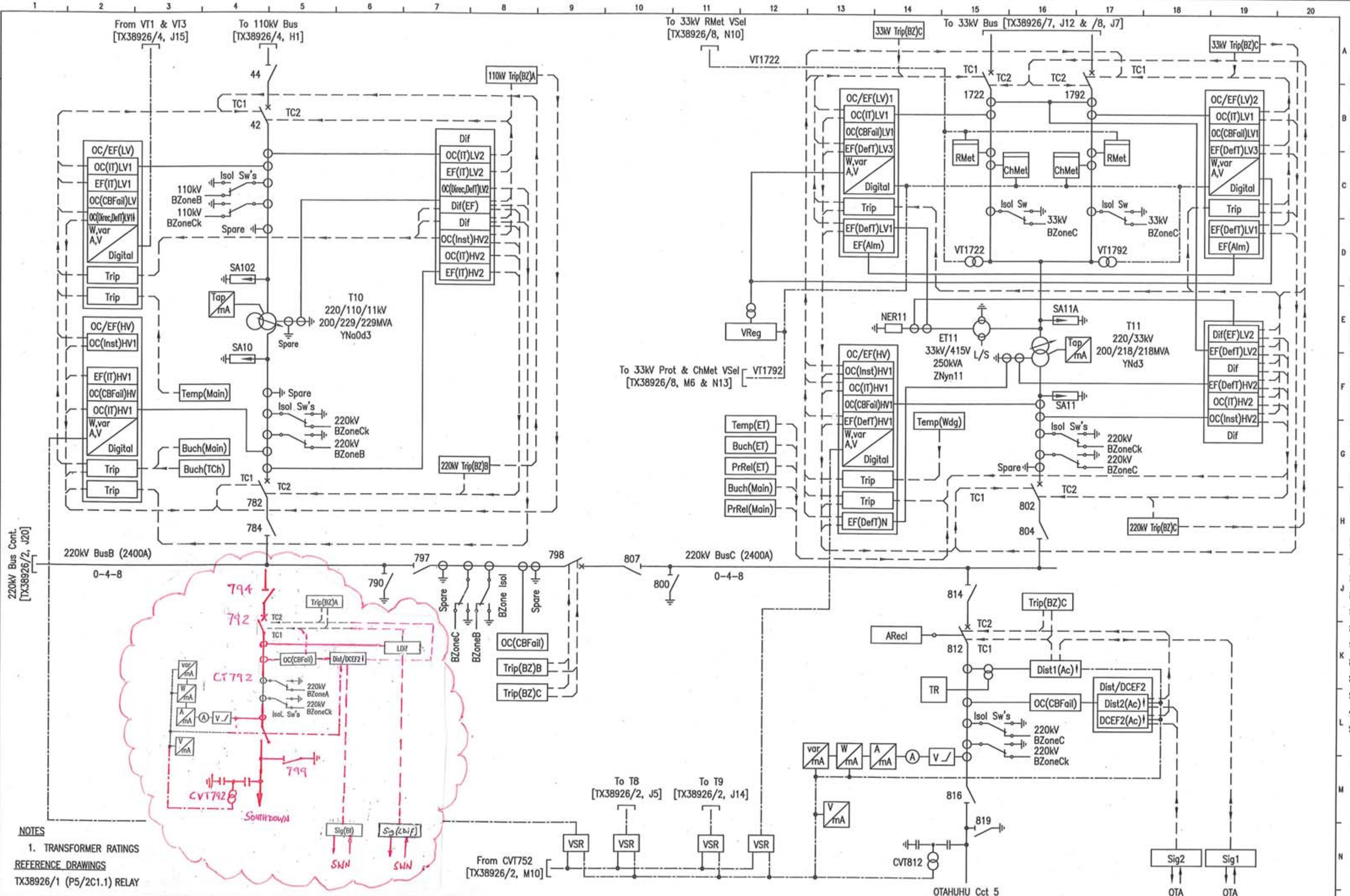
TRANSPOWER

SOUTHDOWN SUBSTATION
220kV SINGLE LINE DIAGRAM
(PROPOSED)

SCALE N.T.S.
FOLDER S30/2C1.1
DRAWING NUMBER TX39568
REVISION F
CAD FILE NAME TX39568

A1

DRAWING NUMBER TX39568



NOTES

1. TRANSFORMER RATINGS

REFERENCE DRAWINGS

TX38926/1 (P5/2C1.1) RELAY

REV	DESCRIPTION
D.3	AS BUILT: AMENDED TO APPROVAL COMMENTS
E	AS BUILT: REVISIONS D, D.1, D.2 & D.3 APPROVED
F	AS BUILT: T10 RATINGS UPDATED
D	AS BUILT: T10 & OTA5 INFORMATION ADDED
D.1	AS BUILT: OTAHUHU Cct 5, T10 & T11 PROTECTION UPDATED
D.2	AS BUILT: TRANSFORMER T11 RATINGS UPDATED

NAME	DSN	DATE	DRN	DATE	CHK	DATE	QC	DATE	APP	DATE	APP	DATE
EDISON			JM	7/05	ML	7/05	CB	7/05	MN	7/05		
EDISON			JM	7/05	ML	7/05	CB	7/05	MN	7/05	KJ	7/05
EDISON			JEB	9/05	ML	9/05	CB	9/05	MN	9/05	JH	10/05
EDISON	ML	11/02	ML	11/02	CB	11/02	CB	11/02	MN	11/02		
EDISON			JM	10/04	ML	10/04	CB	10/04	MN	10/04		
EDISON			JM	2/05	ML	2/05	CB	2/05	MN	2/05		

DESIGNED	S.ZARKOVIC	08.10.98
DRAWN	V.MITIC	08.10.98
CHECKED	M.JANJIC	12.98
QC CHECKED	G.WINTHROP	12.98
APPROVED	G.WINTHROP	12.98
TP APPROVED		

PREPARED BY:
Beca Carter Hollings & Ferner
132 Vincent St Auckland Ph3009000

TRANSPOWER

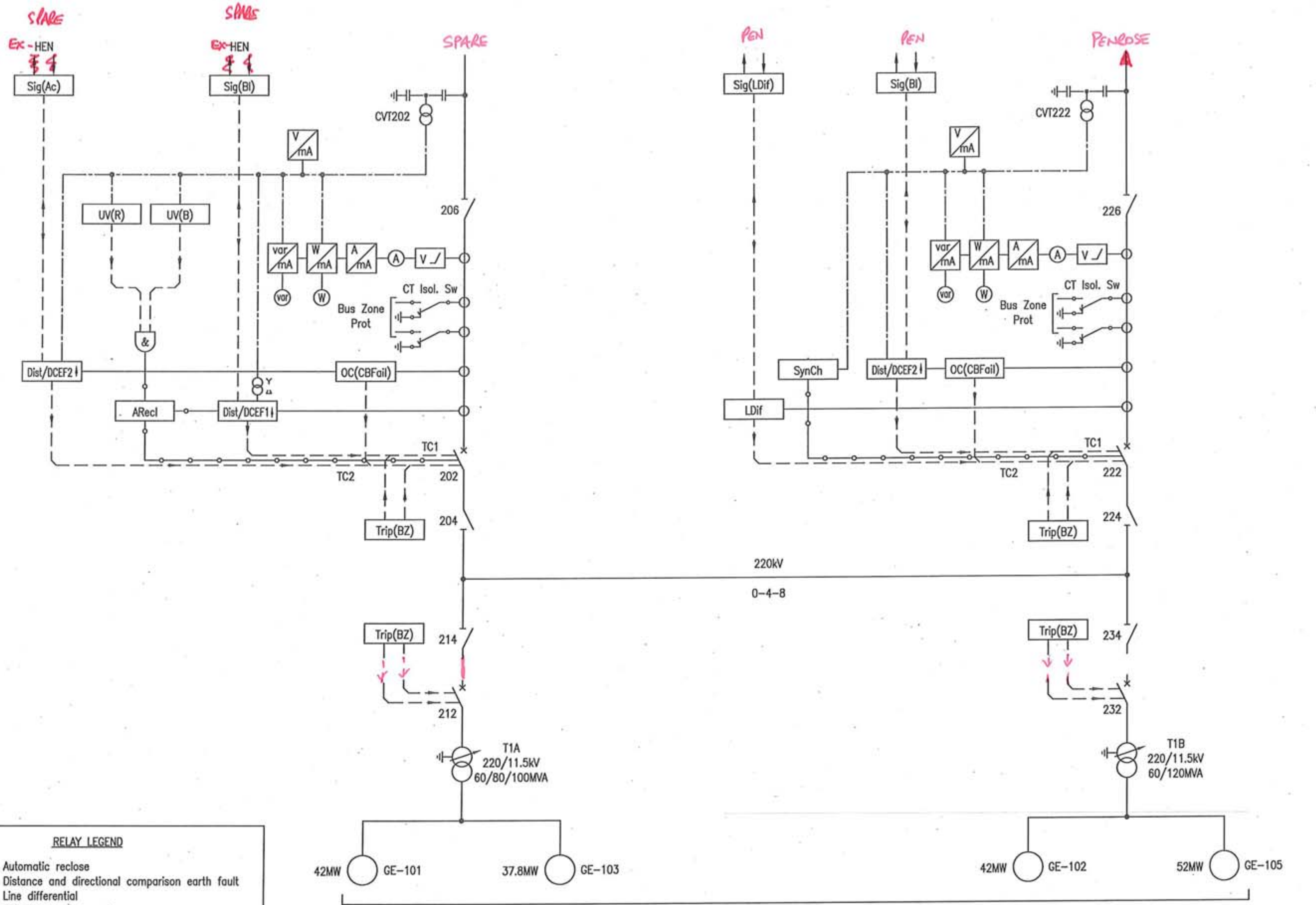
PENROSE SUBSTATION

220/110/33kV RELAY & INSTRUMENTATION DIAGRAM (OPERATING)

SCALE: N.T.S.
FOLDER: P5/2C1.1
DRAWING NUMBER: TX38926/3
REVISION: F
CAD FILE NAME: TX38926-3.DWG

A1

DRAWING NUMBER TX38926/3



SYMBOL LEGEND

V/mA	Voltage transducer
var/mA	var transducer
W/mA	Watt transducer
A/mA	Current transducer
V ⁄	Voltage limiter
(A)	Ammeter
(var)	var meter
(W)	Wattmeter
(&)	"And" function

~~TRANSPOWER EQUIPMENT~~
MIGHTY RIVER POWER EQUIPMENT

RELAY LEGEND

ARecl	Automatic reclose
Dist/DCEF	Distance and directional comparison earth fault
LDif	Line differential
OC(CBFail)	CB failure overcurrent
Sig(Ac)	Signalling accelerating
Sig(BI)	Signalling blocking
Sig(LDif)	Line differential signalling
SynCh	Synchronous check
Trip(BZ)	Bus zone trip
UV(B)	Blue phase undervoltage
UV(R)	Red phase undervoltage

GENERATION SUPPLIED BY MIGHTY RIVER POWER
REFER TO MRP R&I A0-93551-232LE13 FOR FULL ORIENTATION OF MRP EQUIPMENT

REFERENCE DRAWINGS

TX39568	(S30/2C1.1) (S60/7c.1)	220kV SINGLE LINE DIAGRAM (OPERATING)
A0-93551-232LE13	(S30/2C1.1) (S60/7c.1)	PRIMARY SYSTEMS SINGLE LINE DIAGRAM

CATEGORY 4
MUTUAL INTEREST DRAWING
MIGHTYRIVERPOWER FOLDER REF : S60/7c.1
SUPPLEMENTARY DISTRIBUTION FILE TO : MIGHTYRIVERPOWER

REV	DESCRIPTION	NAME	DSN	DATE	DRN	DATE	CHK	DATE	QC	DATE	APP	DATE	APP	DATE
G	AS BUILT: DRAWING NOW CAT 4	EDISON			JB	11.06	ML	11.06	ML	11.06	MN	11.06	JH	11.06
H	AS BUILT: MRP DETAILS UPDATED	EDISON			IAT	09/07	ML	09/07	ML	09/07	MN	09/07	JH	09/07
J	AS BUILT: GENERATION DETAILS CORRECTED	EDISON			IAT	11/07	ML	11/07	ML	11/07	MN	11/07	JH	11/07
D	AS BUILT: MITZ ADDED.	DP			ZD	4/97	CEL	4/97	JS	4/97	JS	4/97	MJ	9/97
E	AS BUILT: INSTRUMENTS ADDED & TITLE AMENDED.	ECG			MS	4/01	ML	9/01	ML	9/01	MN	9/01	KJ	12/01
F	AS BUILT – HENDERSON Cct 1 LINE TRAP REMOVED	EDISON			JM	7/04	ML	7/04	CB	7/04	MN	7/04	BO	7/04

DESIGNED	A.E. PAGE	11/95
DRAWN	Z. DRACA	11/95
CHECKED		
QC CHECKED	KM WARD	3/96
APPROVED	S MUTTON	3/96
TP APPROVED		

PREPARED BY: DESIGNPOWER NZ LTD PO Box 1037 Hamilton

TRANSPOWER

SOUTHDOWN SUBSTATION

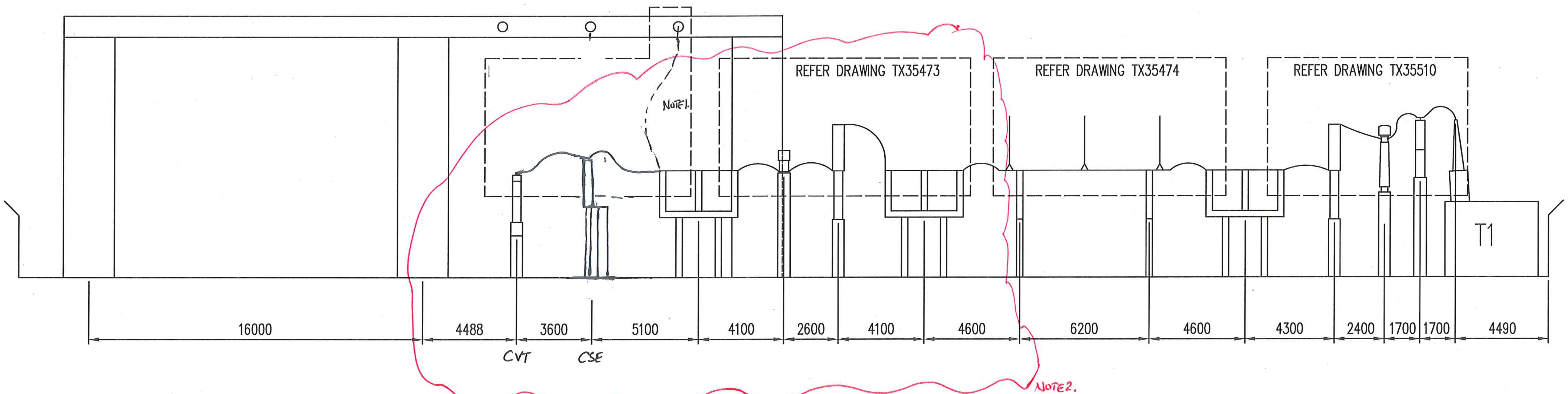
220kV RELAY & INSTRUMENTATION DIAGRAM (OPERATING)

SCALE N.T.S.
FOLDER S30/2C1.1
DRAWING NUMBER TX35516
REVISION J
CAD FILE NAME 35666/TX35516.dwg

A1

DRAWING NUMBER TX35516

PLANT NORTH



SECTION A–A

DRAWINGS FOR OTHER PHASES, FOLDER S30/3C3		
	CVT202	CVT202
R PHASE	TX35507	TX35472
Y PHASE	TX35508	TX35471
B PHASE	TX35506	TX35470

NOTES

1. DOTTED CONNECTION SHOWS POSSIBLE EMERGENCY CONNECTION IN CASE OF CABLE FAILURE.
2. SIMILAR BAY ARRST AT PENROSE.

REFERENCE DRAWINGS

TX35505	220kV CONNECTIONS: EQUIPMENT SCHEDULE AND DETAILS	(S30/3c3)
TX35475	ALUMINIUM BUSBAR DETAILS ELEVATION B–B	(S30/3c3)
TX35511	220kV CONNECTIONS: SCL EQUIPMENT SCHEDULE AND DETAILS	(S30/3c3)

ALL DIMENSIONS ARE IN MILLIMETRES

REV	AMENDMENT	CONTRACTOR	DSN	DRN	CHKD	QC CHKD	APPD	T.P. APPD
1	WAS ON TX35456 ISSUE –.	DP HAMILTON		ZD 3.96				
A	NOTES REMOVED	DP HAMILTON		WB 3.96	JS 4.96		SM 4.96	
B	FENCE HAS MOVED.	DP HAMILTON		ZD 4.96		JS 4.96	SM 5.96	
C	AS BUILT: CT ADDED.	DESIGNPOWER		ZD 4.97	CEL 4.97	JS 4.97	JS 4.97	MJ 9.97
D	SWN COMMS UPGRADE LINE TRAPS REMOVED (6680738)	MAUNSELL	EJS 3.04	PGJ 3.04	MA 3.04	DB 3.04	RC 3.04	
E	As Built C/SWN/1542 No Change	MAUNSELL	JP 6.04	NS 7.04	MA 7.04	–	–	RC 7.04	SJW 7.04

DESIGNED	R. LOVELESS	3.96
DRAWN	Z. DRACA	3.96
CHECKED	R. LOVELESS	3.96
QC CHECKED	A. BURNS	3.96
APPROVED	S. MUTTON	3.96
TP APPROVED		

PREPARED BY: DESIGNPOWER
P.O. BOX 1037 HAMILTON PH. 0-7-8390840

TRANSPOWER

SOUTHDOWN 220kV SUBSTATION

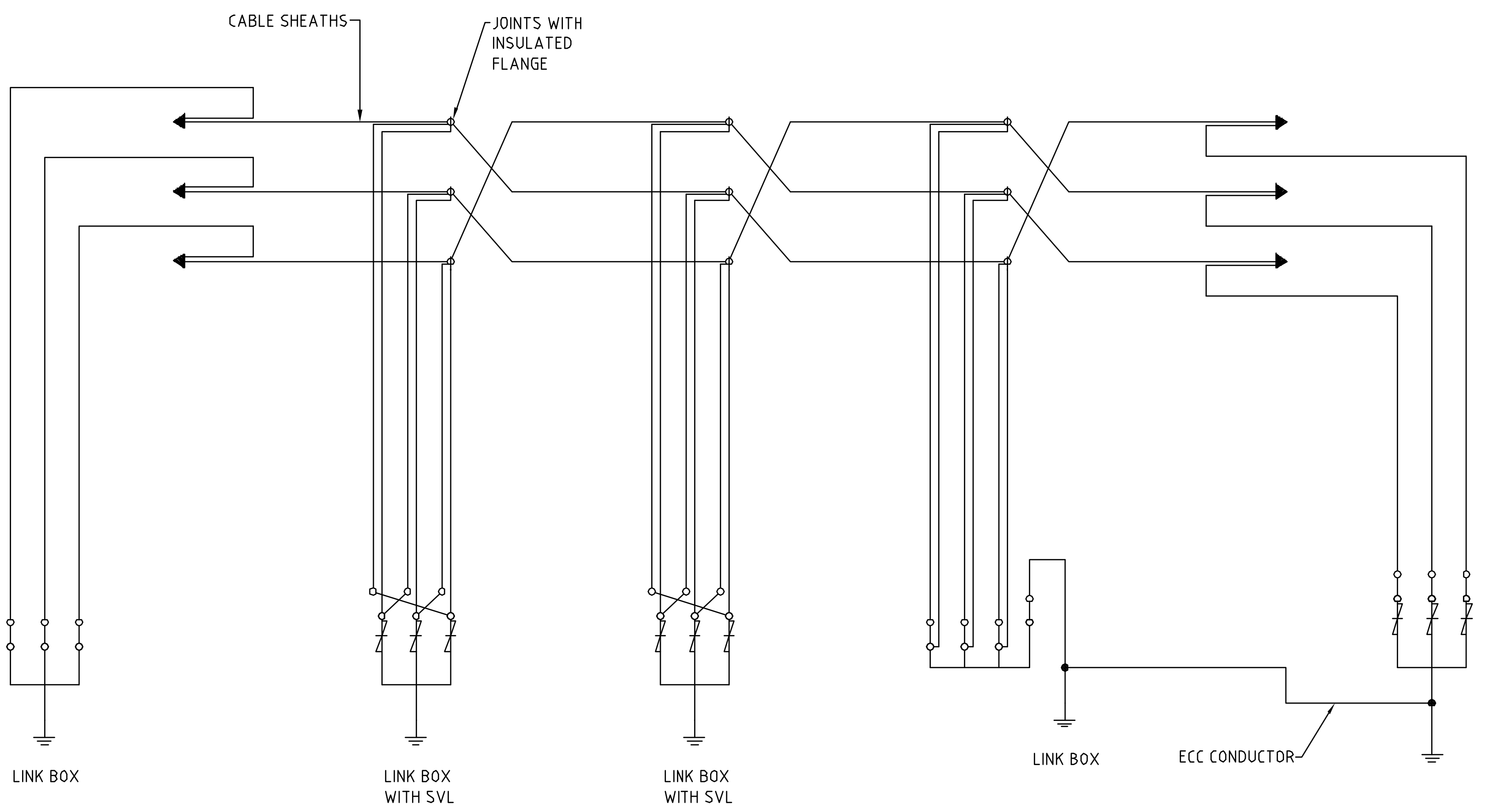
220kV STRUCTURE SECTION A–A

SCALE 1:100
FOLDER S30/3a1
TX35456/2
ISSUE E
CAD FILE NAME \35666\X35456_2.DWG

A1

DRAWING No. TX35456/2

Appendix D Typical Cable Design Drawings & Proposed Cable Info



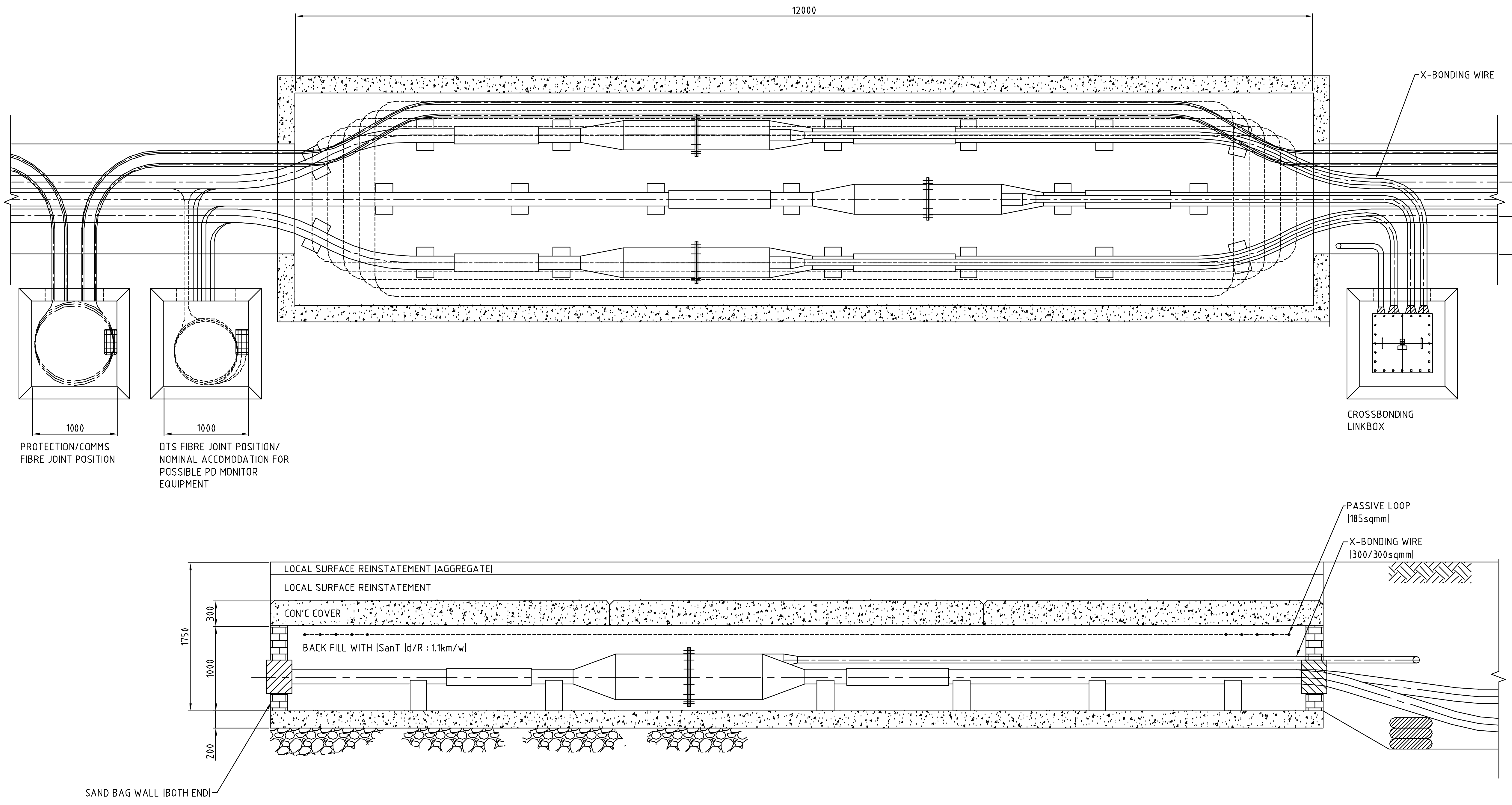
CLIENT: MIGHTY RIVER POWER

PROJECT: SOUTHDOWN TO PENROSE 220kV CABLE PROJECT

TITLE: TYPICAL SHEATH BONDING ARRGT

DRAWN	DRAFTING CHECK	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
DESIGNED DEB	DESIGN REVIEW AVM	REF	NAM

SCALE	PROJECT No	DRAWING No	REV
	ZP00777	ZP00777-002	A



NO	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.D.R	REVISION
-					

REF	DRAWING NUMBER	REFERENCE DRAWING TITLE

SKM

Sinclair Knight Merz Ltd.
Carlaw Park Commercial
12-16 Nicholls Lane
Parnell, Auckland
NEW ZEALAND

Tel: +64 9 928 5000
Fax: +64 9 928 5001
Web: www.skmconsulting.com

CLIENT: MIGHTY RIVER POWER

PROJECT: SOUTHDOWN TO PENROSE 220kV CABLE PROJECT

DRAWN	DRAFTING CHECK	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
		REF	RAM
DESIGNED DEB	DESIGN REVIEW AMW		

TITLE

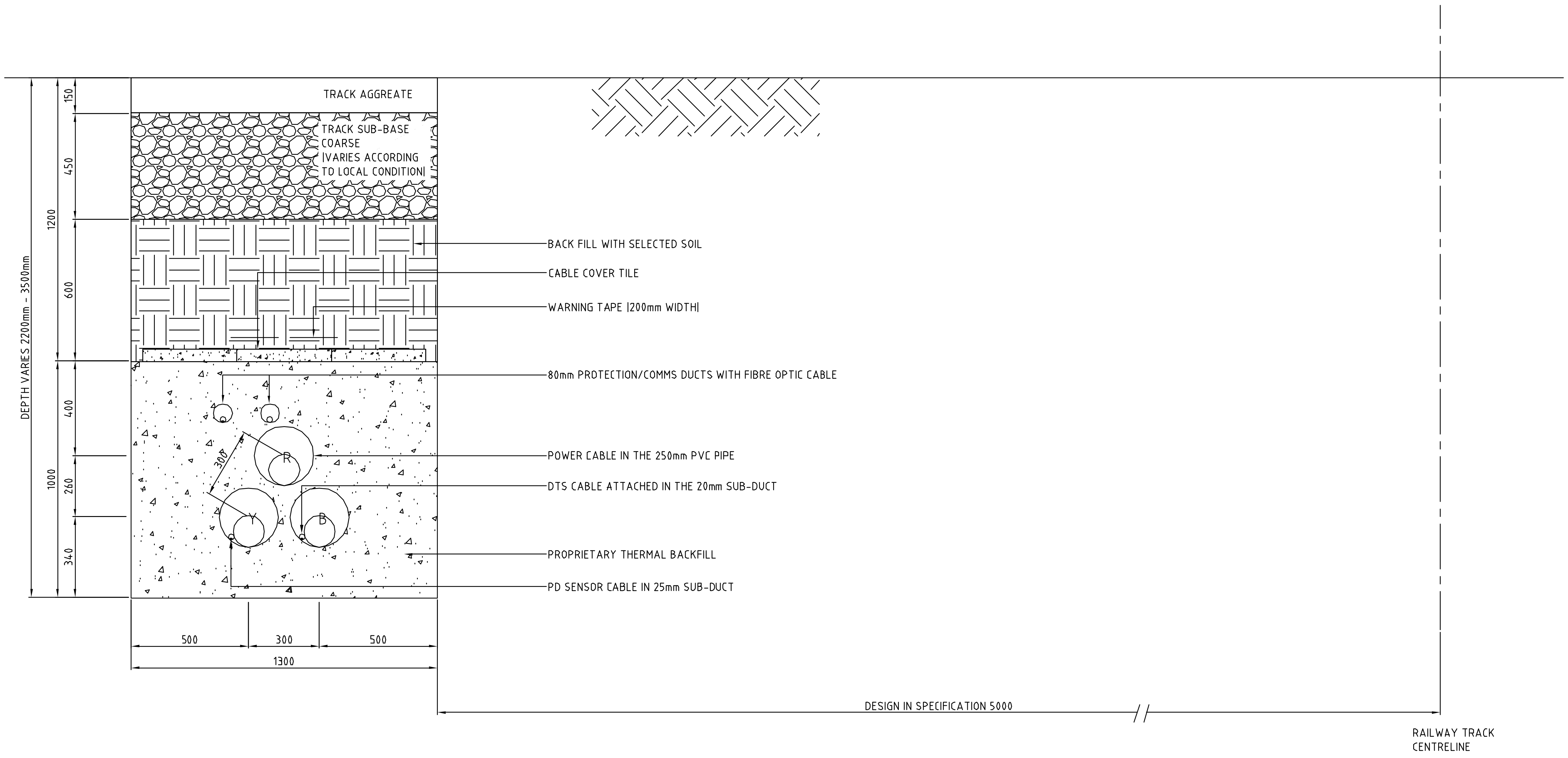
TYPICAL JOINT BAY

SCALE	PROJECT No	DRAWING No	REV
	ZP00777	ZP00777-003	A

A1

NOTES

1. NOMINAL CABLE SEPARATION ASSUMED. TO BE CONFIRMED BY CABLE CONTRACTOR AS PART OF DETAILED DESIGN.



NO	DATE	DESIGN REVIEW	REVD PMGR	APPD PDR	REVISION
-					

REF	DRAWING NUMBER	REFERENCE DRAWING TITLE

SKM
Sinclair Knight Merz Ltd.
Carlaw Park Commercial
12-16 Nicholls Lane
Parnell, Auckland
NEW ZEALAND
Tel: +64 9 928 5500
Fax: +64 9 928 5501
Web: www.skmconsulting.com

CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN TO PENROSE 220kV CABLE PROJECT

DRAWN	DRAFTING CHECK	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
DESIGNED DEE	DESIGN REVIEW AVM	REF	NAM

TITLE: TYPICAL CABLE TRENCH

SCALE	PROJECT No	DRAWING No	REV
	ZP00777	ZP00777-001	A

A1

I:\ZPINA\Projects\ZP00777\DELIVERABLES\Drawings\Civil\Dwg\ZP11777-DRG-ELEC-111.dwg Plot Date: 25 June, 2010 - 1:19 PM

Olex Australia Pty Limited
ABN 61 087 542 863
207 Sunshine Road, Tottenham
Victoria, 3012, Australia
Facsimile +61 3 9314 0383
Telephone +61 3 9281 4444
www.olex.com.au

Customer: SKM 26/05/2010
Reference: 20019892 Item 30

DESCRIPTION: 1 Conductor 1600 mm2 Milliken Sector Plain Annealed Copper, Semiconductive Conductor Screen (1 mm nom wall), 127/220 kV Superclean XLPE Insulated (25.0 mm nom wall), Semiconductive Insulation Screen (1 mm nom wall), Water blocking screen taped, Corrugated Aluminium (2.8 mm) Sheath, HD Polyethylene Sheathed (4.6 mm nom wall), Graphite Coated, Generally to IEC 62067.

Ident Number: **5699,029996,01,3712** Marketing Code: not available

Colour Code:

Insulation	Natural
Sheath	Black

Physical Properties:

Cable dimensions :

Overall cable diameter:	132.1 mm nom ± 0.6 mm
Depth over insulation :	102.3 mm
Conductor Diameter :	49.7 mm
Net mass of cable:	26126 kg/km

Recommended minimum internal bending radius :

Pulling In :	3300 mm
Set in Position :	2000 mm

Recommended maximum safe pulling/working tension :

Conductors :	20.0 kN

Electrical Properties:

Maximum conductor resistance =	0.0113 ohm/km
Minimum insulation resistance =	11650 megohm.km
Capacitance of main conductor =	0.190 μF/km

Despatch Parameters:

Lengths	3 x 918 m
Internal drum size	4300 mm x 2600 mm B x 2400 mm
Overall drum size	4300 mm x 2620 mm (Steel Drum)
Gross mass per drum	26006 kg
Minimum barrel diameter	2580 mm

Subject to change without notice

V030829

1600 mm² Cu 127/220 kV XLPE CAS/HDPE

Conductor	No. of cables	3	
	Material	Plain Annealed Copper	
	Form	Milliken	
	Area	1600	mm²
	No. of wires	61	
	Wire diameter	N/A	mm
	Rdc at 20°C	0.0113	Ohm/km
	Diameter	49.7	mm
Conductor screen	Diameter	52.3	mm
Insulation	Material	XLPE (HV)	
	Vpe	127	kV
	Vpp	220	kV
	Diameter	102.30	mm
Insulation screen	Diameter	104.30	mm

Core screen 1	Type	Corrugated aluminium	
	Thickness		
	2.8		
	Diameter	122.90	mm
Core screen 2	Type	None	
	Diameter		mm
Armour bedding	Material	None	
	Diameter		mm
Armour	Type	None	
	Diameter		mm
Sheath	Material	HDPE	
	Diameter	132.10	mm
Covering	Material	None	
	Diameter		mm

PERFORMANCE DATA

		Cables, trefoil touching	Cables, flat touching	Cables, flat spaced	Ducts, trefoil touching	Ducts, flat touching	Ducts, flat spaced	
Conductor ac resistance at 90°C		0.0158		0.0155	0.0156		0.0155	Ohm/km
Inductive reactance		0.1211	0.1424	0.1881	0.1546	0.1776	0.2232	Ohm/km
Cable pf		0.1295	0.1104	0.0823	0.1001	0.0873	0.0691	
3p volt drop	- maximum	0.2115	0.2481	0.3268	0.2691	0.3087	0.3876	mV/A.m
	- at load pf	0.1478	0.1699	0.2170	0.1822	0.2061	0.2534	mV/A.m

Core screen 1	- dc resistance at 20°C	0.0284	Ohm/km
	- dc resistance at 90°C	0.0364	Ohm/km
Core screen 2	- dc resistance at 20°C	0.0000	Ohm/km
	- dc resistance at 90°C	0.0000	Ohm/km
Armour	- dc resistance at 20°C	0.0000	Ohm/km
	- dc resistance at 90°C	0.0000	Ohm/km

Conductor to screen capacitance	0.190	µF/km
Charging current	7.60	A/km/phase
Dielectric loss	965	W/km/phase
Zero sequence resistance at 20°C	0.0410	Ohm/km
Zero sequence resistance at 90°C	0.0519	Ohm/km
Zero sequence reactance	0.0682	Ohm/km
Surge impedance	26.5	Ohm

MATERIAL PROPERTIES

Insulation	- thermal resistivity	3.5	K.m/W
	- relative permittivity	2.3	
	- loss factor	0.001	
	- solar absorption coefficient	0.4	
Armour bedding thermal resistivity		N/A	K.m/W
Sheath	- thermal resistivity	3.5	K.m/W
	- solar absorption coefficient	0.4	
Covering	- thermal resistivity	N/A	K.m/W
	- solar absorption coefficient	N/A	
Duct in air	- thermal resistivity	6.0	K.m/W
	- solar absorption coefficient	0.6	
Duct in ground thermal resistivity		6.0	K.m/W

Ducts	Type in air	PVC		
	Type in ground	PVC		
		Nominal size	Actual OD, mm	Actual ID, mm
In air	Single cable	200 mm	225.3	201.6
	Three cables	250 mm	280.4	251
In ground	Single cable	200 mm	225.3	201.6
	Three cables	250 mm	280.4	251

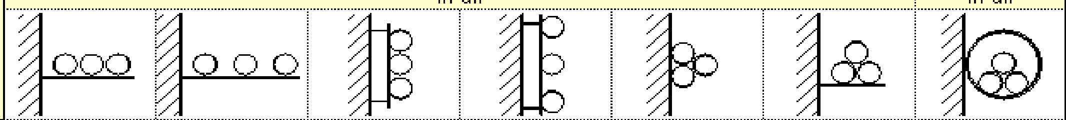
OPERATING CONDITIONS

Supply frequency		50	Hz
Load power factor		0.8	
Conductor operating temperature		90	°C
Ambient air temperature		40	°C
Solar radiation intensity			W/m²
Ambient ground temperature		25	°C
Depth of burial, to cable/group axis		1200	mm
Thermal resistivity of ground		1.2	K.m/W
Backfill	- thermal resistivity	1.2	K.m/W
	- envelope width	1000	mm
	- envelope depth	450	mm
Non standard axial spacing between cables			mm
Non standard axial spacing between ducts			mm
Screen bonding		Bonded at both ends	

CURRENT RATINGS

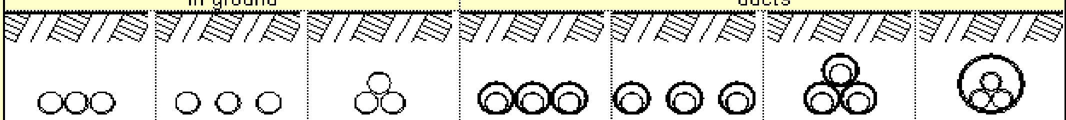
Thermal resistances		
- Insulation	0.4129	K.m/W
- Bedding	0.0000	K.m/W
- Sheath	0.0402	K.m/W
- Covering	0.0000	K.m/W

Unenclosed in air / Enclosed in air



		Unenclosed in air						Enclosed in air
Continuous current rating	A	1321	1503	1301	1437	1329	1415	888
External thermal resistance	K.m/W	0.3716	0.2508	0.3883	0.2894	0.4862	0.4067	1.3161
Cable surface temperature	°C	63	58	63	59	66	64	77
Screen loss factor		2.3401	2.4315	2.3401	2.4315	1.5645	1.5645	1.5645
Armour loss factor		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Direct in ground / Underground ducts



		Direct in ground			Underground ducts			
Continuous current rating	A	816	838	899	805	833	823	791
External thermal resistance	K.m/W	1.6327	1.5312	1.6976	1.6646	1.5666	1.8224	2.2661
Cable surface temperature	°C	76	75	76	76	75	77	79
Screen loss factor		2.3401	2.4315	1.5645	2.4325	2.4164	1.9891	1.5645
Armour loss factor		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

V030829

1600 mm² Cu 127/220 kV XLPE CAS/HDPE

Conductor	No. of cables	3	
	Material	Plain Annealed Copper	
	Form	Milliken	
	Area	1600	mm²
	No. of wires	61	
	Wire diameter	N/A	mm
	Rdc at 20°C	0.0113	Ohm/km
	Diameter	49.7	mm
Conductor screen	Diameter	52.3	mm
Insulation	Material	XLPE (HV)	
	Vpe	127	kV
	Vpp	220	kV
	Diameter	102.30	mm
Insulation screen	Diameter	104.30	mm

Core screen 1	Type	Corrugated aluminium		
	Thickness			
	2.8			
	Diameter	122.90	mm	
Core screen 2	Type	None		
	Diameter		mm	
Armour bedding	Material	None		
	Diameter		mm	
Armour	Type	None		
	Diameter		mm	
Sheath	Material	HDPE		
	Diameter	132.10	mm	
Covering	Material	None		
	Diameter		mm	

PERFORMANCE DATA

		Cables, trefoil touching	Cables, flat touching	Cables, flat spaced	Ducts, trefoil touching	Ducts, flat touching	Ducts, flat spaced	
Conductor ac resistance at 90°C		0.0158		0.0155	0.0156		0.0155	Ohm/km
Inductive reactance		0.1211	0.1424	0.1881	0.1546	0.1776	0.2232	Ohm/km
Cable pf		0.1295	0.1104	0.0823	0.1001	0.0873	0.0691	
3p volt drop	- maximum	0.2115	0.2481	0.3268	0.2691	0.3087	0.3876	mV/A.m
	- at load pf	0.1478	0.1699	0.2170	0.1822	0.2061	0.2534	mV/A.m

Core screen 1	- dc resistance at 20°C	0.0284	Ohm/km
	- dc resistance at 90°C	0.0364	Ohm/km
Core screen 2	- dc resistance at 20°C	0.0000	Ohm/km
	- dc resistance at 90°C	0.0000	Ohm/km
Armour	- dc resistance at 20°C	0.0000	Ohm/km
	- dc resistance at 90°C	0.0000	Ohm/km

Conductor to screen capacitance	0.190	μF/km
Charging current	7.60	A/km/phase
Dielectric loss	965	W/km/phase
Zero sequence resistance at 20°C	0.0410	Ohm/km
Zero sequence resistance at 90°C	0.0519	Ohm/km
Zero sequence reactance	0.0682	Ohm/km
Surge impedance	26.5	Ohm

MATERIAL PROPERTIES

Insulation	- thermal resistivity	3.5	K.m/W
	- relative permittivity	2.3	
	- loss factor	0.001	
	- solar absorption coefficient	0.4	
Armour bedding thermal resistivity		N/A	K.m/W
Sheath	- thermal resistivity	3.5	K.m/W
	- solar absorption coefficient	0.4	
Covering	- thermal resistivity	N/A	K.m/W
	- solar absorption coefficient	N/A	
Duct in air	- thermal resistivity	6.0	K.m/W
	- solar absorption coefficient	0.6	
Duct in ground thermal resistivity		6.0	K.m/W

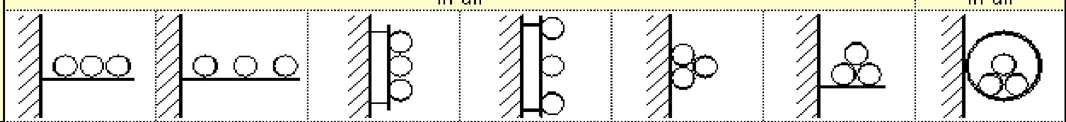
Ducts	Type in air	PVC		
	Type in ground	PVC		
		Nominal size	Actual OD, mm	Actual ID, mm
In air	Single cable	200 mm	225.3	201.6
	Three cables	250 mm	280.4	251
In ground	Single cable	200 mm	225.3	201.6
	Three cables	250 mm	280.4	251

OPERATING CONDITIONS

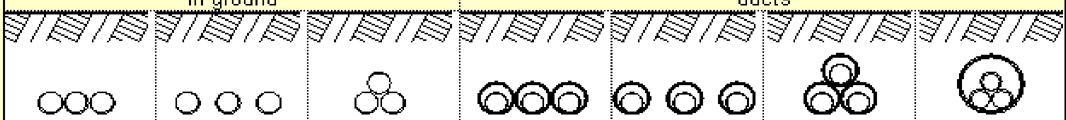
Supply frequency		50	Hz
Load power factor		0.8	
Conductor operating temperature		90	°C
Ambient air temperature		40	°C
Solar radiation intensity			W/m²
Ambient ground temperature		25	°C
Depth of burial, to cable/group axis		1200	mm
Thermal resistivity of ground		1.2	K.m/W
Backfill	- thermal resistivity	1.2	K.m/W
	- envelope width	1000	mm
	- envelope depth	450	mm
Non standard axial spacing between cables			mm
Non standard axial spacing between ducts			mm
Screen bonding		Single point bonded	

CURRENT RATINGS

Thermal resistances		
- Insulation	0.4129	K.m/W
- Bedding	0.0000	K.m/W
- Sheath	0.0402	K.m/W
- Covering	0.0000	K.m/W



		Unenclosed in air						Enclosed in air
Continuous current rating	A	1531	2010	1510	1949	1564	1652	1079
External thermal resistance	K.m/W	0.3716	0.2508	0.3883	0.2894	0.4862	0.4067	1.3161
Cable surface temperature	°C	63	58	63	59	66	64	77
Screen loss factor		1.2326	0.2932	1.2326	0.2932	0.6356	0.6356	0.6356
Armour loss factor		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000



		Direct in ground			Underground ducts			
Continuous current rating	A	981	1291	1100	1202	1369	1235	972
External thermal resistance	K.m/W	1.6327	1.5312	1.6976	1.6646	1.5666	1.8224	2.2661
Cable surface temperature	°C	76	75	76	76	75	77	79
Screen loss factor		1.2326	0.2932	0.6356	0.4054	0.1009	0.2036	0.6356
Armour loss factor		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

V030829

1600 mm² Cu 127/220 kV XLPE CAS/HDPE

Conductor	No. of cables	3	
	Material	Plain Annealed Copper	
	Form	Milliken	
	Area	1600	mm²
	No. of wires	61	
	Wire diameter	N/A	mm
	Rdc at 20°C	0.0113	Ohm/km
	Diameter	49.7	mm
Conductor screen	Diameter	52.3	mm
Insulation	Material	XLPE (HV)	
	Vpe	127	kV
	Vpp	220	kV
	Diameter	102.30	mm
Insulation screen	Diameter	104.30	mm

Core screen 1	Type	Corrugated aluminium		
	Thickness			
	2.8			
	Diameter	122.90	mm	
Core screen 2	Type	None		
	Diameter		mm	
Armour bedding	Material	None		
	Diameter		mm	
Armour	Type	None		
	Diameter		mm	
Sheath	Material	HDPE		
	Diameter	132.10	mm	
Covering	Material	None		
	Diameter		mm	

PERFORMANCE DATA

		Cables, trefoil touching	Cables, flat touching	Cables, flat spaced	Ducts, trefoil touching	Ducts, flat touching	Ducts, flat spaced	
Conductor ac resistance at 90°C		0.0158		0.0155	0.0156		0.0155	Ohm/km
Inductive reactance		0.1211	0.1424	0.1881	0.1546	0.1776	0.2232	Ohm/km
Cable pf		0.1295	0.1104	0.0823	0.1001	0.0873	0.0691	
3p volt drop	- maximum	0.2115	0.2481	0.3268	0.2691	0.3087	0.3876	mV/A.m
	- at load pf	0.1478	0.1699	0.2170	0.1822	0.2061	0.2534	mV/A.m

Core screen 1	- dc resistance at 20°C	0.0284	Ohm/km
	- dc resistance at 90°C	0.0364	Ohm/km
Core screen 2	- dc resistance at 20°C	0.0000	Ohm/km
	- dc resistance at 90°C	0.0000	Ohm/km
Armour	- dc resistance at 20°C	0.0000	Ohm/km
	- dc resistance at 90°C	0.0000	Ohm/km

Conductor to screen capacitance	0.190	µF/km
Charging current	7.60	A/km/phase
Dielectric loss	965	W/km/phase
Zero sequence resistance at 20°C	0.0410	Ohm/km
Zero sequence resistance at 90°C	0.0519	Ohm/km
Zero sequence reactance	0.0682	Ohm/km
Surge impedance	26.5	Ohm

MATERIAL PROPERTIES

Insulation	- thermal resistivity	3.5	K.m/W
	- relative permittivity	2.3	
	- loss factor	0.001	
	- solar absorption coefficient	0.4	
Armour bedding thermal resistivity		N/A	K.m/W
Sheath	- thermal resistivity	3.5	K.m/W
	- solar absorption coefficient	0.4	
Covering	- thermal resistivity	N/A	K.m/W
	- solar absorption coefficient	N/A	
Duct in air	- thermal resistivity	6.0	K.m/W
	- solar absorption coefficient	0.6	
Duct in ground thermal resistivity		6.0	K.m/W

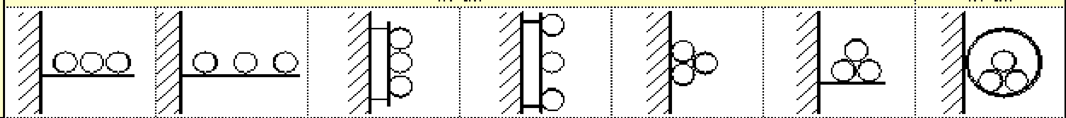
Ducts	Type in air	PVC		
	Type in ground	PVC		
		Nominal size	Actual OD, mm	Actual ID, mm
In air	Single cable	200 mm	225.3	201.6
	Three cables	250 mm	280.4	251
In ground	Single cable	200 mm	225.3	201.6
	Three cables	250 mm	280.4	251

OPERATING CONDITIONS

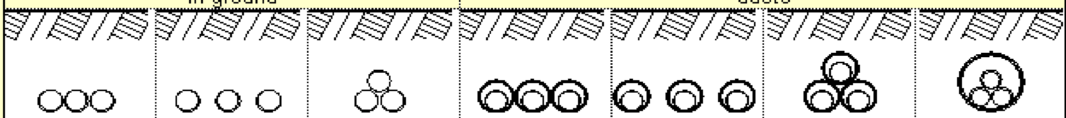
Supply frequency		50	Hz
Load power factor		0.8	
Conductor operating temperature		90	°C
Ambient air temperature		40	°C
Solar radiation intensity			W/m²
Ambient ground temperature		25	°C
Depth of burial, to cable/group axis		1200	mm
Thermal resistivity of ground		1.2	K.m/W
Backfill	- thermal resistivity	1.2	K.m/W
	- envelope width	1000	mm
	- envelope depth	450	mm
Non standard axial spacing between cables			mm
Non standard axial spacing between ducts			mm
Screen bonding		Cross bonded	

CURRENT RATINGS

Thermal resistances		
- Insulation	0.4129	K.m/W
- Bedding	0.0000	K.m/W
- Sheath	0.0402	K.m/W
- Covering	0.0000	K.m/W

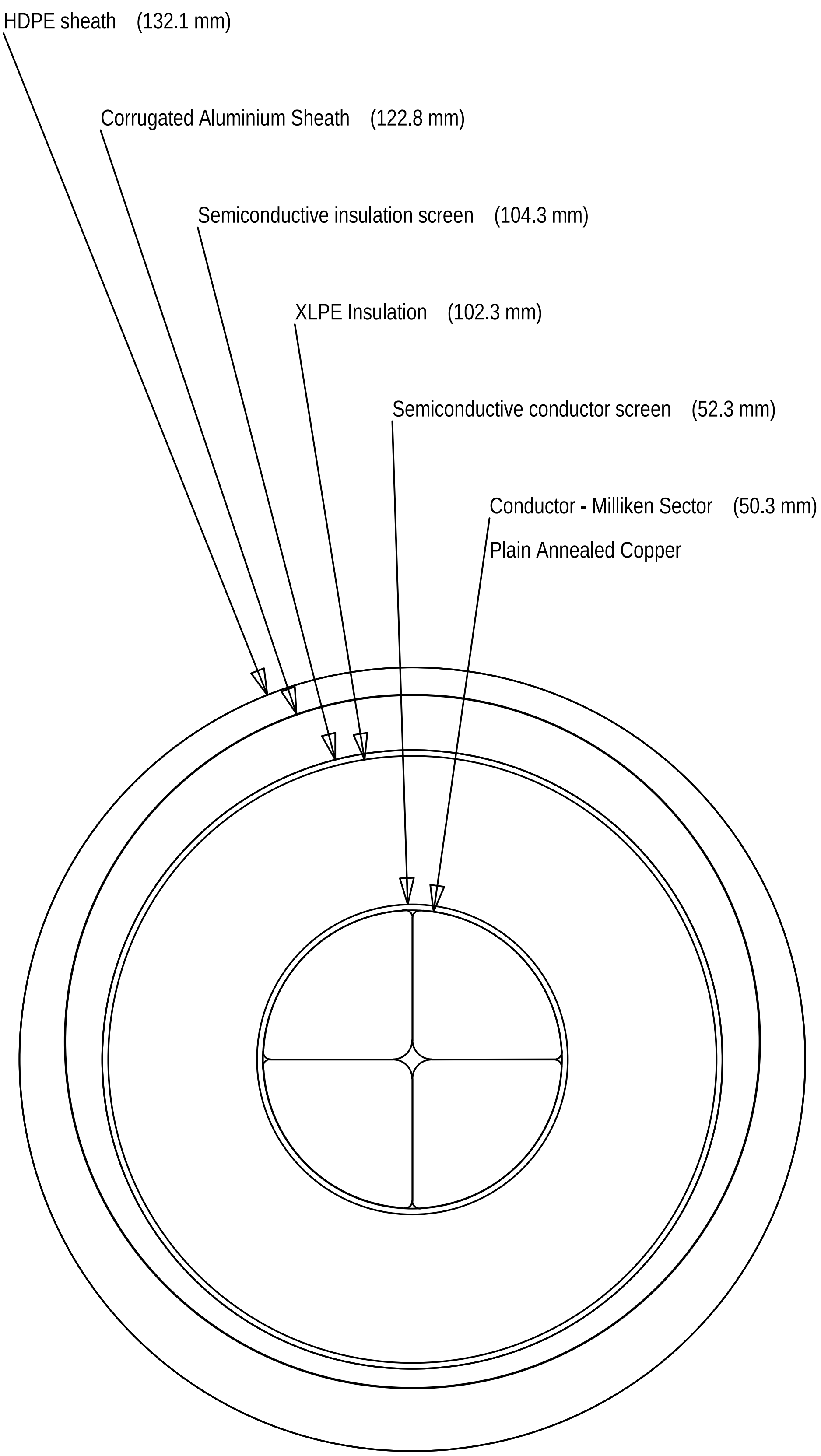


		Unenclosed in air						Enclosed in air
Continuous current rating	A	1531	2010	1510	1949	1564	1652	1079
External thermal resistance	K.m/W	0.3716	0.2508	0.3883	0.2894	0.4862	0.4067	1.3161
Cable surface temperature	°C	63	58	63	59	66	64	77
Screen loss factor		1.2326	0.2932	1.2326	0.2932	0.6356	0.6356	0.6356
Armour loss factor		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000



		Direct in ground			Underground ducts			
Continuous current rating	A	975	1279	1092	1184	1345	1214	959
External thermal resistance	K.m/W	1.6327	1.5312	1.6976	1.6646	1.5666	1.8224	2.2661
Cable surface temperature	°C	76	75	76	76	75	77	79
Screen loss factor		1.2626	0.3232	0.6656	0.4554	0.1509	0.2536	0.6856
Armour loss factor		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

20019892 Item 30



Overall Diameter:
132.1 ± 0.6 mm
Net Mass:
26126 kg/km

<u>DESCRIPTION:</u> 1 Conductor 1600 mm2 Milliken Sector Plain Annealed Copper, Semiconductive Conductor Screen (1 mm nom wall), 127/220 kV Superclean XLPE Insulated (25.0 mm nom wall), Semiconductive Insulation Screen (1 mm nom wall), Water blocking screen taped, Corrugated Aluminium (2.8 mm) Sheath, HD Polyethylene Sheathed (4.6 mm nom wall), Graphite Coated, Generally to IEC 62067.

Olex a Nexans company

Olex Australia Pty Limited
207 SUNSHINE ROAD, TOTTENHAM

Prepared: S Pollauszach	26 May 10
Approved:	Scale: 0.9 x full size

IDENT: 5699,029996,01,3712

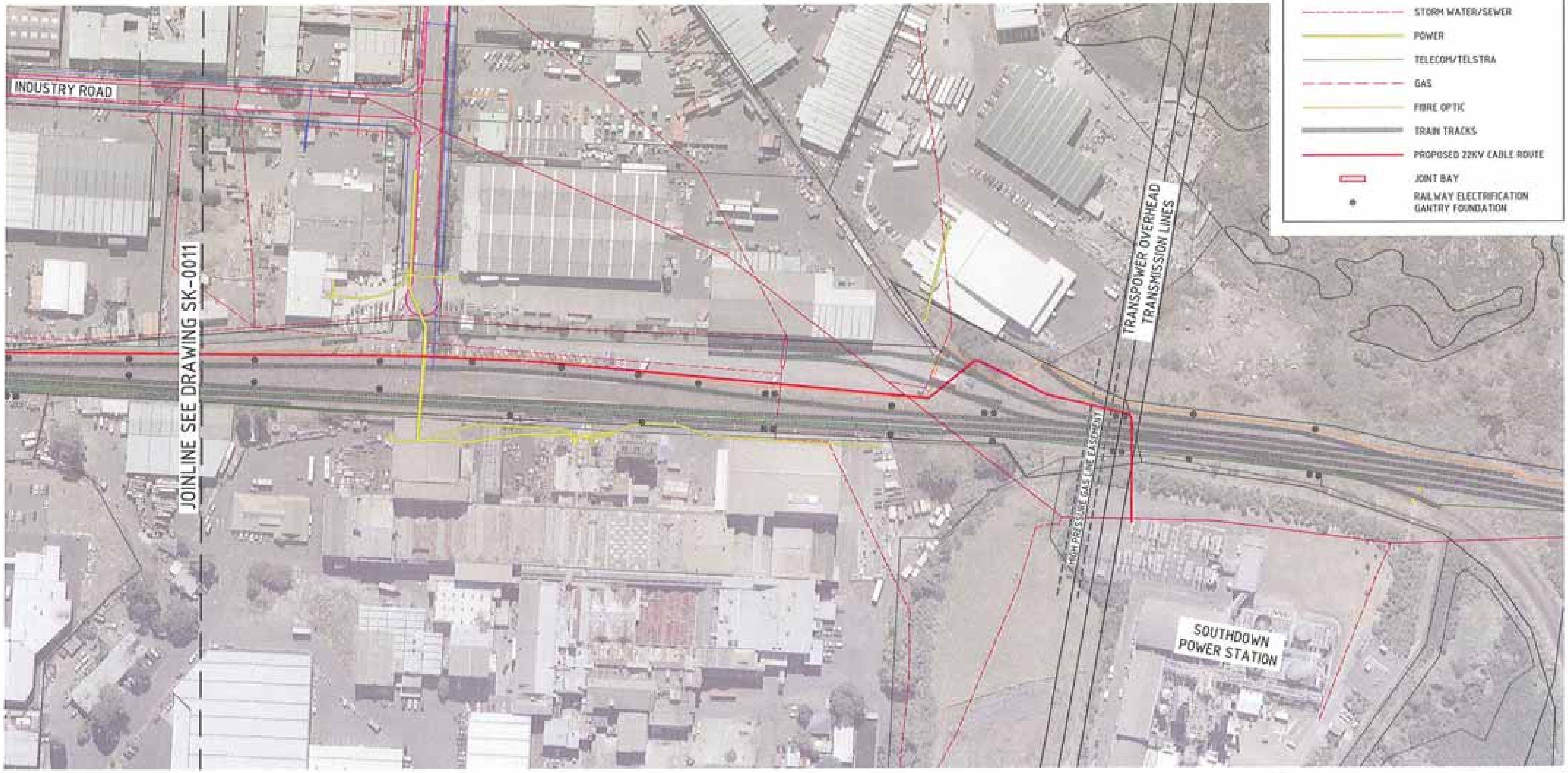
Appendix E Civil Cable Route Drawings

NOTES

1. THE POSITION OF RAILWAY ELECTRIFICATION GANTRIES IS PRELIMINARY AND SUBJECT TO FINAL DESIGN BY KIWIRAIL. DO NOT USE FOR DETAIL DESIGN.

LEGEND

- BOUNDARY
- RAILWAY BOUNDARY
- WATER SUPPLY
- WASTE WATER
- STORM WATER/SEWER
- POWER
- TELECOM/TELSTRA
- GAS
- FIBRE OPTIC
- TRAIN TRACKS
- PROPOSED 22KV CABLE ROUTE
- JOINT BAY
- RAILWAY ELECTRIFICATION GANTRY FOUNDATION



ISSUED FOR CLIENT REVIEW

SCALE 1:1000 (A1) 20 10 0 20 40 60 80 100m

REV	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.DIR	AMENDMENT
A					ISSUED FOR CLIENT REVIEW

SKM

CLIENT: MIGHTY RIVER POWER

PROJECT: SOUTHDOWN PDA PROJECT

DRAWN: JMD | DRAFTING CHECK: SDH | REVIEWED PROJECT MANAGER: RP | APPROVED PROJECT DIRECTOR: RM

DESIGNED: SDH | DESIGN REVIEW: AG

TITLE: PROPOSED 220KV CABLE ROUTE SHEET 1 OF 5

SCALE: 1:1000(A1) | PROJECT No: ZP00777 | DRAWING No: ZP00777-SK-0010 | REV: A

A1

NOTES

1. THE POSITION OF RAILWAY ELECTRIFICATION GANTRIES IS PRELIMINARY AND SUBJECT TO FINAL DESIGN BY KIWIRAIL. DO NOT USE FOR DETAIL DESIGN.

LEGEND

- BOUNDARY
- RAILWAY BOUNDARY
- WATER SUPPLY
- WASTE WATER
- STORM WATER/SEWER
- POWER
- TELECOM/TELSTRA
- GAS
- FIBRE OPTIC
- TRAIN TRACKS
- PROPOSED 22KV CABLE ROUTE
- JOINT BAY
- RAILWAY ELECTRIFICATION GANTRY FOUNDATION

ISSUED FOR CLIENT REVIEW

SCALE 1:1000 (A1) 20 10 0 20 40 60 80 100m

A	ISSUED FOR CLIENT REVIEW

SKM

CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN PDA PROJECT

DRAWN: JMO | DRAFTING CHECK: SDH | REVIEWED PROJECT MANAGER: RP | APPROVED PROJECT DIRECTOR: RM
DESIGNED: SDH | DESIGN REVIEW: AG

TITLE: PROPOSED 220KV CABLE ROUTE
SHEET 2 OF 5

SCALE: 1:1000(A1) | PROJECT No: ZP00778 | DRAWING No: ZP00777-SK-0011 | REV: A

A1

NOTES

1. THE POSITION OF RAILWAY ELECTRIFICATION GANTRIES IS PRELIMINARY AND SUBJECT TO FINAL DESIGN BY KIWIRAIL. DO NOT USE FOR DETAIL DESIGN.

LEGEND

- BOUNDARY
- RAILWAY BOUNDARY
- WATER SUPPLY
- WASTE WATER
- STORM WATER/SEWER
- POWER
- TELECOM/TELSTRA
- GAS
- FIBRE OPTIC
- TRAIN TRACKS
- PROPOSED 22KV CABLE ROUTE
- JOINT BAY
- RAILWAY ELECTRIFICATION GANTRY FOUNDATION

ISSUED FOR CLIENT REVIEW

SCALE 1:1000 (A1) 20 10 0 20 40 60 80 100m

REV	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.DIR	AMENDMENT
A					ISSUED FOR CLIENT REVIEW

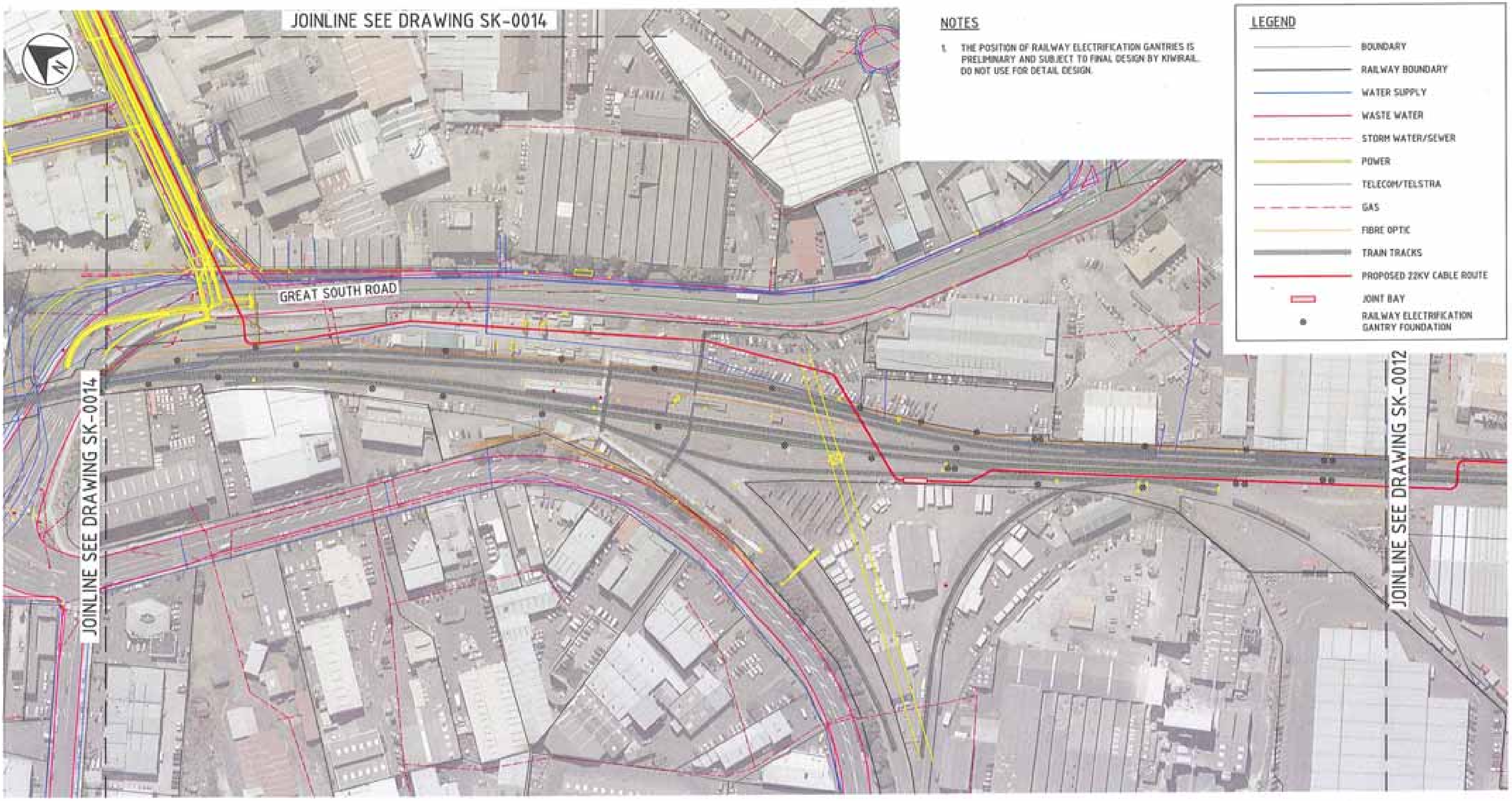
SKM

CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN PDA PROJECT

DRAWN: JMD | DRAFTING CHECK: SDH | REVIEWED PROJECT MANAGER: RP | APPROVED PROJECT DIRECTOR: RM
DESIGNED: SDH | DESIGN REVIEW: AG

TITLE: PROPOSED 220KV CABLE ROUTE
SHEET 3 OF 5

SCALE: 1:1000(A1) | PROJECT No: ZP00779 | DRAWING No: ZP00777-SK-0012 | REV: A



NOTES

1. THE POSITION OF RAILWAY ELECTRIFICATION GANTRIES IS PRELIMINARY AND SUBJECT TO FINAL DESIGN BY KIWIRAIL. DO NOT USE FOR DETAIL DESIGN.

LEGEND

- BOUNDARY
- RAILWAY BOUNDARY
- WATER SUPPLY
- WASTE WATER
- STORM WATER/SEWER
- POWER
- TELECOM/TELSTRA
- GAS
- FIBRE OPTIC
- TRAIN TRACKS
- PROPOSED 22KV CABLE ROUTE
- JOINT BAY
- RAILWAY ELECTRIFICATION GANTRY FOUNDATION

ISSUED FOR CLIENT REVIEW

SCALE 1:1000 (A1) 20 10 0 20 40 60 80 100m

REV	DATE	AMENDMENT
A		ISSUED FOR CLIENT REVIEW

SKM

CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN PDA PROJECT

DRAWN: JMD | DRAFTING CHECK: SDH | REVIEWED PROJECT MANAGER: RF | APPROVED PROJECT DIRECTOR: RM
DESIGNED: SDH | DESIGN REVIEW: AO

TITLE: PROPOSED 220KV CABLE ROUTE SHEET 4 OF 5

SCALE: 1:1000(A1) | PROJECT No: ZP00780 | DRAWING No: ZP00777-SK-0013 | AMDT: A

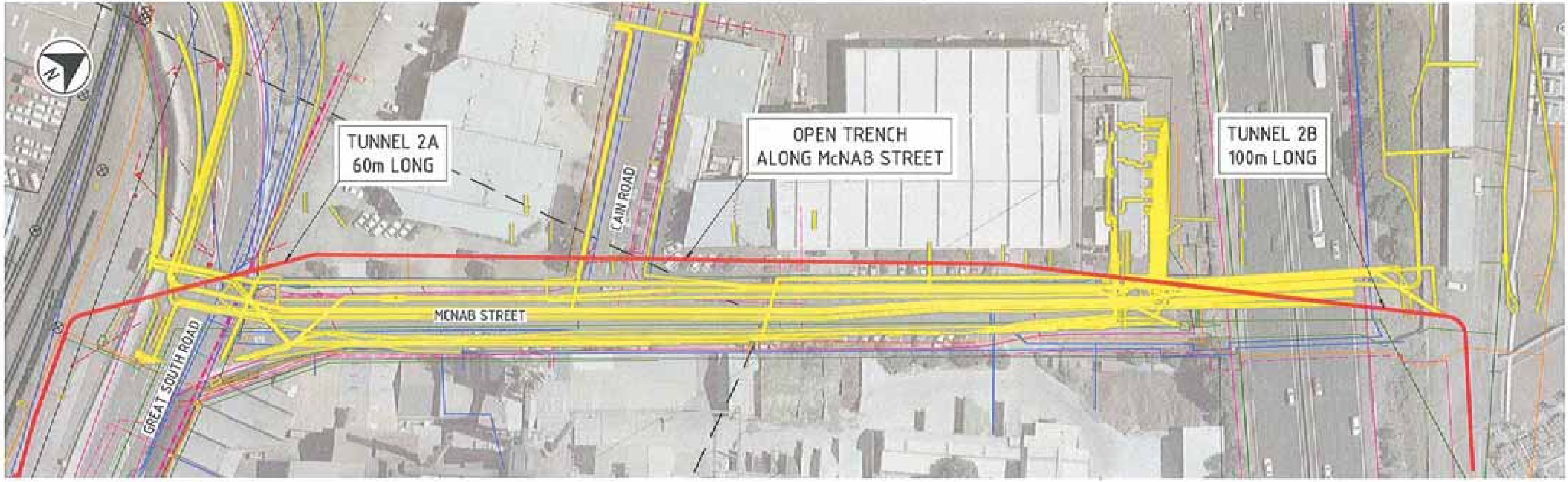
A1

NOTES

1. THE POSITION OF RAILWAY ELECTRIFICATION GANTRIES IS PRELIMINARY AND SUBJECT TO FINAL DESIGN BY KIWIRAIL. DO NOT USE FOR DETAIL DESIGN.

LEGEND

- BOUNDARY
- RAILWAY BOUNDARY
- WATER SUPPLY
- WASTE WATER
- STORM WATER/SEWER
- POWER
- TELECOM/TELSTRA
- GAS
- FIBRE OPTIC
- TRAIN TRACKS
- PROPOSED 220KV CABLE ROUTE
- JOINT BAY
- RAILWAY ELECTRIFICATION GANTRY FOUNDATION



OPTION 2: 2 SHORT TUNNELS 1.80mØ
SCALE 1:500 (A1)

ISSUED FOR CLIENT REVIEW

SCALE 1:500 (A1) 0 10 20 30 40 50m

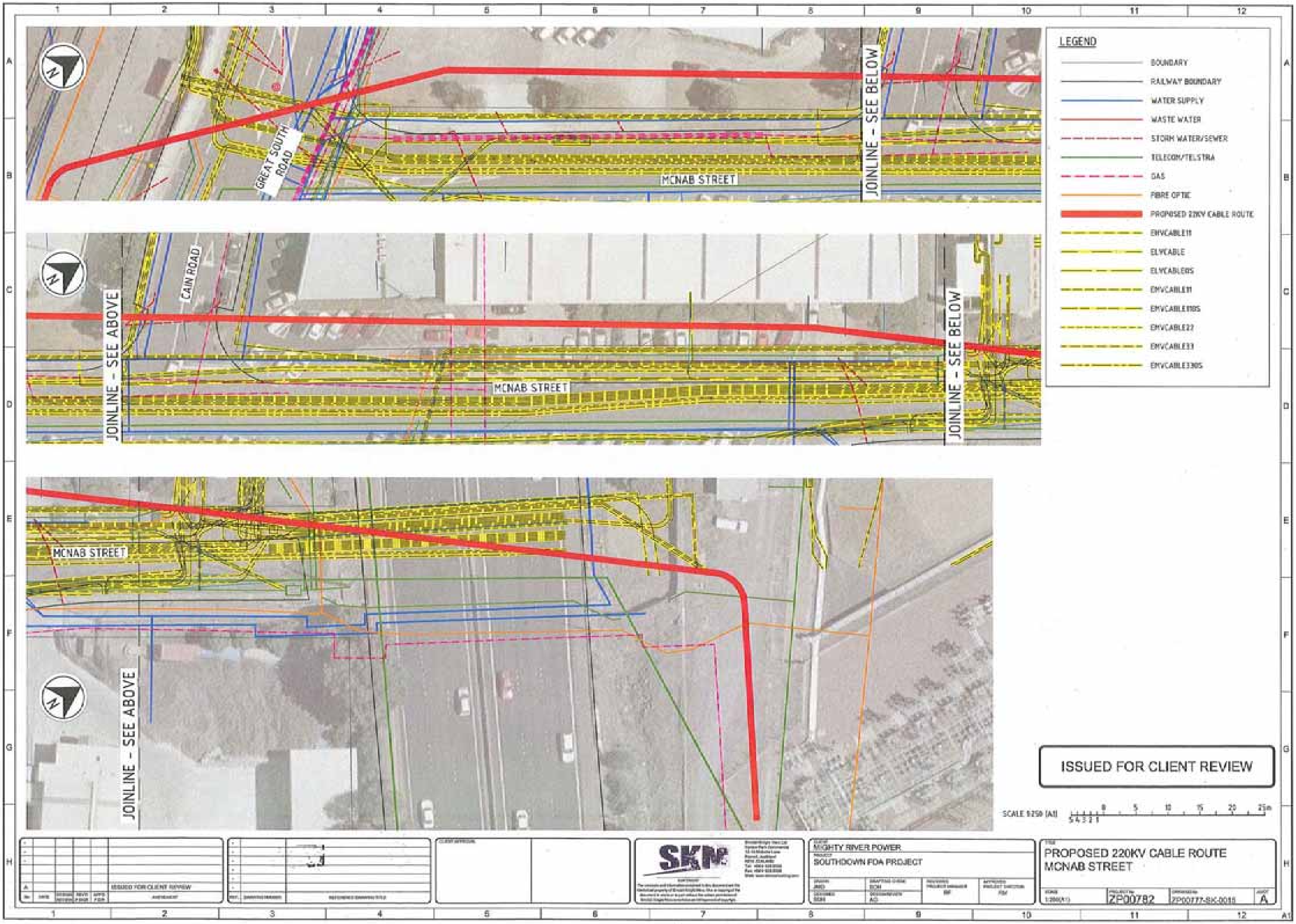
REV	DATE	AMENDMENT
A		ISSUED FOR CLIENT REVIEW

SKM

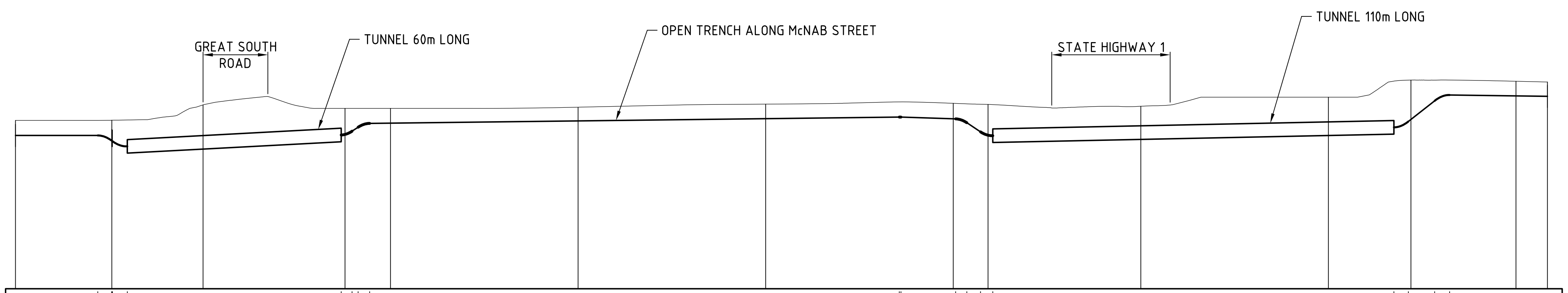
CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN POA PROJECT
DRAWN: JMG | DRAFTING CHECK: SCH | REVIEWED PROJECT MANAGER: BF | APPROVED PROJECT DIRECTOR: RM
DESIGNED: SCH | DESIGN REVIEW: AO

TITLE: PROPOSED 220KV CABLE ROUTE
SHEET 5 OF 5

SCALE: 1:500(A1) | PROJECT No: ZP00781 | DRAWING No: ZP00777-SK-0017 | AMDT: A



GREAT SOUTH ROAD
MCNAB STREET
JOINLINE - SEE BELOW
CAIN ROAD
JOINLINE - SEE ABOVE
MCNAB STREET
JOINLINE - SEE BELOW
MCNAB STREET
JOINLINE - SEE ABOVE
LEGEND
BOUNDARY
RAILWAY BOUNDARY
WATER SUPPLY
WASTE WATER
STORM WATER/SEWER
TELECOM/TELSTRA
GAS
FIBRE OPTIC
PROPOSED 220KV CABLE ROUTE
EMVCABLE11
ELVCABLE
ELVCABLE0S
EMVCABLE11
EMVCABLE110S
EMVCABLE22
EMVCABLE33
EMVCABLE330S
ISSUED FOR CLIENT REVIEW
SCALE 1:250 (A1)
0 5 10 15 20 25m
A ISSUED FOR CLIENT REVIEW
MIGHTY RIVER POWER
SOUTHDOWN FDA PROJECT
PROPOSED 220KV CABLE ROUTE
MCNAB STREET
ZP00782
ZP00777-SK-0015
A



DATUM RL 1.0

VERTICAL DATA: 0% | -37.28% | 2.64% | 33.2% | 0.59% | -1.66% | -33.35% | 1.04% | 39.36% | -0.71%

CHAINAGE	220 kV CABLE LEVEL	EXISTING SURFACE LEVEL
0.000	21.400	23.398
25.682	20.704	23.427
50.000	20.486	25.473
87.853	21.537	25.000
100.000	23.042	25.000
150.000	23.340	25.153
200.000	23.637	25.566
250.000	23.616	25.669
259.249	21.435	25.528
300.000	21.778	25.278
350.000	22.298	26.500
371.998	23.527	28.764
400.000	26.660	28.614
408.385	26.600	28.516

HORIZONTAL DATA: R10m (at 25.682) | R20m (at 87.853) | R20m (at 259.249) | R10m (at 371.998)

LONGITUDINAL SECTION MICROTUNNEL 2
SCALE 1:750H (A1)
1:375V (A1)

ISSUED FOR CLIENT REVIEW

SCALE 1:750 (A1) 15 9 3 0 15 30 45 60 75m

SCALE 1:375 (A1) 6 3 0 15 30m

No	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	AMENDMENT
A					ISSUED FOR CLIENT REVIEW

REF.	DRAWING NUMBER	REFERENCE DRAWING TITLE

CLIENT APPROVAL

SKM
Sinclair Knight Merz Ltd
Carlaw Park Commercial
12-16 Nicholls Lane
Parnell, Auckland
NEW ZEALAND
Tel: +64 9 928 5506
Fax: +64 9 928 5507
Web: www.skmconsulting.com

CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN PDA PROJECT
DRAWN: JMD | DRAFTING CHECK: SDH | REVIEWED PROJECT MANAGER: RF | APPROVED PROJECT DIRECTOR: RM
DESIGNED: SDH | DESIGN REVIEW: AG

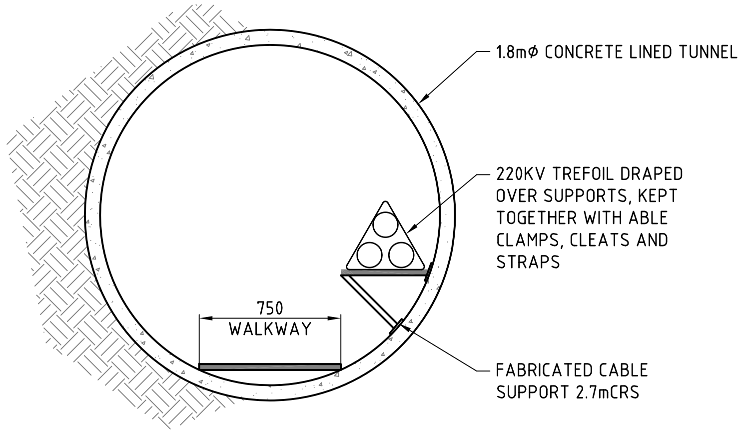
TITLE: MCNAB STREET TUNNEL LONG-SECTION
SCALE: AS SHOWN | PROJECT No: ZP00783 | DRAWING No: ZP00777-SK-0016 | AMDT: A

A1

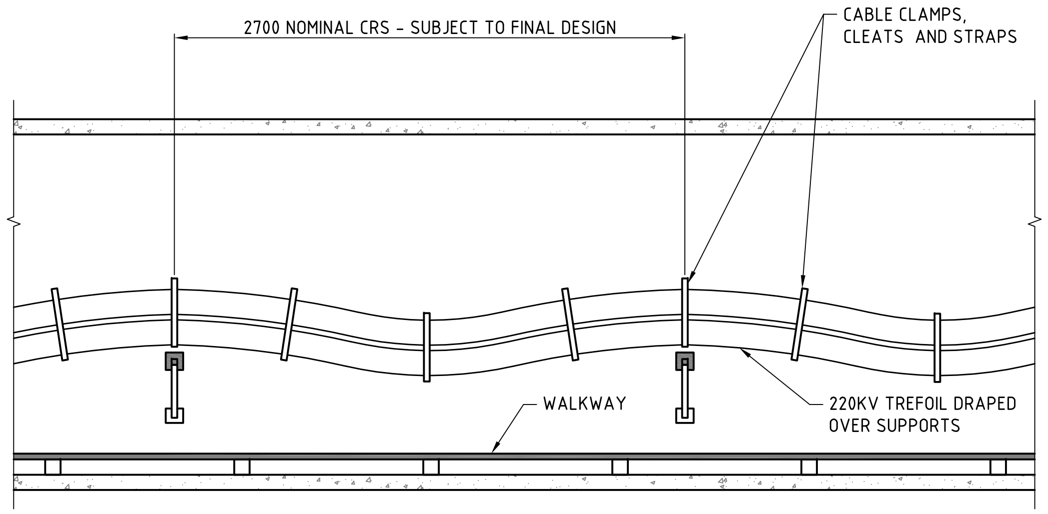
I:\ZPINA\Projects\ZP00777\DELIVERABLES\Drawings\Civil\Sketches\ZP00777-SK-0016.dwg Plot Date: 20 August, 2010 - 1:45 PM

NOTES

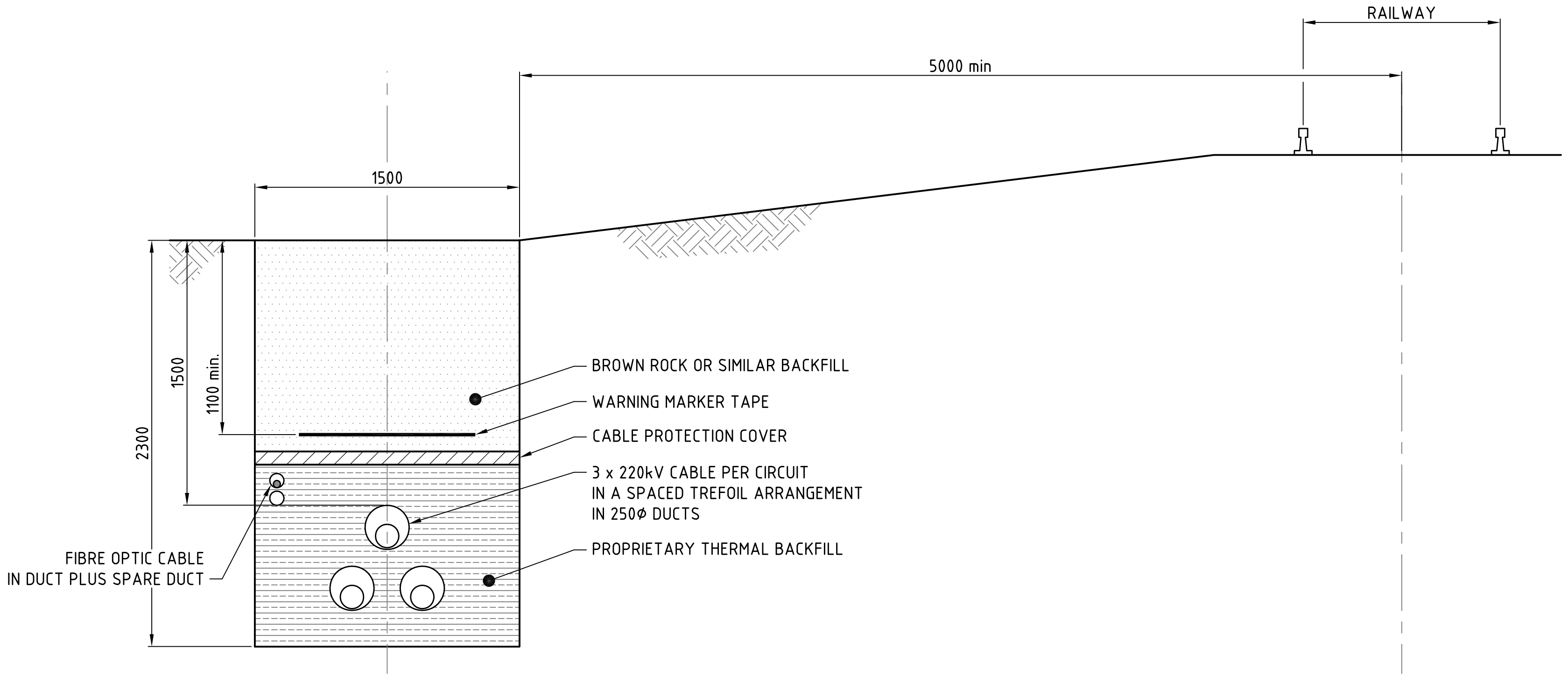
1. CABLE SUPPORT INSIDE TUNNEL FOR ILLUSTRATIVE PURPOSES ONLY - SUBJECT TO FINAL DETAIL DESIGN.



TUNNEL SECTION
SCALE 1:20@A1



TUNNEL INTERIOR ELEVATION
SCALE 1:20@A1



TYPICAL SECTION IN RAIL CORRIDOR
SCALE 1:20@A1

NOT FOR CONSTRUCTION

ISSUED FOR CLIENT REVIEW

SCALE 1:20 (A1) 0.4 0 0.4 0.8 1.2 1.6 2.0m

No	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	AMENDMENT
-					
-					
-					
A	24/06/10				ISSUED FOR CLIENT REVIEW

REF.	DRAWING NUMBER	REFERENCE DRAWING TITLE
-		
-		
-		
-		
-		
-		

CLIENT APPROVAL

SKM

Sinclair Knight Merz Ltd
Carlaw Park Commercial
12-16 Nicholls Lane
Parnell, Auckland
NEW ZEALAND
Tel: +64 9 928 5500
Fax: +64 9 928 5501
Web: www.skmconsulting.com

CLIENT: MIGHTY RIVER POWER
PROJECT: SOUTHDOWN PDA PROJECT

DRAWN	DRAFTING CHECK	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
JMD	SDH	RF	RM
DESIGNED: SDH	DESIGN REVIEW: AG		

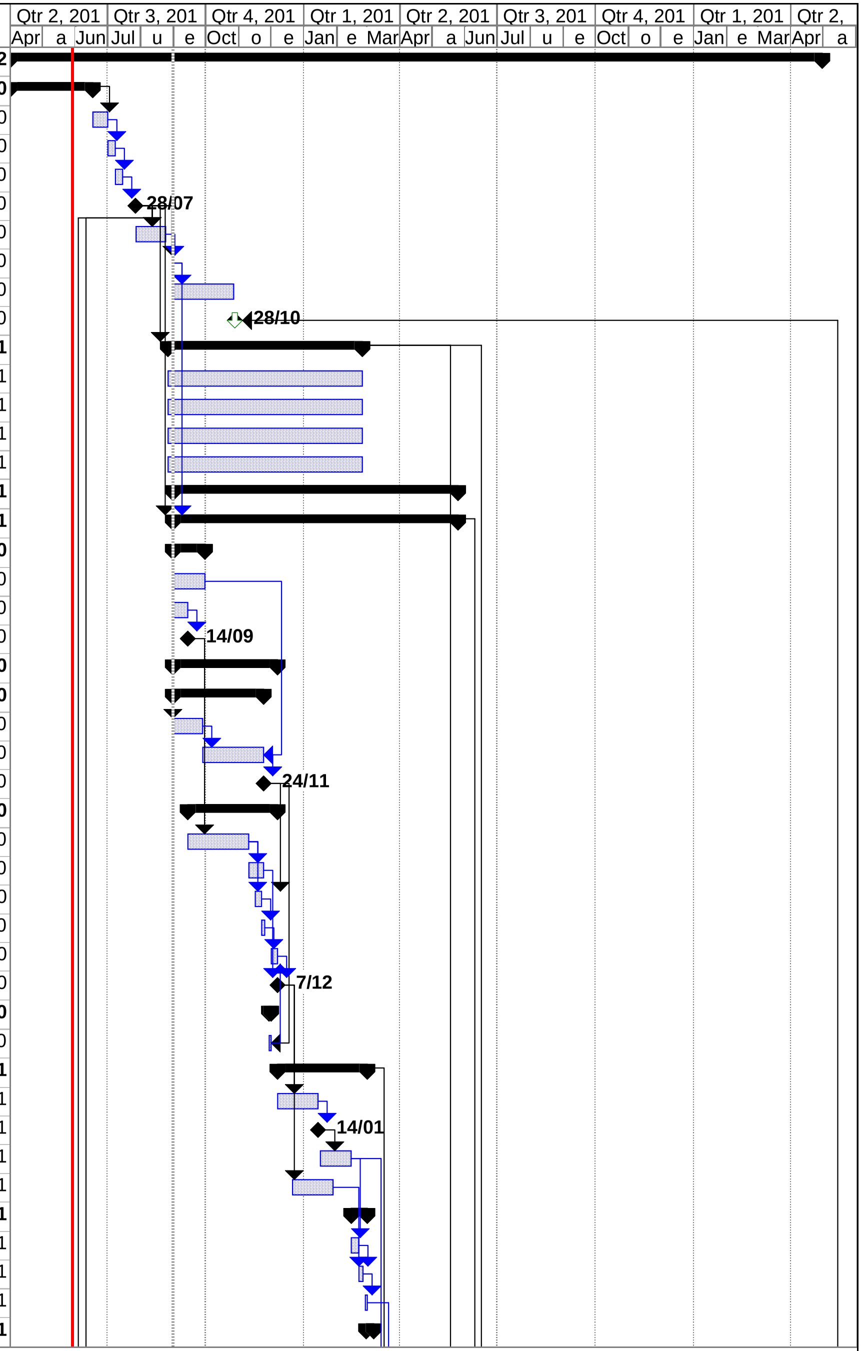
TITLE: TYPICAL SECTIONS

SCALE	PROJECT No	DRAWING No	AMDT
1:20(A1)	ZP00777	ZP00777-SK-0001	A

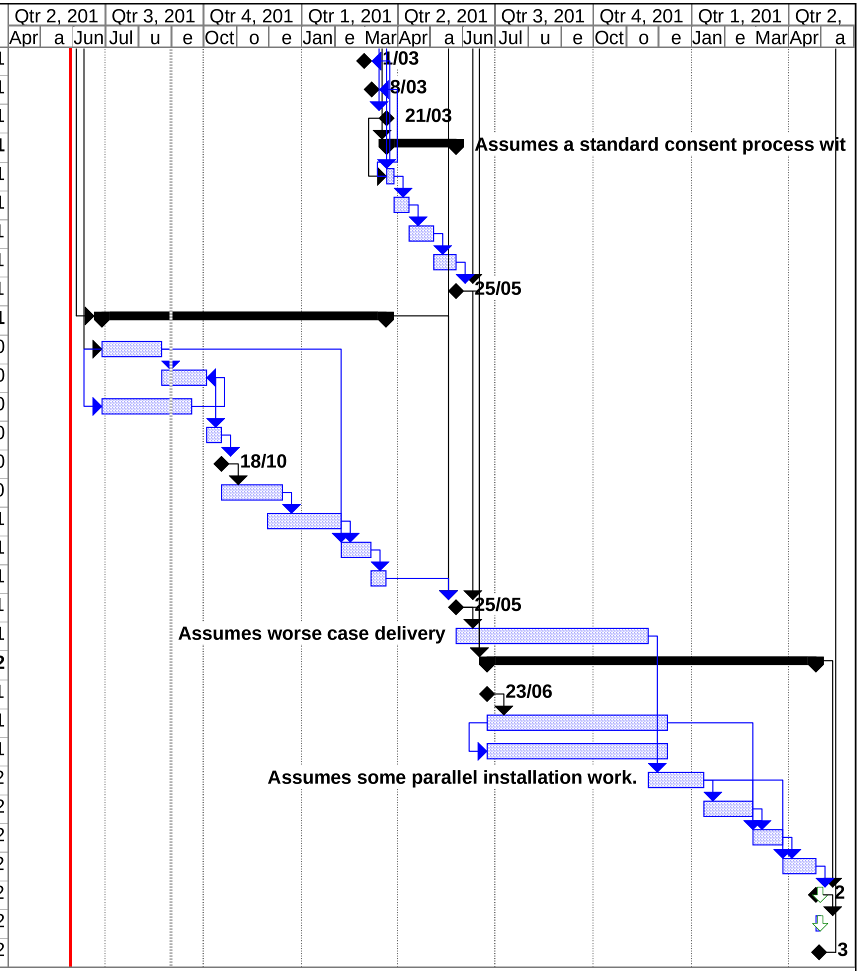
A1

Appendix F Project Programme

ID	Task Name	Duration	Start	Finish
1	**Southdown connection to Vector**	**102.6 wks**	**Thu 1/04/10**	**Mon 30/04/12**
2	**PDA Preparation**	**10.6 wks**	**Thu 1/04/10**	**Thu 17/06/10**
9	Complete the board paper	10 days	Fri 18/06/10	Thu 1/07/10
10	Review and sign off for board paper	5 days	Fri 2/07/10	Thu 8/07/10
11	Submit board paper to board	5 days	Fri 9/07/10	Thu 15/07/10
12	Board meeting	0.1 days	Wed 28/07/10	Wed 28/07/10
13	Vector review and sign off	20 days	Wed 28/07/10	Wed 25/08/10
14	Submit application for PDA with Transpower	1 day	Tue 31/08/10	Tue 31/08/10
15	negotiate PDA with Transpower	8 wks	Wed 1/09/10	Wed 27/10/10
16	Deadline to achieve agreement	0 wks	Thu 28/10/10	Thu 28/10/10
17	**Negotiate Access**	**24 wks**	**Fri 27/08/10**	**Fri 25/02/11**
18	Negotiate acces to rail corridor (On Track)	6 mons	Fri 27/08/10	Fri 25/02/11
19	Negotiate acces to Road reserve (ACC)	6 mons	Fri 27/08/10	Fri 25/02/11
20	Negotiate acces to private land	6 mons	Fri 27/08/10	Fri 25/02/11
21	Negotiate acces to cross motorway (Transit)	6 mons	Fri 27/08/10	Fri 25/02/11
22	**Consent and construction period**	**35.8 wks**	**Tue 31/08/10**	**Wed 25/05/11**
23	**Resource Consent**	**35.8 wks**	**Tue 31/08/10**	**Wed 25/05/11**
24	**Resource Consent Preparation**	**4.4 wks**	**Tue 31/08/10**	**Thu 30/09/10**
25	Resource consent - Carry out Archaeological survey	1 emon	Tue 31/08/10	Thu 30/09/10
26	Resource consent - Produce draft Project Description report	10 days	Wed 1/09/10	Tue 14/09/10
27	Resource consent - Commence AEE development	0 wks	Tue 14/09/10	Tue 14/09/10
28	**Power Plant - Prepare application for resource consent**	**13.8 wks**	**Wed 1/09/10**	**Tue 7/12/10**
29	**AEE technical reports**	**12 wks**	**Wed 1/09/10**	**Wed 24/11/10**
30	Develop brief and obtain proposals and Engage consultants	20 days	Wed 1/09/10	Tue 28/09/10
31	Produce effects assesment reports for AEE	40 days	Wed 29/09/10	Wed 24/11/10
32	Resource consent - Final reports to finalise AEE	0 wks	Wed 24/11/10	Wed 24/11/10
33	**WRITE AEE**	**11.8 wks**	**Wed 15/09/10**	**Tue 7/12/10**
34	Resource consent - Draft AEE	40 days	Wed 15/09/10	Wed 10/11/10
35	Resource consent - Present draft AEE for Consultation	10 days	Thu 11/11/10	Wed 24/11/10
36	Resource consent - Complete AEE	4 days	Wed 17/11/10	Mon 22/11/10
37	Resource consent - MRP Review draft AEE	3 days	Tue 23/11/10	Thu 25/11/10
38	Resource consent - Governance review of AEE	4 days	Thu 2/12/10	Tue 7/12/10
39	Power Plant - AEE approved, Lodge Resource Consent	0 days	Tue 7/12/10	Tue 7/12/10
40	**AEE Consultation**	**0.4 wks**	**Tue 30/11/10**	**Wed 1/12/10**
41	Resource consent - Present 2nd draft AEE for Consultation	2 days	Tue 30/11/10	Wed 1/12/10
42	**Consent processing earliest Lodge date**	**10.2 wks**	**Wed 8/12/10**	**Tue 1/03/11**
43	Power Plant - Resource Consent notification decision by ARC	13 days	Wed 8/12/10	Fri 14/01/11
44	Power Plant - Resource Consent Section 92 request delay	0 days	Fri 14/01/11	Fri 14/01/11
45	Power Plant - Resource Consent submissions period ARC	20 days	Mon 17/01/11	Mon 14/02/11
46	Power Plant - Resource consent Preparation of Evidence	20 days	Wed 22/12/10	Fri 28/01/11
47	**Power Plant - Resource consent post submission evidence**	**2.2 wks**	**Tue 15/02/11**	**Tue 1/03/11**
48	Power Plant - Resource consent update evidence and review	5 days	Tue 15/02/11	Mon 21/02/11
49	Power Plant - MRP governance sign off of evidence	4 days	Tue 22/02/11	Fri 25/02/11
50	Power Plant - Production and final preparation for hearing	2 days	Mon 28/02/11	Tue 1/03/11
51	**Evidence exchange earliest**	**1 wk**	**Tue 1/03/11**	**Tue 8/03/11**



ID	Task Name	Duration	Start	Finish
52	Resource consent - Deadline to produce evidence to submitters	0 wks	Tue 1/03/11	Tue 1/03/11
53	Resource consent - Deadline to produce evidence to ARC	0 wks	Tue 8/03/11	Tue 8/03/11
54	Resource Consent hearing start 25d after submissions close	0 wks	Mon 21/03/11	Mon 21/03/11
55	**Likely hearing phase**	**9 wks**	**Tue 22/03/11**	**Wed 25/05/11**
56	RC hearing - Resource Consent hearing	5 days	Tue 22/03/11	Mon 28/03/11
57	RC hearing - Resource consent hearing adjourned	10 days	Tue 29/03/11	Mon 11/04/11
58	RC hearing - Resource Consent deliberation (Earliest)	15 days	Tue 12/04/11	Wed 4/05/11
59	Resource Consent process - Consent appeal period	15 days	Thu 5/05/11	Wed 25/05/11
60	Earliest date for consent beyond challenge	0 days	Wed 25/05/11	Wed 25/05/11
61	**Design and tender period**	**36 wks**	**Mon 28/06/10**	**Mon 21/03/11**
62	Tender documents preparation Cable Systems inc Desktop Geotech	8 wks	Mon 28/06/10	Mon 23/08/10
63	Cable Tender Period	6 wks	Mon 23/08/10	Mon 4/10/10
64	Field Geotech & Soil Thermal Testing Survey	12 wks	Mon 28/06/10	Mon 20/09/10
65	Cable Tender Review	2 wks	Mon 4/10/10	Mon 18/10/10
66	Award Cable System Design Contract	0 wks	Mon 18/10/10	Mon 18/10/10
67	Cable System Design	2 mons	Mon 18/10/10	Tue 14/12/10
68	Design & Tender Document Route Construction Contract	8 wks	Tue 30/11/10	Mon 7/02/11
69	Tender period for Route Construction Contract	4 wks	Mon 7/02/11	Mon 7/03/11
70	Evaluation of Route Construction tenders	2 wks	Mon 7/03/11	Mon 21/03/11
71	Award contracts (Route Construction & Cable Materials)	0 days	Wed 25/05/11	Wed 25/05/11
72	Cable delivery	6 emons	Wed 25/05/11	Mon 21/11/11
73	**Construction**	**41.2 wks**	**Thu 23/06/11**	**Thu 26/04/12**
74	Commence construction	0 days	Thu 23/06/11	Thu 23/06/11
75	Construct new switchyard at southdown & Penrose	6 mons	Fri 24/06/11	Fri 9/12/11
76	Cable Installation Civil Works	6 mons	Fri 24/06/11	Fri 9/12/11
77	Lay cable	30 days	Tue 22/11/11	Thu 12/01/12
78	Join cables (9 joints)	30 days	Fri 13/01/12	Mon 27/02/12
79	Dress and Terminate cables at switchyard	20 days	Tue 28/02/12	Mon 26/03/12
80	Test and commission cables and protection	4 wks	Tue 27/03/12	Thu 26/04/12
81	Handover	0 days	Thu 26/04/12	Thu 26/04/12
82	Float	0.4 wks	Fri 27/04/12	Mon 30/04/12
83	Must complete by	0 wks	Mon 30/04/12	Mon 30/04/12



Appendix G Background Information