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Tuesday, 16 August 2022

Nicole Brewer
Director- Energy Assessments
NSW Department of Planning and Environment
4 Parramatta Square,
12 Darcy Street
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Dear Nicole

Response to DPE Request for Additional Information – 8 April 2022

The enclosed provides a response to a request for additional information received on 8 April 2022 in relation to the following matters:

- Further clarifications in relation to a monopole and over canopy transmission connection design and use of helicopters during construction
- A comparison of impacts between a substation using indoor gas insulated switchgear and one with outdoor switchgear
- Schedule of all proposed road works and upgrades
- Detail of the proposed works to improve the amenity values of Kosciuszko National Park
- Clarify whether the disturbance footprint includes areas for spoil classification prior to its disposal, and detail the assumptions used in sizing erosion sediment controls
- Biodiversity offsetting arrangements
- Additional management actions for the Yellow-bellied Glider
- Inconsistencies identified in the BAM calculator and BDAR

In addition, a response to two key issues raised by the NSW Office of Energy and Climate Change in their letter addressed to DPE and dated 26 June 2022 has also been provided. The response includes further clarity on the following:

- Issues associated with a connection to Lower Tumut switching station
- A comparison of potential benefits of undergrounding the connection compared to an overheard connection approach.

Yours faithfully

Chris Page

Senior Environmental Planner

Snowy 2.0 Transmission Connection Project

Response to Request for Additional Information– DPE, July 2022

1. Project options

The NSW Department of Planning and Environment (DPE) has requested additional information on key environmental impact, construction and network planning factors in relation to potential alternative overheard connection design approaches from the Snowy 2.0 cable yard to Line 64. Alternative design approaches which DPE is seeking additional information on includes:

- An overhead connection using monopole structures instead of the proposed steel lattice structures
- An overhead connection with steel lattice structures with increased maximum tower heights
- The use of helicopters for the construction of the proposed base case steel lattice structure overhead transmission connection.

A comparison of alternative design approaches against the preferred project is detailed in the *Snowy 2.0 Transmission Connection Project Amendment Report* (the Amendment Report), however further information of the three alternative as requested by DPE is discussed further below and detailed in Table 4.

1.1. Monopole design

Overhead transmission line connections in 330 kV networks (like the proposed Snowy 2.0 transmission connection) are generally designed and constructed using steel lattice towers as the main structure type. Steel pole designs are typically more common at lower voltage levels. Due to the alpine terrain associated with the project area, which is characterised by mountain/hill peaks and valley crossings, including the approximate 1.5 km long Talbingo reservoir crossing, specific engineering, maintenance and environmental factors need to be considered when considering a monopole design in challenging terrain.

A technical assessment was carried out by Jacobs (2022) (refer to Appendix A), which compared the base case steel lattice concept design against a design using steel monopole structures (option 4a) with consideration to key engineering, safety, environmental and constructability factors. To allow a comparative analysis and maintain consistency with the necessary conductor clearance requirements, the assessment modelled a steel monopole design with structures that are the same height as the concept base case steel lattice tower design. Concrete monopoles were not considered in the assessment due to the inability to meet the necessary engineering requirements. Further commentary is provided in Table 4 in relation to an estimated disturbance footprint, environmental considerations, costs and project scheduling using a steel pole design.

Jacobs assessed an additional line design option of implementing a steel bi-pole structures at the tension structure sites, which comprise 31 of the 42 structures. The bi-pole structure type would replace a single tension lattice tower with two steel poles rather than a single monopole. The bi-pole arrangement reduces the base width of the steel poles compared to a single monopole structure however this reduction is offset by the requirement for an additional 31 poles and larger structure footings when compared to the single monopole design. As such, this option was discounted and the assessment below is based on the single monopole structure.

1.1.1. Structure type and footings

Due to the alpine environment of the project area, there is increased loading on the overhead transmission connection when compared to 330 kV double circuit connections in more favourable, flatter non-alpine terrain due to the following factors:

- The large separation distance between towers due to the need to position the towers on the hilltops and ridgelines to allow the conductors to span across the valleys. The span across Talbingo Reservoir alone is 1.5 kilometres, with five spans having a tower separation distance exceeding approximately 600 metres
- The steepness of the terrain and associated change in altitudes across spans
- High wind and snow and ice loading affording to the alpine environment, which can result in conductor galloping. This galloping is caused through the build-up of ice and snowy on the conductor and under high wind conditions can cause the lifting of the conductors, creating a galloping or jumping type motion. Consequently, there is a requirement for the Snowy 2.0 connection to be able to withstand the additional loading on the transmission structures under such environmental conditions.

Steel lattice towers are constructed through the bolting together of a larger number of steel members to form the lattice structure. This formation allows for the sharing of load across the tower. Furthermore, the loading is shared across four legs using circular bored concrete pile footings which are bolted to a bored concrete footing to a depth of approximately 12 metres depending on the load. To withstand the large loading, a steel monopole design would require much larger footings compared to a steel lattice tower design as detailed in Table 1.

Table 1: Footing requirements

Structure type	Footing requirements
Steel lattice tower (base case)	• Bored piles of approximately 1-1.5 metres in diameter, down to approximately 12 metres for each tower leg • Each tower would require approximately 150 cubic metres of concrete • Standard drill rig used to establish each of the four boreholes for each tower leg footing.
Steel monopole	• Pad and pedestal comprising and area of approximately 11x11 metres, incorporating four piles established to a depth of approximately 6 metres • Each tower would require approximately 800 cubic metres of concrete • Compared to the steel lattice tower, a larger area would be required to excavate and lay reinforcement including additional excavation for step back/battering to protect against ground collapse.

The load analysis indicated that the maximum base width required for steel monopole would need to be in the order of approximately 3.7 metres in diameter. The middle cross arm for the steel monopole design would need to extend approximately 10 metres each side of the steel pole. These structure widths and cross arm lengths are significant and are comparable to a medium sized wind turbine. It could be possible to reduce the size/width of the steel monopoles; however, this would involve the inclusion of addition structures to reduce the span width. The inclusion of additional structures would result in further revegetation clearing along the easement and additional clearing for access tracks. As such, reducing the size of the steel monopoles through the establishment of more structures along the approximate 9-kilometre-long connection route was not considered as it would not align with the project objectives in minimising vegetation clearing and habitat loss.

*Note: The photo above shows a short span 220 kV monopole design. The base diameter and cross arm length required for Snowy 2.0 connection would be approximately two times larger than that shown in the figure.

Figure 1: Typical steel monopole for a 220 kV connection.

An indicative concept design for the steel monopole for the Snowy 2.0 connection compared to the base case steel lattice tower is shown in Figure 2. Furthermore, photomontages have been prepared to show the steel monopole design based on the revised concept design at viewpoint 12, which is a sensitive receiver location at Lobs Hole. One key photomontage is shown in Figure 3 with the full suite provided in Appendix B.

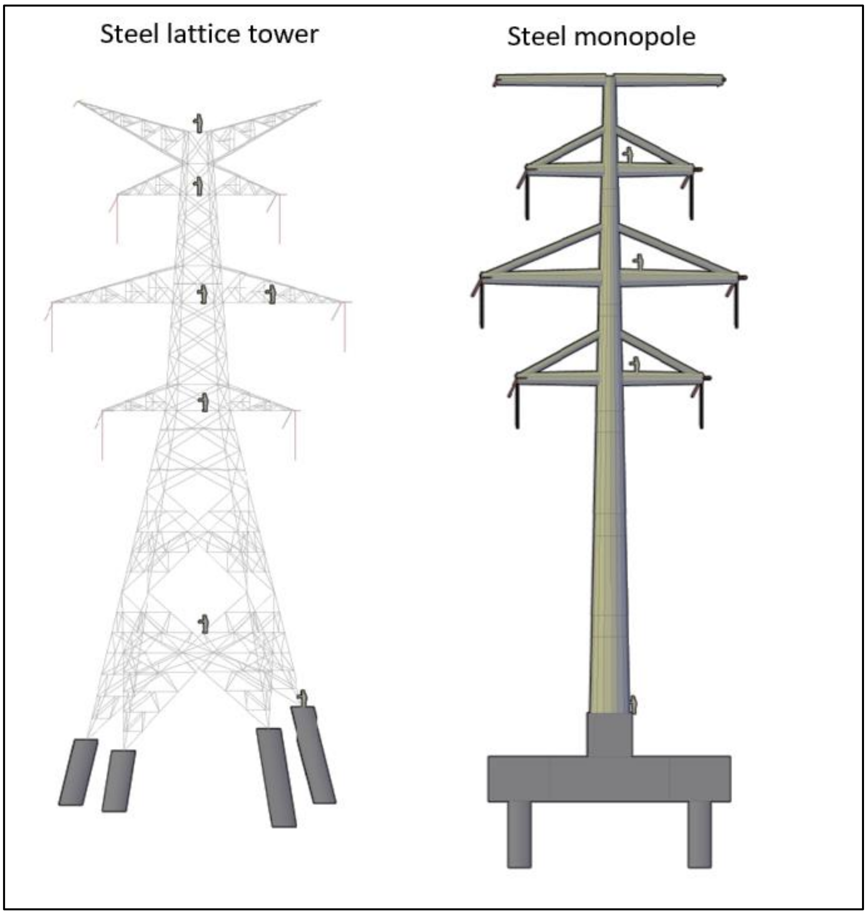


Figure 2: Concept steel lattice tower (base case) and steel monopole design

Figure 3: Photomontage at viewpoint 12 showing steel monopole as presented in the Supplementary LCVIA and the updated concept design

1.1.2. Key considerations

Due to the significant size and width of the steel monopole structures and footings required to support a 330 kV steel pole overhead connection, safety, constructability, maintenance, procurement and environmental factors need to be considered when compared to the steel lattice design. These factors are outlined in Table 2.

Table 2: Key considerations for steel monopole design

Factor	Overview
Constructability and safety	The construction of a steel lattice tower typically involves the use of standard cranes (truck mounted cranes to 150 tonne cranes). Break points in the tower are designed in to allow the towers to be assembled in smaller sections on the ground, then progressively lifted into position and bolted into place. Due to the increased size and weight of the steel monopoles, larger cranes are required to lift the pole sections into position. It is expected that the poles would be fabricated in four sections. To account for the increased cranage requirements, larger cleared bench areas would be required to support the safe construction of the poles. In addition, widening of the access tracks and reducing the grade in some sections would be required to accommodate the transport of the large cranes and pole sections to transmission structure sites. Given the expected width of the monopoles being up to 3.7 m, a built track width of approximately 8 m would be required to safely transport the pole segments to the structure locations. This required track width is 3 m wider than what is required for the base case design. These requirements would result in a larger disturbance footprint and spoil volumes when compared to the steel lattice tower design option (refer to Table 4). Compared to steel lattice tower, a 330 kV steel pole design would result in higher risk to work crews during construction due to the: • Cranage of large pole segments and flange plates in challenging terrain • The establishment of larger footings and construction bench areas encroaching on steep terrain, requiring larger cut-ins. Notwithstanding the above, safety risks could be managed sufficiently with appropriate construction planning and risk assessments.
Operation and maintenance	Minimising the duration for repair in the event of an unexpected failure on the transmission connection is a key design principle. Given the criticality of the Snowy 2.0 generator to the National Electricity Market (NEM) (refer to Section 1.2), it is vital to minimise any response time to carry out urgent repairs. The maintenance and inspection regimes for assessing steel corrosion and physical damage in steel poles is much more complicated as opposed to steel lattice towers. Lattice towers can be climbed and all sides of the tower members can be inspected with ease. In the event that corrective maintenance is required it can generally be limited to the targeted replacement of members that have been corroded or damaged. Targeted member replacements can be performed with smaller construction vehicles to minimise disturbance. Steel poles are tubular and the plate sections are not easily viewed for any thickness degradation from the inside of the circular/ tapered sections unless decommissioned and un-installed. The corrective maintenance on a 330 kV steel pole to repair a corroded or damaged section would require the remobilisation of large specialised construction plant resulting in a larger ground disturbance to gain safe access to work areas when compared to the lattice towers. Due to these reasons, any unexpected failure of a steel pole would result in an increased response time to address and rectify the failure compared to a steel lattice tower.

Factor	Overview
Cost	The cost was estimated to be approximately $38 million more than the base case. The additional cost is attributed to: • Requirement for custom engineered poles which cannot be easily procured • Increase in the extent of civil and construction works associated with larger footings, bench areas and wider access tracks. The average yearly operational and maintenance cost is expected to be approximately $515,000 per year inclusive of the substation component.
Environmental factors	Compared to the base case steel lattice tower design, a design utilising steel poles would have a larger disturbance footprint resulting from the larger footings, larger construction benches and wider access track sections. Based on the outcomes of the Jacobs (2022) report it is estimated that steel pole designs would have a total disturbance area of 138 hectares, which is 13 hectares more than the base case. Minimising the footprint as far as practicable has been a key objective of the project as to reduce the extent of native vegetation clearing and associated habitat loss. The steel pole design is not consistent with this objective. Impacts on visual amenity is a key consideration associated with overhead transmission connections, particularly in sensitive environments such as Kosciuszko National Park (KNP). Since lodgement of *Snowy 2.0 Transmission Connection Project- Submissions Report,* (Jacobs, 2022) (the Submission report), further assessment of the steel pole design has been carried out. The steel pole design in the landscape would be significantly more visually prominent (refer to Figure 2) compared to that shown in photomontages presented in Section 3 of the *Snowy 2.0 Transmission Connection Project-Supplementary Landscape and Visual Impact Assessment* (the Supplementary LCVIA). The photomontages in the Supplementary LCVIA were based on standard steel monopole types as specific engineering requirements to address the high level of tip loading in the alpine environment were not known at that time. Consequently, the photomontages do not accurately reflect the required size and width of the steel pole as determined by Jacobs (2022), noting that the base diameter of a single steel pole would need to be approximately 3.7 metres. Based on the above, the assessed level of visual impact at the highly sensitive viewpoints previously assessed in the Supplementary LCVIA would remain as high. Furthermore, due to the visual prominence of the steel monopoles affording to their scale to address the necessary loading requirements, the perceived view of the steel poles is not expected to be improved when compared to the steel lattice towers. With no improvement to the assessed level of impact or the perceived view of the steel pole design, combined with the larger disturbance footprint, there is no benefit from an environmental impact perspective with a steel pole design compared to a steel lattice tower design.

1.2. Increased maximum tower height

This option (referred to an Option 4b) would involve an overhead transmission connection which would be constructed at a height where the safe electrical clearance of the overhead conductors would be sufficient to enable the connection to span above the underlying tree canopy, therefore avoiding the requirement to clear the transmission connection easement.

As detailed in Section 3.3.4 of the *Snowy 2.0 Transmission Connection- Amendment Report* (Jacobs, 2022) (the Amendment Report), the vegetation clearance requirement (VCR) for this project has been set at 7.5 metres and was established in accordance with Transgrid's *Maintenance Plan – Easement and Access Tracks* (December 2020). This means that for a given overhead line design, all vegetation which is within the 7.5 metre clearance area beneath the conductors or has the potential to grow into the safe clearance space, would need to be removed during the initial construction of the line and maintained throughout operation. As part of the initial optioneering carried out during the preparation of the *Snowy 2.0 Transmission Connection Project – Environmental Impact Statement* (the EIS), an over-canopy transmission line design was considered. Based on the high level concept design that was developed, the maximum tower height under this approach was determined to be approximately 94 m to ensure the underlying tree canopy does not encroach the VCR of 7.5 metre and therefore avoiding the need to clear the transmission line easement.

Under the over-canopy design approach, vegetation clearing would still be required to establish access to the structure sites for construction and operation and to establish the necessary construction work sites and benching at each structure location. Whilst the extent of clearing is estimated to be approximately 75 hectares which equates to a 36 percent reduction compared to the base case (Option 4), key factors pertaining to network and asset risk, constructability, safety, operational maintenance and cost need to be considered. These factors are outlined in below and in Table 3.

1.2.1. Asset and bushfire risk

With a vegetated transmission line easement, the extensive fuel load beneath the transmission connection asset within an environment such as the Snowy Mountains poses a significant risk of a catastrophic failure of the asset in the event of a bushfire. Furthermore, the ability to respond to failure of the asset in the event of damage by fire (or other environmental events) would be more difficult if the easement was vegetated due to the inability to easily access areas along the transmission connection to carry out urgent repairs. Any delays to repairing the asset would have detrimental impacts to the NEM as detailed in the next section.

Typically, tall growing vegetation is only retained within transmission line easements when spanning high above gully areas where there is a significant distance above the mature tree canopy, well in excess of the VCR. A bushfire occurring in these gully area beneath an overhead transmission line would pose much less risk of potential impact to the asset when compared to mature vegetation which mature canopy height is much closer to the safe clearance space established by the VCR.

It is acknowledged that existing high voltage transmission assets have been built above the tree canopy in sensitive rainforest environments in far North Queensland. However, the bushfire risk profile of an over-canopy design in a rainforest environment is considerably less compared to the project area located in the Snowy Mountains region, which is characterised by a significantly dryer climate dominated by subalpine woodland and sclerophyll forest. This risk is highlighted by the recent Dunns Road bushfire which swept through the project area in December/January 2019/20. It should be noted that Transgrid's existing Transmission Line 2 which traverses the project area at Lobs Hole and other transmission lines in the Snowy Mountains were significantly damaged during the Dunns Road fire. To maintain electrical supply and avoid outage clashes, all damaged transmission line assets could not be repaired at the same time. Consequently, major repairs to Line 2 did not commence until Autumn 2022, some two years after the bushfire occurred. For an over-canopy design which retains vegetation within the easement (aside from the high spans above gully areas), damage caused by a fire event such as the Dunns Road bushfire is expected to have been far more extensive due to the quantum of fuel load beneath the asset.

1.2.2. National Electricity Market risks

As demonstrated through the Critical State Significant Infrastructure (CSSI) declaration, power generation from Snowy 2.0 is critical to the stability, energy security and reliability for the NEM. Consequently, a key transmission connection design objective is to minimise the risk of losing the ability to transmit this power to consumers.

Electricity network reliability standards govern how network infrastructure is designed, built and operated to avoid or manage interruptions to electricity supply which includes damage to network infrastructure. In the event of complete failure (loss of all four circuits) of the Snowy 2.0 transmission connection, this would result in an instantaneous loss of up to 2,000 MW Snowy 2.0 generation or pumping at that point of time. This is because the connection is in the radial configuration (meaning there is only one source of power transmission) and there is no other flow path for Snowy 2.0 generation during an outage. Any instantaneous loss of this magnitude would be significant and could lead to widespread loss of supply and load including the possibility of cascading tripping and system blackout. Whilst the n-1 redundancy has been applied (hence four circuits), the risk of fire impacting both lines would be significantly reduced with a cleared easement. An intense bushfire event such as the Summer 2019/20 bushfire event would have an increased potential of impacting both lines under an over-canopy design, compared to the base case.

Given the criticality of Snowy 2.0 to the NEM, it is essential that the transmission connection is constructed in a manner that reduces the risk of failure and increases the response time to carry out urgent repairs. An over-canopy design would impose a significantly higher bushfire risk and associated risk of failure or damage in the event of a bushfire compared to the base case (Option 4). Additionally, the time to respond to urgent repairs under the base case is expected to be significantly faster compared to the over-canopy design due the improved access from the cleared easement. Response times are further complicated under the over-canopy design due to the availability of key mobile plant such as elevated work platforms, and cranes to carry out repairs. Given the height of the structures being up to 94 metres, having suitable plant and equipment readily available to respond to urgent repairs at these heights would prove challenging.

1.2.3. Summary of over-canopy design factors

A summary of the key factors which have been considered for the over-canopy design option are discussed in Table 3.

Table 3: Key considerations for over-canopy design

Factor	Overview
Constructability and safety	Similar to the base case design, the transmission towers would be assembled in sections on the ground, prior to being lifted into position using a crane. The segments would then be bolted and secured by work crews operating in EWPs. Given the increased height of the towers, larger cranes and EWPs would be required resulting in the need for larger construction benches at the tower locations to safety operate the bigger plant. Stringing of the conductors under the base case is proposed to be undertaken using drones, which is a safer method compared to using helicopters. Given the increased height of the towers to support an over-canopy design, drone stringing may not be possible, therefore requiring the use of a helicopter, which is not the preferred method adopted by Transgrid. Whilst there are additional constructability challenges with the taller structures, it is expected that these could be overcome with careful construction planning and safety based risks assessments.
Operation and Maintenance	Key operational and maintenance constraints for an over-canopy design include: • The ability to respond to emergency repairs would be significantly longer compared to the base case due to access needing to be established and the area made safe for works crews to carry out repair works. • The risk of damage to the transmission lines in the event of a bushfire passing through the area would be considerably higher compared the base case, whereby cleared sections of the easement corridor under the base case would offer increased protection for the asset. • Routine maintenance on existing lines in the Snowy Mountains is already limited to outside of the winter months. Due to increased wind speeds (> safe speed of 12 m/s) at these heights, it would likely further result in limitations as to when routine maintenance could be carried out on the taller structures

Factor	Overview
	• Some routine vegetation management along the transmission connection corridor may still need to be carried out, such as the removal/trimming of the tree crown and/or branches that violate the vegetation clearance requirement of 7.5 metres. This would need to be undertaken by personnel climbing the tree or by helicopter. Both these methods pose significant safety risks.
Cost	The cost to construct an over-canopy design would be approximately $320 Million, approximately, $30 Million more than the base case. The average yearly operational and maintenance cost is expected to be approximately $506,000 per year inclusive of the substation component..
Environmental factors	The extent of clearing is estimated to be approximately 75 hectares which equates to a 36 percent reduction compared to the base case. As such, impact on biodiversity would be reduced under this option..

1.3. Helicopter use during construction

This option (referred to an Option 4c) would involve the use of helicopters as part of the construction methodology for the base case (Option 4). Under this approach, the steel lattice towers would be assembled in segments within a designated cleared area within the disturbance footprint at the substation site. The pre-assembled segments would then be airlifted by helicopter from the pre-assembly site at the substation to the transmission structure locations, where the structure would then be assembled using a combination of plant and equipment including elevated work platforms (EWPs) and cranes.

Under this approach, the disturbance footprint and clearing regime is expected to remain unchanged from the base case as the same network of access tracks to the structure locations and cleared tower construction sites would be required. Whilst the size of the cranes required for construction may be reduced, the same size EWPs used for the base case would be required as to allow the workforce to safely access the tower. As such, the construction areas around each structure is assumed to be the same size as the base case.

However, the use of helicopters to construct the transmission towers would result in a reduction of heavy vehicle movements associated with the project during construction. This reduction in heavy vehicle movements along Elliott Way and the network of proposed new access tracks is expected to:

- Reduce potential wear and tear on Elliott Way and the newly constructed access tracks
- Improve safety and amenity for motorists driving along Elliott Way
- Reduce dust generation as part of the use of the access tracks during construction.

A summary of the key environmental impact, construction and network planning factors associated with Option 4c is detailed in Table 1.

Given the benefits of reducing heavy vehicle movements through the use of helicopters during construction, Transgrid will further explore this option, however its implementation would be dependent on key factors such as:

- Outcomes of safety assessments associated with tower segment delivery and assembly using a helicopter
- Outcomes of constructability assessments
- The availability of suitable aircraft to carry out the works.

1.4. Options summary

A comparative analysis of each of the variations of Option 4 is provided in Table 3. Furthermore, an analysis of all other options which passed through the initial screening assessment carried out as part of the *Transmission Connection Project for Snowy 2.0 – Options Report* (EMM, 2021) (the Options Report) is provided in Appendix C. Key outcomes include:

- **Option 4a** - There is no apparent benefit of a steel pole design over the steel lattice tower design on the balance of cost, constructability, operational maintenance, safety, environmental and visual amenity considerations.
- **Option 4b** - Whilst, this option would involve approximately 36% less clearing than the base case, the construction of the transmission connection above the tree canopy presents considerable operational risk to the asset and the broader NEM due to the increased level of damage in the event of a bushfire. Furthermore, the ability to respond to emergency events and carry out urgent repairs would be increasingly difficult with a fully vegetation transmission connection corridor. This could impose considerable risk on the NEM due to any extended removal of up to 2,000 MW of generation from the market. Consequently, due to the increased operability constraints under Option 4b, the base case is preferred.
- **Option 4c** - The use of helicopters to assist in the construction of the transmission line would have a positive benefit through the reduction in construction vehicle movements. Whilst we cannot commit to the use of helicopters at this stage, helicopter use would be further investigated by Transgrid's construction contractor as part of detailed construction planning. As such, Transgrid is seeking the flexibility to use helicopters should they be deemed safe based on detailed risk assessment to be carried out by the construction contractor, suitable aircraft being available and constructability assessments.

Table 4: Options summary table

Element	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)
Estimated area of vegetation disturbance				
Within KNP	75 ha	91.5 ha	41 ha	75 ha
Outside KNP	43 ha	46.5 ha	34 ha	43 ha
Max. disturbance total	125 ha. Of this 118 ha of vegetation removal would be required.	138 ha	75 hectares This is based on the same construction disturbance footprint for the tower sites and access tracks as the base case. This disturbance area is expected to be more based on the requirement for large footings and larger cranage due to the increased tower heights.	125 ha. Of this 118 ha of vegetation removal would be required. Whilst the crane size may be reduced for construction, the same size EWPs as the base case would be required. Further, the same network of access tracks would be required to facilitate construction and ongoing operational maintenance as the base case.
Other environmental considerations				
Visual amenity	Low to high based on the physical presence of the overhead line and cleared easement within a national park.	Low to high based on the physical presence of the overhead line and cleared easement within a national park. No expected improvement on the perceived view of the steel poles due to the sheer size and width of the steel monopoles to address the loading requirements. No expected improvement from the base case.	Low to high based on the physical presence of the transmission connection within a national park.	No change from the base case

Element	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)
Biodiversity	Requires clearing of native vegetation which provides habitat for threatened species though no significant impacts are predicted.	With a larger disturbance footprint compared to the base case, additional clearing of native vegetation which provides habitat for threatened species would be required. Higher level of impact on biodiversity compared to the base case.	Compared to the base case would require approximately 43 ha less clearing. As such, extent of predicted impact on biodiversity under this option is expected to be less compared to the base case (Option 4).	No change from the base case
Heritage	Disturbance of 3 potential archaeological deposits (PAD) and four Aboriginal heritage artefact sites. Disturbance to one site of local heritage significance and five items with archaeological potential. No significant impacts to historic heritage are predicted including the National Heritage Listing of the Australian Alps National Parks and Reserves and Snowy Mountains Scheme.	No expected change from the base case.	Disturbance of 3 potential archaeological deposits (PAD) and four Aboriginal heritage artefact sites (no change to the base case (option 4). Potential disturbance to one site of local heritage significance and three items with archaeological potential. No significant impacts to historic heritage are predicted including the National Heritage Listing of the Australian Alps National Parks and Reserves and Snowy Mountains Scheme.	No change from the base case
Water	Erosion and sediment impacts during	Erosion and sediment impacts during construction which require mitigation and control. The	Erosion and sediment impacts during construction which require mitigation and control. The extent of risk to	No change from the base case

Element	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)
	construction which require mitigation and control	extent of risk to receiving waters is expected to be higher compared to the base case due the larger footprint and higher volume of spoil generated.	receiving waters is expected to be less compared to the base case due the retention of all easement vegetation.	
Transport	Temporary impacts on traffic and access during construction.	Higher volume of heavy vehicle movements as part of the transport of the large pole segments compared to the base case. Modification of sections of the access tracks, particularly on the narrow bends would be required to facilitate the haulage of the pole segments to the structure locations	No change from the base case	Reduction in heavy vehicle movements along Elliott Way and internal access tracks having an overall beneficial impact on the safety and function of the project transport network.
Excess Spoil quantity	~180,000 m^3 of material (subject to change following detailed design)	~234,000 m^3	No change from the base case	No change from the base case
Cost				
Construction cost (including the Maragle substation)	$290 Million	$328 Million	$320 Million	Potentially minor increase in cost
Operational and maintenance (average yearly)	~$496,000	~$515,000	~$506,000	~$496,000
Time				
Project planning approvals	The CSSI application for the project is currently in	Approximately 12 months to develop a revised	Approximately 12 months	No additional time required.

Element	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)
	the assessment phase with DPE.	concept design and amend existing approval documentation.		
Construction and rehabilitation (excluding the 500 kV switchyard at the substation)	30 Months	6 – 12 months	Additional 6 months	Potential reduction in construction duration (up to two months).
Commissioning	3 months	3 months	3 months	3 months
Network resilience	Acceptable level of network stability and resilience	Acceptable level of network stability and resilience	Unacceptable	No change from the base case

2. Road works and upgrades

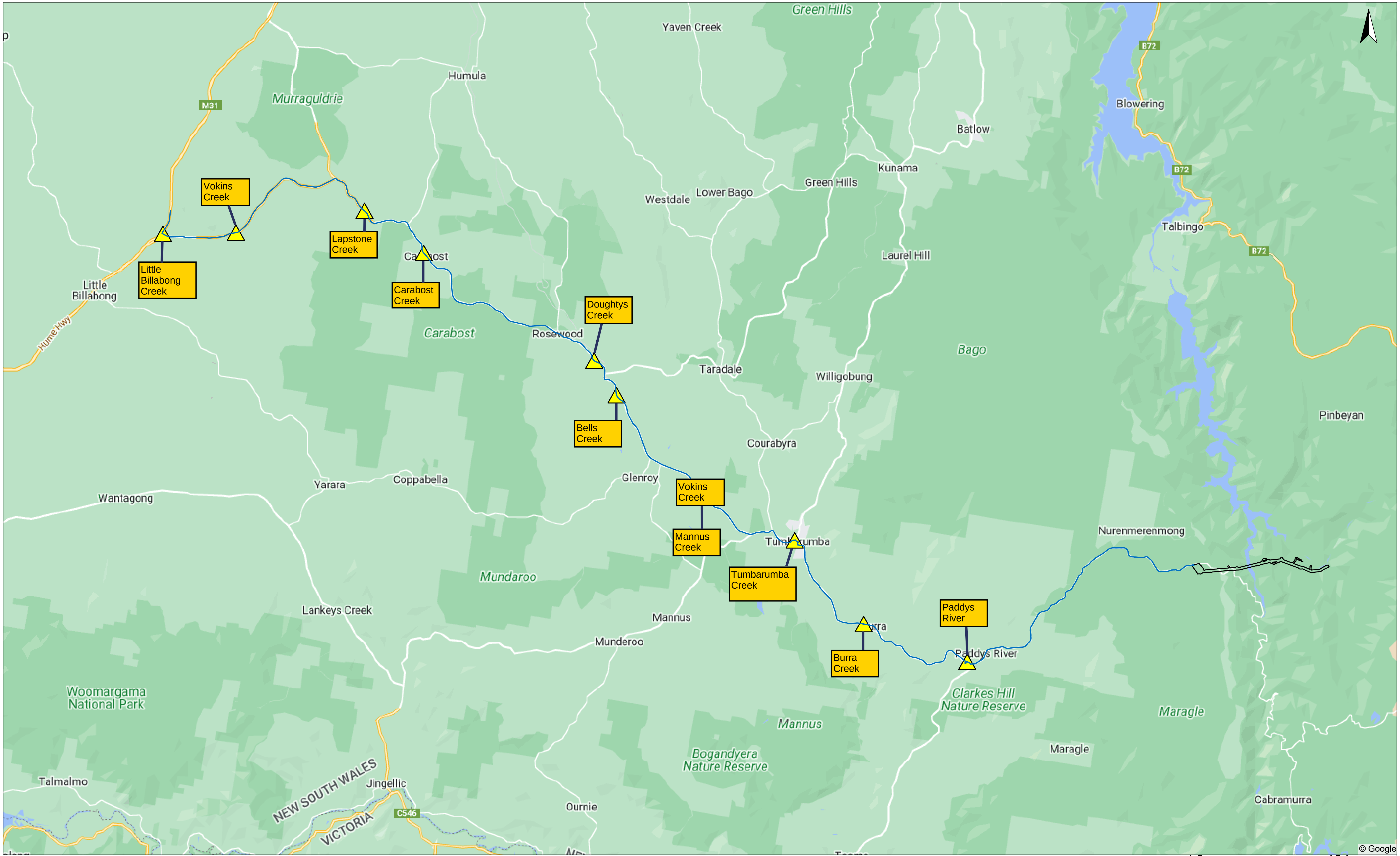
DPE are seeking clarification on all proposed road works and upgrades (including water crossings) on the public road network to support general construction traffic and oversize-overmass (OSOM) vehicle movements. This section is supported by the following assessments:

- *Route Study - Newcastle Port to Maragle,* Rex J Andrews Engineered Transportation (2021) provided in Appendix D
- *Bridge Assessment- Port Kembla to Paddys River*, Rex J Andrews Engineered Transportation (2019) provided in Appendix E

No road or bridge upgrades are anticipated along the State Road network from the Port of Newcastle (anticipated point of delivery for the high mass substation equipment) to the turn-off from the Hume Highway at Little Billabong Creek Road as this route is already an approved Higher Mass Limit vehicle route.

From the Hume Highway to the Tumbarumba Township, the haulage route would continue along the Classified State Road network traversing Little Billabong Creek Road, Tumbarumba Road, Wagga Road and Albury Street. The bridge assessment carried out by (Rex J Andrews Engineered Transportation (2019), assessed the use of these roads with an assumed load of 125 tonnes. Eight bridges are traversed along this section of the route, however none were identified as requiring upgrade (refer to Figure 4 and Photograph 1 to Photograph 8. Prior to delivery of the high mass equipment, further assessment would be carried out should any equipment exceed the assessment rating of 125 tonnes.

The initial bridge assessment only included an assessment of bridge crossings along the State Road network, under the jurisdiction of Transport for NSW only and did not include the network of Council roads from Tumbarumba to the proposed Maragle substation site. This section of the route would traverse two bridge crossings, south east of Tumbarumba: Burra Creek and Paddys River along Tooma Road (refer to Figure 4 and Photograph 9 and Photograph 10.



Project Area

Haulage Route From Hume Highway

Bridge Crossing

Transgrid

0 10 km

Figure 4: Bridge Crossings

Scale: 1: 237324.422465823

Photograph 1: Bridge crossing over Little Billabong Creek, Little Billabong Road (Classified State Road)

Photograph 2: Bridge crossing over Vokins Creek, Little Billabong Road (Classified State Road)

Photograph 3: Bridge crossing over Lapstone Creek, Tumbarumba Road (Classified State Road)

Photograph 4: Bridge crossing over Carabost Creek, Tumbarumba Road (Classified State Road)

Photograph 5: Bridge crossing over Doughtys Creek, Wagga Road (Classified State Road)

Photograph 6: Bridge crossing over Bells Creek, Wagga Road (Classified State Road)

Photograph 7: Bridge crossing over Mannus Creek, Wagga Road (Classified State Road)

Photograph 8: Bridge crossing over Tumbarumba Creek, Albury Street (Classified State Road)

Photograph 9: Bridge crossing over Burra Creek. Tooma Road (Council Road)

Photograph 10: Bridge crossing over Paddys River, Tooma Road (Council Road)

Transgrid has commenced consultation with Snowy Valleys Council and is in the process of obtaining the relevant design/engineering plans to carry out the loading assessment for the haulage of the high mass substation equipment. Given the age of these bridges, designs have not been digitised. As such, delays have been experienced in undertaking the necessary bridge assessments due to the availability of the hard copy of the bridge designs. At the time of preparing this response, the designs for one of the bridge crossings have still not been located by Council. Notwithstanding this, given both bridges are comprised of two lanes (one in each direction), no widening of the bridge is required. Furthermore, any upgrade/reinforcement works is expected to be limited to the existing bridge structure such the placement of temporary or permanent bracing and/or supports. Any piling or reinforcement of bridge columns that may be required to uprate the bridges would be carried out in a manner that would not affect stream flows or fish passage. Furthermore, appropriate sediment controls (such as sediment curtains) would be used to control the dispersal of sediment, should any in-stream works be required. Further information would be provided to DPE once the loading assessments of the two bridges has been completed.

As detailed in Section 4.3.7.1 of the *Snowy 2.0 Transmission Connection Project – Submissions Report* (Jacobs, 2022) (the Submissions Report), two locations were identified by the *Route Study - Newcastle Port to Maragle,* carried out by (Rex J Andrews Engineered Transportation (2021) as requiring upgrade to support OSOM movements (refer to Table 5).

Table 5: Road modification works

<table>
<tr><th>Location</th><th>Description of works</th></tr>
<tr><td>Albury Street and Bridge Street in Tumbarumba

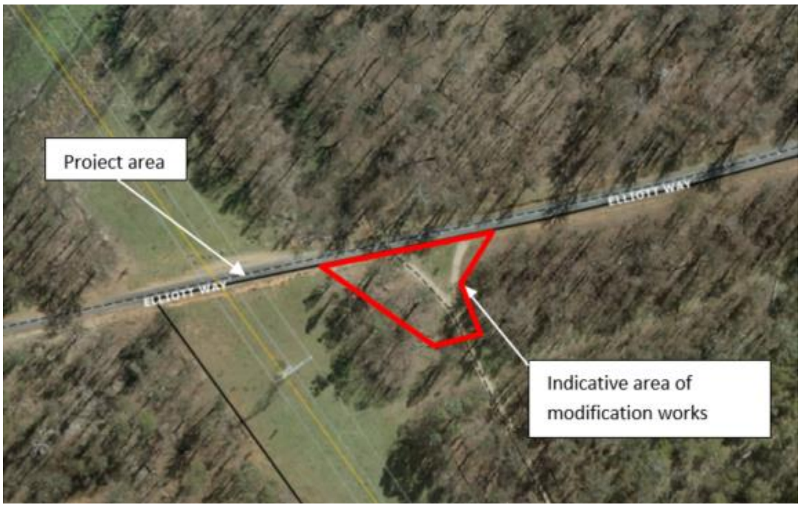
Unclassified Council Road</td><td>Lowering of sections of the median strip on Albury Street and Bridge Street in Tumbarumba and signage to be made removable to allow OSOM vehicles to pass through the township.

All works would be confined to the disturbed areas of the existing road reserve as shown below in red.


</td></tr>
<tr><td>Elliott Way/proposed substation site access road

Unclassified Council Road</td><td>Modification works at the intersection of the substation site access road and Elliott Way. This is required to support the swept path of the OSOM vehicles entering the substation access road off Elliott Way.

All works would be confined to the proposed project area.


</td></tr>
</table>

3. Substation switchgear

DPE is seeking an understanding of impacts associated with the use of outdoor switchgear equipment (as proposed) compared to indoor gas insulated switchgear (GIS). Whilst there are limitations associated with indoor GIS equipment, such as the requirement for large buildings to house the equipment, the footprint size is often smaller compared to substations using outdoor switchgear equipment.

Further investigation for the potential to use indoor GIS at the proposed substation was carried out by Transgrid. The following limitations associated with the use of indoor GIS at the proposed substation from a technical and network planning perspective include the following:

- To manage voltage dips during switching activities, system planning studies require the circuit breakers at the proposed substation to be switched using pre-insertion resistors. Transgrid sought technical clarification from two trusted GIS suppliers in the market. This confirmed that the GIS suppliers could not provide 500 kV GIS circuit breakers to meet the system planning requirements and further, could not provide 330kV GIS circuit breakers suitable for switching the power transformers. As such suitable GIS circuit breakers were only identified for 7 out of the 24 circuit breakers required at the substation. As such outdoor air insulated switchgear (AIS) circuit breakers are required for the remaining 17 out of 24 circuit breakers at the substation.
- Quality of supply monitoring requires Capacitive Voltage Transformers (CVTs) with Power Quality (PQ) sensors. Transgrid has not identified a GIS supplier that can meet the CVT with PQ sensor specifications without special testing. As such, outdoor AIS CVTs are required
- Power Voltage Transformers (PVT) are required for auxiliary power prior to the delivery of the 500/330kV transformers. Transgrid has not identified a GIS supplier that can meet the PVT specifications. As such, outdoor AIS PVTs are required
- System planning studies require the power transformers to have an overload capacity of 600MVA (single phase). Further, system planning studies require a basic insulation level (BIL)/Lightning impulse withstand of 1550kV. Transgrid has not identified a Gas Insulated Transformer (GIT) supplier that can meet these specifications. As such, outdoor AIS power transformers are required.
- System planning studies require a BIL/Lightning impulse withstand of 1550 kilovoltage peak. Transgrid has not identified a Gas Insulated Reactor (GIR) supplier that can meet these specifications. As such, outdoor AIS reactors are required.

This would result in the transformers, reactors, 500 kV Circuit Breakers, 330 kV transformer switching circuit breakers, Power VT's and Quality of Supply CVT's needing to be AIS. If the remaining High Voltage plant was then installed in GIS, the reduction in site footprint afforded by the GIS would be minimal and the ad hoc nature of the site along with the complicated AIS to GIS interfaces would likely offset any potential reduction in site footprint. The substation layout which shows all high voltage equipment where a GIS solution could not be found is shown in Figure 5.

Transgrid

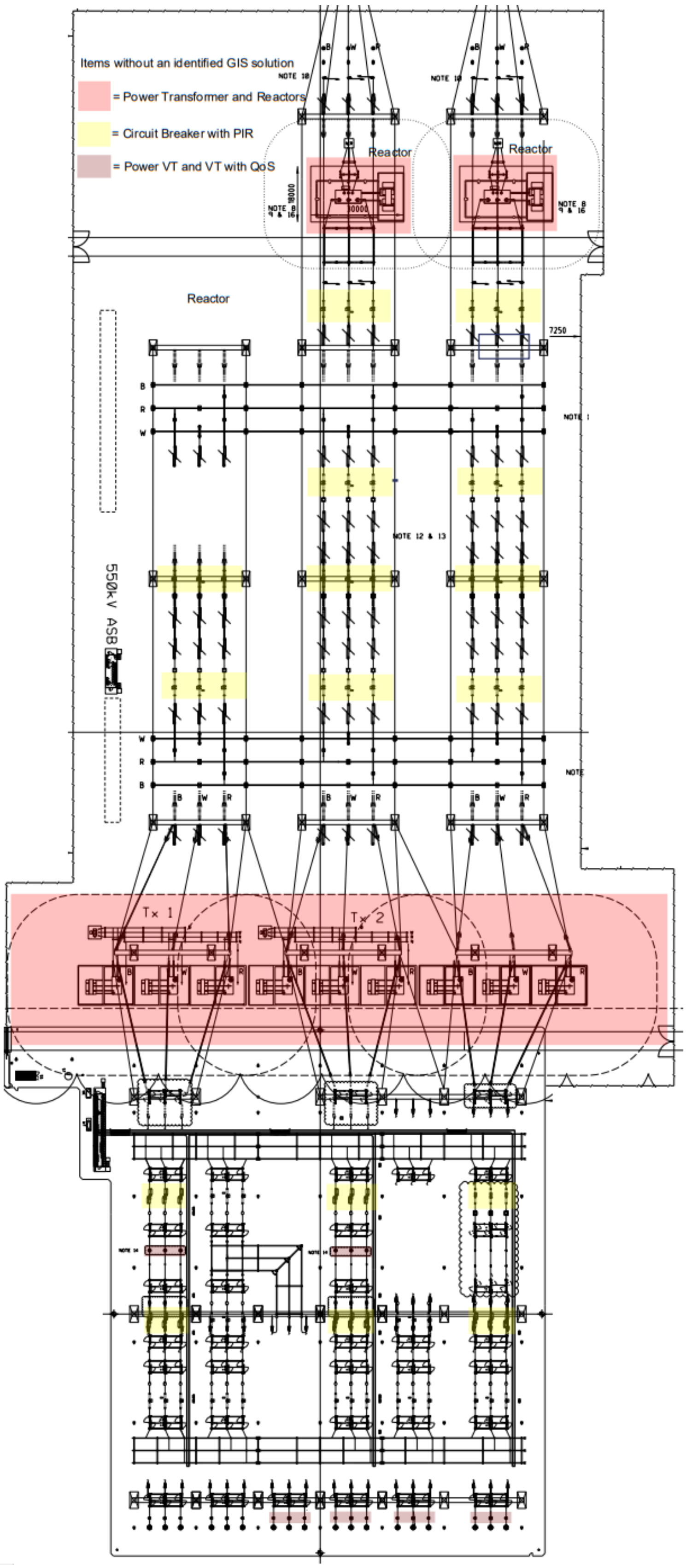


Figure 5: Substation layout showing components where a GIS solution could not be found

4. Improvement of amenity values of KNP

The package to be offered to improve amenity values within KNP is currently in the process of being resolved between DPE, NPWS and Snowy Hydro Ltd (on behalf of Transgrid). A separate response will be provided to DPE once the matter has been agreed to in principal by all parties.

5. Spoil classification and sizing of erosion and sediment controls

DPE is seeking clarification that the disturbance footprint includes areas for spoil classification prior to its disposal and detail on the assumptions used in the sizing of erosion sediment controls.

5.1. Spoil classification

As described in Section 4.1.3.1 in the Submissions Report, prior to transporting excess spoil material from the work locations in project area east (portion of the project east of the Talbingo Reservoir) to the relevant approved Snowy 2.0 emplacement areas, the material would be classified to ensure it meets the approved Snowy 2.0 spoil parameter requirements. Further clarification is provided below.

Where possible, initial soil classification (including testing for naturally occurring asbestos) would be carried out as part of the geotechnical assessment of the work locations (including access tracks) prior to bulk earthwards commencing. Classifying the material *in-situ* would avoid the requirement to stockpile material, therefore reducing exposure of the material and reducing the risk of erosion and sedimentation.

Given the nature of the terrain, being located within an alpine area characterised by steep slopes, there will be a requirement to stockpile spoil where it cannot be tested *in situ* due to access constraints for mechanical geotechnical equipment. In project area east, spoil would be stockpiled in areas within the disturbance footprint, which area designated for full clearing (Transmission Structure Zone and Tensioning and Pulling Zone). A tower site used as a stockpiling location would only be subject to the construction of the tower once stockpiling at the location has ceased. Consequently, multiple tower sites may be utilised for stockpiling as work progresses. All stockpiles would be subject to stringent erosion and sediment controls, implemented in accordance with approved erosion and sediment control plans (as detailed in mitigation measure B11, Appendix B of the Amendment Report) to protect receiving watercourses and important Booroolong Frog habitat. Transgrid has engaged with its delivery contractor who have confirmed there is sufficient space within the areas designated to full clearing in project area east to accommodate the stockpiling of excess material.

Once material, whether *in situ* or within stockpiles is classified, the material would be transported directly to the relevant Snowy 2.0 emplacement area or stored in temporary stockpile for use in Snowy 2.0 Main Works project rehabilitation, where it would be managed in accordance with the approved *Snowy 2.0 Spoil Management Plan* and any approved Snowy 2.0 rehabilitation plan.

In project area west (portion of the project area west of Talbingo Reservoir), the same process would occur where soil classification would be determined as part of the geotechnical works, where access can be obtained. Where *in situ* testing cannot be carried out, excess spoil would be transported to a designated stockpiling area within the substation site, where it would be tested prior to disposal. As detailed in Section A.4.7.1 of the Amendment Report, excess spoil generated within project area west would be disposed of within the designated substation zone. Following classification, the excess material would be spread out in disturbed and exposed areas and appropriately contoured prior to being stabilised and rehabilitated with low growing native grass species. Similarly, with project area east, the risk of erosion and sedimentation associated with the stockpiles would be managed in accordance with approved erosion and sediment control plans.

5.2. Sizing of erosion sediment controls

The revised project disturbance footprint as detailed in the Amendment Report has been developed in consultation with Transgrid's delivery contractor with due regard to allowing sufficient space to encompass fit-for-purpose erosion and sediment controls, to appropriately manage impacts on water quality in receiving surface waters and important Booroolong frog habitat in project area east. A review of available detailed project designs was carried out in consultation with the delivery contractor, which confirmed the following:

- The assessed impact area for the transmission structure zone for each set of transmission structures occupies an area of 1.5 hectares. On average, the bench at each transmission structure zone would only occupy an area of approximately 0.7 ha. Consequently, at each structure site, there is sufficient space to encompass the necessary level bench for the construction of the transmission towers and for the installation of site specific erosion and sediment controls which are over and above the necessary requirements set out in the *Managing Urban Stormwater: Soil and Construction Volume 1 (Landcom, 2004)* ('the Blue Book').
- The access tracks present a key source of erosion risk for the project and a key source of potential sedimentation and associated water quality impacts to watercourses within and down gradient to the disturbance footprint if not managed appropriately. As such, ensuring there is appropriate space within the disturbance footprint for the access tracks to support the establishment of both temporary and permanent erosion and sediment control was paramount when sizing the width of the track footprint. On average, the nominated disturbance width of the access tracks is 30 metres with a built track surface of 5 metres in width. As such, on average there is a buffer of approximately 12.5 m each side of the track surface to support permanent and temporary drainage structures, erosion and sediment controls and the necessary batters. The main sediment control structures will be confined to a sediment containment structure at each outlet from the table drains. These are yet to be designed in detail, however, they can be located within the full disturbance footprint. Given the steepness of the terrain, capturing, diverting and slowing the flow of run-off down gradient as to promote natural absorption will be key. As such, placement of rock on disturbed track areas and along the batters on steeper slopes would be used to slow the velocity of run-off.
- Disturbance beyond the ground cover within the easement clearing zone would not occur. As such, given this area would only be subject to the removal of the tall growing tree and shrub species with the ground cover being retained, the risk of erosion is low. During construction, any localised exposed areas within the easement clearing zone would be typically managed through the placement of mulch in manner that would not restrict regeneration of the ground cover.

As detailed in Section 3.3.3.2 of the Amendment Report, under consultation with the NSW Environment Protection Authority (EPA), there is a commitment to prevent any change to the existing baseline surface water quality within and adjoining the project area. Should the project be approved, Transgrid is committed to working closely with the EPA, NPWS and the Biodiversity Conservation Division (BCD) to develop the post approval Soil and Water Management Plan (SWMP) and associated site specific erosion and sediment control plans for implementation during construction. The erosion and sediment control plans would clearly define the type, location and sizing of key erosion and sediment control features with consideration to the proximity and location of receiving surface waters, steepness of the terrain and the extent of ground disturbance. Staging of works and progressive rehabilitation will also be considered to minimise the duration of ground exposure. Further information on erosion and sediment controls is provided in Section 3.3.3.2 of the Amendment Report.

The SWMP and associated sub-plans would be developed in consultation with NPWS, EPA and BCD and to their satisfaction prior to lodgement with DPE.

6. Biodiversity offsetting arrangement

Transgrid has an arrangement with Snowy Hydro Limited (SHL) to meet the offset obligations under the NSW Biodiversity Offsets Scheme and provide the relevant security for meeting those obligations, by the mechanisms set out below.

Within the Kosciusko National Park (KNP), offsets will be managed by direct payment of funds towards defined management actions within the National Park. No security is required for these funds.

Outside the KNP, mechanisms for meeting offset obligations outlined in the Biodiversity Offset Strategy (BOS) will be adopted. Available mechanisms supported under the NSW Biodiversity Offsets Scheme include securing 'like-for-like' credits through Biodiversity Stewardship Agreements (BSA's) or retiring credits under the variation rules. If offset obligations cannot be satisfied via these mechanisms, payment would be made into the Biodiversity Conservation Fund ('BCF') for any residual offset liability.

To secure delivery of the required "Outside the KNP" offsets, the Transgrid and SHL intend to enter into a deed with the Planning Secretary. This deed will secure the financial liability equivalent to the cost of payment into the BCF. In the event that offsets are unable to be secured via the mechanisms outlined above, the Planning Secretary would enforce the security and pay relevant funds into the BCF.

Should the project be approved, it is expected that conditions of the approval would be imposed, adopting a similar mechanism to that adopted in the conditions imposed on the Project Energy Connect (West) approval. Proposed wording is set out below:

A Prior to carrying out any development that would impact on biodiversity values, the Proponent must prepare a Biodiversity Offset Package (Package) that is consistent with the EIS and RTS, in consultation with the Biodiversity, Conservation and Science Directorate of the Department of Planning and Environment and to the satisfaction of the Planning Secretary in writing. The Package must include, but not necessarily be limited to:

(a) details of the specific biodiversity offset measures to be implemented and delivered in accordance with the EIS and RTS;

(b) the cost for each specific biodiversity offset measure, which would be required to be paid into the Biodiversity Conservation Fund if the relevant measure is not implemented and delivered (as calculated in accordance with Division 6 of the Biodiversity Conservation Act 2016 (NSW) and the offsets payment calculator);

(c) the timing and responsibilities for the implementation and delivery of the measures required in the Package; and

(d) confirmation that the biodiversity offset measures will have been implemented and delivered no later than 2 years following the grant of this approval.

Following approval, the Proponent must implement and deliver the Biodiversity Offset Package.

B. Prior to carrying out any development that could impact the biodiversity values requiring offset, the Proponent or its nominee must procure and provide to the Planning Secretary a bank guarantee for the amount of [$X million], in accordance with the Deed of Agreement with the Planning Secretary and Snowy Hydro Limited executed on [*date]. The Proponent must comply with the terms of the Deed.*

Note: this condition provides security to the Minister for the performance of the Proponent's obligations under this approval in relation to biodiversity offsets and release funds for payment into the Biodiversity Conservation Trust in the event that the biodiversity offsets (either in whole or part) are not delivered in accordance with the Package by the Proponent.

7. Management actions for Yellow-bellied glider

Further information was requested in relation to additional management actions for Yellow-bellied glider with respect to both project specific mitigation measures and management actions to be carried out more broadly as part of the biodiversity offsets strategy.

7.1.1. Project specific management actions

A number of measures to mitigate and monitor the impact of the project on Yellow-bellied Glider during construction and operation of the project will be incorporated into a revised biodiversity assessment report (BDAR) for lodgement with DPE on 24 June 22. Key management actions include:

- A targeted connectivity strategy
- Arboreal crossing structures
- Targeted surveys for Yellow-bellied Glider to refine crossing structure locations
- Nest box strategy
- A staged habitat removal process consistent with mitigation measure B4 (refer to Appendix B of the Amendment Report) and the Biodiversity Management Plan
- The minimum design and locations of crossing structures for Yellow-bellied Glider will be based on the process for managing connectivity requirements described in a Yellow-bellied Glider Connectivity Strategy
- Implementation of a comprehensive monitoring program
- The proposed approach to management of potential impacts to the Yellow-bellied Glider population throughout the pre-construction, construction and operational will be documented in the Biodiversity Management Plan.

A Yellow-bellied Glider connectivity strategy will be developed for the project which aims to address the barrier effect that an open transmission easement would have on glider movements. The strategy will continue to be developed during detailed design and form part of the Biodiversity Management Plan.

The goal of the strategy is to maintain connectivity in the landscape for Yellow-bellied Glider, as well as enhance movement where feasible and reasonable near the transmission easement. Additionally, the Yellow-bellied Glider connectivity strategy will present opportunities for a targeted survey to inform the location fauna crossing structures.

The strategy will outline measures to be adopted for the detailed design in the form of connectivity design for crossing structure principles. The project will comprise dedicated fauna crossing structures based on the current project area. The location of crossing structures (glider poles) are subject to refinement during detailed design and consultation with BCD as part of the strategy.

The Biodiversity Management Plan will identify specific goals for Yellow-bellied Glider management, implementation of management actions, followed by a monitoring program with an adaptive management approach. This will allow for performance thresholds to be evaluated to measure the effectiveness of management goals and implement corrective actions to improve mitigation if required.

7.1.2. Clarification of management actions in the biodiversity offsets strategy

The biodiversity offset strategy (BOS) includes management actions to address key threats to the Yellow-bellied glider population on the Bago Plateau. The approach is consistent with the approach used to develop the Snowy 2.0 Main Works BOS and will provide significant funding to gain a better understanding of occupancy across the Bago plateau, assess gene flow to adjacent populations of the species and address the key threats threatened population by improving connectivity. These works have been fully costed.

At the species expert workshop help for the project in February 2022, the potential for the Tumut River to act as a barrier to movement was raised and the possibility of installation of poles in the river to facilitate crossing was discussed. Analysis of canopy width along the Tumut River south of Talbingo Reservoir to below Cabramurra against gliding angles outlined in Goldingay (2014) [1]indicates that the Yellow-bellied Glider can readily cross the river at numerous points. Goldingay (2014) reports a glide ratio (horizontal distance vs height dropped) of 2.0 and a glide angle of 27.3 degrees. Canopy height at the outer edge of the canopy vary along the Tumut River, with many locations where the outer edge of the canopy exceeds 20 metres, meaning the Yellow-bellied Glider is capable of spanning gaps of 34 metres (assuming they land 6 metres off the ground). At these locations the canopy from one side of the river to the other is around 20-30 metres, meaning the Yellow-bellied Glider is capable of spanning these gaps easily. Based on this, placement of poles within the Tumut River is not required.

BCD has highlighted the requirement to identify the location of proposed poles across existing easements. It is proposed that poles will be placed in locations where there are records of Yellow-bellied Glider and/or suitable habitat to ensure best usage. These locations will be informed by the initial survey work proposed in the BOS and habitat modelling. As such, the location of poles cannot be identified prior to the completion of these surveys. In addition, it is submitted that the location of these poles is not necessary prior to approval being granted to the project.

For species recorded during the Snowy 2.0 Main Works, the costing for management actions proposed for Snowy 2.0 Main Works with be applied to project to calculate the payment cost. It is noted that for the Booroolong Frog and *Caladenia montana,* BCD wishes to utilise these funds to fund actions not outlined in the Snowy 2.0 Main Works BOS. The management actions outlined in the Main Works BOS were used to determine the payments to the NPWS to offset the residual biodiversity impacts of the Snowy 2.0 Main Works project. As outlined in Schedule 3 Condition 12 of the Snowy 2.0 Main Works Infrastructure Approval:

"*. . . the NPWS will:*

- develop and implement a detailed program for the allocation of these funds to specific projects, focusing on the ecosystems and species affected by the development."

Under this condition, NPWS (and BCD) would be able to identify actions not identified in the BOS as a part of the development of the detailed program of works.

The identification of suitable land based offsets for the project are well progressed. To date, a number of sites have been identified as suitable, with preliminary investigations undertaken across three sites. Based on these preliminary investigations, two sites have been identified which are capable of meeting 90% of the ecosystem credit requirements for the project. Recent surveys have also identified the Yellow-bellied Glider on one of these properties, with initial analysis indicating that more than sufficient credits will be generated to meet the species credit requirements for the Yellow-bellied Glider. Detailed surveys will be undertaken over the next few months, including further targeted species surveys. Subject to agreements with landowners, Biodiversity Stewardship Agreements (BSAs) are intended to be developed over these sites to offset the

[1] Goldingay R, 2014, *Gliding performance in the yellow-bellied glider in low-canopy forest,* Australian Mammalogy, 36, 254–258.

impacts arising from the project. BCD have requested that BSAs are developed before clearing occurs. This requirement is contrary to discussions with DPE and would place a significant constraint on the project- a project declared to be critical to the State for economic, environmental and social economic reasons. To address any risk, Transgrid and SHL (who would fund the offsets) intends to enter into a deed of agreement with the Planning Secretary. Further information of the structure for the delivery of offsets is provided in the BoS and Section 6 of this document.

8. Biodiversity assessment report

During the review of the revised *Snowy 2.0 Transmission Connection Project - Biodiversity Development Assessment Report* (Jacobs, December 2021), BCD identified a number of inconsistencies between the biodiversity assessment method (BAM) calculator and the BDAR including spatial data, figures and tables and vegetation integrity scores for partial loss that may affect credit obligation and transparency. Jacobs have carried out a review of the BDAR and BAM calculator inputs and have prepared a revised BDAR accordingly.

The spatial dataset is very comprehensive which comprises a full breakdown of information such as vegetation clearing zones within partial clearing zones, vegetation zones, PCTs and IBRA bioregions. A re-calculation of all spatial data was completed to ascertain any issues with impact areas for both ecosystem credits and species credits. The following inconsistencies were identified:

- The vegetation clearing zones spatial layer contained errors in the topology (ie small polygon slithers and overlaps) that were not accounted for previously. This means that calculations derived from the vegetation clearing zones layer are not comparable to the disturbance area layer. This explains errors in some of the rounding issues that weren’t reflected in reported numbers, many of these are unlikely to affect credit calculations, but will need to be re-entered in BDAR and BAM-C.
- There were minor differences in Gang Gang Cockatoo species polygon calculations.
- An error was identified for the Yellow-bellied Glider species polygon, which has now been rectified.
- Partial impacts in Australian Alps bioregion for Yellow-bellied Glider and Eastern Pygmy Possum were previously calculated incorrectly.

The BDAR, BAM-C and spatial data have now all been updated and provided with this resonse.

8.1. Further information on threatened entities

BCD requested further information in relation to the following:

- How avoid, minimise and impact mitigation for Booroolong Frog (EPBC Act) will be achieved
- Details of mitigation measures for all impacted threatened species.

The project will avoid direct impacts on Boorloolong Frog habitat. However, the BDAR has identified potential indirect impacts to Boorloolong Frog habitat associated with constructing the transmission easement. This may result in an increased risk of displaced sediment entering Yarrangobilly River via the slopes and ridge east of Lobs Hole Ravine road and associated with Sheep Station Creek, Lick Hole Gully, Cave Gully and Wallace Creek. While vegetation clearing will be largely avoided in gullies, there is a proposed access track crossing Sheep Station Creek, and partial clearing zones within proximity to the riparian corridor of Wallace Creek, and upstream habitats along Lick Hole Gully and Cave Gully. The introduction of the partial clearing zones are likely to reduce the risk of erosion and sedimentation from the project to downstream waterways where parts of the groundcover in the ECZ, HCZ and HTZ will remain partially intact or intact, and reduce soil disturbance. Over the long-term operational phase, the recovery of ground layer vegetation in the disturbance area would be expected to prevent further movement of sediment.

A range of mitigation measures will be implemented to prevent sediment entering waterways in general, and specifically the habitat for Booroolong Frog and Murray Crayfish and these will be documented in the Soil and Water Management Plan (SWMP) and the Biodiversity Management Plan. A summary of these include:

- Detailed design for the permanent crossing structures on access roads (such as Sheep Station Creek) will focus on options that ensure stream flow is unaffected.
- A 50 m exclusion zone around Yarrangobilly Creek, Lick Hole Gully Cave Gully, Wallace Creek and Sheep Station Creek and exclusion of heavy machinery from the riparian zone, which will be hand-cleared only.
- The SWMP will include stringent controls to mitigate impacts of runoff and sediment transfer from the project area during construction and operation. Controls measures will remain in situ until site stabilisation completion criteria are met.
- An assessment of the current sediment basin design for the Snowy 2.0 Main Works project to determine if the design specifications are suitable for the additional sediment load expected during construction of the project. Where modification or augmentation is required, sediment basins will be increased in size to cope with any additional expected sediment load.

Indirect impacts are uncertain during high rainfall events during and/or after clearing. If mitigation measures and sedimentation controls fail, this could lead to a substantial loss or adverse impact to Booroolong Frog breeding and dispersal habitat. An adaptive management plan will be prepared in consultation with NPWS and BCD to address risk of increased sedimentation/run off to the identified breeding habitat and population extent downhill and downstream of the project area. This will require an estimation of the residual impact if sediment mitigation measures fail. Information on stream health associated with Booroolong Frog breeding and dispersal habitat will be used as part of the adaptive management program.

The timing of monitoring surveys is to be provided in the program including pre-construction and post-construction duration and should be sufficient to allow any changes and/or degradation of Booroolong Frog habitat to be recorded and appropriate mitigation measures implemented as part of the adaptive management program. As a minimum the program should commence a minimum of 6 months prior to construction.

The Biodiversity Monitoring Program will include provision for annual reporting of monitoring results to the DPE and DAWE. As the program will focus on performance indicators and provide an adaptive management framework (refer to Table 11-2 of the BDAR), the outcomes of these would be reported in the monitoring program annual reports.

Furthermore, the mitigation measures have been revised specific to managing impacts on threatened species breeding habitat including Yellow-bellied Glider and Gang-Gang Cockatoo. Also detailed in Section 7, there is now a commitment to preparing and implementing the Yellow-bellied Glider connectivity strategy to manage impacts on this species.

9. Office of Energy and Climate Change

On 12 July, DPE provided Transgrid with a letter they received from the NSW Office of Energy and Climate change. The letter requests Transgrid provide the following additional information:

- An analysis of the system resilience risks of co-locating the connection at Lower Tumut switching station (LTSS) compared to running parts of HumeLink close to existing transmission lines through bushfire prone areas, showing why the risk is acceptable in one situation, such as for the Humelink transmission project but not in the other, such as for the placement of the Snowy 2.0 connection.

- A clear comparison of the potential benefits of the underground options (including vulnerability to environmental factors, and visual impacts) against the potential costs (including operation and maintenance costs, as well as construction delays.

Response to these questions are detailed below.

9.1. Co-locating the connection at Lower Tumut Switching Station

It is acknowledged that HumeLink is proposing to co-locate new transmission lines with existing Transgrid lines across land that is prone to bushfire. However, when considering the potential points of connection for Snowy 2.0, other factors also needed to be considered. A new route diverse node at Line 64 would increase system resilience by having an overall reduced concentration of assets and localised power density. The proposed connection location creates a node on an alternative interconnection path to south-west NSW and Victoria relative to the existing single interconnection between Victoria and NSW (VNI1).

Furthermore, the Options Report assessed four methods of transmission connection to LTSS of which all were considered to not be feasible as outlined in Table 6.

Table 6: LTSS connection option

Connection option assessed	Assessment outcomes
Option 9 – Hybrid trench/submarine cable to Lower Tumut Switching Station	Refer to Section 8.6 of the Options Report. • Major constructability and operability constraints associated with laying and operating submarine cables in Talbingo Reservoir. • Likely to be prohibitively expensive to construct. • Overall, was determined to not be technically viable.
Option 10 – Trench to Lower Tumut Switching Station	Refer to Section 7.11 of the Options Report. • Significant vegetation clearance and earthworks required for construction purposes and operational maintenance requirements compared. • Significant excavation volumes, surface works and required equipment along public roads.
Option 11 – Overhead to Lower Tumut Switching Station	Refer to Section 7.12 of the Options Report. • Significantly more vegetation clearing and spoil generation required compared to other options, resulting in increased biodiversity impacts and impacts on values of KNP compared to other options.
Option 12 – Deep cable tunnel to Lower Tumut Switching Station	Refer to Section 7.13 of the Options Report. • Major constructability and operability constraints • Likely to be prohibitively expensive to construct • Would generate in the order of 1,000,000 m^3 of spoil which would require local disposal.

9.2. Comparison of the potential benefits of the underground options

It is acknowledged that for underground transmission connections, damage to the asset is largely avoided in the event of adverse weather (such as storms and high winds), bushfire and other events such as lightning strikes. Notwithstanding this, it’s important that providing full protection of the asset to these adverse events is not considered in isolation. The options assessment considered a broad suite of criteria when assessing each connection option. A revised options assessment table has been provided in Appendix C, which includes all options which progressed beyond the initial screening phase in the options assessment process as well as the variations to the base case (Options 4A, 4B and 4C) as detailed in Section 1. To improve clarity on the comparison of the options, constructability and operability constraints as well as operation and maintenance costs have been included in the table. These factors were not initially included in the options summary table (Table 8.3) in the Options Report.

There is a fundamental requirement that the project is to be constructed and commissioned in readiness for first power being generated by Snowy 2.0. First power was anticipated to occur in 2026, however it is acknowledged that there are reported potential delays, extending the completion of Snowy 2.0 to 2028. Regardless of this delay, there would be considerable risk with pursuing an underground connection at this point on the basis that a deep cable tunnel to Line 64 (Option 5) is estimated to take approximately 7.5 years and a cable trench (Option 6) taking approximately 6 years. These estimates are inclusive of feasibility studies, design, planning approvals, construction and commissioning. Based on these estimates, the consideration of these options in the absence of other critical constraints would not meet one of the key project objectives of meeting first power generated by Snowy 2.0.

Appendix A - Comparison of lattice towers and steel pole designs for 330 kV loadings

Comparison of lattice towers and steel pole designs for 330kV loadings

Document no: IS358000-UGL-000X-Concept
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UGL
VARSTPC001

Snowy 2.0 Transmission Connection Project
2 June 2022

Jacobs

Comparison of lattice towers and steel pole designs for 330kV loadings

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Executive summary

The Snowy 2.0 pumped hydro generation project (Snowy 2.0), is proposed by Snowy Hydro Limited to provide up to 2000 megawatts (MW) of generation capacity. Snowy 2.0 will link the Tantangara and Talbingo Reservoirs through underground tunnels and include an underground pumped hydro power station.

Snowy 2.0 is proposed to be connected to Transgrid's existing network at Line 64 by two 330 kV double circuit overhead transmission lines extending from the Snowy 2.0 cable yard at Lobs Hole to the proposed Maragle substation adjoining Line 64. The main objective of this document is to show a comparison between lattice tower and steel pole options, viability of steel pole designs and compare the environmental disturbance impacts between lattice towers and steel poles.

Overhead transmission lines in 330kV networks are generally designed and constructed using lattice steel towers as the main structure type. Single pole designs are typically encountered in short connections and are more common at lower voltage levels. Standard configurations are typically governed by electrical and electromagnetic clearance requirements.

In the recent past, with the improvement of manufacturing facilities and availability of higher steel grades, it has become possible to fabricate and construct stronger steel poles in high voltage transmission line spans. However during the design process for new overhead transmission lines, a number of factors are considered when selecting the appropriate structure type(s). Key factors to be considered are visual impact, safety in design, safety of construction personnel, constructability, terrain, rationalisation of tower types, location, site access, procurement, cost, environmental impacts and the long term maintenance and operability of the towers.

Utilities and other Owner/ Operators for transmission assets continue to engage in the design, construction and maintenance using lattice steel as an accepted industry practice. One of the main reasons for such practice to continue is the presence of well-defined asset management strategies that provide clear guidelines to maintain the operational effectiveness of such structures with frequent inspection regimes to check corrosion and galvanisation issues. There is very limited operational/ maintenance data associated with high voltage steel poles as these are relatively new compared to installed lattice towers which predominately age between 50-60 years.

At 132kV and 220kV voltage levels, pole sections are relatively small compared to their peers at 330kV voltage. The maintenance and inspection regimes for assessing steel corrosion and physical damage in steel poles is much more complicated as opposed to lattice towers. Lattice towers can be climbed and all sides of the tower members can be inspected with ease. In the event that corrective maintenance is required it can generally be limited to the targeted replacement of members that have been corroded or damaged. Targeted member replacements can be performed with smaller construction vehicles to minimise disturbance. Steel poles are tubular and the bend plate sections are not easily viewed for any thickness degradation from the inside of the circular/ tapered sections unless decommissioned and un-installed. The corrective maintenance on a 330kV steel pole to repair a corroded or damaged section would require the remobilisation of large specialised construction plant resulting in a larger disturbance when compared to the lattice towers. However, the available data relating to the long term issues associated with maintaining 330kV steel poles is limited due to 330kV steel poles being a relatively new structure type globally compared to the traditional lattice tower type.

From a design perspective, the Maragle 330kV transmission lines requires span lengths beyond 500-600m between structures. This results in significant tip loads arising from conductor swing tensions, wind load including galloping and ice loading due to its alpine location. Traditionally steel poles have been designed and supplied for 132kV, 220kV and 330kV with ultimate tip strengths up to 200 – 300kN with pole heights upto 40-50m. However, for the Maragle 330kV transmission lines tip loads of >400-500 kN (or 40tonnes – 50tonnes) would be required including up to 900kN (90 tonnes) for the river crossing with pole heights up to 60m. These tip loads are impractical for a 330kV steel pole transmission structure. This load resembles the size of a medium height wind turbine structure. To cater for such large loads, the steel poles would require a much larger base diameter and a much larger shaft thickness (up to 25mm - 32mm) and base plate thickness (up to 60mm - 72mm). Large thickness plates of this size are only sourced from specific mills around the Globe which are tailored to suit a certain volume of steel required for any specific project. Hence, it becomes impractical to source such steel for smaller volume projects (short line length). Traditional designs using steel lattice sections made up of bolted steel 'L' shaped angles have successfully catered for such large loads. This has been the most reliable design strategy for the past 100+ years for high voltage structures and continues to be so.

From a fabrication perspective, steel poles with tip loads of 200-300kN are optimised to connect cross-arms and shafts using bolted and welded plate connections. Steel plate sizes are around 200mm – 400mm requiring around 10-16 bolts in any connection design. For the larger steel pole tip loads required on the Maragle 330kV transmission lines the pole cross-arm lengths are greater than 10m each side for the middle phase which results in large forces under a broken conductor scenario. To cater for these forces a larger number of bolts for the cross-arm and shaft connection is required with over 30-40 bolts per connection and a plate size of 600mm to 800mm. Such large plates become impractical for shop fabricators and present significant safety and constructability challenges for site crews during installation.

As steel poles are fabricated with a limitation of 11.8m to suit the length of the galvanisation bath pool, the poles would need to be sectionalised for fabrication and installation. For the Maragle 330kV transmission lines, an approximate 58m height pole, would require 4-5 segments per pole. There are generally two ways to connect pole section together. One is using a flange plate connection between segments and the other is using a slip jointing technique. The slip jointing technique is where each segment is slipped into the shaft of the other segment and locked in with friction. To achieve the force required to slip joint, the large diameter poles required by the 330kV Maragle pole design becomes impractical due to the requirement for larger lay down areas to assemble the required ropes/ pulleys and hydraulic machinery to pull each section together. The alternative technique is jointing the poles using a flange plate connection. This requires large bolted plate connections between pole sections (similar to the cross arm connections). The additional size and weight introduced by the flange plates becomes impractical for shop fabricators and presents significant safety and constructability challenges for site crews during installation.

As steel tower footings are designed to cater for compression and tension forces on all four legs, circular 'bored' concrete pile footings are proven to be an efficient form of construction. The bored pile footing results in less disturbance at the tower sites when compared to the pedestal footing arrangement for a steel pole.

Bored footings rely on the friction between the native soil and the concrete piles and are drilled to average depths of 8-10m in normal dry soil. For steel poles as the reliance is to transfer the load into the ground with only one connection via the bottom shaft of the pole to the footing, large rectangular/square concrete pedestals/pads need to be formed. The pedestal type footings require large ground excavation. With the addition of battering or step backs to protect against ground collapse, the size of the excavation required for a pedestal type footing increases significantly beyond the dimensions of the pedestal itself.

For example, the estimated maximum ground moment for a tension pole on the Maragle 330kV transmission line is in the order of 50,000 kN. This magnitude of ground moment is directly comparable to a medium to large size wind turbine pole. To construct a footing of this size is the mountainous terrain would require large areas of excavation and cut-out into the side slope leading to significant safety and constructability challenges. In addition to this, the amount of concrete and steel reinforcement required for a steel pole on the Maragle 330kV transmission line is estimated to be 4-5x greater than that of the lattice tower footings.

Due to the steep and mountainous terrain, reducing the size, weight and quantity of deliveries to the structure sites is directly proportional to reducing the amount environmental disturbance. The larger and heavier steel pole sections require larger and heavier plant to deliver. This results in larger access track disturbance to facilitate the larger delivery vehicles when compared to steel lattice towers. The larger and heavier pole sections require larger and heavier cranage to erect the steel pole sections. This results in larger benching at each tower site when compared to steel lattice towers. The larger footings for the steel poles results in larger excavations and more concrete deliveries when compared to steel lattice towers.

As the Maragle 330kV transmission line follows an undulating terrain which includes Alpine (ice) loading and a major river crossing of 1.5km, the use of steel lattice towers remains the most viable and safe option with a smaller disturbance footprint when compared to a steel monopole type design.

Contents

Appendices

1. Introduction

The Snowy 2.0 pumped hydro generation project (Snowy 2.0), is proposed by Snowy Hydro Limited to provide up to 2000 megawatts (MW) of generation capacity. Snowy 2.0 will link the Tantangara and Talbingo Reservoirs through underground tunnels and include an underground pumped hydro power station.

Snowy 2.0 is proposed to be connected to Transgrid's existing network at Line 64 by two 330 kV double circuit overhead transmission lines extending from the Snowy 2.0 cable yard at Lobs Hole to the proposed Maragle substation adjoining Line 64.

This document covers concept information only related to the design criteria and preliminary findings of replacing the existing lattice tower designs with steel poles for the Maragle 330kV transmission lines. The main objective of this document is to show a comparison between lattice tower and steel pole options, viability of steel pole designs and compare the environmental disturbance impacts between lattice towers and steel poles. This is not intended to be considered as final and requires electrical and civil/structural checks associated with the standing variation submitted to UGL as part of the agreement related to these works.

2. General

Overhead transmission lines in 330kV networks are generally designed and constructed using lattice steel towers as the main structure type. Single pole designs are typically encountered in short connections and are more common at lower voltage levels. Standard configurations are typically governed by electrical and electromagnetic clearance requirements.

With the increasing improvement of manufacturing facilities and availability of higher steel grades, it has become possible to fabricate and construct stronger steel poles in high voltage transmission line spans. However, during the design process for new overhead transmission lines, a number of factors are considered when selecting the appropriate structure type(s). Key factors to be considered are visual impact, safety in design, safety of construction personnel, constructability, terrain, rationalisation of tower types, location, site access, procurement, cost, environmental impacts and the long term maintenance and operability of the towers.

Figure 1. Typical angle sections for towers

Photo (R) 220kV Towers, Rio Tinto

Photo (L) of 330kV Tower (Western Power)

Below

Photo (R) 33kV Pole Line for FMG

Photo (L) 220kV Pole for AusNet

Figure 2 Typical steel plate sections for steel poles at lower voltages

3. High level comparison of towers vs poles

Applying the design criteria and the analysis methodology described in the Appendix the comparison of steel lattice towers vs steel poles is summarised in table 1 below.

Table 1

Description	Steel Lattice Tower	Single Steel Pole Structure	Steel Bi-Pole Structure
Tip Loads (Refer to Appendix B)	Multiple members bolted together to form a lattice tower enables load sharing	Large tip forces on steel poles resulting in large steel sections, cross-arms and flange plates that are impractical for shop fabricators and presents significant safety and constructability challenges for site crews during installation	Large tip forces on steel poles resulting in large steel sections, cross-arms and flange plates that are impractical for shop fabricators and present significant safety and constructability challenges for site crews during installation
Steel availability, manufacturing, handling and delivery to site (Refer to Appendix C)	Maximum angle sizes in a typical tower are up to 200mm flange width resulting in relatively easy handling and transportation	Large diameter base up to 3.5-4.0m	Large diameter base up to 2.5-3m
Foundations (Refer to Appendix D)	Typical tower footings augered bored piles of 1-1.5m diameter up to a maximum depth of 12m +150m3 of concrete for 4 legs of one structure	Pad and pedestal 11x11m wide pad area, 4 piles 6m deep with tie-pad of another 10m width (see sketch) +800m3 of concrete for single pole (one structure location)	Pad and pedestal 8.5x8.5m wide pad area for one pole, 4 piles 6m deep with tie-pad of another 4m width (see sketch) +600m3 concrete for 2 poles (one structure location)
Structure Construction	55 tonnes total tower weight	67 tonnes in 4 sections special cranes for lifting/ assembly larger clearing and benching area	56 tonnes per pole x 2 poles in four sections each, special cranes for lifting/ assembly larger clearing and benching area

Appendix A. Concept steel pole design

A.1 Concept design criteria

For the purposes of a comparing the lattice tower design with a steel pole structure design on the 330kV Maragle Transmission Line, Jacobs carried out a concept design with steel poles with the following design criteria:

Table 2

No.	Description	Criteria/ Properties	Comment
1	Wind speeds and electrical/ mechanical line design criteria including ice loading	As per the current 330kV Maragle Transmission Line criteria	Includes all electrical, conductor tension limits, galloping and vibration requirements unchanged for the catenaries (conductors and optic fibre/ earthwire)
2	Grade of steel	450MPa	Available as high tensile steel sourced from China
3	Plate thicknesses	Up to 25mm for the pole shaft Up to 60mm for pole base plates	
4	Deflection limits	Ultimate wind - 6% of pole height	TLDM Clause 12.8.4
5	Footing assessment	Pad and chimney with underlying rock (typical) throughout the line including short bored piles up to 6m	Table L3 AS7000, soft and medium strength rock with ultimate bearing pressures of 450 – 1500kPA
6	Double circuit design	Single pole arrangement	All tension structures only including river crossing including suspension structures as single poles
7	Single circuit design	Bi-pole arrangement	All tension structures in a bi-pole arrangement only including river crossing. Suspension structures in single circuit design are still 'single poles' as per the double circuit design

A.2 Analysis methodology

Jacobs has carried out a preliminary assessment using the afore-mentioned design criteria using PLS-CADD and preliminary PLS-POLE models.

- Using a single pole with double circuit arrangement replicating a like-for-like replacement with lattice towers that provides no change to the catenary attachment points on the structures, Jacobs assessed the magnitude of the single steel poles and the load on the footing. Results are shown in the Appendices. There is no change to the easement with this option as the conductor attachments are kept intact (same location).
- Using two poles achieving a double circuit arrangement for strain structures replicating a like-for-like replacement with lattice towers that provides no change to the catenary attachment points on the structures, Jacobs assessed the magnitude of the poles and the load on the footings. Results are shown in the Appendices.

  Similar to the above there is no change to the easement with this option as the conductor attachments are kept intact (same location).
- In addition, Jacobs carried out a high-level pad and pedestal type design check associated with overturning and ultimate bearing pressures. It was noted that in all cases bearing pressures fall in the mid-range of soft to medium rock bearing pressures as stated in the criteria of this memo.

A.3 Results

- Appendix B provides the estimated tip loads for the steel poles
- Appendix F and Appendix G provide single pole and bi-pole design tonnage and base widths
- Appendix H and Appendix I provide a comparison of the footing reactions for a single pole and bi-pole arrangement including preliminary footing sizes

A.4 Limitations and future work

- Initial deflection analysis of pole loading has been limited to ultimate wind loads only. Everyday deflection limits will be assessed at the next stage of analysis as these can become governing cases which would further increase the strength requirements of the poles.
- Electrical clearances will require assessment to satisfy jumper arrangement for strain poles which is not part of this memo.
- Further optimisation for selected pole base widths and footing sizes can be carried out to satisfy transfer of load. Pedestal and pad designs are currently based on high bearing pressures with a loss of contact area (tension/ uplift) which may require multiple piles for heavily loaded poles. This memo does not address pile design.
- Based on available pole tip ratings from Australia (sourced locally) additional poles would be required to reduce the tip loads. This would increase the easement width as the number of poles will be greater than the concept bi-pole option.

Appendix B. Tip loads

Description	Steel Tower	Steel Pole
Tip loads	Multiple members bolted together to form a lattice tower enables load sharing design mechanism to pass large river crossing spans such as >1500m in Maragle with standard steel grades and sizes. No special manufacturing or higher than normal tip strengths required for transmission towers.	Large spans introduce large tip forces on steel poles which lead to excessive torsional load on poles thus introducing the need to carry out excessive welding and/or bolted plate connections on cross-arms leading to impractical sizes of cross-arm connections which are unsafe/ heavy to construct and lift in assembly. In the case of Maragle 330kV Transmission Line (concept) design, there exist large tip loads on steel poles which are impractical and unsafe to construct. For example majority tip loads from the below table for steel poles are > 400-500kN which are not commonly procured/ fabricated in the transmission line industry.

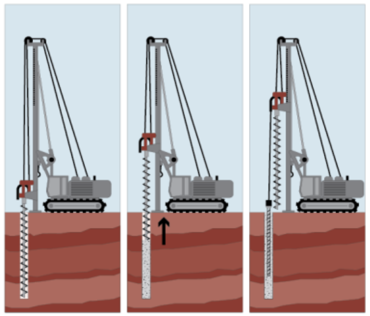
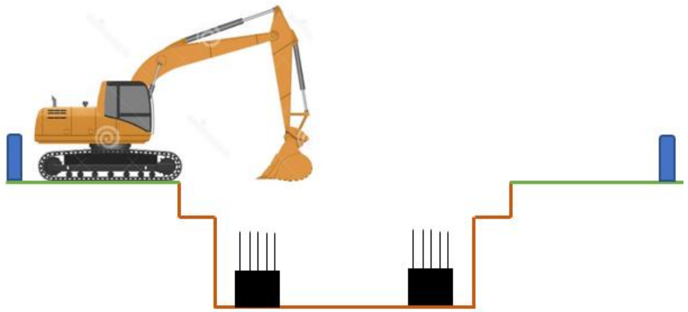
Single pole structures	Tip Rating (kN)
61m_str 14	533
58m	622
61m pole	732
48m	430
67m landing	809
58m crossing	908
55m	520
55m str18 suspension	235
50m	487
58m landing	773
67m str4	767
52m suspension	277
55m str9	695
58m str 2 str 13	538
67m	550

Bi-pole structures	Tip Rating (kN)
61m Bipole Strain	273
58m Bipole Strain_Str 3	348
61m_bipole_str 4	405
48m bipole	222
67m Bipole Strain_Landing	421
58m Bipole Strain_Landing_Crossing	479
55m bipole Maragle Concept Steel Pole	272
55m str18 suspension	235
50m bipole strain	248
58m Bipole Strain_Landing	402
67m Strain Str4	426
52m suspension	277
55m bipole st 9	390
58m Bipole Strain	298
67m bipole	286

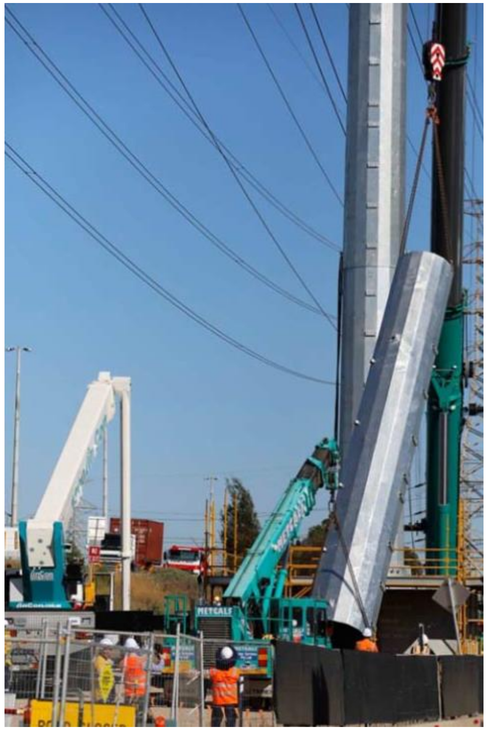
Appendix C. Steel availability, manufacturing, handling and delivery to site

Description	Steel Tower	Single Pole	Bi-pole
Steel availability, manufacturing, handling and delivery to site	• Steel angle sections easily available from overseas suppliers, regular mill fabrication with no minimum order requirements • Standard manufacture at plant with steel angle cutting and bending on short member lengths and practical steel plate sizes – no special safety protocols required • Maximum angle sizes in a typical tower are up to 200mm flange width resulting in relatively easy handling and transportation in standard 20 feet container • Regular truck sizes used for transporting angle sections and standard off-loading equipment utilised at site – no special training required 	• Steel plate thickness up to 25mm for bottom shaft and up to 60mm base plate – special procurement from steel mills and minimum order requirements • Large diameter base up to 3.5-4.0m resulting in non-standard manufacture with large plate bending techniques in shop – special safety protocols • Typically, pole segments fabricated with 11.8m section lengths to minimise multiple joints resulting in impractical heavy tonnage for handling and transportation - special sea freight required • Impractical handling at site for off-loading especially in undulating terrain with increased areas of disturbance on access tracks and benching to facilitate larger construction plant • Special permissions required from local authorities and traffic management for transport to site - similar to turbine pole and steel blade handling techniques 	• Steel plate thickness up to 20mm for bottom shaft and up to 40mm base plate • Large diameter base up to 2.5-3m • Very similar comments to the single pole solution however the diameters and tonnages are relatively shorter compared to single pole solution albeit not resulting in major gains in terms of handling and special permissions  

Appendix D. Foundation construction

Description	Steel Tower	Single Pole	Bi-pole
Foundation construction	• Typical tower footings augered bored piles of 1-1.5m diameter up to a maximum depth of 12m • +150m3 of concrete for 4 legs of one structure • Standard drill rig for only 4 hole locations  	• Pad and pedestal 11x11m wide pad area, 4 piles 6m deep with tie-pad of another 10m width (see sketch) • Approximately +800m3 of concrete for single pole (one structure location) including concrete piles • Larger area to excavate and lay reinforcement including additional excavation for step back/battering to protect against ground collapse  	• Pad and pedestal 8.5x8.5m wide pad area for one pole, 4 piles 6m deep with tie-pad of another 4m width (see sketch) • Approximately +600m3 concrete for 2 poles (one structure location) including concrete piles • Larger area to excavate and lay reinforcement

Appendix E. Structure construction

Description	Steel Tower	Single Pole	Bi-pole
Structure construction	• 55 tonnes total tower weight • Using standard Cranes (from truck-mounted cranes to 150 tonne cranes) towers are assembled in sections on the ground. Each section is then lifted and bolted into place.	• 67 tonnes in 4 sections, special cranes for lifting/ assembly • Larger clearing and benching area • Special transportation of cranes to site, permissions and traffic management 	• 56 tonnes per pole x 2 poles in four sections each, special cranes for lifting/ assembly • Larger clearing and benching area • Special transportation of cranes to site, permissions and traffic management 

Description	Single Pole erection for a comparable short span 220kV pole
Structure construction Compared with the adjacent photos of a 220kV steel pole the Maragle 330kV Concept designs would require: 1) Approx. 2x larger base diameter 2) Approx. 2x larger cross-arm length 3) Approx. 3x larger span length	  

Appendix F. Single pole design tonnage and base widths

#	Type	No. of Structures	Height (m)	Slope	Tip dia (mm)	Base dia (mm)	Body+Arms (Tons)	Total Tonnage
1	58m	4	58	32	1030	2886	53.43	259.71
2	58m type 2	3	58	32	1030	2886	47.89	178.16
3	55m	3	55	32	1030	2790	44.77	168.81
4	55m str9	2	55	40	1030	3230	52.97	128.93
5	58m crossing	4	58	45	1030	3640	67.67	316.69
6	58m landing	2	58	40	1030	3350	57.51	138.02
7	67m	4	67	32	1030	3174	64.22	302.86
8	67m landing	2	67	40	1030	3710	82.09	187.18
9	67m str4	1	67	40	1030	3710	76.64	88.14
10	61m pole	1	61	40	1030	3470	66.73	78.23
11	61m_str 14	2	61	32	1030	2982	55.77	134.54
12	48m	2	48	26	1030	2278	36.13	95.26
13	50m	1	50	32	1030	2630	39.79	51.29
14	55m str18 suspension	4	55	22	1030	2240	30.23	166.89
15	52m suspension	7	52	19.2	1030	2028.4	33.46	314.69
		42						**2,609.40**

Appendix G. Bi-pole design tonnage and base widths

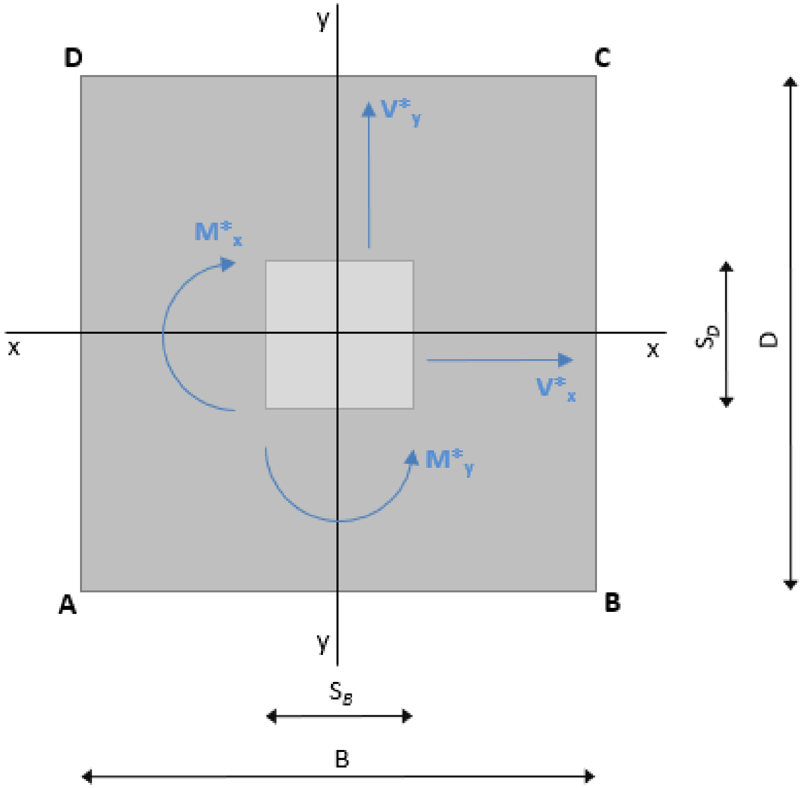
#	Type	No. of Structures	Height (m)	Slope	Tip dia (mm)	Base dia (mm)	Body+Arms (Tons)	Total Tonnage
1	58m Bipole Strain	5	58	19.2	1030	2143.6	75.98	399.29
2	58m Bipole Strain_Str 3	2	58	22	1030	2306	80.31	168.38
3	55m bipole Maragle Concept Steel Pole	3	55	19.2	1030	2086	71.42	225.34
4	55m bipole st 9	2	55	22	1030	2240	86.79	180.96
5	58m Bipole Strain_Landing_Crossing	4	58	32	1030	2886	111.35	460.92
6	58m Bipole Strain_Landing	2	58	22	1030	2306	92.89	193.53
7	67m bipole	4	67	19.2	1030	2316.4	94.85	394.18
8	67m Bipole Strain_Landing	2	67	22	1030	2504	118.14	244.05
9	67m Strain Str4	1	67	22	1030	2504	118.14	121.84
10	61m_bipole_str 4	1	61	22	1030	2372	97.34	101.22
11	61m Bipole Strain	2	61	19.2	1030	2201.2	85.15	178.06
12	48m bipole	2	48	19.2	1030	1951.6	46.37	100.13
13	50m bipole strain	1	50	19.2	1030	1990	64.06	67.76
14	55m str18 suspension	4	55	22	1030	2240	30.23	166.89
15	52m suspension	7	52	19.2	1030	2028.4	33.46	314.69
		42						**3,317.23**

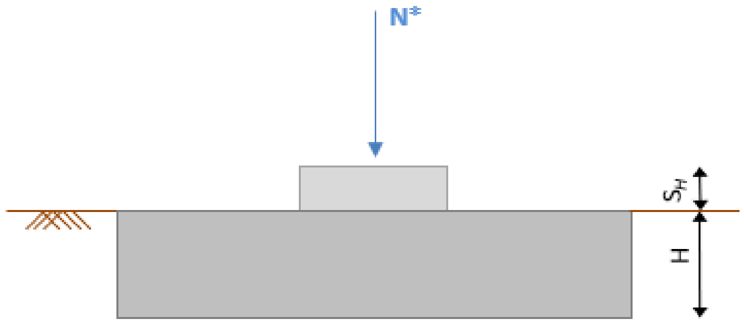
Appendix H. Preliminary footing reactions

Pole Type (SINGLE)	Vert. Force (kN)	Shear Force (kN)	Bending Moment (kN-m)	Load Case
61m_str 14	-997.71	719.93	32536.56	832. Temporary Full Terminations DD Ahead NA-,S NA-
58m	-913.25	882.57	36075.44	422. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor NR+,T NR+
61m pole	-1047.82	1050.42	44636.67	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
48m	-683.56	633.36	20654.18	829. Temporary Full Terminations SN Ahead NA+,S NA+
67m landing	-1135.85	1080.86	54175.82	818. Conductor SAP MAX SN WIND WITH SNOW Back span SYN NA-,S NA-
58m crossing	-771.34	1283.69	52677.48	814. Conductor SAP MAX SN WIND WITH SNOW Ahead span SYN NA-,S NA-
55m	-901.26	728.94	28589.76	830. Temporary Full Terminations SN Ahead NA-,S NA-
55m str18 suspension	-603.38	378.48	12942.94	297. Reliability Max Weight TORNADO 90+ Group a,T BI+
50m	-618.25	712.78	24346.66	836. Temporary Full Terminations DD Back NA-,S NA-
58m landing	-839.34	1085.82	44819.44	813. Conductor SAP MAX SN WIND WITH SNOW Ahead span SYN NA+,S NA+
67m str4	-1197.27	1085.59	51362.24	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
52m suspension	-499.9	401.21	14392.44	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
55m str9	-972.25	1033.51	38201.87	408. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor-,T BI-
58m str 2 str 13	-665.7	736.83	31223.45	834. Temporary Full Terminations SN Back NA-,S NA-
67m	-927.62	727.1	36819.79	829. Temporary Full Terminations SN Ahead NA+,S NA+

Pole Type (BIPOLE)	Vert. Force (kN)	Shear Force (kN)	Bending Moment (kN-m)	Load Case
61m Bipole Strain	-619.03	368.16	16675.07	832. Temporary Full Terminations DD Ahead NA-,S NA-
58m Bipole Strain_Str 3	-574.84	501.75	20206.08	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
61m_bipole_str 4	-654.52	580.95	24733.48	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
48m bipole	-355.78	329.03	10666.62	829. Temporary Full Terminations SN Ahead NA+,S NA+
67m Bipole Strain_Landing	-739.17	567.55	28211.95	818. Conductor SAP MAX SN WIND WITH SNOW Back span SYN NA-,S NA-
58m Bipole Strain_Landing_Crossing	-601.48	700.22	27787.49	814. Conductor SAP MAX SN WIND WITH SNOW Ahead span SYN NA-,S NA-
55m bipole Maragle Concept Steel Pole	-553.86	383.88	14945.48	830. Temporary Full Terminations SN Ahead NA-,S NA-
55m str18 suspension	-603.38	378.48	12942.93	297. Reliability Max Weight TORNADO 90+ Group a,T BI+
50m bipole strain	-400.53	362.34	12423.3	834. Temporary Full Terminations SN Back NA-,S NA-
58m Bipole Strain_Landing	-585.35	572.43	23324.16	813. Conductor SAP MAX SN WIND WITH SNOW Ahead span SYN NA+,S NA+
67m Strain Str4	-784.47	603.39	28566.62	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
52m suspension	-500.35	401.1	14389.41	406. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor+,T BI+
55m bipole st 9	-630.82	579.84	21471.42	408. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor-,T BI-
58m Bipole Strain	-814.65	404.75	17307.99	408. RELIABILITY 0.8 SNYP Wind 0.2 Ice -Sub-Alpine Conductor-,T BI-
67m bipole	-595.75	381.98	19183.96	829. Temporary Full Terminations SN Ahead NA+,S NA+

Appendix I. Preliminary footing sizes





Assumptions:

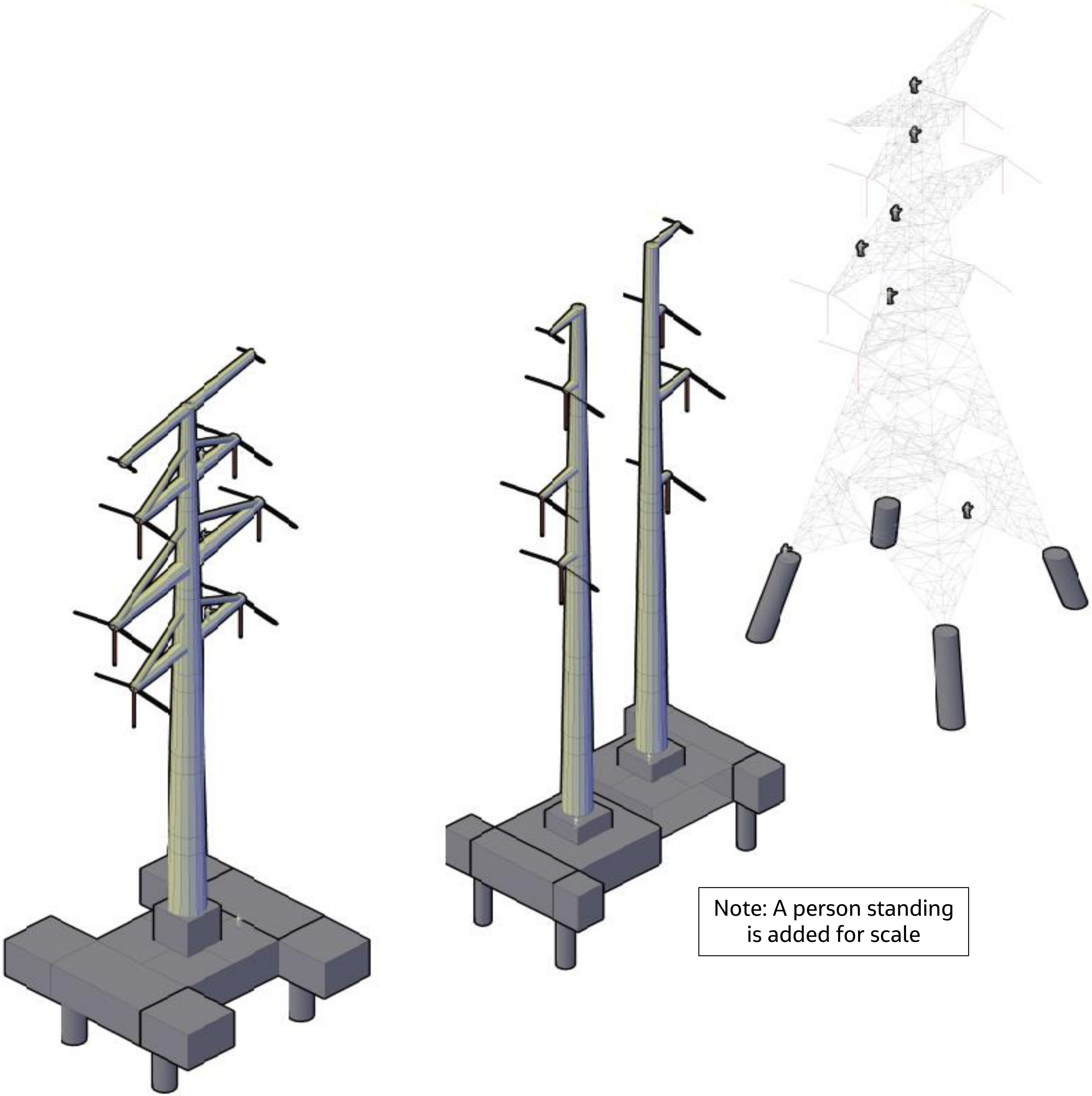
1. Transfer of load with pedestal and pad as shown above will be facilitated using a minimum of 4 piles into the ground.
2. Each pile would be upto 2000mm diameter up to a maximum bore depth of 6m.
3. Allowable bearing pressure on the soil is assumed to be less than 400kPA to avoid significant loss of contact area.

Comparison of lattice towers and steel pole designs for 330kV loadings

Structure Type Single Pole	Stump Height, S_H (mm)	Stump Length, S_B (mm)	Stump Depth, S_D (mm)	Base Height, H (mm)	Long Length, B (mm)	Transv. Depth, D (mm)	Weight of Footing (KN)	Volume of concrete for selected footing size (m^3)	Soil weight (KN)	Loss of Contact Area %	Net Bearing Stress (KPa)
61m_str 14	2500	2000	2000	4000	12,500	9,500	11,640	571	4,751	2.49	340
58m	2500	2000	2000	4000	14,250	9,800	13,646	656	5,616	13.39	401
61m pole	2500	2000	2000	4000	12,000	12,000	14,064	674	5,796	9.37	358
48m	2500	2000	2000	4000	10,000	10,000	9,840	494	3,974	0.05	322
67m landing	2500	2000	2000	4000	13,500	12,500	16,440	775	6,821	1.64	370
58m crossing	2500	2000	2000	4000	14,500	11,600	16,387	773	6,798	2.15	356
55m	2500	2000	2000	4000	11,500	9,500	10,728	532	4,357	4.38	365
55m str18 suspension	2500	2000	2000	4000	9,000	6,100	5,510	310	2,107	12.34	378
50m	2500	2000	2000	4000	11,000	9,400	10,166	508	4,115	2.99	342
58m landing	2500	2000	2000	4000	12,500	11,000	13,440	647	5,527	1.05	420
67m str4	2500	2000	2000	4000	12,500	12,500	15,240	724	6,303	9.44	361
52m suspension	2500	2000	2000	4000	10,500	6,950	7,246	384	2,856	18.19	430
55m str9	2500	2000	2000	4000	14,250	10,000	13,920	668	5,734	14.54	415
58m str 2 str 13	2500	2000	2000	4000	12,500	9,700	11,880	581	4,854	0.36	319
67m	2500	2000	2000	4000	12,500	9,950	12,180	594	4,984	5.37	376

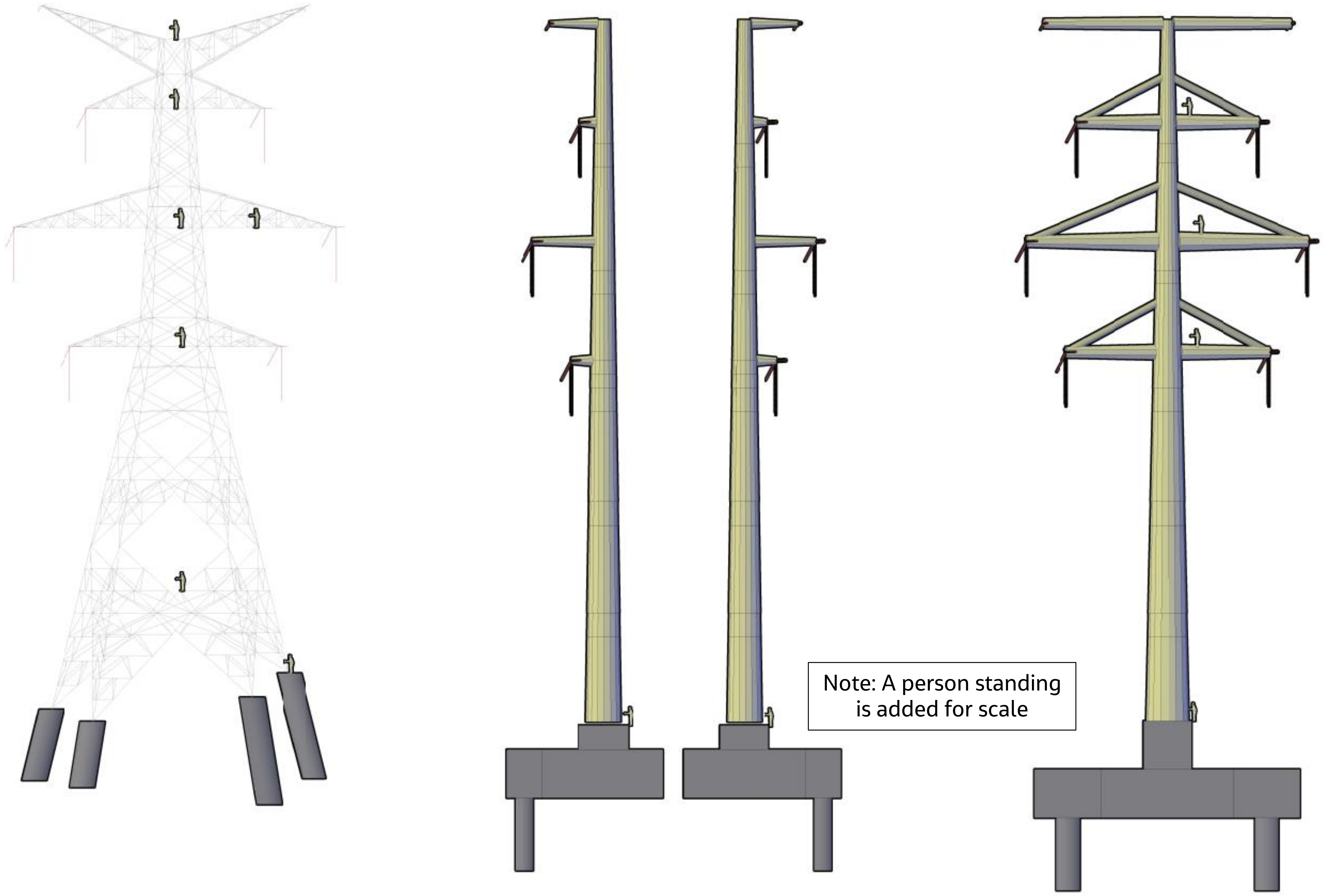
Structure Type Bipole	Stump Height, S_H (mm)	Stump Length, S_B (mm)	Stump Depth, S_D (mm)	Base Height, H (mm)	Long Length, B (mm)	Transv. Depth, D (mm)	Weight of Footing (KN)	Volume of concrete for selected footing size (m^3)	Soil weight (KN)	Loss of Contact Area %	Net Bearing Stress (KPa)
61m Bipole Strain	2500	2000	2000	4000	9,500	7,900	7,445	354	2,941	4.42	370
58m Bipole Strain_Str 3	2500	2000	2000	4000	14,500	7,550	10,750	495	4,367	12.66	365
61m_bipole_str 4	2500	2000	2000	4000	13,500	7,850	10,414	481	4,222	20.47	424
48m bipole	2500	2000	2000	4000	8,900	6,650	5,922	290	2,285	0.98	350
67m Bipole Strain_Landing	2500	2000	2000	4000	10,900	9,600	10,285	475	4,166	2.84	395
58m Bipole Strain_Landing_Crossing	2500	2000	2000	4000	10,900	9,750	10,442	482	4,234	3.19	391
55m bipole Maragle Concept Steel Pole	2500	2000	2000	4000	9,500	7,650	7,217	345	2,843	0.63	361
55m str18 suspension	2500	2000	2000	4000	9,500	6,100	5,803	285	2,234	7.17	340
50m bipole strain	2500	2000	2000	4000	8,500	7,650	6,482	314	2,526	3.87	364
58m Bipole Strain_Landing	2500	2000	2000	4000	9,200	9,300	8,454	397	3,377	1.95	443
67m Strain Str4	2500	2000	2000	4000	13,000	10,000	12,720	579	5,216	2.40	304
52m suspension	2500	2000	2000	4000	13,000	6,950	8,914	417	3,575	9.27	347
55m bipole st 9	2500	2000	2000	4000	13,000	8,000	10,224	473	4,140	14.47	398
58m Bipole Strain	2500	2000	2000	4000	13,000	6,900	8,851	414	3,548	17.21	400
67m bipole	2500	2000	2000	4000	10,500	7,900	8,203	387	3,269	1.28	364

Appendix J. Pole and tower visual comparison



Note: A person standing is added for scale

Comparison of lattice towers and steel pole designs for 330kV loadings



Appendix B Photomontage at viewpoint 12

VIEWPOINT 12

L A N D F O R M
ARCHITECTS

P: +61 438 677 175
E: hayden@landformarchitects.com.au

LANDSCAPE ARCHITECTURE
VISUAL IMPACT ASSESSMENT

PHOTOGRAPHY

CO-ORDS: 55H 626702E, 6038252N
CAMERA: NIKON D850
LENS: 70mm
PHOTOGRAPHY: XX/XX/2021

SNOWY HYDRO II

CLIENT

LANDFORM
ARCHITECTS

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LANDSCAPE ARCHITECTURE
VISUAL IMPACT ASSESSMENT

PHOTOGRAPHY

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PHOTOGRAPHY: XX/XX/2021

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SNOWY HYDRO II

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LANDSCAPE ARCHITECTURE
VISUAL IMPACT ASSESSMENT

PHOTOGRAPHY

CO-ORDS: 55H 626702E, 6038252N
CAMERA: NIKON D850
LENS: 70mm
PHOTOGRAPHY: XX/XX/2021

SNOWY HYDRO II

CLIENT

Appendix C Options assessment table

Options Assessment Table

Snowy 2.0 Transmission Connection project

Element	Option 3 –overhead to Upper Tumut Switching Station	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)	Option 5- cable tunnel to Line 64	Option 6 – trenched cable to Line 64	Option 8 – hybrid trench/tunnel to line 64	Option 9- hybrid trench/submarine cable to Lower Tumut Switching Station
Estimated area of vegetation disturbance									
Within KNP	185 ha	75 ha	91.5 ha	41 ha	75 ha	8 ha	77 ha	5 ha	8 ha
Outside KNP	nil	43 ha	46.5 ha	34 ha	43 ha	27 ha	33 ha	35 ha	4 ha
Max. disturbance total	*185 ha* *This does not include future disturbance associated with bringing HumeLink lines into KNP	*125 ha* *Of this 118 ha of vegetation removal would be required.	*138 ha*	*75 ha* *This is based on the same construction disturbance footprint for the tower sites and access tracks as the base case. This disturbance area is expected to be more based on the requirement for large footings and larger cranage due to the increased tower heights.	*125 ha.* *Of this 118 ha of vegetation removal would be required. Whilst the crane size may be reduced for construction, the same size EWPs as the base case would be required. Further, the same network of access tracks would be required to facilitate construction and ongoing operational maintenance as the base case.	*35 ha*	*110 ha*	*40 ha*	12 ha
Other environmental considerations Note: impacts have not been subject to detailed impact assessments and are predicted based on existing area knowledge where available. Option 4 impacts are assessed as per the EIS									
Visual amenity	Potential low to high impacts resulting from taller towers in new easement adjacent to existing lines. Any network expansions will have to come into the KNP in the future. These lines would also have additional visual impacts	Low to high based on the physical presence of the overhead line and cleared easement within a national park.	Low to high based on the physical presence of the overhead line and cleared easement within a national park. No expected improvement on the perceived view of the steel poles due to the sheer size and width of the steel monopoles to address the loading requirements. No expected improvement from the base case.	Low to high based on the physical presence of the transmission connection within a national park.	No change from the base case	Likely low impacts given minimal surface infrastructure.	Likely low to moderate visual impacts due to the required excavation works, particularly large cuts required within KNP (O'Hares Track) and along Elliot Way and maintenance of grassed easement. Visual impacts of reservoir bridge crossing if proposed.	Likely low to moderate visual impacts due to required excavation works and maintenance of grassed easement for trench component.	Likely low to moderate impacts permanent shipyards required to be built and barges stored for maintenance. Likely low to moderate visual impacts for trench component due to required excavation works and maintenance of grassed easement
Biodiversity	Approximately 142 ha of Smoky Mouse (critically endangered species listed under NSW and Commonwealth legislation) habitat cleared with additional indirect impacts. This is a significant impact that is unlikely to be tolerable.	Requires clearing of native vegetation which provides habitat for threatened species though no significant impacts are predicted.	With a larger disturbance footprint compared to the base case, additional clearing of native vegetation which provides habitat for threatened species would be required. Higher level of impact on biodiversity compared to the base case.	Compared to the base case would require approximately 43 ha less clearing. As such, extent of predicted impact on biodiversity under this option is expected to be less compared to the base case (Option 4).	No change from the base case	Disturbance footprint has been largely surveyed. Significant impacts to biodiversity are unlikely	Potential biodiversity impacts (disturbance area not surveyed).	Potential biodiversity impacts (disturbance area not surveyed for trench component).	Potential biodiversity impacts (disturbance area not surveyed). Potentially significant impacts on the threatened Murray crayfish from dredging

Transgrid

Element	Option 3 –overhead to Upper Tumut Switching Station	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)	Option 5- cable tunnel to Line 64	Option 6 – trenched cable to Line 64	Option 8 – hybrid trench/tunnel to line 64	Option 9- hybrid trench/submarine cable to Lower Tumut Switching Station
	Additional future network expansion impacts due to HumeLink KNP connection.								
Heritage	Potential Aboriginal and non-Aboriginal heritage impacts (disturbance area not surveyed).	Disturbance of 3 potential archaeological deposits (PAD) and four Aboriginal heritage artefact sites. Disturbance to one site of local heritage significance and five items with archaeological potential. No significant impacts to historic heritage are predicted including the National Heritage Listing of the Australian Alps National Parks and Reserves and Snowy Mountains Scheme.	No expected change from the base case.	Disturbance of 3 potential archaeological deposits (PAD) and four Aboriginal heritage artefact sites (no change to the base case (option 4). Potential disturbance to one site of local heritage significance and three items with archaeological potential. No significant impacts to historic heritage are predicted including the National Heritage Listing of the Australian Alps National Parks and Reserves and Snowy Mountains Scheme.	No change from the base case	Disturbance footprint has been largely surveyed. Significant impacts to Aboriginal heritage, and non-Aboriginal heritage are unlikely.	Potential Aboriginal and non-Aboriginal heritage impacts (disturbance area not surveyed).	Potential Aboriginal and non-Aboriginal heritage impacts (disturbance area not surveyed for trench component).	Potential Aboriginal and non- Aboriginal heritage impacts (disturbance area not surveyed).
Water	Erosion and sediment impacts during construction which require mitigation and control.	Erosion and sediment impacts during construction which require mitigation and control	Erosion and sediment impacts during construction which require mitigation and control. The extent of risk to receiving waters is expected to be higher compared to the base case due the larger footprint and higher volume of spoil generated.	Erosion and sediment impacts during construction which require mitigation and control. The extent of risk to receiving waters is expected to be less compared to the base case due the retention of all easement vegetation.	No change from the base case	Potential interaction with groundwater. Groundwater information in the area is poorly understood. Unlikely to impact nearby groundwater users. Potential impacts to groundwater dependent ecosystems (GDEs). Erosion and sediment impacts during construction.	Erosion and sediment impacts during construction.	Potential interaction with groundwater for tunnel component. Groundwater information in the area is poorly understood. Unlikely to impact nearby groundwater users. Potential impacts to GDEs. Erosion and sediment impacts during construction.	Significant turbidity impacts due to dredging required. Likely downstream impacts to water users.
Transport	Temporary impacts on traffic and access during construction.	Temporary impacts on traffic and access during construction.	Higher volume of heavy vehicle movements as part of the transport of the large pole segments compared to the base case. Modification of sections of the access tracks, particularly on the narrow bends would be required to facilitate the haulage of the pole segments to the structure locations	Higher volume of heavy vehicle movements due to larger towers and footings resulting in more concrete and steel deliveries	Reduction in heavy vehicle movements along Elliott Way and internal access tracks having an overall beneficial impact on the safety and function of the project transport network.	Temporary impacts on traffic and access during construction.	Temporary impacts on traffic and access during construction.	Temporary impacts on traffic and access during construction.	Temporary impacts on traffic and access during construction.

Element	Option 3 –overhead to Upper Tumut Switching Station	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)	Option 5- cable tunnel to Line 64	Option 6 – trenched cable to Line 64	Option 8 – hybrid trench/tunnel to line 64	Option 9- hybrid trench/submarine cable to Lower Tumut Switching Station
Excess Spoil quantity	~ 500,000 cubic metres (m^3) of material.	~180,000 m^3 of material (subject to change following detailed design)	~234,000 m^3 of material	No change from the base case *This is based on the same construction disturbance footprint for the tower sites and access tracks as the base case. However, the taller tower are likely to result in excess spoil as a result of larger footings and larger benching requirements	No change from the base case	~ 770,000 m^3 of material	~ 4,228,527 m^3 of material	~ 1,750,000 m^3 of material.	Unable to quantify however likely to be in the range of several million cubic metres.
Constructability and operability constraints									
Design/ constructability constraints	No significant constraints identified. Suitable tower construction sites available although terrain is challenging. Safety risks can be appropriately managed	No significant constraints identified. Suitable tower construction sites available although terrain is challenging. Safety risks can be appropriately managed	Larger cranes and construction pads required. Increased safety risks due to larger footings and construction bench areas encroaching on steep terrain, requiring larger cut-ins.	Very large cranes and elevated work platforms required. As a result, larger construction pads would be needed. Increased safety risks due construction crew working at increased heights. Stringing of conductors may need to be undertaken using a helicopter instead of by drone, imposing increased risks on safety. Taller tower design may result in larger tower footprint and require the towers to be spaced further apart.	The constructability is dependent on the availability of suitable aircraft, outcomes of safety assessments associated with tower segment delivery and assembly using a helicopter	To maintain a safe tunnel boring gradient, an approximate 530 m deep vertical cable shaft would be required to extend the connection cables vertically to the Maragle substation. Due to the weight of the cables, there are significant constructability related issues and risk of damage to the cables associated with suspending them to the wall of the shaft at this depth.	Due to the need for excavation within steep terrain, there would be a very large volume of spoil generated (in the order of 20 times the base case) which would require local disposal. Suitable disposal sites would need to be identified.	Similar to option 6, there would be a significant volume of excess spoil generated (in the order of 10 times the base case. which would require disposal. Suitable disposal sites would need to be identified. Significant constructability and design constraints associated with need for an approximate 550 m deep vertical cable shaft similar to Option 5.	Re-profiling the reservoir bed across a width of 25 m for 21 km in water ranging up to 120 m deep would be required. This would require excavation and clearing of silt, clays, rock, boulders, and vegetation including submerged trees. In addition, bedding material is likely to be required to prevent sections of the cable from impinging on sharp objects, sudden changes in terrain and also to prevent the cable from spanning across old ravines, creeks, large boulders and the like. At this stage it is not considered to be feasible.
Operability constraints	No significant constraints identified. Although overhead lines are susceptible to fault/damage, they are cost effective to fix and allow for more straightforward maintenance.	No significant constraints identified. Although overhead lines are susceptible to fault/damage, they are cost effective to fix and allow for more straightforward maintenance.	Corrective maintenance to repair a corroded or damaged section would require the remobilisation of large specialised construction plant resulting in a larger ground disturbance to gain safe access to work areas when compared to the lattice towers. Any unexpected failure of a steel pole	Ability to respond to emergency repairs would be significantly longer compared to the base case due to access along the transmission corridor potentially needing to be established and larger cranes and EWPs being required. Higher risks of damage to the asset in the event that a bushfire passes through the area.	No significant constraints identified. Although overhead lines are susceptible to fault/damage, they are cost effective to fix and allow for more straightforward maintenance.	Impacts from adverse events such as bushfire, storms and lightning strike are avoided by undergrounding the connection. Significant maintenance of the tunnel and shafts would be required. This would include maintenance of the excavation support systems, ventilation systems, power supply systems, security and	No significant constraints identified. Impacts from adverse events such as bushfire, storms and lightning strike are avoided by undergrounding the connection. A trenched cable along a maintained access road is unlikely to be prone to damage but can be	As per Options 5 and Option 6.	Divers are expected to be required to assist with maintenance operation and checks on the cables, posing significant safety risks. Slow response time address to identify and address any faults and carry our repairs.

Element	Option 3 –overhead to Upper Tumut Switching Station	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)	Option 5- cable tunnel to Line 64	Option 6 – trenched cable to Line 64	Option 8 – hybrid trench/tunnel to line 64	Option 9- hybrid trench/submarine cable to Lower Tumut Switching Station
			would result in an increased response time to address and rectify the failure compared to a steel lattice tower.	Routine vegetation management would likely still need to be carried out. Removing the violations through trimming of the crown/branches would need to carried out by helicopter or climbed. Both these methods pose significant safety risks. Potential limitations on maintenance opportunities due to higher wind speeds experienced atop the taller towers.		communication systems, lifts and access, drainage and water management systems (constant pumping would be required to drain tunnel/shaft seepage and potentially treat and discharge it). Any major repairs required to cables affixed to the vertical shafts would be very challenging, would impose considerable safety risks and would likely take considerable time. The repair time for a cable in a tunnel would depend on its location and distance from the nearest access point. Safety protocols such as purging the air using the ventilation system, planning for emergency evacuation and requirement to use specialist equipment would mean that any repair could take between one month to four months.	difficult to fix should it be damaged.		
Cost									
Construction cost (including the Maragle substation)	~ $450 Million	~ $290 Million	~ $328 Million	~ $320 Million	Potentially minor increase in cost	~ $1,393 Million	~ $1,087 Million	~ $1,304 Million	Unable to quantify however likely to be >$1,000 Million
Average yearly Operation and maintenance costs for asset life inclusive of the substation component	~$588,000	~$496,000	~$515,000	~$506,000	~$496,000	~$514,000	~$400,000	~$469,000	Unable to quantify
Time									
Project planning approvals inclusive further feasibility studies, environmental surveys and preparation of planning approval documentation	Approximately 24 months	The CSSI application for the project is currently in the assessment phase with DPE.	Approximately 12 months to develop a revised concept design and amend existing approval documentation.	Approximately 12 months	No additional time required.	Approximately 24 months	Approximately 20 months	Approximately 20 months	-
Construction and rehabilitation (excluding the 500 kV switchyard at the substation)	30 months	30 months	6 – 12 months	Additional 6 months	Potential reduction in construction duration (up to two months).	64 months	50 months	54 months	-

Element	Option 3 –overhead to Upper Tumut Switching Station	Base case (Option 4)	Monopole Design (Option 4a)	Increased max. structure height (Option 4b)	Construction using helicopters (Option 4c)	Option 5- cable tunnel to Line 64	Option 6 – trenched cable to Line 64	Option 8 – hybrid trench/tunnel to line 64	Option 9- hybrid trench/submarine cable to Lower Tumut Switching Station
Commissioning	3 months	3 months	3 months	3 months	3 months	3 months	4 months	4 months	-
Network resilience	Unacceptable. See Note 1.	Acceptable. See Note 2	Acceptable. See Note 2	Unacceptable See Note 3	Acceptable. See Note 2	Acceptable. See Note 2	Acceptable. See Note 2.	Acceptable. See Note 2	Unacceptable. See Note 1.

Note:

1. Additional assets and Snowy 2.0 connection at UTSS will lower system resilience when assessed using causal events (extreme weather and/or bushfire) due to worsened spatial and temporal factors in combination with the higher concentration of assets and localised power density. Threats at UTSS include loss of significant generation input capacity (2,660 MW and disruption of critical interconnection between Victoria and NSW (VNI1). Threats with connection at LTSS are even higher with loss of extreme generation input capacity of 3,800 MW and similar disruption of critical interconnection between Victoria and NSW. See Section 6 for more detail.

2. New assets and Snowy 2.0 connection at Maragle will increase system resilience when assessed using causal threats of extreme weather and/or bushfire due to improved spatial and temporal factors in combination with overall reduced concentration of assets and localised power density (relative to the two proposed alternative connection point options). The choice of Maragle also creates a node on an alternative interconnection path to south-west NSW and Victoria relative to the existing single interconnection between Victoria and NSW (VNI1). Threats at Maragle include loss of significant generation input capacity (2,000 MW) but avoids disruption of critical interconnection between Victoria and NSW.

3. The increased maximum structure height is deemed unacceptable for the following reasons:

a) Increased risk of a safety incident during the life of the asset

b) Increased risk of catastrophic failure of the asset during bushfire

c) Reduced ability to respond and repair failures due to restricted access along the transmission line

d) Increased risk of a quad circuit trip of the Snowy 2.0 generator circuits during a bushfire

Appendix D Transport route study

REX J ANDREWS
ENGINEERED TRANSPORTATION

ROUTE STUDY:

PROJECT: TRANSGRID HUMELINK

PORT OF IMPORT: NEWCASTLE

SITE LOCATION: MARAGLE

25/10/2021 REV 00

Rev.	Date	Change	Responsible	Checked
00	18/10/21	Route Assessed	W Andrews	✓
00	18/10/21	Report Compiled	W Andrews	✓
00	25/10/21	Report Completed	W Andrews	✓
00	17/11/21	Driven Study Completed	W Andrews	✓

Index:

1.0 Introduction

Transgrid are in the early stages of investigating access to potential substation sites on the Humelink transmission interconnector. The sites are located at Maragle, Gugaa (Gregadoo) and Bannaby in NSW.

This study describes observations and previous experience on route and explains the transport of the transformers and components from Newcastle to the proposed Maragle substation site.

The study will show the most suitable route to transport the transformers from the port through to the site, and the constraints on this route.

The desktop route survey took place on the 18/10/2021

2.0 Evaluation

1	No Cost
2	Some Work
3	Moderate Amount of Work
4	Extreme Amount of Work

(Mark below boxes with an X)

		1	**2**	**3**	**4**
A	Harbour	**X**			
B	Road Modification	**X**			
C	Road Furnishings		**X**		
D	Vegetation	**X**			
E	Site Entrance				**X**
F	Bridge Calculations			**X**	
G	Traffic Control		**X**		

3.0 Project data

Date of latest Route Assessment: 18/10/2021

Survey undertaken by: (Rex J Andrews P/L)

Project name: Transgrid Humelink project

Location: Newcastle Port (NSW) to Nurenmerenmong (NSW)

Components:

- Single phase 550 MVA transformers
- Three Phase 550 kV Reactor

4.0 Transformer types and transport combinations

550 MVA single phase units option 1:

Dimension (10.0 x 4.7w x 4.3h x 125.0T)
Configuration. Prime mover with 12x8 or 14x8 Platform trailer and 2 backup prime movers
Overall dimension: 68.0l x 4.7w x 5.2h x 246.5T

550 MVA single phase units option 2:

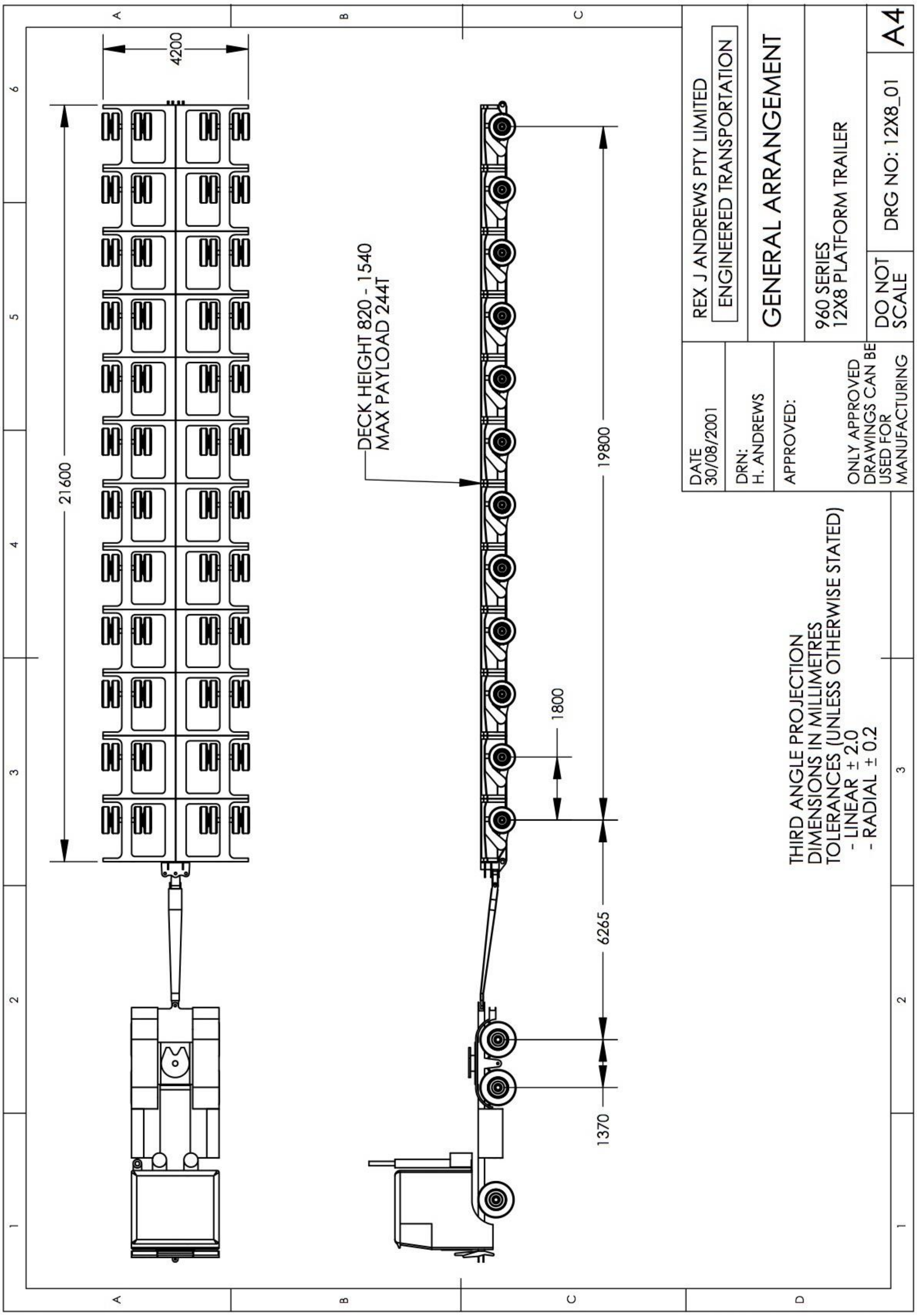
Dimension (10.0 x 4.7w x 4.5h x 125.0T)
Configuration. Prime mover with 7x8-7x8 Beamset with 2 backup prime movers
Overall dimension: 90.0l x 6.5w x 5.2h x 271.5T

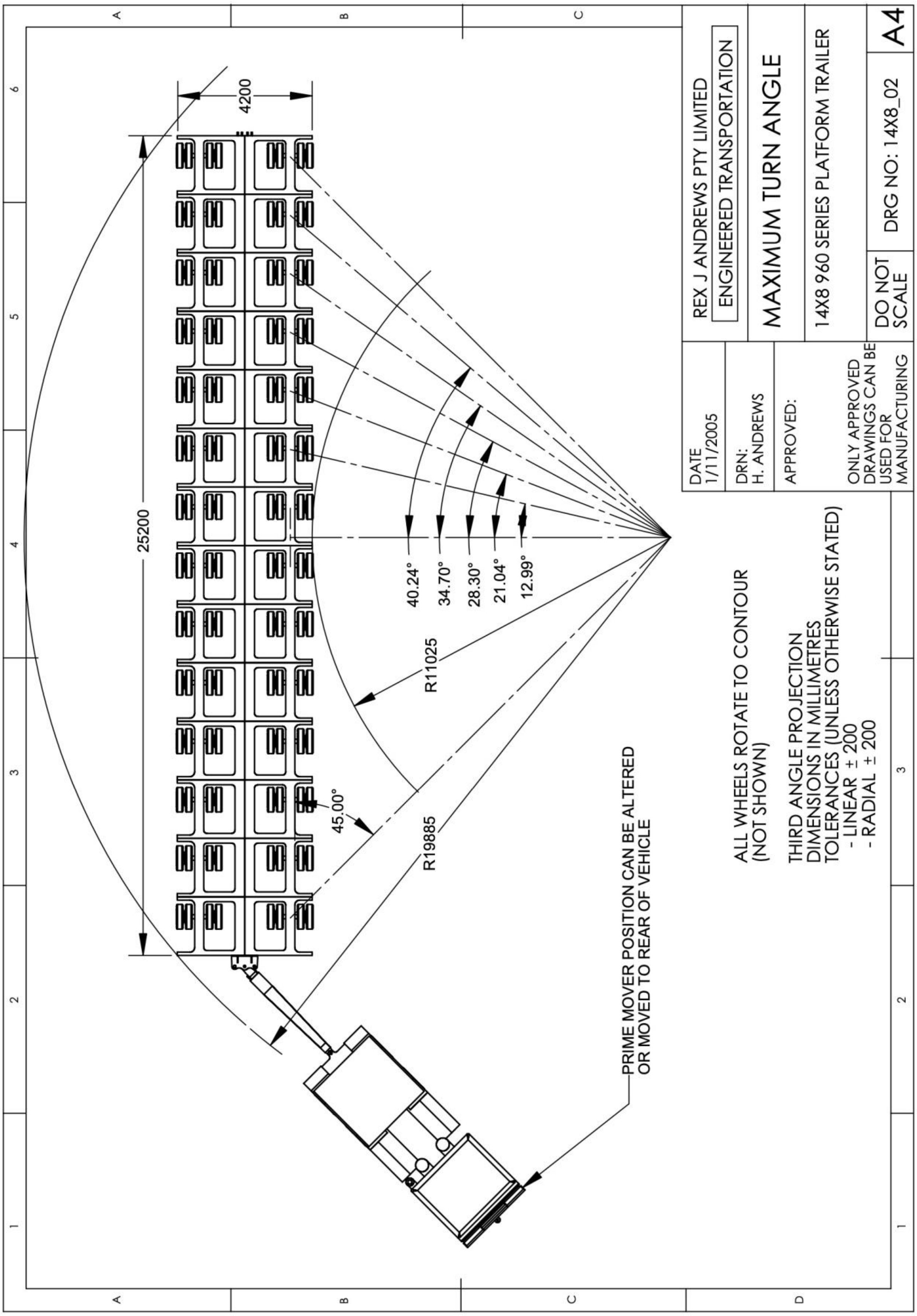
550 kVA three phase units:

Dimension (10.0 x 4.7w x 4.8h x 182.0T)
Configuration. Prime mover with 10x8-10x8 Beamset with 4 backup prime movers
Overall dimension: 120.0l x 6.5w x 5.2h x 422.5T

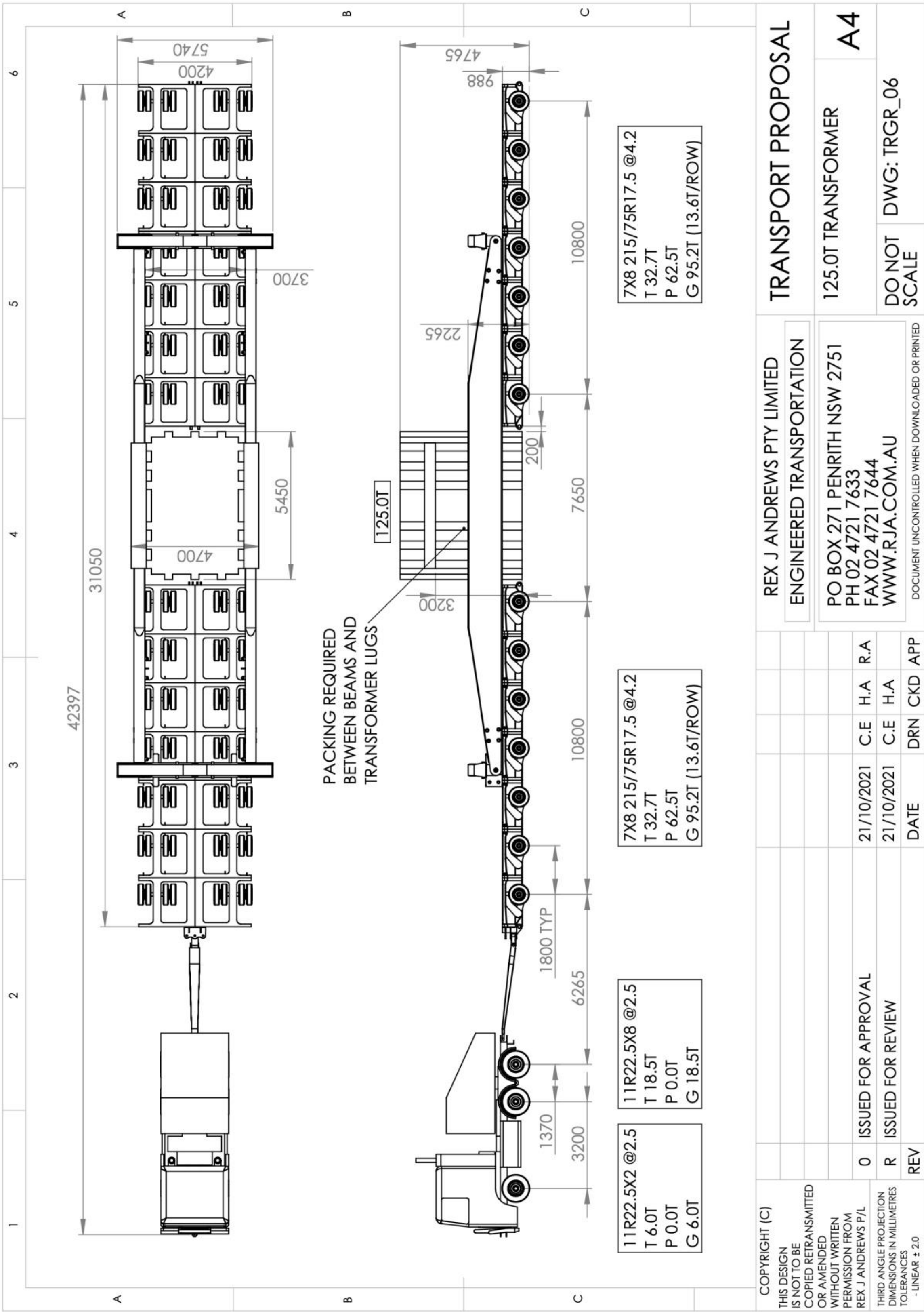
5.0 Transport drawings

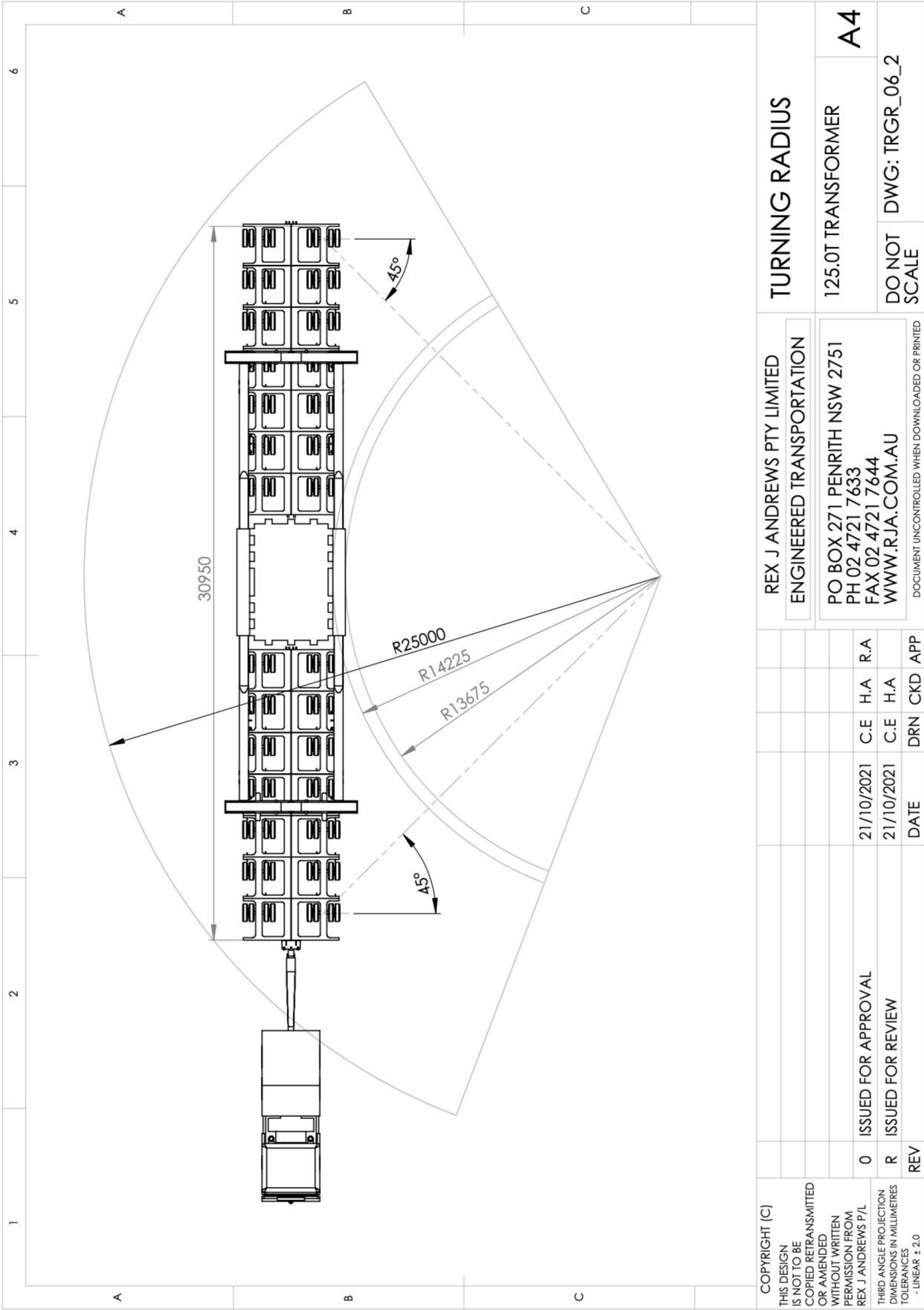
Single phase transformer Option 1




REX J ANDREWS PTY LIMITED
ENGINEERED TRANSPORTATION
MAXIMUM TURN ANGLE
14X8 960 SERIES PLATFORM TRAILER
A4
DRG NO: 14X8_02
DO NOT SCALE
DATE 1/11/2005
DRN: H. ANDREWS
APPROVED:
ONLY APPROVED DRAWINGS CAN BE USED FOR MANUFACTURING
4200
25200
40.24°
34.70°
28.30°
21.04°
12.99°
45.00°
R11025
R19885
ALL WHEELS ROTATE TO CONTOUR (NOT SHOWN)
THIRD ANGLE PROJECTION
DIMENSIONS IN MILLIMETRES
TOLERANCES (UNLESS OTHERWISE STATED)
- LINEAR ± 200
- RADIAL ± 200
PRIME MOVER POSITION CAN BE ALTERED OR MOVED TO REAR OF VEHICLE

Single phase transformer Option 2




TURNING RADIUS
125.0T TRANSFORMER
A4
DWG: TRGR_06_2
DO NOT SCALE
REX J ANDREWS PTY LIMITED
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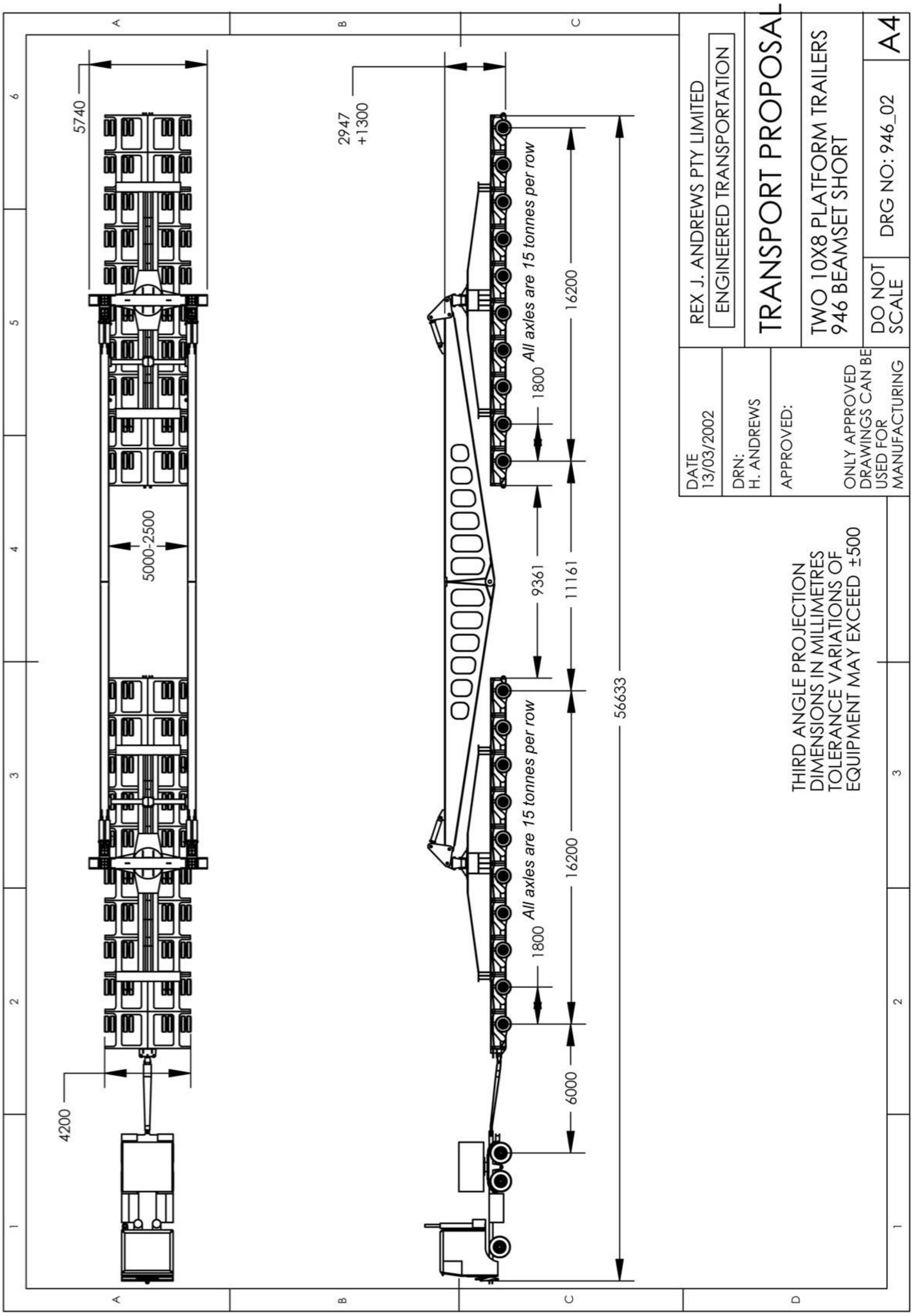
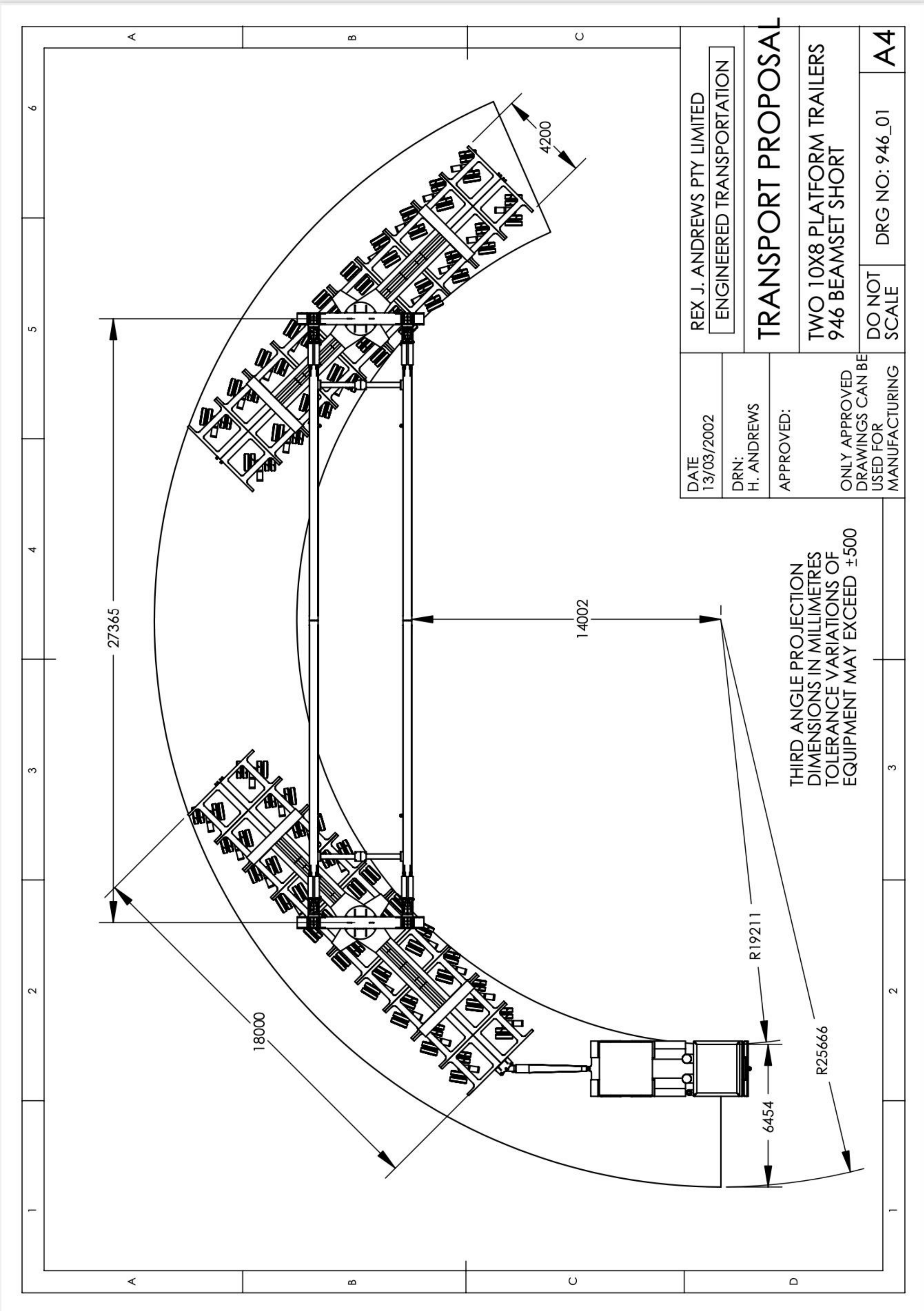
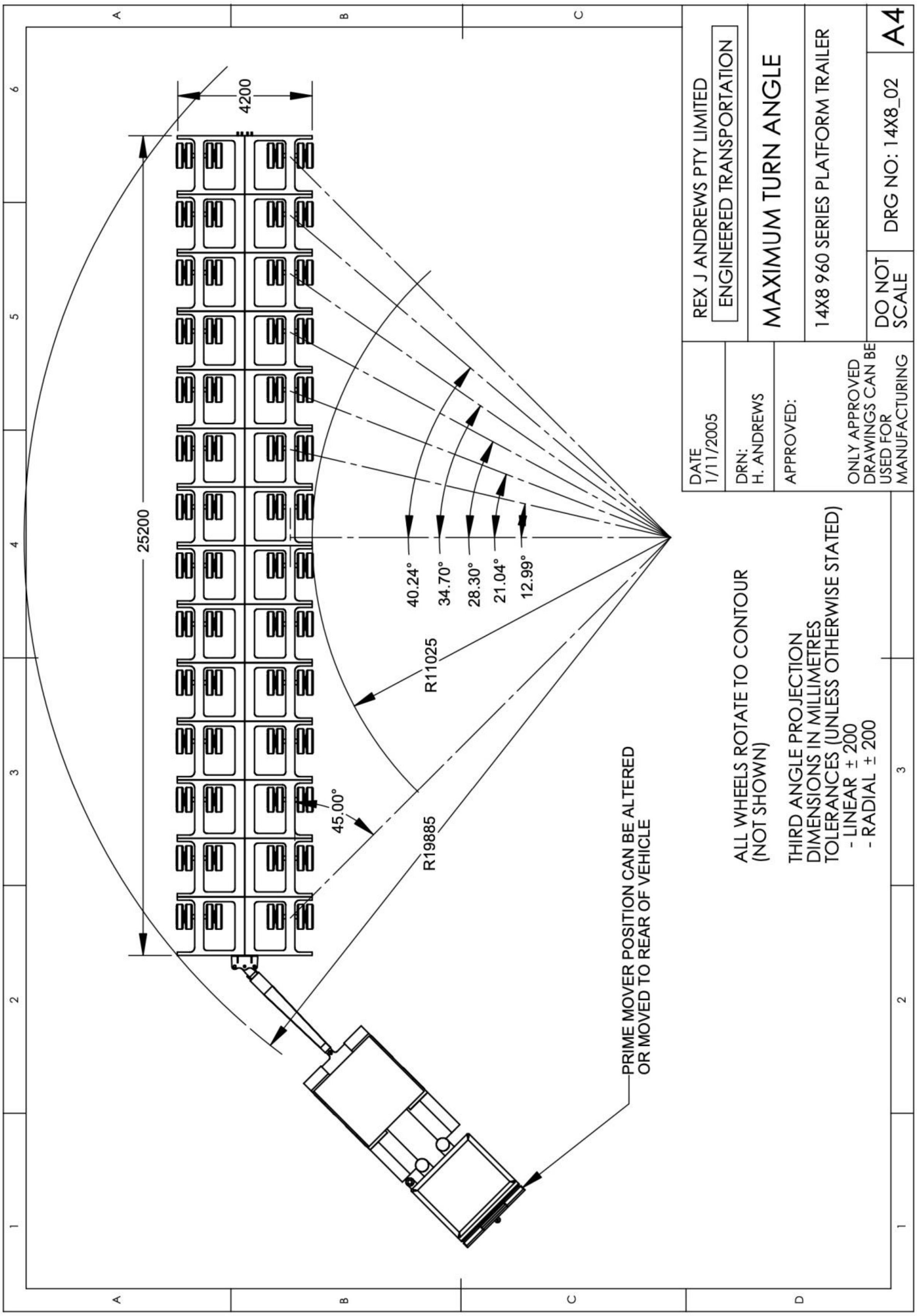
THIRD ANGLE PROJECTION
DIMENSIONS IN MILLIMETRES
TOLERANCES
- LINEAR ± 2.0
30950
R25000
R14225
R13675
45°
45°

Three phase transformers

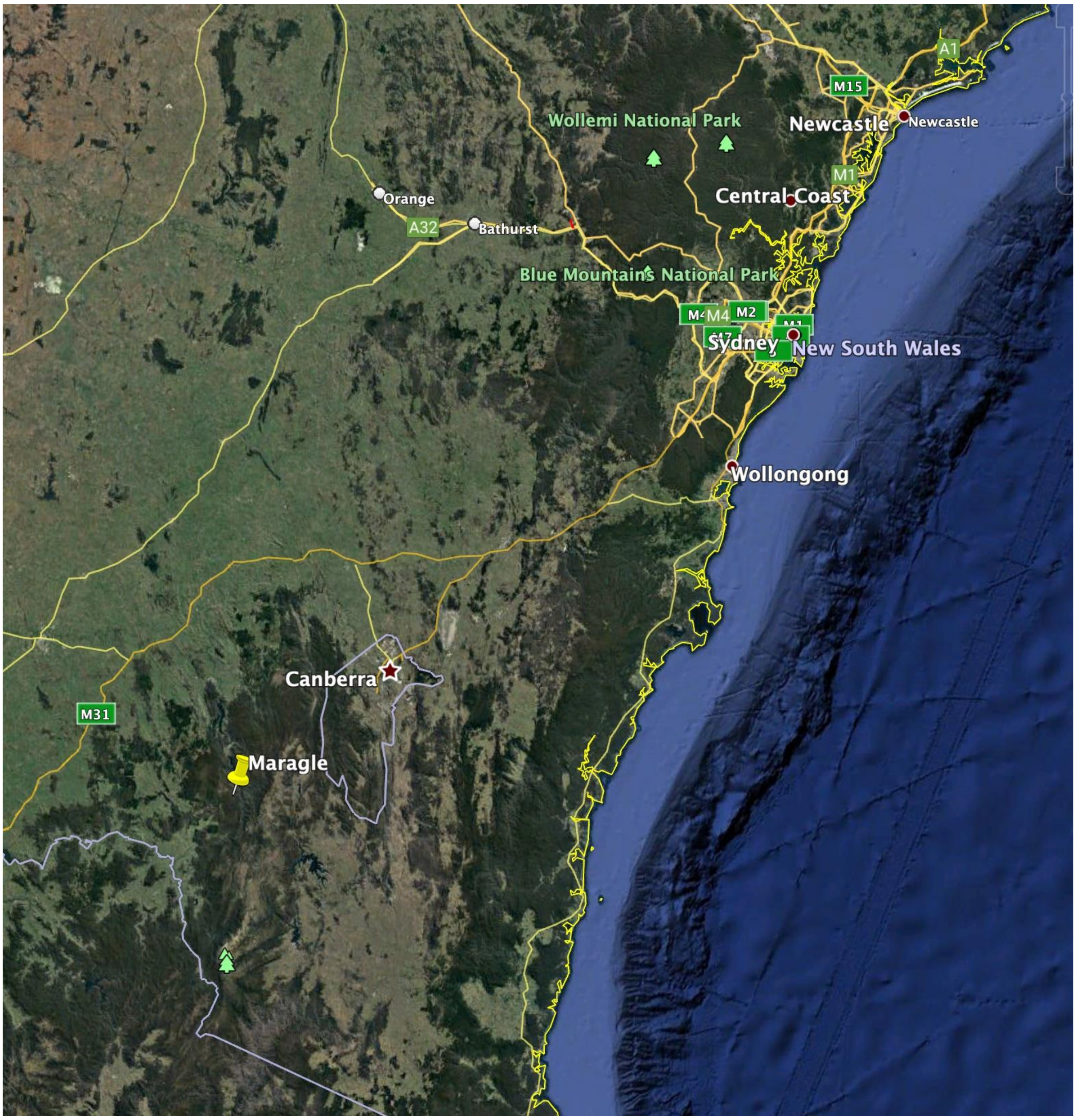



REX J. ANDREWS PTY LIMITED
ENGINEERED TRANSPORTATION
TRANSPORT PROPOSAL
TWO 10X8 PLATFORM TRAILERS
946 BEAMSET SHORT
A4
DRG NO: 946_01
DO NOT SCALE
DATE
13/03/2002
DRN:
H. ANDREWS
APPROVED:
ONLY APPROVED DRAWINGS CAN BE USED FOR MANUFACTURING
THIRD ANGLE PROJECTION
DIMENSIONS IN MILLIMETRES
TOLERANCE VARIATIONS OF
EQUIPMENT MAY EXCEED ±500
4200
27365
14002
18000
R19211
R25666
6454


REX J ANDREWS PTY LIMITED
ENGINEERED TRANSPORTATION
MAXIMUM TURN ANGLE
14X8 960 SERIES PLATFORM TRAILER
DO NOT SCALE
DRG NO: 14X8_02
A4
DATE 1/11/2005
DRN: H. ANDREWS
APPROVED:
ONLY APPROVED DRAWINGS CAN BE USED FOR MANUFACTURING
ALL WHEELS ROTATE TO CONTOUR (NOT SHOWN)
THIRD ANGLE PROJECTION
DIMENSIONS IN MILLIMETRES
TOLERANCES (UNLESS OTHERWISE STATED)
- LINEAR ± 200
- RADIAL ± 200
PRIME MOVER POSITION CAN BE ALTERED OR MOVED TO REAR OF VEHICLE
4200
25200
R11025
R19885
40.24°
34.70°
28.30°
21.04°
12.99°
45.00°

6.0 Site location

The Humelink Maragle substation will be constructed at a proposed location off the Elliot Way at Nurenmerenmong. The proposed site location is 40 Km's East of Tumbarumba. The site is located 718 Kilometers by road from the Port of Newcastle.



7.0 Port of Import

The equipment will be imported from various countries and will arrive on ships into the Port of Newcastle. The ideal berth for these shipments is the Mayfield #4 Berth. This facility has a hardstand storage area of roughly 100,000 s/q meters, adjacent to the berth.

Access from the storage to the public roads, is via a port operated road onto Selwyn Street. There will need to be a small amount of road modifications within the port.

Image 1: Mayfield #4 berth overview

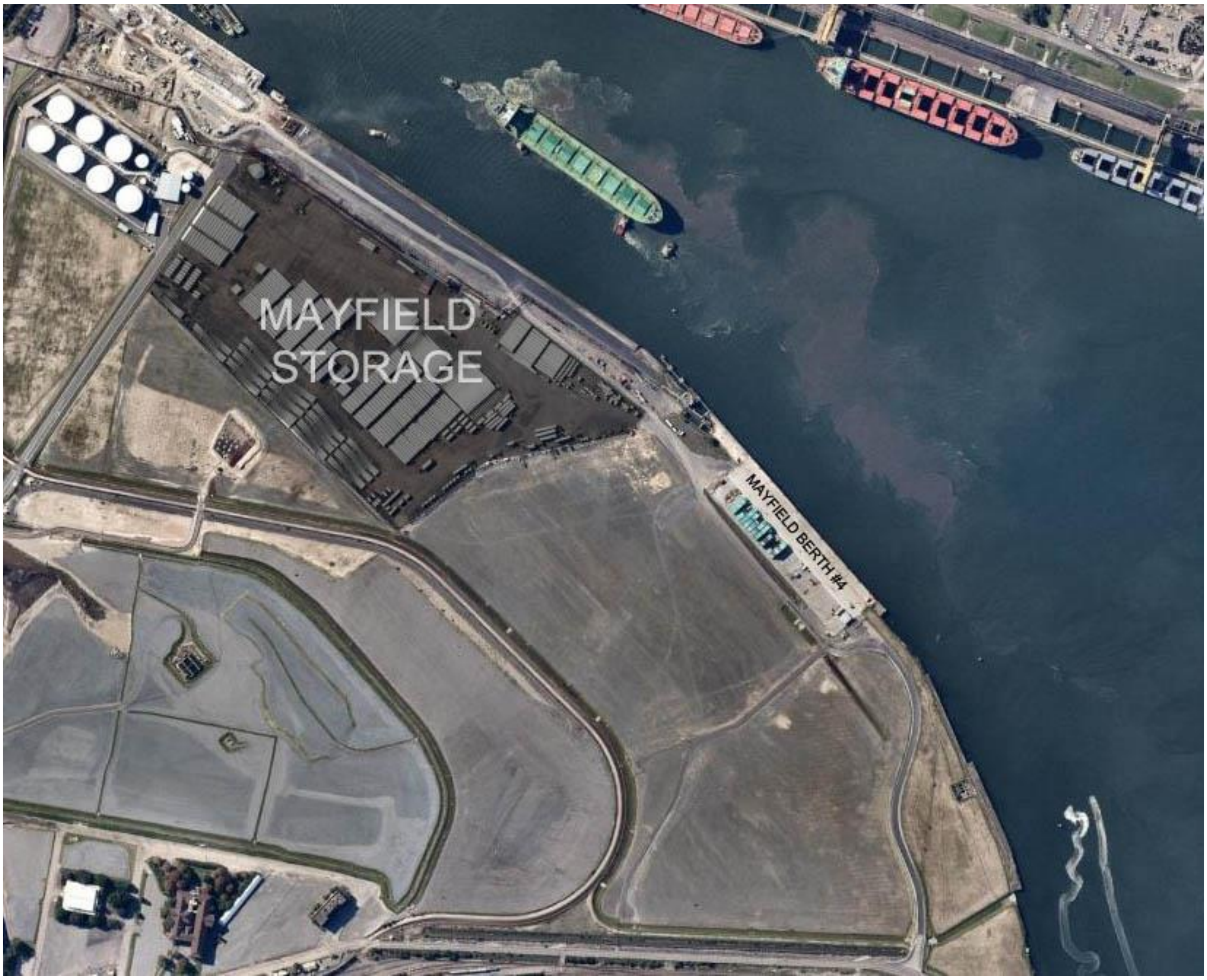


Image 2: Mayfield #4 Port storage area

8.0 Transport Summary

We have based this study on the transformer components entering Australia via the Port of Newcastle, Mayfield #4 berth. This study will show the most suitable route for these components, and the restraints that they may encounter on the route.

ROUTE SURVEY: NEWCASTLE TO MARAGLE

DISTANCE: 629 kilometres

GPS LINK: https://goo.gl/maps/v7JMJmrxwuLorJL28

VIA: Selwyn Street, George Street, Industrial Drive, Maitland Road, (U-Turn Maitland Road at Sandgate), Maitland Road, Newcastle Inner City Bypass, Newcastle Road, Thomas Street, Newcastle Link Road, M1, Pennant Hills Road, M2, M7, M5, Hume Highway, Little Billabong Road, Tumbarumba Road, Wagga Road, Masons Hill Road, Albury Street, The Parade, Bridge Street, Winton Street, Regent Street, William Street, Tooma Road, Elliot Way.

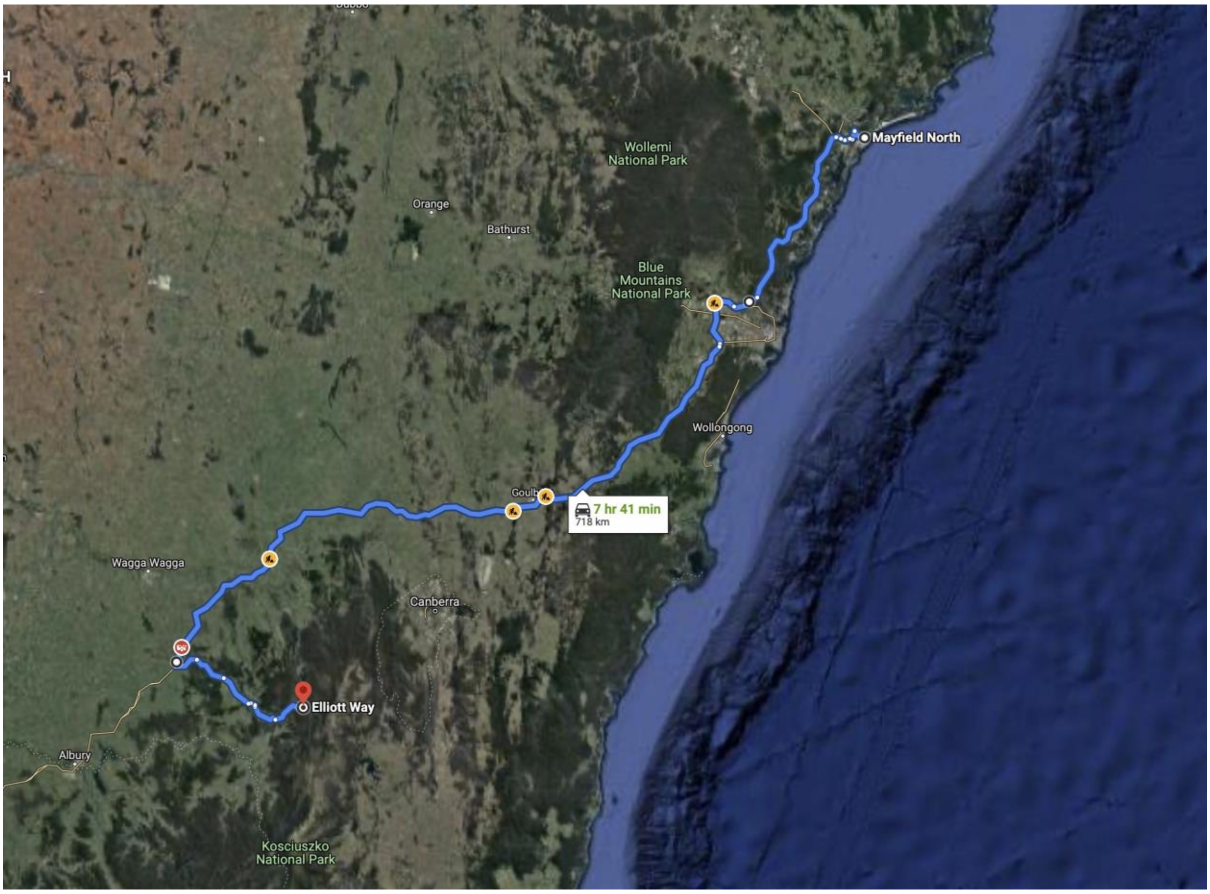
9.0 Route Survey: Newcastle to Maragle

ROUTE SURVEY: NEWCASTLE TO MARAGLE

DISTANCE: 718 kilometres

GPS LINK: https://goo.gl/maps/v7JMJmrxwuLorJL28

VIA: Selwyn Street, George Street, Industrial Drive, Maitland Road, (U-Turn Maitland Road at Sandgate), Maitland Road, Newcastle Inner City Bypass, Newcastle Road, Thomas Street, Newcastle Link Road, M1, Pennant Hills Road, M2, M7, M5, Hume Highway, Little Billabong Road, Tumbarumba Road, Wagga Road, Masons Hill Road, Albury Street, The Parade, Bridge Street, Winton Street, Regent Street, William Street, Tooma Road, Elliot Way.



KEY	
MODIFICATIONS REQUIRED	(red)
MINOR WORKS OR CAUTION	(yellow)
PARKING	(green)

KM index	Location	Section of road	Current clearance	Procedure	Comments
0.0	Mayfield	Mayfield #4 berth onto Selwyn Street https://goo.gl/maps/afLwPYKuNdm	Length: 70.0m Width: 8.0m	Moderate right-hand turn	Load will need to travel around this corner under the guidance of a spotter.
0.4	Mayfield	Selwyn Street rail crossing https://goo.gl/maps/864FhMSaF9P2	Width: 9.0m	Travel directly ahead	Loads to travel over the crossing in the center of the road. Approval required crossing this line, likely cross with caution.
1.3	Mayfield	Selwyn Street onto Industrial Drive via George Street https://goo.gl/maps/brPRAckLr572	Length: 70.0m Width: 8.0m	Right hand turn	Trailer will need to be raised to travel over the hump in the road. Load will need to travel around this corner under the guidance of a spotter.
4.9	Mayfield	Industrial Drive under traffic signals https://goo.gl/maps/5DpD3b7KnT72	Clearance: Height: 5.4m	Travel directly ahead	The lowest traffic signal on route is at the intersection of Steel River Blvd. Trucks that exceed 5.3 metres will need to travel in the right-hand lane.
5.5	Mayfield West	Industrial Drive onto Maitland Road https://goo.gl/maps/Kn49dhWG2qG2	Length: 70.0m Width: 8.0m	Right hand turn	Load will need to travel around this corner under the guidance of a spotter.
7.8	Sandgate	Maitland Road U-Turn https://goo.gl/maps/Avgp1mVZ7TgMi5ej7	Length: 70.0m Width: 7.0m	U-Turn	Load to turn left into Old Maitland Road. Once in a straight line the load will; reverse across both the north and southbound lanes before heading south on Maitland Road. Police and pilots will need to hold all traffic during this procedure.
7.8	Sandgate	Maitland Road onto Newcastle inner city bypass https://goo.gl/maps/x7TiWEQGbChTey3h9	Length: 100.0m Width: 9.0m	Right hand turn	No problems with this section of road.
13.0	Jesmond	Newcastle inner city bypass onto Newcastle Road. https://goo.gl/maps/jki5bKRDRaGW8Uvd7	Length: 60.0m Width: 8.0m	Right hand turn at the Roundabout	Load will need to travel around this corner under the guidance of a spotter.
13.2	Wallsend	Newcastle Road onto Thomas Street. https://goo.gl/maps/pF9L9uF27dQuC55R7	Length: 100.0m Width: 9.0m	Left hand bend	No problems with this section of road.
14.5	Wallsend	Thomas Street onto Newcastle Link Road https://goo.gl/maps/EpzMBXXHYjgYxTk27	Width: 12.0m	Travel directly ahead	No problems with this section of road.

KM index	Location	Section of road	Current clearance	Procedure	Comments
14.5	Wallsend	Newcastle Link Rd https://goo.gl/maps/Ucw3poGb5UjktG2s6	Length: 60.0m Width: 8.0m	Roundabout	Load will need to travel around this roundabout on the correct side of the road under the guidance of a spotter.
15.8	West Wallsend	Newcastle Link Rd https://goo.gl/maps/wVo7bJxgJGvaVpvE9	Length: 60.0m Width: 8.0m	Roundabout	Load will need to travel around this roundabout on the correct side of the road under the guidance of a spotter.
22.0	Minmi	Newcastle Link Rd https://goo.gl/maps/96JexdLMHkgztyC18	Length: 60.0m Width: 8.0m	Roundabout	Load will need to travel around this roundabout on the correct side of the road under the guidance of a spotter.
22.5	Minmi	Newcastle Link Rd onto the M1 Motorway https://goo.gl/maps/9wSD7u3CQU7Bh1iu7	Length: 80.0m Width: 8.0m	Left hand turn	No problems with this section of road.
104.0	Mt White	M1 Motorway under Mt White overpass https://goo.gl/maps/K3fPPe4fNx63xB3j7	Height clearances: Left Lane: 5.2m Centre Lane: 5.3m Right Lane: 5.4ms	Travel directly ahead	Loads that exceed 5.3 metres high are not to travel under this structure. Loads over 5.2 metres high are to travel under the bridge in the far-right lane, and at a speed of no more than 5 km's per hour. Spotter to guide load through this section of road.
114.0	Hawkesbury River	M1 Motorway https://goo.gl/maps/yDzjirEKLAbREE8B6	100.0 long x 6.0 wide	Merge to left	Large parking area
137.0	Wahroonga	M1 onto Pennant Hills Rd https://goo.gl/maps/bskC8kD4CdW9xmwYA	Length: 75.0m Width: 8.0m	Left hand turn	No problems with this section of road.
138.0	Normanhurst	Pennant Hills Road under Pedestrian overpass https://goo.gl/maps/nYbjKf5AJ9D2xvUt7	Height clearances: Left Lane: 5.15m Centre Lane: 5.2m Right Lane: 5.3m	Travel directly ahead	Loads that exceed 5.3 metres high are not to travel under this structure. Loads over 5.2 metres high are to travel under the bridge in the far-right lane, and at a speed of no more than 5 km's per hour. Spotter to guide load through this section of road.
143.0	Beecroft	Pennant Hills Road under Pedestrian overpass https://goo.gl/maps/sjnLQqYRudUSKgTQ8	Height clearances: Left Lane: 5.3m Centre Lane: 5.4m Right Lane: 5.5m	Travel directly ahead	Loads that exceed 5.3 metres high are not to travel under this structure. Loads over 5.2 metres high are to travel under the bridge in the centre lane, and at a speed of no more than 5 km's per hour. Spotter to guide load through this section of road.
148.0	West Pennant Hills	Pennant Hills Rd onto M2 Motorway https://goo.gl/maps/cCsJwSt1NsRi5cSs6	Length: 75.0m Width: 7.0m	Right hand turn	No problems with this section of road.
157.0	Winston Hills	M2 Motorway onto M7 Motorway https://goo.gl/maps/PC96cBq2xqtW85vG7	Width: 10.0m	Travel directly ahead	No problems with this section of road.
163.0	Kings Park	M7 Motorway https://goo.gl/maps/T8WcbR9T84Zs7WpF7	100.0 long x 6.0 wide	Merge to left	Large parking area
196.0	Prestons	M7 Motorway onto M5 Motorway https://goo.gl/maps/FA2mF7PxZkxRDTR9	Width: 10.0 metres	Travel directly ahead	No problems with this section of road.

KM index	Location	Section of road	Current clearance	Procedure	Comments
221.0	Menangle	Hume Highway https://goo.gl/maps/KPMdLS1XuRWHrcyb6	200.0 long x 8.0 wide	Merge to left	Large parking area for towers and motors, no blades to enter this parking bay.
232.0	Wilton	Hume Highway under Farm access overpass https://goo.gl/maps/2ZsVqYJ9j9gPTGqa9	Height clearances: Left Lane: 5.5 mtrs Centre Lane: 5.4 mtrs Right Lane: 5.3 mtrs	Travel directly ahead	Loads that exceed 5.3 metres high are not to travel under this structure. Loads over 5.2 metres high are to travel under the bridge in the left lane, and at a speed of no more than 5 km's per hour. Spotter to guide load through this section of road.
293.0	Sutton Forest	Hume Highway https://goo.gl/maps/uT1ubtSuawS2	150.0 long x 10.0 wide	Merge to left	Large parking area
347.0	Goulburn	Hume Highway https://goo.gl/maps/7HywRcjZiJy	180.0 long x 15.0 wide	Merge to left	Large parking area
370.0	Breadalbane	Hume Highway https://goo.gl/maps/udSVjVxM867VKa466	180.0 long x 15.0 wide	Merge to left	Large parking area
384.0	Cullerin range	Hume Highway https://goo.gl/maps/wud2cMXBFKNw1APq8	180.0 long x 15.0 wide	Merge to left	Large parking area
451.0	Bowning	Hume Highway https://goo.gl/maps/eUGih1C3Fvuv7KQQ9	180.0 long x 15.0 wide	Merge to left	Large parking area
505.0	Coolac	Hume Highway https://goo.gl/maps/7tJB1b12oaJ4K9ZQ6	180.0 long x 15.0 wide	Merge to left	Large parking area
526.0	Gundagai	Hume Highway https://goo.gl/maps/oEYq2UVJfr2xt5VU7	180.0 long x 10.0 wide	Merge to left	Large parking area
543.0	South Gundagai	Hume Highway https://goo.gl/maps/AmCQoqynVVquaS3bA	180.0 long x 15.0 wide	Merge to left	Large parking area
620.0	Little Billabong	Hume Highway onto Little Billabong Road https://goo.gl/maps/KDRooJeTfA4JHioL8	Length: 50.0m Width: 7.0m	Left hand turn	Load will need to travel around this corner under the guidance of a spotter.
634.0	Carabost	Little Billabong Road onto Tumbarumba Road https://goo.gl/maps/uRkGxSiB3b5rQGSN9	Length: 60.0m Width: 7.0m	Right hand turn	Load will need to travel around this corner under the guidance of a spotter.
657.0	Rosewood	Tumbarumba Road onto Wagga Road https://goo.gl/maps/eQnmoEzX5W9kk4kF9	Length: 60.0m Width: 7.0m	Travel directly ahead	No problems with this section of road.
676.0	Tumbarumba	Wagga Road onto Masons Hill Road https://goo.gl/maps/UZRr2vurqsbrVYyb7	Length: 60.0m Width: 7.0m	Travel directly ahead	No problems with this section of road.

KM index	Location	Section of road	Current clearance	Procedure	Comments
677.0	Tumbarumba	Masons Hill Road onto Albury Street https://goo.gl/maps/Qjb5bWNbAQwuAKtX7	Length: 60.0m Width: 7.0m	Travel directly ahead	No problems with this section of road.
679.0	Tumbarumba	Albury Street onto The Parade https://goo.gl/maps/4cLjRndvaqn1E9HNA	Length: 40.0m Width: 7.0m	Right hand turn	Load will need to travel around this corner under the guidance of a spotter.
679.2	Tumbarumba	The Parade onto Bridge Street https://goo.gl/maps/4cLjRndvaqn1E9HNA	Length: 60.0m Width: 7.0m	Left hand turn	Load will need to travel around this corner under the guidance of a spotter.
679.8	Tumbarumba	Bridge Street onto Winton Street https://goo.gl/maps/SguQfESJELtgtkTi9	Length: 50.0m Width: 7.0m	Right hand turn	Load will need to travel around this corner under the guidance of a spotter.
680.0	Tumbarumba	Winton Street onto Regent Street https://goo.gl/maps/R2Ybeju6YuYaGCYE6	Length: 50.0m Width: 7.0m	Left hand turn	Load will need to travel around this corner under the guidance of a spotter.
680.4	Tumbarumba	Regent Street onto William Street https://goo.gl/maps/d6qXvaHEkMzwQA44A	Length: 70.0m Width: 7.0m	Right hand turn	Load will need to travel around this corner under the guidance of a spotter.
681.0	Tumbarumba	William Street onto Tooma Road https://goo.gl/maps/3Em4745SLvapALmp6	Length: 90.0m Width: 8.0m	Travel directly ahead	No problems with this section of road.
697.0	Tumbarumba	Tooma Road onto Elliot Way https://goo.gl/maps/C7iMq64P9z64p7M39	Length: 60.0m Width: 7.0m	Left hand turn	Load will need to travel around this corner under the guidance of a spotter.
717.0	Nurenmerenmong	Elliot way onto Maragle site access Road https://goo.gl/maps/hikAu5k4CQk9ancY6	Length: 30.0m Width: 4.0m	Right hand turn	Site to construct a suitable access road for the swept path of the largest load. Load will need to travel around this corner under the guidance of a spotter.

0.0 Km's: Mayfield #4 onto Selwyn Street at Mayfield

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/afLwPYKuNdm
PROCEDURE: Right hand turn from Mayfield Storage to Selwyn St.
COMMENTS: A spotter will need to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No works required.

Image2

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/afLwPYKuNdm
PROCEDURE: Right hand turn from Mayfield Storage to Selwyn St.
COMMENTS: A spotter will need to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No works required.

0.4 Km's: Rail crossing over Selwyn Street at Mayfield

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/864FhMSaF9P2
PROCEDURE: Travel directly ahead over the crossing.
COMMENTS: Large width clearance and good ground clearance over this crossing.
Police and escorts to control local traffic either side of the crossing. ARTC approval will need to be obtained to travel over this crossing. Likely to cross with caution, no escort required.
ROAD MODIFICATIONS: No works are required.

1.3 Km's: Selwyn Street onto Industrial Drive, via George Street at Mayfield

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/brPRAckLr572

PROCEDURE: Right hand turn from Selwyn Street through George Street and onto Industrial Drive.

COMMENTS: A spotter would need to assist the load through this intersection.

ROAD MODIFICATIONS: No work is required.

Image2

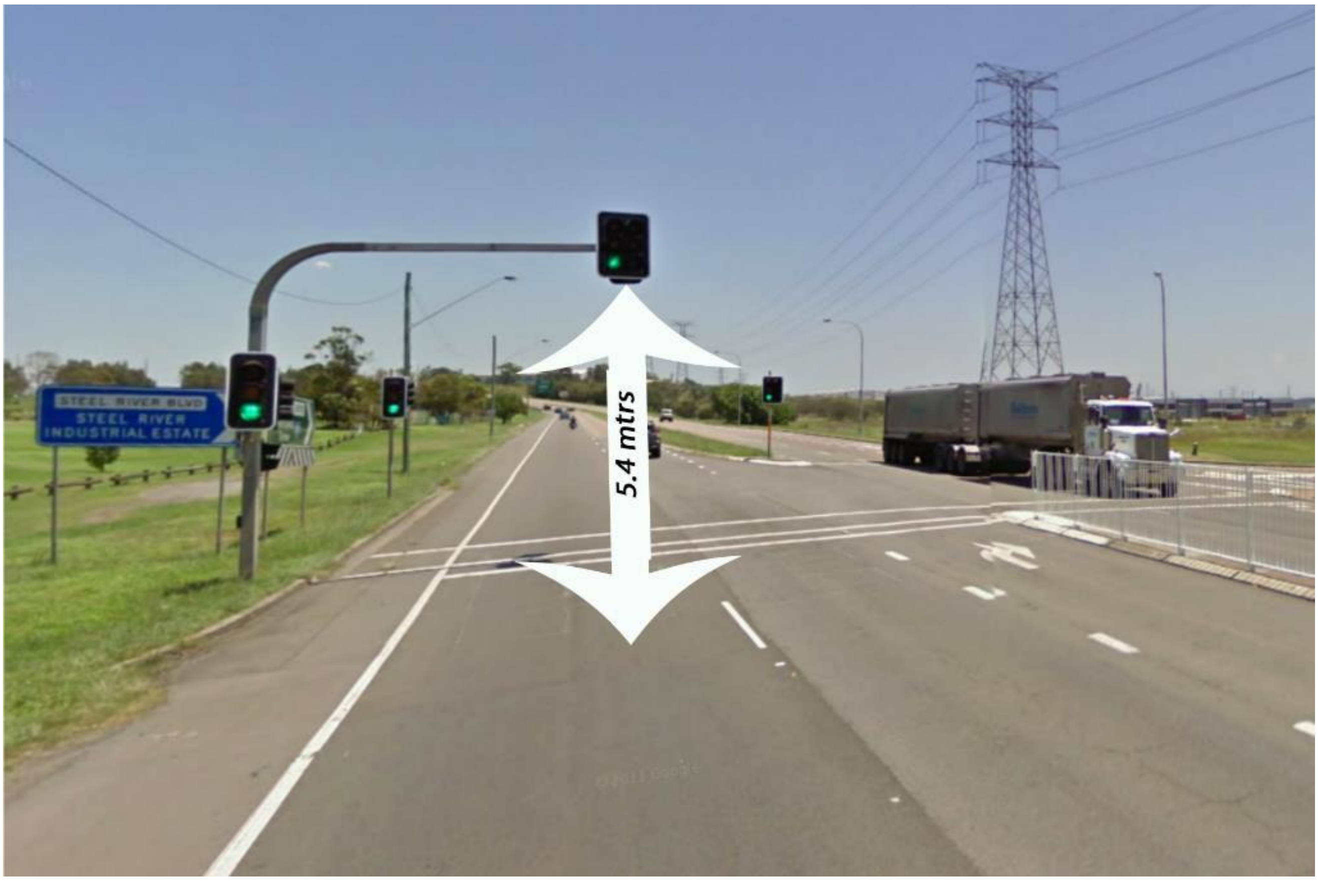
GPS LINK FOR THIS LOCATION: https://goo.gl/maps/brPRAckLr572

PROCEDURE: Right hand turn from Selwyn Street through George Street and onto Industrial Drive.

COMMENTS: A spotter would need to assist the load through this intersection.

ROAD MODIFICATIONS: No work is required.

4.9 Km's: Standard overhanging Traffic signals Mayfield to Hunter Expressway



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/5DpD3b7KnT72

PROCEDURE: Overhanging signals while travelling through the intersection.

COMMENTS: The lowest traffic signal on route has 5.4 metres clearance. This signal is on the corner of Steel River Blvd at Mayfield West. Loads with an overall height of 5.3 or higher, can avoid this signal by travelling in the centre lane. Loads to slow down while doing this manoeuvre. All other signals exceed 5.6 metres high on this section of road.

ROAD MODIFICATIONS: No works are required.

5.5 Km's: Industrial Drive onto Maitland Road at Mayfield West

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/Kn49dhWG2qG2
PROCEDURE: Right hand turn from Industrial Drive onto Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2

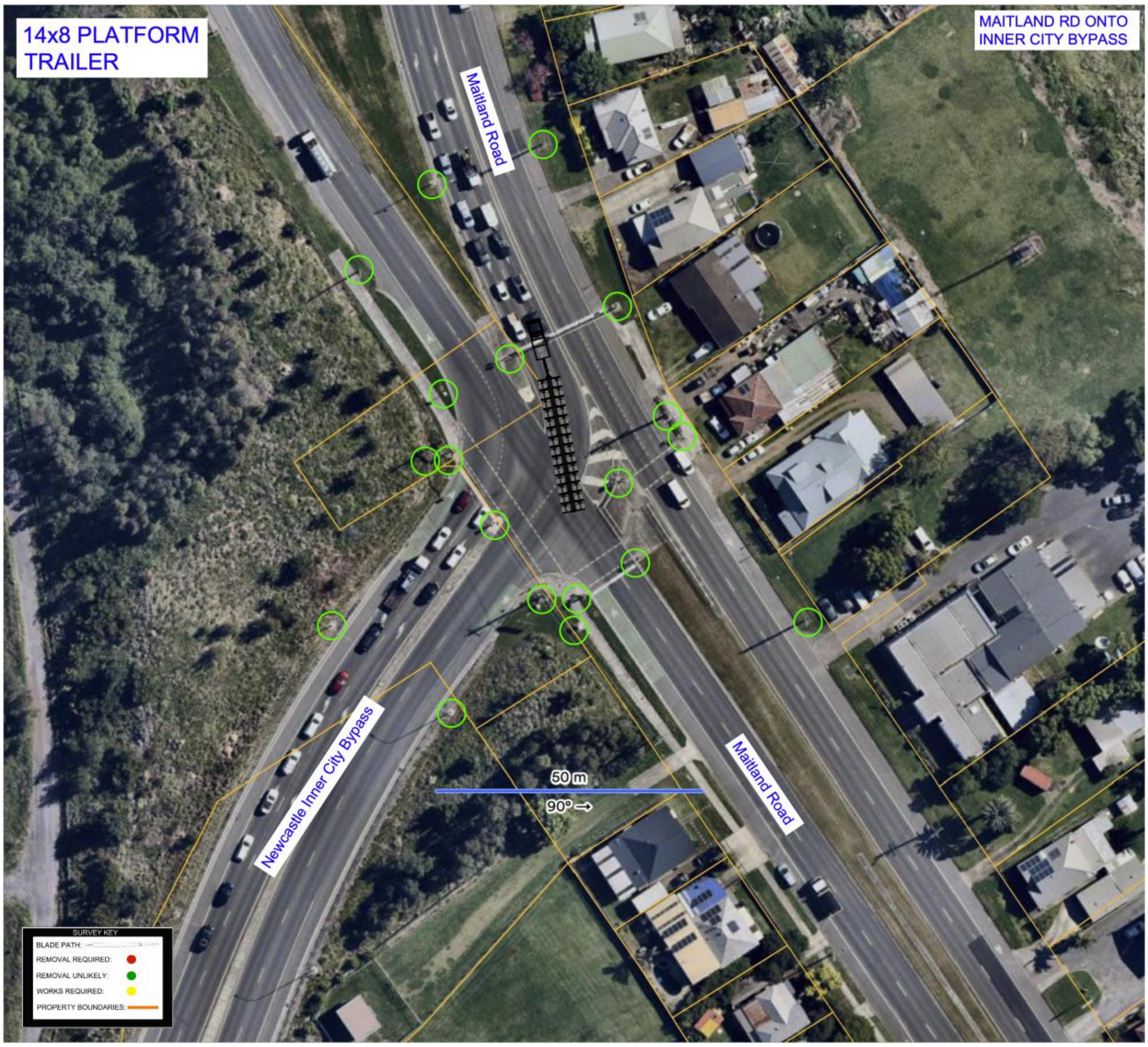
GPS LINK FOR THIS LOCATION: https://goo.gl/maps/Kn49dhWG2qG2
PROCEDURE: Right hand turn from Industrial Drive onto Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

7.8 Km's: Maitland Uturn Stage 1 wrongside to Maitland Rd

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/zCgz7cuCigLVNQdA9
PROCEDURE: Right hand turn on Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/zCgz7cuCigLVNQdA9
PROCEDURE: Right hand turn on Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

7.8 Km's: Maitland Uturn Stage 2 left turn to Maitland Rd

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/7nAErJMHcPbp1kSE8
PROCEDURE: Left hand turn on Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/7nAErJMHcPbp1kSE8
PROCEDURE: Left hand turn on Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

7.8 Km's: Maitland Uturn Stage 3 right turn to Maitland Rd

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/7nAErJMHcPbp1kSE8
PROCEDURE: Right hand turn on Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2

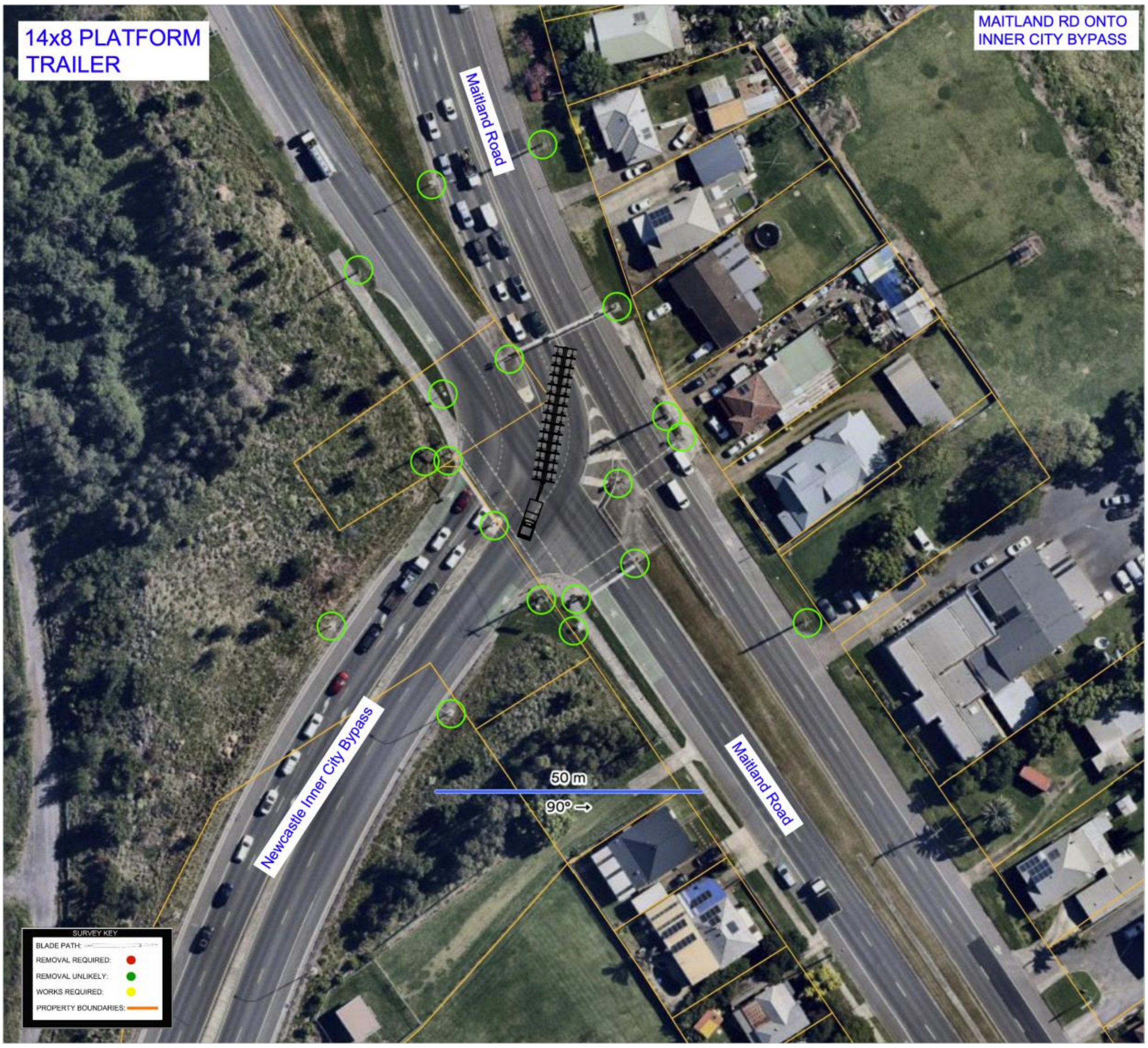
GPS LINK FOR THIS LOCATION: https://goo.gl/maps/7nAErJMHcPbp1kSE8
PROCEDURE: Right hand turn on Maitland Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

7.8 Km's: Maitland Rd to Inner City Bypass

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/idbvTX5Z82yeT48d6
PROCEDURE: Right hand turn on Inner City Bypass.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/idbvTX5Z82yeT48d6
PROCEDURE: Right hand turn on Inner City Bypass.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

13.0 Km's: Inner City Bypass Jesmond Roundabout

Image1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/zRikQrLgUxfhR4br9
PROCEDURE: Right hand turn at Jesmond roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/zRikQrLgUxfhR4br9
PROCEDURE: Right hand turn at Jesmond roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

14.5 Km's: Inner City Bypass Wallsend Roundabout

Image1

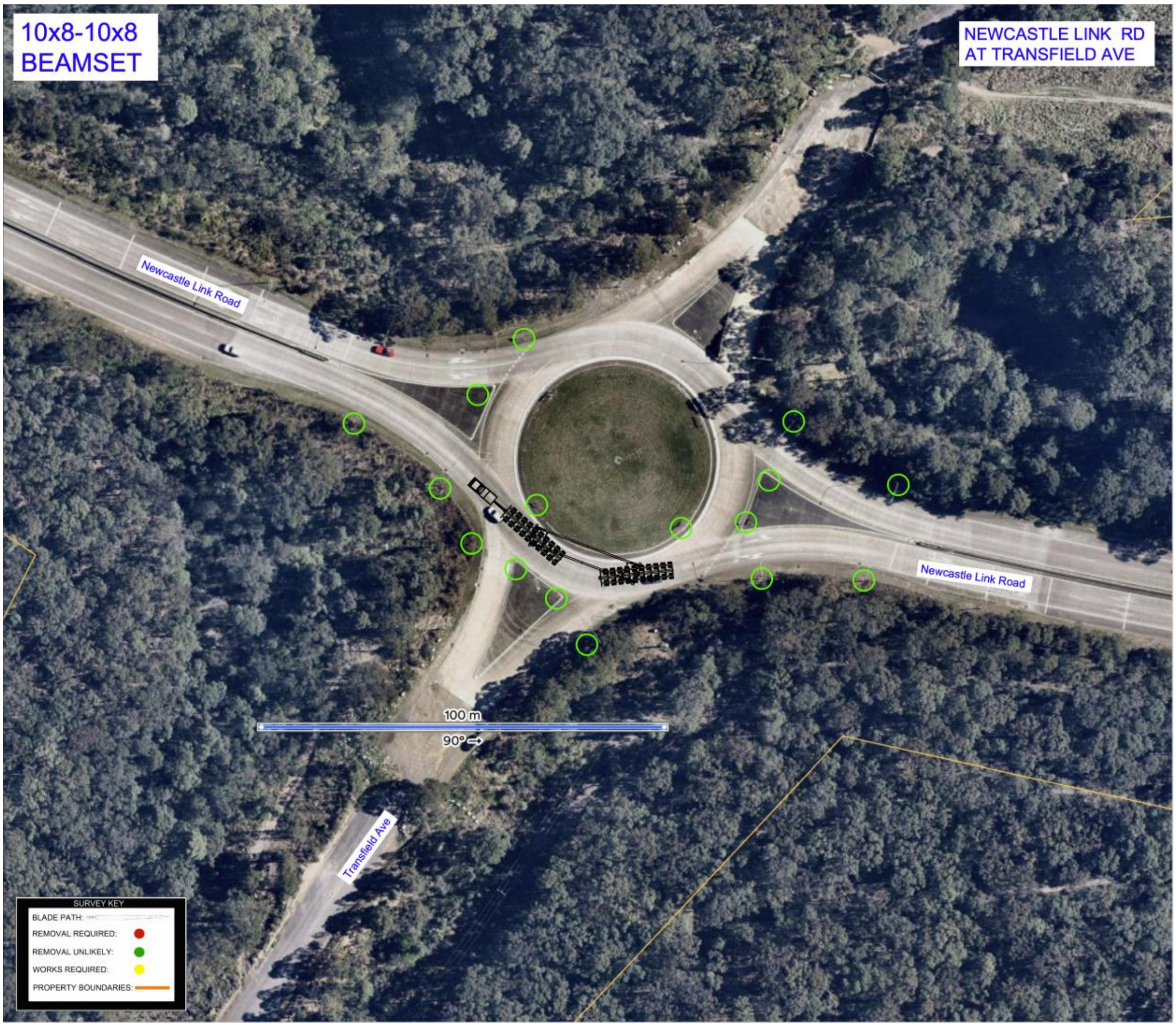
GPS LINK FOR THIS LOCATION: https://goo.gl/maps/RUAwHPfBmqFg43mj8
PROCEDURE: Left hand turn at Wallsend roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

Image2

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/RUAwHPfBmqFg43mj8
PROCEDURE: Left hand turn at Wallsend roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

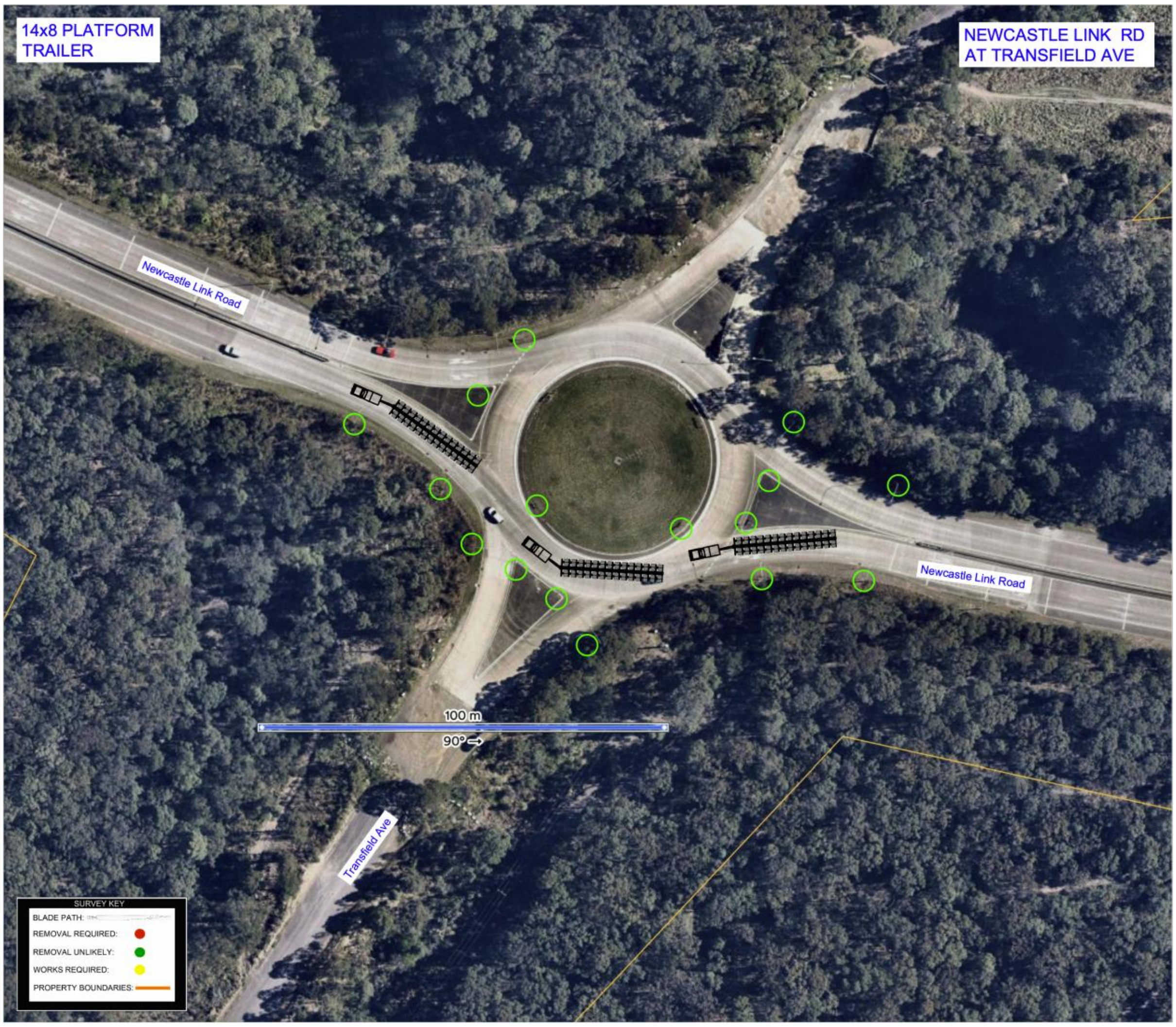
15.8 Km's: Inner City Bypass Transfield Ave Roundabout

Image1



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/MFdUA5YLJNhpdw3M9
PROCEDURE: Straight through roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

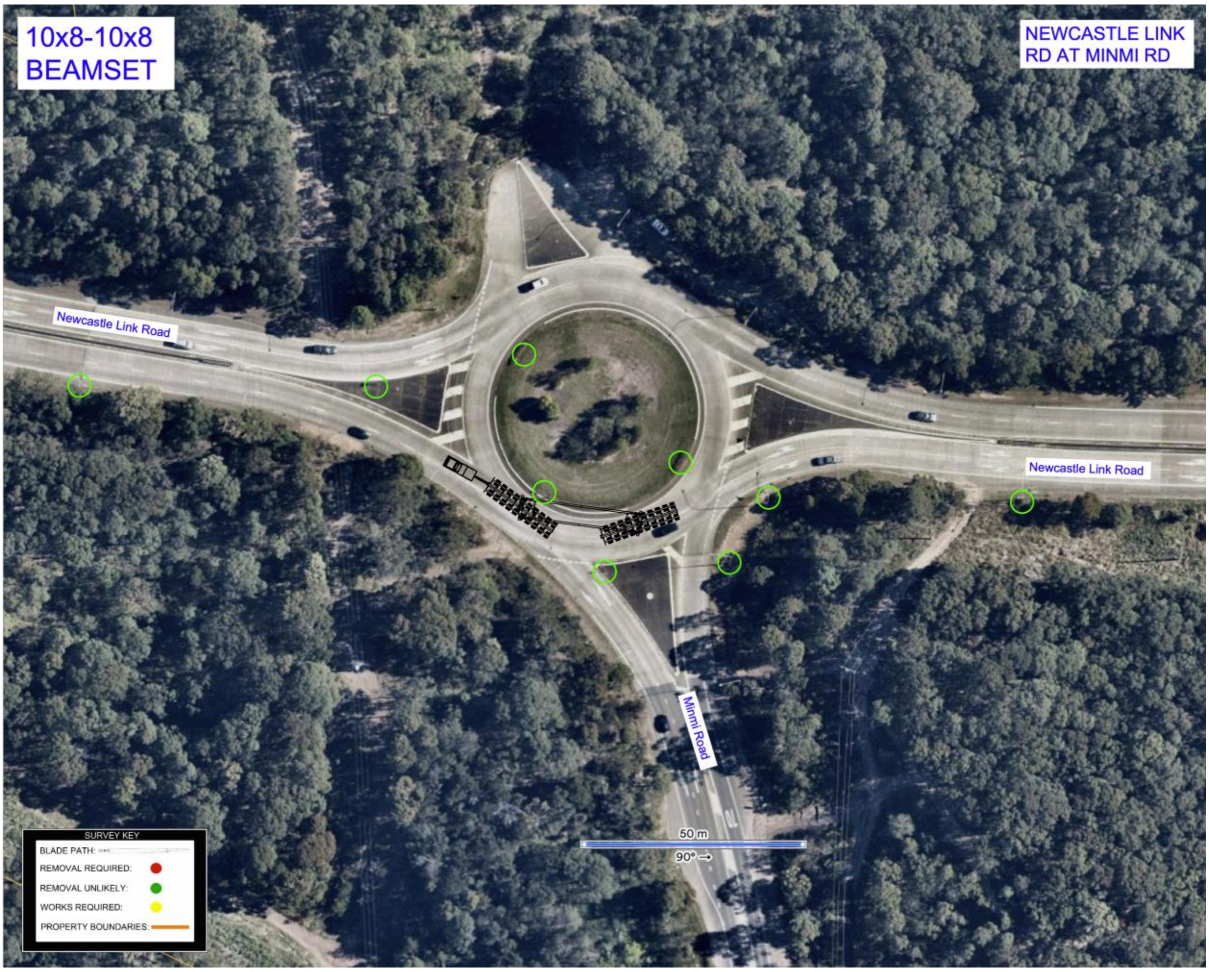
Image2



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/MFdUA5YLJNhpdw3M9
PROCEDURE: Straight through roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

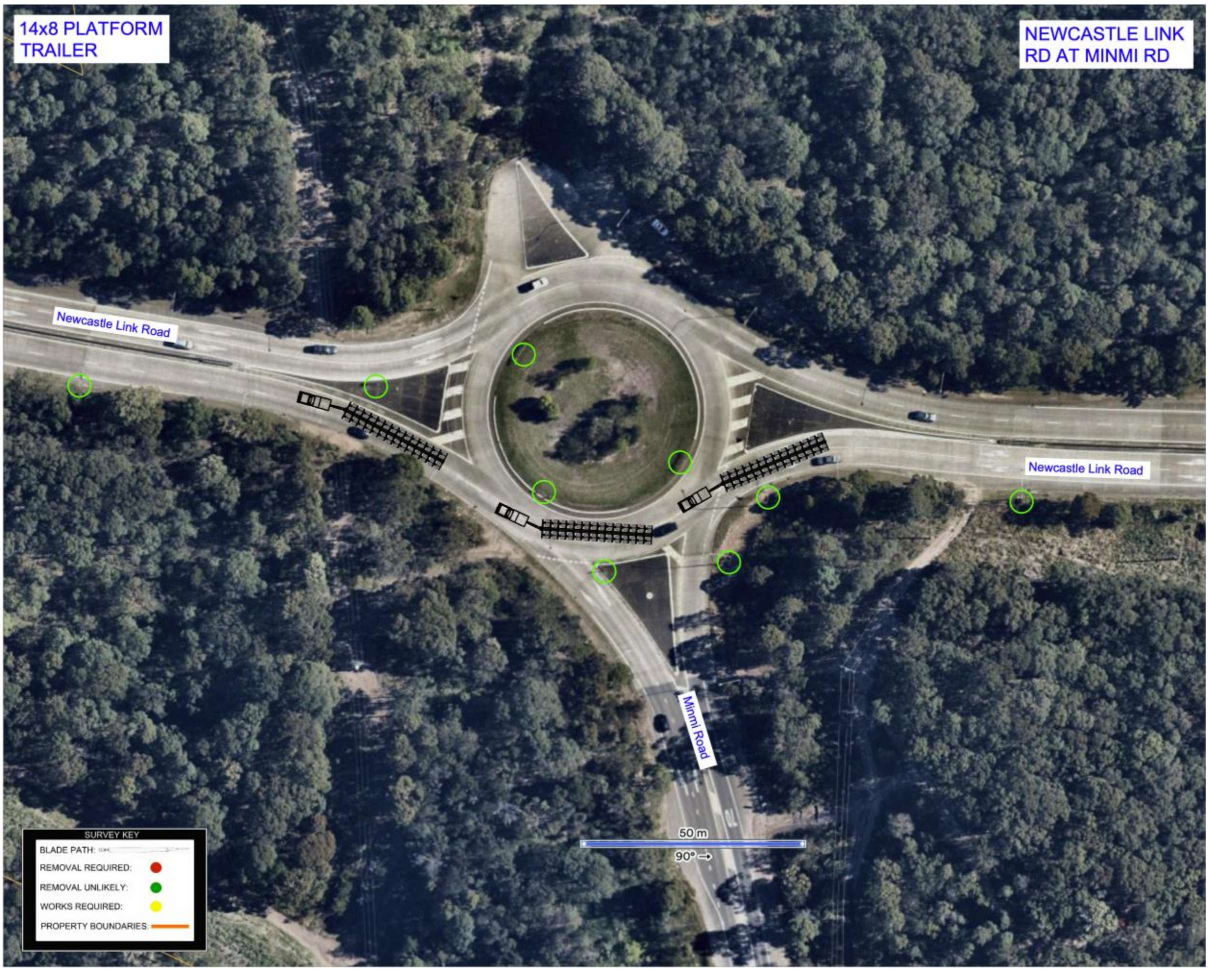
22.0 Km's: Inner City Bypass Minmi Rd Roundabout

Image1



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/2qhPiUHy3uH5XzaPA
PROCEDURE: Straight through roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

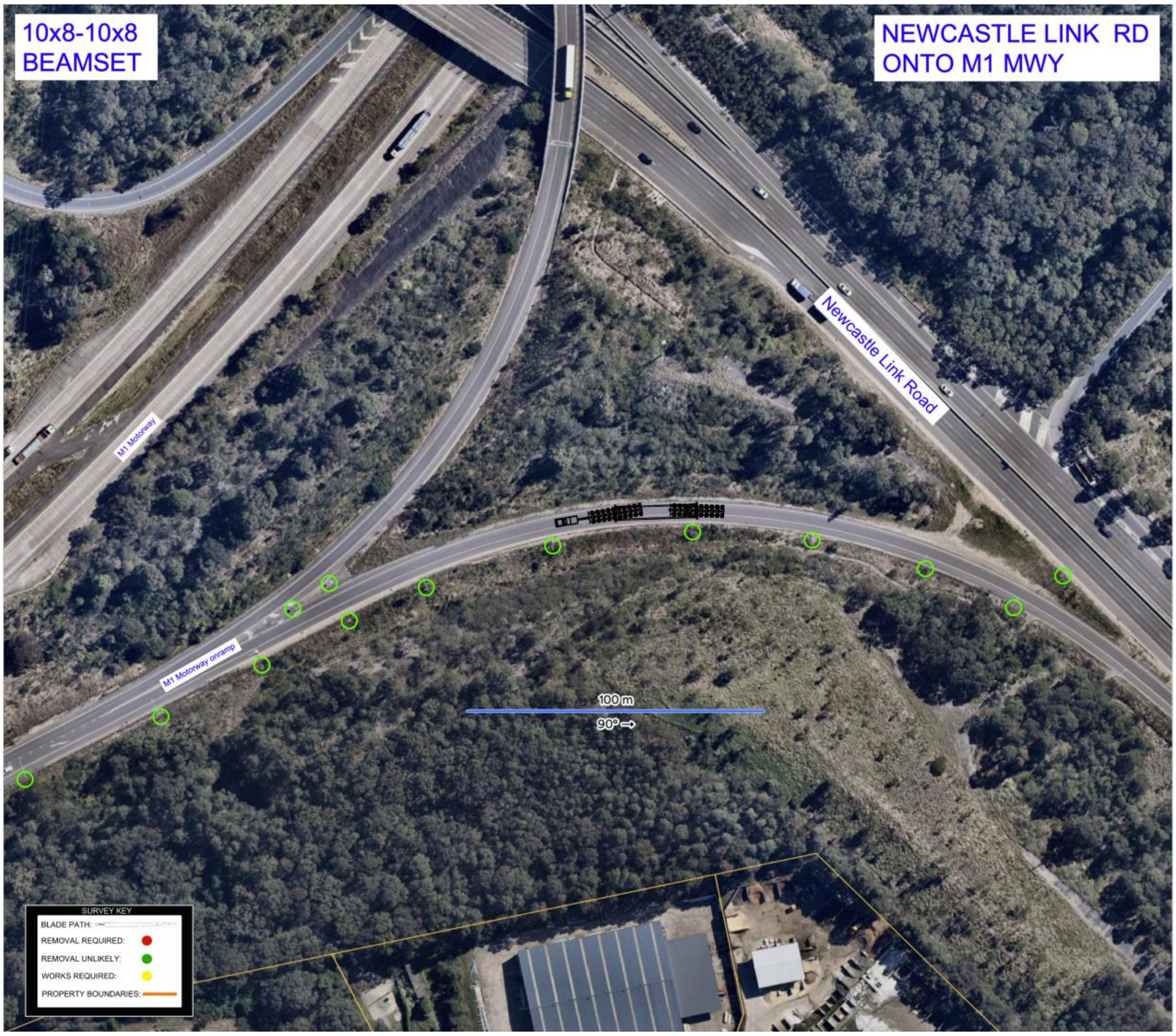
Image2



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/2qhPiUHy3uH5XzaPA
PROCEDURE: Straight through roundabout.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

22.5 Km's: Inner City Bypass to M1

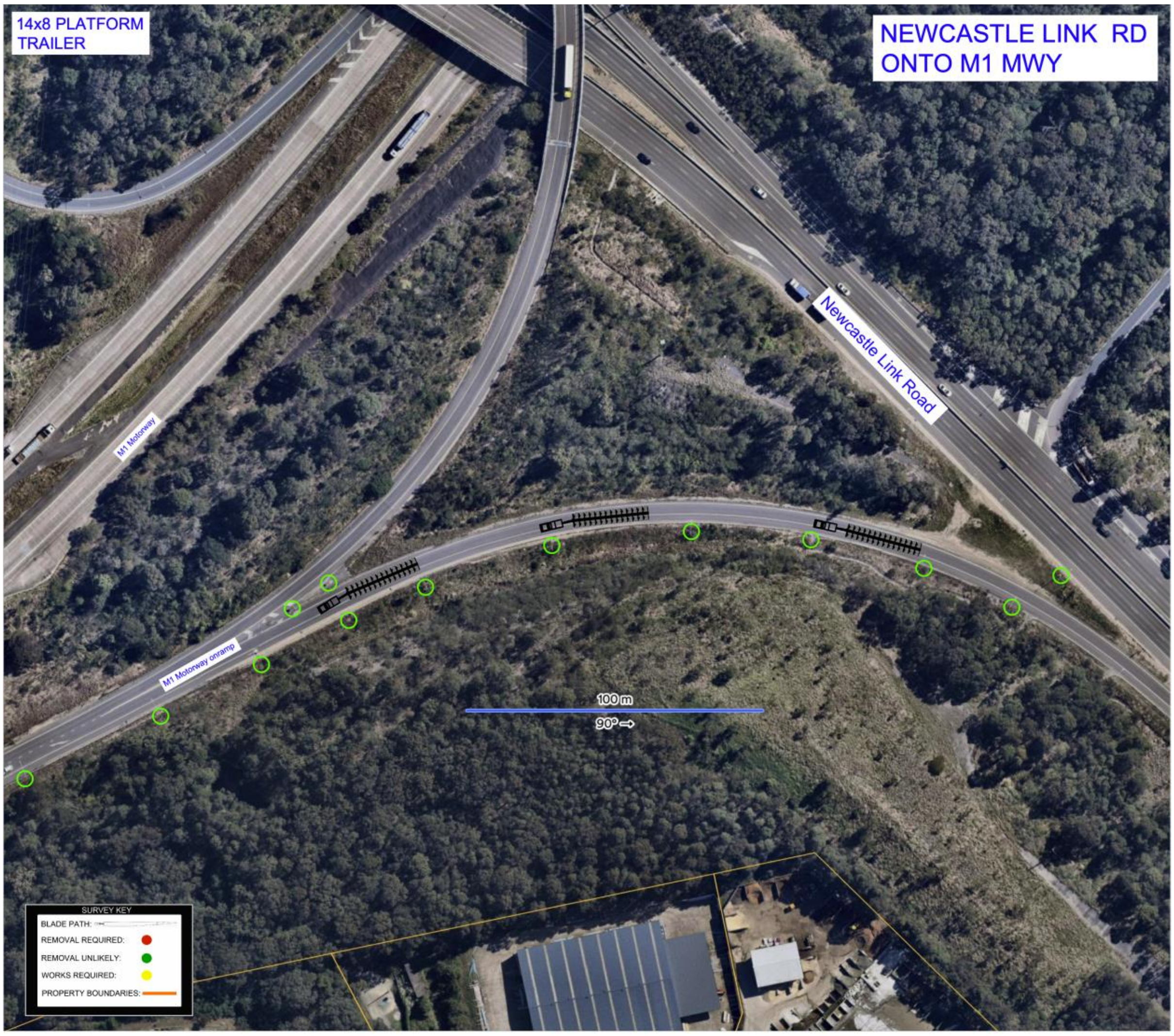
Image1



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/tAZifJpuwK2daPBp9
PROCEDURE: Left hand sweeper.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

22.5 Km's: Inner City Bypass to M1

Image2



GPS LINK FOR THIS LOCATION: https://goo.gl/maps/tAZifJpuwK2daPBp9
PROCEDURE: Left hand sweeper.
COMMENTS: Spotter to keep the driver informed throughout the procedure.
ROAD MODIFICATIONS: No work is required.

137.0 Km's: M1 Motorway onto Pennant Hills Road at Wahroonga.

Image 1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/bskC8kD4CdW9xmwYA
PROCEDURE: Left hand turn from the M1 Motorway onto Pennant Hills Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.

ROAD MODIFICATIONS: No works are required.

Image 2

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/bskC8kD4CdW9xmwYA
PROCEDURE: Left hand turn from the M1 Motorway onto Pennant Hills Road.
COMMENTS: Spotter to keep the driver informed throughout the procedure.

ROAD MODIFICATIONS: No works are required.

148.0 Km's: Pennant Hills Road onto the M2 Motorway at West Pennant Hills.

Image 1

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/cCsJwSt1NsRi5cSs6

PROCEDURE: Right hand turn from Pennant Hills Road onto the M2 Motorway.

COMMENTS: Trucks are to turn from the correct side to the correct side of the road. The prime mover will need to turn from the far-left lane on Pennant Hills Road and enter the on ramp as wide as possible.

Spotter to guide the load through the corner.

ROAD MODIFICATIONS: no works are required.

Image 2

GPS LINK FOR THIS LOCATION: https://goo.gl/maps/cCsJwSt1NsRi5cSs6

PROCEDURE: Right hand turn from Pennant Hills Road onto the M2 Motorway.

COMMENTS: Trucks are to turn from the correct side to the correct side of the road. The prime mover will need to turn from the far-left lane on Pennant Hills Road and enter the on ramp as wide as possible.

Spotter to guide the load through the corner.

ROAD MODIFICATIONS: no works are required.

620.0 Km's: Hume Hwy onto Little Billabong Rd at Little Billabong.

Image 1

GPS LINK FOR THIS LOCATION https://goo.gl/maps/rfcttD7MEChhRG7a9
PROCEDURE: Left hand turn From Hume Hwy onto Little Billabong Rd.
COMMENTS: Trucks are to turn from the correct side to the incorrect side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: no works are required.

Image 2

GPS LINK FOR THIS LOCATION https://goo.gl/maps/rfcttD7MEChhRG7a9
PROCEDURE: Left hand turn From Hume Hwy onto Little Billabong Rd.
COMMENTS: Trucks are to turn from the correct side to the incorrect side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: no works are required.

634.0 Km's: Little Billabong Rd onto Tumbarumba Rd at Carabost

Image 1

GPS LINK FOR THIS LOCATION https://goo.gl/maps/eajMkdvFLKhbEwjg8
PROCEDURE: Right hand turn From Little Billabong Rd onto Tumbarumba Rd.
COMMENTS: Trucks are to turn from the correct side to the correct side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: no works are required.

Image 2

GPS LINK FOR THIS LOCATION https://goo.gl/maps/eajMkdvFLKhbEwjg8
PROCEDURE: Left hand turn From Little Billabong Rd onto Tumbarumba Rd.
COMMENTS: Trucks are to turn from the correct side to the correct side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: no works are required.

677.0 Km's: Albury St to Bridge St to Winton St at Tumbarumba

Image 1

GPS LINK FOR THIS LOCATION https://goo.gl/maps/FgTh7bBBPwnRsVBBA

PROCEDURE: Right hand turn Albury St into Left hand turn into Bridge St into right hand turn Winton St

COMMENTS: Trucks are to turn from the correct side to the correct side of the road.

Spotter to guide the load through the corner.

ROAD MODIFICATIONS: there are a moderate amount of works are required. The medians needs to be lowered and signs made removable.

Image 2

GPS LINK FOR THIS LOCATION https://goo.gl/maps/FgTh7bBBPwnRsVBBA

PROCEDURE: Right hand turn Albury St into Left hand turn into Bridge St into right hand turn Winton St

COMMENTS: Trucks are to turn from the correct side to the correct side of the road. Spotter to guide the load through the corner.

ROAD MODIFICATIONS: there are a moderate amount of works are required. The medians needs to be lowered and signs made removable.

680.0 Km's: Winton St onto Regent St at Tumbarumba

Image 1

GPS LINK FOR THIS LOCATION https://goo.gl/maps/vCvFULm3UjnJ2yes9

PROCEDURE: left hand turn from Winton St into Regent St

COMMENTS: Trucks are to turn from the correct side to the correct side of the road. Spotter to guide the load through the corner.

ROAD MODIFICATIONS: No works are required.

Image 2

GPS LINK FOR THIS LOCATION https://goo.gl/maps/vCvFULm3UjnJ2yes9
PROCEDURE: left hand turn from Winton St into Regent St
COMMENTS: Trucks are to turn from the correct side to the correct side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: No works are required.

697.0 Km's: Tooma Rd onto Elliot Way at Tumbarumba

Image 1

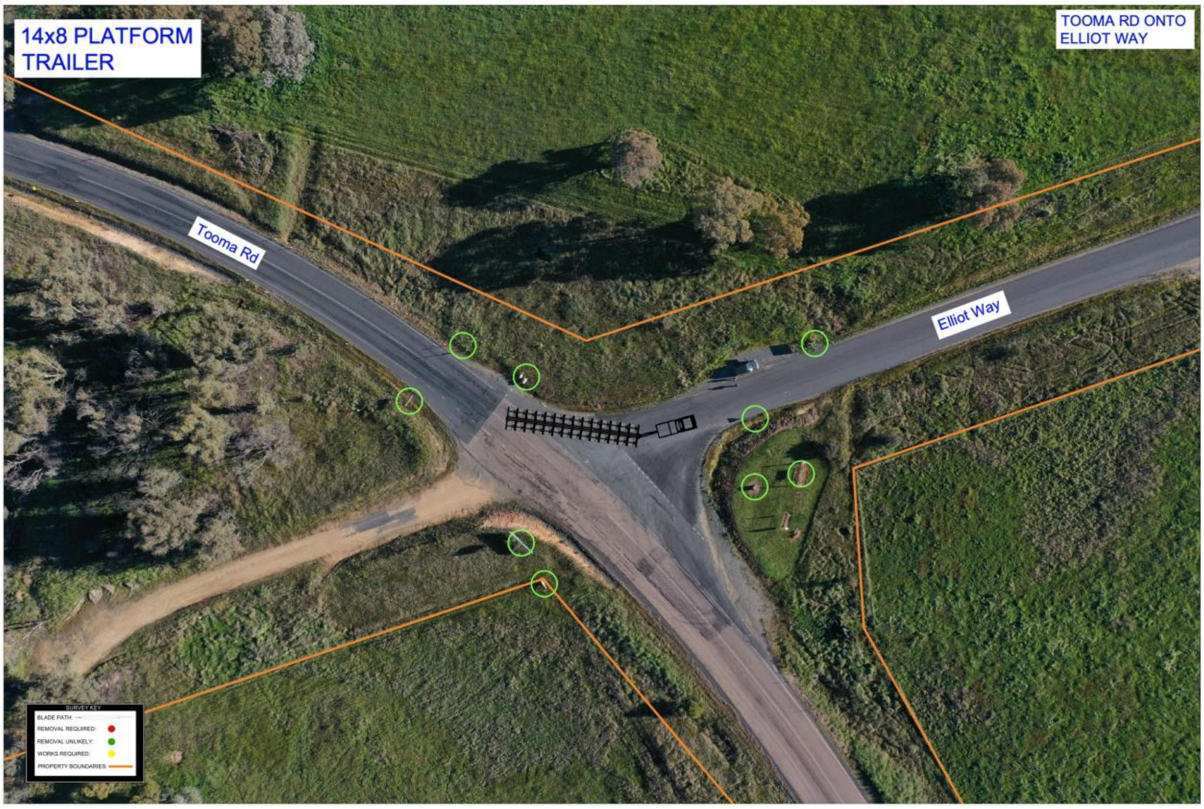
GPS LINK FOR THIS LOCATION https://goo.gl/maps/TbgETrbK7p3KCstJ8

PROCEDURE: left hand turn from Tooma Rd onto Elliot Way

COMMENTS: Trucks are to turn from the correct side to the incorrect side of the road. Spotter to guide the load through the corner.

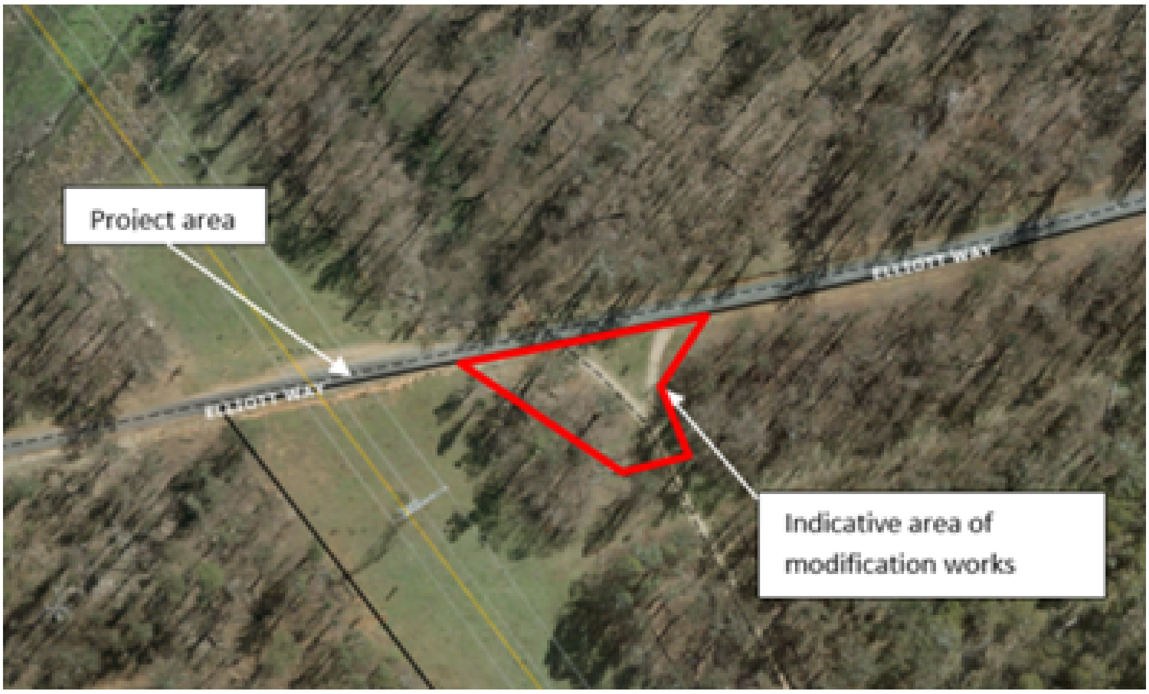
ROAD MODIFICATIONS: No works are required.

Image 2



GPS LINK FOR THIS LOCATION https://goo.gl/maps/TbgETrbK7p3KCstJ8
PROCEDURE: left hand turn from Tooma Rd onto Elliot Way
COMMENTS: Trucks are to turn from the correct side to the incorrect side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: No works are required.

717.0 Km's: Elliot Way into Site at Maragle
Image 1



GPS LINK FOR THIS LOCATION https://goo.gl/maps/hVgLPkV7aCv2KtB46
PROCEDURE: right hand turn from Elliot Way into Site
COMMENTS: Trucks are to turn from the correct side to the incorrect side of the road. Spotter to guide the load through the corner.
ROAD MODIFICATIONS: the road is in poor condition and major works are required.

10.0 Summary of route

After studying all the options and undertaking a route survey, it was observed that the components could be delivered through to the proposed Transgrid sub station with little to no road modifications required. However, we would recommend the following take place.

NEWCASTLE:

- The U-turn on Maitland Road at Sandgate will require traffic management. This could be performed with the police and pilots that would be travelling with the load.

MT WHITE:

- Loads to slow while travelling under Mt White overpass and travel in the far right lane.

SYDNEY:

- OSOM loads will need to use Pennant Hills Road and not the Northconnex tunnel.
- Loads to slow while travelling under the Normanhurst and Beecroft pedestrian bridges and travel in the far-right lane.
- The M2 and M7 motorways may need bridge slowdowns. This is usually performed by the motorways escort, Police escorts and pilot vehicles.

WILTON:

- Loads to slow while travelling under the Farm Road overpass and travel in the far-left lane.

TUMBARUMBA:

- A spotter will need to assist the loads through Tumbarumba.
- Some signs will need to be removed and replaced in several section while travelling through the township. These signs are already removable.

MARAGLE SUBSTATION SITE:

- The road surface is gravel and in poor condition. The site construction Road would need to be made suitable for the swept path of the largest loads.

OVERHEAD STRUCTURES: (5.3 Maximum loaded height)

- There are a large number of overhead structures between Newcastle and Maragle substation. The lowest of these structures is the pedestrian bridge over Pennant Hills Road at Normanhurst. There are a number of other structures noted as pinch points in the survey. Each of these pinch points will show the height clearance in each lane.
- Loads up to 5.3m loaded height can travel from Newcastle through Sydney to Maragle on this route, however the steps shown in this report must be taken.

OVERHEAD UTILITIES:

- This route will need to be checked by an authorised scoping company. It is likely that a route of at least 5.3 metres is required for this project.

BRIDGES:

- There are a number of bridges on route that will require bridge assessments.
- The route up to the turnoff of the Hume Highway is likely to be okay for the mass of the components listed in this report.
- There are a number of bridges after the Hume Highway which will need to be assessed.
- Once RMS have compiled a bridge investigation they will determine if addition pull trucks are required to be disconnected to reduce weight.
- We generally allow 100mm of clearance with trailer at lowest travel height in our surveys and we list lowest and highest dimensions as roads may have crossfall

RAIL ASSETS:

- There are a number of rail overbridges and crossings on route that will require approval from authorities before loads can access the routes.

VEGETATION:

- The route up until Little Billabong is clear of vegetation removal.

CLASSIFIED ROADS:

- There are no classified roads on this route.

PAVEMENT:

- The Pavement up to Tumbarumba is of a suitable highway grade.

ROADWORKS:

- The project will need to start discussions with government authorities at least 18 months prior to transformer transport to understand if the project would conflict with any upcoming roadworks. Once a TMP has been approved for the transport of the transformers, then the exact movement dates need to be communicated with transport NSW to make all road stakeholders aware of the

TRIGGERS FOR SIZES AND DIMENSIONS:

- For the transformers 130 tonnes max for the 12 axle 4.2 high
- For the transformers 155 tonnes max for the 14 axle 4.2 high
- For the reactor 187 tonnes max for the Beamset 4.9 high with beam supports at 3.2 high from base

CONCLUSION OF ROUTE:

- After reviewing the routes, we are under the opinion that loads could be delivered through to the proposed Maragle substation once a bridge report has been completed. There are several pinchpoint procedures on route that would need to be implemented to get these loads safely to site.
- We recommend that the listed actions in this report are undertaken at a minimum.

11.0 Approvals:

At a minimum, the following are required for approval to access these routes.

- NHVR
- TfNSW
- Newcastle Council
- Snowy Valley council
- NSW Police
- Ausgrid
- Essential Energy
- Telstra
- CRN JHG (Rail)
- ARTC (Rail)

12.0 References:

Rex J Andrews Pty. Ltd.
Rex J Andrews Route survey # 329
Transgrid
Google Earth/Maps
Nearmaps
NHVR
NHVAS Maintenance Management (NHVAS21193)
NHVAS Basic Fatigue Management (NHVAS21193)

Disclaimer: This route study is a guide only; government approvals would be required before these routes could be deemed suitable for transporting the components over the listed routes.

Any, and all parties using information contained this submission do so at own risk.

RJA accept no responsibility for the use of all information contained within this report.

Proposed routes may change subject to approvals from authorities.

This study was undertaken using data supplied by Rex J Andrews P/L. Equipment and swept paths might vary if using transport methodology other than the data supplied by Rex J Andrews.

Appendix E Bridge assessment

Pt2414_PS/EY
PROJECT NO IO 404870/2414
File no. 94M3171 Vol. 31

REX ANDREWS PTY LTD: TRANSPORT OF TRANSFORMER FROM PORT KEMBLA TO PADDYS RIVER

ROUTE: PORT KEMBLA TO PADDYS RIVER
Tom Thumb Rd (ccl), Springhill Rd (581), Masters Rd (602), M1 Princes Mwy (6006), Northern Distributor (626), Old Princes Hwy/ Mount Ousely Rd/ Picton Rd (95), Hume Hwy (2), Little Billabong Rd/ Tumbarumba Rd/ Wagga Rd (284), Masons Hill Rd/ Albury St/ The Parade (85), Bridge St/ Winton St/ Regent St/ William St/ Tooma Rd/ Elliot Rd (ccl)
[Note: The route has been checked for travel in both directions.]

VEHICLE CONSIDERED:

Vehicle Description:	3x Prime Mover + 12x8 Platform @ 4.2m gcw
Item Carried:	Transformer
Item Weight:	125
Axle Width:	4.2
Axle Spacings:	3.2,1.2, 6.0, 3.2, 1.2, 6.0, 11 x 1.8, 6.0, 3.2, 1.2
Axles:	O-OO/ O-OO/ OOOOOOOOOOOO/ O-OO
Wheels per Axle:	2-44/ 2-44/ 888888888888/ 2-44
Tyre Dimensions:	279mm on prime mover, 190mm on trailing unit
Gross Weight per Axle:	6.0, 18.5, 6.0, 18.5, 174, 6.0,18.5
Total Weight:	247.50
Axle Summary:	12x8/4.2
Weight Summary:	174
Tonne per Axle Group 1:	14.5
Tonne per Axle Group 2:	
Width:	4.2
Length:	60
Height:	5

ASSUMPTION:

In assessing the bridges on the route, assumption has been made that the bridges are in good condition, and do not have any inadequacies.

ROUTE: PORT KEMBLA TO PADDYS RIVER
(i.e. TRAVEL IN BOTH DIRECTIONS)

The vehicle travelling as a permit vehicle, can be permitted to travel over the above route Subject to the following:

1.
   a. Hume Highway – NB BRIDGE OVER MR243 BIDGEE MURRUMBIDGEE RIVER SHEAHAN BRIDGE (B6298)

   This bridge is to be bypassed pending detailed analysis.

[Alternatively, travel over this bridge is permissible provided that the axle loading is reduced from 14.5t/axle to 13.7t/axle.]

2. The vehicles travel only along the centreline of the carriageway of all the bridges on the route at a speed not exceeding 10 km/h with no sudden braking or acceleration. No other vehicles are permitted on the bridge while the Permit vehicle is on the bridge.

   [Note: The centreline of the carriageway on the bridge is the centreline of the roadway between the faces of the kerbs, or the centreline of the roadway between the kerb face and the face of the central concrete median, as applicable.]

3. Southern Region's concurrence is obtained to the movement of the vehicles over the route.

4. Transport firm is required to obtain approval from ARTC or Sydney Train (formally Railway Access Corporation or State Rail Authority) and Department of Land and Water Conservation or private infrastructure owners for travel over their infrastructures. The RMS Bridge Inventory shows the following:

   a. B6250 – BRIDGE OVER RAILWAY (STHBOUND) NEAR YARRA

   b. B6251 – BRIDGE OVER RAILWAY (NTHBOUND) NEAR YARRA

5. Councils' approval is obtained by the transport firm for travel over the structures on the route maintained by the Councils, and for travel over the local roads.

6. The transport firm should satisfy itself that adequate height clearance is available under the overhead structures on the above route. The firm should refer to Region for further details.

   a. B655 - BRIDGE OVER MR626 (MEMORIAL DRIVE) AT NORTH WOLLONGONG. Vertical Clearance = 4.7m
   b. B677 - BR ON SH1 OVER F.6 AT GHOSTS CREEK. Vertical Clearance = 4.7m

The cost of investigation is $600 + GST.

(Parvez Shah)
Senior Bridge Engineer
Bridge Assessment and Evaluation
19 February 2019