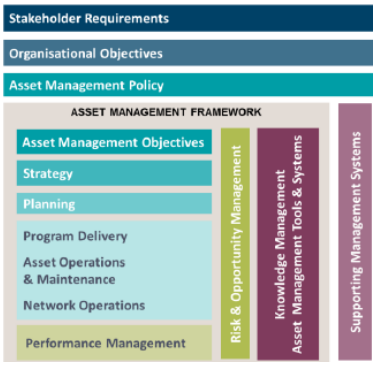
Earthworks, Roads and Drainage

Design Standard



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Western Power's Engineering & Design Function is responsible for this document

CONTACT

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Contents

Revision Details

Version	Date	EDM Version	Description
0	May 2019	1	First issue
1	February 2024	2	Standard Online Update

1. Introduction

This Engineering Design Instruction (EDI) outlines the general requirements and criteria for Earthworks, Roads and Drainage design.

1.1. Purpose and Scope[1]

This EDI applies to all Greenfield substations and Brownfield augmentation and asset replacement work. It applies to both Terminal and Zone substations.

The construction of earthworks, roads and drainage shall comply with Western Power Technical Specification -Earthworks, Roads and Drainage.

1.2. Acronyms

Acronym	Definition

1.3. Definitions

Term	Definition
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AS	Australian Standard
Brownfield site	Site with existing or previous electrical assets
DTM	Digital Terrain Model
EDI	Engineering Design Instruction, describes in detail a particular type of design. This is the “how” to implement a design with clear boundaries defined.
EPBC	Environment Protection and Biodiversity Conservation
Greenfield site	New site with no previously installed electrical assets
HMR	Hazard Management Register
HV	High Voltage
NCC	National Construction Code
RL	Reduced Level
RRST	Rapid Response Standby Transformer

[1] See Western Power Internal Document

SEQT	Safety Environment Quality and Training
SFAIRP	So Far As Is Reasonably Practicable
SiD	Safety in Design

1.4. References

References which support implementation of this document

Table 1.1 References

Reference No.	Title

2. Supporting Documentation[2]

3. Compliance[3]

This EDI complies with the latest revision of higher- level Western Power technical documentation such as Network Standards and Functional Specification.

This Engineering Design Instruction should encompass all requirements of the relevant Australian Standards which are current at the time of issue. These relevant Australian Standards are listed in Table 3.1 below. A period will be set when the standard needs to be reviewed. If significant changes occur on an Australian Standard which affects safety, then an out of cycle review can be completed.

Table 3.1: Standards and Guidelines

Standard Number	Document Title
AS/NZS 2890.1	Parking facilities – Off-street car parking
AS 2890.2	Parking facilities – Off-street commercial vehicle facilities
AS 5100	Bridge Design (Set)
AS/NZS 3500.3	Plumbing and Drainage- Stormwater drainage
AS 1742	Manual of Uniform Traffic Control Devices
AS1743	Road Signs - Specifications
AS 3798	Guideline on earthworks for commercial and residential developments
AS 2150	Hot mix asphalt- A guide to good practice
	Australian Rainfall and Runoff (AR&R) - A Guide to Flood Estimation

[2] See Western Power Internal Document
[3] See Western Power Internal Document

Standard Number	Document Title
	Austroads - Guide to Road Design Part 1: Introduction to Road Design
	Austroads - Guide to Pavement Technology Part 2: Pavement Structural Design
	Austroads - Guide to Road Design Part 3: Geometric Design
	Austroads - Guide to Road Design Part 5 Drainage (set)
	Main Roads WA Guide to Road Design - MRWA Supplement to Austroads Guide to Road Design
	Environmental Protection Act 1986 - Environmental Protection (Unauthorised Discharges) Regulations 2004
	National Construction Code

4. Functional Requirements

This Engineering Design Instruction is intended to be used by Substation Engineering staff and by companies completing outsourced design work for Western Power, as it outlines the Western Power requirements pertaining to design of earthworks, roads and drainage for transmission substations.

5. Safety in Design[4]

The Safety in Design (SiD) process shall be adhered to when designing earthworks, roads and drainage. Any potential risks that may cause harm, affect the operation and maintenance of assets, or impact the environment or construction activities shall be identified during design stages.

All projects are required to have a SiD Hazard Management Register (HMR) and these risks shall be registered in the HMR and eliminated or minimised so far as is reasonably practicable (SFAIRP).

6. Overview of the Design Elements

This EDI provides guidance on the design of the substation Earthworks, Roads and Drainage based on the criteria provided in Sections 8, 9 and 10, considering the environmental requirements outlined in Section 7.

7. Environmental Consideration[5]

Environmental issues associated with earthworks, roads and drainage design shall be identified and assessed throughout the design processes. Project-specific environmental assessment provides information about the condition of the existing environment, the proposed project area, the associated environmental impacts of the proposal and the identification of any opportunities for environmental management and reduction of adverse environmental impacts.

Special consideration related to drainage and road run-off (via stormwater, site water run-off, rainfall and spills) shall be made, as the contaminant material in run-off and drainage from substations have the potential to adversely affect the water quality of receiving water bodies.

[4] See Western Power Internal Document
[5] See Western Power Internal Document

8. Earthworks Design

8.1. Scope

This section provides instructions on the design of Western Power zone substation and terminal yard earthworks. The earthworks design shall provide a safe, accessible, dry and maintenance-free site considering the following:

- Setting a finished earthwork level
- Grading of the site
- Design optimization
- Geotechnical and environmental requirements

8.2. Required information

8.2.1. Site Inspection

The designer should conduct a site inspection before design to gather information from the site and any site-specific issues that might affect the design.

This will help the designer prepare appropriate scopes for collecting survey and geotechnical data depending on the site inspection findings.

8.2.2. Survey Information

A survey of the site is required to identify existing topography and features. The survey should include ground elevations as well as features including, but not limited to:

- Existing roads, access tracks, railroads
- Top and bottom of topographic features such as depressions, bunds, open channels
- Overhead utilities and pits for underground utilities
- Other features, such as trees, fences, retaining walls and buildings

The extent of the survey should include the immediate site for the substation and include a minimum of 20m into adjacent properties where possible to allow an understanding of the interface with surrounding properties. Access permission shall be sought before surveying.

8.2.3. Geotechnical Information

A comprehensive geotechnical investigation report is required before earthworks design. The following information is provided in the geotechnical report, which may impact the earthworks design:

- Interpretation of surface and groundwater condition
- Geotechnical design parameters and advice on earthworks design and site preparation
- Possible environmental issues and contamination

8.3. Site Elevation

The elevation of the site shall be determined, allowing for the ultimate substation development, and shall meet the most onerous of following requirements:

8.3.1. Protection from flooding

Site elevation shall be such that the finished site level is a minimum of 600mm above 1% AEP flood level; studies should be undertaken to predict this level. This information may be found in the geotechnical investigation report.

8.3.2. Groundwater table

The substation finished site level shall be a minimum of 300mm above the groundwater table to minimise the potential impact of groundwater on drainage and earthworks design, substation maintenance and operation.

In cases where the substation finished site level is at or below the groundwater table, the impact of groundwater shall be considered in the design and construction. These include, but are not limited to, the following:

- Perform construction during the dry season or design an appropriate dewatering system
- Design a proper groundwater drainage system
- Any discharge to stormwater must be per “Environment Protection Act 1986- Environment Protection (Unauthorised Discharges) Regulations 2004” and comply with local government authorities' requirements
- In situations where the quality of the groundwater does not meet the discharge requirements, alternative options shall be investigated and implemented like the following:
  - Collection and treatment onsite
  - Collection via tanker for off-site management

8.3.3. Tie-In with Existing Roads

If the site requires a connection with existing roads, the allowable grade requirements to match in with existing road levels shall be considered. This constraint may impact the selection of the site elevation.

Main road or local Government authority requirements shall be considered when designing the crossovers and intersections. More information about the road design criteria is provided in Section 9 of this document.

8.3.4. Adjacent Property Level Constraints[6]

Land and property levels adjacent to the site may vary from the site design level; therefore, the most cost-effective solution, which may include retaining walls or setting an elevation that more closely matches the surrounding land, should be considered.

The fence location is preferred to be a minimum of 2.0m from the property boundary, and this should be considered in earthwork design. Refer to Engineering Design Instruction- Transmission Substation Fences and Gates for more information about the fence location.

8.4. Grading of the Site

Grading of the site depends on the site topography, drainage design, economics and construction feasibility. The following options could be considered in site grading:

[6] See Western Power Internal Document

- Flat
- Sloped
- Stepped

A flat site is preferred unless there are constraints on adjacent property levels, existing topography, volume of the earthworks, and drainage design. A flat site allows all structure foundations to be at the same level, which is an advantage from an operational point of view.

The site may need to be designed in continuous slope or even stepped if there are constraints such as rocky ground profile, differences in the existing ground level adjacent to the site, and drainage requirements. A slopped site introduces extra design considerations, coordination with electrical design, and operational and maintenance requirements.

It is recommended to have a mono slope perpendicular to the main busbar/s with a minimum of 0.5% to a maximum of 2.5% if required.

8.5. Optimisation in Earthworks Design

The designer shall calculate the earthworks volume and provide options analysis with different site elevations and grades based on the project design requirements to establish the most optimised and cost-effective earthworks design. When the design is done by external companies, the proposed site elevation and grade, including the optimisation study, must be provided for Western Power Substation Design review before detailed design. The following should be considered in optimising the earthworks design:

- Balance of cut and fill

  The volume of cut and fill shall be considered in the earthworks design. Where there are no constraints on setting site level, the most cost-effective is to design based on the balance of cut and fill material, and the elevation is the result of this balance.

  Where possible, material from the cut or other excavations shall be re-used for filling. Recommendations of re-using the cut material or any necessary actions like mixing with clean fill before re-using shall be investigated during the geotechnical investigation.

- Fill material

  Fill material might be required to:

  a. Improve the site drainage for flat sites

  b. Replace unsuitable topsoil or material. Topsoil removal and site clearing shall be considered in calculating the earthworks volumes. Recommendations for removing topsoil are provided in the geotechnical investigation report.

  In such cases, borrow pits and water resources shall be investigated and located. If those are located far from the site, then the earthworks design shall be re-evaluated with consideration of site grading to reduce the fill cartage cost.

8.6. Design Parameters

The substation bench inside the security fence, except the substation roadways, shall be trafficable for maintenance vehicles up to 9 tonnes of axle loading in all weather conditions.

8.7. Environmental consideration[7]

Hygiene should be considered when bringing in fill or spoiling/stockpiling cut material. The main factors of concern are the introduction or spread of weed species and dieback.

Before the clearing of remnant vegetation, appropriate biological studies need to be undertaken to determine that impacts are not significant, such as the clearing of Declared Rare Flora that are protected under the Wildlife Conservation Act (1950) at a state level or under the EPBC Act (1999) at a national level.

Consultation should be undertaken with the Department of Environment and Conservation or the Department of Environment, Water and Heritage at a national level where impacts are considered significant.

Sensitive environmental areas must be identified before design to allow for alterations, thus minimising the clearing of significant vegetation. The design should limit the extent of clearing to the design footprint with a buffer for constructability.

In areas where remnant vegetation is removed, consideration should be given to removing and stocking topsoil for use in revegetation works when considered appropriate. This is only suitable in areas with low a level of weeds.

8.8. Aggregate cover in switchyards[8]

Switchyard shall be surfaced with a minimum 100 mm thick 20mm single-size aggregate, subject to project earthing design requirement. For the aggregate specification requirements, refer to Technical Specification-Earthworks, Roads and Drainage.

8.9. Design Deliverables[9]

There are software tools available to assist in the design of earthworks. They all require digital topographic information to establish a digital terrain model (DTM), which can be compared to a design surface. A comparison can be made, and the difference between the DTM and the design surface provides earthworks quantities of cut and fill. Autodesk Civil 3D is the preferred Western Power software for earthworks design.

Earthworks drawings shall provide, but not limited to, the following information:

- Site location
- Cadastral boundary
- Extent of earthworks
- Existing and proposed easements
- Existing contours of the site and adjacent surveyed area
- Design contours
- Feature survey
- Hatched areas of cut and fill
- Cross-sections of the site showing existing ground and finished surface level

The digital files shall be provided if external companies carry out the design.

[7] See Western Power Internal Document
[8] See Western Power Internal Document
[9] See Western Power Internal Document

The designer shall prepare a Scope of Works for construction. Refer to WP document for Template Scope of Work.

9. Road Design

9.1. Scope

This section guides designers in designing a site access road and substation roadway inside the substation. An access road, substation roadway, and intersections shall:

- Provide access for heavy vehicles, including construction vehicles, cranes and low loader trailers to transport 132 kV, 330 kV transformers and RRST units where applicable under all-weather conditions
- Provide safe electrical clearances from live equipment
- Allow sufficient clearance to switch room/relay room building to accommodate large transportable vehicles and crane access for delivery and unloading the equipment
- Cater for the ultimate substation development

This Design Instruction is intended to give guidelines mainly related to road geometric design required for heavy vehicle access to and from a substation.

Access road and substation roadway shall be individually designed per current road design principles, including Austroads design guides and Main Roads WA supplement to Austroads guides, and modified where applicable, per this Design Instruction.

9.2. General Requirements

- Transformer and access roads from a public road, including the intersections or crossovers, shall be designed per this Design Instruction and comply with all local Government and statutory authority requirements, including Main Roads WA and Austroads design guides.
- All roads leading into the substation shall provide ready access during all weather conditions, allow for efficient transformer replacement, and provide emergency access to the yard or substation buildings.
- The designer shall consider turning circles, slopes, changes in the grade, and maximum grade in the road design.
- Transformer roadway shall have a minimum width of 6.0m, and other substation roadway to have a minimum width of 4.5m (one-way traffic)
- The transformer and substation roadway inside the substation shall be constructed using sealed flexible pavement with a minimum of 40mm thick Hot-Mix asphalt surfacing. All internal roads shall have flush concrete kerbs.

The designer shall verify the availability of hot-mix asphalt, especially for remote projects. In cases where hot-mix asphalt is not viable, a two-coat seal shall be used for road surfacing.

9.3. Design Criteria

9.3.1. Roadway Design Load

9.3.1.1. Transport of Heavy loads

The largest and/or heaviest vehicles that will use a substation access road are prime movers towing large flatbed trailers used to transport transformers and prime movers towing RRST units.

This EDI covers guidelines for designing the access roads and substation roadway and intersection to accommodate the vehicles and trailers required for the transport of:

- 330 kV transformers weighing approximately 200 ton
- 132 kV transformers weighing approximately 60 ton
- Western Power's mobile RRST Units, as below in Table 9.1.

Table 9.1: Details of Western Power's RRST Units

Unit name	Weight (ton) Including trailer	Length (m) excluding prime mover
T71 (wheel/suspension units and gooseneck has been removed for towing)	56	15
T81	94	20
T72 and T82	76	15

Heavy transformer loads are normally transported on multi-axle flatbed trailers towed by one or two prime movers. Trailers can be custom assembled from modules making up numerous configurations to suit the size and weight of the load to be transported. However, the allowable wheel load may be substantially reduced when the proposed heavy vehicle route involves bridges or other special restrictions. Therefore, the trailer configuration required to carry a particular load not only depends upon its weight but also on the route taken by the load to reach its destination.

Representative turning templates have been developed for prime mover/trailer combinations required to transport the 330 kV and 132 kV transformers and for the T71 unit (representative of all four RRST Units) (Refer to Figures 7, 8 & 9 in Appendix A:).

The trailer configurations adopted to derive the turning templates for the trailers required to transport the transformers and for the RRST Units are shown in Table 9.2. The designer should know that the provided trailer configuration should be used as a guide only, and the detailed design shall be based on specific project requirements.

9.3.1.2. Transformer installation loads

Transformer weight and installation method shall be considered in transformer roadway design. Transformers may be installed by either skating or mobile crane methods, depending on the substation layout, site constraints and transformer specifications. Road pavements for the transformer roadway shall be designed to take highly concentrated loads associated with mobile crane installation or skating. An appropriate method of transformer installation shall be established during the road design.

Road pavements shall be designed for the expected number of equivalent standard axles (E.S.A.), up to a maximum of $3x10^5$.

9.3.2. Horizontal Alignment

The horizontal alignment of the access road and substation roadway might consist of a series of straights and circular curves, which shall be designed per design principles and standards considering the following design criteria:

9.3.2.1. Design Speed

The access road recommended design speed is 20 km/hr; however, this should be a case-based assessment. Substation roadways inside the substation shall be designed for a speed of 10 km/hr.

9.3.2.2. Intersections[10]

The access road intersections with public roads would either be under the jurisdiction of Main Roads WA or of the Local Government Authority. Design approval shall be sought from the relevant authority.

As it would likely be known from which direction the heavy load would approach (and leave) the intersection, it should only be necessary to provide for the heavy load turning movement from the approach side. Turning in and out of the intersection from the other side need only be designed for a lesser vehicle.

It is preferred that the access road intersection with the main road be at 90 degrees; however, if this cannot be achieved, the intersection angle must not be less than 70 degrees unless a specific decision is made to adopt a lesser angle and approved by Substation Design and relevant authority. Where the intersection angle is other than perpendicular, the heavy load vehicle should, wherever possible, approach the intersection from the obtuse angle side so that the vehicle need only turn through an angle of less than 90 degrees.

Typical suggested intersection curve details have been developed to enable the movement through an intersection for each or a combination of:

- 330 kV transformer
- 132 kV transformer
- RRST Units
- 19m long semi-trailer
- Single unit (SU) vehicle

These are given in Figures 2 to 6 in Appendix A:.

The following trailer configurations have been adopted to derive the turning templates for the trailers required to transport the transformers and RRST units as a guide:

Table 9.2: Trailer Configuration

Transformer	Trailer
330 kV transformer	NICOLA 18 Row 2 File trailer
132 kV transformer	Drake 6 Row 2 File trailer
RRST Units	The actual trailer Unit

[10] See Western Power Internal Document

The suggested intersection design details should be adequate for the transformers and RRST movement and access. However, the designer should determine the actual trailer configuration for each instance to verify the suggested intersection design with the transformer supplier and/or transport contractor.

The designer shall review and satisfy all Authorities about associated street works, connections to utilities, footpath crossings, parking facilities and general town planning matters. Requirements for parking facilities as per AS/NZS 2890.1 Parking facilities – Off-street car parking shall be met.

The designer shall ensure that the substation gate can accommodate the heavy load delivery. Refer to Engineering Design Instruction-Transmission Substation Fences and Gates.

9.3.2.3. Road Crossfall and Superelevation

Crossfall shall be considered for draining purposes and to provide superelevation on horizontal curves. Typical crossfall for asphalt pavement is between 2.5% to 3%. Crossfall can be zero for the roads which have a longitudinal fall. The maximum superelevation shall be 5%.

9.3.3. Vertical Alignment

The longitudinal profile of an access road and substation roadway may consist of a series of grades and vertical curves. Considering the following design criteria, it shall be designed per current design principles and standards:

9.3.3.1. Vertical Clearances

The designer shall check the vertical clearance for objects over the roadways and seek the relevant authority consultation and approval to ensure their requirements are met; special attention is to be made to the HV overhead line, which could be the most likely clearance issue for the substation access road.

9.3.3.2. Existing Underground Services

An underground services survey shall be carried out before road design to identify and locate underground services to ensure minimum required clearances are met. Consultation and approval shall be sought from relevant authorities. Services commonly looked at are gas mains, water mains, telecommunication cables and HV electrical cables.

9.3.3.3. Flood level and Water Table

To prevent losing the strength of subgrade and pavements when saturated with water and keep those dry, top of subgrade level shall be a minimum of 300mm above 1% AEP flood level.

Top of subgrade level shall be above groundwater table level.

Subsoil or cut-off drain may be needed in the slope area to keep the subgrade above the hydraulic grade line of any source of groundwater.

9.3.3.4. Grade

The maximum longitudinal grade for substation access roads and substation roadways shall not be more than 6% unless otherwise approved by Western Power Substation Design.

The change in slope shall be no more than 460mm from a 20m straight edge to allow for adequate low loader clearance.

9.4. Signs and Road Markings

Signs, road markings, speed signs, and road furniture shall be designed per AS 1743 and AS 2890.2, and drawings shall be provided accordingly.

9.5. Design Deliverables[11]

Drawings for roadways shall have information including, but not limited to:

- horizontal alignments with all required set-out dimensions for straights and curves with turning circle radius and coordinates
- longitudinal profile of the road, including chainage, RL to AHD of existing surface and finish level vertical curves and superelevation
- Road cross sections including kerbing, shoulder, drainage and batters
- sufficient cross sections to determine cut and fill quantities
- Pavement details
- Roads markings and signs
- All drainage requirements adjacent to or under the roads, including invert levels

A Scope of Works for construction shall be prepared by the designer. Refer to the WP document for Template Scope of Works.

10. Drainage Design

10.1. Scope

The purpose of this section is to guide drainage designers in designing an efficient and effective drainage system.

The drainage system shall collect and discharge surface and subsoil water, which might compromise the functionality of foundations, roads, buildings, slopes and retaining walls.

10.2. General Requirements[12]

The stormwater drainage system shall be designed per "Australian Rainfall and Runoff-A Guide to Flood Estimation" and AS 3500.3 Stormwater design requirements and guidelines provided by the Local Government Authority, Main Roads Western Australia, Department of Environment and Conservation or any other statutory or governing body.

A separate drainage system shall be designed to drain oil and oil-contaminated water to the appropriate containment system. The design of drainage for the oil containment system shall comply with the applicable requirements stated in the Engineering Design instruction- Oil Containment and Fire Protection.

Water ponding or standing water within the site shall be prevented by designing an appropriate drainage system.

[11] See Western Power Internal Document
[12] See Western Power Internal Document

Subsurface drains shall be designed where earthworks intersect impermeable water-bearing strata. In cases where a roadway's performance may be affected by groundwater, subsoil drains shall be designed parallel to the roadway to intercept groundwater.

Subsoil drains may also be required to mitigate the effects of groundwater on foundations, retaining walls, switchyard and drainage structures.

Cable trenches shall drain into the switchyard stormwater drainage system. Where a cable trench impedes surface or groundwater flows, drains shall be constructed adjacent to the cable trench to capture the water. Where a subsoil drain is constructed, the cable trench may incorporate drainage weep-holes to the subsoil drain to assist in removing the water from the cable trenches.

Substation building roof drainage shall be designed as per Engineering Design Instruction- Substation Buildings.

In brownfield projects, introducing additional flow to the existing drainage system shall be done after assessing the existing drainage capacity to ensure the functionality of the existing drainage system is not affected.

10.3. Required information

Site inspection would help designers identify the existing drainage system and any risks that might affect the drainage design, such as:

- Site adjacent to, or proposed over existing water courses or open channels
- Site within an area known for flooding
- Located within or adjacent to topographic low
- Site being within the path of sheet flow

In addition to the feature and topographic survey required for the earthworks design, all existing drainage features within and surrounding the site should be collected during the feature survey. These may include:

- Top and bottom of existing open drains and levees/bunds
- Inverts, obverts, and end treatments of existing culverts/pipes, including a profile of existing ground above culvert/pipe
- Existing culverts, bridges or open channels that convey flows that intersect or are directly adjacent to the site

The extent of the survey should include the immediate site for the substation and include 20m into adjacent properties to allow an understanding of the interface with surrounding properties. Permission from the adjacent landowner shall be sought before entering.

A comprehensive geotechnical investigation report, as discussed in Earthworks design section 8.2.3, is required for drainage design, which interprets ground and groundwater conditions and advises for drainage design (i.e. infiltration for drainage basins, risk of erosion).

10.4. Drainage Strategy

A strategy for drainage management, both internal and external to the site, should be developed before implementing the detailed design.

The drainage strategy should be consistent with the Regional and Local Drainage Schemes as specified by the Local Government Authority and Water Corporation and should include, as a minimum:

- Management of flows internal to the site
- Management of flows external to the site
- Method of discharging flows from the site if permitted, considering quantity and quality

10.4.1. Flows Internal to the site

Management of flows internal to the site could include either:

- Allowing flows to remain on the surface with conveyance via open channels
- Conveying flows through a closed pit and pipe system
- Conveying through subsoil drain

Management of flows on the surface through open channels and drains is a more cost-effective option and can generally be adopted when land availability is not constrained. Using pit and pipe systems requires less space but pushes the infrastructure's invert below the finished level, which could pose problems at the downstream end when discharging flows from the site.

Subsoil drains should not be used to capture surface runoff when other drainage methods are practical.

10.4.2. Flows external to the site

If there is runoff from outside the site, overland flows, open drains, waterways or floodplains adjacent to the site, a strategy for managing both their impact on the site and the site's impact on external flows needs to be considered.

Management of flows external to the site could include:

- Intercepting and diverting flows around the substation site
- Conveying flows through the site by an open channel or piped system with an easement
- Ensuring the placement of the site does not increase the flood level within a floodplain

Approval to modify the existing flows shall be sought through the Department of Water, Water Corporation or the Local Government Authority, depending on the authority responsible for the flow. The authority may guide the requirements for modifying the flow path.

10.4.3. Flows Discharging from the Site

Flows discharging from the site should be managed so that the quantity and quality do not adversely impact the environment to which the flows are discharging. This includes consideration of:

- The requirements of the Local Authority's Local Drainage Scheme or Water Corporations Regional Drainage Scheme
- The capacity of the receiving system to manage the peak flow estimated from the site for the chosen design storm
- The velocity of the flows leaving the site and their erosive impact on the receiving environment.
- The quality of runoff leaving the site and the potential for the runoff to contain pollutants collected within the site

Management options may include introducing a storage basin that will compensate for the peak flow from the site to an acceptable flow rate that the receiving system can manage (upon advice from the governing authority). Guidance on the design of compensating basins is provided in AR&R.

Provisions should always be made to allow safe escape from drainage basins during wet weather, i.e. when the banks are wet and slippery. Clear warning signs should be displayed prominently, and consideration should also be given to the placement of depth indicators. Fencing may be required to protect the public from drainage infrastructure.

Ideally, the velocity of flows discharging from the site should be consistent with existing velocities into the receiving system. Achieving acceptable velocity almost always requires some means of dissipating the flow energy, as flows are generally more concentrated in the developed situation than in the natural state. Energy dissipation and velocity reduction can be achieved in various ways and depend upon the application (i.e., whether applied at surface level, within an open channel or a basin). Where reducing velocities to their natural state is not feasible, velocities should be reduced to ensure no erosion occurs in the design event.

The pipe outlets and inlets shall use stone pitching, riprap, or head wall to dissipate flow energy and minimise soil erosion of embankments or the surrounding area.

Drainage flows, where possible, should be directed away from natural watercourses to minimise the chance of contamination should a significant spill occur. Where this is not feasible, the design should include a drainage basin to contain runoff, with the minimum volume equivalent to the 2-year ARI, 12-hour duration storm, plus the largest potential pollution spill from the site.

Any specific environmental requirements should be included in the design drawings and registered in HMR.

Vegetation can be used as an effective means of dissipating the energy of flows and minimising erosion in open channels within the site or discharging from the site.

10.5. Drainage Design Criteria

The following design criteria should be applied to designing drainage infrastructure within the site:

Table 10.1: Drainage Design Criteria

Design Element	Criteria
Major Storm	1% AEP
Freeboard to top of pit	150mm in Major Storm
Freeboard to top of road subgrade	300mm in Major Storm
Free board to top of the open channel	150mm in Major Storm

For the level of service or design criteria relating to flows external to the site, guidance should be sought from the relevant authority, which may include:

- Local Authority for local drains, piped systems, culverts
- Water Corporation for Main Drainage systems
- Department of Water for Rivers and Creeks
- Department of Environment and Conservation for wetlands

10.6. Design Deliverables[13]

Drainage drawings shall provide information including, but not limited to:

- Location of existing drainage infrastructure
- Location of proposed drainage infrastructure
- Reference to design calculations
- Details of drainage infrastructure like pipe and pit details, open channel cross-section, required fall, subsoil drain and culverts
- Invert level of all drainage infrastructure
- Any specific environmental requirements

The designer shall prepare a Scope of Works for construction. Refer to WP document for Template Scope of Works.

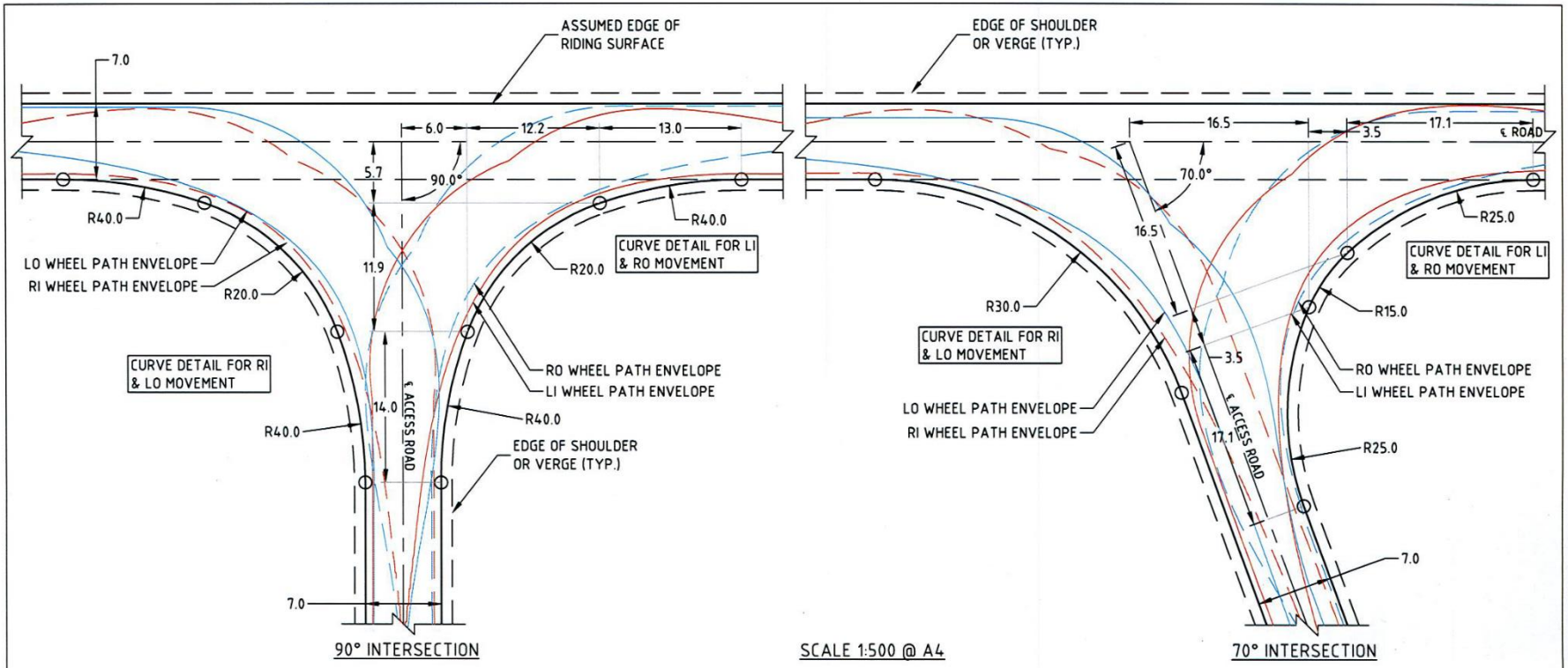
[13] See Western Power Internal Document

Appendix A: Curve Details and Turning Templates

A.1 Examples of Turning Circles

Typical suggested intersection curve details and turning template have been developed in the below Figures 2 to 11 to enable the movement through an intersection for each or a combination of a:

- 330 kV transformer
- 132 kV transformer
- RRST Units
- 19m long semi-trailer
- Single unit (SU) vehicle



PROCEDURE

1. DETERMINE THE HEAVY VEHICLE MOMEVENT(S) REQUIRED (USUALLY EITHER LI & RO OR RI & LO).
2. USE SUGGESTED INTERSECTION CURVE DETAILS AS SHOWN FOR THE APPROPRIATE MOVEMENTS.
3. FOR THE CURVE OPPOSITE SELECT THE CURVE DETAIL FOR THE CHOSEN DESIGN VEHICLE, EITHER A SINGLE UNIT (SU), SEMI-TRAILER OR OTHER AS REQUIRED.

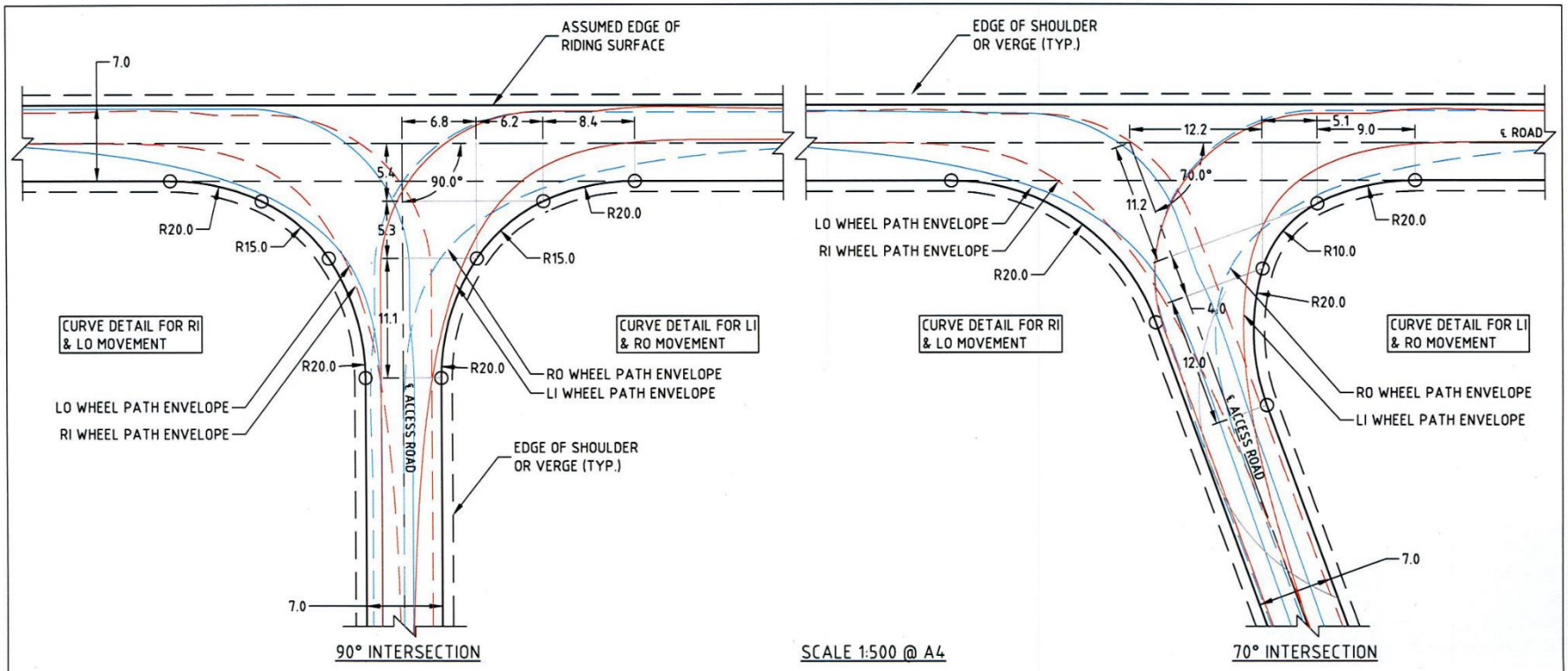
NOTES

1. FOR INTERSECTIONS OF ANGLES OTHER THAN 90° OR 70° DETERMINE CURVE DETAILS FROM APPROPRIATE TURNING TEMPLATES.
2. REFER TO MAIN ROADS WEB SITE FOR TURNING TEMPLATES FOR VEHICLES OTHER THAN THOSE PROVIDED HERE.
3. VEHICLE MOVEMENTS:

LI	LEFT IN	RI	RIGHT IN
RO	RIGHT OUT	LO	LEFT OUT

FIGURE 2 - SUGGESTED CURVE DETAILS FOR 330 Kv TRANSFORMER MOVEMENT

(BASED ON TURNING TEMPLATE, FIGURE 7)



PROCEDURE

1. DETERMINE THE HEAVY VEHICLE MOMEVENT(S) REQUIRED (USUALLY EITHER LI & RO OR RI & LO).
2. USE SUGGESTED INTERSECTION CURVE DETAILS AS SHOWN FOR THE APPROPRIATE MOVEMENTS.
3. FOR THE CURVE OPPOSITE SELECT THE CURVE DETAIL FOR THE CHOSEN DESIGN VEHICLE, EITHER A SINGLE UNIT (SU), SEMI-TRAILER OR OTHER AS REQUIRED.

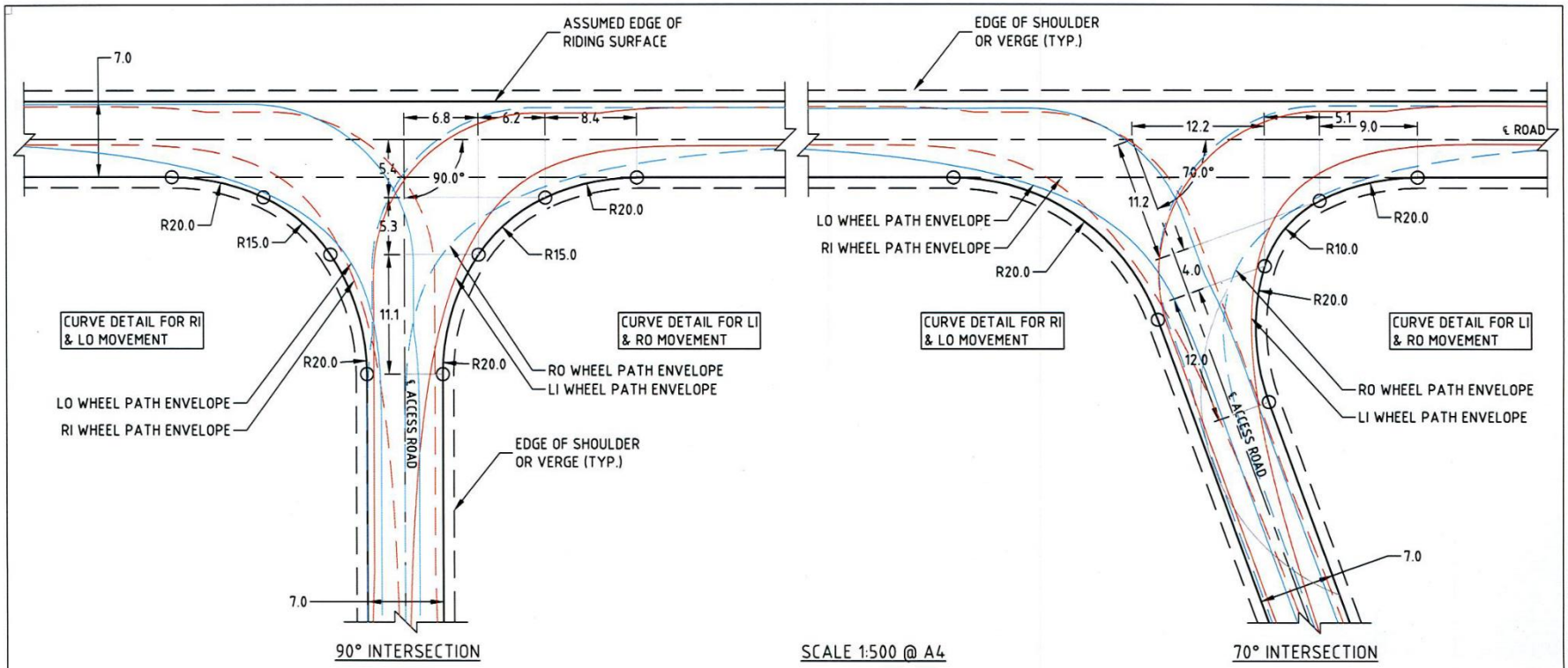
NOTES

1. FOR INTERSECTIONS OF ANGLES OTHER THAN 90° OR 70° DETERMINE CURVE DETAILS FROM APPROPRIATE TURNING TEMPLATES.
2. REFER TO MAIN ROADS WEB SITE FOR TURNING TEMPLATES FOR VEHICLES OTHER THAN THOSE PROVIDED HERE.
3. VEHICLE MOVEMENTS:

LI	LEFT IN	RI	RIGHT IN
RO	RIGHT OUT	LO	LEFT OUT

FIGURE 3 - SUGGESTED CURVE DETAILS FOR 132 Kv TRANSFORMER MOVEMENT

(BASED ON TURNING TEMPLATE, FIGURE 8)



PROCEDURE

1. DETERMINE THE HEAVY VEHICLE MOMEVENT(S) REQUIRED (USUALLY EITHER LI & RO OR RI & LO).
2. USE SUGGESTED INTERSECTION CURVE DETAILS AS SHOWN FOR THE APPROPRIATE MOVEMENTS.
3. FOR THE CURVE OPPOSITE SELECT THE CURVE DETAIL FOR THE CHOSEN DESIGN VEHICLE, EITHER A SINGLE UNIT (SU), SEMI-TRAILER OR OTHER AS REQUIRED.

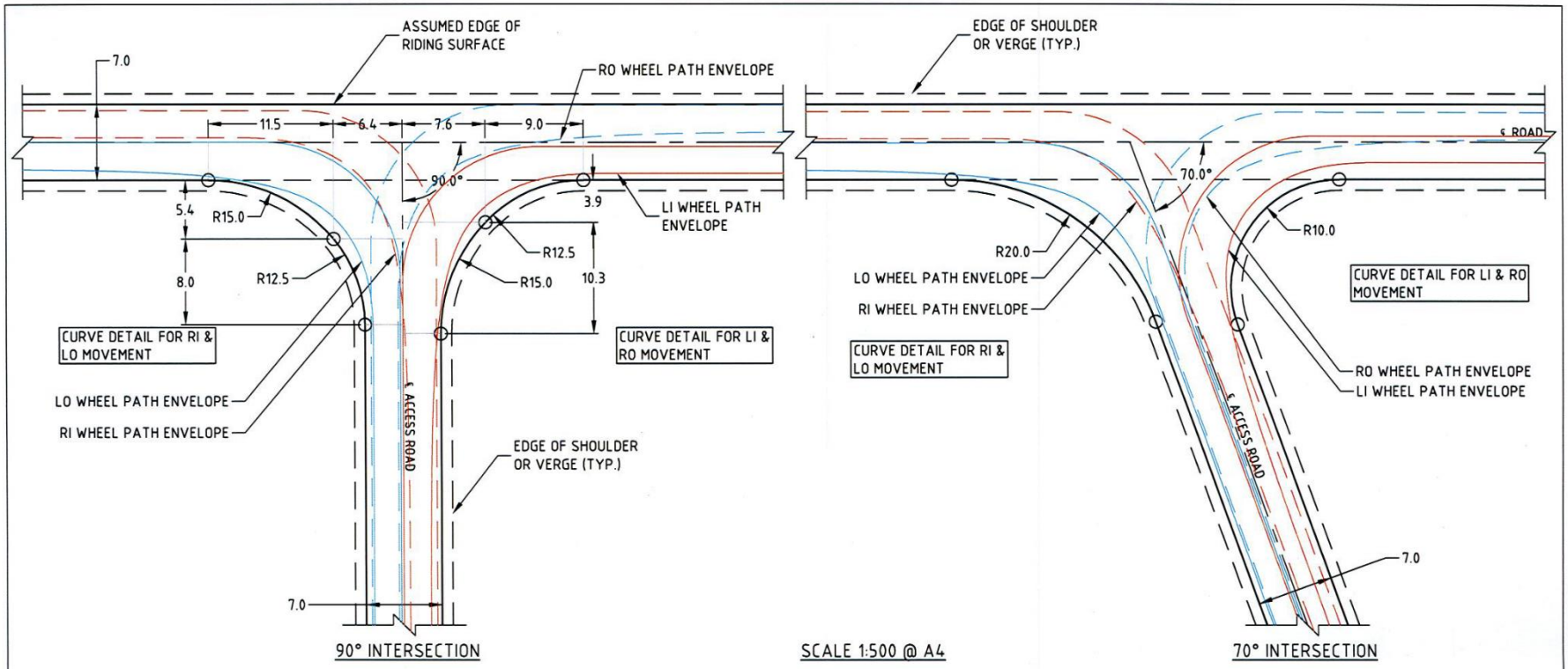
NOTES

1. FOR INTERSECTIONS OF ANGLES OTHER THAN 90° OR 70° DETERMINE CURVE DETAILS FROM APPROPRIATE TURNING TEMPLATES.
2. REFER TO MAIN ROADS WEB SITE FOR TURNING TEMPLATES FOR VEHICLES OTHER THAN THOSE PROVIDED HERE.
3. VEHICLE MOVEMENTS:

LI	LEFT IN	RI	RIGHT IN
RO	RIGHT OUT	LO	LEFT OUT

4. RRST T81 MAY HAVE SOME DIFFICULTY IN NEGOTIATING THESE INTERSECTIONS (IN HIGHWAY MODE).

FIGURE 4 - SUGGESTED CURVE DETAILS FOR RRST T71, T81, T72 & T82 TRANSFORMER MOVEMENT
(BASED ON TURNING TEMPLATE, FIGURE 9)



PROCEDURE

1. DETERMINE THE HEAVY VEHICLE MOMEVENT(S) REQUIRED (USUALLY EITHER LI & RO OR RI & LO).
2. USE SUGGESTED INTERSECTION CURVE DETAILS FOR THE APPROPRIATE MOVEMENTS.
3. FOR THE CURVE OPPOSITE SELECT THE CURVE DETAIL FOR THE CHOSEN DESIGN VEHICLE, EITHER A SINGLE UNIT (SU), SEMI-TRAILER OR OTHER AS REQUIRED.

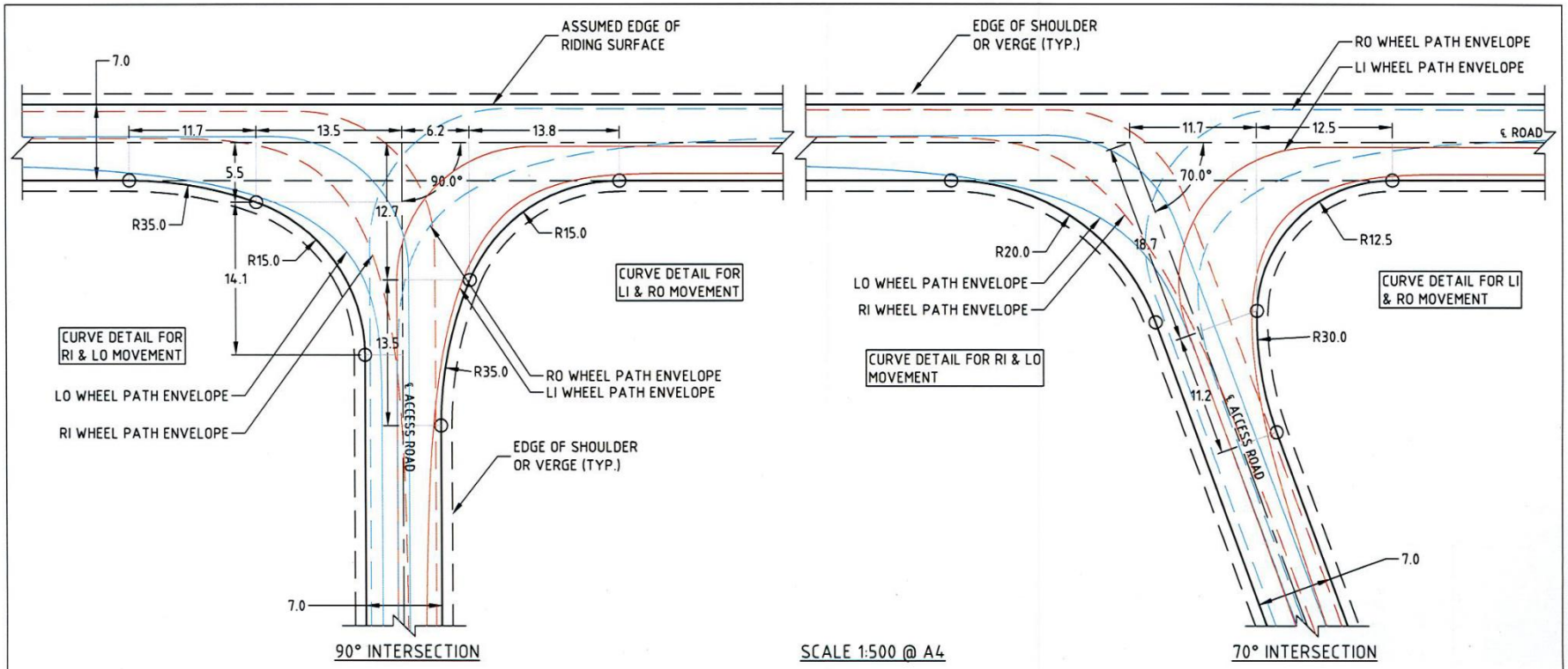
NOTES

1. FOR INTERSECTIONS OF ANGLES OTHER THAN 90° OR 70° DETERMINE CURVE DETAILS FROM APPROPRIATE TURNING TEMPLATES.
2. REFER TO MAIN ROADS WEB SITE FOR TURNING TEMPLATES FOR VEHICLES OTHER THAN THOSE PROVIDED HERE.
3. VEHICLE MOVEMENTS:

LI	LEFT IN	RI	RIGHT IN
RO	RIGHT OUT	LO	LEFT OUT

4. CURVES DETERMINED ALLOWING LANE ENCROACHMENT 1.0m OVER CENTRE LINE ON MAIN ROAD AND 1.5m ON SIDE ROAD.

FIGURE 5 - SUGGESTED CURVE DETAILS FOR SINGLE UNIT 12.5m LONG
(BASED ON TURNING TEMPLATE, FIGURE 10)



PROCEDURE

1. DETERMINE THE HEAVY VEHICLE MOMEVENT(S) REQUIRED (USUALLY EITHER LI & RO OR RI & LO).
2. USE SUGGESTED INTERSECTION CURVE DETAILS AS SHOWN FOR THE APPROPRIATE MOVEMENTS.
3. FOR THE CURVE OPPOSITE SELECT THE CURVE DETAIL FOR THE CHOSEN DESIGN VEHICLE, EITHER A SINGLE UNIT (SU), SEMI-TRAILER OR OTHER AS REQUIRED.

NOTES

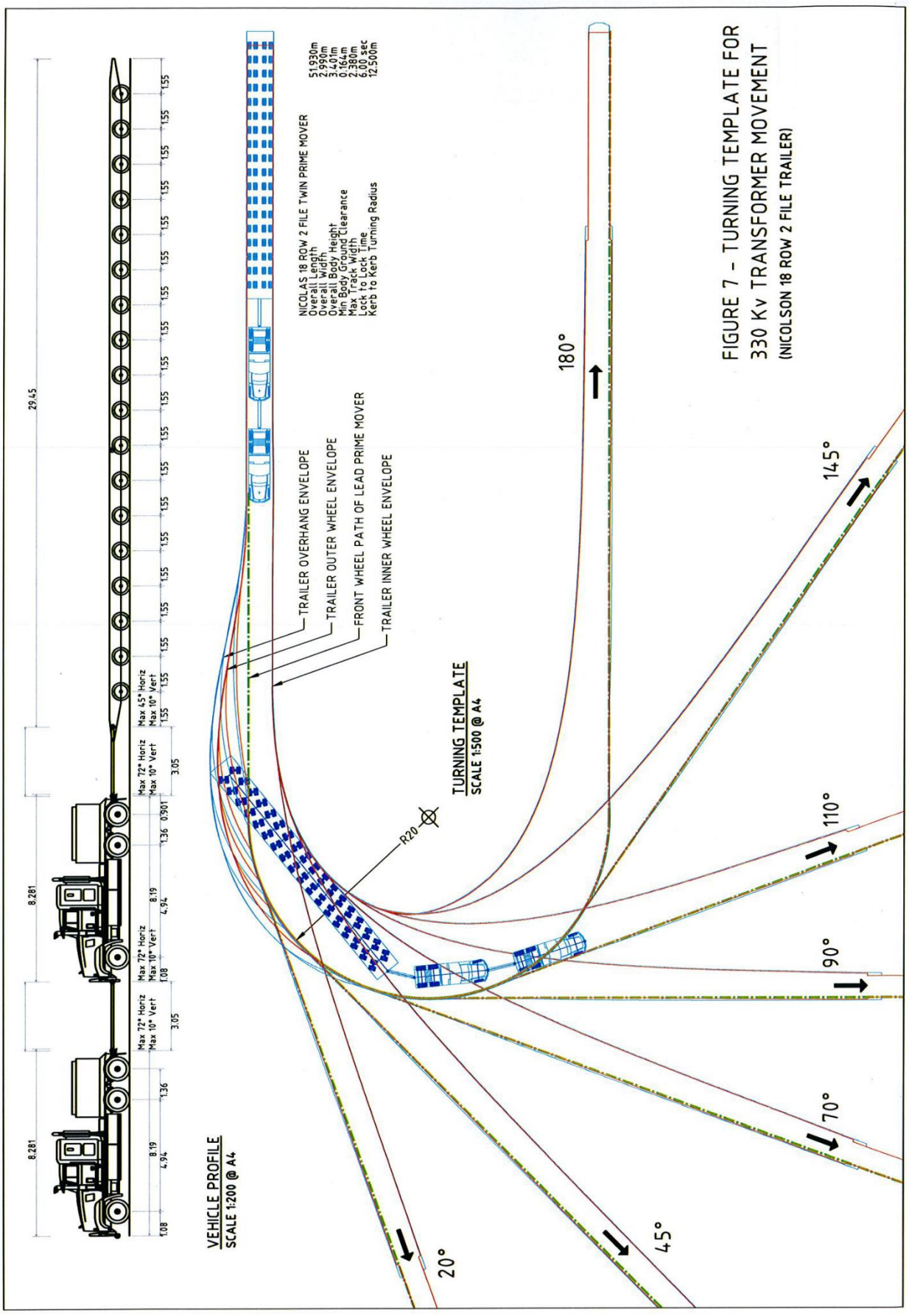
1. FOR INTERSECTIONS OF ANGLES OTHER THAN 90° OR 70° DETERMINE CURVE DETAILS FROM APPROPRIATE TURNING TEMPLATES.
2. REFER TO MAIN ROADS WEB SITE FOR TURNING TEMPLATES FOR VEHICLES OTHER THAN THOSE PROVIDED HERE.
3. VEHICLE MOVEMENTS:

LI	LEFT IN	RI	RIGHT IN
RO	RIGHT OUT	LO	LEFT OUT

4. CURVES DETERMINED ALLOWING LANE ENCROACHMENT 1.0m OVER CENTRE LINE ON MAIN ROAD AND 1.5m ON SIDE ROAD.

FIGURE 6 - SUGGESTED CURVE DETAILS FOR SEMI-TRAILER 19m LONG

(BASED ON TURNING TEMPLATE, FIGURE 11)



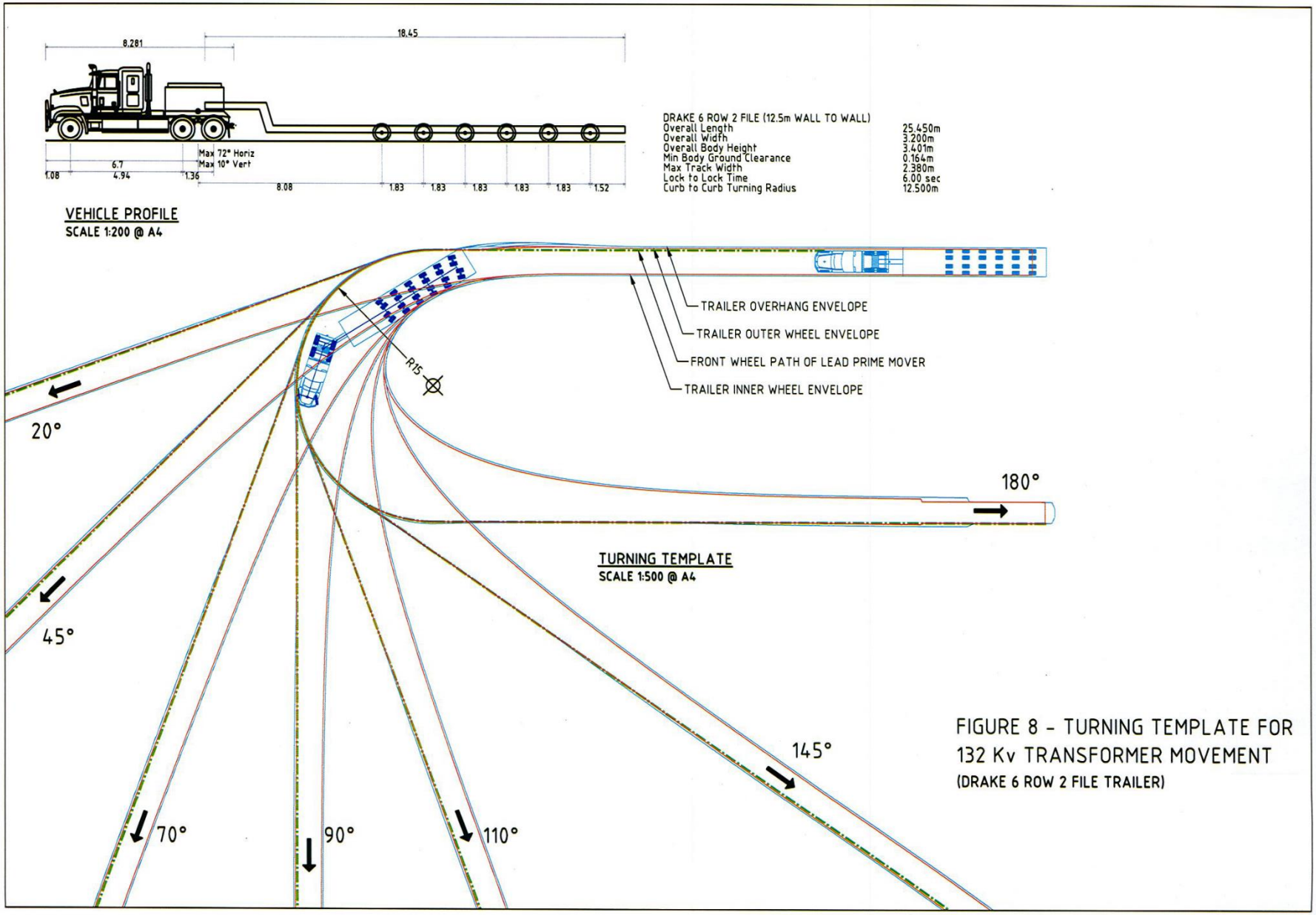


FIGURE 8 - TURNING TEMPLATE FOR 132 Kv TRANSFORMER MOVEMENT
(DRAKE 6 ROW 2 FILE TRAILER)

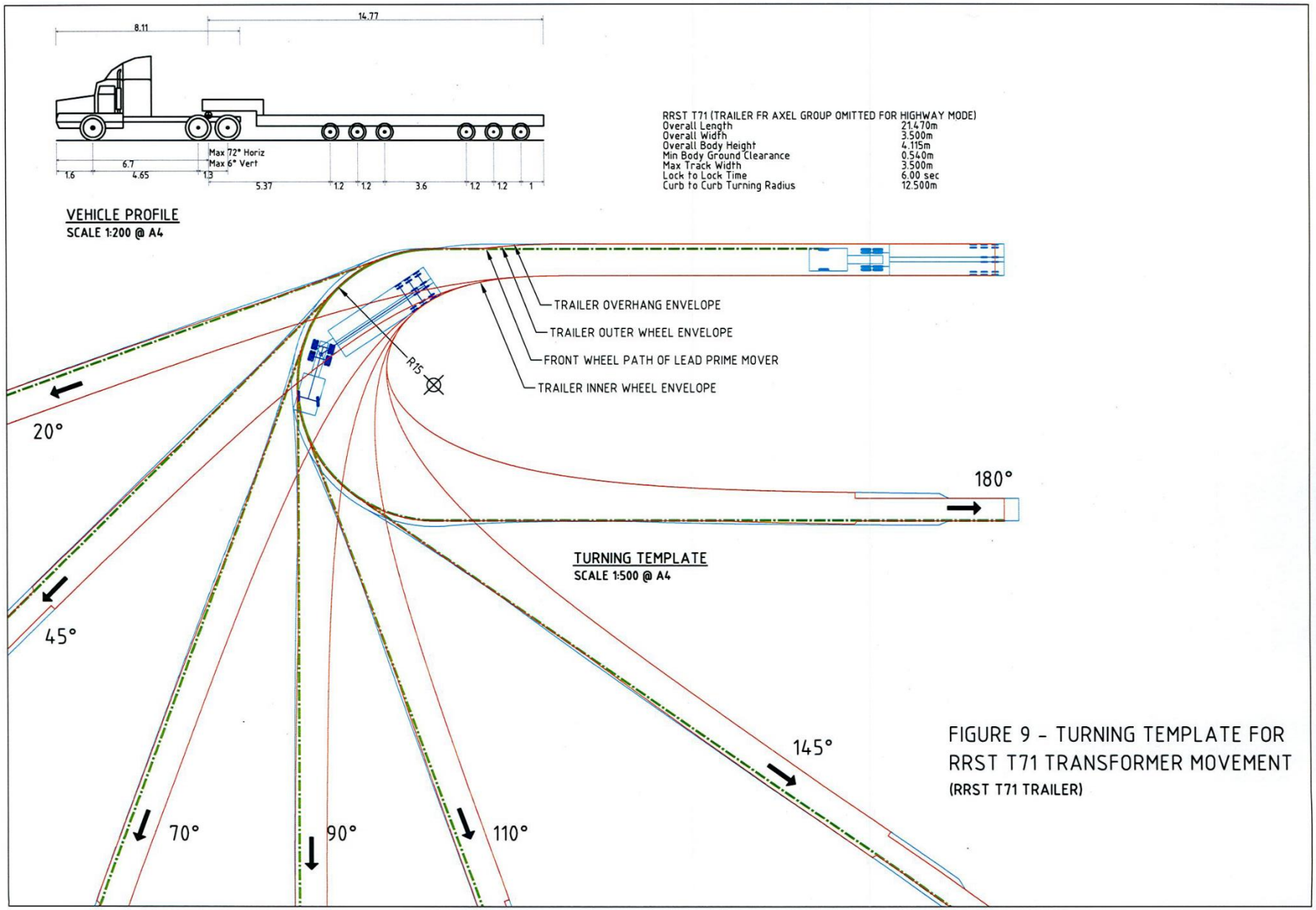


FIGURE 9 – TURNING TEMPLATE FOR RRST T71 TRANSFORMER MOVEMENT
(RRST T71 TRAILER)

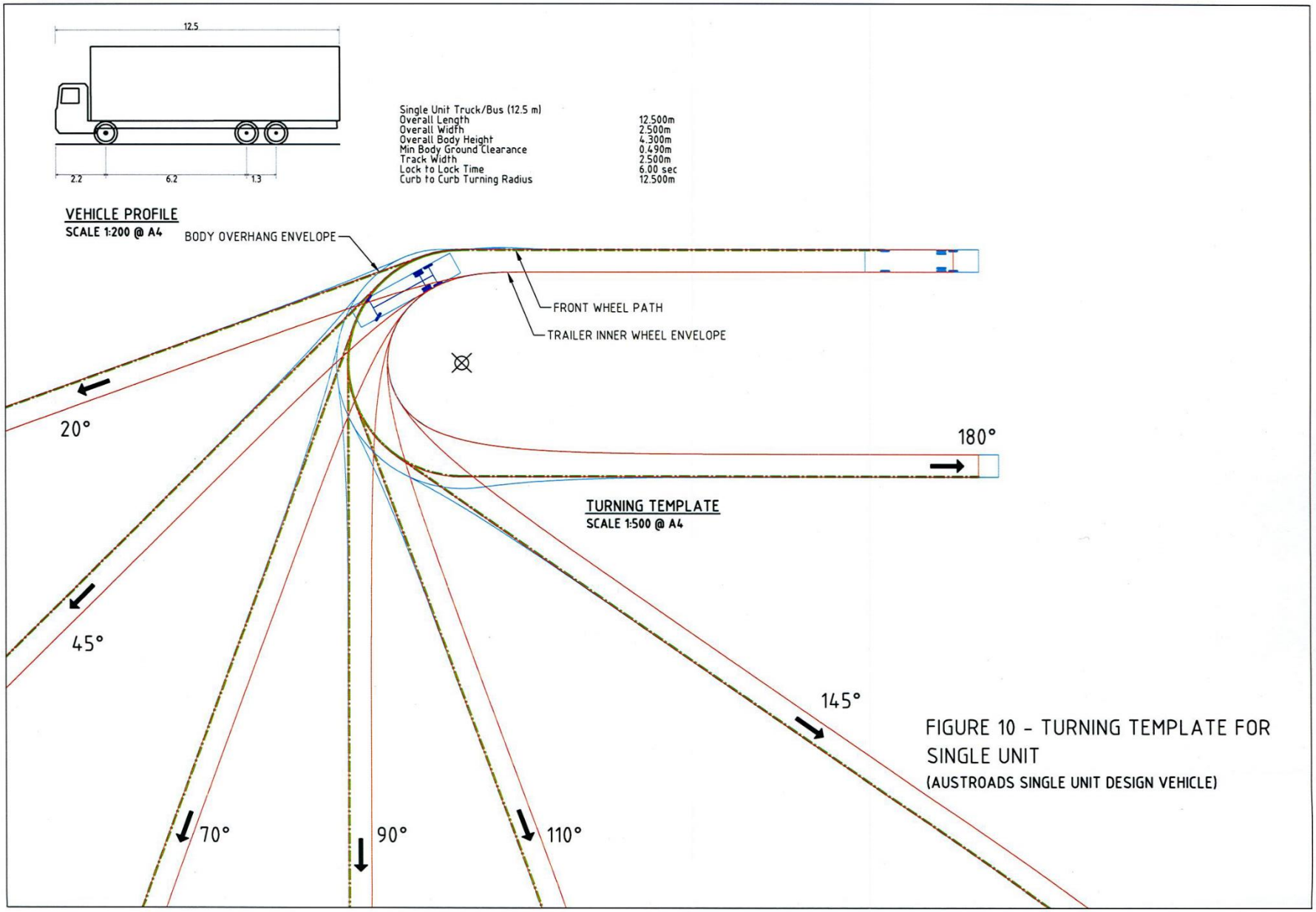


FIGURE 10 – TURNING TEMPLATE FOR SINGLE UNIT
(AUSTROADS SINGLE UNIT DESIGN VEHICLE)

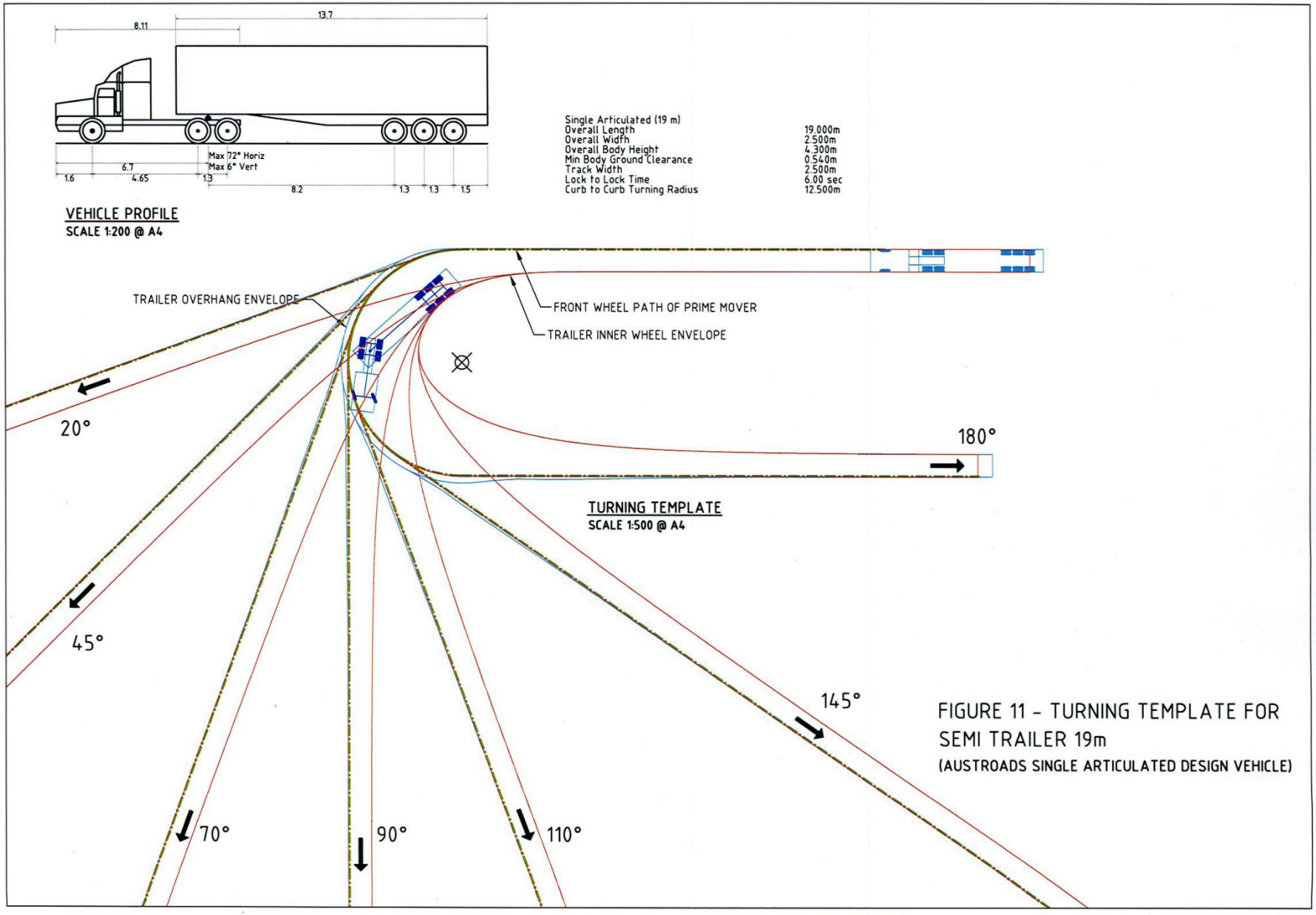


FIGURE 11 – TURNING TEMPLATE FOR SEMI TRAILER 19m
(AUSTROADS SINGLE ARTICULATED DESIGN VEHICLE)

Appendix B: Approval Record and Document Control[14]

[14] See Western Power Internal Document