



TS 05164:1.0

SPG 0705

Specification

Construction of Signalling Cable Routes

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Document history

Revision	Effective date	Summary of changes
1.17	08/02/2013	Published as SPG 0705 <i>Construction of Cable Routes and Signalling Civil Works</i> .
1.0	24/05/2024	Renumbered as TS 05164:1.0. Version number recommenced in line with new designation. Changes to previous content include conversion of the standard to AMB format and style, removal of requirements for signalling civil works, and inclusion of requirements related mainly to the design and construction of cable routes for the MRA signalled network.

Preface

This specification is a first issue as TS 05164:1.0 and supersedes SPG 0705 *Construction of Cable Routes and Signalling Civil Works*, version 1.17.

The previous version of this document included requirements for signalling civil works. These requirements have been removed from this version as civil engineering requirements have either been transferred to a relevant civil engineering standard or to TS 05165.

This version has been revised to include requirements related mainly to the design and construction of cable routes for the MRA signalled network.

The terms 'normative' and 'informative' are used in asset standards to define the application of the appendices to which they apply. A 'normative' appendix is an integral part of an asset standard, whereas an 'informative' appendix is only for information and guidance.

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1 Scope

This document sets out requirements for the design and construction of signals and communications cable routes, above and below ground, in the MRA signalled network.

This document includes requirements for the following:

- construction of cable routes
- construction of underline and under-road crossings
- removal of redundant material, equipment, and surplus spoil
- installation and testing of cables.

This document also includes requirements for the installation of air lines that carry compressed air to control signalling equipment and are run in the same route as cables. However, if compressed air is reticulated in a separate stand-alone pipe, then the construction requirements in TS 05171 apply.

This document does not cover requirements for the running of low voltage electrical services. The requirements in AS/NZS 3000 and TS 03954 generally apply to this work.

This document also does not cover requirements for the running of high voltage and dc traction cables, except for stated minimum clearances. The requirements in TS 03750 or TS 03752 apply to this work.

2 Application

This document applies to the construction of above and below ground services for signalling and control systems.

The document is intended for use by operators, maintainers, and TAOs.

The requirements in this document are intended to meet or exceed the requirements in AS/NZS 3000 and AS/CA S009, which set out the minimum requirements that apply to cabling and wiring systems.

If there is any conflict between this document and these standards, then the requirements in the standards take precedence. AMB should be notified of any conflict.

This document should be read in conjunction with TS 05165.

3 Referenced documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS 1074 *Steel tubes and tubulars for ordinary service*

AS 1345 *Identification of the contents of pipes, conduits and ducts*

AS 1379 *Specification and supply of concrete*

AS 2758.1 *Aggregates and rock for engineering, Part 1: Concrete aggregates*

AS 3972 *General purpose and blended cements*

AS 4750 *Electrogalvanized (zinc) coatings on ferrous hollow and open sections*

AS 5488.1 *Classification of subsurface utility information, Part 1: Subsurface utility information*

AS 61386.1 *Conduit systems for cable management*

AS/CA S009 *Installation requirements for customer cabling (Wiring rules)*

Note: AS/CA S009 is an Australian Standard that is published and maintained by Communication Alliance Limited.

AS/NZS 3000 *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

AS/NZS 3013 *Electrical installations – Classification of the fire and mechanical performance of wiring system elements*

Transport for NSW standards

TS 00008.1 *Fire Life Safety – Part 1: Principles*

TS 01455 *Configuration Management*

TS 01466 (T MU AM 06016 GU) *Guide to Verification and Validation*

TS 01547.1 (T MU MD 00006 ST) *Engineering Drawings and CAD Requirements*

TS 01608 (T HR CI 12110 ST) *Earthworks and Formation*

TS 01638 (T HR CI 12130 ST) *Track Drainage*

TS 01640 (T HR CI 12111 SP) *Earthwork Materials*

TS 01658 (T HR CI 12003 ST) *Civil Infrastructure Construction*

TS 01722 (ESC 340) *Tunnels*

TS 02388 (T HR CI 12160 ST) *Boundary Fences*

TS 02390 (T HR CI 12190 ST) *Service Installations within the Rail Corridor*

TS 02391 (T HR CI 12200 ST) *Access Roads*

TS 03500 (ESC 215) *Transit Space*

TS 03505 (SPC 207) *Track Monitoring Requirements for Undertrack Excavation*

TS 03609 (T HR TR 00192 ST) *Ballast*

TS 03750 (T HR EL 20003 ST) *Underground Installation Configurations for High Voltage and 1500 V DC Cables*

TS 03751 (T HR EL 20004 ST) *High Voltage AC and 1500 V DC Traction Power Supply Cable Infrastructure*

TS 03752 (T HR EL 20005 ST) *Above Ground Installation Configurations for High Voltage AC and 1500 V DC Cables*

TS 03947 (T MU MD 21001 ST) *Equipment Rooms and Cubicles for Programmable Electronic Systems*

TS 03954 (T HR SS 80002 ST) *Low Voltage Electrical Installations*

TS 05165 (SPG 0706) *Installation of Trackside Equipment*

TS 05166 (SPG 0707) *Installation of Equipment Racks and Termination of Cables and Wiring*

TS 05171 (SPG 0714) *Compressed Air Systems*

TS 05313 (SPG 0711.3) *Inspection and Testing Principles*

TS 05314 (SPG 0711.4) *Inspection and Testing Procedures*

TS 05316 (SPG 0711) *Inspection and Testing of Signalling – Standard Forms*

TS 06210 (T MU TE 01001 ST) *Campus Backbone Telecommunication Route and Cabling*

TS 06210:2021 *Campus Backbone Telecommunication Routes and Cabling*

TS 06212 (T MU TE 01005 ST) *Optical Fibre Cable*

TS 06213 (SPM 0123) *Reinforced Pre-Cast Concrete Cable Pits*

TS 10504 *AEO Guide to Engineering Management*

Transport for NSW drawings

112000/5/1 *Structure Gauge*

112000/5/2 *Preferred Cable Route Location*

112000/5/3 *Preferred Cable Route Location*

112000/5/4 *Buried Cable Route Types 1, 2, and 3*

112000/5/5 *Buried Cable Route Type 4*

112000/8/1 *GST/GLT Interface*

112000/8/2 *GST/Buried Route Interface*

112000/8/3 *GST to Pit Interface*

112000/14/3 *GST to Location Case – Typical Arrangement*

M07-100 *Ground Level Troughing*

M07-101 *Ground Level Troughing*

M07-114 *Steel Troughing*

M12 *Series Standard Installation Drawings*

Legislation

Work Health and Safety Act 2011 (NSW)

Other referenced documents

PR A 00450 (TMG 1310) *Locating of Underground Services*

This document is not publicly available. To obtain access email
standards@transport.nsw.gov.au

PR A 00498 *Detailed Site Survey (DSS) Survey and Drafting*

This document is not publicly available. To obtain access email
standards@transport.nsw.gov.au

PR D 78700 *Working Around Electrical Equipment*

This document is not publicly available. To obtain access email
standards@transport.nsw.gov.au

SMS-06-FM-4384 *Services Search Request*

This document is not publicly available. To obtain access email
standards@transport.nsw.gov.au

SMS-06-GD-3144 *Organisational Guide Excavation and Earth Works*

This document is not publicly available. To obtain access email
standards@transport.nsw.gov.au

4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document.

access road any track or roadway within the railway easement other than the defined entrance or exit roadway to a station, goods yard or compound or easement for access to property owned by others

ATP automatic train protection

backfill compactable material free of rocks that will not pass through a 50 mm sieve and free of broken concrete, brick, rubble, wood, glass, rubbish, steel or other metal objects that could damage cables or affect the operation of electronic cable locators

ballast material in accordance with TS 03609

BYDA Before You Dig Australia

cable route material installed, or excavation carried out for the installation of cables between two points

CAD computer-aided design

CCB configuration control board

CCTV closed-circuit television

clean fill sand (or soil) that is free of stones, rocks, wood, metal, and rubbish

cover strip the strip (or layer) of recycled plastic protective material placed over buried cables

DSS detailed site survey; surveys for the acquisition of field data for the preparation of plans, cross-sections, and long sections of underground and above ground services

EPR earth potential rise

FRP fibreglass reinforced plastic

GIS geographic information system

GLT ground level troughing

GPR ground penetrating radar

GRC glass reinforced concrete

GRP glass reinforced plastic

GST galvanised steel troughing

HDPE high density polyethylene

high voltage voltage exceeding 1000 V ac or 1500 V dc

ISS internal services search

ITP inspection and test plan

LLDPE linear low-density polyethylene

local cable route (also called local route) any cable route, which does not fall into the category of main or internal cable route

local cables all cables not being main cables

location case (also called location cupboards or locations) signalling equipment cupboards or housings that are not buildings

low voltage voltage exceeding 50 V ac or 120 V ripple-free dc but not exceeding 1000 V ac or 1500 V dc

LSZH low smoke zero halogen

main cable route (also called main route) any external cable route, which contains or is intended to contain at least one main cable. A main cable route would typically run from one signalling location to another

main cables any cables, which are run from a cable termination point in one building, equipment room or location case to a cable termination point in another building, equipment room or location case. This includes the cables used for the reticulation of the signalling supply that joints in cables including those for loading and balancing purposes do not constitute a termination of the cable for the purposes of defining main cables

MRA metropolitan rail area; rail freight network and the rail passenger network within the metropolitan rail area bounded by Newcastle (in the north), Richmond (in the northwest), Bowenfels (in the west), Macarthur (in the southwest) and Bomaderry (in the south), and all connection lines and sidings within these areas, but excluding private sidings

NDD non-destructive digging

OHW overhead wire

OHWS overhead wiring structure

PVC polyvinyl chloride

RIM rail infrastructure manager; in relation to rail infrastructure of a railway, means the person who has effective control and management of the rail infrastructure, whether or not the person:

- a. owns the rail infrastructure; or
- b. has a statutory or contractual right to use the rail infrastructure or to control, or provide, access to it;

(Source: *Rail Safety National Law (NSW) 2012*)

rock any aggregate of minerals and/or organic materials that cannot be disaggregated by hand in air or water with prior soaking

shale fine-grained, clastic sedimentary rock formed from mud that is a mix of flakes of clay minerals and tiny fragments of other minerals, especially quartz and calcite

signalling cables include, but are not limited to, cables to signals, points, trainstops, ground frames, releasing switches, level crossings, buffer stop lights, guards' indicators and so on, plus cables between equipment rooms and between equipment rooms and location cases. Some fibre cables are also deemed as a signalling asset

signalling fibre optic cable fibre optic cable that runs from signalling location to signalling location. Typically, this would be carrying signalling data from say one housing to another

signalling fibre optic interface cable fibre optic cable that interfaces the signalling system to the fixed telecommunications network. The cable carries only signalling data be this for

telemetry or diagnostics (thinking loggers remote diagnostics and wayside monitoring systems etc)

stabilised sand mixture of sand and Portland cement (such as in the ratio of 10:1 or 10 parts sand to one part cement)

structures overbridges or under bridges, road, rail or pedestrian bridges, overhead wire supports, retaining walls, parapet walls and platforms

TAO Technically Assured Organisation

telecommunications cable all main and local telecommunications cables including telecommunication cables to station buildings, relay rooms, location cases, trackside telephones that support operational technology systems

telecommunications fibre optic cable fibre optical cable carrying non signalling data which may be operationally critical or more for business needs. They do not connect directly to any signalling asset but may carry signalling data

TfNSW Transport for NSW

TfNSW metropolitan heavy rail network area bounded by Newcastle Interchange (165.746km), Woodville Junction (163.981 km and 164.045 km), Bomaderry (153.630 km), Unanderra (91.080 km), Macarthur (57.965 km), and Bowenfels (158.800 km) but does not include the South Sydney Freight Line and Metropolitan Freight Network (bound by Marrickville 6.370 km, Flemington South Junction 18.909 km, and Sefton Park East Junction 21.285 km). In addition light rail and metro networks are not included in the TfNSW metropolitan heavy rail network

track circuit cables include, but are not limited to, cables from the equipment room or location case to the bootleg riser or to the trackside equipment boxes in the case of the Jeumont Schneider high voltage impulse and the audio frequency track circuits plus cables from the Jeumont Schneider and the audio frequency track circuit trackside equipment to the track

track plan (also called signalling plan) plan showing general signalling arrangements

ULX underline crossing

UPVC unplasticised polyvinyl chloride

URX under-road crossing

5 Cable route design life

Construction of the cable route and the materials used to construct it shall be designed and installed such that the cable route achieves a minimum in-service life of:

- 120 years for buried cable route
- 50 years for above ground cable route.

Note: This excludes cables.

Cable routes form an integral part of the operation of the MRA signalled network and as such their installation shall achieve long-term reliability.

Construction of a cable route presents an initial high capital cost to a project, but this is amortised over the life of the asset. Design and construction of the route shall ensure that maintenance requirements are minimised or that any trade-off made to these requirements addresses and provides a benefit to the whole-of-life cost to TfNSW.

6 Approvals and inspections

Approval to construct or modify an existing cable route shall be obtained through the established configuration control management process (TS 01455) set up by the project. As part of the approval process, relevant stakeholders shall be identified and briefed on the details prior to the CCB meeting.

Construction works shall not begin until approval has been obtained by way of Gate 3 approval in the CCB process. All stakeholders shall have endorsed the construction documents.

Where this specification states that a product, process, or installed work requires inspection or submission for review, consideration acceptance, or approval before further work is to be carried out, such inspection or submission shall be arranged through the TfNSW project's representative. The evidence shall be captured in the ITP, especially hold points.

Similarly, where this specification states that an action is to be carried out, is 'nominated' or 'as directed' or is 'authorised', such nomination, direction, or authorisation shall be obtained from the TfNSW project's representative.

7 Testing requirements and responsibilities

The commissioning tests prescribed in this document form part of the requirements as detailed in the systems engineering system life cycle model (V model) provided in TS 10504 and TS 01466.

One of the requirements of the model is to verify the following:

- unit (unit level tests)
- subsystem (subsystem integration level and tests)
- system interfaces (system integration level and tests)
- system (operational system acceptance tests).

TS 01466 provides more details on the general TAO requirements.

8 Designer responsibilities

Design verification shall occur at each level. The designer at the design phase shall specify the ITP requirements, including accept or reject criteria.

During the construction or installation phase, the designer shall verify the installation has been installed according to the approved design.

During the inspection and test and commissioning phases, the designer shall verify the installation has been tested to meet the design requirements as specified in the ITP.

9 Environmental considerations

9.1 General requirements

Cable routes shall be designed to be as unobtrusive as possible so as to reduce the visual impact on the surroundings and to avoid drawing attention to the presence of copper cable.

The route shall not be attached to or alter the appearance of any building or structure that is on a heritage list or is subject to a preservation order without specific approval from the relevant heritage authorities.

Trees or shrubs shall only be removed or lopped to the least extent necessary for construction of the route. Damage to the root systems of mature or substantial trees shall be avoided.

Saplings and other immature vegetation shall also be removed if, in their grown state, they will significantly encroach and alter the alignment of the GST run.

During the construction of trenches for buried cable route or ground level ducting, silt runoff into any waterway shall be prevented. Blockage of any natural or track drainage shall also be prevented.

9.2 Bush fire prone areas

Certain areas of the TfNSW metropolitan heavy rail network are in locations that carry a medium to high exposure to bush fires of severe intensity. Other sections of the network are adjacent to lands with significant levels of vegetation that also pose a probable risk of fire with a high intensity. At these locations, the placement of the cable route and its protection in the event of a fire shall be taken into account.

Factors to be taken into account shall include the following:

- the intensity of the fire
- the direction of the fire
- the type of cable route proposed

- protection of the route
- level of required vegetation control to mitigate the risk of damage to the route, both during construction and in the maintenance phase.

At locations identified as having a high risk to fire, the design TAO shall provide a design report that outlines all considerations of the design with respect to a fire and how the route is to be protected.

10 Cabling in tunnels and other similar subsurface locations

Cable routes and air line hoses in tunnels have additional fire and life safety requirements over and above that installed in open areas. Details of such requirements can be found in TS 00008.1 and TS 01722.

Cables, cabling systems, and air line hoses used within the underground passenger rail network shall comply with the requirements for fire safe cables. When exposed to a fire, they shall not emit dangerous fumes or chemicals.

LSZH cables shall be used in tunnels and other similar subsurface locations where it has been deemed that tunnel and underground standards are applicable.

For critical circuits, such as those used to indicate the location of a tunnel fire phone, fire-rated cables shall be used.

Wiring systems installed in the tunnel environment shall be designed to a minimum wiring system of WS 42 W, as specified in AS/NZS 3013.

Where a cable is run as part of a circuit for a safety system such as a fire phone, the wiring system shall be designed to a minimum wiring system of WS 52 W.

11 Site surveys

11.1 General requirements

Site surveys shall be carried out to determine locations for external work including equipment, structures, buildings, equipment housings, track section limits, foundations, cable routes, under-track crossings, and all like work. Detailed site survey drawings, installation drawings and notes, and other required documentation shall be prepared and submitted for acceptance through the appropriate configuration management process.

Site works shall be executed in accordance with the accepted approved for construction drawings and proposed methodologies.

11.2 Detailed site surveys

DSS plans and CAD files provide an accurate representation of TfNSW and external agency buried services. They can be used to identify buried assets and service owners, as base information for design and as a base for providing work as executed information.

Service searches and validation of DSS services shall be carried by a TAO who has the appropriate surveyor credentials.

Work as executed plans shall be provided for all new service installations and changes to existing services in accordance with TS 01547.1 and PR A 00498.

12 Location of equipment

No equipment shall be located within the standard structure gauge envelope as shown in TS 03500. If site constraints are such that the equipment cannot be installed without infringement of this envelope, details of the required infringement shall be referred for specific approval by way of a concession to the applicable requirement in TS 03500.

13 Local cable route – design

To facilitate the design of the local cable route, a site survey shall be undertaken to identify the position for the installation of signals and other items of trackside equipment. The position of this equipment shall be set out in accordance with the requirements in the relevant sections of TS 05165.

With the positions of the trackside equipment confirmed, the design of the local cable route can then be finalised and incorporated into the main cable route.

14 Installation drawings

This document references a number of standard installation drawings illustrating guidelines for the construction of cable route and the installation of trackside equipment. The arrangements shown in the M12 standard installation drawings series shall be used.

Where standard installation drawings are not supplied or where particular problems are encountered on site that require special arrangements or equipment to complete the work, then the necessary construction or installation drawings shall be prepared.

Design TAOs providing these detailed drawings shall provide the necessary assurance statements needed to demonstrate compliance to this and other standards as applicable.

Drawings shall comply with the requirements of TS 01547.1.

Certified as-built drawings shall be submitted to the virtual planroom.

15 Existing equipment

Where existing signalling or telecommunications equipment that is ultimately to be removed or recovered inhibits the installation of new signalling or telecommunications equipment, the TfNSW project's representative shall determine the action to be taken. The construction TAO may be directed to do the following:

- carry out temporary work
- temporarily reposition the old equipment.

If either of the above actions is adopted, it does not exempt the TAO from fulfilling their obligations under Section 31.

16 Location of services

16.1 General

This section sets out the requirements for the identification of other services installed in the rail corridor as part of the prerequisite planning, design, and construction of a new cable route.

16.2 Services search

A number of different types of services are typically installed within the rail corridor, such as:

- high voltage, low voltage, and 1500 V traction cables
- signalling cables and compressed air lines (where these lines are used to control signalling equipment)
- telecommunication cables, which also include:
 - telecommunications carrier cable routes
 - CCTV
 - public address
 - station data cabling
- gas and fuel pipelines
- water mains
- stormwater and sewer pipelines
- earth grids and their components (for example, earthing cables, and earth electrodes) for pole-mounted transformer locations and outside electrical substations.

In accordance with SMS-06-GD-3144, a services search shall be undertaken for locating all buried services prior to any excavation or post driving activities work being undertaken.

For excavation work in the rail corridor, a SMS-06-FM-4384 form shall be completed and emailed to TfNSW Services Search Request (Services.Request@transport.nsw.gov.au).

For external services (that is, non-MRA) underground services outside or within the rail corridor, BYDA shall be contacted.

16.3 Methods for locating and validating existing services

Methods to confirm the location of existing underground services onsite shall be non-destructive to the service and any protective elements. Methods used to locate and validate existing services include the following:

- locating methods such as:
 - use of electronic cable locating equipment
 - use of GPR equipment
 - survey measurements from existing DSS plans
- validating methods such as:
 - potholing by hand digging
 - potholing by vacuum excavation, which is a method that uses compressed air or water to break up the ground and a vacuum to remove the loosened material.

Electronic cable locating equipment may interfere with the operation of the signalling system. The use of electronic cable locating equipment shall be in accordance with PR A 00450 (TMG 1310).

Marking and identification of services shall be done in accordance with AS 5488.1.

The validation of services shall be coordinated with the maintenance RIM.

17 Alternative materials, products, or processes

Where this document proposes a particular material, product or process, or range of materials, products, or processes, alternatives may be accepted for use, provided that they have been type approved, and it can be demonstrated that the alternative is as follows:

- fit for purpose
- better rather than worse in optimally achieving the performance requirements
- improves rather than reduces system safety, security, and availability
- closer rather than further from best practice
- equally or more suitable in form, fit, and function, and equally or more compatible with its interfaces, operating environment, and maintenance environment

- increases rather than decreases compliance with environmental and work health and safety requirements
- decreases rather than increases life cycle costs
- improves rather than reduces maintainability and supportability
- increases rather than decreases adaptability for foreseeable change
- provides a net benefit to TfNSW.

18 Painting or finish of metal surfaces

All steel components or constructions shall be proofed against corrosion by a process that will provide a minimum service life of 50 years in the environment in which the components or constructions are installed.

In selecting the process to be used, the likelihood of minor damage during installation such as scrapping, scratching, and chipping shall be taken into account.

Painted or powder coated finishes shall not be used as the primary corrosion proofing process in external applications. Such finishes may be used to provide additional protection in those instances or locations where the primary process cannot provide the specified service life.

Fasteners used externally to buildings shall be either plated or of a material that will provide the specified life. Where stainless steel nuts are used on stainless steel fasteners, an anti-seize product shall be used between the nut and bolt.

For applications within buildings, except in wet areas such as cable pits, the level of protection may be reduced to zinc plating or equivalent.

Painting of galvanised (or equivalently plated) steel, stainless steel, and aluminium metalwork is not necessary, except where required for additional protection or where it is called for in other sections of this document.

Where a paint finish is specified, powder coating, enamel, epoxy coatings, or acrylic lacquer finishes may be used. The metal shall be surface cleaned, etched, primed, undercoated, and finished in accordance with the paint manufacturer's recommendations.

Finish colour of painted surfaces shall be compatible with the environment in which they are located.

See Appendix A for more details on corrosion.

19 Excavation, boring, backfilling, and compaction

19.1 General requirements

Excavation, boring, backfilling, and compaction of a buried cable route shall be done in accordance with TS 02390.

The construction TAO shall take into account the following issues while the route is being constructed:

- the identification and protection of any existing service
- environmental issues such as the removal of vegetation, erosion, spoil, impacts to drainage and run off
- public safety
- stability of the excavation especially if near the running line
- backfilling and compaction.

Where a conflict is identified between requirements regarding excavation, trenching, boring, earthworks, capping layer, or compaction, then TS 02390 shall take precedence.

If the excavation is within 1 m of the existing signalling services, the construction TAO shall organise for a qualified signals engineer to be on site during excavation.

19.2 Locating of existing services

Before excavation or boring operations commence, and with the approval of the service owners of each service identified within the agreed mandatory validation area, the precise location of the buried asset shall be verified.

Non-destructive potholing techniques approved by the service owner shall be used to validate all underground services. The use of vacuum, air, and water excavation (that is, NDD) is the primary method of potholing, although other techniques are available such as hand digging using hand tools with non-conductive handles.

Where water excavation is undertaken, the operator shall manage the level of water pressure and the shape of the spray from the nozzle such that when a cable is unearthed, the strength of the jet does not damage the outer sheath of the cable or the jacket of a cable joint.

For underground services, services validation shall be carried out in accordance with the agreed mandatory validation area or the following, whichever is greater:

- 2 m either side, both horizontally and vertically, of any located or suspected service
- 3 m either side, both horizontally and vertically, of any high voltage service

- The mandatory clearance distance specified by the service owner and provided as a result of BYDA, ISS requests, and subsequent consultation.

Refer to PR D 78700 and SMS-06-GD-3144 for further information.

Underground services up to 5 m from the proposed workplace shall be marked. An exclusion zone shall be set up and enforced. Where the nominated areas of authorities or services differ or overlap, the greatest area shall be used. Work shall not start until all service search information is received and validated.

All staff involved in the excavation works shall be briefed on the identified hazards and the agreed controls.

Explosives shall not be used in the performance of the work.

The search for services shall be carried out in accordance with Section 16.2.

19.3 Cable route site preparation

The area of the proposed cable route shall be cleared and levelled only to the extent necessary to permit trenching and access for plant or vehicles. Any debris, or excess soil or rock shall be disposed to a rubbish tip or other approved location.

This work shall not block natural drains or create undrained areas.

Backfill material permeability and potential undrained subsurface flow paths along trenches shall be avoided. Undrained sections may require subsoil drainage systems to discharge ground water away from trench and track formation.

19.4 Excavation

Excavations shall be to the minimum width and depth necessary to best carry out the work in accordance with this document. The bottom of trenches shall be level and even, free from stones, sharp objects, and so on.

Excavation works shall be carried out in accordance with the requirements of TS 02390.

19.5 Stability of excavation

Excavations shall be securely shored in accordance with the requirements of TS 02390 to prevent the sides of the excavation from collapsing. Additional safety requirements for such work are provided in *Work Health and Safety Act 2011 (NSW)*.

Particular emphasis and consideration shall be applied to areas around rail infrastructure.

Excavation work shall not commence in or near tracks, platforms, or access roads until sufficient shoring material is available on site to shore up the excavations as the work progresses.

19.6 Placement of spoil

Spoil shall not be placed on ballast or foul of track gauge or access ways. If spoil has to be temporarily placed on the track, tarpaulins, plywood, or other suitable material shall be used to provide a barrier between the ballast and the spoil.

Spoil placed between the rails or within 1000 mm from any rail shall not extend above the top of rail level.

Spoil shall not be placed in a position:

- where it could obstruct track drainage or be washed into track drains or onto the ballast during periods of heavy rain
- where it may damage or affect the operation of existing equipment (for example, mechanical signalling control rodding or wires, points rodding, cable routes, cable pits and covers, power operated points, trainstops, and so on).

A driver's safe and unrestricted access to signal telephones shall be maintained at all times.

The placement of spoil shall also allow the safe and unimpeded access to operational assets for maintainers.

19.7 Programming of work

As far as possible, trenching, installation of conduits, and backfilling shall be carried out progressively and concurrently so that trenches are open for the minimum possible time. Work shall be planned such that trenches are required to be kept open for a maximum of five working days, except for any of the following:

- trenches under or within 3 m from the nearest rail of operating tracks, used and unused sidings
- where the stability of an embankment or cutting or formation is affected.

At these locations, trenches shall not be kept open overnight unless they are shored to prevent any movement of surrounding ground under any weather conditions.

The shoring methodology shall be approved by the maintenance TAO.

Where a conflict of requirements exists regarding excavation, trenching, boring earthworks, capping layer, or compaction, then TS 02390 shall take precedence.

19.8 Public safety

To ensure the safety of the public, barricades shall be erected around excavations, or covers across excavations where continuous access is required across them, when work is not actually taking place. Barricades shall have a minimum height of 1000 mm. Additional safety

requirements that apply to barricades and covers are provided in the *Work Health and Safety Act 2011*.

Excavation on platforms shall cause minimum interference and risk to the public and train operations. Temporary covers shall be provided for trenches to allow access to trains, platform amenities, and booking offices. At no time while train services are running shall access to or from the platform to any part of a train be blocked.

19.9 Proximity to existing services

When trenching alongside or across gas, water mains, or service utility lines, the construction TAO shall comply with any restrictions that may apply to the easement. The construction TAO shall also liaise with the owners of that easement to establish mutually agreed on methods of protection and support for the services.

When excavation or trenching is to be carried out adjacent to existing services (that is, cables, wiring, gas, or water pipes) and no such restrictions exist, the service, if within 500 mm of the excavation, shall be carefully exposed and protected with 12 mm steel plate. Materials other than the steel plate shall not be used unless it can be assured that the material used will be able to effectively prevent damage to the service being shielded. Plywood is not deemed as an acceptable alternative product. On completion of the work, the service shall be jointly inspected by the regional representative, service owner, and the construction TAO to check that no damage has occurred and the service is operating correctly.

19.10 Inspection before backfilling

Trenches and other excavations shall not be backfilled until each aspect of the route has been confirmed to be compliant with this and other standards as applicable.

Demonstration of compliance shall be captured and documented in the ITP.

19.11 Backfilling

Pipes and cables shall be encased in clean fill to 50 mm above the uppermost pipe or cable.

Where the buried pipe or cable is located in areas other than track formation, platforms, access roads, or pathways, the trench above the clean fill shall be:

- filled with material free of broken concrete, brick, rubble, wood, glass, rubbish, steel, or other metallic objects that could damage the cable or affect the operation of an electronic cable locator
- free of stones that will not pass through a 50 mm sieve.

Backfilling of the cable route shall be in accordance with TS 02390.

19.12 Compaction

The first 150 mm of fill over cover strips or pipes shall be carefully compacted so that the cover strips or pipes are not disturbed.

Trenches and other excavations in the track formation, platforms, roads, pathways, through shunting yards or at the base of embankments shall be compacted in accordance with the requirements in TS 02390.

19.13 Using trenchless techniques

Trenchless techniques for cable installation may be used.

The level of soil displacement and settlement post-installation shall be discussed and approved by the appropriate CCB.

An appropriate period of monitoring (for settlement or subsidence) shall be agreed to through the CCB approval process.

Bore logs and all relevant installation reports shall be attached and submitted with the work as executed DSS plans.

Where matters of design and approval cannot be resolved through the CCB process, the issue shall be escalated to AMB.

20 Concrete and stabilised sand

20.1 General

This section details the requirements for the supply of the following:

- concrete for the construction of foundations, footpaths, cable pits, and other concrete structures of a minor nature
- stabilised sand.

Except when otherwise approved, ready mixed concrete shall be used in the construction of all concrete structures.

20.2 Ready mix concrete and stabilised sand

Ready mixed concrete and stabilised sand shall be produced in accordance with the requirements of AS 1379. The construction TAO shall be responsible for ensuring that concrete and stabilised sand is ordered with the correct properties for its intended application.

Concrete strength grade at 28 days shall be not less than 20 MPa. Concrete additives shall not be used without approval.

20.3 Site mixed concrete and stabilised sand

The materials for site mixed concrete and stabilised sand shall be kept free of foreign matter at all times.

Concrete mix portions by volume shall be as necessary to obtain the required strength for the particular application with a minimum strength grade of 20 MPa for any application.

Portland cement type A to AS 3972 shall be used unless otherwise specified. Aggregate shall comply with AS 2758.1.

Mixing water shall be clean and free from substances deleterious to concrete or steel. Chemical admixtures or fly ash shall not be used in the concrete mix.

21 Cable routes in general

21.1 General requirements

The setting out and the construction of the cable route shall be in accordance with this document. Where the requirements of this document cannot be met, as a minimum, the requirements set out in AS/CA S009 and AS/NZS 3000 shall be complied with.

Except as otherwise specified or where there are less than four tracks, the main cable route shall be installed on one side of the track. Where there are four tracks or more, the route shall be split to run down each side when possible. The route shall cross the track the least possible number of times. Local cable routes shall be installed as required.

The cable route shall, so far as possible, follow a constant grade and line. Rough and uneven ground shall be levelled to the extent necessary to achieve this objective. Where a buried route is to be installed, only sufficient surface levelling to provide access shall be carried out. Levelling work shall not adversely affect track or natural drainage, or pedestrian or vehicular access routes.

The location of the cable route shall take into account accessibility requirements and the presence of other services. Where there is a conflict, the matter shall be resolved and in agreement with the affected parties (for example, with the maintenance TAO).

21.2 Location of the cable route

The location for the main cable route shall be designed to maximise the use of the railway easement and minimise trenching. This infers that the cable route shall be positioned at or near the railway boundary line. The preferred locations for cable routes are shown on Drawings 112000/5/1, 112000/5/2, and 112000/5/3.

Where this is impracticable to do so, the design TAO shall submit an impact assessment statement to the appropriate CCB providing evidence as to why the route cannot be placed on

the boundary line and how the use of the easement is being maximised, including the assessment of, but not limited to, the following:

- position of the cable route
- accessibility requirements, such as access road and maintenance access
- future land use
- other factors as applicable.

The cable route shall not be installed inside the kinematic envelope.

Where a conflict in the proposed position of the route arises, the matter shall be referred to the project representative and the cable route's maintenance TAO for resolution.

Local routes shall initially follow the main cable route. Where the local route then leaves the main route, it shall run directly to the ground equipment it is connecting to. The local route shall be run perpendicular to the track alignment.

Main cable routes shall be parallel to the running lines wherever possible.

The cable route shall be located and installed so that it does not divert or interfere with any track or natural drainage or any other underground service. The route shall not affect the stability of any embankment or cutting.

Where large waterways, gullies, or roadways under tracks are encountered, the cable route shall be fixed to the available bridge structure using approved attachments as set out in Section 26.10.

For small creeks and occasional waterways, the cables shall be enclosed in pipes laid in trenches under the creek bed as set out in Section 24.13.

Cable routes shall, where possible, be on the side of the tracks not occupied by high voltage earthed locations such as:

- ac or dc traction substations
- traction system sectioning huts
- high voltage aerial lines, where down lead earth conductors and earth electrodes exist.

The cable route shall not allow for unauthorised access to live high voltage or OHW equipment.

Cable routes under roadways shall be installed within the railway corridor whenever possible.

The cable route shall be installed within the rail corridor to minimise the risks associated with external parties. Where it is not feasible, easements, leases, and rights of way shall be acquired by the project representative as necessary in favour of TfNSW for the portions of the asset location on or over private land.

Rights of way shall be acquired where necessary to gain access to the cable route. The minimum width of the right of way shall be such that vehicles and plant are able to travel through from public roads or other parts of the easement to the site of the cable route.

Access roads shall be designed and constructed to provide a safe work practice and environment. Refer to TS 02391 for design and construction requirements of access roads. All vegetation activities within an access road shall be undertaken in accordance with relevant environmental management system requirements.

Fences, locks, gates, or signs installed along access roads shall comply with the requirements of TS 02388. The locking arrangement on gates shall be such that authorised personnel including property owners are able to gain access to the land.

All easements and rights of way permitting TfNSW access for installation of new cable route, cable renewal and repair, including any special conditions of entry, shall be documented. All easement and rights of way shall also be recorded on the DSS drawing showing the landowner's name and the deposited plan and folio numbers pertaining to the land.

For the MRA, the new easement and rights of way plan shall be recorded in the GIS. A copy of any new easement and rights of way plan shall be given to the GIS group within one month of the finalisation of a tenure arrangement.

All records relating to acquisition of easements, leases, and rights of way shall be retained by the cable route's maintenance TAO.

As far as granting of the easement, the risk of damage to the cable route through third party work shall be taken into account.

21.3 Separation

Separation of signalling and telecommunication cabling shall comply with TS 06210, AS/CA S009 and AS/NZS 3000 as a minimum.

For the purposes of separation:

- signalling cables shall be laid a minimum of 300 mm from high voltage cables
- telecommunications cables shall be laid a minimum of 450 mm from high voltage cables
- track drainage shall be in accordance with TS 01638.

Telecommunications cables in GLT shall be in a separate compartment within the GLT, except where the telecommunications cable is housed in a pipe or duct in which case it may be in the same compartment as signalling and low voltage cables subducted.

Telecommunications cables in above ground troughing shall be in a separate trough.

Copper and non-metallic fibre optic cables that run between signalling locations may also be used to run with the signalling control cables.

Where a copper or non-metallic fibre optic cable runs from the signalling location to the fixed telecommunications apparatus room, the cable shall either be subducted in the signalling cable route or run in a separate 'telecommunications' duct.

Note: Details on the running of high voltage cables and the segregation from other services can be found in TS 03752 and TS 03751.

21.4 Installation at high-risk locations

Main cable routes shall not be installed at locations where it could be reasonably expected that a single, predictable event could damage the route. Examples of this are as follows:

- a main route runs across the expected trajectory of a train derailed through catch points
- a main route in GST runs along the fence line at the apex of a bend on a busy road.

Where this is the case, the route shall be constructed such that the risk is eliminated. This may require the route to be installed at a different location or buried, or other protective measures to be applied such that the hazard is effectively mitigated.

Where a local route is exposed to these same hazards, its positioning shall be risk assessed where the consequence of the damaged route is to be taken into account.

An example of where a local route may be permitted at such a location would be if the route had only one or two cables that, if damaged, would have only a minor impact to the operation of the network and the time to repair would be less than one hour.

An example of where a local route would not be permitted at such a location would be if the route contained multiple cables to signals, points, and track circuits that would affect multiple lines and would take in excess of one hour to repair.

21.5 Installation of cable routes in a geo-sensitive location

Where a section of the cable route has to pass through an area that is, from a civil engineering perspective, deemed a critical or sensitive area, the design TAO shall consult with an appropriately qualified geotechnical engineer as to the suitability of the proposed route and the construction methodologies.

Examples of geo-sensitive areas are as follows:

- along the foot of cuttings and embankments
- across the top of cuttings and embankments
- up or down cuttings and embankments
- near footings of substantial built assets.

Designs shall be approved by a suitably qualified geotechnical engineer.

The assessment shall be contained in a design assessment report along with details of all assumptions and any calculations used to deem the solution as acceptable. This report shall form part of the safety in design submission.

21.6 Cable routes in areas of high-water tables

The TfNSW network has many locations where the water table is close to the surface. At these locations, the design TAO shall take into account having the signalling cables immersed in ground water for long periods of time and the deleterious effects, if any, this might have on the cables.

Signalling cables should not be exposed to long periods of immersion. At these locations, the design TAO shall take into account using other non-sub-surface cabling systems options over that of a buried route.

21.7 Cable route diversity

Availability of the signalling system is increased by the use of duplicated systems. In a cabling context, this infers the following:

- cabling for the normal and emergency power supplies
- duplicated data links.

Services that form part of a duplicated network shall be run in separate, diverse routes.

The design intent is that a single event does not result in a failure of both the main and standby service.

Diversity can be achieved by the following means:

- cable diversity, where duplicated services are run in a separate cable in the same duct
- duct diversity, where duplicated services are run in separate and separated ducts within the same route (in this case, the design outcome should be as much separation as possible within the confine of the route)
- route diversity, where duplicated services are run in separate diverse routes.

The design TAO shall aim to achieve the maximum diversity as much as possible given the project scope, commensurate with the risk and scale of the work undertaken.

Where these cables enter a building, there is usually only one point of cable entry. When this is the case, sections of the cable route approaching the equipment room may have both sets of cables in the common route. The length of commonality is constrained by the design and size of the equipment room; however, the length of commonality shall be no more than 20 m. For these common sections, the potential for damage from a single event shall be risk assessed and the details captured in the safety in design report and submitted to the approving CCB.

At these common sections of the route, additional treatments shall be applied to minimise the likelihood of damage occurring or the consequence of damage when it occurs. The nature of the treatments is dependent on the identified risks but could include additional layers of protection or enhanced treatments.

Where a wholly separate route is not available, the services shall be run in separate ducts, separated as far as possible.

For telecommunications cabling route diversity requirements, refer to TS 03947 and TS 06210.

21.8 Cable route intersection with access roads

Where a railway access road intersects with an area where buried cables are being installed at the standard depth of 800 mm, generally no special arrangements are required at that location and backfilling shall be carried out in accordance with Section 19.

Where the access road intersects with an above ground troughing route, the cables shall be run in buried pipes with pits each side of the roadway, generally in accordance with Section 24. In extenuating circumstances, where a pit cannot be installed, an alternative arrangement may be used as described in Section 30.3.

Details for the construction of access roads can be found in TS 02391.

21.9 Repurposing of existing cable routes

Repurposing of existing routes may be done on a selective basis following the submission and approval of a dilapidation report, which contains an assessment of remaining life and whole-of-life cost assessment comparing a new route against the repurposing of an existing route.

Criteria to upgrade a local route or ULX to a main route shall be done through concession.

22 Conduits

22.1 Conduits and fittings used for signalling

All conduits used in the construction of the cable route shall comply with the requirements in AS 61386.1.

Conduits shall be rigid UPVC, 'HD Coreflo' or HDPE jointed using the manufacturer's recommended jointing methods.

The conduits in Table 1 represent the typical sizes generally used in each application. The sizes may vary according to local constraints. Where a smaller conduit is proposed, the construction TAO shall take into account the need for spare capacity and the minimum cable bending radius.

Table 1 – Conduits

Conduit location	Material specification
Main cable route	Not less than 100 mm orange
Local cable buried route	Not less than 50 mm orange
Surface run to electric point machines and trainstops	50 mm ID and 63 mm OD orange (thick-walled) flexible
From the local buried route to other trackside equipment (for example, to track circuit equipment)	Not less than 25 mm polyamide corrugated conduit
At locations with public access (for example, a local run to a guard's indicator on an external wall of a platform control room)	Not less than 25 mm steel
At locations inaccessible to the public (for example, a cable run across a platform canopy to a guard's indicator)	Not less than 25 mm light duty
Level crossings boom mechanisms to the gate	Not less than 50 mm polyamide corrugated conduit
ATP trackside equipment	50 mm ID and 63 mm OD orange (thick-walled) flexible
Surface run to axle counter	Not less than 32 mm orange (thick wall) flexible

Grey or orange PVC corrugated conduit shall not be used.

At locations where rigid orange conduits are exposed to sunlight, the construction TAO shall:

- prime and paint the conduits in an orange colour
- use UV stabilised conduits.

Where UV stabilised conduits are used, the design life of the conduits shall be 50 years or greater (in Australian conditions).

Where a location is prone to vandalism, steel flexible conduit shall be used.

Conduits used in tunnel environments shall comply with the fire life safety requirements in TS 00008.1.

22.2 Protection of air line

Surface runs of flexible air line hoses to trackside equipment shall be protected by the sleeving of the air line using thick-walled orange flexible conduit.

22.3 Conduits used for telecommunications

Details on conduits used for telecommunication circuits can be found in TS 06210.

22.4 Conduits used for low voltage services

Details on conduits used for low voltage circuits can be found in TS 03954.

22.5 Conduits used for high voltage and 1500 V dc feeders

Details on conduits used for high voltage circuits can be found in TS 03750.

23 Types of cable route

23.1 General

Cable route types are shown in Table 2.

Table 2 – Cable route types

Type	Description	Cross-reference
type 1	Cable buried in heavy duty conduits with pits at regular intervals – Drawing 112000/5/5	Section 24
type 2	GLT, heavy wall type concrete or equivalent type approved ducting for areas where vehicles do not have access	Section 25
type 3	GST on posts or brackets	Section 26
type 4	Galvanised steel ladder on wall	Section 27
type 5	Aluminium ladder on wall	Section 27
type 6	Stainless steel ladder on wall	Section 27

23.2 Radius of bends

The smallest radius bend in any cable route shall not be less than the cable manufacturer's recommended minimum radius for the largest cable to be installed in that route.

24 Buried cable route (type 1 cable route)

24.1 General requirements

The excavation of trenches, backfilling, and compaction shall be carried out in accordance with the requirements of Section 19.

To avoid the need to re-open cable trenches, main and local cable route conduits shall be installed and buried at the same time.

Air lines may be included in the trench alongside the cables as set out in TS 05171.

24.2 Depth of cable route

Cables and pipe buried in the ground shall have a minimum cover of 800 mm from the cover strip or topmost pipe to ground level.

The top of cables and pipe buried in the track formation shall be a minimum of 1600 mm below rail level.

Where cables are installed in ULX and URX pipes, the provisions of Section 29 shall apply.

24.3 Shared trenches

Where telecommunications and signalling cables are installed in the same trench (possibly also with power, other services, or both), then the following requirements shall apply:

- Conduits shall be grouped, as shown in Figure 1 and Figure 2, with horizontal separation between signalling conduits, telecommunications conduits, and conduits for other services.
- In a situation where there are odd numbers of conduits (for example, three signals and three telecommunication conduits), the arrangement shall be such that the middle conduits would have signals and telecommunications on top of each other to reduce the width of the trench.
- Signalling air mains shall be included in the signalling conduit group.
- The minimum separation between telecommunications cables and high voltage power cables shall be the greater of the separation specified in TS 06210, TS 03750, and AS/CA S009. The minimum separation between telecommunications cables and signalling or other power cables shall be as specified in AS/CA S009.
- Where practical, the signalling cable group shall be located on the side nearest the running rails, to facilitate the installation of tail cables to trackside equipment.
- Telecommunications conduits shall be coloured white. Signalling and power conduits shall be orange. (If air mains are run in a separate conduit, that may be coloured blue, or else the same colour as other signalling conduits.) Conduits for other types of service shall be appropriately coloured, generally in accordance with AS 1345.

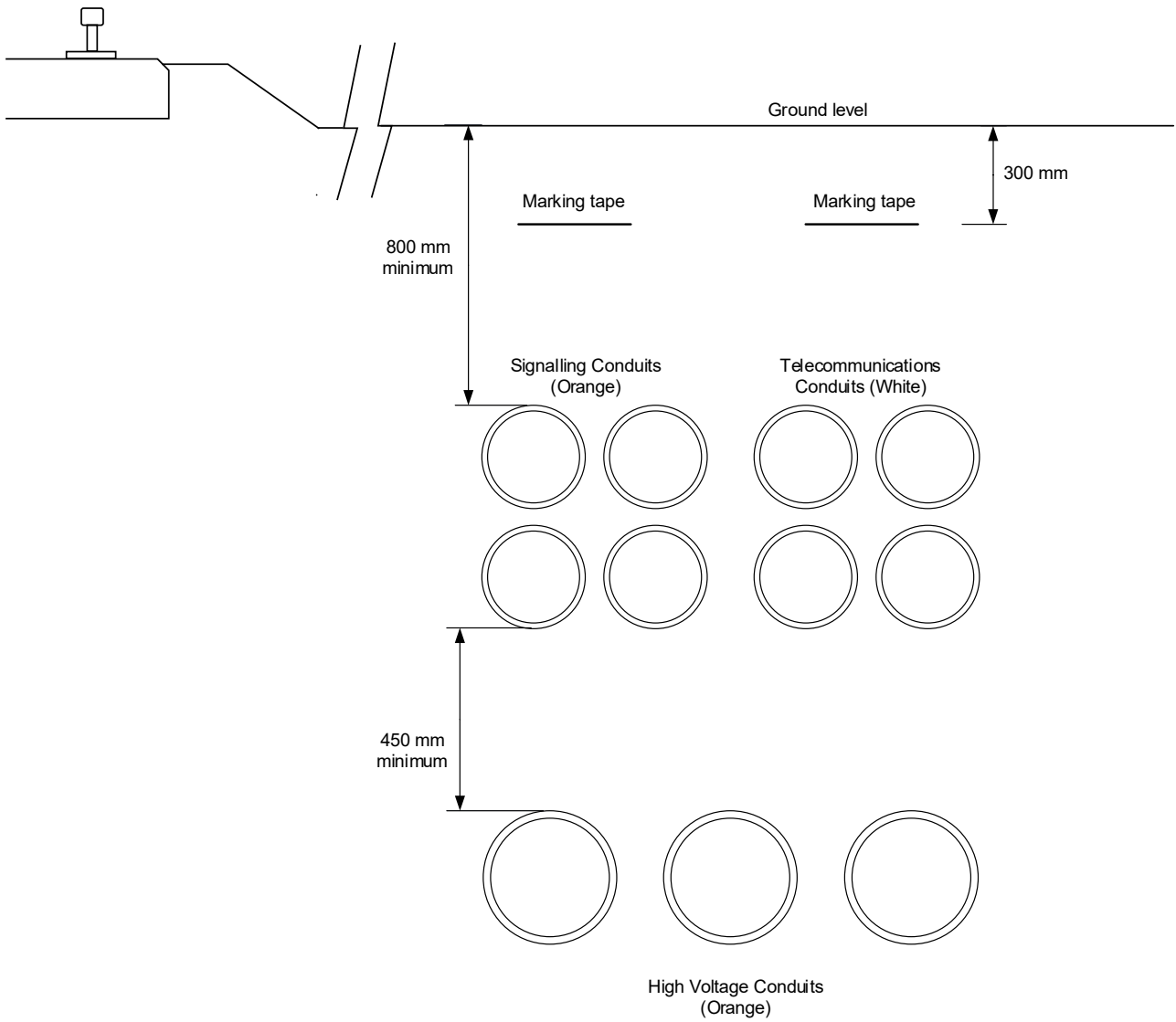
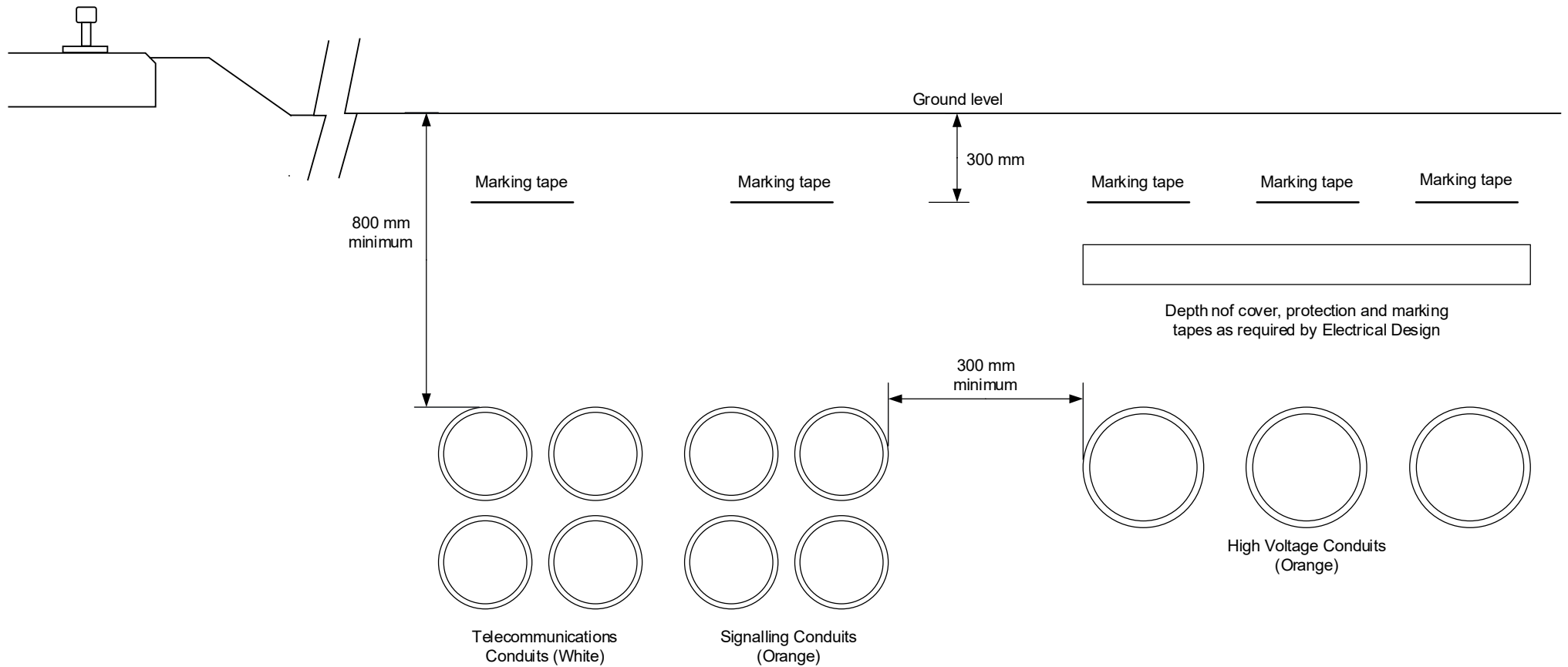


Figure 1 – Arrangement of conduits in shared services route – Sharing with vertically separated high voltage power conduits



Note: Telecommunications and Signalling conduits may be reversed but the separation between HV conduits and the telecommunications conduits shall be 450 mm.

Figure 2 – Arrangement of conduits in shared services route – Sharing with horizontally separated high voltage power conduits

24.4 Protective cover over signalling and telecommunications cables

To provide mechanical protection to signalling, telecommunications, and power cables, the construction TAO shall provide a separate cover strip covering all the cables. The minimum cover width shall be 150 mm. The cover strip shall be placed on top of the cables and overlap the cables by not less than 50 mm on each side as shown on Drawing 112000/5/4.

24.5 PVC cable marker tape in trenches

Orange PVC marker tape that is 150 mm wide with the words 'DANGER RAILWAY SIGNALLING CABLES' shall be installed in all trenches 300 mm below ground level as shown on Drawings 112000/5/4 and 112000/5/5.

Where cables are used in shallow trenches, the depth of the marker tape shall be not less than 100 mm above the protective cover or conduits.

24.6 Rock areas

In areas of unbroken rock, the installation shall comply with category C system in AS/NZS 3000.

In trafficable areas, the concrete cover shall be of sufficient strength to carry the wheel loads of maintenance support vehicles with up to 20 t axle loads. The cover shall be engineered so that the load is distributed through the slab to the surrounding ground rather than directly onto the conduits.

24.7 Shallow buried cable routes

Where a cable route cannot be installed to the required depth, the requirements in AS/NZS 3000 shall be adhered to for a category B system. In addition to those requirements, the cables shall be installed in heavy duty conduits to allow for cable re-entry.

A protective cover strip shall be installed midway between conduits and top of cover.

The position of the route and its surveyed depth shall be noted and highlighted as being 'not to depth' with the depth details added on the work as executed DSS plan.

24.8 Buried pipes

The wall thickness or class of conduit shall be sufficient to guarantee that there will be no loss of cross-sectional area and that there will be less than 10% loss of diameter in any direction during or after backfilling, boring, or pulling.

The minimum inside diameter of conduits shall be at least three times the outside diameter of the cable to be pulled through the pipe with a minimum of 50 mm diameter.

The number of conduits to be provided in ULXs, URXs and under access roads will depend on the cable route requirements in that area. However, provision shall be made for the following, as applicable:

- Signalling and power cables shall be in separate conduits to telecommunication cables.
- High voltage cable shall be in a separate conduit to signalling or telecommunications cable.
- Signalling optical fibre cable shall be in a separate conduit to telecommunications optical fibre cable.
- Signalling optical fibre cable shall be in a separate conduit to the signalling optical fibre interface cable.
- Main air lines shall be in a separate conduit. (For air lines that branch off the main air line to feed pneumatic load, see Section 32.5).

Except for directionally bored ULXs and URXs, conduits shall be laid parallel and level in a consistent format in the trench and secured in that position.

Heavy-duty conduits shall be used when installed in trenches. Medium-duty conduit can be used for direct bore sections of cable routes.

Where a conduit is only partially used and some spare capacity exists for additional cables to be drawn in, a polypropylene draw rope shall be drawn in with the last of the cables and anchored at each end of the conduit. During installation, every attempt shall be made to prevent the draw rope from becoming entangled in the last of the cables.

Spare capacity in used and unused pipes shall be sealed using an appropriate re-enterable grouting material to prevent siltation and access for rodents.

24.9 Pipes in high voltage areas

Where telecommunications cables are required to be run into high voltage earthed locations such as sub-stations, power sectioning huts, and transformer locations, these shall be looped into and out of the locations and be protected by conduits.

An 'earth mat' is provided around high voltage locations as part of the earth protection arrangements for the installation. All cables (signalling and telecommunications) to be installed within 430 V of the EPR zone of the substation earth mat shall be run in non-conductive conduits. The TfNSW project representative shall provide the details of the extent of the earthing arrangements around each high voltage installation.

Existing high voltage earthing arrangements shall not be disturbed under any circumstances.

24.10 Spare buried pipes

Either one pipe or 20% of the number of pipes, whichever is the greater, shall be provided.

In determining the number of spare pipes to be provided based on the percentage of pipes, reference shall be made only to the resultant whole number. Fractions shall be ignored.

All spare pipes shall be tested for correct diameter by drawing a test mandrel 240 mm long of a diameter 90% of the internal pipe diameter through the pipe after installation, backfilling, and compaction.

Where type 1 route is specified, the spare pipes shall be laid over the other pipes as shown on Drawing 112000/5/5.

Spare pipes shall be cleaned and fitted with a polypropylene draw rope anchored at each end of the pipe.

Spare capacity in used and unused pipes shall be sealed using a re-enterable grouting material to prevent siltation and access for rodents.

Spare capacity requirements do not apply to local or tail cable routes.

24.11 Spare capacity in cable routes

Spare capacity shall be provided in accordance with Section 24.10 for any new cable route fully or partially constructed (for example, an extension to a main cable route).

Where a project is of a scale that does not warrant the construction of any new cable route and plans to use the existing spare capacity, the consumption of this spare capacity shall be coordinated such that other stakeholders' needs are considered and prioritised.

Where a conflict exists, this shall be managed during the design phase and coordinated through the regional CCB or other approving body.

The approving body shall take into account the scale of the project, project timelines, and the priorities to TfNSW in order to determine which project or stakeholder has the rights to the spare capacity.

For a project that has been permitted to consume the spare capacity, the spare capacity requirements in Section 24.10 do not apply.

For any following project where there is no spare capacity and expansion to the cable route is required, spare capacity in accordance with Section 24.10 shall be required.

Where a project is of such a scale that considerable parts of the cable route are impacted, the project should take into account the longer term benefits to TfNSW of adding spare capacity in accordance with the requirements of Section 24.10.

It shall be up to the CCB to determine whether the scale of the project justifies the need for spare capacity in the route to be added using longer term asset management plans to justify the need for spare capacity.

24.12 Pipes in platforms and other paved areas

Pipes shall be arranged in fixed format for the full length of the platform or paved area. Pipes shall be supported so that backfilling will not disturb the format. The requirements of Section 19 shall apply.

Where only pedestrian traffic is involved, the depth of the pipes from the top of the trench to the top of the highest layer of pipes shall be not less than 300 mm.

Where motor vehicles can run over the surface, the following requirements apply:

- Where conduits are buried at a depth of 300 mm or more, no further treatment shall be required.
- Where conduits are buried not less than 300 mm below the surface, a reinforced concrete slab that is 150 mm thick as a minimum shall be designed and constructed to withstand the maximum expected trafficable load. The slab shall overlap the pipes by 300 mm each side. The reinforcing concrete may be provided immediately under the pavement surface or used as the pavement surface material.

Cable pits for cable pulling purposes shall be provided in platforms in accordance with the requirements of Section 30.

24.13 Buried cables through water courses

For small creeks and occasional waterways, the cables shall be enclosed in pipes laid in trenches not less than 1 m under the creek bed. The pipes shall be covered to a minimum depth of 300 mm with porous bags filled with stabilised sand. The remainder of the trench shall then be filled to the top with heavy grade scour resistant materials.

Hardcore materials shall resist scouring or water velocity of the water course. Refer to TS 01658 for details.

The pipes on creek banks shall be laid at a gentle slope in grooves in the banks so that the pipes have a minimum cover of 800 mm. The pipes in the banks shall be secured in position with suitable anchors. The pipes shall be covered with porous bags filled with stabilised sand and topped with other suitable fill to protect the pipes and prevent erosion of the banks. Every effort shall be made to avoid placing the pipes in any part of the bank where obvious erosion has been taking place. If this cannot be avoided, stabilisation of the bank on each side of the trench shall be provided.

The buried pipes shall be extended past the edge of the creek banks a minimum of 4 m on either side of the creek or waterway. The minimum depth of the whole of this pipe run shall be 800 mm.

24.14 Underground services of other authorities

Where any service including power, telephone, water, sewerage, stormwater, signals, telecommunications, gas, or drainage exist and will be affected by the proposed cable route, the buried cable route shall be laid 500 mm below the obstacle. Alternatively, and with permission from the TfNSW project representative, it may be laid above the service if the required clearance from the service and compliance with Section 21 can be achieved.

The method to be used shall be determined by agreement. Buried metal pipes (for example, for water, gas, sewerage, and so on) and the metal armour on some high voltage cables are connected to the traction power supply return rail by means of 'electrolysis bonds' at a number of points along the line. The construction TAO shall ensure that electrolysis bond connections or equipment is not damaged or disturbed.

Where new electrolysis bonds, new connections, or both are to be provided, then the old connections shall only be removed when the new connections are ready for connection. All changes shall be carried out under the direction of the regional representative.

24.15 Cable route markers

Cable route markers shall be installed on all buried cable routes.

In yard areas, the markers shall be mounted on posts with 500 mm protrusion above ground (or on an adjacent fence line where available). In all other areas, markers shall be mounted on posts with 1200 mm protrusion above ground.

Cable route markers shall be installed at each point where the route changes direction, at each end of under-track, under-road and under-creek crossings. The markers shall be at no greater than 50 m intervals along the route so that at least two markers are visible at any point along the route.

Cable route markers shall be placed close to a fence or other fixed structure and in such a position that they are not likely to be run over by track maintenance or other vehicles. They shall not be placed directly over the cable route. In yard areas, they shall not obstruct footpaths, walkways, or vehicle access ways.

Cable route markers may be installed on OHWS where approved. The bonding agent used to attach the marker to the OHWS shall not cause deleterious effects to the structure or its protective coating.

Cable route markers are not required where a cable route is installed, and the work is surveyed and drafted on DSS plans in accordance with PR A 00498.

25 Ground level troughing cable route (type 2 cable route)

25.1 General requirements

GLT shall be manufactured from reinforced concrete in accordance with Drawings M07-100 and M07-101 or from type-approved moulded composite materials.

Concrete troughing shall be fitted with lids as shown on Drawings M07-100 and M07-101.

GLT shall be accurately manufactured to enable each segment to interlock securely with each other and lids to fit securely on the top of the troughing without rocking.

25.2 Whole-of-life cost analysis

GLT is both intricate to install and costly to maintain over its life, the expectation being that sections of the GLT will require replacement over its lifetime.

In locations where GLT is being considered, a whole-of-life cost analysis shall first be undertaken in order to demonstrate that both the installation and ongoing maintenance costs compare favourably with other potential cabling options.

25.3 Trafficable areas

GLT shall not be used in areas where regular traffic could be expected. Examples of this are a run of GLT crossing, a vehicle access road or a materials or equipment lay-down area.

Where a main GLT cable route runs parallel to an access road, the GLT route shall be protected from damage from any traffic that may travel over it or material that may be placed on it. Protection shall typically be by way of 'W-beam' barrier, bollards, or similar such that traffic is prevented from driving on the GLT or the land immediately near it.

Where a local GLT cable route runs parallel to an access road, the construction TAO shall consult with the RIM and provide any additional protection to the route as required.

The decision to provide mechanical protection shall be based on a risk assessment where the more services that are carried in the route, the potential need for mechanical protection becomes more apparent or justified.

If GLT is to be used in an area where vehicle access (railway maintenance vehicles including tractors, front end loaders, and so on) is possible, the trough and lid shall be capable of carrying a load of not less than 4.5 t over a contact area of 100 mm x 300 mm applied to any part of the lid.

25.4 Bush fire prone areas

Approved GLT products come in a range of different materials. Section 9 requires that the location of the cable route take into account the risk of fire and the consequential damage to the route as a result of such a fire.

If that review process confirms the acceptability of the use of GLT, the design TAO shall take account of the material properties of the chosen GLT so that the risk of damage to the GLT and the cables within will be to levels that are deemed superficial only (for example, the scorching of a lid).

In areas where there is a risk of bush fires or where radiant heat from a fire could significantly damage the GLT that would require wholesale replacement, GLT made of plastic, GRP, or other plastic- or resin-based materials shall not be used.

25.5 Enclosed spaces

Where GLT is intended to be run in enclosed spaces (for example, tunnels, (electrical) equipment rooms, or other such environments), the material composition of the GLT shall comply with relevant fire and life safety requirements in TS 00008.1. The GLT shall be constructed of self-extinguishing material. The GLT shall have LSZH properties.

25.6 Troughing route capacity

One or more troughs shall be installed to provide the necessary capacity to accommodate the cables and provide 30% spare capacity, in each compartment of the trough, to provide for future requirements.

25.7 Installation

To avoid siltation, GLT shall be installed with the top of the lid approximately 75 mm above ground level. If the GLT represents an unacceptable trip hazard, a batter comprised of road base materials (crushed gravel) shall be installed to reduce the hazard.

Where rock is encountered, approval may be granted to raise the level of GLT where vehicles cannot access.

GLT runs shall have the least practical number of changes of direction and gradient.

The method to be used for a change in direction of the GLT route shall be determined by the extent of the angular change in direction and the minimum bending radius of the largest cable in the route. The GLT may be cut in a series of angles. Alternatively, a turning chamber may be used. Moulded or formed bends or similar shall be used with HDPE or LLDPE trough.

Proposed detailed designs shall be submitted to the CCB for approval.

Construction of a GLT route on banks and sloping sites shall include measures to prevent the supporting ground from being eroded during periods of rain.

Where GLT is being installed near a running line, it shall be positioned such that it will not obstruct or be likely to be damaged by, the removal and replacement of railway sleepers.

GLT to be installed within 3 m of the face of the nearest running rail shall be installed such that the top of the GLT lids are not higher than 200 mm below the underside of adjacent sleepers.

25.8 Use in ballasted track

In some applications, GLT may be run in the six foot or potentially on the cess side of the track.

In all cases, the installation of GLT in the track ballasted area shall not hinder or prevent the replacement of sleepers or form a barrier to track drainage.

If the GLT is to be run on the cess side of the track, there is a likelihood of misalignment of the route over time due to unequal side pressures. Installation methodologies shall apply appropriate treatment to prevent this from occurring.

If the GLT is mounted in the six foot, the construction TAO shall first seek the approval of the maintainer RIM. The maintainer RIM shall be responsible for taking into account any implications that may arise from damage to the route from off track plant equipment and how this is to be mitigated, managed, and protected during track maintenance activities for the intended life of the asset.

GLT shall be placed no closer than 450 mm from the toe of the sleeper to allow access for mechanised track maintenance.

When installing the GLT, it shall not be allowed to 'flat' in the ballast. The GLT shall be required to sit on a bed of compacted road base or similar.

When installed in the track, the ballast shall be loaded as evenly as possible on each side.

25.9 Use with other services

Telecommunications cables shall not be installed in the same compartment within the GLT as power or signalling cable without additional treatment as specified in TS 06210.

Section 6.1.4 of TS 06210:2021 limits the length of the GLT section to a maximum of 5 m.

High voltage cables shall not be installed in the same compartment as signalling cables.

Signalling cables are approved to run in GLT.

Telecommunications cables (fibre or copper types) are approved to be run in GLT if they are segregated from signalling cables or are subducted in the signalling compartment. Where the telecommunications cables are subducted, the proposed cabling scheme shall comply with AS/CA S009 and the colour of the subduct shall be white.

ATP point-to-point look-ahead fibre cable is classed as a signalling fibre cable and is excluded from the subducting requirement.

Low voltage cable may be run with the signalling cable if the following applies:

- it is approved by the maintenance RIM
- it is assured that there will be no electromagnetic interference from the low voltage service to the signalling cables
- the low voltage cables are subducted in orange conduit
- the design of the GLT or its position will prevent the entry of track ballast.

25.10 Drainage

When designing and installing the GLT cable route, the TAO shall ensure that neither the track nor the drainage system on TfNSW's property is affected. Ramping of the GLT over drains, or alternatively ducts or pipes under the GLT route, shall be provided.

GLT shall be installed in such a manner as not to redirect or concentrate overland flow paths or track drainage.

Where GLT could act as a barrier to slow the dispersal of water during wet periods, drainage ducts shall be installed under the GLT at not greater than 20 m intervals. These shall be located at suitable positions to enable the quick dispersal of storm water. Drainage ducts may be constructed from inverted GLT, pre-cast concrete box drains or PVC or HDPE pipes. The proposed solution shall not require ongoing maintenance.

Refer to TS 01638 for additional drainage requirements.

25.11 Lids

Where the laying of cables is part of the same contract as the construction of the cable route, the GLT lids shall be installed after all the cables are laid. Otherwise, the lids shall be fitted as the GLT laying progresses. The GLT shall be thoroughly cleaned prior to installing lids.

If the GLT is in the vicinity of pedestrian walkways and pathways, the construction TAO shall be required to fit the lids as the work progresses and reopen the GLT when required for cable laying.

After the cables are laid, all cable entry points to GLT shall be sealed with an approved compound to prevent the entry of rodents and vermin. If the laying of cables is not part of the construction of the cable route contract, the cable laying construction TAO shall be responsible for sealing the cable entries and refitting the lids after cable laying.

Where PVC air lines are installed in GLT, these shall be laid on top of the signalling cables.

Where the lid of the GLT cannot be secured in position, low voltage electrical cables (excluding signalling cables) shall require additional mechanical protection by way of either subducting, a protective cover strip, or other effective means. The solution shall effectively prevent a puncture to the cables sheath or insulation as a result of the lid and/or ballast falling into the GLT.

25.12 Prevention of rodent access

At some locations, rodents nest inside the GLT; evidence suggests that nesting is more prevalent at locations near permanent water.

The use of GLT makes it difficult to prevent vermin access; however, the following measures shall be taken into account when installing GLT:

- ensuring that lids are a snug fit
- filling voids at cable entry points.

26 Galvanised steel troughing cable route (type 3 cable route)

26.1 General requirements

GST shall be constructed from steel, hot dip galvanised to AS 4750 with a coating mass equal to Z600 or better. Freshly cut surfaces shall be painted with cold galvanising paint.

GST shall comply with the minimum base metal thicknesses shown on Drawing M07-114 for the various size ranges but variations in shape (height, width, or both) are acceptable. GST with a side wall height of 140 mm or more shall have a stiffening rib in each side wall similar to that shown on the drawing.

The bottom and sides of GST shall be provided with a continuous 9 mm thick lining of stable thermal insulating material, such as fibre-reinforced cement, for fire protection.

Thermal insulation shall be continuous so that no cable is exposed to the base metal of the troughing. Any gaps in the thermal insulation shall be sealed with suitable thermally non-conductive, non-flammable sealant or cement.

Note: Evidence from the 2019 and 2020 bush fires in the Blue Mountains where significant damage occurred found that cables in the centre of the GST survived but those close to the corners where there were gaps in the thermal insulation were severely damaged.

In restricted areas, and only where clearance limitations demand it, such as in tunnels and along platform walls, slimline cable ladders shall be used instead of the GST in accordance with the provisions of Section 27.

GST shall be generally constructed using troughing 6 m in length. Shorter length GST may only be used to accommodate changes in direction of the route, or to suit equipment positions.

Cable jointing bays shall be provided as required to ensure that there is no net reduction in trough capacity where cable joints occur. The bays shall be supported to prevent any deflection or twist of the jointing bay or cable route.

GST on walls or in tunnels shall not obstruct access to staff refuge recesses.

26.2 Arrangement at or near substations and other high voltage locations

GST shall be installed outside the 430 V EPR zone. Where this is not possible, the transfer of the EPR voltage to a remote location shall be prevented by means of insulation barriers.

Treatments may include insulated GST post (post sleeved in conduit) and insulated sections of the troughing.

Treatments shall be rated to withstand the expected EPR voltage.

Any treatment shall not require ongoing maintenance or surveillance. Treatments shall have a life expectancy commensurate with the route itself.

26.3 Arrangements at or near overhead wiring structures

GST or support brackets shall not be fixed to or installed within 2 m of any part of any OHWS at any point in the cable route. Where this clearance cannot be achieved, insulated joints shall be installed at least 2 m from each side of the OHWS.

26.4 Troughing route capacity

One or more troughs shall be installed to provide the necessary capacity to accommodate all the main and local signalling, and low voltage signalling power cables in the cable route plus an allowance of not less than 30% spare capacity to provide for future requirements.

Additional and separate troughs shall be provided for the following:

- high voltage power cables
- low voltage power cables
- telecommunications cable.

Steel air lines shall not be installed in GST. However, flexible PVC air lines up to 25 mm bore may be installed on top of signalling cables in GST.

26.5 Bends

The minimum radius of all bends in the steel troughing route shall comply with the requirements of this section.

All bends shall be smooth and rounded to prevent damage to or pressure on cables due to sharp corners or edges.

Changes in direction in the vertical or horizontal plane of the troughing route shall be at a maximum angle of 22.5 degrees in all cases. Where 90-degree bends are required, they shall be made up of four 22.5 degree bends.

26.6 Expansion joints and insulated sections

Troughing expansion joints shall be installed in the troughing runs at intervals of not greater than 50 m. Each expansion joint shall provide for change in length for an ambient temperature range from 5 °C to 60 °C.

GST shall be fixed to the expansion joint support brackets at the expansion joint only. GST shall be arranged so that the troughing between expansion joints is free to expand and contract with temperature changes.

Strapping of lids around expansion joints shall not inhibit movement.

To minimise the effects of stray or induced currents in GST, insulated saddle joints shall be installed in GST runs at intervals of not greater than 300 m and at each end of steel bridges when the route is attached to or supported by the bridge.

The insulated joints shall be arranged to provide a gap of 30 mm between the ends of adjacent lengths of GST.

There shall be at least two insulated joints provided between any two signalling locations.

The insulated joints shall line up with any other insulated joints in metal objects that run continuously between signalling locations.

26.7 Mounting brackets and fittings

Troughing support brackets, fixings, and other fittings shall be of sufficient strength to support the troughing without permanent deflection when loaded to full capacity with cable plus incidental loads up to 100 kg applied at any point on the trough. A safety factor of not less than three shall be applied to the brackets.

All components shall be protected against corrosion or made of corrosion resistant materials, which will provide a service life of at least 50 years.

Troughing brackets shall generally not extend past the side of the trough by more than 25 mm.

26.8 Troughing on posts

Freestanding GST shall be mounted on posts set in the ground to a depth of at least one-third of the total length of each post or 500 mm, whichever is the greater. All posts shall be vertical.

The design needs to be validated by a competent civil engineer taking into account the soil conditions. The minimum diameter of the concrete footing shall be 300 mm as per Drawing M12-010.

Posts shall be spaced so that any trough attached to the posts will not deflect or distort when loaded as specified in Section 26 with the incidental load at the mid-point of the span. Post spacing shall be consistent, except where a reduction is necessary for change of direction, support of a joint bay, or termination of route.

Where post spacings in excess of 2 m are proposed, proof of the capacity of the smallest trough in the route to support the specified loadings shall be submitted.

Posts shall be of sufficient section to support and not move in the ground with either or both of the following applied to the top of the post in any direction:

- a vertical load of 250 kg
- a horizontal load of 150 kg.

The minimum height from ground level to the bottom of the lowest trough on a post line shall be 500 mm.

Where either the placement or height of the troughing run prevents access to the track, the design shall take into account the installation of access ways at regular intervals. Access ways shall be provided at intervals no greater than 200 m.

Concrete placed around the post shall have a dome finish such that water does not pool around the post.

26.9 Bridges, viaducts, rock faces, retaining walls, tunnels, and underbridges

26.9.1 Installation

Installation of GST on bridges, viaduct, rock faces, retaining walls, tunnels, and underbridges shall be carried out in accordance with TS 02390.

26.9.2 Troughing on railway bridges or viaducts

Where necessary, and subject to approval of the asset owner and the authorising CCB, a GST cable route may be attached to the structures of bridges and viaducts. However, the bridge or viaduct structures shall not be drilled, cut, bent, welded or otherwise deformed for such an

attachment. Suitable clips shall be provided for securing brackets to bridge metalwork. All bolts shall have self-locking nuts.

Concrete bridges or viaducts shall not be drilled to fix brackets to the structure without approval.

Where approval is granted to fasten to concrete bridges or viaducts, troughing or brackets or both shall be affixed using stainless steel chemical anchors of 12 mm diameter and 75 mm minimum anchoring depth. Expanding masonry anchors shall not be used.

The brackets and braces shall be of sufficient strength to support the loadings and safety factor specified in Section 26.7. Spacing shall be in accordance with the requirements of Section 26.8.

26.9.3 Troughing on rock faces

GST on rock faces shall be supported by brackets epoxy grouted into holes bored in the rock face. Bracket lengths shall be varied as necessary to account for variation in the line of the rock face. Where projection of more than 400 mm from the rock face is required, the bracket shall be suitably braced. The brackets and braces shall be of sufficient strength and the depth of penetration into the rock face sufficient to support the loadings and safety factor specified in Section 26.7. Spacing shall be in accordance with the requirements of Section 26.8.

Attachment to the rock faces shall be by stainless steel chemical anchors of a size and length to carry the specified load and that suit the rock substrate. Anchors shall not be less than 12 mm in diameter with a minimum anchoring depth of 75 mm.

The minimum height to the bottom of the lowest trough from ground level shall be 500 mm.

GST attached to rock faces shall have a minimum clearance between the trough and the rock face of 25 mm.

26.9.4 Troughing on walls

GST supports may be fixed to retaining or other walls provided that secure fixings can be obtained and there is sufficient clearance between the wall and the closest running rail.

Attachment to the wall shall be by stainless steel chemical masonry anchors of not less than 12 mm in diameter with a minimum anchoring depth of 75 mm.

The brackets shall be of sufficient strength to support the loadings and safety factor specified in Section 26.7. Spacing shall comply with the requirements of Section 26.8.

The minimum clearance between the troughing and wall shall be 25 mm.

26.9.5 Troughing in tunnels or through underbridges with limited clearances

In tunnels and through underbridges where clearances are limited at low level or where the troughing would interfere with access to refuges, the route shall be mounted on the wall at a height not less than 3800 mm above rail level.

If in a limited clearance area the required clearances cannot be obtained using GST, cable ladders may be used to carry the signalling, telecommunications, and power cables.

26.9.6 Spanning of steel troughing

Where it is not practical or desirable to install a cable route across culverts, gullies, stormwater channels, third party utilities, or to use above ground troughing on posts, a bridge structure to support the GST shall be used.

The bridge structure shall be wide enough to carry the number of troughs required. The structure shall be of sufficient strength to avoid permanent deflection under the weight of all troughs plus 100% cable load in each trough plus two incidental loads of 150 kg, one at one-third span and one at two-thirds span. A safety factor of at least three shall be applied.

The bridge structure shall be supported on bearing plates, fixed at one end and free to expand or contract at the other. Matched expansion joints shall be provided in each trough.

26.10 Transition between different cable routes

An acceptable arrangement for transition between the GST and GLT is shown on Drawing 112000/8/1 and for transition between GST and buried route on Drawing 112000/8/2.

The transition between GST and ULX and URX shall be made with a purpose-built adaptor manufactured to the same material standards applying to GST. The adaptor shall be of sufficient size to accommodate all pipes, including spares, from the buried cable route, ULX, or URX. The adaptor shall extend from the cable route to within 300 mm of ground level.

The void between the adaptor and the pipes shall be sealed to prevent access to rodents.

Modifications to the GST route to accommodate the adaptor shall not result in cables being unsupported over lengths exceeding 600 mm.

Acceptable arrangements for GST entering pits are as shown on Drawing 112000/8/3. Where GST contacts the ground:

- it shall be painted with a protective bitumen coating to prevent corrosion
- an insulated section shall be included to prevent electrolysis.

26.11 Droppers

At some locations the local route needs to drop out of the main GST route. Where this occurs, GST droppers shall be used as follows:

- Local cables shall drop out of the GST section from the bottom face.
- Rigid conduit of the appropriate size shall be run from the GST to where it enters the ground.
- Where a conduit adaptor is used, the cable within the GST shall be protected from sharp or acute edge.
- The section of conduit from the GST to the ground shall have an additional means of protection by way of a metal shroud. The shroud shall be able to withstand impacts from flying debris and that from line trimmers when undergoing vegetation management. The base of the shroud shall have additional means of protection against corrosion such as bitumen paint.
- At the point of contact with the ground, the conduit shall have the following:
 - a small concrete pad around it to act as a small fire break and to prevent vegetation growth. This concrete pad shall be weather domed to prevent the accumulation of water
 - a site to which the metal shroud can be anchored in position.
- The arrangement shall prevent the entry of rodents.

Where more cables are required to exit the GST or larger conduits are used, a section of GST may be removed if the following applies:

- The GST is supported on either side of the break by way of additional posts.
- Through cables and cables that drop out of the GST have their weight fully supported.
- The tee section formed by the drop out is materially equal to that of the GST itself.
- If the tee section is in contact with the ground, it has additional means of protection against corrosion.
- There are no sharp edges.
- The arrangement is such that it does not permit the entry of rodents.

26.12 Arrangements at entries to location cases

Drawing 112000/14/3 illustrates the preferred arrangement for GST at the entries to location cases for typical site conditions. This arrangement shall be applied as far as possible for GST entries to all location cases.

Alternative designs may be used but shall take into account the following:

- access to the location
- the corrosive effects of dissimilar metals
- electrolysis due to metallic components in contact with the ground
- touch potential (location earthing)
- spare capacity
- point of cable entry with respect to weather and vermin proofing.

26.13 Fitting of lids

Lids shall be fitted onto GST and secured with 12 mm stainless steel strapping 100 mm from each end of each lid plus additional straps as required to ensure a maximum of 2 m intervals between straps.

Lids shall not be fitted until the cables have been inspected and signed off on the inspection and test plan.

Any insulated joints shall not be bypassed with the strapping.

Where the temporary fitment of lids is required during construction works, nylon cable ties of a suitable strength and durability may be used.

Adhesive tapes to temporarily secure the lids shall not be used.

27 Cable ladder (types 4, 5, and 6 cable route)

27.1 General requirements

Cable ladder shall be provided where clearance limitations prevent the installation of GST or other types of cable route, such as in tunnels and along platform walls.

Cable ladder shall be manufactured from marine grade aluminium or stainless steel or, in areas that are not subject to ground water leaching through the tunnel or platform wall, galvanised steel.

Ladder widths shall generally be restricted to either 150 mm, 300 mm, 450 mm, or 600 mm. However, other widths may be used if space limitations dictate.

Cable ladder shall not be installed within 1500 mm of the overhead wiring, except where the tunnel profile precludes this clearance being achieved. The design TAO shall assess potential earthing and bonding requirements if the cable ladder is installed within 1500 mm of the overhead wiring.

The ladder shall be of adequate strength to support the cable route when full to capacity with cable plus an additional load of 10% or 10 kg, whichever is greater, without permanent deflection.

Cable ladder cable route shall be generally constructed using the maximum available lengths of cable ladder. Shorter lengths of cable ladder shall only be used to accommodate changes in direction of the route, or to suit equipment positions.

Cable ladder shall be installed and supported in accordance with the manufacturer's specifications or recommendations.

27.2 Cable ladder environment

Cable ladder is generally required in areas where clearance limitations demand it. These areas include tunnels and along platform walls.

The environment in tunnels and platform walls suffers from the following:

- contaminated groundwater carrying highly corrosive products leaching through the wall
- stray electrical currents
- high levels of ground born vibration
- high velocity winds with buffeting from train movements.

The design, construction of, and the materials used in the cable route shall be suitable for this environment.

27.3 Cable ladder capacity

One or more cable ladders shall be installed to provide the necessary capacity to accommodate all the main and local signalling cables, and low voltage signalling power cables in the cable route, plus an allowance of not less than 30% spare capacity to provide for future requirements.

Separation of telecommunications cables shall be as required by TS 06210 and AS/CA S009.

27.4 Bends

The minimum radius of all bends in the ladder route shall comply with the requirements of Section 26.5.

All bends shall be smooth and rounded to prevent damage to or pressure on cables due to sharp corners or edges.

Changes in direction in the horizontal and vertical planes of the ladder route shall be constructed using the appropriate preformed bends and tees from the ladder manufacturer's range.

27.5 Joints, expansion joints, and insulation gaps

Joints in the cable ladder shall use the appropriate splice plate from the ladder manufacturer's range and be fixed using the recommended size of fastener. Fastener material shall not corrode or cause corrosion of the ladder in the environment in which the ladder is installed.

Expansion joints shall be installed in the ladder route at intervals of not greater than 100 m using appropriate splice plates and purpose designed fasteners. Attachment to brackets between expansion joints shall be purpose designed to permit movement of the ladder due to a change in temperature.

Air gaps of 30 mm to 40 mm shall be installed in the cable ladder route at intervals of not more than 300 m.

There shall be at least two insulated joints provided between any two signalling locations. The insulated joints shall line up with any other insulated joints in metal objects that run continuously between signalling locations.

27.6 Mounting brackets and fittings

Cable ladder brackets, supports, and fittings shall be of sufficient strength to support the loading specified in Section 26.7, without deflection or distortion of bracket or support.

Ladder supports shall be secured to concrete (except for pre-stressed or post-tensioned structures) using stainless steel expanding masonry anchors. Chemical anchors with stainless steel bolts shall be used in pre-stressed or post-tensioned concrete structures and in brickwork.

Attachment to steel structures shall be by clamp type fastenings.

Cable ladder brackets and supports shall be constructed of materials that are compatible with the ladder material and will not result in electrolytic corrosion under the installed environment.

All bolts shall include self-locking nuts or other nut locking methods.

27.7 Cable ladder in tunnels or through underbridges

Installation of cable ladder in tunnels or underbridges shall be carried out in accordance with TS 02390.

Cable ladder and ladder supports and brackets in tunnels or underbridges shall be installed clear of water springs, seepage, and weep holes. Support centres shall not exceed 2 m, except where it can be proven that the ladder to be used and the support system is capable of carrying longer spans with the loading specified in Section 26.8.

A minimum clearance of 25 mm shall be maintained between the cable ladder and the walls of the tunnel or underbridge.

The main cable ladder shall be mounted such that the lowest part of the ladder is at least 3800 mm above rail level. The ladder shall not obstruct access to personnel refuge recesses under any circumstances.

Cable ladder on an irregular or rough finished tunnel wall (such as a shotcrete finished wall) shall be maintained in generally straight alignment by using stand-off pillars as necessary.

The construction TAO shall ensure that all cable ladder, fittings, brackets, supports, and covers are securely fixed and fastened before trains are permitted to run on the track adjacent to the installation.

27.8 Transitioning between cable ladder and different cable routes

The transition between different cable ladder sizes shall be made using purpose-built adaptors from the ladder manufacturer's product range.

The transition between cable ladder and GST, GLT, pits, or buried route, including ULX and URX, shall be made using purpose-built adaptors fabricated from the same material as the cable ladder.

The transition between cable ladder and GST, GLT, pits, or buried route shall support the load requirements as specified in the appropriate section for the transition solution used. For example, if GST is used in the transition, see Section 26.10.

Adaptors used for transitioning to ULX and URX shall be of a sufficient size to accommodate all pipes from the ULX or URX, including spare pipes. Adaptors shall extend from the cable route to within 300 mm of ground level.

The void between the adaptor and the pipes shall be sealed.

Modifications to the cable ladder to accommodate the adaptor shall not result in cables in the cable ladder being unsupported over lengths exceeding 600 mm.

27.9 Cable ladder arrangements for local cable route and equipment

To allow for the local cable to drop out of the main cable route, purpose-built tee pieces from the manufacturer's product range shall be used.

27.10 Cable installation

Cables shall be attached to the cable ladder using stainless steel cable ties at intervals not exceeding 600 mm.

Cables shall be installed neatly in the cable tray and laid in such a manner that minimises the need for cables to cross other cables.

27.11 Vertical drops

Vertical drops of cable tray that exceed 2 m in length shall ensure that the cables are not exposed to undue stresses at the top transition point.

Manufacturer's requirements for unsupported cables shall not be exceeded.

When fixing the cables into position, strain relief measures shall be used to ensure the weight of the cable is not transferred to the top transition point until all fixings are in place.

27.12 Cable ladder covers

Cable ladder covers are only required where the bottom of the cable ladder is less than 2.4 m above the adjacent rail level or where the cables are exposed to sunlight or UV or unless otherwise specified.

Covers shall not be fitted until the cables have been inspected with details captured in the ITP.

Cable ladder covers shall overlap the adjacent covers (away from the direction of normal train movements) by a minimum of 20 mm. The cable ladder covers shall be secured with stainless steel straps, one 100 mm from each end of each lid plus additional straps as required to ensure a maximum of 600 mm intervals between straps for 600 mm wide ladder and a maximum of 800 mm intervals between straps for other ladder widths.

28 Pipe cable route

Pipe cable route shall only be used for local cable route.

The pipe shall be a 50 mm minimum diameter nominal bore medium galvanised steel pipe in accordance with AS 1074. The pipe shall be attached to the platform coping wall and tunnel walls using full saddles at centres not exceeding 1500 mm. Saddle connections shall also be installed adjacent to each side of any change in direction of the pipe and adjacent to any connection to equipment.

Saddles, other than those at changes in direction, shall allow for pipe expansion and contraction. Where necessary, an expansion sleeve shall be provided in the pipe.

The saddles shall be attached to the walls with stainless steel chemical anchors with 8 mm diameter stainless steel bolts (brickwork).

Note: Drilling into platform walls would be subject to approval of the maintenance RIM civil design lead.

Where pipe sections are to be joined, threaded couplings shall be used. Exposed ends of pipes where a thread has been cut and the protective galvanised coating removed shall be protected from corrosion by the application of a protective coating such as cold galvanising paint.

Application of the cold galvanising paint shall uniformly cover the entire exposed area around the cut thread. Coating thickness shall be such to provide the required level of protection against corrosion.

29 Underline and under-road crossings

29.1 General requirements

ULX and URX shall be designed and installed in accordance with TS 02390.

Whenever excavation of the track formation occurs, the formation shall be restored with materials in accordance with TS 01640 and TS 01608. Any geotechnical fabric encountered during excavation shall be replaced with like material, which overlaps the original by at least 300 mm.

Ballast shall not be replaced until the trench or excavation has been filled and compacted level with the top of the capping layer.

ULX and URX may be constructed by boring, except where:

- access for boring machinery is not available
- the nature of the terrain or the size of ULX or URX renders boring impractical
- the risk of striking existing services is considerable.

Boring shall be carried out in accordance with TS 02390. The executed DSS plan and associated bore logs shall be submitted in accordance with the relevant rail infrastructure maintainer's procedures.

ULX and URX shall use either UPVC or HDPE pipes of sufficient wall thickness so that no loss of cross-sectional area occurs and there is less than 10% loss of diameter in any direction under track or road impact loadings.

ULX and URX shall include a minimum of 25% spare capacity. As a minimum, there shall be three spare pipes in main route ULX and URX and one spare pipe in local route ULX and URX. No spare pipes are required for individual track circuit feeds or tail cables to individual pieces of equipment.

Where a single large diameter pipe is installed by boring, spare capacity in this pipe, provided it is not less than 50% of the cross-sectional area, may be used in place of additional pipes. Following the cable installation, the spare capacity in large pipes shall be sealed at each end of the pipe.

Steel pipe shall not be used for a ULX under or within 1 km of electrified areas.

Spare pipes shall be cleaned, fitted with a polypropylene draw rope that is anchored at each end of the pipe and then sealed with proprietary end caps to prevent the ingress of dirt, and so on.

29.2 Depth of crossings

The top of ULX pipes shall be a minimum of 1600 mm below rail level or 800 mm below ground level, whichever is the deeper.

The top of URX pipes shall be not less than 800 mm below road or natural ground level, whichever is the deeper. Buried route on each end of the ULX or URX shall be graded as required to line up with the ULX or URX pits or cable route.

Pipes shall be provided in the ULX and URX to segregate the various cables as specified under Section 21.3.

Water shall not be used to soften the under-track or under-road formation for boring purposes.

29.3 Installation by trenching

If it is not practical to install an underline or under-road crossing by the boring process, the ULX or URX shall be installed by trenching, backfilling, and compaction in accordance with the provisions of Section 19.11, as applicable.

In continuous rock areas, the authorising CCB may grant permission for the depth of ULX and URX to be reduced. In such cases, the pipes shall be placed in a trench chased into the rock and encased in concrete with a minimum concrete cover of 75 mm or greater from the natural surface.

The construction TAO shall submit a completed 'Inspection report – trenched underline crossings' form as shown in Appendix B. The form shall be completed during the construction of the ULX and be submitted not later than the next working day.

Monitoring of the ULX shall be done in accordance with the relevant requirements in TS 03505.

29.4 Underline crossings

Underline crossings shall comply with the requirements in TS 02390 and TS 03505.

ULX pipes shall extend not less than 4 m beyond the outer rail on each side of the track, except where the TfNSW rail corridor ends within 4 m or there is a physical obstruction that precludes this requirement.

A cable pit in accordance with the provisions of Section 30 shall be provided at each end of main cable route ULX pipes.

A cable pit is not required for a ULX that is installed for a local cable route.

Where the ULX originates from GST or GLT, a dropper may be used instead of a pit. The ULX shall comprise of no more than two conduit bends.

29.5 Under-road crossings

If a cable route is to be installed under a roadway, it shall be planned and constructed so as to cause the minimum disruption possible to the users of the roadway.

The design TAO shall liaise with the roadway asset owner to obtain approval for the URX and the construction methodology.

URX pipes shall extend under nature strips and pathways into TfNSW property on each side of the roadway so as to provide a cable pit at each end of the URX that is wholly within TfNSW property. Where the URX is wholly within TfNSW property, the cable pits shall be at least 2.4 m clear of the roadway edge.

Where TfNSW property is unfenced or where the URX is wholly within TfNSW property, bollards shall be installed on the roadside of the pits to protect them from vehicular traffic.

30 Cable pits, cable jointing pits, and cable turning chambers

30.1 General requirements

Except where the width of the TfNSW rail corridor precludes, pits that are installed in the main cable route shall not be located within 3 m from the nearest rail of any track.

At some locations, cable route requirements or local site conditions are such that this 3 m requirement cannot be met. Where this is the case, the design TAO shall confirm that the pit, in its planned position, can withstand the expected static and dynamic loads placed against the pit wall. The dynamic load is the live loading from passing trains.

Smaller pits used as part of the local cable route may be installed within this 3 m requirement but only if the design TAO confirms that the pit size and its location will not undermine the footing or foundation of any nearby structure and that the pit is capable of withstanding the static and any dynamic loads impressed on it.

The positioning of these smaller pits closer to the track shall take into account the need for track maintenance, the need for sleeper removal or replacement, and the space provisions required by mechanised track maintenance vehicles.

Evidence of the analysis shall be submitted in the design report and approved by the relevant CCB.

Telecommunication cables shall not occupy pits with signalling or power cables unless the separations specified are maintained or by subducting in conduit within the pit.

High voltage power cables in pits shall not be installed with low voltage and signalling cables.

Pits shall be designed and constructed in accordance with the requirements detailed in TS 06213.

30.2 Location of cable pits

Cable pits shall be provided as follows:

- at each end of main cable route ULX and URX
- at intervals of not greater than 300 m
- at interfaces with other type cable routes
- where routes change direction.

Additional pits, as required to facilitate cable installation and access, shall also be provided.

Cable pits are also required at entries to equipment buildings but, unless otherwise provided for in the project's scope of works, the construction of these shall form part of the work covered by the relevant building specification.

Small cable pits (typically 600 mm x 600 mm x 600 mm) are also required at or near a signal base for the marshalling of trackside equipment cabling such as track circuits, axle counters, points machine, trainstop, and balises.

The position of these pits shall not weaken the foundation of the signal.

30.3 Alternate arrangements

Where site constraints are such that a pit cannot be installed, alternative arrangements may be used if the following applies:

- there are no more than two 90-degree bends in the ULX or URX
- that the size and number of cables to be pulled in can be done so without exceeding the maximum pulling tensions.

At transitions from surface run (GST or GLT) and buried cable routes, where a pit cannot be installed, alternative arrangements may be used if the following applies:

- the section of buried route is in alignment with the surface run route (that is, it is a 'straight pull')
- the transition angles down
- the section of buried conduit that angles towards the surface has additional mechanical protection over the area where it is not to depth
- a perimeter concrete pad is constructed to allow the interfacing of GST or GLT.

30.4 Pits in trafficable areas

When sighting the location for a pit, the need for maintenance vehicle access shall be taken into account. A pit shall not be installed on a maintenance vehicle access road unless there is no other option for its position. In this case, the pit and cover shall be designed, built, and installed to carry the intended trafficable loads.

In all other locations, a light duty cover shall be used. In addition, the pit shall be protected from being driven over by using bollards.

30.5 Location of cable jointing pits

Cable jointing pits shall be provided wherever a cable is to be jointed and a suitable cable termination cabinet does not exist.

If vehicular access for the joining of cables is needed, cable jointing pits shall, where possible, be positioned where road access is available.

30.6 Location of cable turning chambers

Cable turning chambers shall be installed in buried, GLT, GST, and cable ladder routes wherever cables are required to change direction sharply and either of the following applies:

- The minimum bend radius for the cable cannot be achieved within the GLT, GST, or cable ladder
- the cable is likely to bear heavily against sharp edges at the bend.

Additional cable turning chambers shall be installed where specified in the approved for construction documentation.

30.7 Construction of cable pits, cable jointing pits, and cable turning chambers

Cable pits and cable turning chambers shall be made from precast concrete, concrete cast in situ, brick, concrete block, GRP, GRC, or polyester cement depending on the size, location, and loading to which the pit cover will be subject.

Reinforced pre-cast concrete cable pits shall be manufactured according to TS 06213.

Concrete, concrete block, and brick pits and cable turning chambers shall have a concrete floor of not less than 75 mm thick.

FRP, GRC, and polyester cement pits and cable turning chambers shall be bedded on stabilised sand not less than 75 mm thick.

Cast in situ concrete pits and cable turning chambers less than or equal to 1500 mm deep shall be constructed with a minimum wall thickness of 100 mm with a layer of F82 galvanised mesh

reinforcement. The reinforcement shall be located to provide a minimum cover of 50 mm from the outside of the wall.

Cast in situ concrete pits and cable turning chambers deeper than 1500 mm shall be constructed with a minimum wall thickness of 150 mm with two layers of F62 galvanised mesh reinforcement. The reinforcement shall have a cover of 50 mm.

Pits and cable turning chambers constructed from brick or concrete block shall include appropriate steel reinforcement.

The internal size of all pits and cable turning chambers shall provide for the minimum bending radius of the largest cable to be installed in them. The following requirements also apply:

- Any pit more than 600 mm deep shall be large enough to provide for a person to stand in the pit clear of cables.
- The minimum internal diameter of round pits in main cable route shall be 1000 mm to a depth of 1500 mm, or 1200 mm if over 1500 mm.
- The minimum internal size of square or rectangular pits in main cable route shall be 1000 mm x 1000 mm to a depth of 1500 mm, or 1200 mm x 1200 mm if over 1500 mm.
- Pits associated with GST to location case interface shall have minimum dimensions of 600 mm x 600 mm as shown on Drawing 112000/14/3.

The depth of pits and cable turning chambers shall be to suit the depth of buried cables, pipes, as applicable.

The top of each pit or cable turning chamber shall be 100 mm to 200 mm above the surrounding ground level, except on platforms, paved areas, pathways or roadways, sealed or unsealed.

On platforms, paved areas, sealed or unsealed pathways and roadways, the top of lids shall be flush with the surrounding ground level. The pit and lid shall be load rated to the vehicular or pedestrian load applying to the location.

All cable entries into pits and cable turning chambers shall have large radius rounded edges to prevent damage to cables during installation and to eliminate the danger of cables bearing on sharp corners or edges after installation. The ends of pipes and conduits shall be de-burred and chamfered.

Where pipes or GLT enter pits or cable turning chambers, the pipe ends or GLT shall be encased in concrete for a distance of not less than 300 mm to hold them securely in position.

An approved bracket or tray shall be built into the side of each cable jointing pit for securing the optical fibre cable joint unit. This shall be 200 mm from the top of the pit on the opposite side to the cable route.

Drainage arrangements shall be provided at the base of each pit and cable turning chamber.

These shall include installing drainage pipes to the nearest approved railway drain or to a public

stormwater drain or natural drainage course, where possible. If no suitable drains exist, a gravel drainage sump or pipe to the side of an embankment shall be installed where applicable. Gravel drainage sumps shall consist of 20 mm aggregate with a minimum depth of 300 mm.

To provide for the support of cables in the vertical plane, purpose-made brackets and fittings shall be supplied and installed, at intervals of not greater than 600 mm. Alternatively, cable trays or ladders may be used.

Pits and cable turning chambers in excess of 750 mm deep shall have rungs cast into the wall at 300 mm (maximum) centres to permit safe and easy entry and exit from the pit or chamber. The rungs shall be a minimum width of 300 mm, constructed from 20 mm diameter galvanised steel rod or other approved material. Alternatively, a galvanised steel ladder fixed securely to the wall at the top and the bottom of the ladder may be provided. If provided, the ladder shall have a minimum width of 300 mm, with 20 mm diameter rungs. It shall be of a length that suits the space in which it is to be used.

30.8 Covers

All cable pits and cable turning chambers shall be provided with removable covers.

In platforms, other paved areas, sealed or unsealed roads and pathways, 'Gatic' covers or covers of similar construction shall be used. Covers shall be rated for the vehicular or pedestrian load applicable to the location.

Covers on all other pits and cable turning chambers shall be capable of carrying incidental live loads of 1.5 kPa. Covers shall be sectioned as necessary to limit the maximum weight of each section to 45 kg.

Gatic or similar covers shall be provided with recessed sockets or eyes for lifting with appropriate tools. All other covers shall be provided with recessed or retractable handles so that the cover can be removed without tools.

Except for covers in platforms, paved areas, sealed or unsealed roadways and pathways, covers shall be secured to pits and cable turning chambers with padlocks to guard against theft and vandalism.

30.9 Erosion of embankments

Where pits and cable turning chambers are installed on embankments, protection against erosion around and adjacent to the pit and special drainage arrangements shall be provided so that there will be no undermining or deterioration of the embankment during periods of heavy rain.

31 Temporary cable routes

31.1 General

Temporary cable routes may be required to be installed in the following situations:

- in an emergency after infrastructure damage
- to relocate services out of a construction area
- during staging while rebuilding cable routes.

31.2 Design requirements

Main cable routes require a higher degree of security than tail cables. Temporary routes shall be designed to achieve the following:

- physically protect the cables from damage due to plant and equipment, vehicles, fires, vandals, and other hazards
- not impinge or alter the safety elements of other discipline infrastructure, including the track structure, drainage, or electrical clearances
- not impact public or maintenance access
- not decrease the level of safety for maintainers, unless controlled in an agreed manner
- be removed as soon as they are no longer necessary.

Arrangements for temporary cable routes shall include the following:

- Supports or a firm foundation shall be used that enable the route to retain alignment and not distort or collapse under the cable load. This includes troughs, which shall retain their shape from external pressure as well as the whole route structure itself.

Note: Ballast is not usually a suitable support.

- Cable routes shall not perform secondary functions such as footpaths, ballast barriers, and so on.
- Physical barriers (for example, jersey kerb type) shall be provided to limit vehicular access, except at specially constructed vehicle crossings. Barriers shall be continuous, except where openings are provided for access by personnel. Such openings shall not be wide enough for vehicles.
- Where relevant, temporary routes shall be located near the boundary fencing.
- Cable routes or troughs shall be sealed closed by metal straps.
- Where a temporary route is a shallow underground route, protection shall be applied as if it were on the ground. Warning signage shall be provided at intervals not greater than 50 m.

- Warning signage shall be provided for people and vehicles to avoid the area.
- Steel troughs shall have fibre cement sheeting included, and no sharp internal edges or protrusions.
- Steel troughs shall be designed and installed in accordance with Section 26.
- Procedures shall be put in place to control work and access that may affect the cable route.
- All works involving telecommunications cable shall comply with TS 06210 and AS/CA S009.

Where relevant, a new final route shall be constructed first to permit the cable to be relocated once, at the beginning of a project to minimise the duration of the temporary route.

Planned temporary cable routes shall be risk assessed so that the risk of damage to the route is minimised over its life, and there is either no impact on other infrastructure or any impacts are controlled.

The maintenance RIM shall be included in any risk assessments and give approval for any temporary cable routes. The signalling asset engineer shall be consulted regarding regular maintenance inspections and repairs to be done by the installer.

Temporary cable routes (other than tail cables) to be installed in the danger zone shall be approved by AMB.

32 Cable installation

32.1 General requirements

As a minimum, cable installation shall comply with TS 06210, AS/CA S009 and AS/NZS 3000. The requirements specified in this document, however, exceed the requirements in those standards.

Main cables shall be installed in a properly designed and constructed cable route. The main cable route shall be parallel to the railway and close to the boundary. Tail cables from housings to equipment shall be laid in the main cable route, except where required to leave the main cable route to access the equipment. Such tail cable routes shall be as direct as possible and at 90 degrees to the lie of the track.

Cables shall not be installed until the construction of the cable route has been certified.

Following the installation of the cables, the cable route shall again be inspected and certified prior to the backfilling of trenches or the fitting of lids, as applicable.

Certification shall be documented on the ITP.

Cables shall be laid in accordance with the cable laying diagrams. The diagrams shall nominate cable sizes to provide a minimum of two spare cores or 10% spare cores in each cable, whichever is the greater.

Telecommunications cables shall be installed under the direct supervision of a person licensed by the Australian Communications and Media Authority. Telecommunications cables shall be installed in accordance with AS/CA S009.

Flexible air lines shall be laid in cable routes. Where pipes are installed or a GST route is installed, the main air lines shall occupy a separate duct or pipe to the other cables. Flexible air lines shall not be laid unprotected or exposed to sunlight.

32.2 Telecommunications cables

To ensure telecommunications cables are not overstressed or damaged during installation, cable pit separation shall be designed to limit cable pulling tension and account for the following values:

- cable pulling tension limits
- tension due to straight sections, curves, and bends
- conduit and cable coefficients of friction
- reducing coefficients of friction using lubricants
- feed tension
- jamming
- weight correction factor or occupancy factor due to existing cables.

32.3 Protection of cables

Cables shall not be placed in any position, prior to laying, where they may be run over by vehicles or other machinery or where they are laying on sharp objects or over sharp edges. If a cable is run over at any time or otherwise damaged, then that cable shall be replaced before it is laid into the trench or troughing.

Cables shall be laid neatly, flat and parallel in trenches and troughing. Interlocking or bunching of cables shall be avoided at bends or corners in the cable route and at entries into relay rooms and equipment buildings.

32.4 Order of laying

In buried cable route, ULXs and URXs, telecommunications cables shall be installed in the shallowest pipes. All other cables shall be installed in the deepest pipes prior to using other pipes. Pipes shall be sealed immediately following cable installation.

Cables shall be arranged to permit easy access for the installation of additional cables or air lines in the future.

Main cables shall be laid first in trenches and troughing with the local cables laid on top.

Unless otherwise approved, all telecommunications cables shall be laid so that the outer end of the cable on each drum is at the Sydney end of the route.

32.5 Running of air line in trough or pipe

Where air lines are installed with cables, the air lines shall be laid on top and the cables arranged so that they will not crush the air lines or otherwise restrict the flow of air through them. Also, cables shall not restrict access to air line drainage devices installed in pits.

32.6 Bonding cables

In buried cable areas only, long series bonds (longer than 8 m) shall be laid in the main or local cable trenches and terminated at each end in bootleg risers located at a distance of 2.5 m from the nearest rail.

32.7 Length of cables

Sufficient length shall be allowed on the cable ends for the cables to be run to their final destination and be terminated on equipment, equipment racks, MDF blocks, and so on, as applicable.

Ends of cables (excluding fibre optic cables) to be jointed shall overlap a minimum of 1 m.

Ends of fibre optic cables shall overlap a minimum of 5 m. In areas of poor access, additional cable overlap shall be provided.

32.8 Cable joints

Joints in cables shall be kept to an absolute minimum.

New cables or new cable routes shall not include joints unless the length of the run exceeds a standard drum length.

Joints in power distribution cables shall be avoided to minimise earth leakage faults.

There shall be no joints in cables under rivers, creeks, flood-prone areas, under roads or railway tracks, within conduits, in buildings, in tunnels, within 10 m of any earth mat, or in areas where the earth potential rise exceeds the 430 V contour. Cable lengths shall be arranged accordingly. Cable termination boxes shall be provided where necessary.

Un-terminated ends of all cables shall be neatly coiled and securely fixed to prevent damage. They shall be sealed with approved heat shrink end caps to prevent the ingress of moisture before and after the cables are laid.

Flexible air lines shall not be jointed in pipes or pits.

32.9 Relocation of existing routes

If a section of the cable route needs to be relocated, a joint may be used.

In addition to the prohibited areas for joints as detailed in Section 32.8, any cable joints in a pit shall be held clear from any water which may pool in the bottom of the pit. The joint shall be fixed high in the pit.

Cable joints shall not be included in pits in areas of high water.

32.10 Protection of cables during installation

Signalling and telecommunications cables shall be installed by hand pulling or by using mechanical tension limiting winches.

The limits of the mechanical properties of the cables as specified by the cable manufacturer shall not be exceeded, particularly the maximum tensile rating, the maximum twist, the crush and impact resistance, and the recommended minimum bending radius of each cable.

Unless otherwise specified, the minimum bending radius for any cable shall be the cable manufacturer's recommended minimums for pulling and for fixed installation.

During cable pulling, cable drums shall be supported on a horizontal shaft and turned by manually or mechanically rotating the drums to feed out the cable. Drums shall not be rotated by pulling the cable. Cables shall not be flaked off the drum under any circumstances.

Cables shall be fully supported clear of the ground and other cables during pulling operations by the use of cable rollers or other approved means.

Pipes into which cable is to be hauled shall be proven for adequate bore and cleanliness prior to cable installation by drawing a test mandrel 240 mm long and 90% of the nominal internal diameter of the pipes through the pipes prior to cable hauling. Cable pulling lubricant shall be used to lubricate all cables being hauled through pipes or conduits.

Cables shall not be laid on or pulled over any projection, edge, or corner or subjected to any localised compression.

When pulling cable through pits, rollers or guides shall be used to prevent the cable from rubbing on the ends of conduits, pipes, or on concrete surfaces.

Optical fibre cable shall be handled so as to avoid tension, crushing, kinking, and bending outside the limits that will cause irreparable damage to the optical fibres.

Optic fibre cable shall be fitted with hauling eyes. When the cable requires hauling, a minimum twist draw rope shall be fitted to the hauling eye using an approved swivel. Connection to the cable shall not be by any other means.

A flexible tube shall be used for protecting and leading the optic fibre cable down to a duct entrance.

32.11 Labelling of cables

A form of permanent and unique identification shall be applied to both ends of every length of cable. This shall be as near as possible to the ends of the cables but clear of any part that may be trimmed off when the cables are terminated.

The cable identification shall remain clearly legible for at least three years after installation with complete exposure to the elements. Identification shall be clearly visible when installation is complete.

Cable identification codes shall be in a standard format to the requirements of the maintenance TAO.

Labelling shall be in accordance with the requirements of TS 05166.

33 Testing of cables

33.1 General requirements

All cables shall be tested on the drum before laying to ensure compliance with the cable specification.

The cable ends shall be recapped (using heat shrink end caps) after testing unless such ends are located inside weatherproof buildings or location cases and the cable ends are not laying on the floor or in cable trenches in relay rooms.

33.2 Cables with copper conductors

Cables with copper conductors shall be continuity and insulation tested in accordance with the requirements of TS 05313 and TS 05314.

33.3 Optical fibre cables

Optical fibre cables shall be tested in accordance with TS 06212.

33.4 Test records

Test results shall be maintained in logical order. The results shall be available at all times for inspection.

For signalling cable and cable routes, the work packages process as detailed in TS 05316 shall be used. Records and photos of the installation shall be captured as part of the ITPs.

34 Bollards

Bollards are used to protect cable route assets. They shall be provided where specified or directed. Typical locations where bollards are required for installation are:

- cable pits
- route transitions from buried to surface run
- signalling equipment locations.

The bollards shall be constructed of greater than or equal to 100 mm nominal bore heavy galvanised steel pipe in accordance with AS 1074. Bollards shall include caps. In-ground bollards shall be concreted 1 m into the ground.

The minimum height above ground level shall be 1.2 metres. The bollard shall be finished in gloss white enamel.

35 Removal of redundant material, equipment, and surplus spoil

35.1 General requirements

Unless otherwise stated in the project's scope of works, all redundant signalling and associated telecommunications equipment shall be removed from the contract area and sorted. Re-useable equipment shall be stockpiled at locations nominated by the regional representative. The remainder of the recovered equipment shall be disposed of progressively and expeditiously.

The work shall include the removal and disposal of any carcinogenic or environmentally hazardous material, or any equipment contained therein.

35.2 Time limit

A time limit of 28 days shall apply to each and every separable part of the works with regards to the clean-up of material made redundant by the commissioning of the particular separable part of the works. This time limit shall not apply to existing cable route or cables where in-service cables continue to pass through the newly commissioned area. All redundant material shall be removed within 28 days of the final commissioning.

35.3 Reclaimable equipment

The regional representative shall nominate which redundant material and equipment is required for reclamation and reconditioning. This material and equipment shall be carefully removed, transported, and unloaded at a nominated storage site, within a 20 km radius of the worksite.

All redundant material not nominated by the regional representative as being required for reclamation or reconditioning shall be removed by the construction TAO. The material shall be the property of the construction TAO.

35.4 Disposal of equipment and materials

The disposal of redundant signalling assets is the final element in the whole-of-life cycle.

Equipment to be demolished and removed shall include, but not be limited to, disused cable, alternating current cable, GRC and steel troughing and supports, cupboards and location cases, signals, signal gantries, ground frames, releasing switches, trainstops, impedance bonds, telecommunications facilities, walk-in enclosures and buildings, redundant fencing material, unsuitable backfilling material, and surplus spoil.

Any water, sewerage, and gas services shall be disconnected and sealed in accordance with the utility owner's requirements.

Disconnection of electricity supplies shall be arranged by the regional representative. No demolition work shall commence until disconnection is confirmed.

Signal gantries and all attachments shall be removed to foundation level.

Signal gantry foundations shall be removed to a depth of 200 mm below the immediate adjacent ground level.

Equipment post footings, troughing route post footings, and other similar small footings up to 600 mm deep shall be removed entirely.

Concrete slabs shall be removed entirely. Perimeter footings shall be removed to at least 500 mm below ground level.

All depressions and excavations, resulting from the removal of redundant buildings and equipment, shall be filled and compacted to the levels of the surrounding ground. The backfill used shall be consistent with the surrounding ground.

Redundant material and spoil to be removed from TfNSW's property shall be disposed of responsibly at an approved location.

35.5 Reclamation of de-commissioned cables

All decommissioned cables shall be reclaimed.

Prior to reclamation, a risk assessment shall be conducted that takes into account the potential damage to any working cable during the removal of the now redundant cables. The identified risks shall be managed accordingly.

An agreement shall be reached by way of the approving CCB for any decommissioned cables to be left in situ. For example, a direct buried cable in a non re-enterable cable route.

A report that includes the following information shall be submitted to the approving CCB:

- the likely impacts to any future use of the rail corridor
- justification for leaving the now redundant cables in place
- an assessment and estimate to the ongoing whole-of-life costs to TfNSW for any serviceability requirements for the now redundant route.

Note: An example of this would be the costs incurred by another project intending to excavate in the area of the decommissioned route and the work required to confirm that a section of the route is in fact decommissioned.

The route shall then be identified on the DSS plan as a redundant route.

36 Location data recording

The location data recording of underground cables and cable enclosures shall comply with TS 01547.1.

Appendix A Corrosion (informative)

A.1 General

Metallic cabling schemes in the rail corridor can be exposed to levels of accelerated corrosion that, if not treated correctly at the time of installation, can lead to a premature failure of the cable route and drastically shorten its life.

The main forms of corrosion are described in sections A.2 to A.6.

A.2 Age-related corrosion

Age-related corrosion is a typical form of corrosion that occurs when metals are exposed to the environment over many years.

A.3 Electrolysis

Electrolysis occurs when dc traction return currents find a path to earth. Corrosion due to this effect is managed by the following means:

- breaking up the continuity of the GST
- ensuring that any metallic component either does not touch the ground or has additional treatments applied.

A.4 Galvanic corrosion

Galvanic corrosion occurs when two dissimilar metals are in contact with each other. This type of corrosion is best managed by selecting materials that avoid this from occurring.

A.5 Crevice corrosion

This occurs where there is a difference in oxygen levels. It typically occurs around GST posts. The effect is magnified when water is allowed to pool around the base of the post. This type of corrosion is best managed by weather-doming the concrete footing around the post to prevent water from pooling.

A.6 Environmental factors

Some lines that are very close to the coast and exposed to high concentrations of salt-laden air can accelerate corrosion and shorten the life of anything metallic exposed to this environment. To avoid this from occurring, alternative products or solutions should be taken into account for installing cable routes around these locations.

Other locations have localised high levels of pollution such as around steel mills where the particulate matter in the air can attack the metal troughing, significantly shortening its life.

Also, some soil types can be reactive and lead to corrosion, and so have an effect on the materials selected for use in these locations.

When designing the cabling scheme, the design TAO should take into account these forms of corrosion and prepare a design to prevent them from occurring.

Appendix B Inspection report – trenched underline crossing (normative)

Excavation

Trench depth*

Ballast depth*

Trench width

Type of soil.....

Final cross-section

Depth to top of pipe(s)*

Type of cover (fill) used over pipe(s)

Type of fill used to top of formation

Width of pipe(s)

* Measured from bottom of sleeper

Distance from centreline of nearest structure

Type of structure and ID number

Shoring used Y/N Baulks used Y/N

Method used to compact ballast under sleepers

.....

Follow up inspections 24 hours 72 hours

2 weeks

Length of ULX No of pipes

Size of pipes

Distance extended outside running face Up Down

Depth of each fill layer

Method of compaction

Provide a plan view of the ULX including any other services in the vicinity.