DESIGN DOCUMENTS

CONTRACT NO. WT22-17/18

TECHNICAL SPECIFICATIONS

Works Specification
Civil Works Specification
Pipework Specification
Structural Concrete Specification
Structural Steel Specification
Mechanical Specification
Pump Station Functional Specification
Electrical Switchboard Design and Installation Specification
Electrical Design and Installation Specification
Magnesium Hydroxide Specification
WORKS SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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1 General

The work described in this Works Specification includes, but is not limited to, the design, supply of materials and equipment, construction, testing, pre-commissioning and commissioning of the pump stations, rising mains and gravity sewers.

The scope of this Contract is for the design, supply, construction, installation and commissioning of the civil, structural, mechanical and electrical works required to produce fully functional pumped sewage transfer system.

1.1 Order of Works

The Contractor shall ensure that operation of the existing sewerage systems are not adversely impacted by the Contractor’s activities during the implementation of the project.

The Contractor shall plan the works, provide all necessary temporary works and pumping systems, maintain and operate pumping systems, remove the temporary works and pumping systems when they are no longer required and reinstate any area disturbed by the temporary works. For all pumping systems a standby system shall be available on site at all times the permanent pump stations are not operational.

In general, start construction work from the furthest downstream point and connect incoming sewage after all the Works have been constructed, tested and accepted. Sewage discharge connections to the existing infrastructure shall be made prior to in-situ pump performance testing.

1.2 Standards, Codes and Regulations

Unless specified or agreed otherwise, all equipment, installations and site work shall comply with the most recent revision and amendments of the referenced AS, AS/NZS, Codes, Regulations and other international standards, codes and regulations. Where the specification includes no reference to a standard, then the most relevant standard shall apply as determined by industry best practice.

The Contractor shall be responsible for ensuring that all equipment and materials supplied are in complete accordance with the requirements of all relevant Authorities.

1.3 Engineering Inspection and Certification

The Contractor shall engage suitable competent persons to perform:

- Level 1 inspection and testing to AS3798-2007 for all earthworks, including that below all buildings and structures;
- independent third party RPEQ certification for all building and structural works; and
- for all WUC associated with Contractor’s Approvals requiring certification.
Details of proposed competent persons shall be provided by Tenderers within the Tender Submission Documents.

2 Materials

All materials and equipment used in the works shall be in accordance with the current and relevant specifications of the Standards Association of Australia for those particular items and classes of material, where such specifications are applicable and do not conflict with this specification. If there is no Australian Standard Specification then the relevant British or ISO Standard Specification shall apply.

All equipment and materials supplied under this Contract shall be suitably protected from corrosion or deterioration from the presence of sewage and the environment. Protective coatings shall be types suitable for the surfaces to be protected and the prevailing conditions.

3 Site Specific Requirements

3.1 General

The Contractor shall provide and maintain in good order all access roads, sidetracks and detours required for use by his plant and personnel and authorised public or other traffic.

The Contractor shall obtain landowner agreement prior to entering private properties.

The Contractor should be aware that there are operating sewage pump stations and trunk sewers and as a result there are some health risks associated with working within this environment. The Contractor shall ensure that all staff and sub-contractors are aware of these risks, and properly instructed on managing these risks.

3.2 Site Establishment

Site establishment shall include the following:

- Transport of all personnel, plant, equipment and materials to and from the site;
- Establishment and disestablishment of all site offices and facilities including electrical, communications, water and sewerage services;
- Sanitary facilities, shelters, storage facilities and the like;
- Materials, equipment and plant laydown and hard stand areas
- Temporary fencing and site security
- Maintenance of site facilities, access roads;
- Any other works and activities required by the Contractor to establish and dis-establish from site.

The Contractor’s construction facilities shall be located in an area to be agreed by the Principal’s Representative, and the landowner or relevant authority (if applicable). All
approvals to temporarily occupy land for construction facilities shall be the responsibility of the Contractor.

The Contractor shall be responsible for the security of the Contractor’s Work Area and of constructional plant and materials and shall provide such attendance, fencing and locks as may be needed.

Dis-establishment shall include the removal of all equipment, offices, workshops, buildings, services and all temporary accesses and full reinstatement of all areas to a standard at least that prior to the Contract commencement.

3.3 Approvals

The Contractor shall be responsible for securing all applicable approvals.

Approvals include (but are not limited to) Building Compliance Certification Form 16 Approval.

3.3.1 Activities in Watercourses

The Contractor shall meet all necessary Queensland Government requirements for carrying out an activity within or adjacent to a watercourse, lake or spring in accordance with ‘Guideline – Activities in a watercourse, lake or spring carried out by an entity’.

3.3.2 Department of Transport and Main Roads

The Contractor shall comply with the requirements of Queensland Department of Transport and Main Roads (QDTMR). Specifically the Contractor shall obtain an Ancillary Works & Encroachment (AWE) Permit and meet all necessary Main Roads Conditions for works in road reserves. The Contractor shall comply with the Department of Transport and Main Roads Conditions of Approval for Works within State-Controlled Road Reserves (Installation of Pipeline/Conduit).

3.3.3 Existing Asset Owners

The Contractor shall obtain the appropriate approvals from all existing asset owners as necessary.

3.3.4 Power and Water Services

The Contractor shall be responsible for sourcing and providing all of its power (all types) and water requirements whilst constructing the works.
4 Site Works

4.1 General

The Contractor shall undertake Civil Works, including but not limited to:

- Bulk Earthworks
- Roadworks including concrete, gravel pavements and surfacings
- Kerb and channel
- Stormwater drainage including pipes and open drains
- Subsoil drainage
- Remediation of disturbed areas.

Works shall be in accordance with this specification and in accordance with the Technical Specification - Civil Works.

4.2 Drainage

Drainage works shall be undertaken in accordance with the Technical Specification - Civil Works. Notwithstanding the requirements of Technical Specification - Civil Works all concrete for drainage structures, excluding kerb, kerb and channel, but including kerb crossings shall be a minimum of N32.

5 Concrete Works

5.1 General

Works shall be in accordance with this specification, and in accordance with the Structural Concrete Specification.

All concrete with the exception of totally concealed area, shall have a class 3 surface finish in accordance with AS 3610.

Notwithstanding anything to the contrary in the specification the Technical Specification - Structural Concrete, concrete and concrete work shall be classified as pathways, anchor blocks, cable pits, zero manhole, wet well, valve chamber, building slabs and conversion of existing infrastructure.

All concrete shall be supplied by a suitable readymix supplier with certified mix designs. All concrete shall not be mixed, or remixed on site.

Backfill around concrete structures to the full extent of the excavation shall be compacted to a dry density ratio of not less than 95% (standard compaction) or a density index of 70%. Cement-stabilised sand shall be compacted beneath concrete structures in layers not more than 150 mm thick.
5.2 Anchor Blocks

The Contractor shall be responsible for design and construction of suitable pipeline restraints at all locations where unbalanced thrust forces exist and transmit all thrust loads to the adjacent native soil or rock.

Thrust blocks shall be constructed in accordance with WSAA standard drawings.

5.3 Cable Pits

The Contractor shall construct reinforced concrete cable pits complete with sealed access covers where required.

The Contractor shall excavate as required to construct the cable pits. Care should be taken during construction of the pits and during backfilling and compaction to ensure that no damage occurs to conduits or electrical cabling.

5.4 Pump Station Wet Well

The Contractor shall design and construct pump station wet wells as per the design documents.

All the Pump station wet wells shall be of reinforced concrete.

The Contractor shall construct a reinforced concrete slab on top of the pump well. The top surface of the slab shall be finished with a steel trowel and broom finish to create a non-slip surface. The Contractor shall provide mass concrete benching at the base of the wet well.

5.5 Sewer Manholes

The Contractor shall design and construct sewer manholes in accordance with the contract documents.

The Contractor shall design and construct new sewer manholes on the gravity main. The Contractor shall also connect the gravity main into existing sewage network as indicated. The works shall include the removal or cutting out of the top of the sewer and bench to suit sewers and/or rising main discharge pipes.
6 Structural Steelworks

6.1 General

Structural Steelworks shall be in accordance with the Structural Steelwork Specification.

7 Mechanical Works

7.1 General

Mechanical works shall be carried out in accordance with the Mechanical Specification, and the manufacturer’s recommendations.

8 Pipework

8.1 General

Pipework shall be carried out in accordance with the Pipework Specification.

Unless otherwise directed by the Principal’s Representative or noted in this specification, all existing water and sewage pipelines shall remain in service until the final cut-ins and connections are made for Commissioning.

Concrete lining of pipework shall be of type suitable for the transport to raw sewage in accordance with Manufacturer’s specifications.

8.2 Supply of Pipe, Fittings and Valves

The Contractor shall be responsible for supplying all necessary pipes, valves and fittings required to complete the Works.

8.3 Pump Station Pipework

Pipe materials and pressure ratings shall be a minimum of PN16 for Rising main and SN8 for Gravity main.

Pump Station pipework shall be adequately braced and supported as required for dead loads and unbalanced pressure forces.

8.4 Rising Main Pipework

Pipe materials and pressure ratings shall be a minimum of PN16.

8.5 Gravity Sewerage Pipework

Road verge and private property - unplasticised Polyvinylchloride (uPVC, PVC-M) Series 2, Rubber ring joint (RRJ), SN8 or as specified in the Principal’s Project Requirements
8.6 Waterway Crossings

The Contractor shall design and construct the pipeline across waterways in accordance with the Specification.

The works are to be performed in accordance with the approved Environmental Management Plan (Construction) and all other relevant environmental legislation and approvals as detailed in the Environmental Management Plan (Planning).

8.7 Plumbing and Drainage

8.7.1 General

Refer AS 3500—Plumbing and Drainage.

The Contractor shall develop and implement a plumbing and drainage plan in accordance with AS 3500 and local plumbing authority requirements.

8.7.2 Water Services

The Contractor shall design, supply and install potable water services to the pump stations in accordance with AS 3500.

The potable water services pipeline shall include design, supply and installation of backflow prevention.

If required by Council, a pressure reducing valve (PRV) and water meter shall be provided at the offtake on the discharge pipeline.

The PRV shall be PN16 globe type, hydraulically actuated with threaded ends and diameter sized to match adjacent pipework. PRV discharge pressure shall be set to 600kPa.

The mechanical water meter shall be sized to match adjacent pipework.

Gate valves (50mm dia and less) shall be threaded copper in accordance with AS2638.1, complete with cover boxes and margin sets in accordance with drawing WAT-1304.

8.8 Inspection and Hydrostatic Testing of Pipework

Inspection and Hydrostatic Testing of pipework shall be in accordance with the Pipework Specification.
8.9 Pipeline Cut-ins

8.9.1 General

The Contractor shall design and make connections (cut-ins) to the existing pipelines as indicated in the Design Documents. Pipework within the extent of each cut-in shall be fabricated prior to cut-in and connection.

8.9.2 Stakeholders

The Contractor shall liaise with Council and any other Stakeholders who may be involved and/or impacted by the pipeline shutdowns. Liaison shall be during the planning for the shutdowns and during the shutdown works. Liaison with the Stakeholders shall be in accordance with the Stakeholder Management Plan.

8.9.3 Construction Constraints

The Contractor shall liaise with the Principal’s Representative to determine the allowable shutdown time for each pipeline, inclusive of time to drain, carry out the work and refill. The Contractor shall program to carry out the works involved for each cut-in during a clear working period of within the time specified by the Principal’s Representative.

No additional payment shall be made for work at night or on weekends necessary to carry out the connections within the time frame specified.

8.9.4 Planning and Programming for Pipeline Connections

The Contractor shall prepare a detailed plan and program for construction of the pipeline connections. The plan and program shall be prepared in consultation with the Stakeholders, and the Contractor shall be required to attend planning meetings prior to the cut-ins.

The plan shall include a detailed program of pipeline connection activities and program. Activities shall be listed against 30-minute time intervals at each cut-in location.

The Contractor shall be required to provide operational and standby personnel and equipment for each cut-in, and these shall be nominated in the detailed program. The cut-in plan shall detail the contingency strategies proposed to be implemented should the cut-in or connection not be achieved within the required time.

The Contractor shall prepare a Job Safety Assessment (JSA) for each shutdown.

The plan and program for the pipeline connections shall be submitted to the Principal’s Representative for review at least 4 weeks prior to commencement of any construction work. The Principal’s Representative may direct the Contractor to amend the plan and program so that it complies with the Contract requirements.
8.9.5 Shutdown Arrangements

The Contractor shall provide a minimum two weeks’ notice to the Principal’s Representative of its intention to carry out pipeline connections. The Principal’s Representative will liaise with relevant parties to determine if the proposed timing is suitable.

Should the Principal’s Representative be unable to arrange for a shutdown to suit the Contractor’s required program, with due consideration of the 28 days notice required, the Contractor shall have no claim other than for an extension of time.

The Principal’s Representative will arrange for all relevant advice to be issued to parties who will be affected by the shutdown of the pipeline and will arrange for the closure of all necessary line valves to take the pipelines out of service and for re-opening all such valves on completion of the works by the Contractor. Under no circumstances will the Contractor be authorised to operate valves on the existing pipelines when in service.

The Contractor under supervision of the Principal’s Representative will be responsible for depressurising the pipelines, and preparing it such that cut-ins can be made.

The Contractor will be responsible for all plugging and temporary bypass / diversion of gravity mains to enable cut-in and modification of gravity sewer mains and manholes. Works shall be arranged to maintain service, including to affected properties house drainage, at all times.

The Principal will be responsible for pumping out or scouring out the relevant sections of rising mains and disposal of contents (water or sewage). The Contractor shall provide a minimum of 1 days notice to the Principal’s Representative if the cut-ins are to be postponed from the previously advised time. If the cut-ins are postponed without providing this notice the Contractor will be responsible for the Principal's costs incurred as a result.

Once the existing pipelines and manholes have been drained, and the Contractor’s agreed personnel and equipment is checked as present and correct, the Principal's Representative will hand the pipeline over to the Contractor for the duration of the cut-in. During that period the Principal’s Representative will be present to provide site directives to the Contractor. If it becomes apparent that the work may not be completed in the scheduled time frame, the Principal’s Representative may direct the Contractor to provide additional personnel and/or equipment to accelerate the work.

The Contractor is advised that it may not be possible to stop all flow, and the Contractor shall make contingency plans to cope with that event.

Following the completion of the cut-in, the Contractor will hand the pipeline back to the Principal’s Representative to be re-filled and pressurised as required.

Should any leaks in the cut-in section be discovered after the pipeline is brought back into service the Contractor shall immediately locate and repair the leaks at own cost.
The Contractor shall notify the Principal's Representative of all items of equipment and personnel required to suit the proposed methodology.

8.9.6 Pipeline Construction at Cut-ins

The Contractor shall fabricate all pipework within the extent of the cut-in prior to cut-in and connection.

Pipe cuts into the existing pipeline shall be made with a petrol powered saw and cutting disc or pipe cutters as appropriate. Care shall be taken not to damage the cement mortar lining of the existing pipelines. Any damage that does occur shall be repaired with a fast setting epoxy mortar (Epirez 633 Epoxy Binder and D1419 accelerator or approved equivalent).

The Contractor shall provide all equipment and carry out all measures necessary to divert any water interfering with the progress of the cut-in works, keep the work site free from water while the works are in progress and prevent any injury to the works by water due to floods or other causes.

The construction sequence for the connections shall generally be as follows unless otherwise approved by the Principal's Representative:

Prior to Cut-in:

- Confirm lines and levels of connection points (by Contractor's surveyor)
- Assemble pipes and pipe specials that comprise the connection
- Measure length, lines and levels of assembled section (by Contractor's surveyor)
- Mark cutting points on pipelines or manholes.

During Cut-in:

- Drain pipeline (by others)
- Check of equipment and personnel at each cut-in location (by Principal's Representative)
- Make cuts through existing pipe
- Place assembled section into gap and support
- Complete welded joints
- Anchor blocks placed
- Refill pipeline and bring back into service (by others).

After Cut-in:

- Check for leaks and make repairs if necessary
- Externally wrap weld joints (after a minimum of 24 hours has elapsed)

Wherever feasible, work activities shall proceed in parallel.
9 Pavements, Re-instatement and Landscaping

9.1 Pavements

Pavement works shall be carried out in accordance with Technical Specification - Civil Works.

9.2 Reinstatement and Landscaping

9.2.1 General

The Contractor shall reinstate and restore any kerbs, bitumen, channels, concrete pathways and earth surfaces disturbed during the construction to an equivalent or better standard than before construction.

The Contractor shall not destroy or damage any property and all fences, gardens, walls, paved areas, concrete surfaces, paths, trees, roads, gravelled surfaces, grass and other surfaces shall be left by the Contractor in the same order as they were before the commencement of work.

Topsoiling and grass reinstatement shall be undertaken in accordance with Technical Specification – Civil Works. The Contractor shall maintain such areas as necessary to ensure regrowth of grass.

9.3 Fencing, Bollards, Fenders and Guardrails

Fencing, bollards, fenders and guardrails shall be supplied and installed at locations where required to protect any structures or equipment. Bollards shall be robust, coloured with yellow and black alternating diagonal stripes and founded in concrete in accordance with the Civil Works Specification.

Where the works cross an existing fence, the Contractor shall take down the section of fence affected, store the materials for the duration of the works and reinstate the fence at completion of the construction. Any materials damaged during the works shall be replaced by new materials matching the existing.

Where a fence is part of the security of a property, the Contractor shall erect a temporary fence to provide adequate security at all times the works are not attended for the purpose of preventing unauthorised access.
10 Rising Mains

Rising main works shall be designed and constructed in accordance with the relevant specifications. Where applicable, construction of rising mains shall include, site works, manholes, gravity sewers, pressure mains, connections to new or existing infrastructure, appurtenances (including chambers), anchor blocks, reinstatement and other miscellaneous work.

11 Pump Stations

11.1 General

Pump station works shall be carried out in accordance with this specification and as indicated in the Principal’s Project Requirements.

11.2 Wet Well and Zero Manholes

Wet Well and Zero Manhole works shall be designed as per the Principal’s Project Requirements, reference documents and carried out at in accordance with this specification.

11.3 Supply and Installation of Pump Sets

Pump set works shall be carried out at the sewage pumping station in accordance with the technical specification.

The supply and installation of pump sets includes pumps, motors, mounting pedestals, guide rails, lifting chain systems and all other materials and associated works.

11.4 Not Used

11.5 Sewer Manholes

Sewer manhole works shall be carried out in accordance with this specification and as indicated on the Design Drawings.

11.6 Pavements, Reinstatement and Landscaping

Pavements, Reinstatement and Landscaping shall be carried out in accordance with the Technical Specification.

12 Electrical Works

12.1 Scope of Works

The Contractor shall design, supply, install, test, commission, insure and warrant all electrical equipment and works in accordance with Specifications, Datasheets and Drawings for the works under this Contract. The works shall include:
- Design of all electrical components, equipment and systems specific to each pump station,
- Liaison with the Electricity Service Provider,
- Supply of all equipment,
- Installation of Earthing System,
- Supply and installation of Motor Control Centres,
- Installation of switchboard,
- Installation of new consumer mains conduit,
- Installation of electrical conduit,
- Installation of power and control cabling,
- Installation of Instrumentation cabling,
- Installation of small power and lighting equipment,
- Installation of pump connect pillar,
- Supply of variable speed drive cubicles,
- Installation of variable speed drive cubicles,
- Supply and Installation of Ergon metering Panel, and
- All other works necessary to meet the requirements of the Specifications.

12.2 Design by Contractor

Refer to the Electrical Design and Installation Specification.

The contractor shall undertake all necessary detailed design for the electrical and control system including sizing of all above and below ground conduits.

12.3 Liaison with Electricity Service Provider

Refer to the Electrical Design and Installation Specification.

The Contractor shall be responsible for sourcing construction power.

12.4 Supply of Equipment

The Contractor shall supply all equipment, materials, tools, consumables, temporary structures and all ancillary equipment necessary to complete the works under this Contract as designed by the Contractor.

This shall include, ordering, procurement, insurance, packaging for transport, transport from place of manufacture to site, temporary secure, weatherproof storage, crating, dunnage, organisation and co-ordination of lifting equipment, removal of packaging and all other works necessary for the supply of equipment, materials, consumables, temporary structures and ancillary equipment to site.

The equipment and materials shall include all cabling, lugs, conduit, fittings, hardware, lighting and small power equipment, terminals, termination equipment, inspection and testing equipment, ferrules, labels, tags, ducting, cable tray and ladder, support structures, Unistrut,
specialised, hand and power tools and all other materials and equipment required to 
complete the works under this contract.

Refer Electrical Design and Installation Specification, Switchboard Specification and WSA 
Addendum.

12.5 Installation of Earthing System

The contractor shall install an earthing system in accordance with Technical Specification -
Electrical Design and Installation and industry regulations. The earthing system shall be 
installed in strict accordance with the Contractor’s approved construction drawings. All 
exposed metallic parts shall be bonded to the earthing system and it shall provide effective 
limitation of touch, step and transfer voltage hazards.

The Contractor shall test the earthing system individually and as a whole to demonstrate the 
earthing system resistance to remote earth. If the measured values exceed the maximum 
design values, the Contractor shall install supplementary earthing structures to satisfy the 
design limitations.

12.6 Supply of Motor Control Centres

Refer Technical Specific – Switchboard.

The Contractor shall manufacture, populate, wire up, test, insure, package for transport, 
transport from place of manufacture to site, provide lifting equipment for and conduct all 
other works necessary for the supply of the Motor Control Centre.

The MCC’s shall be manufactured in strict accordance with the Contract technical and 
functional specifications, datasheets, drawings and the Contractor’s construction drawings 
and documentation as approved by the Principal’s Representative. The Contractor shall 
provide temporary secure, weatherproof storage for the MCC until such time that it may be 
installed in its final location on-site in secure, weatherproof conditions.

The Contractor shall make the MCC available for Factory Acceptance Testing (FAT) and 
provide not less than two weeks notice to the Principal’s Representative of intention to 
conduct the FAT. The Contractor shall prepare and provide suitable Inspection and Test 
Plans (ITP’s) with this notification for approval by the Principal's Representative. The 
Contractor shall alter or update the ITP’s as directed by the Principal's Representative.

12.7 Installation of Motor Control Centres

Refer Technical Specific – Switchboard.

The Contractor shall install each MCC in its final location on site, as detailed in the 
Contractor’s construction drawings. The Contractor shall remove all temporary packing, 
crating and dunnage from site after installation of the MCC. The MCC shall only be delivered 
to site after successful completion of the Factory Acceptance Testing.
12.8 Supply of Switchboard

Refer Technical Specific – Switchboard.

The Contractor shall manufacture, populate, wire up, test, insure, package for transport, transport from place of manufacture to site, provide lifting equipment for and conduct all other works necessary for the supply of each switchboard.

The switchboards shall be manufactured in strict accordance with the Contract Specifications, Single Line Diagram, datasheets, drawings and the Contractor’s construction drawings and documentation as approved by the Principal’s Representative. The Contractor shall provide temporary secure, weatherproof storage for the switchboards until such time that it may be installed in its final location on-site as a secure, weatherproof structure.

The Contractor shall make the switchboards available for Factory Acceptance Testing (FAT) and provide not less than two weeks notice to the Principal’s Representative of intention to conduct the FAT. The Contractor shall prepare and provide suitable Inspection and Test Plans (ITP’s) with this notification for approval by the Principal’s Representative. The Contractor shall alter or update the ITP’s as directed by the Principal’s Representative.

12.9 Installation of Switchboard

Refer Technical Specific – Switchboard.

The Contractor shall install each switchboard in its final location on site, as detailed in the Contractor’s construction drawings. The Contractor shall remove all temporary packing, crating and dunnage from site after installation of the switchboard. The switchboard shall only be delivered to site after successful completion of the Factory Acceptance Testing.

12.10 Installation of Consumer Mains Conduit

Refer Technical Specification - Electrical Design and Installation.

The Contractor shall install new consumer mains conduit at each pump station listed below. This conduit shall be installed in strict accordance with the Contract specifications and the relevant Electricity Service Provider regulations.

All Conduit penetrations shall be grouted using a compound suitable for the application and environment. Conduits exposed to heavily sulphiding atmospheres shall have the accessible ends sealed with a removable shallow filling of expanding foam after installation of cabling to reduce corrosive attack on equipment.

Care shall be taken to ensure that all conduits susceptible to condensate build up are installed such that all condensate drains to the vapour source, either via the conduit itself, or by installation of supplementary drainage lines.
12.11 Installation of Electrical Conduit

Refer Technical Specification - Electrical Design and Installation.

The Contractor shall install all electrical conduits as required under this contract. All Conduits shall be sized and installed in strict accordance with the Contract specifications. Installation of Power and Control Cabling

12.12 Installation of Electrical Cables

Refer Technical Specification - Electrical Design and Installation.

The Contractor shall install all power and control cabling as required under this Contract including new or replacement consumer mains cabling as required. All power and control cabling shall be installed according to the requirements laid out in the contract specifications.

All cables shall be installed without joints and all terminations shall be made using crimp lugs of an appropriate size. Cabling shall be specifically rated for the application including the installation conditions. All cables entering the wet well shall be suitable for submersible applications.

Power and control cabling shall be segregated from Instrumentation cabling by installation in separate enclosures for the length of the cable, or installation of metallic barriers where this is not practical.

12.13 Installation of Pump Vendor Cables

Refer Technical Specification - Electrical Design and Installation.

Pump vendor cables for all other pump stations shall have the phase and earth cores terminated using suitable crimped lugs of standard size to suit the link bolts installed in the disconnection pillar.

The pump instrumentation cables shall be terminated with sufficient slack to enter the instrumentation terminal box using bootlaces. The Contractor shall clearly label all cores and install a heat shrink crutch boot to seal the cable opening from ingress. The Contractor shall ensure that any instrumentation cabling screens are maintained to the interior of the instrumentation terminal box.

The Contractor shall provide sufficient looped cable excess for re-termination of all cores within the wet well within easy reach of the well access point.

No epoxy or gel compound type terminations / enclosures shall be used for the purposes of terminating pump cables in the disconnection chamber / pillar.

12.14 Installation of Instrumentation Cabling

Refer Technical Specification - Electrical Design and Installation.
The Contractor shall install all power and control cabling as required under this Contract including new or replacement consumer mains cabling as required. All power and control cabling shall be installed according to the requirements laid out in the contract specifications.

All cables shall be installed without joints and all terminations shall be made using crimp lugs of an appropriate size. Cabling shall be specifically rated for the application including the installation conditions. All cables entering the wet well shall be suitable for submersible applications.

Power and control cabling shall be segregated from Instrumentation cabling by installation in separate enclosures for the length of the cable, or installation of metallic barriers where this is not practical.

12.15 Installation of Small Power and Lighting Equipment

Refer Technical Specification - Electrical Design and Installation.

The Contractor shall install all small power and lighting equipment in accordance with the contract drawings, specifications and the Contractor's construction drawings at each of the pump stations.

Outdoor floodlighting shall be provided to fully illuminate the wet well area to a level consistent with the manner of maintenance tasks to be undertaken in the area.

12.16 Installation of Pump Disconnection Pillar

Refer Technical Specification - Electrical Design and Installation.

The Contractor shall provide a suitable vandal resistant enclosure adjacent to the wet well to house the pump cable link bolts. The enclosure shall be sized to allow easy passage of lugged submersible pump cables from the wet well.

The Contractor shall construct a suitable panel for mounting of pump cable link bolts using inherently corrosion resistant materials. Surface coatings or treatments shall not be acceptable and all fixings shall have the same electro-chemical potential as the equipment to be fixed. Sufficient link bolts shall be provided for the termination of all power cores and the cable screen, which shall be maintained electrically continuous through the disconnection chamber.

The Contractor shall provide a shielded metallic terminal box within the disconnect pillar for the purposes of terminating the pump instrumentation cores of the submersible pump cable. Entry and exit glands shall be provided to seal this terminal box against corrosive gas attack after installation.

The Contractor shall demonstrate practical methods of condensate limitation and drainage from the disconnection pillar. The conduits entering the disconnection pillar shall form an effective gas barrier between the wet well and the pillar to prevent corrosive damage to links and switchboard components.
The Contractor shall demonstrate any EMC conformance measures required for the installation of the VSD cables within the disconnection pillar in the installed environment.

All cabling entering the wet well shall pass through the pump disconnection chamber. The method of conduit sealing shall be such that it forms a demonstrated effective gas seal and may easily be removed and replaced for maintenance activities.
CIVIL WORKS SPECIFICATION

WIRRAGLEN AND LORRIMER STREET
SEWERAGE PROJECT
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1 Clearing and Grubbing

1.1 General

1.1.1 Commencement of Clearing
Clearing shall not be commenced until initial clearing and mulching and protective fencing to retained trees have been completed. Cleared vegetation shall be chipped immediately and shall not be left windrowed on site.

On receipt of notice, the Principal’s Representative shall advise the Contractor of any limitations on the extent and manner of clearing and/or grubbing additional to those specified herein or elsewhere in the Contract Documents. In particular the Principal’s Representative may direct that individual trees, shrubs and boughs within the clearing limits be left undisturbed and that timber obtained from clearing be chipped or stacked on the Site.

A trained fauna spotter catcher with Department of Environment and Heritage Protection rehabilitation accreditation and dedicated Koala handler shall be engaged by the Contractor and present during disturbance and clearing of large habitat trees, woody debris and terrestrial / arboreal termite mounds.

1.2 Clearing

1.2.1 Limitations on Clearing
Clearing shall be limited to the areas specified. The Contractor shall have no authority to clear beyond those areas and the Principal’s Representative may direct the Contractor to rehabilitate or restore any area cleared beyond those areas.

Trees within protective fencing shall not be cleared or damaged.

1.2.2 Areas to be Cleared
The Contractor shall clear over the full area required to contain the earthworks and pavement works to be carried out under the Contract. Clearing in areas of trench excavation shall be included if needed and limited to the minimal working area in order to perform the work.

1.2.3 Trees to Be Cleared Outside of Cleared Areas
The Contractor shall submit a tree clearing plan to the Principal’s Representative for the clearing of any trees outside of the cleared areas.

Any trees or boughs hung up as a result of clearing shall be cut down.

1.2.4 General Requirements
Clearing shall comprise the felling of trees and shrubs remaining after initial clearing and not within protective fencing by cutting or breaking off not higher than 750 mm above ground level, the demolition and removal of all buildings, fences, gates and other structures, the
collection and removal of all litter and all waste material left after demolition by others and disposing of the material resulting from such felling, demolition and collection.

The Contractor shall remove all existing fencing, including any buried concrete and steel supports and other appurtenances.

1.2.5 Trees with Hollows
Trees with hollows are to be suitably marked by the Contractor. The Contractor shall confirm the location of these trees prior to commencement of clearing and shall stockpile trees with hollows separately from other trees that may be stockpiled. Trees with hollows shall be stockpiled so as to allow the hollows to be cut away from the tree by chainsaw.

Once hollows have been removed from the trees, the Contractor shall chip or stack the remaining sections of the trees as directed by the Principal’s Representative.

1.3 Grubbing

1.3.1 General Requirements
Grubbing shall comprise the removal from the ground, to a depth of 300 mm below the existing surface, of all stumps, roots, small rocks (i.e. rocks having a greatest dimension more than 300 mm but not more than 600 mm), artificial obstructions, remnants of structures etc. and the removal from the site and disposal of all vegetable and other waste material resulting from such removal from the ground.

1.3.2 Areas to be Grubbed
The Contractor shall grub over the full area required to contain the earthworks and pavement to be carried out under the Contract.

1.3.3 Grub Holes
Grub holes shall be filled with material satisfying the requirements of this Specification. The material shall be compacted as required by this Specification where relevant and in any case to a dry density ratio not less than 95% (standard compaction).

1.4 Mulching of Removed Existing Trees
Chipped vegetation is to be recovered from the clearing operations for reuse in the landscape works. Cleared vegetation shall be chipped immediately and shall not be left windrowed on site.

The Contractor shall chip all cleared native trees, native shrubs and other native vegetation. The Contractor shall put the material through a tub grinder to reduce the pieces to no larger than 100mm shreds and shall stockpile the finished product. Chipped vegetation is to be stockpiled in locations as determined by the Principal's Representative. The stockpiles are to be managed so that they are not affected by wind or combustion. Any loss of stockpiled mulch will be replaced by the contractor at its own expense.
Exotic species and weeds / declared plants are not to be chipped but removed from the site. Exotic species and weeds and all other waste material resulting from clearing and grubbing and materials that cannot be chipped shall be removed from the site and disposed of lawfully by the Contractor.

1.5 Weed And Pest Plant Species And Plant Biosecurity Requirements

The Contractor is to ensure that all vehicles and materials entering and exiting Private Property or Council owned/managed land or easements are free of all weed species, weed seed and other biological material which may spread propagative or pathogenic material and that on completion of the works and during the defect period that no weed species are present within the part of the property impacted by construction activity (including stockpile areas and machinery travel paths). Such actions required to prevent the importation and spread of weed species shall include, but not limited to, washing down and cleaning of plant and machinery prior to entering site, and shall be detailed in the Contractor’s Construction EMP.

The Contractor shall complete and submit, as part of their Construction EMP, a Weed Hygiene Declaration and reserves the right to request a copy of plant wash down certification.

The Contractor and all subcontractors and suppliers shall observe and abide by all applicable codes of practice, regulations and laws under local, state and federal jurisdiction.

2 Earthworks

2.1 General

2.1.1 Definitions

"Pavement" includes any sub-base and any blinding layer to be placed prior to the construction of a pavement.

"Subgrade" means the surface upon which a pavement is to be constructed.

"Excavation" includes all operations necessary for the removal of soil and rock from the existing ground, for the disposal of the excavated material and for subsequent treatment of the excavated surface as specified herein.

"Excavated surface" means the surface of the ground remaining after excavation.

"Fill" means earthworks raised above the existing surface or above an excavated surface by the placing and compaction of material and includes formations, embankments and banks.

"Filling" includes all operations necessary for the construction of a fill, including the obtaining of material and including all treatment of the material specified herein.
“Acid Sulfate Soil” means Actual Acid Sulfate Soils or Potential Acid Sulfate Soils as per the definitions of the Queensland Acid Sulfate Soils Investigation team (QASSIT).

2.1.2 Existing Surface Levels
Prior to commencing earthworks the Contractor shall satisfy itself that the existing surface levels indicated fairly represent the existing ground surface. If the Contractor is not so satisfied it shall immediately give written notice of its dissatisfaction to the Principal’s Representative and shall not disturb or cover the surface until the Principal’s Representative shall have investigated the matter. On receipt of such notice given by the Contractor the Principal’s Representative shall investigate promptly the grounds for the Contractor’s dissatisfaction and shall carry out such new surveys of the existing ground surface as it considers necessary and shall determine the changes, if any, to be made to the existing surface levels indicated.

2.1.3 Removing Grass etc
After stripping topsoil (where relevant) and prior to commencing earthworks the Contractor shall remove all grass, other vegetation and organic matter from all areas on which filling is to be carried out and from all areas to be excavated where the excavated material subsequently may be used in filling.

2.1.4 Earthworks to be Drained
The Contractor shall ensure that the earthworks are drained at all times and to that end shall provide such drains, banks and other protective works and provide and operate at its own expense such pumps etc. as may be necessary.

2.2 Excavation

2.2.1 Scope
This Section applies to excavation required to be executed under the Contract, including bulk excavation, excavation for roads, car parks, compounds, hardstands and excavation to finished surfaces elsewhere and applies to excavation entailed in ancillary earthworks.

This section also applies to excavation of any kind that forms part of or is necessary for the execution of any of the work under the Contract.

2.2.2 Excavation to be inspected
Independently of notifications for Witness Points and Hold Points in the Contractor’s Quality System, the Contractor shall advise the Principal’s Representative when excavation has been carried out to the levels indicated on the submitted Drawings and shall give at least one working days’ notice before proceeding with further work that entails the covering-up of the excavated surface.

2.2.3 Protection Slabs to Existing Services
Refer to Technical Specification – Structural Concrete.
2.2.4 Removal and Replacement with Cement Modified Gravel
The Principal’s Representative may direct the Contractor to carry out additional excavation and replace the material removed with cement modified gravel.

The Contractor shall give the Principal’s Representative at least one working days’ notice before placing cement modified gravel.

The gravel shall be Type 3.1 material complying with this Specification.

Cement shall be type GB in accordance with AS 3972. The cement content shall be 3% by mass.

The Principal’s Representative may direct the Contractor to vary the cement content.

The gravel, cement and water shall be plant-mixed and delivered direct to the work site.

The material shall be placed in one layer, trimmed and compacted to a dry density ratio not less than 95% (standard compaction).

The compacted material shall be kept moist until it is covered by fill or pavement.

2.2.5 Geotextile Treatment

2.2.5.1 General
The Principal’s Representative may direct the Contractor to carry out geotextile treatment before placing fill material or pavement material.

Geotextile treatment shall comprise the placing of a geotextile followed by the placing and compaction of a crushed concrete layer.

The Principal’s Representative shall direct the length and width of geotextile treatment.

The Principal’s Representative shall direct the compacted thickness of the crushed concrete layer, which may vary from place to place.

2.2.5.2 Materials
Geotextile shall be "Bidim" A34 or equivalent.

The geotextile shall be stored so that it shall not be exposed to direct sunlight until it is being laid.

Material for the crushed concrete layer shall be crushed concrete won by the Contractor from the existing stockpile. The Principal’s Representative shall direct the areas of the stockpile from which the crushed concrete is to be won.

2.2.5.3 Construction
The geotextile shall be laid over the excavated surface or the ground surface where fill is to be placed.
The fabric shall be laid in full roll widths as supplied, with the length of the fabric laid parallel to the road centre line or to the longer dimension directed by the Principal’s Representative. Adjacent strips shall be lapped not less than 300 mm and where end laps are required they shall be not less than 500 mm.

Any fabric that is torn shall be replaced or shall be patched by laying over it an additional piece of fabric extending a minimum of 1m from the extremities of the tear.

The whole of the fabric shall be fixed down by spikes or other effective means to prevent its moving.

No more than three weeks shall elapse from the time that the fabric is laid to the time that it is completely covered. Any fabric that is exposed to sunlight for a period greater than three weeks shall be removed and replaced by the Contractor at the Contractor’s expense.

The covering layer of crushed concrete material shall be placed and compacted in one layer, if the depth directed by the Principal’s Representative is 300 mm or less, or in two approximately equal layers, if the depth directed by the Principal’s Representative is 300 mm or more, on top of the geotextile and the final layer of material shall be compacted and trimmed so that the material in the next layer of fill or pavement above can be placed in a uniform layer and can be compacted to the specified dry density ratio.

When compaction of the crushed concrete is complete the Contractor shall notify the Principal’s Representative and shall not proceed with further work until directed by the Principal’s Representative.

The Contractor shall proof roll the crushed rock layer in the presence of the Principal’s Representative.

Proof rolling shall comprise a single pass of a loaded water cart, with a maximum of three (3) axles and a minimum Gross Vehicle Mass 22.5 tonne, over the whole of the surface.

There shall be no visible movement of the crushed rock layer under the proof rolling.

If there is visible movement the Contractor shall re-compact the crushed concrete and repeat proof rolling.

2.2.6 Overbreak to be Backfilled

Unless the Principal’s Representative directs otherwise, any overbreak beyond the lines and levels indicated on the submitted Drawings or directed by the Principal’s Representative shall be backfilled with material taken from that part of the excavation. The material shall be compacted to the relative dry density specified by this specification as appropriate to the location of the backfill and in any case to a dry density ratio not less than 90% (standard compaction).
2.2.7 Compaction after Excavation

In areas where gravel pavement to building platform is to be constructed and the excavated surface is to be the subgrade or is less than 300 mm below the subgrade levels, the soil remaining below the excavated surface, for a depth of 150 mm, shall be brought to a moisture content within ± 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 98% (standard compaction).

In other areas to be paved, where the excavated surface is to be the subgrade or is less than 300 mm below the subgrade levels, the soil remaining below the excavated surface, for a depth of 150 mm, shall be brought to a moisture content within ± 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 95% (standard compaction).

Where the excavated surface is to be the surface of the footpath to a road or is less than 300 mm below the finished surface levels of such a footpath as indicated, but excluding any part of a footpath containing a batter steeper than 1 vertical on 10 horizontal, the soil remaining below the excavated surface, for a depth of 150 mm, shall be brought to a moisture content within ± 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 90% (standard compaction).

2.2.8 Proof Rolling

When compaction of the subgrade and of excavated surfaces within 300 mm below the subgrade is complete, and in addition to notice given for inspection of excavation as specified in this specification, the Contractor shall notify the Principal’s Representative and shall not proceed with further work until the Principal’s Representative gives a direction.

The Contractor shall proof roll the subgrade and excavated surfaces within 300 mm below the subgrade in the presence of the Principal’s Representative.

Proof rolling shall comprise a single pass of a loaded water cart, with a maximum of three (3) axles and a minimum Gross Vehicle Mass 22.5 tonne, over the whole of the surface.

There shall be no visible deflection of the surface being proof rolled.

The Principal’s Representative may direct the Contractor:

- To excavate further.
- To carry out additional excavation and replace the material removed with fill material. The Contractor shall give the Principal’s Representative at least one working days’ notice before placing fill material.
- To carry out additional excavation and replace the material removed with cement modified gravel. Refer to this Specification.
- To carry out geotextile treatment. Refer to this Specification.
2.2.9 Use or Disposal of Material from Excavation

2.2.9.1 Use
Excavated material that satisfies the relevant requirements of this Specification may be used in fill.

2.2.9.2 Disposal
Excavated material that is not used in the work under the Contract shall be disposed of off Site by the Contractor.

2.3 Fill and Filling

2.3.1 Scope
This Section applies to filling required to be executed under the Contract, including fill for roads, car parks, compounds, hardstands and building platforms and fill to finished surfaces elsewhere and applies to filling entailed in ancillary earthworks.

This section also applies also to filling of any kind that forms part of or is necessary for the execution of any of the work under the Contract.

2.3.2 Preparation for Filling

2.3.2.1 Initial Preparation
Following the removal of grass etc. as specified in this Specification and before any fill material is placed the whole of the surface upon which any fill is to be constructed shall be prepared by draining any surface water or saturated areas and compacting any loose or soft areas as may be necessary to ensure that the fill material can be compacted to the specified dry density ratio and that there will be no apparent vertical movement of the fill under compaction equipment.

2.3.2.2 Surface to be Inspected
The Contractor shall advise the Principal's Representative when initial preparation specified in this specification has been completed and shall give at least one working day's notice before proceeding with further preparation for filling or with the placing of fill.

2.3.2.3 Removal and Replacement of Material
The Principal’s Representative may direct that excavation be carried out to remove material below the partially-prepared surface.

In that event the Contractor shall excavate to not less than the depths directed by the Principal’s Representative or to levels not higher than the levels directed by the Principal’s Representative.

The excavation shall be backfilled to the original surface levels with material satisfying the requirements of this specification. The material shall be compacted as specified for loose or soft areas in this specification.
Such excavation and backfilling shall be measured for removal and replacement of material below levels indicated on submitted Design Drawings and the quantity of excavation and backfilling so measured shall be included with the quantity of removal and replacement of material below levels indicated on submitted Design Drawings.

2.3.2.4 Benching
Where a batter in fill is to be constructed out on a surface having a slope greater than 1 vertical on 8 horizontal, a bench shall be cut at the toe of the batter of sufficient width to permit construction of the fill to be commenced with horizontal layers of uniform depth.

Where a fill is to be constructed on a surface having a slope greater than 1 vertical on 3 horizontal the surface shall be excavated to provide a continuous series of horizontal steps forming a key for the fill.

2.3.2.5 Compaction
In addition to the compaction of loose or soft areas as specified in this specification, in areas to be paved where the surface on which fill is to be constructed is less than 300 mm below the pavement subgrade levels, the soil below the surface on which fill is to be constructed, for a depth of 150 mm, shall be brought to a moisture content within ± 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 95% (standard compaction).

2.3.3 Fill Material
2.3.3.1 Sources and Supply of Material
Excavated material may be used in fill pursuant to this Specification.

The Contractor shall supply all fill material necessary for the execution of the work under the Contract.

2.3.3.2 Properties of Fill Material
2.3.3.2.1 General
The properties specified in this specification shall be exhibited by the material in the completed fill.

This Clause applies to all fill material regardless of its description.

2.3.3.2.2 Limitation of Stone Size
No stones with greatest dimension more than 100 mm shall be included within 300 mm below the subgrade to pavement or, where shoulders are to be provided to a road or other pavement, above a plane 300 mm below the plane of the subgrade of the pavement or, where an unpaved area is to remain between the edge of a pavement and the adjacent kerb or future kerb, within 600 mm below the finished surface of that unpaved area or, where a footpath or verge is to be provided, within 300 mm below the finished surface of that footpath or verge.
No stones with greatest dimension more than 50 mm shall be included in the top 150 mm of the shoulder to any road or other pavement.

No stones with greatest dimension more than 20 mm shall be included in the top 100 mm of any fill that will not be covered by pavement or concrete works constructed under this Contract or by topsoil placed under this Contract or by building works that are in progress when the fill is being constructed.

Elsewhere no stones with greatest dimension more than 200 mm shall be included, provided that isolated boulders having a greatest dimension not more than 600 mm or one third of the depth of fill, whichever is the lesser, may be placed in the lowest third of a fill in such a manner that the placing and compaction of the fill material between and over them and the construction of underground services including drainage and light pole footings shall not be impeded.

2.3.3.2.3 California Bearing Ratio
The California Bearing Ratio (CBR) (soaked) of fill material, reported at the maximum dry density and optimum moisture content for standard compaction shall be not less than 3, unless a greater minimum CBR is required in the fill area.

2.3.3.2.4 Exclusion of Certain Materials
Material containing an excess of clay lumps, organic matter or other deleterious material shall not be used.

Highly dispersive clay shall not be used.

Permeable granular material shall not be used in such a location or in such a manner that its presence in a fill will permit water to penetrate the fill.

2.3.4 Construction

2.3.4.1 Lowered Surface
Filling shall commence on the surface existing after preparation for filling is complete, regardless of any lowering from the levels indicated on the submitted Drawings.

2.3.4.2 Compacted Layer Method
Fill shall be constructed by the compacted layer method.

The fill shall be placed in uniform layers not more than 200 mm thick (measured loose before compaction).

Each layer shall be compacted to the compaction standard specified in this specification before the material for the next layer above is placed.

In general each layer shall be placed and compacted over the full area of the fill before the material for the next layer above is placed.
2.3.4.3 Compaction Standard
In building sites the material in fill of any type shall be brought to a moisture content within ±/− 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 98% (standard compaction) for the full depth of the fill.

In and near areas to be paved, other than building platforms, the material in fill of any type for a depth of 300 mm below the pavement subgrade shall be brought to a moisture content within ±/− 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 95% (standard compaction).

Elsewhere, unless otherwise specified in this specification the material in fill of any type shall be compacted to a dry density ratio not less than 90% (standard compaction).

2.4 Moisture Content of Subgrades
The Contractor shall water or otherwise maintain the moisture content of subgrades, in excavation and in fill, so that at the time that pavement material is placed the moisture content of the top 150 mm of the subgrade shall be within ±/− 2% (moisture content) of the subgrade material’s optimum moisture content.

2.5 Tolerances
Earthworks shall be finished to the dimensions, grades and levels indicated on the submitted Drawings within the tolerances specified in Table 1.

Table 1: Tolerances

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Levels</td>
<td></td>
</tr>
<tr>
<td>Subgrades</td>
<td>Subgrades shall be finished to levels allowing for the thickness of pavement to be constructed on them (regardless of whether the pavement is to be constructed under this Contract or by others) and in no case shall the level of a subgrade be higher than the indicated pavement surface level, less the indicated pavement thickness, plus such upper tolerance to pavement surface levels as may be specified under this Contract. No tolerance specified herein shall permit the subsequent construction under this Contract of pavement of lesser thickness than that indicated. Subject to the above the following tolerances apply to levels etc.</td>
</tr>
<tr>
<td>General</td>
<td>± 0 mm</td>
</tr>
<tr>
<td></td>
<td>- 30 mm</td>
</tr>
<tr>
<td>Uniformity of Grading:</td>
<td></td>
</tr>
<tr>
<td>Longitudinal grade (measured over 25 m)</td>
<td>± 0.15%</td>
</tr>
<tr>
<td>Crossfall (mean slope)</td>
<td>± 0.40%</td>
</tr>
<tr>
<td>Overall, deviation from a 3 m straight</td>
<td>± 12 mm</td>
</tr>
</tbody>
</table>
edge on the surface

### At Adjoining Works

<table>
<thead>
<tr>
<th>Description</th>
<th>Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerbing and channelling</td>
<td>± 0 mm, - 45 mm on level calculated as lip of channel level less indicated pavement thickness (including surfacing)</td>
</tr>
<tr>
<td>Kerbing, dwarf walls, building footings etc</td>
<td>± 0 mm, - 45 mm on level calculated as top of kerb etc level less indicated height of kerb etc less indicated pavement thickness (including surfacing)</td>
</tr>
<tr>
<td>Existing pavements</td>
<td>± 0 mm, - 45 mm on level determined by marking indicated thickness of new pavement below surface of new pavement (including surfacing) below surface of existing pavement</td>
</tr>
<tr>
<td><strong>Elsewhere</strong></td>
<td></td>
</tr>
<tr>
<td><strong>General</strong></td>
<td>± 30 mm - 45 mm</td>
</tr>
<tr>
<td><strong>Uniformity of Grading</strong></td>
<td></td>
</tr>
<tr>
<td>Longitudinal grade or crossfall</td>
<td>± 0.5% on grade or crossfall or Not less than 0.25% where direction of fall only is indicated.</td>
</tr>
<tr>
<td><strong>At adjoining Works</strong></td>
<td></td>
</tr>
<tr>
<td>- Kerbing (behind kerb)</td>
<td>± 10 mm, - 0 mm on top of kerb</td>
</tr>
<tr>
<td>- Kerbing (face), dwarf wall, retaining wall etc</td>
<td>± 25 mm, -15 mm on level calculated as top of kerb etc, level less indicated height of kerb etc.</td>
</tr>
<tr>
<td><strong>Batters</strong></td>
<td></td>
</tr>
<tr>
<td>- In cut, other than rock</td>
<td>Neatly cut to slopes not steeper than those indicated, with tops rounded where indicated, and carried regularly round curves.</td>
</tr>
<tr>
<td>- In fill</td>
<td>Trimmed to slopes not steeper than those indicated and so that any point shall be within ± 150 mm of the average batter line, provided that the toe of the batter shall not be less than 1 m, or such other distance as may be indicated, from the edge of any drain or natural water course.</td>
</tr>
</tbody>
</table>

### 2.6 Testing

In addition to the provisions of this Specification, in respect of earthworks within the areas of buildings as indicated:

- The Contractor shall coordinate geotechnical testing as described in Appendix B to AS 3798-1996, Guidelines on earthworks for commercial developments.
- The geotechnical testing authority’s responsibility shall be Level 1 as described in paragraph (a) Section B1 of that Appendix B.
- The Contractor shall supply to the Principal’s Representative a report by the geotechnical testing authority as described in that paragraph (a), including an
expression of the geotechnical testing authority's opinion that the Contract Works comply with the Contract.

3 Rock Mattress

3.1 General
This Clause applies to rock mattress protection at stormwater drain outlets.

Rock mattress comprises wire baskets filled with rock.

The Contractor shall excavate, in any material encountered to a length, width and depth sufficient to permit the construction of the rock mattress, the subsequent removal of formwork and refilling.

In all other respects excavation shall be in accordance with this Specification.

3.1.1 Refilling
The Contractor shall give the Principal’s Representative not less than one working days’ notice before commencing refilling.

Prior to refilling all fallen soil, loose stones, timber and other debris shall be removed from the excavation.

Refilling to each side of each structure shall be in accordance with this Specification as relevant to the location and levels of the structure and as required by the drains connected to the structure.

3.1.2 Tolerances
Rock mattresses shall be constructed within the dimensional tolerances specified in the specifications for concrete work generally, provided that:

- such departures from the dimensions as indicated are necessary to accommodate drains constructed in accordance with the Contract;
- except as indicated otherwise the tops of rock mattresses shall be finished flush with the surrounding surface so that there shall be no discernible step; in backfilling the finished level of the surrounding surface shall be matched to the completed rock mattress;

3.2 Materials

3.2.1 Fabric
Fabric (geotextile) shall be Bidim A34.

3.2.2 Wire Baskets
Wire baskets shall be prefabricated from flexible steel wire mesh.
The core wire diameter shall be not less than:

<table>
<thead>
<tr>
<th>Wire Diameter, mm</th>
<th>Body of Mesh</th>
<th>Selvedge</th>
<th>Lacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>3.4</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>

All wire, including lacing wire, shall be heavily galvanized (Type A described in AS 1650) and shall have PVC coating of nominal thickness 0.55 mm.

Purpose made stainless steel clips, supplied by the manufacturer of the baskets and used in accordance with the manufacturer's instructions, may be used instead of lacing wire.

The mesh shall be hexagonal, woven with double twist. The hexagon size shall be 60 mm across flats.

Baskets shall be complete with lids and shall include internal full-height diaphragms at 1m spacing.

All panels shall be selvedged. The selvedge wire shall be woven integrally with the mesh or shall be fastened by binding the edges of the mesh about the selvedge wire or shall be fastened to the mesh by stainless steel clips.

Basket dimensions shall permit the construction of the Works with the least practicable number of basket units.

3.2.3 Anchor Pickets
Anchor pickets for mattresses shall be star pickets 1.8m long.

3.2.4 Rock
Rock used in filling the baskets shall be fresh or slightly weathered igneous or metamorphic rock. The maximum size shall be 150 mm. The rock shall be reasonably well graded down to 80 mm. Not more than 10% of the material by mass shall be smaller than 80 mm.

Rocks shall be approximately cubical or spherical. No individual rock shall have a least dimension less than half its greatest dimension.

3.2.5 Construction
Cut off walls shall have been constructed before mattress baskets are assembled.

The area on which mattresses are to be constructed shall be excavated as necessary and trimmed to within ± 50 mm of the levels indicated. Any protruding rocks, roots and stumps shall be removed.

The fabric shall be placed evenly over the surface on which the rock mattress is to be constructed. At joins the fabric shall be lapped not less than 300 mm and pinned to the fill at
a spacing not greater than 1m. The top edge of the fabric shall be pinned to the fill at a spacing not greater than 1m.

Anchor pickets shall be installed at 1m spacing along the line of the upstream edge of mattresses to be constructed on outlet beds and along the line of the top edge of mattresses to be constructed on sloped areas. Unless hard ground prevents driving to full depth, the pickets shall be driven so that their tops shall be level with the tops of the completed mattresses.

If proprietary mattress baskets are used their assembly, joining, filling and closing shall be in accordance with the manufacturer’s recommendations unless a recommendation is inconsistent with this Specification.

The baskets shall be assembled and placed empty.

Where baskets are to be placed in multiple rows the first row shall be placed and filled before succeeding rows are placed and joined.

The corners and all diaphragm points along the edge of the first row of mattress baskets shall be tied to the anchor pickets before the baskets are filled with rock.

Where basket units must be formed to shapes the mesh panels shall be cut and folded as necessary. Surplus mesh shall be cut off or shall be folded back onto and tied to retained mesh. Cut and folded edges shall be selvedged and adjacent cut or folded edges shall be laced together.

Unfilled baskets shall be tensioned so that their shapes shall be retained before and during filling with rock.

Adjoining basket units shall be joined by lacing together at all edges.

Rock shall be placed to fill the baskets while the baskets are under tension.

The rock shall be placed to produce a dense, evenly distributed filling with no significant distortion of the basket shapes.

The baskets shall be closed as soon as practicable after rock filling. The lids shall be laced at all edges and to diaphragms.

Anchor pickets that have not been driven to full depth shall be cut off level with the tops of the baskets.
4 Stormwater Drainage

4.1 General

4.1.1 Definitions

"Pavement" includes any subbase and any blinding layer to be placed prior to the construction of a pavement.

"Subgrade" means the surface upon which a pavement is to be constructed.

"Excavation" includes all operations necessary for the removal of soil and rock from the existing ground, for the disposal of the excavated material and for subsequent treatment of the excavated surface as specified herein.

"Excavated surface" means the surface of the ground remaining after excavation.

"Fill" means earthworks raised above the existing surface or above an excavated surface by the placing and compaction of material and includes formations, embankments and banks.

"Filling" includes all operations necessary for the construction of fill including all specified treatment of the material.

4.2 Materials

4.2.1 Reinforced Concrete Pipes

Reinforced concrete pipes (RCPs) shall satisfy the requirements of AS 4058, "Precast concrete pipes (pressure and non-pressure)".

Refer to Section B2 of AS 4058.

RCPs shall be for drainage applications.

Pipes of size class 600 or less shall be of a spigot and socket joint type and pipes of size class greater than 600 shall be of an external flush joint type.

Joint rings and joint bands shall be natural rubber.

4.2.2 PVC Pipes

PVC pipes shall satisfy the requirements of AS/NZS 1254, PVC pipes and fittings for storm and surface water applications.

Pipe designations (nominal pipe sizes) and jointing systems shall be as indicated on the Technical Specification.
4.2.3  Concrete and Cement Mortar

4.2.3.1  Concrete
All concrete in cast in situ concrete work (other than lean mix concrete and concrete infill to multiple RCBC drains) shall be standard strength grade N32.

Lean mix concrete shall be 1 part Type GP cement to 10 parts aggregate, by loose volume.

Concrete infill shall be 1 part Type GP cement to 10 parts aggregate, by loose volume. The maximum aggregate size shall not exceed 9.5 mm.

4.2.3.2  Cement Mortar
Cement mortar shall consist of one part Type GP cement to three parts sand, by volume.

4.2.4  Grates, Covers and Frames
Grates, covers and frames shall satisfy the requirements of AS 3996.

Except where indicated otherwise, grates, covers and frames shall be of cast iron.

Grates, covers and frames shall be of Australian or New Zealand manufacture.

4.2.5  Bedding and Fill Materials (Other than Backfill)
Bedding and fill materials are:

- bedding material
- select fill material
- ordinary fill material
- backfill material.

4.2.6  Properties of Materials
All bedding and fill materials shall be free of soluble salts and organic matter. The properties of bedding material, selected fill material and ordinary fill material shall be as set out in Table 2.

Table 2: Properties of Bedding Material, Selected Fill Material and Ordinary Fill Material

<table>
<thead>
<tr>
<th>Material</th>
<th>General Description</th>
<th>Classification*</th>
<th>AS Sieve (mm)</th>
<th>% Passing By Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding</td>
<td>Sand, crusher dust, fine to medium gravel</td>
<td>SP, SW, GM</td>
<td>19.0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.36</td>
<td>50 – 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.60</td>
<td>20 – 90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
<td>10 – 60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.15</td>
<td>0 – 25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.075</td>
<td>0 – 10</td>
</tr>
<tr>
<td>Bedding (alternative)</td>
<td>Cement stabilised with unconfined compressive</td>
<td></td>
<td>19.0</td>
<td>100</td>
</tr>
</tbody>
</table>
4.2.7 Materials to Be Used in Zones
The materials used in the zones of bedding and refilling, shall be as set out in Table 3.

Table 3: Material to be used in Zones

<table>
<thead>
<tr>
<th>Zones</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed Zone</td>
<td>bedding material</td>
</tr>
<tr>
<td>Haunch Zone</td>
<td>bedding material</td>
</tr>
<tr>
<td>Side Zone</td>
<td>select fill material; bedding material</td>
</tr>
<tr>
<td>may be used</td>
<td></td>
</tr>
<tr>
<td>Overlay zone (other than existing roads or</td>
<td>ordinary fill; select fill material or</td>
</tr>
<tr>
<td>pavements)</td>
<td>bedding material may be used</td>
</tr>
<tr>
<td>Overlay zone (existing roads or pavements)</td>
<td>select fill material or bedding material</td>
</tr>
</tbody>
</table>
4.3.3 Cleaning Existing Drains
Before commencing stormwater drainage construction, the Contractor shall inspect retained existing drains and shall notify the Principal's Representative of any contained sediments and debris.

The Principal’s Representative may direct the Contractor to flush retained existing drains to remove sediments and debris and to remove the sediments and debris from the Site and disposed of them.

4.3.4 RCP Pipe Drains
This Clause applies also to PVC pipe drains where the pipe designation is DN 375 or smaller.

This Clause does not apply to PVC pipe drains where the pipe designation is larger than DN 375.

Solvent welded joints shall be made in accordance with the manufacturer's recommendations.

4.3.4.1 General
RCP pipe drains shall be constructed by trench installation.

Fills shall have been completed to not less than 600 mm above the level of the top of the pipe (or to the finished surface of the fill, whichever is the lower) before any pipe drain crossing the fills is constructed.

If for any drain the support Type is not specified in the Specification, the support shall be Type HS2.

The material in fill, at levels matching the side zone and for a width of 1.5 times the pipe size class or nominal size on each side of the drain trench, shall have been compacted to a dry density ratio not less than 90% (standard compaction).

At no time shall the total length of trench for drains of any type opened up and not backfilled exceed 300 metres.

The construction of each drain shall be commenced at its lower end.

4.3.4.2 Excavation
The Contractor shall saw cut existing asphalt pavements or bitumen surfacing, outside the lines of the sides of trench excavation, before trench excavation is commenced.

In areas where topsoil has not been stripped in earthworks, material excavated from the top 100 mm of trench excavation shall be set aside for use in backfilling.

Below the level of the top of the overlay zone the sides of the trench shall be vertical.
The Contractor’s OHS&E management system shall provide for the safety of persons in and near all trenches. The Contractor shall provide any timbering or other support necessary for the prevention of damage to the works and of injury to workmen or to others.

Such timbering or other support shall be withdrawn as refilling proceeds.

The Contractor shall ensure that the trench is drained at all times and to that end shall construct such drains, banks and other protective works and provide and operate such pumps etc, as may be necessary.

The Contractor shall advise the Principal’s Representative when excavation has been carried out to the depth specified in this Clause and shall give the Principal’s Representative not less than four hours’ notice before placing bedding material.

If the Principal’s Representative directs that a greater depth of bed zone than that indicated be provided, the Contractor shall excavate further to a depth sufficient to permit the construction of the extra depth of bed zone directed by the Principal’s Representative.

The Principal’s Representative may direct that further excavation be carried out to remove material below the depth specified in this Clause and that the material so removed is replaced.

In that event the Contractor shall excavate further, over the length and width directed by the Principal’s Representative, to not less than the extra depth directed by the Principal’s Representative.

The further excavation shall be filled with bedding material or with select fill material (as the Principal’s Representative may direct) and the material shall be compacted to a dry density ratio not less than 90% (standard compaction).

Any overbreak beyond the depth specified in this Clause or directed by the Principal’s Representative shall be filled at the Contractor’s expense with bedding material or select fill material (as the Principal’s Representative may direct) and the material shall be compacted to a dry density ratio not less than 90% (standard compaction).

Excavated material shall be used or disposed of as specified for earthworks elsewhere in the Contract.

4.3.4.3 Bed Zone

The bed zone shall extend for the full width of any trench and at least to 100 mm each side beyond the external diameter of the pipe.

The Principal’s Representative may direct that a greater depth of bed zone than is indicated be provided and may direct that select fill material be used instead of bedding material in part or all of the bed zone.
The bedding material shall be compacted to a dry density index not less than 60 or to a dry density ratio not less than 90% (standard compaction).

The surface of the bed zone shall be shaped so that the pipes shall fall uniformly for the full length of the reach of drain and so that the pipes shall rest upon the bedding material for the full length of their barrels. Where socket and spigot pipes are to be laid holes shall be excavated at each joint location to ensure that the weight of the pipe shall not be taken by the socket.

4.3.4.4 Laying
Where necessary the Contractor shall break into existing manholes or other structures and shall connect the new drains neatly into them. The drains shall be sealed into the structure walls with cement mortar.

Pipes shall be laid and bedded to form a straight barrel, with the invert falling continuously to the lower end of the reach of drain and with the pipes closely jointed together.

Pipes marked “TOP” shall be laid with that mark at the top. Pipes with a lifting hole shall be laid with the lifting hole at the top.

Where rubber ring jointed or other socketed pipes are used they shall be laid with the socket ends upstream.

Pipes shall be cut as required to give the lengths of drains indicated on the Drawings and to provide for skewed connections into structures, provided that in no case shall the shortest remaining length of wall of any pipe used be less than 1 metre.

Cut ends of pipes shall be incorporated into drainage structures or, in the case of socket and spigot pipes, may be the spigot in a joint provided that adequate depth of engagement shall be retained all round and that the strength of the completed joint shall not be reduced.

4.3.4.5 Jointing
External band joints to RCPs shall be made in accordance with the manufacturers’ recommendations.

Where flush jointed RCPs (other than rubber band jointed pipes) are used, the jointing space (internal or external) shall be filled with cement mortar forced in and struck off flush with the surface of the pipe wall.

Joint space shall be filled for the full circumference of the pipe.

Lifting holes in pipes shall be filled with cement mortar.

4.3.4.6 Haunch Zone
The Contractor shall give the Principal’s Representative not less than one working day’s notice before commencing the construction of haunch zone.
Haunch zone shall be constructed in layers not more than 200 mm thick, on both sides of single pipes and between multiple pipes, extending for the full width of the trench.

Each layer of material in the haunch zone shall be compacted before the material for the next layer above is placed.

The material in the haunch zone shall be compacted to a density index not less than 60 or to a dry density ratio not less than 90% (standard compaction).

4.3.4.7 Side Zone
The Contractor shall give the Principal’s Representative not less than four working hours’ notice before commencing the construction of side zone.

Side zone shall be constructed in layers not more than 200 mm thick, on both sides of single pipes and between multiple pipes, extending for the full width of the trench.

Each layer of material in the side zone shall be compacted before the material for the next layer above is placed.

The material in the side zone shall be compacted to a density index not less than 60 or to a dry density ratio not less than 90% (standard compaction).

4.3.4.8 Overlay Zone
In this specification, the requirements for materials and construction in drains crossing roads or pavements apply to overlay zone and backfill between planes intersecting the edge of pavement or back of kerb at pavement surface level and sloping at 1.4 vertical on 1 horizontal away from the pavement.

The Contractor shall give the Principal’s Representative not less than four working hours’ notice before commencing the construction of overlay zone.

Overlay zone shall be constructed in layers not more than 200 mm thick, on both sides of single pipes and between multiple pipes, extending for the full width of the trench.

Each layer of material in the overlay zone shall be compacted before the material for the next layer above is placed.

For drains crossing existing roads or pavements, the material in the overlay zone shall be compacted to a density index not less than 70 or to a dry density ratio not less than 95% (standard compaction).

Elsewhere, the material in the overlay zone shall be compacted to a density index not less than 60 or to a dry density ratio not less than 90% (standard compaction).

4.3.4.9 Backfill
The Contractor shall give the Principal’s Representative not less than one working day’s notice before commencing the construction of backfill.
Backfill shall be constructed in layers not thicker than the maximum thickness specified for the adjacent fill and in any case not more than 200 mm thick for drains crossing roads or pavements and 250 mm thick elsewhere, extending for the full width of the trench.

Each layer of material in the backfill shall be compacted before the material for the next layer above is placed.

The material in the backfill shall be compacted to a density index not less than 60 or to a dry density ratio not less than 90% (standard compaction).

4.3.4.10 Pavement Restoration
Existing gravel, crushed rock and other flexible pavements shall be reconstructed to the original thickness or to not less than 200 mm thickness, whichever shall be the greater, using the original pavement material. The Contractor shall supply any additional material needed to achieve the specified thickness.

The Principal's Representative may direct the Contractor to incorporate up to 5% by volume of cement into the material.

The material shall be placed in uniform horizontal layers not exceeding 150 mm in thickness and shall be compacted to a dry density ratio not less than 100% (standard compaction).

4.3.4.11 Bitumen Surfacing Restoration
Existing asphalt pavements 50 mm or less in thickness and existing asphalt or bitumen surfacing shall be reconstructed with asphalt paving mix, which shall be placed in a layer not less than 50 mm in compacted thickness, trimmed to match the adjacent existing surface levels and thoroughly compacted.

4.3.4.12 Not Used

4.3.4.13 Clean-up
Drains shall be cleaned of all spilt concrete and mortar, loose soil, silt and other obstructions to the flow of water.

4.4 Testing
Refer to Clause 11 of this Specification.
5 Kerb and Channel

5.1 General
This Clause applies to concrete kerb, kerb and channel and kerb and toe in barrier and layback types, to median kerb, to pedestrian access ramps, to road invert crossings and to paver edge restraint.

This Clause applies also to precast concrete wheel stops.

5.2 Materials

5.2.1 Concrete
Concrete shall be Grade N25.

Manually placed concrete shall have a slump of 75 mm.

The slump of machine-placed concrete shall be to suit the extrusion machine such that adequate compaction of the concrete shall be achieved and such that the concrete shall retain its shape following the extrusion process. Water may be added to the machine-placed concrete mix on site to obtain the correct slump.

5.2.2 Cement Mortar
Cement mortar shall comprise one part Portland cement to 3 parts sand by volume. The water content shall be as low as possible consistent with obtaining thorough mixing and sufficient workability.

5.2.3 Bedding Material
Bedding material shall be:

- crusher dust;
- gravel or crushed rock suitable for use in pavement base or subbase; or
- the same material as is used in the adjacent pavement.

5.3 Construction

5.3.1 Subgrade to Kerb, etc.
Construction of bedding or the laying of concrete shall not proceed until such time as the subgrade has been trimmed and compacted to a dry density ratio of not less than 95 per cent, standard compaction, for a depth of 150 mm.

5.3.2 Bedding
Bedding material shall be compacted to a dry density ratio not less than 100% (standard compaction).

The thickness of the completed compacted bedding shall be not less than 75 mm.
5.3.3 Formwork
Formwork shall be placed such that the finished concrete shall meet the tolerance requirements of this Specification and shall be braced so that no movement can occur during placement and compaction of the concrete.

The formwork shall be mortar-tight and surfaces that are to come in contact with the concrete shall be cleaned and oiled.

Formwork shall not be stripped until at least 20 hours after placing the concrete.

5.3.4 Concrete in Formwork
Concrete shall be placed and compacted by vibration.

Exposed surfaces shall be screeded and floated to a smooth finish. Channel and dish crossing surfaces shall have a steel float finish and all other exposed surfaces shall have the finish obtained by a wood float. All arrises and rounds shall be neatly made.

As soon as formwork is removed, all mortar fins on exposed faces shall be tooled away.

5.3.5 Extruded Concrete
The extrusion machine shall compact the concrete to a dense homogeneous mass.

Exposed surfaces shall be screeded and floated to a smooth finish with steel floats shaped to conform with the shape of the extruded concrete.

5.3.6 Transverse Joints
Transverse joints shall be formed at 2 metre maximum intervals in concrete kerb, kerb and channel and kerb and toe.

Transverse joints shall be constructed by guillotining extruded concrete and by the placing of templates in concrete formwork. The joint shall extend to at least 30 per cent of the area of the section and to all exposed faces.

Transverse joints shall be normal to the alignment of the kerb, kerb and channel or kerb and toe, and shall be neatly finished using a jointing tool.

5.3.7 Service Markers
In addition to the installation of kerb markers as may be required by the Contract, the Contractor shall permit and assist persons and Authorities to install service markers in kerb, kerb and channel and kerb and toe during its construction.

5.3.8 Repair of Concrete Work
If requested by the Contractor, the Principal's Representative may permit the rectification of isolated defective work using cement mortar. If the Principal's Representative permits such rectification work, the concrete shall be chipped out with edges cut straight and sides undercut slightly to key in the repair.
The repair area shall be washed and a suitable jointing compound applied to the surface prior to rendering with cement mortar.

The minimum thickness of cement mortar shall be 6 mm.

5.3.9 Water Test
The Contractor shall make a water test on every section of kerb and channel or crossing.

In making the test, water shall be discharged into the channel or crossing at a rate sufficient to fill the channel or crossing section for not less than 2 minutes.

When the water is flowing in the channel or crossing there shall be no visible obstruction to uniform flow.

When the water has ceased flowing the depth of ponding in the invert of the channel or crossing shall not exceed 5 mm.

6 Gravel Pavement

6.1 Construction

6.1.1 General
The Contractor shall supply, place, mix, water, compact and finish the gravel to produce a completed pavement exhibiting the compaction standard required, within the dimensional tolerances specified and exhibiting the material properties specified in this Specification.

6.1.2 Materials
In this specification gravels are classified in accordance with the classifications of Subtypes in the Department of Transport and Main Roads document, Main Roads Standard Specification Unbound Pavements MRS11.05.

Gravel shall be free of organic matter, clay lumps or other deleterious material.

6.1.3 Not Used

6.1.4 Subgrade Other than Existing Bitumen Surfacing
Material shall not be placed on any subgrade that has not been prepared satisfactorily or has become wet, muddy or disturbed.

Where the subgrade has been constructed under the Contract the Contractor shall carry out any work necessary to repair or restore the subgrade so that at the time of placing pavement material it shall comply with the requirements for the subgrade specified in the Contract. Such work shall be at the Contractor’s expense.

Where the subgrade has been constructed other than under the Contract the Contractor shall carry out any work necessary to repair or restore the subgrade so that at the time of
placing pavement material it shall be in the same condition as it was at the time of the Contractor's being given possession of it. Such work shall be at the Contractor's expense.

At the time that material is placed the moisture content of the top 150 mm of the subgrade shall be within ± 2% (moisture content) of the subgrade material's optimum moisture content.

6.1.5 Existing Bitumen Surfacing
Where gravel pavement is to be constructed over existing bitumen surfacing:
- the Contractor shall not damage the bitumen surfacing;
- the Contractor shall sweep the bitumen surfacing as necessary so that there shall not be soil or other material present that may affect the properties of the gravel.

6.1.6 Construction in Layers
The gravel pavement shall be constructed in layers with a minimum compacted layer thickness of 75 mm and a maximum compacted layer thickness of 200 mm.

6.1.7 Compaction Standard
The gravel shall be compacted to a dry density ratio not less than 100% (standard compaction).

6.1.8 Surface Finish
The pavement shall be finished to a dense even surface, free from lenses and caking and resistant to damage by sweeping, within the tolerances on levels, dimensions and alignment specified in Table 5.

The surface of the pavement shall be so graded that there are no depressions capable of holding water or valleys concentrating the flow of water.

Table 4: Gravel Pavement Tolerances

<table>
<thead>
<tr>
<th>Surface Levels</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>± 20 mm, -15 mm</td>
</tr>
<tr>
<td>(b) Uniformity of grading</td>
<td></td>
</tr>
<tr>
<td>(i) Longitudinal grade (measured over 25 m)</td>
<td>± 0.10%</td>
</tr>
<tr>
<td>(ii) Crossfall (mean slope)</td>
<td>± 0.20%</td>
</tr>
<tr>
<td>(iii) Overall deviation from a 3 m straight edge laid on the surface</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>(c) At adjoining structures</td>
<td></td>
</tr>
<tr>
<td>(i) Kerbing and channelling or kerb and toe</td>
<td>± 5 mm on lip of channel or ±0, -10 mm at lip of toe for base to receive sprayed bitumen surfacing or ± 5 mm on level calculated as lip of channel or toe level minus nominal thickness of other</td>
</tr>
</tbody>
</table>
6.1.9 Pathway Levels  
Pathways shall have a crossfall, not less than 15 mm and not more than 25 mm, in the direction of the slope of the adjacent surface of completed landscape works.

6.2 Sampling and Testing

6.2.1 General  
Refer to this Specification.

6.2.2 Testing by Principal’s Representative  
If the Principal’s Representative carries out any testing or directs that testing be carried out by another person:

- The Principal’s Representative may take samples of material at any locations that it may select and may make any tests on those samples.
- The Principal’s Representative may test the compaction standard of the pavement at any locations that it may select.
- The Principal’s Representative is not required to follow any system in the selection of sample or test locations, nor is the Principal’s Representative required to make any random selection.

6.2.3 Material Properties  
The Principal’s Representative may reject any stockpile or source of material if samples taken from it fail to exhibit the properties required by the Contract.

Tests made on samples taken prior to the completion of any layer of the pavement shall not be compliance tests.

The material in the completed pavement shall have the properties required by the Contract.

6.2.4 Backfilling Test Holes  
Holes from which samples have been taken or in which tests have been made shall be backfilled with gravel and compacted by the Contractor. The Principal’s Representative may direct the Contractor to incorporate up to 10% cement in the backfill material.
7 Plant-Mixed Stabilised Pavement

7.1 General
This Clause applies to:

- cement modified base for gravel pavements
- cement modified subbase below concrete pavements
- cement treated backfill

7.2 Materials

7.2.1 Material to Be Stabilised
The materials to be stabilised shall be:

- Cement Modified Base Gravel Type 2.1
- Cement Treated Subbase Gravel Type 2.1
- Cement Stabilised Backfill Gravel Type 3.1

7.2.2 Stabilising Agent
Stabilising agent shall be cement type GB in accordance with AS 3972.

7.2.3 Curing Agent
Curing agent to cement modified base shall be bituminous emulsion or cutback bitumen.

7.2.4 Cover Material
Cover material to curing agent shall be clean dry sand.

7.3 Stabilising Agent Content

7.3.1 Cement Modified Base
The target strength range for cement modified base is an unconfined compressive strength (UCS) of 0.8 to 1.2 MPA. for Type 2.1 materials.

The Contractor shall conduct tests, carried out on samples of the material to be stabilised and in accordance with Department of Transport and Main Roads test method Q115, for at least four specimens, to determine the stabilising agent content that will give a UCS within the target strength range. The Contractor shall furnish the results of the tests to the Principal's Representative and shall propose a stabilising agent content to be used.

The Principal's Representative shall review these results and may direct that a different stabilising agent content be used.

The stabilising agent content shall not be less than the ordered content and in no case shall be less than 1.5% for Type 2.1 materials.
7.3.2 Cement Treated Subbase
The target strength range for Cat 2 cement treated subbase is an unconfined compressive strength (UCS) of 2Mpa for Type 2.3 materials.

The Contractor shall conduct tests, carried out on samples of the material to be stabilised and in accordance with Department of Transport and Main Roads test method Q115, for at least four specimens, to determine the stabilising agent content that will give a UCS within the target strength range. The Contractor shall furnish the results of the tests to the Principal’s Representative and shall propose a stabilising agent content to be used.

The Principal's Representative shall review these results and may direct that a different stabilising agent content be used.

The stabilising agent content shall not be less than the ordered content and in no case shall be less than 3% for Type 2.3 materials.

7.4 Mixing and Delivery
The gravel materials, stabilising agent and water shall be mixed in a purpose-made stationary, driven pugmill.

The mixed material shall be delivered directly to the work and shall not be stockpiled.

7.5 Construction

7.5.1 General
The Contractor shall place, trim, compact and finish the mixed material to produce a completed pavement exhibiting the compaction standard required, within the dimensional tolerances specified and exhibiting the material properties specified in this Specification.

7.5.2 Subgrade
Material shall not be placed on any subgrade that has not been prepared satisfactorily or has become wet, muddy or disturbed.

The Contractor shall carry out any work necessary to repair or restore the subgrade so that at the time of placing pavement material it shall comply with the requirements for the subgrade specified in the Contract. Such work shall be at the Contractor's expense.

At the time that pavement material is placed the moisture content of the top 150 mm of the subgrade shall be within ± 2% (moisture content) of the subgrade material's optimum moisture content.

7.5.3 Existing Pavement Layer as Subgrade
Where existing pavement gravel is removed to provide for construction of new base, the gravel remaining shall be trimmed to within the tolerances specified in this specification, brought to a moisture content within ± 2% (moisture content) of its optimum moisture content and compacted to a dry density ratio not less than 100% (standard compaction).
7.5.4 Construction in Layers
The material for each course shall be placed in a single layer not less than 75mm and not exceeding 200mm thickness to achieve the final compacted thickness.

7.5.5 Compaction Standard

7.5.5.1 Compaction
The maximum period between mixing cement with the base gravel material and the completion of compaction and finishing shall be 3.5 hours.

The material shall be compacted at a moisture content within ±1% of the optimum moisture content for the compaction equipment and procedure being used.

The material shall be compacted to a dry density ratio not less than 100% (standard compaction).

7.5.6 Successive Placing and Construction Joints
The material in a layer shall be placed against previously-placed material in the same layer within the time limit specified in this specification as applicable to that previously-placed material.

If the material is not placed within that time limit a construction joint shall be made. In making a construction joint:

- the previously-placed material shall be cut back to material that has been compacted in accordance with this specification and in any case for a distance not less than 150 mm.
- the cut face of the previously-placed material shall be trimmed vertical and shall be treated with a cement-water slurry having a water-cement ratio between 0.6 and 0.7 to give a cement application rate of 2 kg/m2.

Whether or not a construction joint has been made, compaction of newly-placed material shall commence with the roller partly supported by the previously-placed material.

7.5.7 Curing
Curing shall commence no later than 30 minutes after the completion of compaction. Curing shall commence progressively as sections of the work are compacted.

Cement treated materials shall be moist cured by maintaining the layer surface and edges in a continuously damp condition, using a fine spray only, for seven days or until the layer is covered by another layer of pavement, whichever is the earlier.

The moist curing process has the potential to “wash” the cementitious paste from the upper surface, which leaves an unbound, non cohesive soft pavement matrix which has high embedment potential for the subsequent sealing aggregate.
Moist curing shall be carried out using equipment fitted with spray jets that deliver water to the pavement as a fine mist only. The use of conventional spray bars or high-pressure water nozzles with large aperture spray holes will not be permitted.

7.5.8 Segregation
Given the presence of cement additive in the material, the relevant test for segregation shall be as specified in AS 1289.3.6.1.

All samples are to be wet sieved. This is to be done within ½ hour of being pugged. The two samples to be compared are to be from the same batch. One is to be obtained from a pugged source before entering the site; the second is to be obtained from the placed pavement before rolling.

7.5.9 Surface Finish and Tolerances
The pavement shall be finished to a dense even surface, free from lenses and caking and resistant to damage by sweeping, within the tolerances on levels, dimensions and alignment specified in Table 6.

The surface of the pavement shall be so graded that there are no depressions capable of holding water or valleys concentrating the flow of water.

Table 5: Stabilised Pavement Tolerances

<table>
<thead>
<tr>
<th>Surface Levels</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) General</td>
<td>± 25 mm - 15 mm</td>
</tr>
<tr>
<td>(b) Uniformity of grading</td>
<td></td>
</tr>
<tr>
<td>(i) Longitudinal grade (measured over 25 m)</td>
<td>± 0.10%</td>
</tr>
<tr>
<td>(ii) Crossfall (mean slope)</td>
<td>± 0.20%</td>
</tr>
<tr>
<td>(iii) Overall deviation from a 3 m straight edge laid on the surface</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>(c) At adjoining structures</td>
<td></td>
</tr>
<tr>
<td>(i) Kerbing and channelling or kerb and toe</td>
<td>± 5 mm on lip of channel or ±0, -10 mm at lip of toe for base to receive sprayed bitumen surfacing</td>
</tr>
</tbody>
</table>
8 Asphalt Surfacing

8.1 General

8.1.1 Definitions
"Asphalt surfacing" means asphalt laid and compacted to a thickness less than or equal to 50 mm.

"Granular pavement" means:
- any unbound pavement (including gravel or crushed rock).
- Any cement-treated, cement-stabilised or lime-stabilised pavement.

8.1.2 Department of Transport and Main Roads Specifications
Department of Transport and Main Roads Standard Specifications Roads (MRS) are incorporated by reference in this Specification.

8.1.3 Testing
Testing of mineral filler shall be in accordance with Australian Standards.

Otherwise, testing for design, production control and compliance assessment shall be in accordance with the Department of Transport and Main Roads Materials Testing Manual.

8.2 Asphalt Mix Constituent Materials

8.2.1 General
Asphalt mix shall incorporate coarse aggregate, fine aggregate, mineral filler and bitumen and may incorporate additives.

8.2.2 Coarse Aggregate
Coarse aggregate shall be crushed rock or crushed gravel particles of 2.36 mm size or larger.

Coarse aggregate shall be clean, hard, angular and durable and shall be free from laminated particles, clay, aggregations of fine material, soil, organic matter and any other deleterious material.

Coarse aggregate shall have the properties specified in Table 7.

Table 6: Coarse Aggregate Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flakiness Index</td>
<td>Maximum 35</td>
</tr>
<tr>
<td>Ten Percent Fines Value (Wet) (kN)</td>
<td>Minimum 150</td>
</tr>
<tr>
<td>Crushed Faces (%)</td>
<td>Minimum 80</td>
</tr>
<tr>
<td>Polished Aggregate Friction Value (for wearing course only)</td>
<td>Minimum 45</td>
</tr>
</tbody>
</table>
In addition, for combined coarse aggregate used in DG14 asphalt mix:

- the wet/dry strength variation shall not exceed 30%;
- the degradation factor shall be at least 50.

8.2.3 Fine Aggregate
Fine aggregate shall be natural sand or crushed rock or crushed stone particles smaller than 2.36 mm size. Fine aggregate may be derived from a mixture of sources.

The natural sand content of fine aggregate used in DG14 asphalt mix shall not exceed 10%.

Fine aggregate shall be clean, hard and durable and shall be free from clay, aggregations of fine material, soil, organic matter and any other deleterious material.

8.2.4 Mineral Filler
Mineral filler shall satisfy the requirements of AS 2357.

Voids in dry compacted filler shall be not less than 40%.

The clay content of mineral filler shall be nil.

8.2.5 Bitumen
Binder in DG7, DG10 and DG14 asphalt mixes shall be Class 320 bitumen satisfying the requirements of MRS11.30 Dense Graded Asphalt Pavements.

8.2.6 Additives
Asphalt mix may include adhesion agents.

The Contractor shall notify the Principal's Representative of any additive proposed to be used before asphalt is delivered to the site of the work. The Principal's Representative may direct that any additive not be used.

8.3 Asphalt Mix

8.3.1 Asphalt Mixes to Be Used
The asphalt classes nominated shall comply with all requirements of MRS 11.30 Dense Graded Asphalt Pavements, except for the modifications and/or additions contained in this specification.

8.3.2 Design
The Contractor shall design the asphalt mix.

The Marshall method of design shall be used.

If the Contractor (or its asphalt supplier) holds a current mix design approval certificate issued by the Department of Main Roads and is recognised by the Department for the supply...
of asphalt of the type and nominal size called for by the Contract, the mix design referred to in the certificate may be used.

The Principal's Representative may direct the Contractor to furnish details of the asphalt mix design and samples of the constituent materials.

8.3.3 Grading

The mix should generally conform with the grading requirements of MRS 11.30. However, gradings that do not conform with the nominated gradings of MRS 11.30 may be accepted subject to the approval of the Principal's Representative.

In mix design, the selection of the proportions of materials shall be such that the grading of the combined coarse aggregate, fine aggregate and mineral filler, according to the nominal size of the mix, shall be as specified in Table 8.

Table 7: Grading Limits for Combined Aggregates and Filler

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dense Graded Asphalt</td>
</tr>
<tr>
<td></td>
<td>Nominal Size (mm)</td>
</tr>
<tr>
<td></td>
<td>DG7</td>
</tr>
<tr>
<td>37.5</td>
<td></td>
</tr>
<tr>
<td>26.5</td>
<td></td>
</tr>
<tr>
<td>19.0</td>
<td></td>
</tr>
<tr>
<td>13.2</td>
<td>100</td>
</tr>
<tr>
<td>9.5</td>
<td>100</td>
</tr>
<tr>
<td>6.7</td>
<td>90 - 100</td>
</tr>
<tr>
<td>4.75</td>
<td>68 - 82</td>
</tr>
<tr>
<td>2.36</td>
<td>44 - 58</td>
</tr>
<tr>
<td>1.18</td>
<td>29 - 41</td>
</tr>
<tr>
<td>0.60</td>
<td>19 - 29</td>
</tr>
<tr>
<td>0.30</td>
<td>12 - 20</td>
</tr>
<tr>
<td>0.15</td>
<td>7 - 13</td>
</tr>
<tr>
<td>0.075</td>
<td>4 - 8</td>
</tr>
</tbody>
</table>

In addition:

- the grading curve shall be smooth and shall not vary from the outer one-third of the range between the specified limits for one sieve size to the opposite outer one-third of the range between the specified limits for an adjacent sieve size.
- not less than 50% of the material passing the 0.075 mm sieve shall be mineral filler.

In production, the grading of an asphalt mix shall not vary from its design grading by more than the maximum permitted Variations specified in Table 9.
Table 8: Maximum Permitted Variations from Design Grading

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Maximum Permitted Variation (% by mass of sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;9.5</td>
<td>±7</td>
</tr>
<tr>
<td>6.7</td>
<td>±6</td>
</tr>
<tr>
<td>4.75</td>
<td>±6</td>
</tr>
<tr>
<td>2.36</td>
<td>±5</td>
</tr>
<tr>
<td>1.18</td>
<td>±4</td>
</tr>
<tr>
<td>0.60</td>
<td>±4</td>
</tr>
<tr>
<td>0.30</td>
<td>±3</td>
</tr>
<tr>
<td>0.15</td>
<td>±2</td>
</tr>
<tr>
<td>0.075</td>
<td>±1</td>
</tr>
</tbody>
</table>

8.3.4 Bitumen Content

In mix design, the bitumen content shall be such that the asphalt mix shall have the voids properties specified in Table 10.

In production, the bitumen content of an asphalt mix shall not vary from its design bitumen content by more than ±0.3% bitumen content.

8.3.5 Asphalt Properties - Design and Production

Asphalt mix, as designed pursuant to this Specification, and production asphalt, regardless of any Variation from the designed mix, shall have properties within the limits specified in Table 10.

Table 9: Asphalt Properties - Limits

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Limit</th>
<th>Limit Value</th>
<th>Dense Graded Asphalt Mix Nominal Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>DG7</td>
<td>DG10</td>
</tr>
<tr>
<td>Number of Marshall blows</td>
<td>-</td>
<td>Minimum</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Stability</td>
<td>kN</td>
<td>Minimum</td>
<td>6.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Flow</td>
<td>mm</td>
<td>Minimum</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Stiffness</td>
<td>kN/mm</td>
<td>Minimum</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Voids in the mineral aggregate (VMA)</td>
<td>%</td>
<td>Minimum</td>
<td>15.0</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum</td>
<td>16.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Voids filled with bitumen (VFB)</td>
<td>%</td>
<td>Minimum</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum</td>
<td>78</td>
<td>78</td>
</tr>
</tbody>
</table>

*Stiffness = Stability/Flow
In addition, for DG14 asphalt mix:

- the binder film thickness shall be not less than 7.5 μm and the binder content for the target mix shall be not less than 4.5% by mass;
- in laboratory hand compaction the compaction standard shall be 75 blows Marshall;
- air voids within compacted asphalt shall be in the range 3% to 7%;
- the tensile strength ratio shall be not less than 80%;
- in the dynamic creep test the asphalt shall achieve at least 15000 pulses to 2% plastic strain.
- When tested in accordance with Q205C, the wet/dry strength variation for the combined coarse aggregate shall not exceed 30%. (DG 14 mixes only)
- When tested in accordance with Q208B, the Degradation Factor value for the combined coarse aggregate shall be a minimum of 50. (DG 14 mixes only)
- Air voids within the compacted asphalt shall lie between 3% and 7% for the nominated and tolerance mixes.
- When tested in accordance with Q315, the tensile strength ratio shall be not less than 80%.
- The natural sand content shall not exceed the percentages of the total mix given in Table 11 below except that, if it can be demonstrated that the sand has angular particles and/or the performance of the asphalt is not affected by an increase in the natural sand content, the natural sand content may be increased subject to prior approval by the Principal’s Representative.
- Evidence for the above shall include at least a sand angularity test, a resilient modulus test and dynamic creep tests on the target and tolerance mixes using the mix assessment requirements of MRS11.30.

<table>
<thead>
<tr>
<th>Mix Nominal Size</th>
<th>Maximum Natural Sand Content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Class 2 &amp; 3</td>
</tr>
<tr>
<td>DG14</td>
<td>10%</td>
</tr>
</tbody>
</table>

### 8.4 Asphalt Production and Storage

#### 8.4.1 Asphalt Mixing Plant

Asphalt shall be produced in a purpose-built plant that is capable of mixing controlled amounts of coarse aggregate, fine aggregate, mineral filler and bitumen to provide a consistently uniform mix that is in accordance with this Specification.

A mixing plant that is certified by the Department of Transport and Main Roads (having regard to the category assigned in the certification and to the output required by the work under the Contract) is in accordance with this Specification.

Refer to MRS11.10, "Plant Requirements for Hot-mixed Asphalt".
8.4.2 Storage
Asphalt may be stored before it is delivered to the site of the work provided that:

- the manner in which the asphalt is delivered to, deposited in and discharged from the storage bin shall prevent segregation of the asphalt;
- the temperature of the asphalt in the bin shall be maintained essentially uniform in the range 135°C to 175°C throughout the asphalt;
- the storage time shall not exceed 48 hours.

8.4.3 Representative Maximum Density
"Lot" of asphalt means, for each asphalt mix nominal size produced for use under the Contract, a continuous production run or a continuous sequence of production batches that:

- is not more than one day's production
- is not larger than 300 tonnes

"Representative maximum density" for each lot of asphalt means the arithmetic mean of the individual maximum densities of each sample from the lot.

The Contractor shall report the representative maximum density for each lot to the Principal’s Representative.

8.5 Preparation for Asphalt Work

8.5.1 Preparation of Existing Surface

8.5.1.1 General
The existing surface (pavement, floor or deck and including surfaces constructed by others and surfaces constructed under this Contract) on which asphalt surfacing is to be constructed shall be prepared.

This Specification does not provide for reconstruction or reworking of pavements.

8.5.1.2 Preparation
The surface shall be dry.

The surface shall be swept thoroughly, using a rotary broom, to remove loose pavement material, excess curing membrane cover material to cement modified pavements and any deleterious material.

Surface defects shall be rectified by the Contractor:

- potholes and depressions in granular pavements shall be filled and compacted to match the surrounding pavement.
- Local high points and ridges in granular pavements shall be removed.
- At kerbs and other structures granular pavements shall be trimmed as necessary to ensure that the thicknesses of asphalt surfacing shall be as called for by the Contract.
- For tolerances, refer to this Specification.
- Excess bitumen (fatty patches) in bituminous surfaces shall be removed.
- Joints in concrete work shall be cleaned out and defective joint seals shall be replaced.
- Spalled or broken concrete shall be repaired.

Any loose material and any deleterious material that remains after sweeping and rectification of surface defects shall be removed.

8.5.2 Protecting Adjacent Works
Frames for manhole covers and grates and for other removable covers shall be cleaned out so that the covers and grates can be removed and replaced easily.

Kerbs, channels, walls, manholes, signs and other structures shall be cleaned and then shall be protected against overspray from prime coat and tack coat and against adhesion of asphalt and entry of asphalt.

8.5.3 Joins to Existing Asphalt Work
Existing asphalt surfacing to which new asphalt work is to join shall be cut back to give a vertical surface at the join line, to a depth such that the thickness of each layer of new asphalt shall be within the range specified in Table 13.

8.5.4 Prime Coat
A prime coat shall be applied to all exposed granular pavement unless, in the case of stabilised pavement, a cutback bitumen curing membrane has been applied at least the rate specified below and the curing membrane remains in good condition.

A protective strip 300 mm wide shall be laid across the surface at the start and finish of each sprayer run.

Spraying primer shall not begin until the pavement surface temperature has been above 20 °C for one hour.

Spraying shall not proceed if rain is expected during the day.

 Primer shall be cutback bitumen Grade AMC0 or Grade AMC00 satisfying the requirements of MRS11.20, "Medium Curing Cutback Bitumen".

 Primer shall be applied to the pavement surface at a rate of 1.0 L/m² (measured at 15°C.)

 The temperature of the primer at the time of spraying shall be in the range 35°C to 55°C.

 Not less than 2 days shall elapse between the completion of the prime coat and the application of a tack coat or the start of laying asphalt.
Traffic shall be kept off the prime coat until the prime coat has been covered using fine sand as cover material.

8.5.5 Local Level Correction
Generally it is intended that surface irregularities remaining after preparation of the existing surface be corrected by a corrector course as described in this Specification.

Local depressions more than 25 mm in depth that may not be filled adequately by a corrector course or would lead to variable compaction in a corrector course shall be filled with asphalt before any overall tack coat is applied and before a corrector course is laid.

If the surface in the depression has not been primed the surface shall be tack coated with bituminous emulsion.

The asphalt shall be a dense graded asphalt complying with this Specification.

The asphalt may be placed by hand and may be compacted by tamping. The asphalt shall be compacted to the highest relative compaction that reasonably can be achieved.

8.5.6 Tack Coat
Excess sand cover to prime coat shall be removed.

A tack coat shall be applied to all surfaces that have not been primed and to all surfaces that have been primed.

The Principal’s Representative may direct the Contractor to apply a tack coat to the surface of asphalt already laid.

Tack coat shall be bituminous emulsion Grade CRS or Grade ARS satisfying the requirements of MRS11.21, "Bituminous Emulsion".

The emulsion may be warmed to not more than 45°C or may be diluted with water to facilitate spraying.

The emulsion shall be sprayed by a bitumen sprayer truck, with hand spraying only in areas inaccessible to the truck's spray bar.

The application rate shall give a residual bitumen coverage of 0.2 L/m².

The surfaces tack coated shall include join faces in existing asphalt and the contact surfaces of kerbs and other structures.

The tack coat shall be applied shortly before asphalt is to be laid, so that the emulsion shall have broken and the bitumen shall have begun to harden but there shall be no dust or other foreign matter on the tack coat at the time asphalt is laid.
8.6 Weather Conditions at Time of Laying

8.6.1 Moisture
The surface on which the asphalt is to be laid shall be essentially dry and shall be free of surface water.

Asphalt shall not be delivered or laid during rain or when rain is imminent.

8.6.2 Temperature and Wind
If:

- The compacted thickness of a layer under construction is less than 50 mm
- The pavement temperature is less than 25°C
- The wind speed in km/h is more than the pavement temperature (e.g. 20°C and more than 20 km/h or 15°C and more than 15 km/h)
- The Contractor shall use at least one additional roller or shall increase the asphalt discharge temperature (but not exceeding the maximum temperature specified in this Specification).

Notwithstanding that such action has been taken, if the temperature of the asphalt at the start of rolling is lower than is specified in Table 14 or if compaction to the minimum standard specified in Table 15 is not achieved the delivery and laying of asphalt for that layer shall be suspended.

8.7 Asphalt Delivery and Discharge

8.7.1 Loading into Delivery Vehicles
The manner of loading asphalt into the delivery vehicles shall prevent segregation of the asphalt.

The loaded asphalt shall appear uniform in texture, with all particles completely covered with bitumen.

The temperature of the loaded asphalt shall not be higher than 175°C.

There shall be no visible foaming and no other evidence of a moisture content in the asphalt greater than 1.5% by mass.

Loaded asphalt that does not comply with the above requirements shall not be delivered.

8.7.2 Delivery and Discharge
Asphalt shall be delivered to the site of the work in vehicles fitted with leak-proof, spill proof metal trays.

Before each loading the inside surfaces of the tray shall be cleaned of all cold asphalt and foreign matter and then shall be coated with a thin film of release agent so that there shall be no adhesion of the asphalt to the tray surfaces.
The loaded asphalt shall be covered to minimise heat loss and to protect the asphalt from rain and from contamination.

The manner of delivery shall ensure that for the whole of each load the temperature at discharge shall not be lower than is specified in Table 12. To that end:

- The capacities of the delivery vehicles shall be not less than 6 tonnes and not more than 16 tonnes.
- Delivery shall be undertaken as expeditiously as possible and vehicles shall be scheduled to minimise waiting times at the site of the work.
- If the asphalt is to be transported over long distances the trays shall be insulated.

Table 11: Minimum Asphalt Discharge Temperatures

<table>
<thead>
<tr>
<th>Layer Thickness (mm)</th>
<th>Minimum Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤40</td>
<td>135</td>
</tr>
<tr>
<td>&gt;40</td>
<td>125</td>
</tr>
</tbody>
</table>

The temperature of the asphalt at discharge shall not be higher than $175\,\text{°C}$.

Delivered asphalt shall not be reheated.

Provided that the temperature of the asphalt is kept within the limits specified above, and as far as practicable, the asphalt shall be delivered at a rate that enables continuous operation of the paver.

Care shall be taken to avoid jarring the paver away from its correct alignment when the delivery vehicle is backed against it.

The asphalt shall be discharged under control into the receiving hopper of the paver.

8.7.3 Dockets

Each load of asphalt shall be accompanied by a docket from the asphalt plant identifying the delivery vehicle and stating the time of loading the asphalt and the temperature of the asphalt at the time of loading.

The Contractor shall give a copy of each docket to the Principal’s Representative.

8.8 Laying and Compacting Asphalt

8.8.1 Paver

Except as permitted by this specification, self-propelled mechanical pavers shall be used to lay asphalt.
Pavers shall satisfy the requirements of MRS11.10, "Plant Requirements for Hot-mixed Asphalt".

8.8.2 Corrector Course
A corrector course shall be laid to correct any irregularity in the existing surface that remains after preparation of the existing surface and application of a prime coat or tack coat and would prevent compliance with the layer thickness ranges specified in Table 13.

The corrector course shall be asphalt complying with this Specification.

The corrector course shall fill depressions more than 25 mm in depth and shall bring uneven areas to the general height of the surrounding surface.

The asphalt in the corrector course shall be compacted to the highest relative compaction that reasonably can be achieved.

8.8.3 Laying Program and Rolling Pattern

8.8.3.1 Laying Program
The Contractor shall prepare a program for laying asphalt (other than the corrector course). The program shall enable the Contractor to:

lay asphalt in layers of essentially uniform thicknesses, which shall be within the limits specified in Table 14:

- Lay the main longitudinal runs first.
- Make longitudinal joints parallel to the pavement centre line or other base line indicated.
- Locate longitudinal joints away from traffic wheel paths.
- Keep the number of joints, transverse or longitudinal, to a minimum.

The program shall take account of the requirements of this specification.

8.8.3.2 Rolling Pattern
The Contractor shall prepare a rolling pattern. The pattern shall be based on the laying program and on the technique described in this specification and shall enable the Contractor to:

- Begin rolling at asphalt temperatures not lower than are specified in Table 13.
- Achieve the compaction standard specified in this specification throughout the asphalt work.

8.8.3.3 Layer Thickness Limits
The thicknesses of compacted layers of asphalt shall be within the limits specified in Table 13.
Table 12: Layer Thickness Limits

<table>
<thead>
<tr>
<th>Asphalt Mix</th>
<th>Compacted Layer Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal Size (mm)</td>
</tr>
<tr>
<td>DG7</td>
<td>20</td>
</tr>
<tr>
<td>DG10</td>
<td>25</td>
</tr>
<tr>
<td>DG14</td>
<td>40</td>
</tr>
<tr>
<td>DG20</td>
<td>50</td>
</tr>
<tr>
<td>DG28</td>
<td>70</td>
</tr>
</tbody>
</table>

8.8.3.4 Creep and Modulus (DG 10 and 14 mixes)
For asphalt Classes 1.1 and 1.2, the samples shall be tested for dynamic creep to determine the number of pulses to reach 2% plastic strain.

Class 1.2 asphalt shall achieve a minimum number of pulses to 2% plastic strain in the dynamic creep test of 15000.

8.8.4 Paver Operation

8.8.4.1 Paver Level Control
The method of paver level control may be selected by the Contractor, provided that:

- Automatic control actuated by a matching shoe shall be used when asphalt is laid to match the surface level of previously-constructed asphalt work or an adjoining structure.
- The completed asphalt work shall be in accordance with this Specification.

8.8.5 Operation Generally
Laying asphalt shall begin as soon as there is sufficient asphalt in the paver’s receiving hopper.

The operating speed of the paver shall be controlled so that, as far as practicable, laying shall be continuous.

The spreader box shall not be left in contact with laid asphalt for long periods when waiting for delivery of asphalt.

Asphalt shall not be allowed to segregate or to accumulate at the sides of the receiving hopper.

The mat of asphalt produced by the paver shall have a uniform appearance, with no evidence of segregation along the centre line of the paver run or at the end of a load.

8.8.6 Hand Spreading
Hand spreading may be used:

- To correct minor surface irregularities.
- On or very close to drainage channels.
- In tapers.
- In areas where paver operation is not practicable.

Asphalt used in hand spreading shall be fresh asphalt taken from the paver's receiving hopper or from a delivery vehicle.

In correcting surface irregularities a thin layer of asphalt shall be placed over the affected area, spread evenly using board rakes and rolled immediately.

In other hand spreading the asphalt shall be distributed into place by shovel and spread to loose depth using metal rakes or board rakes. Loose stones shall be removed.

Asphalt shall not be spread by broadcasting from shovels.

8.8.7 Joints

8.8.7.1 General

The laying program referred to in this specification shall have taken into account the requirements of this Clause and in general the joints made shall be located as provided for in the program.

Any joint required by this Clause shall be made, notwithstanding that it may not be provided for in the program.

8.8.7.2 Joints Required

A transverse joint shall be made at the start of laying away from existing asphalt.

A transverse joint shall be made at the restart of laying away from a previous day’s work.

A transverse joint shall be made where a delay in or suspension of laying has allowed the laid asphalt to cool below the minimum rolling temperature specified in Table 14.

A longitudinal joint shall be made where new asphalt work is run beside existing asphalt (including asphalt work constructed under this Contract).

A longitudinal joint shall be made if the width of the pavement is such that more than one paver run is necessary.

A join at the end of a run to existing asphalt (including asphalt work constructed under this Contract) shall be made as a longitudinal joint.

8.8.7.3 Making Joints

Join faces in existing asphalt shall have been prepared. Refer to this Specification.

In continuing work, joint faces in previously-laid asphalt shall be formed by cutting back loose, broken or deformed asphalt so that the surfacing or paving that is retained shall be
sound asphalt work that is compacted in accordance with this specification and is within the geometric tolerances specified in this specification.

The cut for each joint shall be for the full depth of the layer, shall be normal to the finished surface of the surfacing and shall be clean and straight.

The cut face shall be tack coated with bituminous emulsion, as specified in this Specification.

In a transverse joint, the new or restarted run shall begin with the full uncompacted depth of the new asphalt layer at the line of the joint.

In a longitudinal joint, the new run shall overlap 25 mm to 75 mm onto the existing or previously-laid asphalt. Before the joint is rolled the overlap material shall be pushed back to the line to form a ridge along the edge of the new asphalt mat; any excess of overlap material shall be removed and discarded.

Excess asphalt shall not be spread across the mat.

8.8.7.4 Offsetting Joints
In multi-layer work a joint in a higher layer, except a longitudinal joint at a crown, shall be offset by 100 mm from the joint in the layer below.

Where asphalt surfacing is constructed instead of bitumen reseal, the edge of the asphalt surfacing adjoining the lip of kerb and channel or road invert crossing shall be tapered over a width of between 50 mm and 100 mm to give a finished asphalt surfacing level not more than 20 mm above the lip.

8.8.7.5 Temporary Ramps
If traffic is to be permitted to run onto new asphalt work the Contractor shall construct temporary ramps.

The ramps shall be constructed to protect the edge of the completed asphalt surfacing and to provide safe passage for traffic at the speed limit in force.

When work restarts the ramps shall be removed and joints shall be made.

8.8.8 Compaction

8.8.8.1 Rollers
Except as permitted by this specification, rollers shall be used to compact asphalt.

Rollers shall satisfy the requirements of MRS11.10, “Plant Requirements for Hot-mixed Asphalt”.

8.8.8.2 Rolling Temperatures
At the start of rolling the temperature of the asphalt shall not be lower than is specified in Table 14.
Table 13: Minimum Asphalt Temperatures at Start of Rolling

<table>
<thead>
<tr>
<th>Layer Thickness</th>
<th>Minimum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mm)</td>
<td>(°C)</td>
</tr>
<tr>
<td>≤40</td>
<td>120</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>110</td>
</tr>
</tbody>
</table>

If the asphalt is at a higher temperature and ridges or other irregularities are formed by horizontal displacement of the asphalt under the action of the roller, rolling shall be suspended until the asphalt has cooled sufficiently to resist displacement.

8.8.8.3 Rolling Technique

Rolling shall begin as soon as practicable after the asphalt has been laid.

Rolling shall follow the pattern referred to in this specification.

Rolling shall comprise:

1) Initial or breakdown rolling.
   - A steel-wheeled roller or a vibratory roller shall be used for initial rolling.
   - A vibratory roller may be used in the vibrating mode if there is no apparent displacement or cracking of the asphalt.
   - Except on steep up-grades, the driving wheels of the roller shall lead.
   - The roller shall be taken as close to the paver as practicable.
   - Transverse joints, then longitudinal joints, then edges shall be rolled first and rolling then shall proceed in parallel longitudinal passes from the lower edge to the higher edge of the asphalt mat.
   - Near the unsupported edge of a layer more than 75 mm in compacted thickness the first pass shall be made approximately 300 mm in from the edge and rolling shall progress inwards. After the balance of the mat has been rolled the outer 300 mm zone shall be rolled, working outwards from the edge of the first pass in 100 mm increments.

2) Intermediate rolling.
   - A pneumatic-tyred roller or a vibratory roller shall be used for intermediate rolling.
   - Transverse joints, then longitudinal joints shall be rolled first and rolling then shall proceed in parallel longitudinal passes from the longitudinal joint, or an edge if there is no joint, to the other edge of the asphalt mat, repeated as necessary.
   - The compaction standard specified in in this specification shall be achieved during intermediate rolling.

3) Final or finish rolling.
   - A steel-wheel roller or a vibratory roller with vibrator disengaged shall be used for final rolling.
   - Final rolling shall produce a uniform finish free of roller marks.
- Tyre pressures on pneumatic-tyred rollers shall be maintained within the limits recommended by the roller manufacturer.
- Steel-wheeled rollers and vibratory rollers shall be operated at steady speeds not exceeding 5 km/h.
- Pneumatic-tyred rollers shall be operated at a speed of 2.5 km/h for the first pass. The speed shall be increased by approximately 2.5 km/h for each subsequent pass, up to a maximum of 15 km/h.
- When a vibrating roller is changing direction of movement or is stationary the vibrator shall be disengaged.
- Rollers shall not remain stationary on newly compacted asphalt.

8.8.8.4 Tamping
Mechanical tampers may be used in areas where roller operation is not practicable.

Hand tamping may be used only where the use of a mechanical tamper is not practicable.

8.8.8.5 Laboratory Compaction (DG 10 and 14 mixes)
Six samples of target mix design asphalt with the specified binder for the work shall be compacted in the laboratory using hand compaction. The compaction standard shall be 75 blows Marshall for Class 1 mixes.

8.8.8.6 Compaction Standard
"Relative compaction" is the ratio of the density of the compacted asphalt surfacing to the representative maximum density of the lot of asphalt used.

The relative compaction shall be within the limits specified in Table 15.

Table 14: Relative Compaction Limits

<table>
<thead>
<tr>
<th>Asphalt Mix Nominal Size</th>
<th>Relative Compaction %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mm)</td>
<td>Minimum</td>
</tr>
<tr>
<td>DG7</td>
<td>92</td>
</tr>
<tr>
<td>DG10</td>
<td>92</td>
</tr>
<tr>
<td>DG14</td>
<td>93</td>
</tr>
<tr>
<td>DG20</td>
<td>93</td>
</tr>
<tr>
<td>DG28</td>
<td>93</td>
</tr>
</tbody>
</table>

8.8.9 Tolerances

8.8.9.1 Horizontal
The lines of crowns, ridges, valleys and other features shall be within ±50 mm of the lines as indicated.

8.8.9.2 Vertical
Thickness tolerance control shall apply.
The thickness of any one layer (other than corrector course) shall be within the tolerances specified in Table 16 of the thickness as indicated or the thickness advised pursuant to this specification.

Table 15: Layer Thickness Tolerances

<table>
<thead>
<tr>
<th>Asphalt Mix Nominal Size (mm)</th>
<th>Layer Thickness Tolerance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DG7</td>
<td>± 5</td>
</tr>
<tr>
<td>DG10</td>
<td>± 5</td>
</tr>
<tr>
<td>DG14</td>
<td>± 7</td>
</tr>
<tr>
<td>DG20</td>
<td>± 10</td>
</tr>
<tr>
<td>DG28</td>
<td>± 10</td>
</tr>
</tbody>
</table>

8.8.9.3 Surface Grading Uniformity
There shall be no depressions capable of holding water and there shall be no valleys concentrating the flow of water.

With allowance made for designed shape, the deviation from a 3 m straight edge placed anywhere on the surface of a layer shall not exceed 5 mm.

8.8.9.4 Surface Level at Adjoining Structures
At the lip of channel in kerb and channel, at the edges of concrete drains, at manholes and at other structures where water is to flow from asphalt surfacing to the structure the level of the surface of the asphalt shall be within ±5 mm, -0 of the lip, edge or structure level.

At the toe of kerb and toe the level of the surface of the asphalt shall be within ±0, -5 mm of the toe level.

At kerbing, dwarf walls, building footings etc. the level of the surface of the asphalt shall be within ±10 mm of the kerb etc. level minus the nominal height of the kerb etc. above the asphalt surface.

At a property line, where the asphalt surfacing is in the property and adjoins the footpath of a public road, the level of the surface of the asphalt shall be within ±10 mm, -0 of the footpath level.
9 Bollards

9.1 Road Signs

9.1.1 Materials
Road sign faces shall be in accordance with Clause 10 of Department of Transport and Main Roads Standard Specifications Roads, MRS11.14 Road Furniture, provided that the Department of Transport and Main Roads corporate logo (Clause 10.6.10 of MRS11.14) shall be omitted.

9.1.2 Construction
The supply of posts, brackets, saddles and fixings and the installation of posts and sign faces shall be in accordance with Clause 11 of Department of Transport and Main Roads Standard Specifications Roads, MRS11.14 Road Furniture.

9.2 Bollards – Industrial
This Clause applies to bollards – industrial in major vehicular areas.

Concrete shall be strength grade N25.

Bollards - industrial shall be 150 mm dia galvanised steel tube.

Bollards - industrial shall be installed In accordance with manufacturer’s requirements.

Bollards - industrial shall be filled with concrete following setting of the footing.

Bollards - industrial shall be painted safety yellow (AS 2700 Y14).

Additional bollards, not indicated on plans, may be added as directed by the Principal’s Representative in areas needed during construction.

9.3 Bollards – Non-Industrial
This Clause applies to bollards – non-industrial in office and store areas.

Concrete shall be strength grade N25.

Bollards – non-industrial shall be fabricated from 150 mm dia x 5.4 mm CHS 1200 mm high with 8 mm thick plate top and 12 mm thick base plate. The components shall be fully welded and the welds shall be ground smooth.

Bollards - non-industrial shall be hot dip galvanized.

Each bollard – non-industrial shall be fixed to thickened concrete pathway or to a mass concrete footing by four M16 Grade 5.8 galvanized studs in Chemset Injection 800 Series anchorings made in accordance with the manufacturer’s recommendations.
10 Landscaping

10.1 General
All areas where the plant has been demolished by the Contractor shall be planted, turfed or treated with native grass seed mix.

10.2 Preparation for Topsoil (In General Landscape Areas)
Topsoil shall be defined in accordance with Technical Specification - Civil Works

Topsoil treatment shall be undertaken as per the following Table 17:

Table 16: Topsoil/Subgrade Treatments

<table>
<thead>
<tr>
<th>Landscape Subgrade Condition</th>
<th>Amelioration/ Fertilisation during Construction Period</th>
<th>Fertilisation during Establishment Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stripped of Topsoil (all turfed areas shown on landscape plans)</td>
<td>Broadcast spread gypsum @ 2 t/ha over total area. Gypsum shall be applied well in advance of Seeding to allow time for irrigation or rainfall to activate. Apply CK88 @ 100 kg/ha via broadcast spreader. Apply and incorporate with the gypsum prior to Seeding Uniformly Blade mix the added top soil and additives noted above. Hand rake the surface to a uniform finished surface removing stones and deleterious materials, stones over 25 mm diameter, clay lumps, weeds and tree roots, sticks and rubbish, material toxic to plants. The site topsoil is to be placed at the nominal levels required levels for seeding, making due allowance for amelioration.</td>
<td>Apply CK50/50 @75 kg/ha broadcast spread in early summer (during landscape establishment period) to help grass tolerate heat stress. Follow with irrigation. Apply CK88 @ 100 kg/ha every 8 weeks via broadcast spreader. Follow each application with irrigation.</td>
</tr>
</tbody>
</table>
10.3 Seed Mix
The grass seed and fertiliser shall be thoroughly pre-mixed and shall include the following species:

- Japanese Millet 30 kg/ha
- Green Couch 35 kg/ha
- Indian Blue Couch 15 kg/ha

The Contractor shall not sow in periods of extreme heat, cold or wet, or when wind velocities exceed 10 km/h, unless otherwise directed.

10.4 Preparation
Prepare the areas to be sown by cultivating and fertilising. If a prepared area becomes compacted from any cause before sowing can begin, rework the ground surface in accordance with the requirements of Table 17.

10.5 Sewing
Sow the seed by a method that achieves the specified application rate and even distribution. The Contractor is to provide details of the proposed seeding / hydro seeding and fertilising method to the Principal’s Representative for review. Sowing machinery shall be purpose made. Lightly rake the surface to cover the seed. Roll the seedbed immediately after sowing with a roller weighing not more than 90 kg/metre of width.

10.6 Germination
Ensure an even sward of healthy grass over the whole of the seeded area is achieved, with no bare patches.

10.7 Watering
Thoroughly water the seeded area with a fine spray immediately after rolling until the soil is moistened to a depth of 150 mm. Continue watering until germination as necessary to keep the surface damp and the soil moist but not waterlogged. Then water as necessary to maintain the grass in a healthy condition progressively hardened off to the natural climatic conditions prevailing in the locality at the time.

The Contractor will be required to submit details of temporary irrigation links, sprinklers and timers for review 2 weeks prior to work commencing. Existing fire hydrants may be utilised as required. Irrigation by water truck is acceptable however a watering plan must be submitted to the Principal’s Representative for review.

10.8 Protection
It is the responsibility of the Contractor to protect the newly seeded areas against traffic until the grass has established.

10.9 Fertiliser
Apply fertiliser as detailed in Table 17.
10.10 Reseeding
Rake over and reseed areas where the grass seed fails to germinate within one month of the date of the original sowing. Failure shall be any area that is not healthy, green and vigorously growing. Failed areas shall be those that have a grass cover of less than 75% coverage within any 10m² area.

10.11 Weeding
Remove weeds that emerge in the grassed areas, or where necessary spray with a selected weedicide for broad leaved weeds, to manufacturer’s recommendations.

Note: it is expected that there will be significant weed growth in the areas that are prepared for seeding and watered regularly as required by this Specification. The Contractor shall remove the weeds that are present on a fortnightly basis until they are suppressed by the germinated seeding.

10.12 Mowing
Make the first cut and subsequent cuts to maintain the grass at 30 mm until the Date of Practical Completion.

10.13 Topdressing
When seeded areas have established, mow and topdress to remove any larger depressions or unevenness in the surface. Topdress with fine sand, as directed by the Principal’s Representative.

When germination has established mow at regular intervals to maintain an average height of 30 mm.
11 Compliance Testing

A NATA-registered laboratory certified for the tests specified in this contract shall carry out all compliance testing (where applicable).

The frequency of compliance testing shall comply at least with the minimum requirements as indicated in Table 18.

Table 17: Minimum Testing

<table>
<thead>
<tr>
<th>Work</th>
<th>Quality Verification Requirements</th>
<th>Testing Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>Property Tested</td>
</tr>
<tr>
<td>Earthworks Excavation</td>
<td>Geometrics</td>
<td>Horizontal</td>
</tr>
<tr>
<td></td>
<td>Compaction</td>
<td>Vertical</td>
</tr>
<tr>
<td></td>
<td>Compaction</td>
<td>Laboratory dry density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry density ratio</td>
</tr>
<tr>
<td>Earthworks Preparation for filling</td>
<td>Compaction</td>
<td>Laboratory dry density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry density ratio</td>
</tr>
<tr>
<td>Earthworks Filling</td>
<td>Materials</td>
<td>Linear Shrinkage</td>
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<td></td>
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<td>Plasticity Index</td>
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<td></td>
<td></td>
<td>Liquid Limit</td>
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<tr>
<td></td>
<td>Geometrics</td>
<td>Horizontal</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Dry density ratio</td>
</tr>
<tr>
<td>Earthworks Subgrades</td>
<td>Preparation of Existing Granular Subgrades</td>
<td>Horizontal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vertical Primary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vertical, additional:</td>
</tr>
<tr>
<td></td>
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<td>- Straight edge</td>
</tr>
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<td>- Crossfall</td>
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<td>Compaction</td>
<td>Lab Dry Density</td>
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<td></td>
<td></td>
<td>Dry Density Ratio</td>
</tr>
<tr>
<td>Stormwater Drainage</td>
<td>Concrete</td>
<td>Compressive Strength</td>
</tr>
<tr>
<td>Structures</td>
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<td>Slump</td>
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<tr>
<td></td>
<td>Geometrics</td>
<td>Specification</td>
</tr>
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<td></td>
<td></td>
<td>tolerances</td>
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<tr>
<td>Kerb and Channel</td>
<td>Concrete</td>
<td>Compressive Strength</td>
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</tr>
<tr>
<td>Asphalt</td>
<td>Materials</td>
<td>Softening point</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Penetration Viscosity (RTFO)</td>
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</tbody>
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### Compaction

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<tr>
<th>content</th>
<th>5000 m²</th>
<th>1 test per 500 m²</th>
<th>4 per lot</th>
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</thead>
</table>

### Geometrics

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<th>1 test per 20 m (3 points)</th>
<th>1 test per 40 m (L&amp;R)</th>
<th>1 test per 40 m (L&amp;R)</th>
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</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Vertical, Primary Other Layer</td>
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</tr>
<tr>
<td>Vertical, additional:</td>
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<tr>
<td>- straight edge</td>
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<tr>
<td>- crossfall</td>
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<tr>
<td>500 m</td>
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</table>
PIPEWORK SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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1 General

1.1 Scope
This Specification shall apply to pipework comprising gravity sewers (other than stormwater drains), pressure mains and rising mains.

1.2 Definitions
"Manholes" and “Maintenance Holes” shall have the same meaning.

1.3 Standard Drawings
Typical details of the works are shown in the following Water Services Association of Australia (WSAA) standard drawings.

1.3.1 Gravity Pipelines
SEW-1200 Soil Classification and Allowable Bearing Pressures for Bulkheads
SEW-1201 Embedment & Trenchfill – Typical Arrangement
SEW-1202 Standard Embedment – Flexible & Rigid Pipes
SEW-1203 Special Embedment – Inadequate Foundations Requiring Over Excavation & Replacement
SEW/-1301 Maintenance Holes – Sewers < DN300- Cast in-situ Types P1 & P2
SEW-1302 Maintenance Holes – Pipe Connection Details
SEW-1303 Maintenance Holes – Sewers<DN300 – Charges in Level Details
SEW-1304 Maintenance Holes – Sewers<DN300 – Typical Channel Arrangements
SEW-1305 Maintenance Holes – Typical Channel Details
SEW-1309 Maintenance Holes – Sewers DN375 to DN 750

1.3.2 Pressure Pipelines
WAT - 1200 Soil Classification Guidelines and Allowable Bearing Pressures for Anchors and Thrust blocks.
WAT - 1201 Embedment & Trenchfill - Typical Arrangement
WAT - 1202 Standard Embedment – All Pipe Types
WAT - 1205 Thrust Block Details – Concrete Blocks
WAT - 1207 Thrust and Anchor Blocks – Gate Valves and Vertical Bends
WAT - 1209 Trench Drainage – Bulkheads & Trenchstop
1.4 Standard Specifications
The following Specifications apply to works described in this specification:

- Technical Specification - Structural Concrete.

1.5 Scope of Work
The work covered by this specification includes the design and supply of all labour, materials and plant for the manufacture and supply of all pipes and fittings, complete as described in the Specification.

1.6 Standards, Codes and Regulations
Unless specified or agreed otherwise, all installations and site work shall comply with the most recent revision and amendments of:

- WS-Spec SP1 Steel Pipes and Fittings
- WS-Spec SP2 Ductile Iron Pipes and Fittings
- WS-Spec SP3 Grey Cast Iron and Fittings
- WS-Spec SP4 PVC Pipes and Fittings
- WS-Spec SP6 Polyethylene Pipes and fittings
- WS-Spec SP8 Concrete Pipes
- WS-Spec SP10 Concrete Drainage Pipes, Pits and Fittings
- WS-Spec SP15 Elastometric Seals
- WS-Spec SP21 Sluice Valves Resilient Seated
- WS-Spec SP22 Ball Valves
- WS-Spec SP23 Knife Gate Valves
- WS-Spec SP17 Air Valves
- WSA 112 Air Valve Industry Standard
- WS-Spec 35 Water Domestic Meters

The Contractor shall be responsible for ensuring that all equipment and materials supplied are in complete accordance with the requirements of all relevant Authorities, and that all required approvals are obtained.
2 Materials

2.1 General
All materials, fittings and pipes shall comply with the requirements of the current Australian Standard Specification. If there is no Australian Standard Specification, the relevant British Standard Specification, if any, shall apply.

Material in contact with potable water shall be approved in accordance with AS/NZS 4020 Testing of products for use in contact with drinking water.

Rigid pipelines are those whose principal load supporting ability lies in the inherent strength or stiffness of the pipe and only limited support from the soil surround. Reinforced concrete pipelines are rigid pipelines.

Flexible pipelines are those which rely principally on the interaction between the pipe structure and the soil surround and only partly on the inherent strength of the pipe to resist external loads. Ductile iron, mild steel, polyvinylchloride and polyethylene pipelines are flexible pipelines. Flexible pipelines shall be designed in accordance with AS/NZS 2566.1 Buried flexible pipelines – Part 1: Structural design and installed in accordance with AS/NZS 2566.2 Buried flexible pipelines – Part 2: Installation.

Pipe materials and pressure ratings shall be as specified in the Contract or as may be specifically accepted in writing by the Principal’s Representative.

Pipe shall be supplied in the longest lengths available and will be cut for the installation of valves and fittings.

2.2 Ductile Iron (DI) Pipelines
Pipes shall be centrifugally cast ductile iron manufactured and tested in accordance with AS/NZS 2280 Ductile iron pipes and fittings. Pipes shall have flanged, spigot or socket ends as scheduled in the Contract.

Fittings shall be either cast ductile iron fittings manufactured and tested in accordance with AS/NZS 2280 Ductile iron pipes and fittings or cast grey iron fittings manufactured and tested in accordance with AS/NZS 2544 Grey iron pressure fittings. Fittings shall be manufactured with flanged, spigot or socket ends as scheduled or applicable.

Spigot and socket pipe and fittings shall be supplied with EPDM rubber gaskets complying with AS 1646 Elastomeric seals for waterworks purposes.

Ductile iron pipes and fittings shall be cement mortar lined internally (DICL) and externally coated with coating complying with AS/NZS 4158 Thermal-bonded polymeric coatings on valves and fittings for water industry purposes and grey iron fittings shall be internally and externally coated with bitumen or pitch paint unless otherwise supplied with special coatings and/or linings.
All ductile iron pipe systems, installed below ground, including fittings and valves, shall be protected with polyethylene sleeving. Polyethylene sleeving and adhesive tape shall comply with AS 3680 Polyethylene sleeving for ductile iron piping.

Thrust flanges on pipes and fittings shall be integrally cast.

Also refer to WS-Spec SP2 & 3 for further specification details and references

2.3 Polyvinylchloride (PVC) Pipelines

2.3.1 General
PVC pipes and fittings shall have spigot and socket ends for elastomeric seal joints. Spigot and socket pipe and fittings shall be supplied with EPDM rubber gaskets complying with AS 1646 Elastomeric seals for waterworks purposes.

Also refer to WS-Spec SP4 for further specification details and references.

PVC pipes and fittings shall not be jointed by solvent welding except as follows:

- Where adaptor couplings and single couplings for jointing cut pipes, require solvent welded joints in the field.
- Where couplings have been solvent welded to pipes and fittings at the manufacturers works.
- Where joints between pipes and fittings are later to be encased in concrete.

2.3.2 Gravity
All PVC sewer pipes and fittings shall be:

- manufactured and tested in accordance with AS/NZS 1260 PVC-U pipes and fittings for drain, waste and vent application;
- minimum SN8 classification;
- elastomeric seal jointed.

Spigot and socket pipe and fittings shall be supplied with EPDM rubber gaskets complying with AS 1646 Elastomeric seals for waterworks purposes.

Where maintenance hole couplings or other uPVC fittings are required to be set in concrete to provide mechanical bond strength and/or water sealing, the Contractor shall use fittings provided with a surface finish compatible with bonding to concrete. In lieu of any alternative system which the Contractor may offer for approval, the bond surface of standard, smooth, moulded or extruded fittings shall be coated with a uniform light wash of solvent cement and immediately dusted with clean dry sand.

2.3.3 Pressure Pipes
All PVC pressure sewer pipes and fittings shall be:
PIPEWORK SPECIFICATION

- manufactured and tested in accordance with AS/NZS 1477 PVC-O or PVC-M pipes and fittings for pressure applications
- minimum PN 16 classification;
- elastomeric seal jointed.

Spigot and socket pipe and fittings shall be supplied with EPDM rubber gaskets complying with AS 1646 *Elastomeric seals for waterworks purposes*.

2.3.4 Ductile Iron and Grey Iron Fittings for PVC Pipelines

Socket ended ductile iron and grey iron fittings for jointing to PVC pipes with high coefficients of linear expansion shall have an allowable penetration depth beyond the rubber ring within the socket equivalent to or greater than the same dimension for the PVC pipe socket. Ductile iron pipes shall be manufactured to AS 1280.

Fittings shall comply with Clause 2.2.

Gibault joints for jointing to PVC pipes shall be supplied with extended sleeves suitable for jointing PVC pipe materials with high coefficients of linear expansion.

2.4 Precast Concrete Pipes (Non-Pressure)

2.4.1 Standard Specification

All concrete pipes shall be manufactured and tested in accordance with AS/NZS 4058 *Precast concrete pipes (pressure and non pressure)*. For joints requiring a sealing rings, EPDM rubber gaskets complying with AS 1646 *Elastomeric seals for waterworks purposes* shall be supplied.

All precast concrete pipes shall have a factory installed Plasti-lining.

2.5 Flanges, Gaskets and Bolt Sets

All flanges shall be manufactured and tested in accordance with AS 4087 *Metallic flanges for waterworks purposes*.

Gaskets and bolt sets shall be provided for all flanged joints in accordance with WSA 109 *Industry Standard for Flange Gaskets and O-rings*.

All nuts, bolts and washers shall be cast 316 Stainless Steel with Nickel anti-seize and appropriate insulation sleeves to prevent contact of dissimilar materials, unless otherwise noted.

2.6 Valves

2.6.1 General

All valves, except ball valves shall have ductile iron, grey cast iron or gunmetal bodies and working parts shall be of first class quality throughout. Grey cast iron or gunmetal bodies are only acceptable when ductile iron is not procurable. No mild steel parts are to be used on
any valve. All valves and actuators shall have a proven record of reliable operation in its selected environment and shall have readily available spare parts. All valves shall have a minimum pressure rating of PN16.

All valves shall be rated appropriately and have flanges in accordance with AS4087 unless noted otherwise.

Valves shall be located and/or orientated in such a way that manual operation of the valves (whether actuators are supplied or not) may be carried out with ease and without the need for any other extra equipment.

All valves shall be easily accessible for maintenance purposes and shall be capable of being removed from their location in a pipeline without obstruction by the pipeline or other equipment. When necessary, dismantling joints shall be provided.

All valves shall close in a clockwise direction, and the direction of opening and/or closing shall be marked in the handwheel casting or valve body.

Cement lining shall not be chipped away or reduced to provide clearance for valve discs or working parts of valves.

Large isolation valves, i.e. 450 mm and larger, shall be fitted with enclosed, oil filled or grease packed, valve gear operators.

Stainless steel Grade 316 bolts; nuts and washers shall be used on bonnets and glands.

Extension spindles of valves shall be of tubular stainless steel, to AS1449 Grade 316, with one end secured to the valve spindle and the other end made to accommodate a Tee Key operator. Adjustable intermediate support brackets of grade 316 stainless steel shall be provided for extension spindles exceeding 1.5 m in length.

Valves associated with bunding operations shall be lockable.

Tee Key valve operators and handwheels shall be sized to operate the valves under all operating conditions throughout their full range with no greater than 180 Newtons applied to the end of the key bar or the rim of the wheel. Handwheels shall display an embossed or engraved arrow, together with “open” and/or “close”.

All valves shall be hydrostatically tested in accordance with AS2638. After all tests have been completed, operationally test the valves by opening and closing several times to ensure freedom of operation. A Certificate of Test and Inspection, signed by the manufacturer, shall be provided for each valve prior to installation.

The following specifications are to be used as a minimum requirement when selecting valves that are not already detailed elsewhere in the Specification.
2.6.2 Gate Valves
Gate valves (also referred to as Sluice Valves) for pipelines rated PN25 or more shall be metal seated. Gate valves shall be resilient seated for pipelines rated up to PN25.

Metal seated gate valves shall be manufactured and tested in accordance with AS 2638.2 *Gate valves for waterworks purposes – Metal seated.*

Resilient seated gate valves shall be manufactured and tested in accordance with AS 2638.2 *Gate valves for waterworks purposes – Resilient seated.*

Gate valves shall be of basic construction for below ground installation with a vertical non rising spindle for clockwise closure and operated by a removable key. Basic construction is specified in Table 2.1 Basic Material Requirements for metal seated valves in AS 2638.1 and Table 2.1 Basic Material Requirements for Resilient Seated Valves in AS 2638.2.

A Type Test Certificate shall be provided for valves rated PN25 or less and DN200 or less. A Production Test Certificate shall be provided for all other valves.

Also refer to WS-Spec SP4 for further specification details and references.

2.6.3 Ball Valves
Ball valves for sewerage pipelines shall be metal/plastic bodied complying with manufacturing and testing requirements set out in WS-Sec SP22.

2.6.4 Non-return Valves – Sewerage Pipelines
Non-return valves for sewerage pipelines shall be resilient seated swing check type valves.

Non-return valves shall be manufactured as follows and to WS-Spec 25 requirements:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body and Cover</td>
<td>Ductile iron to AS 1831 Grade 400-12</td>
</tr>
<tr>
<td>Coating</td>
<td>Complying with AS/NZS 4158 Thermal-bonded polymeric coatings on valves and fittings for water industry purposes</td>
</tr>
<tr>
<td>Cover Gasket</td>
<td>NBR O-ring</td>
</tr>
<tr>
<td>Ball</td>
<td>NBR rubber liner aluminium or cast iron</td>
</tr>
</tbody>
</table>

Valves shall be tested to 1.1 x PN for the seat and 1.5 x PN for the body.

A Type Test Certificate shall be provided for check valves.

2.6.5 Knife Gate Valve
Knife gate valves shall be of 316 stainless steel construction, unidirectional lugged type manufactured to WS-Spec 23 guidelines. The valve shall have a one piece integral cast
body, chest and lugs, with integral gate scrapers. Valves shall be suitable for extension of the operating spindle.

2.6.6 Backflow Prevention (RPZ Valves)
The Contractor shall install slab mounted and testable back-flow prevention devices at the pump station locations where required and in accordance with the manufacturer's procedures.

The back-flow prevention device shall consist of a RPZ valve fitted with isolating valves either side. Details of the back-flow prevention device shall be provided to the Principal’s Representative for review. The installed RPZ arrangement shall be certified by a licensed plumber in accordance with Australian Standards.

2.7 Hosecock
The Contractor shall supply and install hosecocks where required and in accordance with the manufacturer's procedures.

The hosecock shall be 25 mm nominal diameter, stainless steel grade 316, ball valve type, mounted 600 mm above the concrete slab.

The hosecock riser shall be securely fastened to a stainless steel support post or adjacent structure.

A 20 mm dia hose and reel shall be mounted adjacent to the hosecock, with length appropriate to the facility to be serviced by the hosecock, but not less than 10 m.

At all washwater services a prohibition sign shall be fixed adjacent to the hosecock or outlet in accordance with Sign No. 404 of AS 1319-1994 Safety Signs for the Occupational Environment.
3 Handling and Storage of Pipes and Fittings

3.1 General
Transport, handle and store all products and materials in accordance with the manufacturers’ recommendations and in a manner that prevents damage or deterioration or excessive distortion.

Care shall be taken when handling pipes and fittings that internal and external linings and protective coating are not damaged.

Pipes and fittings shall be stored on timber bearers clear of the ground. Pipes shall be stacked in a manner that minimizes pipe ovalisation.

Do not store plastic pipe and fittings near heat emission sources.

Store elastomeric gaskets, other seals and PE sleeving away from sunlight.

3.2 Acceptance and Rejection
The contractor shall instruct the suppliers to deliver materials with adequate product certification and declaration that products and materials comply with the specifications.

Reject any damaged pipe or defective product material and do not use any rejected product/material in the works.

3.3 PVC Pipes and Fittings
uPVC pipes shall be crated and delivered from the point of manufacture to the site strictly in accordance with the provisions of AS 2032, except as modified herein. Each crate of pipes shall be supported by longitudinal timbers in such a manner that when crates are stacked, the load is transferred through the crates and not to pipes within any crate.

Nesting of pipes will be approved provided that the ends of the stack of pipes are covered to prevent the nested pipes sliding out and the maximum weight per stack of pipes shall not exceed two tonnes.

Unless the pipes are stored on site under cover preventing exposure to direct sunlight, the top, sides and ends of all stacks of pipes shall be covered by a fibre-glass reinforced aluminium foil insulating material. The insulating material shall be securely attached to the stacks to prevent its being torn or blown away.

Fittings shall be supplied and stored under conditions equivalent to pipes. The Principal’s Representative may reject any uPVC pipes not delivered to site in approved crates.
4 Jointing of Pipelines

4.1 General
All pipes shall be jointed in the trench unless otherwise approved by the Principal’s Representative. The Contractor shall excavate as required for the proper jointing of fittings. Jointing shall not proceed until the Principal’s Representative has approved the condition of the trench bottom.

After pipes and fittings have been positioned and joints made, no springing of joints will be permitted other than as required to line pipes up true to grade and alignment. If necessary to correct the position alignment or grade of pipes and/or fitting, joints shall be broken, the necessary corrections carried out and the joints remade unless otherwise approved by the Principal’s Representative.

Prior to fixing, all external bolts and nuts on valves, gibault joints, flanged connections etc., shall be liberally coated with an approved heavy grade underwater grease.

4.2 Rubber Ring Joints
In making rubber ring joints, care shall be taken to roll the rubber ring evenly into place when the spigot is driven home into the socket.

Apply the manufacturer’s specified lubricant to the end of the spigot and chamfer of the pipe. Keep the elastomeric seal and its housing free of lubricant, unless otherwise recommended by the manufacturer.

The pipe shall then be lined up true to grade and alignment. In spigot and socket joints each pipe shall be pressed home into the socket of the preceding pipe and the spigot shall be truly concentric with the socket. In pressing home the pipe by means of levers or jacks, precautions shall be taken to ensure that the ends of the pipes are not damaged.

4.3 Flanged Joints
Flanged joints shall be made in accordance with Appendix D, Flange Jointing Procedure, of WSA 109 Industry Standard for Flange Gaskets and O-rings.

4.4 Unrestrained Mechanical Couplings and Other Joints
Where gibault or similar types of joints are to be used they shall be set with equal overlap on each pipe and the collars shall be at right angles to the axis of the pipes. The rubber joint rings shall be rolled into position without twisting, the bolt holes set in line and the nuts screwed up evenly to a uniform tension.
5 Pipe Sleeving
This work involves pipe laying by way of sleeve pipes installation of those sections of pipe where it is not practical to trench due to Queensland Rail and DTMR requirements.

Prior to tendering, the contractor shall satisfy himself as to the nature of the site conditions including soil, groundwater, services, nature of excavation, sensitive buildings and structures, settlement monitoring requirements, dilapidation surveys, dewatering and filling, sediment control and everything necessary to achieve sleeve construction.

5.1 Pipeline Installation through Trenchless Techniques

5.1.1 Scope
This Section covers the installation of pipeline by trenchless installation techniques. Trenchless techniques minimise interference with existing features, facilities or traffic.

The trenchless techniques to be employed in this Contract are:

- Thrust Boring
- Micro-tunnelling.

The work to be executed under this Section consists of installation and all necessary ancillary work, whether such work is temporary or permanent.

5.1.2 Methodology

A clear and detailed methodology for the execution of the trenchless installation shall be prepared and submitted to the Principal's Representative prior to construction. The method statement shall adequately address the following items as a minimum requirement:

- General description of method and sequence of operation.
- Specialist subcontractors to be utilised.
- Conduit type and specification, including compliance with relevant Australian Standard.
- Jointing type and specification.
- Grout type, if required, methodology and equipment for grout injection.
- Description of any motorised pumping, jacking, horizontal boring or micro-tunnelling machine intended for use.
- Existing underground utility services:
  - Treatment at conflict locations
  - Protection of services in zone of influence
  - Survey equipment and methods.
- Direction of installation of conduit.
- Size, depth and position of temporary access pits required.
- Location of temporary spoil site if required and nature of haulage equipment.
- Programmed daily working hours and duration for the operation.
- Strategy for dealing with noise pollution problems.
- Traffic management.
- Dewatering.
- Method of disposal of drilling mud and other waste materials.

5.1.3 Enveloper Pipe
The strength of the enveloper pipes shall be such as to provide adequate (minimum 25%) factor of safety against the maximum working jacking load involved as well as the permanent external loads on the pipes. Calculations demonstrating compliance with this requirement shall be submitted by the Contractor.

The enveloper pipes shall not be installed until the Contractor has produced documentary evidence to the Principal’s Representative that the above requirements are met.

5.1.4 Carrier Pipe
The carrier pipe shall be installed inside the enveloper pipe. The carrier pipe shall be supplied and installed by the Contractor.

5.1.5 Installation
The installation shall provide for the following performance requirements:
- Voiding around the enveloper pipe shall be eliminated by grouting prior to completion of works, with material and methodology of grouting described in the method statement.
- The annular space between the enveloper and the carrier pipes shall be grouted.
- The installation of the pipeline shall not affect any adjacent structures and shall provide for consistent support prior to, during and after installation.

5.1.6 Tolerances
The pipeline shall be installed in accordance with the horizontal and vertical alignment as shown on the Drawings subject to the following tolerances.
- Horizontal: ±50mm
- Vertical: ±50mm
- Gradient: ±0.1 %.

5.1.7 Thrust and Reception Pits
The Contractor shall be responsible for the structural design of the temporary thrust and reception pits required for any trenchless conduit installation. The Contractor shall submit calculations to demonstrate the adequacy of the pits for the conduit installation.

A security fence shall be provided around all pit areas and the pits shall be backfilled as soon as practicable.
5.1.8 Heave/Settlement and Ground Water Levels Monitoring

5.1.8.1 Road Crossing
Heave/settlement monitoring of the roads and ground as well as ground water levels monitoring along the pipeline alignment shall be carried out.

The Contractor shall install appropriate instrumentation or survey beacons to monitor heave/settlement and ground water levels. Proposal to install instrumentation shall be submitted to the Principal’s Representative for approval prior to installation. The proposal shall include the following:

- Identify location of heave/settlement and ground water level monitoring points, reference benchmarks, survey schedules and procedures, and reporting formats.
- Surface heave/settlement markers.
- Locate surface settlement markers according to a grid, spaced 4 m by 4m, but not less than 6m either side of the pipe alignment.
- Take records to nearest 0.25mm before start of dewatering operations and/or shaft excavation.
- Take route monitoring to nearest 0.25mm at regular 12 hour intervals maximum during construction.
- Furnish reports to Principal’s Representative daily.

<table>
<thead>
<tr>
<th>Heave/Settlement (mm) Road Crossing</th>
<th>Follow up Actions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10mm</td>
<td>Advise Principal’s Representative and continue monitoring</td>
<td></td>
</tr>
<tr>
<td>10-20mm</td>
<td>Review working methods and consult Principal’s Representative for agreement and guidance</td>
<td></td>
</tr>
<tr>
<td>&gt; 20mm</td>
<td>Stop works, review working methods, propose remedial action and consult Principal’s Representative</td>
<td></td>
</tr>
</tbody>
</table>

Ground water levels monitoring:

- Take records before start of dewatering operations and/or shaft excavation.
- Take route monitoring at regular 12 hour intervals maximum during construction.
- Furnish reports to Principal’s Representative daily.

In event of heave/settlement of the ground or road, restoration of the ground and road to the existing conditions before start of operations shall be carried out to the satisfaction of the authorities as directed by the Principal's Representative.
6 Installation of Pipes above Ground

6.1 General
Above ground installation of pipework shall be designed and installed in accordance with the pipe manufacturer’s directions and WSAA standard requirements. The maximum spans between supports shall not exceed the pipe manufacturer’s directions.

The Contractor shall ensure that orientation of flanges cast into concrete is considered to ensure correct alignment of adjacent appurtenances within 5 degrees (e.g. valves).

6.2 PVC Pipes and Fittings
Installation of PVC pipes and fittings above ground shall be strictly in accordance with AS 2032 *Installation of PVC pipe systems*.

7 Installation of Pipes below Ground

7.1 General
Below ground installation of pipework shall be in accordance with the pipe manufacturer’s and WSAA standard requirements.

The Contractor shall ensure that orientation of flanges cast into concrete is considered to ensure correct alignment of adjacent appurtenances within 5 degrees (e.g. valves).

Installation of PVC pipes and fittings below ground shall be strictly in accordance with AS 2032 *Installation of PVC pipe systems* to achieve an "out-of-roundness" tolerance after backfilling of ± 2.5% of the mean diameter.

Installation of DICL pipes and fittings below ground shall be strictly in accordance with AS2566 *Buried Flexible Pipelines Part 2: Installation*.

Installation of concrete pipe below ground shall be strictly in accordance with the Concrete Pipe Association of Australasia Technical Bulletin *Installation of Steel-Reinforced Concrete Drainage Pipelines*.

7.2 Trench Excavation

7.2.1 Safety
Do not commence any excavation until all equipment and materials necessary to make the excavation safe are on site and available for use. This includes any necessary fencing and barriers, as well as trench support systems.

Assess site for prior excavations and consider their impact on the new excavation.

Conduct a site hazard and safety assessment prior to commencement of any excavation to identify all potential hazards.
7.2.2 Nature of Site
The contractor shall satisfy himself as to the nature of the soil and subsoil before tendering including groundwater level. Soils investigation has been obtained by TRC as is available from TRC.

No warranty is expressed or implied that such information will give an accurate and complete picture throughout the site.

The contractor shall satisfy himself as to the precise nature of excavation, dewatering and filling as required, so that he will have allowed for everything necessary in connection with this.

7.2.3 Not Used

7.2.4 Dust and Noise
The Contractor shall take all responsibility to control dust and noise from the work site.

7.2.5 Cleaning Vehicles
The contractor shall ensure that mud, dust or debris is not tracked onto and deposited on any adjacent roads, paths and drainage structures. To ensure that this happens, all trucks leaving the site shall be washed down, if necessary, to remove all mud and debris. The contractor shall clean the machines/excavators prior to arrival onsite in order to avoid transporting weeds from other previous site.

7.2.6 Inspection
Prior to any backfilling with hardfill or concrete, the Principal's Representative shall inspect and approve the excavations.

No reinforcement shall be placed in the excavations until they have been inspected by the Principal’s Representative. No filling shall be carried out until the pipes and walls have been inspected by the Principal’s Representative.

A 24 hour notice period is required.

7.2.7 Excavation in Trench
Excavation across roads shall proceed with minimum interruption to traffic and all steps necessary for the protection of the Public shall be undertaken. Alternative routes for pedestrians and vehicular traffic shall be provided when required. Only one half of a road is to be closed at any time unless approved in writing by the Principal’s Representative. All Traffic Control Plans shall be submitted to the Principal’s Representative 7 days prior to undertaking the work. All traffic management shall be undertaken in accordance with the Manual for Uniform Traffic Control Devices.

Should the excavation be taken beyond the limits defined or as directed, the additional material excavated shall be removed and the bottom of the trench shall be filled with ‘Selected Gravel Fill’ complying with Technical Specification – Civil Works compacted to 95
% maximum dry density (standard compaction) and the sides of the trench with approved material.

7.2.8 Excavation across Improved Surfaces

The Contractor shall obtain written permission of the Owner and take photographs to record the improved surface prior to commencing any excavation across improved surfaces.

Trenches shall not be cut through kerbs, kerb and channel, concrete pavements or slabs without prior approval of the Principal’s Representative. In general where the length of trench under concrete pavement or slab is less than 2 metres and the trench is accessible from each side of the concrete, the trench shall be driven under the slab. The Principal’s Representative may order cutting of the slab where the trench is greater than 2 metres long or where the trench is accessible from one side only of the slab.

Where trenches are excavated through concrete, or bituminous penetration surfaces, the surface shall first be cut to a neat line at least 150 mm beyond the outer limits of the excavation and care taken during excavation to avoid lifting or otherwise damaging the surface outside the limits of the trench.

Pavers, blocks or brick pavements shall be taken up, cleaned and stored for later replacement.

7.2.9 Limits of Excavation

Keep the extent of excavation to the minimum possible to allow efficient construction of the Works. Unless specified otherwise, keep the sides of excavations vertical to at least 150 mm above the top of the pipe. Ensure that the minimum and maximum cover requirements are satisfied following any earthworks that may occur in the area of the pipeline. This is particularly relevant in new subdivisions or developments where earthworks are expected to form roads, driveways, footways and for general shaping of the surfaces. If minimum cover requirements cannot be achieved, submit a proposal to the Principal’s Representative to overcome the problem.

7.2.10 Support of Excavations

Support all trenches of depth 1.5 m or greater. Support all excavations as the work proceeds to meet OH&S requirements. Ensure that adjacent structures and services are not subject to disturbance by the trench support system. When removing, raising or withdrawing supports, prevent slips or falls and ensure that no damage, disturbance or displacement occurs to the pipes, fittings, geotextile filter fabric, pipe embedment and trench fill already installed. Fill the trench simultaneously with the raising or withdrawal of trench supports. Ensure that compaction of pipe embedment and trench fill material occurs below such trench support and against native ground.

Where specified, leave the trench support system in place as permanent support. Cut off the support system at a depth below ground surface that will satisfy the structural and development requirements of the site.
7.2.11 Unsuitable Material
Unsuitable material, shall be defined as any material which because of its organic content, strength and/or moisture content the Principal's Representative determines is unsuitable to have a fill constructed over it, or to have a pavement or building footing, or any other structure constructed over it. All unsuitable material shall be excavated to suitable firm material or as directed by the Principal's Representative, and shall be excavated to suitable firm material or as directed by the Principal's Representative and shall be stockpiled clear of the works or shall be disposed as directed by the Principal's Representative.

7.2.12 Unsuitable Material
Unsuitable material, shall be defined as any material which because of its organic content, strength and/or moisture content the Principal's Representative determines is unsuitable to have a fill constructed over it, or to have a pavement or building footing, or any other structure constructed over it. All unsuitable material shall be excavated to suitable firm material or as directed by the Principal's Representative, and shall be excavated to suitable firm material or as directed by the Principal's Representative and shall be stockpiled clear of the works or shall be disposed as directed by the Principal's Representative.

7.2.13 Deep or Unstable Excavations
The Contractor shall bench or otherwise support excavations where necessary to comply with workplace health and safety requirements or to prevent disturbance of adjacent structures.

When removing, raising or withdrawing supports, the Contractor shall ensure that no disturbance or displacement occurs to the pipes, fittings, geotextile filter fabric, pipe embedment and trench fill already installed.

The trench support shall be raised or withdrawn simultaneously with the placement of embedment and fill. The sheeting shall be withdrawn as the ‘embedment’ and ‘trench fill’ is placed and compacted in such as manner as to avoid the formation of any cavities at the side of the trench.

The Principal's Representative may order that the trench support system shall remain in place as permanent support. The Contractor shall cut off the supports at the depth below ground that the Principal's Representative directs.

7.2.14 Drainage, Dewatering and Sediment Control
The Contractor shall:

- Keep all excavation free of water until all trench fill is complete and pipeline is fully sealed;
- provide, maintain and operate intercepting works to prevent surface water from entering the excavations;
- provide all equipment necessary for dewatering the excavations; and
- Lower the water table when necessary.
Flotation of the pipe due to groundwater or inundation before completion of filling shall be prevented.

The Contractor shall submit a sediment control plan 5 days prior to starting work on site. No work is to start until this plan has been approved by the Principal’s Representative.

The Sediment Control Plan shall comply with the DERM guidelines.

### 7.2.15 Foundation and Foundation Stabilisation

Prior to placing embedment, the Contractor shall check the proposed foundation using standard drawings SEW – 1200 and WAT – 1200 as a guide. Where the bottom of an excavation is unable to provide a firm foundation with a bearing capacity of 50 kPa at the bottom of the trench without abrupt irregularities or undulations, the Contractor shall obtain written instruction from the Principal’s Representative on the means of providing a satisfactory foundation.

### 7.2.16 Spoil from Excavations

Material from the excavations shall be deposited in spoil banks which shall not obstruct access to any structure or buildings.

The different kinds of excavated material shall be kept separate from each other and shall be submitted to the Principal’s Representative for his decision as to which may be used for ‘embedment’ and ‘trench fill’, and shall be used accordingly. Under all circumstances any topsoil excavated from the top 150 mm of trenches shall be reserved for filling the top of the trench.

Surplus soil shall be disposed of to site filling or other lawful means by the Contractor.

### 7.2.17 Excavation in Root Zones

Take every precaution to ensure that no undue damage is caused to a tree root system as a result of excavation for the Works. Excavation for construction by hand or by boring may be required to protect the root zone.

Cleanly cut all roots ≤60 mm diameter encountered during excavation.

Do not cut tree roots larger than 60 mm diameter without authorisation of the Principal’s Representative.

### 7.2.18 Blasting

Use alternative methods of excavation to blasting wherever achievable.

Obtain prior authorisation from the Principal’s Representative, relevant Regulator and affected Owners of assets within the vicinity before undertaking blasting.

Where authorisation is granted, prepare a blasting plan that includes management of the blasting and means to be used to satisfy the requirements of AS 2187 and the authorising parties.
7.3 Embedment

7.3.1 General
All pipes laid in trench shall be uniformly bedded on and surrounded with approved materials, to ensure solid and uniform support for the full length of the pipe barrel. The type of pipe bedding and/or pipe surround to be used for any particular section of pipeline will be dependent on the ground conditions, surface loading and the type of pipe being used. The bedding detail shall comply with WSAA standard requirements.

The contractor shall advise the Principal’s Representative upon encountering ground requiring special treatment. These include, but are not limited to, soft and wet subgrade, groundwater presence and areas where over excavation is required for foundation treatment.

After the excavation has been completed and approved, the ‘bedding’ shall be placed leaving hand holes for joining and pipe holes to ensure that the pipe collars are not bearing on the bedding.

On completion of testing and approval of a length of pipeline, the ‘side support’ and ‘overlay’ shall be carefully placed to avoid disturbance of the pipes. Where pressure testing of pipelines will require the ‘trench fill’ to be placed before testing, the ‘side support’ and ‘overlay’ shall be placed after inspection and approval of the pipeline as laid and jointed.

‘Side support’ and ‘overlay’ shall be placed in layers not exceeding 150 mm compacted thickness and compacted on both sides of the pipeline simultaneously so that the pipeline is not displaced or distorted.

Geotextile filter fabric complying with the requirements of Appendix J Specification for Geotextile Filter Fabric of AS/NZS 2566.2 Buried flexible pipelines Part 2: Installation shall be provided when the conditions for control of migration of embedment zone soil particles in Appendix I of AS/NZS 2566.2 Buried flexible pipelines Part 2: Installation are not met.

7.3.2 Material Grading
All embedment material shall be granular with a maximum particle size of 20mm as per WSAA. SEW 1201 and WA PS 359 to 366. Single size aggregates are acceptable for rising main pipeline embedment.

Selected fill embedment material shall only be used with the express permission of the Principal’s Representative.

7.3.3 Compaction of Embedment

7.3.3.1 General
Pipes shall not be damaged by compaction equipment. The Contractor shall not permit equipment placing or compacting embedment to contact the pipes or apply excessive forces on the pipes.

7.3.3.2 Rigid Pipelines
Embedment materials for rigid pipelines shall be compacted in accordance with the minimum requirements set out in WSAA 02 Table 22.2 for gravity systems.

<table>
<thead>
<tr>
<th>Embedment Type</th>
<th>All Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Cohesive</td>
<td>60 ID</td>
</tr>
<tr>
<td>Cohesive</td>
<td>90 RD</td>
</tr>
</tbody>
</table>

7.3.3.3 Flexible Pipelines
Embedment materials for flexible pipelines shall be compacted in accordance with the requirements WSAA 02 Table 22.1 for gravity pipes and WSAA Table 36.2 for rising/pressure mains.

<table>
<thead>
<tr>
<th>Embedment Type</th>
<th>Trafficable Areas</th>
<th>Non Trafficable Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Cohesive</td>
<td>70 ID</td>
<td>60 ID</td>
</tr>
<tr>
<td>Cohesive</td>
<td>95 RD</td>
<td>90 RD</td>
</tr>
</tbody>
</table>

If the contractor nominates the 7mm to 14mm single size coarse aggregates, the material shall be deemed as self-compacting and do not require testing when used for pipe embedment.

7.3.4 Embedment Compaction Testing Frequency
The contractor shall undertake compaction testing of pipeline embedment for all gravity and pressure pipelines of diameter equal to or greater than 150mm. For pipe diameters less than 150mm, compaction of the pipeline is not required provided native ground has a bearing capacity of at least 50kPa, pipe laying is carried out to WSAA requirements and a pre compaction method was used and accepted.

The frequency for testing of embedment shall be every 50m for pipe diameters greater than 150mm and 100m for diameters equal or less than 150mm.

7.3.5 Retesting
If one or more of the initial test results do not comply with the above specification, the contractor shall conduct two additional tests in the zone represented by the initial test. If one or more of the retests do not comply, re-compact the zone represented by the tests and continue the test re-compact cycle until a pass result is obtained.
7.4 Laying of Pipelines

7.4.1 General

Before laying, all pipes, fittings and valves shall be thoroughly cleaned of all dirt on the inside, and the greatest care must be exercised to prevent dirt or any foreign matter entering the pipes during the operation of laying and jointing.

All pipes or fittings shall be carefully examined before placing in the work for damage or inside or outside protective coatings. Any damaged portion of the protective coating shall be repaired in a manner approved by the Principal’s Representative.

All ends of pipes and fittings left open shall be protected by the use of approved plugs against the entrance of dirt or foreign matter.

Pipes shall be lifted with textile slings around the pipe, and mechanical equipment used to close joints shall be suitable for use without damaging the pipe surfaces or ends.

Lay gravity sewers and pressure mains with their sockets at the upstream end.

Walking on the unprotected pipeline shall not be permitted.

7.4.2 Laying Gravity Pipelines

All pipes shall be laid true to line and level with sockets facing up-grade. Pipes shall be kept thoroughly clean so that the gaskets or rings will correctly seal the joint when the spigot is driven home in the socket. The interiors of all pipes shall be kept free of dirt or other extraneous material of any description as the work proceeds.

Pipes shall be laid in such a manner that the barrels bear firmly and evenly on their bed, the sockets being free from pressure in the joint and the spigots concentric with the sockets.

Horizontal tolerances for sewers and on-line structures shall not exceed the following:

- Sewers +100mm lateral displacement from design sewer alignment
- Structures +100mm lateral displacement from design sewer alignment: and
  +200mm displacement (from design position) along the sewer axis.
- Junctions +100mm displacement (from design position) along the sewer axis.

Vertical tolerances from sewers and on-line structures shall not exceed the following:

- Inverts shall not deviate from the specified design level (or interpolated design level) by more than 10mm higher or 50mm lower.
- Reverse grades are not permitted.
7.4.3 Laying Pressure Pipelines
Pressure pipelines shall be uniformly graded. The maximum variation from a true line and gradient shall be ± 20 mm unless otherwise approved by the Principal's Representative. Under no circumstances shall the variation from the line and gradient be such that the allowable deflection is exceeded at pipe joints for the particular pipeline systems used.

Bends shall be used to effect horizontal or vertical changes of direction. Where such bends are not detailed, changes of direction shall be effected by angling joints, including where necessary the use of short lengths of pipe, and thimble or collar joints.

Where changes of direction are provided by angling joints, the maximum deflection at each joint shall be as approved by the Principal's Representative, taking into consideration the type of pipe and joint. All such changes in direction shall be effected in curves of uniform radii. No joint shall be angled to such an extent as to impair its effectiveness and tightness.

Polyethylene sleeving shall be placed to ductile iron pipe systems installed below ground in such a manner as to completely encase the pipeline, fittings and valves. Installation shall comply with AS 3681 Application of polyethylene sleeving for ductile iron piping. Sleeve joints shall be lapped 300 mm and sealed with approved tape. Care shall be taken during laying and backfilling to ensure that the film is not torn or punctured. Damaged sections shall be repaired with additional sleeving and taping as directed by the Principal's Representative.

7.4.4 Installation of Fittings
The laying and jointing of pressure mains shall include the fixing in position of all valves and fittings.

All valves shall be carefully placed in position plumb, and to the correct distance from the surface. If required, trenches shall be deepened and graded in the vicinity of all valves to give the correct depth below the surface.

7.4.5 Scours on Pressure Mains
The Contractor shall design and construct gravity and pumped scours where required in accordance with the WSAA standard requirements.

7.4.6 Protection of Buried Flanged and Gibault Joints
7.4.6.1 General
Buried flanged and gibault joints shall be protected using one of the Denso corrosion protection systems specified below. Preparation of the surfaces to be protected and the application of the corrosion protection shall be strictly in accordance with Denso Specifications.

Where a Denso corrosion protection system is applied to a PVC or PE pipe a temporary mechanical fastener, e.g. bandit strapping, shall be used to retain the corrosion protection system in place during embedment and trench fill.
7.4.6.2 DICL Pipe and Fittings
A ‘Petrolatum’ based system comprising Denso MP Primer, Denso Mastic, Superlight Priming Mastic, Petrolatum Tape and MPHD PVC Overwrap Tape.

The polyethylene sleeving of DICL pipelines shall be applied over the top of any of the Denso corrosion protection systems.

7.4.7 Anchor Blocks
Anchor blocks shall be provided on all fittings (valves, flexibly jointed bends, tees, enlargers and reducers) as detailed in the WSAA standards to resist unbalanced thrusts at changes of direction, valves, dead ends etc., along the pipelines. The dimensions and location of the Anchor Blocks may be adjusted in the field by the Principal’s Representative to suit the individual ground strata encountered. Concrete shall be minimum N20.

7.4.8 Horizontal and Vertical Separations
Maintain horizontal and vertical separation of crossing pipelines as specified in WSA Part 1 Table 4.2 for pressure pipelines and WSA 02 Part 1 Table 3.1 for gravity pipelines.

7.4.9 Floatation Control
Prevent floatation of pipes and wet wells by using:

- Excavation dewatering
- Trench stops to TRC standards
- Placing sufficient fill on the pipe
- Filling the pipeline with water as authorized.

Other methods authorized by the Principal’s Representative.

7.4.10 Trench Stops and Bulkheads Stops
Construct trench stops, bulkheads with trench drainage as specified on WSAA standard drawing WAT-1209.

7.5 Trench Fill

7.5.1 General
As soon as the length of pipe has been bedded, laid, jointed, tested and approved, the trench shall be filled without delay. Where embedment is specified this work shall be completed in accordance with Clause 7.3 of this specification before filling is continued.

7.5.2 Material

7.5.2.1 Trafficable Areas
Trench fill material for trafficable areas shall be hardfill backfill with material similar to subbase material compacted to the requirements of this specification or road authority requirements, whichever is greater.
7.5.3 Non Trafficable Areas
Backfill in non trafficable areas shall consist of any available material harvested from the stockpile of excavated material. Council parks and gardens staff shall be consulted, via the Principal’s Representative, for restoration of parks, and playgrounds where special soil requirements may apply.

7.5.4 Trench Fill Compaction

7.5.4.1 Gravity Pipelines
Trench fill materials for both rigid and flexible gravity pipelines shall be compacted in accordance with the minimum requirements set out in WSAA 02 Table 22.3 for gravity systems.

<table>
<thead>
<tr>
<th>Embedment Type</th>
<th>Trafficable Areas**</th>
<th>Non Trafficable Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Cohesive</td>
<td>70 ID</td>
<td>60 ID</td>
</tr>
<tr>
<td>Cohesive</td>
<td>95 RD</td>
<td>90 RD</td>
</tr>
</tbody>
</table>

**Road authority requirements to be considered

7.5.4.2 Rising/ Pressure Pipelines
Trench fill materials for flexible pipelines shall be compacted in accordance with the requirements WSAA 02 Table 22.1 for gravity pipes and WSAA Table 36.2 for rising/pressure mains.

<table>
<thead>
<tr>
<th>Embedment Type</th>
<th>Trafficable Areas**</th>
<th>Non Trafficable Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Cohesive</td>
<td>70 ID</td>
<td>60 ID</td>
</tr>
<tr>
<td>Cohesive</td>
<td>95 RD</td>
<td>90 RD</td>
</tr>
</tbody>
</table>

**Road authority requirements to be considered

7.5.5 Fill Compaction Testing Frequency
The contractor shall undertake compaction testing of pipeline fill for gravity sewers and pressure pipelines of diameter greater than 300mm. One test per 300m² per 300mm lift in trafficable areas and one test per 1,200m² per 900mm lift in non-trafficable areas is required.

For pipe diameters less than 300mm, compaction testing of the pipeline is not required provided native ground has a bearing capacity of at least 50kPa, pipe laying is carried out to WSAA requirements and a pre compaction method was used and accepted.

7.5.6 Retesting
If one or more of the initial test results do not comply with the above specification, the contractor shall conduct two additional tests in the zone represented by the initial test. If one or more of the retests do not comply, re-compact the zone represented by the tests and continue the test re-compact cycle until a pass result is obtained.
7.5.7 Placement and Compaction
Trenches in any material shall be filled with approved material from the excavation or, if such material is not available from the excavation, with extra filling or borrow from sources outside the limits of Contract, and in such quantities as may be directed by the Principal’s Representative.

Fill shall be placed in layers not exceeding 200 mm compacted thickness and compacted to a dry density ratio of not less than 95% standard compaction or, for cohesionless material, to a density index of not less than 70%, unless specified to a higher level of compaction elsewhere in the Contract. The top 150 m of the trench shall be material retained from the top 150 mm of excavation and shall be lightly watered into place.

The trench shall be filled to the level of the adjoining finished surface. Any settlement of trench fill occurring prior to the expiration of the defects liability shall be made good by the Contractor, using materials as specified for the top layer of trench fill.

7.5.8 Restoration after Excavation and/or Trenchfill

7.5.8.1 General
The Contractor shall restore all surfaces and structures to at least the standard of the original surface, using approved materials to the satisfaction of the Principal’s Representative. Such restoration shall be completed as soon as placement and compaction of the trench fill has been completed.

The Contractor shall take a detailed ‘before construction’ photographic record for evidence that the restoration has been undertaken to an equivalent or better standard. The ‘before construction’ photographic images shall be provided to the Principal's Representative prior to commencing the works.

7.5.8.2 Kerb and Channel
The Contractor shall reinstate all Kerbing and Channels disturbed, relocated or damaged during the works. Kerbing and channels shall be reinstated to match the existing profile (refer Main Roads Department Standard Drawing No. 1033). A 150 mm thick layer of Type 3.1 gravel with 1% by weight of cement added shall be placed below the kerbing and channels. The gravel layer will extend 200 mm beyond the kerb and channels on all sides and be compacted to 100% MDD.

7.5.8.3 Concrete Pathways
The Contractor shall reinstate all concrete pathways disturbed, relocated or damaged during the works to match existing. Existing concrete shall be saw cut prior to removal of concrete and exposed reinforcing sealed with epoxy. New concrete section will be dowelled to existing concrete with N12 dowels at 300 mm centres and a 20 mm x 20 mm rebate cast into the surface of the new concrete where it abuts existing concrete. The rebate shall be filled with a backing rod and flexible poly sulphide sealant. The top surface of the new concrete will be finished flush with existing concrete where it abuts.
7.5.8.4 Topsoil and Grassing
For all disturbed grass areas, topsoil and an approved turf shall be laid to blend smoothly with surrounding ground levels. The type of grass shall be selected to match existing and approved by the Principal’s Representative prior to laying.

The Contractor shall ensure that re-turfed areas are provided with sufficient regular watering so that growth can properly establish. Any areas that fail to satisfactorily re-establish shall be re-turfed at the Contractors’ expense.

7.5.8.5 Road Surfaces
The Contractor shall reinstate all disturbed or damaged road surfaces during the works to an equivalent or better standard. The top of the trench shall be filled with Type 3.1 gravel with 1% cement added to the depth of the existing gravel pavement. Gravel shall be compacted in layers not exceeding 150 mm compacted thicknesses to achieve 100% MDD.

Where the road surface has a bituminous seal the edges of the trench shall be neatly cut prior to excavation and the top 50 mm of the trench will be filled with DG14 asphalt compacted to 92% of maximum density.

7.5.8.6 Creek Beds and Banks
Creek beds as a minimum shall be reinstated with suitable 300 mm thick rock mattresses for a minimum width of 4 m.

The Contractor shall reinstate creek banks using hydromulch over all disturbed areas. Hydromulch shall include native seed and other stabilising grasses as approved by the Principal’s Representative. The Contractor shall be responsible for establishing vegetation.

7.5.8.7 Creek Crossings
The Contractor shall ensure that dewatering equipment is on standby and available for immediate use during pipeline construction across creeks. The Contractor shall bench trenches or provide shoring to maintain trench stability when constructing through creek banks.

All pipelines shall be concrete encased through creek crossing.

7.5.8.8 Fences
Where a Sewer, House Drain, water main, water service, or rising main crosses an existing fence, the Contractor shall take down the section of fence affected, store the materials for the duration of the works and reinstate the fence at completion of the construction. Any materials damaged during the works shall be replaced by new materials matching the existing.

Where a fence is part of the security of a property, the Contractor shall erect a temporary fence to provide adequate security at all times the works are not attended for the purpose of preventing unauthorised access.
7.6 Pipeline Markers
The Contractor shall install pipeline and valve markers along pipelines. As a minimum markers shall be provided at all changes in horizontal alignment greater than 15 degrees, within 20 m of river crossings, air valves, scour valves and at intervals no greater than 100 m distance from the last marker.

The Contractor shall submit a sample marker to the Principal’s Representative prior to commencing manufacture, supply and installation of the markers required for the Contract.

7.6.1 Detectable Marker Tape
All non-metallic pipes shall be installed complete with proprietary marker tapes to the approval of the Principal’s Representative, to enable ready location of all mains installed and to provide warning of the existence of the mains in case of excavation in the area.

All marker tape shall be in accordance with AS 2648 Underground Marking Tape. Minimum width shall be 75 mm, identification colour is Blue and shall be marked with black, vertical block type lettering with a minimum size of 25 mm and text repeated of not more than 1 m.

Marker tape shall be laid 350 mm ± 50 mm above all buried pipework.
8 Maintenance Holes and Chambers

8.1 General
Maintenance holes and chambers shall generally be constructed of reinforced concrete.

Excavation shall be made to the depths and dimensions required for the proper construction of the maintenance hole but any excavation carried to a depth lower than necessary shall be replaced with concrete at the Contractor's expense.

Maintenance holes and inspection chambers shall be finished with a tolerance of + 25 mm to + 75 mm (or as required by the local authority) above the surrounding surface, except where located in paved surfaces where they shall finish flush with the surface, or shall be carried to such other height as directed by the Principal's Representative.

Cast in-situ maintenance holes shall be constructed using both internal and external framework and all concrete shall be placed using vibrators for compaction.

8.2 Cast in-situ Concrete Maintenance Holes
At each construction joint, place dowels, remove laitance and prime with a wet to dry bonding agent or cement slurry before pouring the next lift. If a waterstop is to be used at any construction joint, support it in such a manner that it will retain its position during the pour. Strip internal formwork before stripping external formwork.

8.3 Bottoms and Connections
All maintenance holes shall be constructed with benching for all new and future pipe connections. Future maintenance hole connections shall be sealed off outside the maintenance hole wall to allow extension without breaking into the maintenance hole walls. Sealed couplings shall be the proprietary manufacture or shall be closed with proprietary plugs and flexible joints.

Flexible joints shall be provided outside the maintenance hole where each pipe joins the maintenance hole, as per the WSAA standard drawings.

All inverts and benching shall be finished to smooth curves and lines and levels to direct the flow with minimum turbulence through the maintenance hole. The channel shall be "u" shaped and benching shall be sloped up at 1 vertical to 8 horizontal from the soffit level of the pipe unless otherwise detailed.

8.4 Walls
Walls shall be circular /rectangular shafts cast onto the scabbled surface of the concrete bottom. All construction joints shall be clean and care taken to ensure a water-tight seal.

8.5 Tops
Maintenance hole tops shall be cast in-situ with the cast iron ring or cover frame in place at the same time. Precast tops can be used with the approval of the Principal.
Mortaring or other methods of bonding cast iron rings or cover frames after construction of the concrete top will not be acceptable under any circumstances.

8.6 Cast Iron Covers
Install covers and frames on maintenance hole and chamber tops as specified. Clean sealing surfaces of covers and frames. Fit seal, if applicable, in accordance with manufacturer's printed instructions. Apply grease to sealing surfaces where specified in accordance with manufacturer's printed instructions. Lock down covers as specified.

Standard maintenance holes shall have proprietary cast iron, solid circular covers and seats with a minimum clear opening of 600 mm.

8.7 Step Irons
Unless otherwise scheduled or ordered by the Principal's Representative, step-irons are not required in maintenance holes.

When step-irons are required they shall be 316 stainless steel, fabricated and installed by the Contractor.

8.8 Precast Maintenance Holes
Precast maintenance hole wall systems may be used, subject to approval by the Principal's Representative. All sewer and house drain connections shall be completed to a cast in-situ base constructed with a formed joint to acceptable tolerances, to receive, mechanically lock and waterproof the joint between the precast wall section and the base.

Select component lengths to minimise the number of joints. Where possible, select components to give the specified clearance between the component joint and the pipe entry. Where this cannot be achieved, seal the joint using an authorised epoxy in lieu of rubber ring or mastic joints.

Use a shaft section between 300 and 600 mm long for the base section. Prime the lower 200 mm of the precast component with a wet to dry bonding agent or cement slurry before placing the component onto the wet concrete base. Embed the component 50 mm into the wet concrete base, then build up and compact a 150 mm concrete fillet on the outside to seal against infiltration. Form channels in the base in accordance with this specification.

Do not place other shaft sections until the concrete base has set. Where the concrete in the base sets before the first component can be placed, allow the base to cure for at least seven (7) days before bonding the first component to the base using an authorised epoxy adhesive.

Joints between precast wall sections and between the precast wall and the cast in-situ base shall be sealed with an approved butyl rubber or similar material supplied in preformed rolls or approved dimension to suit the joint, and incorporating a non-extensible chord to prevent stretching when placing the seal. Both concrete surfaces at the joint shall be primed with a compatible surface precoat.
The required vertical wall height shall be provided by adjusting the height of the cast in-situ base to suit the total wall height and the length of standard precast wall sections, the top section of which shall be a minimum of 1.20 metres long to ensure sufficient weight and lateral earth support to prevent mechanical disturbance by earthmoving machinery.

The top of the maintenance hole shall be cast in-situ with the precast maintenance hole wall section set 50 mm into 150 mm thick concrete top.

8.9 Trench Drainage around Maintenance Holes
Where aggregate has been used in the bottom of the trench or where some trench water is present, provide trench drainage as shown on WSAA standard drawing WAT - 1210.

8.10 Benching and Channels
Thoroughly roughen and clean each base. Brush on a coating of wet to dry epoxy, or sulphate-resistant cement slurry or other suitable priming product. Render and shape benches and channels in accordance with WSAA standard drawings SEW-1304 and SEW-1305 using a 2:1 sand: sulphate resistant cement mix. Ensure that the render is no less than 15 mm thick. Maintain in a damp condition for 72 h after finishing. Where foam formwork is used, construct channels and benching with off-form finish.

8.11 Internal Coating of Maintenance Hole
All wet-wells, maintenance holes and chambers shall be internally painted with an approved two part epoxy paint system ‘Sikagard’, or similar produce approved by the Principals Representative. All paint systems shall be applied strictly in accordance with the manufacturer’s recommendations.

8.12 Drops
Construct maintenance hole drops indicated on the drawings as shown on WSAA standard drawing SEW-1303. Core drill holes in precast or cast in-situ maintenance holes using a diamond hole saw of the appropriate diameter. Only use other techniques for creating holes in precast or cast in-situ maintenance holes with the authorisation of the Principal’s Representative.
9 Valve Chambers and Boxes

Cast iron cover boxes shall be fitted to all buried valves in accordance with the WSAA standard drawings.

Concrete margin blocks bedded on gravel or other approved material shall be fixed round all valve cover boxes in accordance with the WSAA standard drawings. Precast concrete blocks shall be Grade 20 concrete. The blocks shall be thoroughly cured for at least fourteen (14) days before being placed in the work.

The concrete bricks which support the cover boxes shall be bedded in sand or gravel and so constructed that as little as possible weight or shock can be transmitted to pipe.
10 Inspection and Testing

10.1 Hold and Witness Points

The works will be controlled through a series of hold and/or witness points, at which construction works will be suspended until an inspection has taken place and approval by the Principal's Representative. These hold and/or witness points would consist of, but not be limited to, the following:

<table>
<thead>
<tr>
<th>Point</th>
<th>Hold or Witness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prestart checks and site establishment</td>
<td>W</td>
</tr>
<tr>
<td>Strategic products and materials</td>
<td>W</td>
</tr>
<tr>
<td>Contractor's submissions for site management</td>
<td>W</td>
</tr>
<tr>
<td>Protection of trees, flora, fauna and other items</td>
<td>H</td>
</tr>
<tr>
<td>Completion of restoration and its certification from public authorities and private property owners</td>
<td>H</td>
</tr>
<tr>
<td>Contractor's submissions and qualifications of inspection personnel</td>
<td>H</td>
</tr>
<tr>
<td>Availability of relevant current referenced Standards</td>
<td>H</td>
</tr>
<tr>
<td>Alignment and level setting out</td>
<td>H</td>
</tr>
<tr>
<td>Services located/exposed</td>
<td>W</td>
</tr>
<tr>
<td>Trench width, and depth to design level</td>
<td>W</td>
</tr>
<tr>
<td>Trench shoring and/or shielding</td>
<td>W</td>
</tr>
<tr>
<td>Trench drainage</td>
<td>W</td>
</tr>
<tr>
<td>Foundation, minimum bearing capacity</td>
<td>W</td>
</tr>
<tr>
<td>Latent conditions</td>
<td>H</td>
</tr>
<tr>
<td>Pipeline installation and embedment</td>
<td>W</td>
</tr>
<tr>
<td>Backfilling of pipelines and structures</td>
<td>W</td>
</tr>
<tr>
<td>Final inspection and testing</td>
<td>W</td>
</tr>
<tr>
<td>Reinforcement, cores and embedment completed and fixed in place</td>
<td>W</td>
</tr>
<tr>
<td>Formwork completed, before concrete placement</td>
<td>W</td>
</tr>
<tr>
<td>Concrete curing</td>
<td>W</td>
</tr>
<tr>
<td>Evaluation of concrete finish</td>
<td>W</td>
</tr>
<tr>
<td>Structures founded, formed and joined</td>
<td>W</td>
</tr>
</tbody>
</table>

10.2 CCTV Inspection

After completion of construction, all new gravity sewers should be CCTV inspected to WSA 02 Clause 22.1 and WSA 05, to enable identification and rectification of faults. Acceptance of construction and rejection of inspection results shall be based on the criteria of Appendix E of WSA 105. For flexible pipe gravity mains, CCTV inspection should also include CCTV light ring and measurement software for deflection (ovality) testing. Refer WSA 02 Clause 22.6 for details.
10.3 Hydrostatic Testing of Construction

10.3.1 General
All pipelines and structures shall be inspected and tested in the presence of the Principal’s Representative and no pipes, fittings or other work shall be covered, until approved by the Principal’s Representative.

All tests shall be carried out by the Contractor at his own risk, and he shall provide labour for installation and dismantling of test equipment and shall supply all approved pumps, engines, pipes, temporary valves, plugs or flanges and other items as may be necessary. Such plant shall remain the property of the Contractor.

Tests shall be carried out as soon as possible after the completion of the various works.

All water necessary for the purpose of testing will be supplied by the Contractor.

Prior to the commencement of hydrostatic testing the Contractor shall prepare a Testing Plan. The testing plan shall detail the following:

- Sections of pipeline to be tested
- Applicable test pressure for section
- Isolation points between sections
- Order of testing
- Program for testing
- Testing procedures
- Test sheets
- Test equipment
- Test Personnel
- Calibration of test equipment.

The Testing Plan shall be submitted to the Principal’s Representative at least 7 days prior to the commencement of hydrostatic testing of the pipelines. The Contractor may be directed to amend the Testing Plan if it does not conform to the stated requirements.

All tests shall be conducted in accordance with the approved Testing Plan.

Hydrostatic test results shall be recorded on a Test Result Sheet to be developed and provided by the Contractor. Each Test Result Sheet shall detail the test carried out and provide spaces to record all test results. In addition there must be facilities for recording the following information on each Test Result Sheet:

- Section of pipeline tested
- Date of test
- Test results
- Tester’s name
- Test equipment number
10.3.1 General
Pressure pipelines, after laying and jointing, shall be filled with water and subjected to a pressure of 1,200 kPa at the lowest point in the section. Two pressure gauges with current calibration certificates from a NATA registered laboratory and suitably accurate over the
range of pressures shall be used. The readings from the gauge recording the lowest pressure shall be used.

Testing shall not be permitted against closed valves. Each pipeline test section will need to be isolated using temporary blank flanges.

The pipeline shall be filled and pressurised to 75% of the test pressure a minimum of 12 hours prior to the commencement of the 4 hour pressure test. During the 4 hour test measure and record the quantity of water added to maintain the test pressure. The pipeline will have successfully passed the pressure test if:

- There is no failure of any thrust block, anchor block, pipe, fitting, valve, joint or any other pipeline component.
- There is no visible leakage
- The total measured quantity of water added during the test does not exceed the quantity calculated from the following formula.

\[
\frac{(0.14 \times d_i \times L_p \times H)}{1000} \text{ (L/h)}
\]

where:

- \(d_i\) = internal pipe diameter, mm
- \(L_p\) = length of pipeline under test, km
- \(H\) = average value of test head m.

10.3.4 Maintenance Holes

The water testing of maintenance holes shall be completed by sealing the inlets and outlets and filling maintenance hole to the level of the top of the cast iron cover frame and observing it for not less than 24 hours. The maintenance hole shall be deemed acceptable if there are no leakages, sweating or faults of whatever description evident during the test period. Loss of water, not otherwise evident by external leaks, shall be acceptable only if the water surface does not drop down to the level of the underside of the concrete maintenance hole top.

If any maintenance hole fails the water test it shall be retested after approved repairs or replacement and the Principal’s Representative may order an additional maintenance holes to be tested for each original test failure.

10.3.5 Liquid Retaining Structures

Testing of water containing structures shall be carried out before any painting of external or internal surfaces is done.

The structure shall be cleaned and filled to the normal top water level at a uniform rate not exceeding 2m in 24 hours. The liquid level shall be maintained for a period sufficient to allow
absorption and autogenous healing to take place. The period should not be less than 7 days, for a crack width of 0.1 mm and up to 21 days for 0.2 mm crack width or greater.

Thereafter the liquid level shall be recorded at 24 hour intervals for 7 days. The maximum permissible drop in level after allowing for evaporation and rainfall shall not exceed 1/500th of the average water depth or 10 mm whichever is the greatest.

Any seepage visible on the outside face shall be made good notwithstanding the test results. Repairs shall be made from the water retaining face.

Should the structure not satisfy the initial 7 day test, after the completion of remedial work, the structure shall be refilled and subject to a future 7 day test.

11 Compliance Inspections and Testing

For compliance assessment inspections the Contractor shall nominate responsible persons, who are not directly involved in performing the work.

A NATA-registered laboratory certified for the tests specified shall carry out all compliance testing (where applicable).

The Contractor shall advise the Principal's Representative of the work lot or work item number and the location within the lot or item, prior to any testing of the lot or item.

The Contractor shall make available a Non-conformance Report and the proposed corrective action for any nonconforming test result. No further compliance assessment testing shall be permitted until approved by the Principal's Representative.

The Contractor’s Quality System shall include at least the testing listed in the table below.

The Contractor shall submit to the Principal's Representative any preliminary results on compliance assessment tests carried out for each work lot or work item within 24 hours of the completion of the tests.

### Minimum Testing

<table>
<thead>
<tr>
<th>Minimum Testing Work</th>
<th>Quality Verification Requirements</th>
<th>Testing Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>Conformity with Australian</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standards. Product</td>
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<td></td>
<td>Verification or</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum Lot Size</td>
<td>Minimum Testing Frequency</td>
</tr>
<tr>
<td></td>
<td>All materials</td>
<td></td>
</tr>
</tbody>
</table>
## Continuous Sampling and Testing

### Excavation

- **Foundation Strength**
  - **Bearing Capacity**
  - **All excavations**

### Alignment

- **Location and invert level**
  - **Ends Property connections**

### Gravity Pipelines

- **Embedment**
  - **Grading Laboratory dry density**
    - **1000 tonnes from one source**
    - **2 per lot**
    - **2 from each source**
  - **Compaction**
    - **-every50m for pipe diameters greater than 150mm-100m for diameters equal or less than 150mm where compaction is required.**
    - **1 per lot**
    - **2**

### Work Quality Verification Requirements and Testing

<table>
<thead>
<tr>
<th>Description</th>
<th>Property Tested</th>
<th>Maximum Lot Size</th>
<th>Minimum Testing Frequency</th>
<th>Minimum No of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trench Fill</td>
<td>Laboratory dry density</td>
<td>Every 300mm2, 300mm lift in trafficable areas and 1,200m2 and 900mm in non-trafficable areas</td>
<td>1 per lot</td>
<td>2</td>
</tr>
<tr>
<td>Pipe</td>
<td>Leakage</td>
<td></td>
<td></td>
<td>All sewers</td>
</tr>
<tr>
<td>CCTV Inspection</td>
<td>Faults</td>
<td>All gravity sewers</td>
<td>All gravity sewers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deflection</td>
<td>All flexible pipes</td>
<td>All flexible pipes</td>
<td></td>
</tr>
<tr>
<td>Infiltration</td>
<td>High groundwater areas</td>
<td>High groundwater areas</td>
<td>TBA</td>
<td></td>
</tr>
</tbody>
</table>
### Maintenance Holes

<table>
<thead>
<tr>
<th></th>
<th>Fill</th>
<th>Laboratory dry density</th>
<th>All maintenance holes</th>
<th>2 per lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Leakage</td>
<td></td>
<td>All maintenance holes</td>
<td></td>
</tr>
</tbody>
</table>

### Pressure Pipeline

<table>
<thead>
<tr>
<th></th>
<th>Pipe</th>
<th>Pressure Test</th>
<th>Total Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment</td>
<td></td>
<td>Location and invert level</td>
<td>Ends Changes of alignment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Embedment</th>
<th>Grading Laboratory dry density</th>
<th>1000 tonnes from one source</th>
<th>2 per lot</th>
<th>2 form each source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaction</td>
<td>Trench fill</td>
<td>Laboratory dry density</td>
<td>200 m of pipeline</td>
<td>1 per lot</td>
<td>2</td>
</tr>
</tbody>
</table>

### Potable Water Pipelines

<table>
<thead>
<tr>
<th></th>
<th>Sterilisation</th>
<th>Residual Chlorine Level</th>
<th>All potable water pipelines</th>
</tr>
</thead>
</table>

## 12 Restoration

### 12.1 General

Restore to pre-existing condition, all surfaces, services and/or improvements disturbed, destroyed, removed or damaged during construction of the Works and/or during installation of temporary Works to the requirements of the Council. This applies to construction by means of trenching, tunnelling or boring.

The construction site shall be:

- Kept in a safe, clean and tidy manner during construction; unsightly items such as spoil stockpiles and barricades shall be kept to a minimum: site debris and excess materials shall be regularly cleaned up, removed and properly disposed.
- Restored progressively and as soon as possible; restoration work shall not be deferred.
- Left in a tidy and presentable condition.

### 12.2 Pavements

Immediately the filling of a trench excavation through a pavement has been completed, restore the pavement to a trafficable condition. Where the initial restoration is of a temporary nature, use a pre-mixed asphaltic material.
Maintain temporary restoration until final restoration is carried out. Carry out final restoration of the pavement to restore both pavement and sub-base to no less than their pre-existing condition. If appropriate, remove temporary restoration when carrying out final restoration work. After their initial temporary restoration, maintain pavements of other than bitumen or concrete with crushed metal, gravel or equivalent material, making due allowance for consolidation, and then restore to a condition equivalent to that of the original pavement. Complete the final restoration of bitumen and concrete pavements within one (1) month of temporary restoration.

12.3 Lawns
Reinstate lawns with turf sods cut and set aside from the original surface or with similar turf imported for the purpose. To make up any deficiencies between the stripped quantity and the quantity required for reinstatement, use imported topsoil consisting of a sandy loam of light to medium texture, containing 5% to 10% by weight of humus, and free of weeds. For areas to be turfed, ensure topsoil is graded to achieve a smooth surface, is free from lumps, stones or other debris, conforms to finished levels, blends gradually into the adjoining undisturbed ground and finishes flush with kerbs, footways and other paved surfaces. Incorporate into the topsoil at the rate of 40 g/m² a fertiliser mix with a nominal Nitrogen: Phosphorus: Potassium ratio of 10:4:6.

12.4 Grassed Areas
For grassed areas that are not lawns, restore by replacing the pre-existing topsoil and maintaining the disturbed area in a condition that will promote the re-growth of pre-existing grasses. Alternatively, replace pre-existing topsoil with clean topsoil and seed the affected area with grass seeds or re-plant with runners of the varieties prevalent in the immediate area. Should re-growth of grass fail to occur, repeat the process until re-growth is established.

12.5 Bushland
Carry out all works in accordance with the requirements of the environmental Regulator. Restore the works area as near as practicable to the pre-existing condition and leave the site in such condition as will promote the rapid re-growth of native bush plant species prevalent in the immediate vicinity. Return the topsoil to its pre-existing location and place it in such a way that erosion will be minimised, e.g. by the use of small contour banks. Use the pre-existing vegetation as a seed source where possible. Upon backfilling of the line and spreading of topsoil, replace the pre-existing vegetation over the line, placing branches and logs across slope to intercept runoff.

Do not use imported topsoil in native bushland areas. Employ a qualified bush regenerator to control weeds for a period of 2 years following restoration. Only local native species are to be used in revegetation of disturbed sites. On steep slopes, use jute mesh and plantings to stabilise the soil.
12.6 Provision for Settlement
Through other than pavements, lawns or other improved surfaces, place trench fill sufficiently high to compensate for expected settlement. Subsequently, carry out further filling or trim the original trench fills, in order that the surface level of the completed trench conforms to the adjacent surface. Remove all surplus material and dispose of without breaching applicable regulations or laws and do not dispose of on any property without the property owner’s written permission.

Within public or private property where the reasonable convenience of persons requires trenches to be levelled off at the time of filling, make any subsequent settlement good as necessary by placing and compacting additional fill. With the written consent of the Owner, their agent or lessee, dispose of surplus material by spreading neatly in the vicinity of the trench in such a way as to minimise further erosion of the backfill and adjacent ground surfaces.

12.7 Maintenance of Restored Surfaces
Maintain all restored surfaces and improvements in a satisfactory condition until the end of the defects liability period.
STRUCTURAL CONCRETE SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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<td>5.5</td>
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<td>27</td>
</tr>
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</table>
1 General

1.1 Scope of Specification

This Specification applies to plain and reinforced concrete work.

1.2 Standards

Subject to this Specification:

- the construction of concrete structures and members shall satisfy the requirements of AS 3600, "Concrete Structures";
- the design, fabrication, erection and stripping of formwork shall satisfy the requirements of AS 3610, "Formwork for Concrete".
- the construction of concrete structures intended to be used for retaining liquids shall comply with AS 3735, “Concrete Structures for Retaining Liquids”.

1.3 Inspection

The Contractor shall give the Principal's Representative not less than 1 working day's notice so that an inspection can be made of the following work:

- foundations;
- completed formwork;
- reinforcement fixed in place;
- placing of concrete.
2 Formwork

2.1 General

The Contractor shall design, fabricate, erect and strip formwork.

2.2 Project Documentation Information

2.2.1 General

Refer to Section 2 of AS3610.

2.2.2 Stacked Materials

Stacked material shall not be placed on newly placed concrete work without the prior knowledge of the Principal’s Representative.

The loading from stacked materials shall not exceed 4.0 kPa.

Materials shall not be stacked on newly placed concrete in the following circumstances:

- in multistorey construction where the lowest level of formwork has been stripped;
- stacked materials consisting of sand, pallets, etc. which can cause deformation between the shores;
- stacked materials which can induce concentrated loads on the concrete surface remote from the support shores.

2.2.3 Restraint of Formwork

Formwork shall not be braced against previously cast concrete. Framed bracing shall be constructed between formwork supports.

2.2.4 Propping Requirements Composite Construction

Refer to Section 11 of AS 2327.1, “Composite Structures, Part 1: Simply Supported Beams”.

2.2.5 Not Used

2.2.6 Not Used

2.2.7 Permanent Formwork

Formwork that is required to remain permanently in the structure shall be incombustible and shall be free from calcium chloride.
2.2.8 Critical Face of Elements

The critical face shall be the surface exposed to view.

2.3 Surface Finishes

2.3.1 General

Refer to Section 3 of AS 3610.

2.3.2 Classes of Surface Finish

The following surface finishes shall be achieved:

- areas subject to close scrutiny (ie complete building facades, visible areas of bridgeworks etc) -2C;
- areas viewed as a whole (eg car parks, basement walls, bridgework not readily visible etc) - 3;
- areas concealed from view (backs of retaining walls, insides of tanks or surfaces with an applied finish) - 4;
- totally concealed areas where the only requirement is structural adequacy (ie footings etc) -5;

2.3.3 Colour Control of Untreated Surfaces

The concrete shall be grey in colour and shall comply with the tonal variations of AS 3610.

Concrete designated to be with colour control shall comply with the following requirements:

- cement shall always be the same type;
- cement content shall not be less than 330 kg/m3;
- aggregates shall come from the same source;
- pozzolans, used as additives, shall come from the same source.

2.4 Structural Design and Documentation

Refer to Section 4 of AS 3610.

All formwork documentation required in accordance with AS 3610, shall be supplied by the Contractor to the Principal’s Representative prior to construction for direction on whether the documentation is suitable.
2.5 Construction

2.5.1 General

Refer to Section 5 of AS 3610.

2.5.2 Multistorey Formwork

Backpropping of multistorey formwork systems shall be in accordance with the requirements of AS 3600 and AS 3610 provided that the following criteria are complied with:

- the minimum number of levels of undisturbed supports to be in place during the time of each pour on a floor shall be in accordance with the Table below;
- if backpropping is to be done, the number of levels of the supports in Table 1 shall be increased by one;
- backpropping may be done only on the lowest set of formwork and it shall not be commenced until 2 days after the pour;
- the service load divided by the slab self-weight shall be greater than 1.8;
- there shall be NO stacked materials on any of the floors;
- the time between pours of successive floors shall be not less than 5 days;
- the average ambient temperature shall be not less than 5°C;
- reshoring shall not be carried out;
- the proposed method of backpropping has been notified to the Principal's Representative.

Table 1: Multistorey Formwork - Minimum Number of Levels of Undisturbed Props

<table>
<thead>
<tr>
<th>Time Between Pours of Successive Floors</th>
<th>Minimum Number of Levels of Supports in Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Ambient Temperature, °C</td>
</tr>
<tr>
<td>Days</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>14 or more</td>
<td>3</td>
</tr>
</tbody>
</table>

2.5.3 Maintenance of Forms

All formwork shall be cleaned before use or re-use.

Temporary openings shall be provided at the base of column and wall forms where necessary to facilitate cleaning and inspection. All forms shall be clean and free from foreign matter immediately before concrete is placed.

The interior surfaces of forms shall be treated with a release agent to prevent adhesion of mortar. Release agents shall be of non-staining type and shall be applied in a thin film before
the reinforcement is placed. The reinforcement shall not be allowed to come in contact with the release agent.

Any reinforcement in contact with the release agent shall be thoroughly cleaned to remove all traces of the release agent or shall be removed and replaced by new reinforcement. Any surplus moisture shall be removed from the forms before concrete is placed.

Any formwork bolts that are to be removed from the concrete shall be coated with a concrete retarder and shall be arranged so that they can be extracted without excessive jarring or hammering and without injury to the concrete surface.

2.5.4 Formwork Stripping

The Contractor shall give the Principal's Representative not less than one working day’s notice before stripping formwork and assemblies.

Refer to Section 5.4 of AS 3610.

Notwithstanding anything to the contrary in Section 5.4 of AS 3610, the minimum formwork stripping times shall be:

Table 2: Minimum Stripping Times

<table>
<thead>
<tr>
<th>Member Type</th>
<th>Member</th>
<th>*Effective Span (mm)</th>
<th>Minimum Stripping Time (Days) For Average Air Temperature During Period Prior to Stripping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>20°C and over</td>
</tr>
<tr>
<td>Vertical, Unloaded</td>
<td>Wall, column, beam side slab</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Vertical, Loadbearing</td>
<td>Wall, column or loadbearing structure</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Horizontal</td>
<td>Slab</td>
<td>Under 3000</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3000-6000</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Over 6000</td>
<td>14</td>
</tr>
<tr>
<td>Horizontal</td>
<td>Beam</td>
<td>Under 3000</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3000-6000</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Over 6000</td>
<td>21</td>
</tr>
</tbody>
</table>

* Effective Span is the maximum distance between supports (either temporary or permanent).
2.5.5 Slip Formwork

Where moving formwork is used, it shall be constructed and operated by personnel experienced in the system.

During concreting the moving forms shall proceed at an average rate of 350 mm per hour. If the Contractor wishes to use a different rate the Contractor shall demonstrate that such a rate can produce a finished structure of the quality and appearance specified. The height of the forms shall not exceed 1200 mm.

The facing of the forms shall be correctly tapered and shall be free from defects that might cause scoring of the fresh concrete at the slip surfaces. The decking system shall be capable of supporting, without excessive deflection, a superimposed load of 5 kPa. Allowance shall be made for impact loading on the deck.

The method of lifting the forms during construction shall be submitted to the Principal's Representative with the Formwork Drawings.

The Contractor shall take precautions to prevent the formwork's jamming against the concrete when the formwork is left stationary overnight.

A hanging scaffolding shall be provided below the moving form on all faces, from which surface treatment and inspection can be carried out.

The Contractor shall use a system that will permit continuous checks to be made on wall verticality and formwork levels.

All equipment associated with the moving form process shall be supplied and used as per the manufacturer’s specifications and their acceptance of the correct use of the equipment shall be obtained throughout the operation.

2.6 Tolerances of Formed Surfaces

Refer to Section 19.5 of AS 3600 and to Section 5 of AS 3610.

Where the requirements of AS 3600 and AS 3610 are in conflict, the more stringent requirements shall apply.
3 Reinforcement

3.1 General

Refer to Clause 19.2 of AS 3600.

3.2 Storage

Reinforcement when delivered to the Site shall be suitably stored and protected clear from the ground to ensure that reinforcing is suitable for incorporation into the Works.

3.3 Fabrication and Placement

Immediately before concrete is placed, reinforcement shall be free from loose rust, loose mill scale, grease, tar, paint, oil, mud, mortar and foreign matter.

The reinforcement shall be secured against displacement by tying at intersections with annealed wire ties not smaller than 1.25 mm diameter or by purpose made clips.

The ends of wire ties shall be bent away from nearby faces of forms and shall not project into the concrete cover.

In reinforcement in the form of a mat, each bar shall be secured at alternate intersections and at other points as required so that the specified fixing tolerances shall be maintained as concrete is placed.

Each beam ligature shall be secured to a bar in each corner of the ligature and all longitudinal column reinforcement shall be secured to all ligatures at every intersection.

3.4 Supports

Reinforcement shall be supported by bar chairs, spacers and ties made from sound concrete, steel (plastic tipped) or plastic but pieces of wood, aggregate, brick etc shall not be used. Unprotected ferrous metal shall not be used in such supports where they extend to the surface of the concrete, or where they are used in conjunction with galvanised or zinc coated reinforcement.

Top and bottom slab reinforcement shall be supported at intervals sufficiently close to ensure that there shall be no undue deflection of the bars as concrete is placed. The spacing of supports shall not be greater than 60 diameters for bars and 750 mm for fabric.

Longitudinal beam and column reinforcement shall be secured by spacers or ties at spacings not greater than 1000 mm.
3.5 Splices

Splices shall be in accordance with AS 3600.

3.6 Welding and Heating

Heating or welding of reinforcement shall be carried out only if accepted by the Principal’s Representative.

Welding of reinforcing bars shall satisfy the requirements of AS 1554.3.

3.7 Fixing Tolerances

Refer to Section 19.5 of AS 3600.

Notwithstanding anything to the contrary in Section 19.5 of AS 3600, reinforcement shall be placed within the following tolerances.

- Bar positions controlled by cover
  - Beams, slabs, columns and walls: -0, +10 mm
  - Slabs on ground: -10, +20 mm
  - Footings cast on the ground: -20, +40 mm

A positive value indicates the amount by which the cover may be increased and a negative value the amount by which may be decreased.

- Bar positions not controlled by cover:
  - Ends of reinforcement: -0, +50 mm
  - Spacing of bars in walls and slabs and of fitments in beams and columns: -10% of specified spacing or 15 mm, whichever is greater.

3.8 Testing

The Principal’s Representative may direct the Contractor to supply a test certificate for each grade of reinforcement.

If certificates are not available and they are required by the Principal’s Representative, the Contractor shall have tests carried out by a NATA registered laboratory and shall supply reports of the results to the Principal’s Representative.
4 Concrete Supply and Placement

4.1 General

The Contractor shall select materials and design concrete mixes.

The Contractor shall be entirely responsible for the design and production of finished concrete and concrete work that is in accordance with this Specification.

4.2 Materials

4.2.1 General

Comply with clause 17.1.1 of AS3600

For liquid retaining structures, the Contractor shall advise the concrete supplier with each order that the concrete is for liquid retaining structures to contain treated and untreated sewage.

4.2.2 Cement

Cement shall be Type GP - General Purpose Portland Cement complying with AS 3972.

Cement delivered to the Site shall be contained in multi-walled bags and kept dry and undamaged in weatherproof shed/sheds.

Cement on Site shall be used in the order which it is received and storage shall be arranged to achieve this requirement. The Contractor shall keep records of the dates and quantities of the deliveries received. Cement that has been stored for more than three months shall be retested at the Contractor's expense and shall not be used if it does not then comply with AS 3972. Cement showing lumps that cannot be broken to the original fineness by finger pressure shall not be used irrespective of its age.

4.2.3 Fly Ash

Fly ash shall be used as an additive to cement, unless it can be established to the satisfaction of the Principal's Representative that aggregates for the concrete mix are unlikely to have the potential to create an environment for an aggregate/alkali reaction.

The proportion of fly ash shall be 30% by weight of the total combined weight of fly ash and cement.

Fly ash shall satisfy the requirements of AS 3582.1 and AS 3583.
Where the Contractor wishes to use both fly ash and an air entraining agent in a concrete mix, the Contractor shall provide to the Principal's Representative proof (from tests on trial mixes or previous production) that the amount of air entraining can be controlled within specified limits and that the compressive strength is satisfactory.

4.2.4 Fine and Coarse Aggregates

Fine and coarse aggregates shall satisfy the requirements of AS 1141 and AS 2758.1 and shall be ‘normal weight’ as defined by AS 2758.1.

Aggregate to be used in concrete of grade S40 shall satisfy the durability requirements for exposure classification B2. Coarse aggregate shall be assessed using the Los Angeles value and sodium sulfate soundness method of AS 2758.1 Clause 9.3.3. Attention is drawn to Clause 10 of AS 2758.1 and alkali-reactive aggregates shall not be used.

The maximum coarse aggregate size shall be 20 mm.

Aggregates shall have a well graded combined grading, free of gaps.

Batch weights and material gradings shall be supplied to the Principal's Representative.

The Principal's Representative may direct the Contractor to supply fine and coarse aggregates for testing 14 days before delivery commences to the job. The quantity of fine aggregate shall be 20 kg and the coarse aggregate 45 kg in weight. The cost of all materials supplied shall be borne by the Contractor and the cost of testing shall be borne by the Principal.

4.2.5 Water

The water used in mixing concrete shall be clean and free from injurious amounts of oils, acid, alkali, organic matter or other deleterious substances and shall be of potable quality.

4.2.6 Admixtures

Chemical admixtures in concrete shall be used only with the written acceptance of the Principal's Representative. Admixtures shall satisfy the requirements of AS 1478. Fly ash is not considered an admixture under the terms of this clause.

Calcium chloride shall not be used as an admixture in concrete.

4.3 Performance Requirements

4.3.1 Concrete Mix Design

The concrete mix design including details of the materials shall be submitted to the Principal's Representative not less than 7 days prior to the first placement of such concrete together with
sufficient test data to demonstrate that the proposed mixes will satisfy the specified performance requirements.

4.3.2 Not used

4.3.3 Concrete Grade S40

Concrete designated Grade S40 shall comply with the following requirements:

- The nominal maximum aggregate size is 20 mm
- The water-cement ratio shall not exceed 0.45
- The drying shrinkage strain at 56d shall not exceed 650x10^-6 determined in accordance with AS 1012.13
- The cement (as defined in AS1379) content shall be not less than 320 kg/m3
- It shall be delivered at site at a temperature not exceeding 24°C.

4.3.4 Ready Mixed Concrete and Pumped Concrete

Ready mixed concrete shall be used for all parts of the project. Ready mixed and pumped concrete shall satisfy the requirements of this Specification and of AS 1379.

The concrete for every part of the works shall be supplied as pre-mixed concrete.

Delivery of pre-mixed concrete in non-agitating trucks will not be permitted.

4.3.5 Site Mixed Concrete

Site mixed concrete shall only be used after approval by the Principal’s Representative. Concrete shall be batched, mixed and placed under procedures accepted by the Principal’s Representative.

All site mixed concrete shall be batched and mixed in equipment conforming to the relevant requirements of AS 1379.

The equipment shall be regularly inspected and maintained and the calibration of all weighing equipment shall be verified at intervals not exceeding 2 weeks.

Concrete shall be batched and mixed only in quantities required for immediate placing in the forms.

4.3.6 No Fines Concrete

No-fines concrete shall consist of Portland cement and coarse aggregate. The coarse aggregate for 20 mm maximum particle size, shall have the following grading:
No-fines concrete shall be proportioned as follows:

- aggregate: cement ratio in the range of 6:1 to 8:1 by weight;
- water: cement ratio in the range of 0.35 to 0.45 by weight.

4.3.7 Grout

Grout shall consist of Portland cement and water or of Portland cement, sand and water.

An additive designed to produce fluidity and for expansion of the grout may be used provided that additives containing aluminium powder, chlorides or nitrates shall not be used.

Sand, if used, shall satisfy the requirements of AS 2758 except that the grading may be modified to obtain increased workability.

The water content shall be the minimum necessary for proper placement.

4.4 Mixing and Placing

4.4.1 Addition of Water and Other Materials

After all ingredients of the concrete have been mixed the further addition of water or other materials shall not be permitted.

4.4.2 Elapsed Time

The maximum elapsed time from the charging of the mixer with all dry materials and any of the required water or cement, to the discharging of the pre-mixed concrete at the site shall generally be in accordance with the following table:

<table>
<thead>
<tr>
<th>Concrete Temperature At Time of Placement</th>
<th>Maximum Elapsed Time From Charging Of The Mixer To Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5°C</td>
<td>Not acceptable</td>
</tr>
<tr>
<td>10 - 24°C</td>
<td>2 hours</td>
</tr>
<tr>
<td>24 - 27°C</td>
<td>1 hour 30 minutes</td>
</tr>
</tbody>
</table>
However, the final criteria shall be the compliance of the Concrete with the specified performance requirements, including slump.

The Contractor shall advise the pre-mixed concrete supplier of all requirements of this Specification and shall require that each truck of pre-mixed concrete be accompanied by a docket bearing the following information:

- The specific part of the works for which the concrete was ordered and is intended
- The quantity of concrete contained
- The time of dispatch
- The type of concrete supplied, including details of:
  (1) Type of cement
  (2) Slump
  (3) Maximum aggregate size
  (4) Concrete grade
  (5) Admixtures used

The Contractor shall retain these dockets as a record of the pre-mixed concrete delivered, and this information shall be available to the Principal's Representative on request.

4.4.3 Temperature Conditions

Concrete shall not be placed when the following conditions occur:

- the temperature of the concrete is less than 10°C or exceeds 35°C or
- the outdoor shade temperature is likely to be greater than 35°C during placement or within 2 hours subsequent to placement, unless special precautions, to the acceptance of the Principal's Representative, are undertaken. Notwithstanding that such special precautions are taken, concrete shall not be placed when the outdoor shade temperature exceeds 38°C.

Where the concrete temperature is less than 32°C, concrete shall reach its final position in the forms within 30 minutes after the introduction of water to the cement and aggregate, or the cement to the aggregate, except in the case of concrete which is continuously agitated in a truck mixer, when 1.5 hours may elapse between introduction of water and final placing. In hot weather where the concrete temperature is greater than 32°C the above times shall be reduced to 15 minutes and 45 minutes respectively. Notwithstanding the above, the Principal’s Representative may direct other times.
When the temperature exceeds 35°C the concrete shall be supplied at a temperature not exceeding 35°C by employing one or more of the following procedures:

- The use of chilled mixing water
- The addition of ice to the mixing water (no ice particle shall remain by the time of discharge of the concrete)
- Cooling of the coarse aggregate by shading and/or cold water spraying of the stockpiles.

Concrete grade S40 shall be delivered at a temperature:

- not exceeding 24°C for elements thicker than 500mm.
- not exceeding 28°C for elements less than 500mm thickness.

This may be achieved by employing one or more of the abovementioned procedures.

Under no circumstances shall the concrete be supplied at a temperature less than 10°C.

4.4.4 Re-Tempering

Concrete that has commenced to harden prior to placement will not be accepted

4.4.5 Slumps

The concrete slumps shall be as follows at the construction site:

- general concrete - 60 + 20 mm;
- pumped concrete - 80 + 15 mm;
- tremie concrete - 150 + 30 mm.

4.4.6 Sequence of Pours

The proposed sequence of pours shall be submitted to the Principal’s Representative for direction on whether it is suitable. Slabs or beams, shall not be poured integrally with supporting columns and walls.

4.4.7 Placing

The Contractor shall not cover up formwork and reinforcement by placing concrete without the prior acceptance of the Principal’s Representative.

Concrete shall not be placed except in the presence of the Principal’s Representative.

Concrete shall not be placed unless materials for curing unformed surfaces are at the site and ready for use.
Before concrete is placed, the formwork and the space into which the concrete is to be placed shall be free of contaminants and free of water.

Concrete shall be brought to the forms and placed in such a manner that there shall be no segregation of the concrete mix. Internal vibrators shall not be used to move concrete within the forms.

Concrete shall not be exposed to rain during mixing, transport or placing, until it has set.

Concrete shall be placed in daylight or under adequate artificial lighting.

Concrete shall be deposited as near as practicable in its final position without segregation. It shall not be dumped from a height greater than 2 metres nor shall it be dumped away from its final position and worked along the forms. If placing operations necessitate a drop greater than 2 metres, the concrete shall be placed using a flexible tube reaching to the base of the formwork.

Chutes, if used to place concrete, shall be used in a manner that avoids segregation of the concrete. Apart from flushing prior to commencement of concreting, the use of water shall not be used to assist the movement of concrete.

Concrete shall be placed continuously between construction joints. Fresh concrete shall not be placed against concrete that has taken its initial set.

The concrete shall be placed and compacted in layers not more than 300 mm.

### 4.4.8 Compaction

During and immediately after placing, the concrete (other than concrete placed underwater) shall be thoroughly compacted by means of high frequency mechanical vibrators. Care shall be taken to fill every part of the formwork, to work the concrete under and around the reinforcement and embedded fixtures without displacing them to work coarse aggregate back from the formed faces and to remove all air bubbles and voids.

Vibrators and their use shall follow the descriptions and recommendations in Chapter 8 of SAA HB 64.

The number of internal vibrators provided shall be not less than one (1) per four cubic metres of concrete placed per hour. In addition, at least one (1) vibrator shall be provided as a reserve for emergency use.

Internal vibration shall be applied in a systematic manner in the area of freshly deposited concrete, at uniformly spaced points not further apart than one and a half times the radius of visible vibration effect. Vibration shall not be continued so as to cause segregation or to draw grout from the surround concrete.
Vibrators shall not be held against forms or reinforcing steel, nor shall they be used for spreading concrete or moving it along forms. Vibrators shall not be left stationary in one position such as to cause segregation.

The Contractor shall supply to the Principal’s Representative details of all vibrating screeds for flat slabs and vibration of formwork that the Contractor proposes to use.

4.4.9 Joints

In general, concrete shall be placed and compacted against unset previously-placed concrete such that the finished work shall be monolithic and uniform in strength and appearance.

Construction joints may be made in such locations and in such manner as may be accepted by the Principal’s Representative, who may direct the Contractor to scabble or otherwise remove laitance and provide for bond and to provide keys, steps and other means of load transfer. If, due to breakdown or other unforeseen contingency, a construction joint becomes necessary at a point not previously agreed to, concreting shall be continued by emergency means to a point designated by the Principal’s Representative and a construction joint made.

4.4.10 Pumping

Pipelines used in pumping concrete shall be connected to the furthest points of delivery and shortened during pumping as work proceeds. The equipment shall be arranged so that no vibrations that may damage freshly placed concrete shall result. Before concrete is pumped the pipeline shall be primed with a 2:1 sand/cement mortar at the rate of 1 cubic metre of mortar to 300 metres of line. All priming mortar shall be discharged to waste. If pumping is stopped for more than a few minutes the pipeline shall be kept free by running the pump for two or three strokes every few minutes, otherwise the pipeline shall be emptied and cleared.

4.4.11 Sprayed Concrete

Placement of concrete by a spraying technique may be used, if accepted by the Principal’s Representative.

Sprayed concrete shall be placed in accordance with Concrete Institute of Australia, “Recommended Practice for Sprayed Concrete”.

The placing equipment shall be of an accepted type and the nozzleman shall be experienced in that type of work.

The air operating pressure at the gun outlet shall not be less than 240 kPa.

The nozzle shall be held at right angles to the receiving surface at a distance of 0.6 to 1.2 metres.

Vertical surfaces shall be worked from the bottom up.
No rebound concrete shall be mixed into any batch.

### 4.4.12 Placing Underwater

Concrete shall not be placed underwater without the prior knowledge of the Principal’s Representative.

Concrete shall not be placed in running water and forms shall be watertight.

The concrete shall be placed carefully in a compact mass in its final position by means of a tremie or similar device. A tremie shall consist of a steel tube at least 200 mm in diameter and be watertight. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be entirely sealed in fresh concrete at all other times. The level of concrete in the tremie shall be kept as close to the top of the tube as possible at all times during concreting.

A concrete pump may be used for placing concrete underwater, provided it has the same characteristics as a tremie.

Vibration or disturbance of the concrete after placing is not permitted.

The quantity of cement in the concrete placed underwater shall be increased by 25% above that normally required for that grade of concrete.

### 4.5 Sampling and Testing

#### 4.5.1 General

Sampling and testing of concrete for compliance shall be in accordance with AS 1379.

#### 4.5.2 Slump

Slump tests shall be undertaken at site in accordance with AS 1379.

#### 4.5.3 Strength

Project assessment of each strength grade shall be undertaken in accordance with AS 1379. In addition to the minimum sampling frequency specified in AS 1379 at least one sample shall be tested for each element of the structure and for each grade of concrete placed in any one day.

#### 4.5.4 Air Content

Air content tests shall be undertaken at site in accordance with AS 1379.
4.5.5 Drying Shrinkage

Project Assessment for drying shrinkage of each strength grade shall be undertaken in accordance with AS1379. As a minimum drying shrinkage tests shall be undertaken for every 500 m$^3$ of concrete.

4.6 Unformed Surface Finishes

Unformed surfaces shall be constructed to a smooth even surface and finished with a wooden float.

4.7 Curing and Protection

All concrete work shall be cured.

For unformed surfaces curing shall be commenced immediately finishing is complete.

The curing period from the time of placing concrete (to be continuous) shall be not less than the following:

- Portland cement concrete - 7 days;
- cements with fly ash pozzolanic materials - 10 days.

The curing method shall include one or a combination of the following methods:

- ponding or continuous sprinkling with water;
- curing compound that is in accordance with the recommendations of AS 3799;
- absorptive cover kept continuously wet;
- impermeable membrane.

The Principal’s Representative may direct that any curing method not be used.

The concrete shall be protected from damage during the curing period.

4.8 Rejection of Concrete

Plastic and hardened concrete that does not meet the requirements of this Specification and of AS 3600, AS 3610 or AS 1379 is not in accordance with the Contract.

4.9 Repairs of Concrete

Where repair of concrete is necessary and permitted, such repairs shall be performed by skilled workmen and shall be completed within 24 hours after removal of formwork or, in the case of unformed concrete, within 24 hours after placing of concrete.
5 Protective Lining

5.1 General
The Contractor shall provide HDPE concrete corrosion protection lining (CPL) to all the internal surfaces of all concrete structures including manholes, wet wells and emergency storage. All internal surfaces shall be coated, including floor, walls, dividing walls, roof and underside of roof slab except for horizontal surfaces to be covered by benching.

The CPL shall be Anchor Knob Sheet (AKS), or equivalent as approved by the Principal and have individual integral anchors (as opposed to linear keys) enabling permanent mechanical fixing by casting the anchors into the face of the concrete surfaces, or by post grouting on horizontal and/or slightly inclined surfaces.

The manufacturer of the CPL must have a proven history of manufacture and supply of the lining to major water and industrial infrastructure projects in Australia and/or overseas for a minimum period of 10 years and/or a minimum production quantity of 1,000,000 square meters during the 10 year period.

5.2 Material Properties
The lining material shall be hexane grade HDPE consisting of virgin resin material, with no recycled material. The CPL shall be resistant to Sulphuric Acid generated in sewers. The CPL and extrusion welding rod shall be manufactured from the same HDPE resins and shall be manufactured to meet the test methods listed below relative to each material property.

5.2.1 HDPE Properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>Test Method</th>
<th>Units</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>ASTM D 792</td>
<td>g/ml</td>
<td>0.94</td>
</tr>
<tr>
<td>Light coloured material</td>
<td></td>
<td>g/ml</td>
<td>0.948</td>
</tr>
<tr>
<td>Black material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon black content (for black material only)</td>
<td>ASTM D 1603</td>
<td>%</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Carbon black dispersion (for black material only)</td>
<td>ASTM D 5596</td>
<td>Category</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Pull-off resistance</td>
<td></td>
<td>T/m²</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Tensile Properties</td>
<td></td>
<td>MPa</td>
<td>&gt;=15.0</td>
</tr>
<tr>
<td>Yield stress</td>
<td>ASTM D 638 Type IV</td>
<td>MPa</td>
<td>&gt;=25.0</td>
</tr>
<tr>
<td>Break stress</td>
<td></td>
<td>%</td>
<td>12</td>
</tr>
<tr>
<td>Yield elongation</td>
<td></td>
<td>%</td>
<td>500</td>
</tr>
<tr>
<td>Break elongation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The surface of the CPL in structures designed to be enclosed and away from direct continuous sunlight shall be white or other light colour approved by the Principal. This is a requirement for future CCTV inspection.
Liners in light colours must include a UV stabilization additive to provide UV protection for a two year period to eliminate deterioration in properties of the material when exposed to direct sunlight during the construction period. CPL for lining of structures exposed to sunlight beyond the construction period shall be black unless otherwise approved by the Principal.

The CPL must have a minimum thickness of 2.5mm and have a minimum of 1,000 anchors per square metre area of lining.

The CPL must have anchors or keys that are integrally and homogenously formed with the sheet during manufacture. Welding or gluing of anchors or studs to the sheet is not an acceptable method of producing the CPL. Ribbed anchoring systems are not permitted.

### 5.3 Installation

Delivery, storage, installation, welding and testing of the CPL must be carried out in accordance with the supplier’s instructions and work method statements; or DVS Technical code 2227-1, with the former taking precedence.

The contractor must engage an installer that can demonstrate the following:

- Accreditation by the CPL supplier as an approved installer of the CPL
- Employs or subcontracts technicians with nationally accredited training, in the installation, welding and testing of HDPE CPL, as managed by the CPL supplier
- Has access to extrusion welding and testing equipment necessary for the welding and testing in accordance with the CPL supplier’s instructions and methods.

In addition, the contractor must engage a suitably qualified and experienced CPL inspector, approved by the CPL supplier, to:

- Review testing and inspection plans with the contractor and the selected installer.
- Prepare or advise on the preparation of shop drawings for CPL sheets to optimize material usage and to plan for penetrations and corners and weld locations.
- Training and documentation for formwork crews in the correct handling, placement and securing of the CPL onto formwork, including provision for penetrations, joining of sheets, tensioning of sheets and stripping of formwork.
- Review methods and plans with the contractor and installer for preparation and grouting of the CPL onto horizontal and/or slightly inclined surfaces.
- Carry out final inspections on completed work and review test results and final QA documentation.

The length of time that the CPL inspector shall be engaged on site is to be decided by the contractor to achieve the quality outcomes nominated by this specification.

### 5.3.1 Fixing to Formwork

Fixing to formwork is a critical operation and the contractor must ensure:
• Shop drawings/sketches are prepared prior to fixing to formwork to plan the sheet sizes and location of joints and penetrations for pipework, etc.
• Formwork is clean and free from defects that could damage the CPL or prevent it from remaining flat.
• That the CPL is pre-tensioned onto the formwork in a manner as accepted by the supplier, within the elastic range of the material, to allow for temperature expansion and contraction without having folds or lumps in the CPL during the concrete pouring operation.
• That the CPL is secured by nails or other means onto the formwork, in locations where future welding or cover strips will cover any or all fixing holes in the CPL.
• The CPL is secured at joints by removing knobs as necessary, using H profiles or sheet overlap such that concrete fines are prevented from travelling between the formwork and the CPL.

5.3.2 Welding and Testing
The installer must ensure that the surfaces to be welded are dry and the structure is adequately ventilated for welding works. All surfaces to be welded must have the oxidized layer removed prior to welding and have the extrusion weld in place within 20 minutes of removing the oxidized layer.

The following testing is mandatory and must be recorded as part of the quality assurance plan:

• Initial qualification of each welding technician by cutting three 20mm wide coupons from 500mm long extrusion weld for tensile testing
• Daily site tensile test on a 20mm wide coupon cut from a 500mm long sample extrusion weld for each welding operator and each welding gun
• Twice daily, check the extruded HDPE from each welding gun for correct temperature
• 100% Visual inspection and mechanical point test of extrusion welds
• DC Spark test or Vacuum box test 100% of extrusion welds
• AC Spark test 100% of the CPL surface to detect any small holes that may have penetrated the lining during the construction process

All permanent welds must be either extrusion welds or double seam welds (in the case of larger prefabricated joined sheets) using equipment and materials in accordance with the supplier’s instructions and work methods or DVS Technical Code 2227-1 (with the former taking precedence). Temporary welds can be carried out with a hot air gun and weld rod (speed weld or tack weld).

5.3.3 Patching of Holes and Void Defects
Holes through the CPL less than or equal to 30mm diameter can be patched with multiple runs of extrusion weld across the hole in accordance with a detailed procedure outlined or approved by the CPL supplier. If holes are greater than 30mm diameter, they must be covered by a circular patch extrusion welded around the perimeter in accordance with a detailed procedure approved by the CPL supplier.
Alternatively, all holes up to 70mm diameter may be repaired by covering with a HDPE repair button using a friction welding procedure approved by the CPL supplier, but only where the surrounding CPL is flat and free of any rips or tears.

Areas in the CPL detected as having less than 100% encapsulation of the anchors into the concrete (by tapping the CPL and looking for distinct changes in sound). Areas with voids under the CPL less than 500mm x 500mm can be injected with a cement grout or epoxy using an approved application method. Larger areas with voids under the CPL shall be repaired by cutting away the CPL, epoxy or cement grouting a larger CPL piece in place and extrusion welding the perimeter.

Destructive anchor pull out testing shall only be conducted on the CPL where directed by the Principal as an additional test type test required for the project. Generally routine tests for pull out of anchors are not required unless regular void areas are detected and the concrete placement process needs to be validated or specially prescribed by the Principal.

5.3.4 Pipe Penetrations and other openings
The CPL must be sealed around pipe penetrations using a fabricated HDPE boot in accordance with a detailed procedure approved by the CPL supplier.

The contractor shall use standardized details from the CPL supplier, with regard to sealing any other openings in the CPL. The penetration / opening detail must demonstrate that it shall provide a sufficient barrier so that there shall be no generation of sulphuric acid behind the CPL which can cause concrete corrosion over the period of structures service life.

5.4 Post Grouting of the CPL
The CPL can be post grouted to horizontal surfaces or slightly inclined surfaces with the following measures taken to ensure appropriate quality:

- The concrete surface must be roughened to a minimum surface roughness of CSP3 (in accordance with the International Concrete Repair Institute manual) by green cutting or another approved site method.
- The grout must be an approved low shrinkage, high strength pre-packaged grout approved by the CPL supplier and mixed and placed strictly in accordance with the grout supplier's instructions. Grout cube samples must be taken from every batch of grout for 28 day compressive strength tests. One and three day tests only if specifically nominated by the Principal at time of tender.
- The grouting works must be planned for periods of minimum change in ambient temperature to limit expansion or contraction of the CPL during the grout setting/curing period. No grouting works must be undertaken where the CPL is exposed to direct sunlight from the start of the grouting operation through to final set of the grout. This is to be accomplished by working under shade cover or at night.
- Edge strips for forming the grout must coincide with joins in the sheet and be placed and secured such that the wet grout thickness is never less than the CPL knob height.
or 12mm whichever is greater. Grout used on slightly inclined surfaces must be of a consistency to prevent grout flow down the incline.

- The concrete surface must be coated with a primer approved by the grout supplier.
- CPL rolls must be rolled out flat and weighted for 48 hours to remove rolled memory in the HDPE material prior to grouting
- The CPL sheets shall be in easily managed sizes and laid into the grout from one direction and weighted down flat during grout set and initial cure.
- Where the grouted CPL could be subjected to a negative pressure of greater than 30KPa during service, pressure relief holes (10mm diameter) must be drilled through the CPL at maximum 2.0m centres and the holes covered with a flat strip with intermittent welds around the strip perimeter, to the CPL supplier’s approved detail.

5.5 Warranty
The contractor must provide, as a minimum, a manufacturer's backed warranty for the CPL materials for a period of 5 years after the date of supply.
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WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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1 General

1.1 Scope of Specification

This Specification applies to the supply, fabrication, erection and protection of structural steelwork.

1.2 Standards

Subject to this specification:

- the supply, fabrication, erection and protection of structural steel shall satisfy the requirements of AS 4100 and other standards and reference documentation identified within this specification and structural design drawings.

1.3 Shop Drawings

The Contractor shall supply to the Principal’s Representative shop drawings of the structural steelwork prepared in accordance with AS 1100 and AS 1101.3. The drawings shall give details of each assembly, member, fixing, fabrication procedure, surface coating/preparation and erection including:

- Hold down bolt drawing showing location, projection and level of top of bolts;
- Dimensions of members;
- Location, size, type of welds and bolts, including site and temporary connections;
- Procedures required for shop and site assembly;
- Orientation of members; and
- Size and location of vents for relieving air pressure for members hot dip galvanised.

The Contractor shall supply three copies of each drawing.

If amendments are required to any drawings, one copy will be returned to the Contractor with the required amendments marked in red. The Contractor shall make the necessary amendments to the shop drawings and resubmit three copies for further consideration and bear the cost of such alterations.

The Contractor shall not commence fabrication until the Principal's Representative has given a direction that the shop drawings are suitable. Notwithstanding any examination by the Principal’s Representative, the Contractor shall take full responsibility for the correctness and accuracy of the shop drawings.

1.4 Inspections

The Contractor shall give the Principal’s Representative not less than two working days’ notice for inspections that may be made for the following stages:
- Start of fabrication;
- Start of welding procedure tests;
- Start of welding;
- Prior to placement of root runs of butt welds (complete penetration);
- Completion of fabrication prior to surface preparation for coatings;
- Surface preparation prior to application of coating;
- Completion of surface coating;
- Steelwork on site prior to erection;
- Setting out;
- Completion of erection before fixing of cladding or encasing;
- Completion of encasing.

In the absence of any directions to the contrary, after the expiring of two days’ notice the Contractor may proceed with the work under the Contract, but this shall not be construed as implying any acceptance or negating the responsibility of the Contractor to complete the work in accordance with the requirements of the Contract.

1.5 Identification

Each member shall have suitable markings for identification for the correct location in the structure.

Connections requiring high strength bolts shall be marked to distinguish these connections from others. High strength bolts and commercial mild steel bolts shall be stored in separate containers.
2 Materials

2.1 General

- Refer to Section 2 of AS 4100;
- Cold formed light gauge sections shall satisfy the requirements of AS/NZS 4600.

2.2 Material Grade

If the grade of steel is not shown on the Drawings or specified, the grade of steel shall comply with the following table:

<table>
<thead>
<tr>
<th>Type of Steel</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot rolled structural bars and sections to AS/NZS 3679</td>
<td>300</td>
</tr>
<tr>
<td>Hot rolled plates, floor plates and slabs to AS/NZS 3678</td>
<td>250</td>
</tr>
<tr>
<td>Hollow Sections to AS 1163</td>
<td>350</td>
</tr>
</tbody>
</table>

2.3 Materials Certificates

For each batch of steel, the Contractor shall supply manufacturer’s Certificate of Compliance and Test Certificates from NATA registered bodies.

2.4 Independent Tests

At any time, the Principal’s Representative may require steel to be independently checked for compliance with chemical composition and mechanical test requirements of the appropriate Standard. The Contractor, if so required, shall supply at his own expense samples suitable for the test.

The Principal shall bear the cost of the above examination and testing only if the testing indicates no defect in materials.

2.5 Defective Material

Steel which cannot be shown to comply with the appropriate Standard shall not be incorporated in the Works. The Contractor shall bear the cost of cutting out and making good.
3 Fabrication

3.1 General

Refer to Section 14 of AS 4100.

3.2 Place of Fabrication

Fabrication shall take place in an accepted workshop unless otherwise permitted.

3.3 Cutting

Hot rolled sections, cold formed sections and steel tubes shall be saw cut. Other sections may be cut by shearing, plasma, cropping or sawing. Hand operating flame cutting tools shall not be used.

3.4 Splices and Joints in Structural Members

All structural steel members shall be in single lengths and no splices and/or joints shall be made except where shown on the Drawings and/or specified or indicated on shop drawings that the Principal's Representative has directed are suitable.

"Off-cuts" or short lengths of members shall not be welded together to make up the required length of a member.

3.5 Stud Shear Connectors

Stud shear connectors where indicated on the Drawings shall conform to the requirements of AS 1554.2.

3.6 Boxed Members

Abutting edges of boxed members shall be connected and sealed with a continuous weld to prevent the ingress of moisture. The weld reinforcement shall be ground flush.

3.7 Temporary Connections

Temporary erection cleats, if required, shall be shown on the shop drawings. After erection they shall be removed and the permanent surface restored.

3.8 Availability and Substitution of Sections

If the Contractor is unable to supply any steel section called for by the Contract, the Contractor shall supply substitute sections with at least the same material and section properties. Before commencing fabrication the Contractor shall advise the Principal’s
Representative of those properties. The Principal’s Representative may direct the Contractor to supply new shop drawings incorporating the substitute sections. The substitution of steel sections and provision of new shop drawings shall be deemed not to be a variation of the work under the contract.

3.9 Fabrication Tolerance

Refer to Clause 14.4 of AS 4100.

4 Bolting

4.1 General

Bolting shall be in accordance with the requirements of AS 4100.

All bolting to aluminium structures shall be stainless steel Grade A4-70 with neoprene separating washers U.O.N.

All structural steelwork shall be bolted with Grade 8.8 bolts U.O.N.

All stainless steel bolts and nuts shall be Grade 316 with nickel-based anti-seize.

All dissimilar metals shall have isolating washers. The isolating washer shall be at least the same size as the main washer.

4.2 High Strength Bolts

All joints made by means of high strength bolts shall use materials complying with AS/NZS 1252.

The fabrication, assembly, tightening and inspecting of bolts used in friction, bearing or tension type joints shall be in accordance with AS 4100. All friction and bearing type joints shall have bolts with load indicating washers.

Bolts shall be threaded with sufficient length to prevent threads included at interfaces of connected parts of the work. Washers, flat or tapered, as necessary, shall be used for each nut or head which is to be rotated.

4.3 Commercial Mild Steel Bolts

Unless specified elsewhere, mild steel bolts shall be commercial grade and conform to AS/NZS 1111. Where precision bolts are required they shall conform to AS 1110. The nuts for both the above types of bolts shall meet the requirements of AS/NZS 1112 while flat washers shall conform to AS 1237.
Bolts shall be threaded with sufficient length to prevent threads included at interfaces of connected parts of the work. Washers circular, clipped, flat or tapered as necessary shall be used for each nut and for each head which is to be rotated. The threaded portion of each bolt shall project through the nut at least one thread.

4.4 Galvanised Bolts

All bolts including masonry anchors, whether high strength or mild steel, shall be hot dip galvanised as a minimum.

4.5 Holding Down Bolts

The Contractor shall provide Quality Assurance certificates for all holding down bolts prior to delivery and installation on Site.

All hold down bolts shall be Grade 4.6 unless otherwise noted.

Permanent survey stations shall be constructed on suitable centrelines for the control of all holding down bolt locations.

All holding down bolts shall be held in their correct positions by steel framed templates fixed rigidly to formwork while placing concrete.

The centrelines shall be marked on the finished concrete so that bolt locations may be checked by the Principal's Representative before steel erection commences. Where bolts are found to be out of position and cannot be satisfactorily corrected, then the footing shall be demolished and reconstructed to allow correct positioning of the bolts.

5 Welding

5.1 General

Welding shall be in accordance with the requirements of AS/NZS 1554.1.

5.2 Welding Processes

The welding processes detailed in AS/NZS 1554.1 may be used in joining steelwork under this Specification.

5.3 Welding Procedures

The weld preparation, welding consumables and welding parameters shall be qualified before welding of the structure or the component commences. The Contractor shall establish welding procedures and list the applicable parameters on a “welding procedure sheet”, which shall be held as a record and be available for perusal by the Principal's
STRUCTURAL STEELWORK

Representative. The format of the "welding procedure sheet" shall be similar to that listed in AS/NZS 1554.1.

If the welding procedures are not prequalified, the Contractor shall meet all expenses associated with the demonstration of welding procedures either as a test piece or prototype model.

5.4 Weld Categories

Welds shall be SP (special purpose).

5.5 Qualifications of Welding Personnel

The welding supervisor and welders shall be qualified in accordance with the requirements of AS/NZS 1554.1.

5.6 Residual Stresses and Distortion

The Contractor shall use welding and fabrication procedures such that residual stresses in the structure do not exceed those permitted and are in accordance with AS/NZS 1554.1. Peening procedures shall not be used to relieve residual stress and distortion.

Where distortion is greater than the limits of AS 4100, the distortion shall be corrected in accordance with the techniques outlined in AS/NZS 1554.1.

5.7 Weld Testing

Dimensional accuracy, position and length of welds, weld defects and appearance shall be in accordance with AS/NZS 1554.1.

Non-destructive testing shall comply with the requirements of AS 1710, AS 2177.1 and AS 2177.2 and AS 2207.

The cost of all testing associated with welding shall be borne by the Contractor. The Contractor shall provide, at his expense, all labour, lifting equipment and access facilities to allow such testing to be carried out. Where testing reveals defective material the Contractor, when directed by the Principal's Representative, shall replace the defective material at his own expense. Re-testing of the repaired areas, after replacement, shall also be at the Contractor's expense.

All welds shall be inspected by a qualified welding inspector in accordance with AS/NZS 1554.1.

The minimum extent of non-destructive testing shall be:

1. 100% visual scanning
2. 50% visual examination

The Contractor shall supply the Principal’s Representative with a written report prepared by a qualified welding inspector confirming compliance.

6  Erection

6.1  General

Refer to Section 15 of AS 4100.

6.2  Site Conditions

The Contractor shall make himself aware of site conditions and satisfy himself that subsurface conditions are suitable for his equipment. He shall acquaint himself with the position of services which may cause difficulty in access and erection.

6.3  Set Out

Each part of the structure shall be aligned as soon as practicable after it has been erected. Permanent connections shall not be made, or other parts of the structure erected, until that part of the structure has been aligned, levelled and plumbed to the tolerances of AS 4100.

The Principal’s Representative may direct the Contractor to supply certificates from an accepted Licensed Surveyor verifying the following:

- A set out of reference lines for the positioning of all footings, anchor bolts and columns included in the works and relationship of the boundaries of the site to all reference lines.
- The correct placement of the first shaft of each column in terms of location and verticality before the grouting of each base plate.
- The correct placement of any subsequent column shaft including alignment and verticality for each lift of a column.

6.4  Erection Equipment and Methods

All erection gear and equipment used shall be of adequate strength and shall comply with all Statutory Regulations and Acts current at the time.

The Contractor shall be responsible for providing all temporary bracing, shores, struts, falsework and the like, to ensure the complete safety of the structure during erection and to maintain the steelwork within the required tolerances. The bracing system, shores and the like are to be capable of safely resisting expected construction loads or wind loads during construction.
Steelwork shall not be erected for a period of at least 10 days after building in of anchorages in concrete work.

6.5 Grouting at Supports
Refer to Clause 15.5 of AS 4100.

6.6 Concrete Encasement

The minimum thickness of concrete encasing shall be 50 mm.

The casing shall be reinforced with wire complying with AS/NZS 4671. The diameter of the wire shall be at least 5 mm. Alternatively, the reinforcement shall be structural grade bars complying with AS/NZS 4671. The diameter of the bars shall be at least 6 mm. In either case, the reinforcement shall be in the form of stirrups or binding at not more than 150 mm pitch and so arranged as to pass through the centre of the covering to the flanges and supported by and attached to at least four longitudinal spacing bars.

6.7 Handling and Storage
Refer to Clause 15.2.2 of AS 4100.

The Contractor shall repair or straighten damaged or bent members only with the consent of the Principal’s Representative, using methods not injurious to the steelwork, or shall replace the members at his own cost.

6.8 Erection Tolerances
Refer to Clause 15.3 of AS 4100.

7 Surface Coatings

7.1 General
All internal steelwork and steelwork eaves to buildings shall be coated.

7.1.1 Referenced Documents
AS 1627: Metal finishing - Preparation and pretreatment of surfaces
AS 3894: Site testing of protective coatings
APAS 2908
7.1.2 Scope and Purpose

This Specification details the surface preparation, application and repair of inorganic zinc silicate or epoxy 2-pack zinc rich / epoxy high build 2-pack-micaceous iron oxide / high gloss, 2-pack topcoat protective coating system to be used for the protection of internal structural steelwork. The environment is considered an aggressive sewer gas environment requiring a high level of protection.

This standard shall be read in conjunction with the manufacturer's technical data sheets and specifications and the products shall be applied in accordance with the manufacturer's written instructions where details are not included in this Specification.

7.1.3 Coating Contractor & Quality Assurance

The Contractor shall be certified under the ‘Painting Contractor Certification Program’ for the appropriate class of work or an approved equivalent. The Contractor shall submit documentation in accordance with their Quality Assurance Plan. However the minimum requirement for Quality Assurance shall be completion of AS 3894.10, AS 3894.11 and AS 3894.12, ‘Site testing of protective coatings’ equipment and inspection reports.

7.1.4 Instructions on Supply of Manuals

Australian Paint Approvals Scheme (APAS) ‘APAS Record of Supply’ shall be obtained when the product is purchased. The purchaser shall request an ‘APAS Record of Supply’ from the manufacturer at the time paint is ordered. A ‘Manufacturer’s Certificate of Test’ can then be obtained if problems in the application of the coating subsequently occur.


Returns as required by APAS Document D-184 instructions shall be completed by the manufacturer and submitted.

7.1.5 Safety and Environment

The Contractor shall conduct the operations (including blast cleaning and coating application) in accordance with the standards of safety laid down in the Queensland Occupational Health, Safety & Welfare Act and all regulations there under.
All operations shall be conducted in accordance with the *Environmental Protection Act*.

Contractors are responsible for obtaining all necessary approvals and disposal of all waste.

### 7.1.6 Surface Preparation

**General**

The fabricator shall ensure that all joints are fully welded and sealed, sharp edges and corners are ground off to a radius not less than 2 mm and all weld spatter and irregularities are removed.

Before commencing coating application the coating Contractor shall inspect the surfaces to be coated. If the Contractor considers there are any imperfections that may render the coating unsatisfactory, the Contractor shall notify the Principal's Representative. Commencement of work on the coating shall indicate unconditional acceptance of the surface to be coated.

All surfaces shall be free from mill-scale, rust, weld-spatter, oil, grease, soil, moisture and any other matter likely to impair the adhesion of the coating.

**Removal of Oil and Grease**

Oil and grease shall be removed from all steelwork using an alkali degreasing process or solvent washing and in accordance with AS 1627.1 "Part 1: Cleaning using liquid solvent and alkaline solutions".

**Abrasive Blast Cleaning**

All surfaces to be coated shall be dry abrasive blast cleaned to class Sa 2.5 finish in accordance with AS 1627.4 "Part 4: Abrasive blast cleaning". The surface profile shall be a medium profile grade with profile height between 45 and 70 microns in accordance with Table A of AS 3894.5 "Method 5: Determination of surface profiles" and shall be determined in accordance with this standard. Abrasive materials used shall be in accordance with AS 1627 Part 4, be free from contamination, contain less than 100 milligrams per kilogram of sodium chloride and contain less than 30 grams per kilogram of copper.

Wet blasting shall not be permitted unless a prior written agreement has been made with the Principal's Representative.

All work shall be coated on the same day as it is cleaned and while the surface remains class Sa 2.5 finish. Coatings shall not be applied if the steel temperature is less than 3°C above dew point. Use of dehumidification or other equipment to alter the atmospheric conditions, particularly in enclosed tanks, may be acceptable to Principal's Representative.

The Contractor shall not apply the coating until the surface preparation has been inspected and approved by the Principal's Representative. If rust-producing salts, chlorides or any
other surface contamination judged by the Principal’s Representative to be detrimental to coating performance is detected, surfaces shall be further prepared to remove all such contamination.

Testing for such contamination shall be conducted in accordance with AS 3894.6 “Method 6: Determination of residual contaminants”. The maximum permissible level of chlorides shall be 50 milligrams per square metre. This equates to 8.3 micrograms per square centimetre of sodium chloride.

7.1.7 Application of Coating System

General

All products shall be approved by the Australian Paint Approvals Scheme (APAS). All products in the system shall be from the same manufacturer. Coating materials shall be mixed and applied in accordance with the manufacturer’s written instructions. Proportioning and mixing of part cans is not permitted. Strict attention shall be paid to the shelf life and onsite storage conditions, which shall meet the manufacturer’s recommendations.

The finish shall be generally smooth and free from protuberances.

The surface temperature of the steel to be painted shall be at least 3°C above dew point. Coating shall not be applied to any surface, which has a temperature less than 10°C or more then 55°C during the cure period.

The first coat shall be applied as soon as the surface preparation has been approved by the Principal’s Representative. Application of subsequent coats shall not exceed the recoat times indicated on the manufacturer’s technical data sheet. If the coating has been allowed to cure beyond the recommended limits the area shall be whip blasted with fine silica free grit before the application of subsequent coats.

Primer Coat

The primer coat shall be a two part (liquid and zinc dust) inorganic zinc silicate coating for the protection of steel to APAS 2908 or APAS 2973 or epoxy, 2-pack zinc rich approved in accordance with APAS 2916. It shall be applied with a minimum dry film thickness of 75 microns. Application shall be by conventional spray equipment as recommended in the manufacturer’s data sheet and shall be continuously mechanically stirred while spraying. Minimum overcoating times as detailed in the manufacturer’s data sheet shall be observed.

Intermediate Coat

The intermediate coat shall be epoxy high build, 2-pack-micaceous iron oxide approved to APAS 2973. The minimum dry film build thickness shall be 200 microns. Spray application shall be used. The coating may be applied in two coats over the inorganic zinc silicate
primer, as a thinned mist coat followed by a build coat. Brush application for small areas may only be used if approval has been given by the Principal’s Representative.

**Top Coat**

Gloss polyurethane, 2-pack solvent borne or gloss catalysed acrylic, 2-pack solvent borne approved to APAS 2911 or APAS 2919. The coating shall be applied by spray to give a minimum dry film thickness of 50 microns. The colour shall be as specified.

Safety and application shall be strictly in accordance with the manufacturer’s written instructions.

**Dry Film Thickness**

The dry film thickness shall be measured in accordance with AS 3894.3 “Method 3: Determination of dry film thickness”. Calibration of instruments shall take account of surface profile height and shall be adjusted in accordance with this test method.

### 7.1.8 Inspection

**General**

The work shall be monitored and inspected by an Australasian Corrosion Association or NACE Accredited Coating Inspector who will be engaged by the Contractor.

**Before Coating**

The Contractor shall not apply any coating until the surface preparation has been inspected and approved by the Principal’s Representative. The Coating Inspector may, at his/her discretion, perform any tests relating to surface preparation or contamination. If testing is required, the test areas shall be prepared again after the testing is complete.

**After Completion of Each Coating**

The coating will be inspected as soon as practicable after completion of each coating to ensure compliance with the standard.

Areas that have been inadequately or unsatisfactorily coated shall be treated in accordance with and as directed by, and to the satisfaction of, the Coating Inspector.

**Re-Inspection**

Should surface preparation or the applied coating prove to be unsatisfactory in the view of the Coating Inspector and require rework and subsequent inspection, the cost of such inspection will be charged to the Contractor and such costs will be deducted from any moneys due and payable.
Reinstatement of Cured Coating

Damaged and defective areas shall be abraded by dry abrasive blast cleaning, power disk sanding till bright steel is exposed and coated with inorganic zinc silicate or epoxy, 2-pack zinc rich in accordance with the relevant standards.

Epoxy high build 2-pack MIO coating shall be abraded by abrasive blasting, power tool sanding or hand sanding and the edges feathered back by the same means for approximately 20 millimetres. Coating shall be re-applied in accordance with the relevant standards, however no coating shall extend beyond the edge of the prepared area.

The topcoat shall be applied in accordance with the relevant standards. Prior to application over cured coating it shall be lightly abraded. Small areas of coating may be applied by brush.

7.2 Coatings - External Structural Steelwork

External steelwork shall be coated.

7.2.1 Referenced Documents

AS 1627: Metal finishing - Preparation and pretreatment of surfaces
AS 3894: Site testing of protective coatings

APAS 2908
APAS 2911
APAS 2916
APAS 2919
APAS 2973

7.2.2 Scope and Purpose

This specification details the surface preparation, application and repair of an ultra high build solventless epoxy coating system intended for the protection of structural steelwork.

This standard shall be read in conjunction with the manufacturer's technical data sheets and specifications and the products shall be applied in accordance with the manufacturer's written instructions where details are not included in this Specification.
7.2.3 Coating Contractor & Quality Assurance

The Contractor shall be certified under the ‘Painting Contractor Certification Program’ for the appropriate class of work or an approved equivalent. The Contractor shall submit documentation in accordance with their Quality Assurance Plan. However the minimum requirement for Quality Assurance shall be completion of AS 3894.10, AS 3894.11 and AS 3894.12, ‘Site testing of protective coatings’ equipment and inspection reports.

7.2.4 Instructions on Supply of Manuals

Australian Paint Approvals Scheme (APAS) ‘APAS Record of Supply’ shall be obtained when the product is purchased. The purchaser shall request an ‘APAS Record of Supply’ from the manufacturer at the time paint is ordered. A ‘Manufacturer’s Certificate of Test’ can then be obtained if problems in the application of the coating subsequently occur.


Returns as required by APAS Document D-184 instructions shall be completed by the manufacturer and submitted.

7.2.5 Safety and Environment

The Contractor shall conduct the operations (including blast cleaning and coating application) in accordance with the standards of safety laid down in the Queensland Occupational Health, Safety & Welfare Act and all regulations there under.

All operations shall be conducted in accordance with the Environmental Protection Act.

Contractors are responsible for obtaining all necessary approvals and disposal of all waste.

7.2.6 Surface Preparation

General

The fabricator shall ensure that all joints are fully welded and sealed, sharp edges and corners are ground off to a radius not less than 2 mm and all weld spatter and irregularities are removed.

Before commencing coating application the coating Contractor shall inspect the surfaces to be coated. If the Contractor considers there are any imperfections that may render the coating unsatisfactory, the Contractor shall notify the Principal’s Representative. Commencement of work on the coating shall indicate unconditional acceptance of the surface to be coated.
All surfaces shall be free from mill-scale, rust, weld-spatter, oil, grease, soil, moisture and any other matter likely to impair the adhesion of the coating.

**Removal of Oil and Grease**

Oil and grease shall be removed from all steelwork using an alkali degreasing process or solvent washing and in accordance with AS 1627.1 “Part 1: Cleaning using liquid solvent and alkaline solutions”.

**Abrasive Blast Cleaning**

All surfaces to be coated shall be dry abrasive blast cleaned to class Sa 3 finish in accordance with AS 1627.4 “Part 4: Abrasive blast cleaning”. The surface profile shall be a high profile grade with profile height between 70 and 90 microns in accordance with Table A of AS 3894.5 “Method 5: Determination of surface profiles” and shall be determined in accordance with this standard. Abrasive materials used shall be in accordance with AS 1627 Part 4, be free from contamination, contain less than 100 milligrams per kilogram of sodium chloride and contain less than 30 grams per kilogram of copper.

Wet blasting shall not be permitted under any circumstances.

All work shall be coated on the same day as it is cleaned and while the surface remains class Sa 3 finish. Coatings shall not be applied if the steel temperature is less than 3°C above dew point. Use of dehumidification or other equipment to alter the atmospheric conditions, particularly in enclosed tanks, may be acceptable to Principal’s Representative.

The Contractor shall not apply the coating until the surface preparation has been inspected and approved by the Principal’s Representative. If rust-producing salts, chlorides or any other surface contamination judged by the Principal’s Representative to be detrimental to coating performance is detected, surfaces shall be further prepared to remove all such contamination.

Testing for such contamination shall be conducted in accordance with AS 3894.6 “Method 6: Determination of residual contaminants”. The maximum permissible level of chlorides shall be 50 milligrams per square metre. This equates to 8.3 micrograms per square centimetre of sodium chloride.

**7.2.7 Application of Coating System**

**General**

All products shall be approved by the Australian Paint Approvals Scheme (APAS). All products in the system shall be from the same manufacturer. Coating materials shall be mixed and applied in accordance with the manufacturer’s written instructions. Proportioning and mixing of part cans is not permitted. Strict attention shall be paid to the shelf life and onsite storage conditions, which shall meet the manufacturer’s recommendations.
The finish shall be generally smooth and free from protuberances.

The surface temperature of the steel to be painted shall be at least 3°C above dew point. Coating shall not be applied to any surface, which has a temperature less than 10°C or more then 55°C during the cure period.

**Application**

The coating shall be applied as soon as the surface preparation has been approved by the Principal’s Representative.

Ultra high build epoxies are generally designed to be applied directly to the prepared substrate without the use of primers. Under some circumstances, however, a primer is required and shall be specified and applied strictly in accordance with the Manufacturer’s written instructions.

Application of the ultra high build epoxy itself shall be by means of airless spray in a single coat with several wet-on-wet passes. High pressure airless spray equipment is suitable for proper application of this product unless specifically recommended otherwise by the coating manufacturer.

Minimum dry film thickness (dft) shall be 1200 microns, noting that average thickness can be expected to be higher than this and needs to be taken into account when considering assembly and fit-up of the structural steel components themselves.

Safety and application shall be strictly in accordance with the manufacturer’s written instructions.

**Dry Film Thickness**

The dry film thickness shall be measured in accordance with AS 3894.3 “Method 3: Determination of dry film thickness”. Calibration of instruments shall take account of surface profile height and shall be adjusted in accordance with this test method.

**7.2.8 Inspection**

**General**

The work shall be monitored and inspected by an Australasian Corrosion Association or NACE Accredited Coating Inspector who will be engaged by the Principal’s Representative.

Inspectors will not be available outside of normal accepted industry working hours, unless specifically agreed to by the inspector.

**Before Coating**
The Contractor shall not apply any coating until the surface preparation has been inspected and approved by the Principal’s Representative. The Coating Inspector may, at his/her discretion, perform any tests relating to surface preparation or contamination. If testing is required, the test areas shall be prepared again after the testing is complete.

**After Completion of Each Coating**

The coating will be inspected as soon as practicable after completion of each coating to ensure compliance with the standard.

Areas that have been inadequately or unsatisfactorily coated shall be treated in accordance with and as directed by, and to the satisfaction of, the Coating Inspector.

**Re-Inspection**

Should surface preparation or the applied coating prove to be unsatisfactory in the view of the Coating Inspector and require rework and subsequent inspection, the cost of such inspection will be charged to the Contractor and such costs will be deducted from any moneys due and payable.

**Reinstatement of Cured Coating**

Damaged and defective areas shall be abraded by dry abrasive blast cleaning, power disk sanding till bright steel is exposed or as approved by the Principal’s Representative. Edges of the coating shall be feathered back by the same means for approximately 20 millimetres. The coating shall then be reapplied in accordance with the relevant standards; however, no coating shall extend beyond the edge of the prepared area.

**7.2.9 Steelwork to be Concrete Encased**

Steelwork which is to be solidly encased in concrete shall not be primed, but shall be cleaned and kept free of oil, grease, dirt, loose mill scale, loose rust and other deleterious matter until so encased.

Only solvents permitted by the Principal’s Representative shall be used for the removal of oil, grease and the like.

Dirt, scale, rust and similar coatings shall be removed by grinding or vigorous wire brushing, chipping and scraping to a finish equivalent to Class Sa 1 described in AS 1627.

Steelwork which is to be built-in using brick, stone or timber shall be prime coat painted in accordance with Specification.
7.2.10 Steelwork to be Hot Dip Galvanised

The steelwork shall be cleaned by a suitable preliminary method prior to subsequent pickling to produce a clean metallic surface suitable for galvanising. Defects following pickling (including embrittlement) shall be rectified by the Contractor at his expense.

7.2.11 Steelwork to be Painted

The steelwork shall be cleaned by abrasive blast to a standard of finish equal to or better than Class Sa 2.5 described in AS 1627. Any substance used for grit blasting that contains free silica shall not be used as an abrasive in blast cleaning operations.

The initial paint coating shall be applied to the freshly cleaned surface before any tarnishing develops. If tarnishing appears on the surface, the steelwork shall be cleaned again.

For shop work not more than four hours and for field work not more than two hours shall elapse between the preparation of the surface and the application of the protective coating.

7.2.12 Hot Dip Galvanising

Bolts, nuts and washers shall be galvanised to the requirements of AS 1214.

Otherwise Steelwork shall only be galvanised if expressly stated in the Job Specification.

The hot dip galvanising shall be carried out in accordance with the requirements of AS/NZS 4680 with a coating Class of Z600.

Steel members which incorporate enclosed sections or hollow sections, shall have provision for adequate draining and venting during galvanising in accordance with AS 4680. These details shall be indicated on the Workshop Drawings for the Steelwork.

Members shall not be double end-dipped in the galvanising bath unless authorised by the Principal's Representative.

The zinc coating shall be free from lumps, blisters, gritty areas, uncoated spots, acid and black spots, dross flux and other imperfections.

Any member distorted during the galvanising process shall be straightened and made to conform to its original shape, size and condition, without cracking or otherwise damaging the member and/or its coating.

Any galvanising shown to be defective by inspection or by any of the tests carried out in accordance with the relevant Australian Standards shall not be incorporated in the Works.

Where material is damaged during galvanising the damaged section shall be replaced or made good by the Contractor at his own expense.
Galvanised coatings that are not in accordance with the contract shall be replaced by a satisfactory coating complying with this specification. All cost of such replacement shall be borne by the Contractor.
MECHANICAL SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
MECHANICAL SPECIFICATION

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1 General

1.1 Scope

This specification provides a description of the mechanical and associated equipment required.

1.2 Standard Specifications

The following specifications apply to the works described in this specification:

- Electrical Design and Installation Specification;
- Pump Station Functional Specification;
- Switchboard Specification; and
- Civil Works Specification.

The Contractor shall conform to the specification documentation in all respects. Any deviations shall be clearly stated for each piece of equipment or plant, together with justification for the variation. Equipment or plant that does not comply with the concepts described shall not be accepted.

1.3 Standards, Codes and Regulations

Unless specified or agreed otherwise, all work shall comply with the most recent revision and amendments of WSA 101, Industry Standard for Submersible Pumps for Sewage Pump Stations, unless otherwise stated in this document.

The Contractor shall be responsible for ensuring that all equipment and materials supplied are in complete accordance with the relevant Australian standards, and that all required approvals are obtained prior to procurement.

2 Submersible Pumps and Motors

2.1 General

The Contractor shall supply and install duplicate submersible pumps in the pump well at each site, complete with all cabling and ancillary equipment. Pumps making up the duplicate set shall be identical and shall be capable of being installed in either pump position.

2.2 Performance Requirements

Pumps shall be suitable for pumping domestic unscreened raw sewage which includes among others, frangible solids, hard solids (grit, sand and stones), fibrous solids (rags, ropes, plastic sheeting, disposal clothing and sanitary napkins) and mineral and other oils. The pump shall be capable of passing 80mm sphere as demonstrated by trial or track record from existing facilities of the same capacity.
2.3 Pump Selection

The Contractor shall be responsible for selecting a suitable pump through detail design which can achieve the required duty points for single pump operation at maximum system resistance and can successfully operate also at minimum system resistance. The Contractor shall also confirm that dual pump operation can successfully be achieved when operating against a minimum system resistance.

Pump selections shall be submitted to the Principal’s Representative for assessment prior to ordering. The pump selection shall be as per the information provided in the Principal’s Project Requirement.

3 Electromagnetic Flow Meter

3.1 Rising Mains

Electromagnetic flow meters shall be installed on each rising main downstream of the valve pad / chamber manifold and shall be capable of measuring flows in the following ranges:

- Wirraglen Sewage Pump station – 0 to 200 L/s, buried installation
- Lorrimer Street Sewage Pump Station – 0 to 50 L/s, buried installation

3.2 Emergency Overflows

Electromagnetic Flow meters shall be installed on the overflow pipework at the following pump stations with the indicative flow range that the flow meter will be required to measure included:

- Wirraglen Sewage Pump Station – 0 to 200 L/s, buried installation
- Lorrimer Street Sewage Pump Station – 0 to 50 L/s, buried installation

3.3 General

The flow meter display unit (remote head) shall be installed in the electrical switchboard. The flow meter shall be able to report an empty pipe.

All flow meters shall be an ABB WaterMaster or approved equivalent. The flow meter shall be installed in accordance with the manufacturer’s requirements. The sensor shall have an Environmental Protection Level of IP68. Flow meter cables shall be of a sufficient length to enable the required site cabling. Flow meter cables are to be a single length and shall not be joined under any circumstances.

Flanges shall be a minimum of Class 16 in accordance with AS 4087. The unit shall be suitable for a minimum test pressure of 1600 kPa and shall be supplied with 1 pair of 316
stainless steel grounding rings. For the flow meter, the internal diameter shall match the internal diameter of the adjacent fittings.

The flow meter shall be factory calibrated and copies of factory calibration certification including flow curve shall be provided to the Principal's Representative. Factor calibration shall comply with the following:

- Provide a six point calibration certificate; and
- The test equipment and procedures are to be traceable to NATA or NATA accredited standards. For flow meters calibrated overseas, the test certificate received from the overseas laboratories shall bear the logo and endorsement of one of the laboratory accreditation bodies listed in NATA's Mutual Recognition Agreement Partners.

Flow metres shall be constructed within a suitable size reinforced concrete access chamber with lid for maintenance access.

4 Other Equipment

4.1 Well Washer

Wet well washers shall be Mc Berne's potable water type or approved equivalent. All parts shall be stainless steel, PE or ABS. The arrangement shall be wall mounted, as per the manufacturer's recommendation.

4.2 Odour Filters

Odour filters shall be McBerns, or approved equivalent.

4.3 Wet well lids and hatches

Wet well lids shall be McBerns LFVP: Flush Mount Lid with 4 Sided Void Protection, or approved equivalent.

5 Operations and Maintenance Manuals

The Contractor shall supply three copies of an Operating and Maintenance Manual for the equipment described in this specification. The manual shall include but not be limited to the following:

- Complete operating and running maintenance instructions together with any precautions necessary or recommended to prevent plant deterioration during prolonged periods of nonoperation;
- Special instructions covering starting and shutdown under normal conditions, starting after extended periods of shutdown, and emergency operation and shutdown;
- Makers recommended lubricants and lubrication schedule for all items of plant;
- Complete instructions and settings for all control alarm, protection and tripping deficiencies;
- Complete details for servicing and adjusting all items of plant included, instruments, relays, operating elements and control equipment;
- Details of the as-installed alignment error including angular, eccentric and axial misalignment measurements;
- All test and commissioning certificates;
- Complete schedules of parts and information on the sources of supply of parts including copies of all contract sub-orders to suppliers (prices may be blanked out). Identifying codes or part number shall be quoted;
- Maintenance log forms for the 52 week period after the Delivery Date; and
- Drawings detailing all connections, moving parts and electrical connections.

The manuals shall be 4-ring binder type, A4 size and shall be clearly labelled and indexed. The manual shall be submitted in draft form three weeks prior to the delivery of the equipment and shall be revised as directed by the Principal's Representative. The three final copies shall be submitted prior to the date of Practical Completion.

All information outlined above shall be placed into the respective sections.

The text of the operating and maintenance instructions together with all drawings, illustrations and diagrams shall refer specifically to the plant being supplied under this Contract. General instructions referring to a range of equipment are not acceptable.

The manuals are documents essential for the use, operation and maintenance of the equipment and the date of acceptance shall not have been reached until manuals in accordance with the Contract have been supplied.

All information contained in the manuals shall also be submitted in electronic form on a CD-ROM. All electronic documents shall be supplied in PDF form, and shall be arranged in folders to mimic the layout of the hardcopy manuals.

All new mechanical and electrical equipment shall be included within the active assets data capture register. The Contractor shall complete and submit the completed register with the Operations and Maintenance Manuals.
PUMP STATION FUNCTIONAL SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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1 General
This document provides the functional description for the requirements and operation of the PLC, HMI, SCADA and Telemetry.

The basic requirements for process monitoring and control of the plant are specified in this functional specification.

The functional specification shall be used for development of the:

- PLC Software programming;
- HMI Configuration;
- SCADA Configuration;
- Telemetry Configuration;
- Dosing system control philosophy;
- Simulation and Factory Acceptance Testing (FAT) of the PLC and HMI software;
- Site Acceptance Testing (SAT);
- Plant Testing and Commissioning procedure; and
- Operator training.

The Pumping Station control system shall consist of the following main system components:

- Pump Station Telemetry equipment consisting of PLC Controller;
- Local HMI; and
- Digital Radio Equipment.

Each Pump Station consists of a Wet Well fitted with two off Submersible Pumps. A Control Building located adjacent to the wet well shall house the station MSB and Control System. Normal plant supply will be via the mains connection to the Network Service Provider (Ergon). In the event of mains failure, back-up power supply shall be able to be provided by a mobile generator.

As noted each pump station will consist of two off pumps operated through Variable Speed Drives.

1.1 Standards, Codes and Regulations
Unless specified or agreed otherwise, all work shall comply with the most recent revision and Council's amendments of WSA 04 – 2005, Sewerage Pumping Station Code of Australia, unless otherwise stated in this document. The Contractor shall be responsible for ensuring that all equipment and materials supplied are in complete accordance with the relevant Australian standards, and that all required approvals are obtained prior to procurement.

2 Control System
2.1 Control Strategy
The Pump Station control system shall be programmed to operate under the following Pump Control Strategy:
PUMP STATION FUNCTIONAL SPECIFICATION

- Telemetry with Local Auto and Manual Control

2.1.1 Control Selection
Each pump within the sewage pump station shall have modes of control via a three-position selector switch. The switch shall allow the Operator to select between Local Auto / Off / Local Manual.

2.1.2 Local Auto
This would be considered the normal mode of operation for the sewage pumping stations. When “Local Auto” is selected the operation of the pump station shall be controlled via the control logic programmed with the plant PLC Controller.

Operation of the pump station would be controlled by the wet well level. The starting / stopping of pumps would be dependent on the wet well level including the rate of rise / fall of this level and the set points programmed in the PLC Controller.

All motor starter functions and motor protection functions will be incorporated in the local hard-wired control circuit with interface to the Local PLC Controller and HMI.

Control of pump station operation, including process and fixed plant shall be locally or via the HMI only. There will be no remote control available from the SCADA for controlling the pump via the telemetry network. Only monitoring (local Alarms and indications) displayed locally and on the HMI shall also be relayed through to the remote SCADA via the telemetry. The assignment of motor duty and selection of various level set-points shall be programmed locally within the PLC Controller via the local HMI.

The status of all motor starter and protection functions will be incorporated in the local equipment display, HMI and PLC Controller. All equipment critical functions i.e. E/Stops (where noted), motor protection, etc, shall remain part of the individual equipment hard-wired control circuit.

The cyclic selection of pump Duty where applicable, shall be achieved via control by the program within the PLC Controller. There shall be a provision to allow the Operator to override this selection to a non-cyclic one through the HMI interface. The resetting of system faults shall be achieved through the HMI only, mounted on the control panel door.

The Chemical dosing pumps including the MHL shall be interfaced with the plant PLC as required. Monitoring and control of the chemical dosing pumps including the dosing control system shall be complete with a self-contained control panel which shall be synchronised with the plant controls through direct interface with the plant PLC. The I/O to interface the controls is as listed in section 3.4 below.

2.1.3 Local Manual
This mode of control will only be used during the undertaking of maintenance activities or a critical failure of the automatic control equipment.
Selection of LOCAL MANUAL will transfer control of all motors to the HMI screen mounted on the control panel door. Selection indication shall be transmitted to SCADA for remote monitoring via the telemetry.

Monitoring of pump station operation via the telemetry network shall remain active. Additionally local monitoring via indication lamps and/or HMI shall also be incorporated.

Under LOCAL MANUAL no automatic or remote operating functions would be active. This also includes any process interlocks that are managed through the PLC Controller. All motor starter functions and motor protection functions will be incorporated in the local hard-wired control circuit.

The resetting of system faults shall be achieved by the HMI screen mounted on the control panel door.

2.1.4 Isolated
This mode of selection shall only be used to isolate a drive on account of undertaking of maintenance activities or critical failure of the equipment. Local indication shall be provided to indicate the same. Selection indication shall be available for remote monitoring via the telemetry.

2.2 Pump Operation Method
The following configurations per Table-1 below are required for the Pump Stations in line with the respective electrical single line diagrams referred to accordingly.

Table 1: Configuration of Pump duty’s for the Sewerage Pumping Stations

<table>
<thead>
<tr>
<th>Normal Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pump 1</strong></td>
</tr>
<tr>
<td>Duty</td>
</tr>
</tbody>
</table>

During normal operation only one of the two pumps would be operating depending on the operating configuration above. The following details the pump operation method for LOCAL AUTO mode only.

2.2.1 Pump Duty Operation – Local Auto
Duty selection is cyclically achieved via the local PLC Controller or an override via the HMI (Operator Selectable). There shall be a provision to allow the Operator to generate an offset, through HMI, on pump duty/standby pumps by ‘x’ 0000 hours to avoid major maintenance points coinciding. i.e. override the cyclic selection of pump motors as Duty, to a non-cyclic one.

If Pump 1 is selected as Duty, then Pump 2 would automatically default to Standby as required and vice versa. For the purpose of this section it shall be assumed that Pump 1 has been selected as Duty.
The operation of the duty pump is controlled by the level of the wet well via the process level measuring instrument. When the level rises to the Duty Start Level set-point, Pump 1 will start and will run at rated speed. If at any stage of operation the wet well level falls and reaches the Duty Stop Level set-point, the duty pump will stop.

If at any point during operation the duty pump faults then the standby pump will be automatically enabled for operation.

Pump running hours shall be recorded for each individual pump as well all equipment having documented service life.

2.2.2 Pump Duty Operation – Local Manual
Duty selection shall be selected via the HMI screen.

2.2.3 Variable Speed Control – Local Manual
In Auto mode the pumps are to be operated in a predetermined fixed speed. However in Local Manual mode, facility for adjusting the pump speed via a keypad shall be provided.

3 Control Philosophy
The following sections detail the pump station control philosophy for the relevant areas. The Contractor shall prepare the overall detailed Pump Station Functional Description based on the following requirements.

3.1 Pumping System
The PLC Controller shall be programmed to provide the pump operating functionality as detailed in this document.

The PLC Controller shall only control the pumping operations when the pump station mode of control has been set to Local Auto. In this mode there should be no provision for Operator override or intervention except for the following:

- Selection of Duty Pump; and
- Resetting of faults where required manually.

In System Manual, the HMI shall be capable of executing a user input to force pump start and stop functions or remove a pump from service.

3.1.1 Duty Pump Selection
Duty Pump Selection shall be achieved via the PLC Controller or via the local HMI. The designation of subsequent pump function shall be determined as per the following table.

<table>
<thead>
<tr>
<th>Duty 1 Selection</th>
<th>System Standby</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump 1</td>
<td>Pump 2</td>
</tr>
<tr>
<td>Pump 2</td>
<td>Pump 1</td>
</tr>
</tbody>
</table>
At any stage of operation, should the Duty Pump be in an isolated condition or register a fault condition that prevents it from operating then the System Standby shall enter into service as the Duty Pump.

Once the registered fault associated with the Duty Pump has been cleared, the system shall return to normal operation once the Wet Well Level has reached the Duty Stop Level set-point.

3.1.2 Start / Stop Set-Points

Starting and stopping of the pumps shall be achieved via two different methods depending on mode selection. When Local Auto is selected, the pump station will be controlled via the Wet Well Level being measured by the Analogue Instrument.

The starting and stopping of the relevant Duty Pumps shall be based on the levels shown on the drawings.

When Local Auto is selected, the Start / Stop Set-Points shall be able to be changed via the local HMI.

In addition to the above, the following level set-points shall be monitored:

- Wet Well Level High-High – Measured by both the analogue instrument and a Multitrode Switch;
- Wet Well Level High – Equates to Duty Start Level set-point;
- Wet Well Level Low – Equates to Duty Stop Level set-point; and
- Well Level Low-Low – Equates to 150mm below Duty Stop Level set-point.

The percentages of the levels shall be related / converted to the corresponding RL levels within the Main wet well and storage tank for each pump station.

3.1.3 Level Control Change Philosophy

The level change philosophy is to prevent the development of a Fat Ring in the pump well.

This is a simple calculation that can be completed by the PLC. The PLC is programmed to enable the pump to start and stop between ranges of values. The outer limits of these values are backed up by secondary level sensing using a Multitrode in case of failure (Upper limit of start and Lower limit of the stop). The operational distance between the inner limits and the outer limits is a fixed value ‘x’ that can be selected depending on the minimum storage volume required by the design. A Random number is generated between (0 and 1) that multiplies with the value X and then added or subtracted to the upper limits. This program is a loop that continues to randomize the number at every start and stop and can be set up as a sub-routine that is called by the main program that outputs the stop/start level of the Pumps.

This can be expressed in the following diagram with the example formula.
Duty Start Level – $DL_{\text{Start}}$

Duty Stop Level – $DL_{\text{Stop}}$

Upper Start Limit – $USL$

Lower Stop Limit – $LSL$

$$DL_{\text{Start}} = USL - (\text{Rand#}) \times x$$

$$DL_{\text{Stop}} = (\text{Rand#}) \times x + LSL$$

The Contractor shall ensure that the $(\text{Rand#}) \times x$ can be rationalized by the PLC to the required resolution of the level sensing device. This can easily be achieved through the following changes to the above equations.

$$DL_{\text{Start}} \geq USL - (\text{Rand#}) \times x$$

$$DL_{\text{Stop}} \leq (\text{Rand#}) \times x + LSL$$

### 3.2 Control I/O

**NOTE: The Contractor shall refer to TRC for reference to I/O Assignment**

The PLC Controller shall monitor, control and alarm (where appropriate) the following I/O points associated with pump operation:

<table>
<thead>
<tr>
<th>Digital / Analog Input / Output</th>
<th>Pump 1</th>
<th>Pump 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Running (DI)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Starter Fault (DI)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Drive Available (DI)</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
### Local Auto Start (DO) ✔

### Local Reset (DO) ✔

### Motor Current (AI) ✔

### Motor Running Hours (AI) ✔

### No of Starts (DI) ✔

### Pump Seal Failure (DI) ✔

<table>
<thead>
<tr>
<th>Digital / Analog Input / Output Signal</th>
<th>Pump 1</th>
<th>Pump 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Circuit Failure (DI)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Wet Well Level (AI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Wet Well High (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Wet Well High-High (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Wet Well Low (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Wet Well Low-Low (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Storage Tank High-High (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Storage Tank High (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Flow meter on mains (AI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Flow meter in overflow (AI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Mains Supply C/B Open / Closed (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Generator Supply C/B Open / Closed (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Mains Supply Phase Failure Relay</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Manual Transfer Switch in Standby Position</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Generator Set OK</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>MHL Storage Tank Level (AI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>MHL Storage Tank High Level Alarm (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 1 Running (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 1 Fault (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 1 “No Flow” (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 2 Running (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 2 Fault (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 2 “No Flow” (DI)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 1 Start/Stop (DO)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 2 Start/Stop (DO)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 1 Speed (AO)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dosing Pump 2 Speed (AO)</td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: VSD status and control may be via Modbus or Ethernet to PLC.
If a Pump Drive returns a faulted condition, then this fault shall be latched within the PLC Controller code, and shall only be unlatched by acceptance of the fault (via a HMI Reset or Reset Pushbutton mounted on the control panel door). A one second Reset Command pulse shall then be sent to PLC Controller to attempt to reset the fault. If the fault condition remains active then the drive shall remain in fault.

The PLC Controller shall be programmed such that a time delay of 20 seconds is maintained between successive motor starts to avoid excessive surges in the power supply. The surge control shall also be programmed in to assist in hydraulic design of the system.

If a pump is given a Local Start Command, and the associated running signal is not received within a 5 second time period, then a “Failed To Start” alarm shall be raised. This shall remove the start signal from the relevant pump and set the pump to fault thereby switching the alternate Pump to Duty.

The above noted time delays shall be HMI adjustable set-points for all drives.

3.2.1 System Control I/O
The PLC Controller shall monitor, control and alarm (where appropriate) the following I/O points associated with pump operation:

- Pump Station LOCAL MANUAL Mode Selected;
- Pump Station LOCAL AUTO mode Selected;
- Wet Well Level – See above for relevant set-points; and
- Discharge Flow – No Flow/ Flow.

3.2.2 Miscellaneous I/O
The following miscellaneous I/O shall also be monitored and alarmed:

- Pump Station Security System – A digital input shall be provided from the Security System to advise “Intruder Alarm” into the Pump Station Building; and
- Odour Control – where provided, a digital input shall be provided from the Odour Control System to provide an “Odour Control System General Alarm”.

4 Control System Equipment

4.1 PLC Controller
The Contractor shall provide the PLC Controller fully programmed with the approved and tested program. The PLC Controllers shall be offered in a cold Standby configuration. The Contractor shall develop a detailed functional specification and submit it to the Principal’s Representative for approval prior to any programming works taking place. This functional specification shall detail the following:

- Programming function blocks or ladder (where applicable);
- Pump Station Control and Operating Modes as proposed to be programmed;
- Details of all Alarm Functions; and
- Details of all communications facilities to remote SCADA and local HMI.

The Principal’s Representative will provide the Contractor with a basic Functional Specification detailing the requirements for the interface between the Sewage Pumping Station PLC and remote SCADA via telemetry.

All programming software shall be in accordance with the AS IEC 611313. The Contractor shall confirm with the Principal’s Representative the current method / type programming of PLC Controllers.

If the Contractor proposes to undertake programming utilising a different software platform, then they shall supply the Principal’s Representative with a licensed copy of the programming software and all relevant communications cables to enable communications between the PLC and engineering laptop.

In addition to the above, the Contractor shall provide detailed training to TRC staff in the use and operation of the software supplied.

The programme shall be constructed in a logical manner to allow ease of understanding and maintenance. The programming code shall be comprehensively documented to permit complete understanding of program by using program print out only. All coils, rungs, contacts etc. shall be addressed by a logical functional name.

The programme shall facilitate all necessary operations to allow successful ongoing use of the PLC Controller and the HMI interface including but not limited to the following:

- Programming;
- Editing;
- Diagnostics;
- Monitoring PLC operations;
- Monitoring program operation;
- ‘Forcing’ inputs and outputs;
- Program documentation;
- Communications with the operator interface and remote SCADA; and
- Maintenance Logs and Alerts.
The interface between the PLC and Telemetry shall be via Modbus RTU using the Modbus TCP/IP connections with the PLC programming mirroring required I/O into %M registers of the PLC.

4.2 HMI
The Contractor shall provide the HMI fully programmed with the approved and tested program. The Principal's Representative will provide the Contractor with a basic Functional Specification detailing the requirements for HMI Screens and Displays. A typical screen shot shall be as attached below.

Example of Maintenance Screen for Pump Station:

Example Screen shot of operator control Panel HMI for Sewage pump Stations

The Contractor shall develop a detailed functional specification and submit it to the Principal’s Representative for approval prior to any programming works taking place. This functional specification shall detail the following:

- Plant MIMIC Screens covering pump station operation;
- Alarm Banner;
- Operator Control Screens for Set-Up of Plant parameters where required;
- Trending of pump station data;
- Programming code; and
- Operator control screens for Maintenance Logs and Alerts.

The Contractor shall allow for as many mimics as required to cover the entire pumping station/plant. These mimics shall be based on the pump station installation to include:

- Wet Well Layout and Pump Station piping configuration;
- Plant which is under PLC control or which is monitored by the PLC system;
- Analogue sensors/transmitters; and
- Other plant which is necessary to clearly show the plant configuration.

The information required to be displayed for each item of plant shall be described in the detailed functional description. The Contractor shall provide the specified controls necessary to facilitate control or monitoring of the plant.

The HMI shall provide trends for all analogue data with variable time bases. The data shall be displayed in standard SI units in accordance with ISO 1000.

Maintenance screen shall be complete with functionality to log oil changes/services etc. for the complete system.

5 Testing

5.1 Factory Acceptance Testing

The Pump Station Control System shall be subject to Factory Acceptance Testing (FAT) at the programmer’s facility prior to installation in switchboards and transport to site. All equipment and personnel necessary for carrying out the tests shall be provided by the Contractor. The Contractor shall present the PLC Controller and HMI with all programs downloaded and communications links installed and operational.

The Contractor shall issue the proposed inspection and test plans for approval and shall provide the Principal’s Representative with 1 week’s notice of intention to conduct the FAT once the ITP’s have been approved. The Principal’s Representative shall witness all tests.

All control actions shall be demonstrated by direct injection of field signals to the I/O. Simulation of I/O within the program code shall only be accepted where previously agreed in writing by the Principal’s Representative.

Should any items of hardware or software not test satisfactorily, the Contractor shall rectify the defects and shall nominate a date for final testing of the equipment. Rectifications shall not be undertaken during the testing period.

The Contractor shall provide a complete set of the FAT ITP’s, signed immediately after the tests have been completed to the Principal’s Representative within three days of successful completion of the FAT.
5.2 Site Acceptance Testing
Following successful completion of the FAT, the control system equipment may be installed on site. The Contractor shall complete all installation relating to the control system and provide 1 week’s notice to the Principal’s Representative of intention to conduct the Site Acceptance Testing (SAT). The SAT shall be undertaken prior to and separate from the site commissioning.

The Contractor shall provide Inspection and Test Plans for the SAT to the Principal’s Representative for approval prior to the SAT. The Principal’s Representative shall witness all tests.

The SAT shall completely demonstrate the full functionality of all I/O and control actions. The code shall be completely verified using direct injection of field I/O at the most distant terminals. The Contractor shall provide all personnel and equipment necessary to conduct the SAT.

Should any items of equipment or sections of code not successfully pass the SAT, the Contractor shall rectify the defects and nominate a date for completion of the SAT. Rectification works shall not be undertaken during the SAT period.

Fully completed and signed documentation shall be provided to the Principal’s Representative to demonstrate successful completion of the SAT within three working days of completion. This documentation shall be considered a prerequisite for scheduling of site commissioning.

5.3 Commissioning
Commissioning of the control system shall only take place after acceptance of the final SAT documentation. The Contractor shall prepare and submit to the Principal’s Representative a commissioning plan detailing all sequential commissioning works and tests to be performed as part of commissioning works two weeks prior to the nominated date for commissioning. This plan shall be provided as part of the as-constructed documentation as the Commissioning verification sheet, dated and signed by the Contractor against each test.

Commissioning shall only commence once the commissioning plan has been approved in writing by the Principal’s Representative.

The Contractor shall demonstrate the functionality of all installed equipment including interfacing with existing equipment. The Contractor shall liaise with the Principal’s Representative to demonstrate remote SCADA operation.

All tests shall be conducted without simulation of process set points or data. Rectification of all faults shall be undertaken by the Contractor. The Contractor shall maintain a database of set points developed during testing and commissioning and include the same in the as-constructed documentation.
The Contractor shall conduct all third party liaisons and provide all equipment, temporary power supplies, personnel, protective equipment, testing fluids, calibration devices and all other equipment necessary to complete the commissioning of the plant.

6 Documentation

All software supplied shall be completely and thoroughly documented. Such documentation shall include but is not limited to the following:

- A comprehensive description of the use of the System Editor;
- Overall block diagrams;
- Flow charts or other logical representations of programme logic;
- Block diagram representations of programme logic;
- Detailed formats of data representations; and
- Well documented “as commissioned” listings of the system programmes (including sufficient explanatory comments to allow rapid understanding of the code).

Two copies of this manual (or as required) shall be supplied.

In addition, the Contractor shall provide two (2) CD’s with the ‘As Commissioned’ software programs.
Electrical Switchboard Design and Installation Specification

Wirraglen and Lorrimer Street Sewerage Project
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1. Scope of Document

This document sets out the requirements to be allowed for the provision of an Electrical control cabinet for a sewerage pump station in the Toowoomba Region.

1.1. General Specification

1.1.1. All electrical and electronic equipment that has microchip technology shall have an accompanying certificate stating that it complies with Australian Standard AS/NZS 3100:2002.

1.1.2. All electrical equipment will be installed in accordance with AS3000:2007 and AS3008:2009

1.1.3. The contractor is to maintain a Quality Management System to certification AS/NZS ISO 9001:2008. Full documentation is to be supplied upon completion of works and is to include flow charts, hazard review, risk analysis, procedures for operations, monitoring and corrective actions.

1.1.4. All works are to be designed in accordance with the Queensland Professional Engineers Act 2002 ensuring that all designs are appropriately signed by a Registered Professional Engineer of Queensland.

1.1.5. Any variation to this specification, references to TRC approved, or approved equivalent clauses will be documented and communicated to Toowoomba Regional Council for approval by the General Manager of Water and Waste Services.

1.2. Additional Documentation

The following TRC Documents associated with this Specification are listed for reference purposes.

1.2.1. Type 1 Cabinet Drawings – for Soft Starters or VSD up to 7.5 kW

DOCS-#6266902 – CSBD
DOCS-#6266904 – Doors Closed
DOCS-#6266905 – Doors Open
DOCS-#6266906 – Notes
DOCS-#6266907 – Plinth
DOCS-#6266908 – Side
DOCS-#6266909 – SLD

1.2.2. Type 2 Cabinet Drawings – for VSD above 7.5kW to 37kW

DOCS-#6266912 – CSBD
DOCS-#6266913 – Doors Closed
DOCS-#6266914 – Doors Open
DOCS-#6266915 – Notes
DOCS-#6266917 – Plinth
DOCS-#6266918 – Side
DOCS-#6266919 – SLD

1.2.3. Type 3 Cabinets – for VSD above 37kW
For Cabinets above 37 kW additional space will be required in the Drive section of the board to facilitate additional cooling of the drive. Layout designs shall be based on the 37 kW board and submitted to TRC for approval.

2. Electrical Specification

2.1. Construction

2.1.1. The Switchboard / control cabinet shall be a totally enclosed self-supporting metal structure. It shall be built of 3mm aluminium alloy S251-H34 to AS1734 with folded welded joints, stiffened where necessary to form a weatherproof enclosure with a rating of IP 65 for both indoor and outdoor installations.

2.1.2. For all installations, the switchboard must meet a minimum form of separation which is described in the annexure.

2.1.3. Removable lifting lugs are required to be able to support the total final mass of the switchboard for installation and removal. If the lugs are removed after installation, then a means must be provided to seal any cabinet openings from water and dust ingress.

2.1.4. Physical dimensions of cabinet will be according to the documents referenced in Sections 1.2.

2.1.5. The cabinet shall be powder coated inside and outside.

2.1.6. Metal preparation for powder coating of aluminium alloy, corrosion class 2.

2.1.7. Powder coat finish:

- Escutcheons and equipment panels inside cabinet – White Dulux code 19143.
- Outside of cabinet – as detailed in annexure

2.1.8. All hinges to be EMKA HIB-650/SS316 stainless steel.

2.1.9. All locks for hinged internal panels shall be EMKA 304 stainless steel ¼ turn 8mm square key with slot. Part number 1000-U134/U352/CAM or TRC approved equivalent.

2.1.10. All doors seals to be Selectlok P/No. 1011-106 or TRC approved equivalent.

2.1.11. All doors shall have a 3-point locking system and inbuilt stiffening clear of all apparatus.

2.1.12. All doors and escutcheons shall have a minimum of 2 lift off pin hinges except those with the hinged dimension over 1,000mm shall have 3 lift off hinges.

2.1.13. All doors to be fitted with EMKA 1087-U2-SS316 stainless steel door stays. The pivot point of the door stay shall be attached to the inside bottom edge of the opening and the slide fixed to the door.

2.1.14. All doors and escutcheons shall be earthed, and shall have an earth stud for the purpose of bonding them to the cabinet earth. Flexible earth straps shall be used for these and be sized for the prospective earth fault current in accordance with the relevant Australian Standard.

2.1.15. “U” shaped gutters are to be provided around all door openings to prevent water ingress.

2.1.16. When unlocking the external doors, the handles shall swing upward so that the handle is pointing toward the hinged side of the door. Door handles shall be Selectlok swing handle part number 1107-SCCU3N (or approved equivalent). Council will supply the lock barrels.
2.1.17. Aluminium gland plates shall be provided in the bottom of cabinets (where cables enter section 4). The opening shall be reinforced with 25mm x 6mm aluminium alloy strips drilled and tapped with 6mm holes for securing of the gland plates. The reinforcing strips shall be fixed to the underside of the opening.

2.1.18. All cables connecting to and from the switchboard are to pass through cable glands. The glands to be used should be appropriate for the cable and seal to prevent ingress of moisture and insects.

2.1.19. All electrical components will be rated to withstand cabinet internal temperatures of at least 55°C.

2.1.20. The switchboard / control cabinet shall be designed in such a manner that when the unit is functioning normally the internal temperature shall not be greater than 10°K higher than the external ambient temperature.

2.1.21. If the anticipated internal temperature exceeds 50°C then temperature control measures shall be required. Control measures may be one of the following types:

- Forced Ventilation: Vents shall be fitted with dust collectors to prevent the ingress of dust, which shall be easily removed for cleaning and maintenance. The filters are not to be mounted with tape or any other perishable adhesive.

- Vortex Cooling: Where a clean pneumatic supply is available vortex cooling is the preferred method of cooling.

- Heat Pump/Compressor: Is to be of the dehumidifying type and include condensate management.

- Thermoelectric: Must include condensate management.

2.1.22. Failure of the temperature management shall result in alarm generation (if applicable).

2.1.23. All equipment is to be mounted on an aluminium backing plate of 3mm thickness (painted white Dulux code 19143).

2.1.24. All electrical / electronic components shall be marked in accordance with the schematics using inscribed Rowmark labelling:

- Main switch shall be red textured background with white letters min 10mm high.

- Thermistor warning shall be a white background with red letters.

- All other components shall be white textured background with black letters.

2.1.25. Internal labels may be glued to panels. Labels external to the cabinet shall be fixed with stainless steel fasteners.

2.1.26. All terminal blocks, cables and conductors (cores) are to be labelled and appropriately identified on the schematics provided.

2.1.27. All control wiring shall be stranded with a cross section of not less than 1.0 mm². Where the cable is subjected to flexing, eg. across hinged door, the cable shall not be less than 32/0.20. Cables to be fitted with insulated ferrules or crimp lugs and labelled both ends.
The type and style of marking system is to be nominated by the contractor and be approved by the General Manager of Water and Waste Services.

2.1.28. All power cables to be stranded and a minimum size of 2.5 mm².

2.1.29. Wire colours shall be in accordance with the following table:

**Low Voltage (400V)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Red</td>
</tr>
<tr>
<td>Phase B</td>
<td>White</td>
</tr>
<tr>
<td>Phase C</td>
<td>Blue</td>
</tr>
<tr>
<td>Neutrals</td>
<td>Black</td>
</tr>
<tr>
<td>240V control</td>
<td>Orange</td>
</tr>
<tr>
<td>Earth</td>
<td>Green/Yellow</td>
</tr>
</tbody>
</table>

**Protected Extra Low Voltage**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12V Battery</td>
<td>Red</td>
</tr>
<tr>
<td>0V Battery</td>
<td>Black (only if different voltage from 24VDC ctrl-)</td>
</tr>
<tr>
<td>24VDC+ control</td>
<td>Brown</td>
</tr>
<tr>
<td>24VDC- control, or 0V</td>
<td>Purple</td>
</tr>
<tr>
<td>Thermistor circuit</td>
<td>White twisted pair</td>
</tr>
<tr>
<td>Telemetry I/O</td>
<td>Grey (or decron shielded twisted pair)**</td>
</tr>
</tbody>
</table>

** Grey to be used for I/O connections between PLC & RTU/Radio or directly to RTU/Radio**

2.1.30. A legend stating cable colour coding is to be fastened to inside of the PLC / control cabinet door.

2.1.31. Cables associated with analogue signals shall be of the 100% shield type appropriately grounded at the controller end of the loop only. The shield will be loomed from the cable and terminated to signal ground in the same section as the controller, Section 5. The shield on the field end of the cable shall be terminated with heat shrink.

2.1.32. Where inputs are wired directly to the telemetry unit the wiring from the terminal strip to the telemetry unit shall be V90-HT 250V 16/0.20.

2.1.33. All IO to the PLC and Telemetry units shall be marshalled through terminals. The terminals used in this arrangement are to facilitate manual isolation of the field instrument from the PLC/Telemetry equipment.

2.1.34. Cables to be ducted in all sections and comply with all Australian Standards;

2.1.35. All electrical / electronic components to be rail mounted unless otherwise approved;

2.1.36. Suitable means of mounting an antenna will be provided by the contractor. Antenna type may vary from monopole, dipole or Yagi and individual site requirements are to be discussed with TRC.
2.1.37. A shelf is required for placement of a laptop computer near the PLC. The shelf may be capable of folding away for storage.

### 2.2. Cabinet Layout

The site specific layout is specified in Annexure B.

#### 2.2.1. Small Cubicle Layout - For DOL Starters less than 7.5kW

Small cabinets are to be set out in six (6) sections that are individually lockable.

**Section 1 – Metering**
- Supply authority meter.
- Isolation link Fuses

**Section 2 – Distribution**
- Main switch
- Pump circuit breakers
- Circuit breaker chassis
- Neutral link.
- Earth bar.
- Main Supply Varistors (Surge Protection)
- 3-phase outlet RCD
- Single phase outlet RCD
- 3-phase Multi-Function Power Meter with Modbus TCP/IP communications protocol

**Section 3 – Motor Control**
- Safety relay
- Motor Soft Starters or Variable Speed Drives (VSD)
- Failure relay for pumps.
- Level Control Relays

**Section 4 – Vapour Seal Chamber / Cable Zone.**
- Cable termination zone
- All cable entries through this zone to form Vapour seal between this zone and the rest of the cabinet
- Vents are required on front of this section.

**Section 5 – PLC, instrumentation mounting**
- PLC equipment.
- 24V DC supply and batteries for PLC.
- Terminal strip and relays for connection of ELV equipment to PLC.
- Flow meter transmitters. Flow meter transmitters may be removed from the control cabinet and mounted adjacently if the transmitters are secured in a lockable room or enclosure. Transmitters are to be powered by 24V DC (battery backup) to allow for flow to be read in case of 240V power failure.
- RCD Protected General Purpose Outlet (10A).
- Any LV equipment in this section shall be double insulated and any exposed 240 V connection shall be appropriately covered to a minimum of IP20.

Section 6 – Telemetry
- Telemetry
- RCD Protected General Purpose Outlet (10A)
- +12V Battery for Telemetry equipment (3 hour min backup).
- Any LV equipment in this section shall be double insulated and any exposed 240 V connection shall be appropriately covered to a minimum of IP20

Section 6a – Escutcheon
- Local HMI Screen
- Motor Control Switches
- Emergency Stop
- RJ45 Programming port for TCP/IP devices

2.2.2. Medium Cubicle layout – Pumps ≤37kW (Direct Wired Metering)

The cabinet is set out in six (6) sections individually lockable. Each section is described below:

Section 1 - Metering
- Supply authority meter
- Isolation link Fuses

Section 2 - Power Distribution
- Main switch
- Pump circuit breakers
- Circuit breaker chassis
- Neutral link.
- Earth bar
- Main Supply Varistors (Surge Protection)
- 3-phase outlet RCD
- Single phase outlet RCD
- 3-phase Multi-Function Power Meter with Modbus TCP/IP communications protocol
Section 3 - Electrical Equipment Pump 1 and 2

- Safety relays.
- Motor Variable Speed Drives (VSD)
- Harmonics and EMC Filters
- Phase failure relay for pumps
- Level Control Relays etc

Section 3a - Electrical Equipment Pump 1 and 2 Escutcheon

- Isolator
- VSD HMI

Section 4 – Vapour Seal Chamber / Cable Zone

- Cable termination zone
- All cable entries through this zone to form Vapour seal between this zone and the rest of the cabinet
- Vents are required on front of this section.

Section 5 – PLC, instrumentation mounting

- PLC equipment.
- 24V DC supply and batteries for PLC.
- Terminal strip and relays for connection of ELV equipment to PLC.
- Flow meter transmitters. Flow meter transmitters may be removed from the control cabinet and mounted adjacently if the transmitters are secured in a lockable room or enclosure. Transmitters are to be powered by 24V DC (battery backup) to allow for flow to be read in case of 240V power failure.
- RCD Protected General Purpose Outlet (10A).
- Any LV equipment in this section shall be double insulated and any exposed 240 V connection shall be appropriately covered to a minimum of IP20.

Section 6 – Telemetry

- Telemetry
- RCD Protected General Purpose Outlet (10A)
- +12V Battery for Telemetry equipment (3 hour min backup).
- Any LV equipment in this section shall be double insulated and any exposed 240 V connection shall be appropriately covered to a minimum of IP20.

Section 6a – Telemetry Escutcheon

- LOCAL Station HMI screen
- Motor Control Switches
- RJ45 Programming port for TCP/IP devices
2.2.3. Large Cubicle Layout (Pumps >37kW)

- Any large cubicle layouts will need to be specifically designed for the application and approved by Toowoomba Regional Council. These cubicles typically include externally mounted equipment and are generally located within a specific structure or building.
- If the cubicle is to be free-standing outdoors, then the design and layout is to be expanded from the Medium Cubicle layout design as required.

2.3. Design Parameters

2.3.1. All electrical / electronic components to be DIN rail mounted or approved equivalent.

2.3.2. Any I/O extending outside the control cabinet will be protected by signal surge arrestors.

2.3.3. The area to be used for the Supply authority energy meter and the CT meter test block will be no smaller than the dimension allowed by the local supply authority. The main switch will be mounted in section 2, no lower than 450 mm above the lower gland plate. This is to allow for ease of connection of the mains cables from the meter in section 1.

2.3.4. Fault current limiters will be required to protect the circuit breaker chassis.

2.3.5. Section 4 will be sealed from all other sections to prevent the ingress of gases from the wet well.

2.3.6. The Telemetry section will be no smaller than 600mm x 600mm. Terminals shall be provided for the connection of all power and signal cables.

2.3.7. Equipment requiring wiring of cables size 6mm² and larger will be mounted no lower than 450mm from the gland plate in section 3 (eg VSD modules). This is to allow for ease of connection of the pump motor cables.

2.3.8. Any LV (240V/415V) in section 6 shall be double insulated and exposed connections appropriately covered to a minimum of IP20 to allow general access.

2.3.9. Sections 2 through to 6 shall have cabinet lighting installed.

2.3.10. The design and layout of the switchboard shall be presented to Toowoomba Regional Council for the approval.

2.3.11. Example cabinet drawings have been provided for your reference – see section 1.2.

2.4. Supply Authority Metering

2.4.1. A polyphase energy meter shall be installed to facilitate supply authority metering. This meter shall be located in section 1 of the cabinet layout.

2.4.2. The wiring of the meter shall be in accordance with the local energy supply authority.

2.4.3. Where there are multiple metering accounts and therefore multiple meters at a site each additional meter is to be installed in a separate enclosure in accordance with the local energy supply authority.
2.4.4. Connection and Disconnection of power shall be the responsibility of the successful contractor. Schedules for power outage shall be written and sent with at least one weeks’ notice to the principal.

2.5. **Main Switch and Circuit Breakers**

2.5.1. The main switch shall be located within section 2 of the switchboard.

2.5.2. Spare space for circuit breakers shall be in excess of three adjacent poles.

2.5.3. Circuit breakers shall be numbered to detail the function of that circuit breaker. A legend of circuit breaker functions shall be provided on the inside of the door to section 2.

2.5.4. Circuit breakers shall be further numbered within the switchboard to correspond to the numbers on the escutcheon.

2.5.5. A circuit schedule shall be provided and fitted to the door of section 2 and will allow for details including:

- Size of main switch
- Size of mains
- Origin and path of mains
- Location of earth stake

2.5.6. Protection of the 24VDC and 12VDC circuits and equipment shall be of the manually resettable type.

2.6. **Variable Speed Drives**

Variable speed drives and appropriate process control shall be implemented on motors rated at 7.5kW or greater

2.6.1. **General Electrical Requirements for Variable Speed Drives**

2.6.1.1. If the drive develops a fault it shall initiate an alarm to the PLC and the telemetry system.

2.6.1.2. The drive shall provide signals to the PLC for the monitoring of motor running data and is to be displayed on the LOCAL HMI display.

2.6.1.3. Critical control components of the drive, such as Start/Stop/Reset/Fault, shall be hardwired for both Manual and PLC control. Drive output current shall also be hardwired. All other diagnostics and I/O shall connect to the PLC via Modbus TCP/IP.

2.6.1.4. The variable speed drive faults shall be reset through the LOCAL HMI screen.

2.6.1.5. The VSD shall include a motor contactor on the line side of the VSD. This contactor will be used in conjunction with the e-stop safety relay circuit.

2.6.1.6. The HMI for the Variable speed drive shall be located on the escutcheon of the VSD section (outdoor boards) or on the door of the VSD section (indoor boards).
2.6.1.7. The VSD shall be suited for each load type application specified. Preference shall be given to drives that for the load types specified can operate without the need for tacho-generator speed feedback. Generally the drive will be specifically designed for constant torque operation; but shall also incorporate a choice of output waveforms designed to control quadratic loads to give the drive flexibility over a wide application area. The Contractor shall state the kVA output power of the drive in both constant and quadratic torque loads.

2.6.1.8. Unless specified otherwise, in constant torque mode of operation the variable speed drive shall be capable of supplying necessary current to provide as a minimum 150% FLT for 60 seconds at start up. In this mode the frequency range for continuous, stable and constant torque output at the motor shaft of the variable speed drive shall be from 5 to 60 Hz or better.

2.6.1.9. In constant torque mode the drive shall provide constant power output from 50 to 100 Hz.

2.6.1.10. The frequency converter shall employ a DC link. Preference shall be given to systems which employ a pulse width modulated voltage source inverter (PWM).

2.6.1.11. Preference shall be given to systems where the output waveform is sinusoidal at all frequencies, and no motor de-rating is necessary. Suppliers that can show a test of motor temperature rise on drive operation, where the motor is operated at full load and speed, shall be seen to be suitable proof. If de-rating is applicable the tenderer shall supply curves showing the necessary de-rating the motor should be given at rated speed and load, using class B temperature rise, to ensure that no overheating occurs.

2.6.1.12. The semi-conductor heat sinks shall be adequately dimensioned to permit reliable operation in the specified ambient conditions. Heat sink fin over temperature protection shall be provided and shall trip the drive in the event of ventilation failure.

2.6.1.13. In order to eliminate any system resonance occurring within the operating range of the motor, the drive shall be provided with several bypass frequency adjustments.

2.6.1.14. The VSD shall be suitable for connection to the chosen Pump.

2.6.1.15. The VSD shall be capable of operating the specified motor connected using PVC/SWA/PVC cables. Where the drive requires special cables to meet capacity, harmonic or EMI specifications, the special cable requirements shall be specified at the time of tendering.

2.6.1.16. Where harmonic distortion results in a THD(v) greater than 2.5%, harmonic suppression shall be installed to reduce the THD(v) to < 2.5%.

2.6.2. Additional Electrical Requirements for externally mounted Variable Speed Drives

2.6.2.1. The VSD shall be mounted within a self-contained Starter Panel as a free standing cubicle in accordance with the manufacturer’s instructions. Ample free space shall be provided around the starter for cooling purposes. If necessary additional cooling shall be provided by a quiet running fan mounted to force air over the unit’s heat sinks. This shall be subject to review and acceptance. For design purposes, the maximum outdoor ambient temperature is 40°C. Where
approved, fan ventilated enclosures shall operate under positive pressure. High quality replaceable filters shall be provided to dust proof the air intakes.

2.6.2.2. A single VSD housed in a panel shall include a full current isolator interlocked with the cubicle door(s).

2.6.2.3. When more than one VSD is located in a single cubicle, the isolation points will be located in the main switch board, remote from the VSD panel. Power circuits for each VSD shall be individually shrouded in a way that the removal of the shrouding on one VSD will maintain the integrity of the shrouding on the power circuit of other VSD. The control circuit and termination for each variable speed system shall be easily identified within the panel and separated from each other.

2.6.2.4. The VSD shall be provided with all necessary control circuitry for interfacing with remote control equipment.

2.6.2.5. The VSD shall employ fully digital control, such that all settings are performed through a display panel local to the VSD that is mounted and operated without the need to isolate supply to the drive.

2.6.2.6. The VSD shall be equipped with a communication port to allow interrogation of the VSD from the PLC. This is to be an Ethernet port using Modbus TCP/IP protocol.

2.6.3. Control System and Indication

2.6.3.1. In panel housing one single VSD, the control voltage shall be derived within the VSD panel from the main incoming power supply.

2.6.3.2. The following indication and control shall be provided on the VSD panel unless specified otherwise in the Data Sheet or on the Drawings.

- VSD System Running indication light.
- VSD System fault indicator light for protection trips.

2.6.3.3. The VSD shall accept a 4-20 mA at 24 VDC input signal from the PLC with minimum and maximum speeds corresponding to 4 and 20 mA respectively. The speed settings shall be continuously adjustable over this range.

2.6.3.4. All analogue and digital control inputs and outputs shall be galvanically isolated from the mains supply and shall be capable of withstanding a test voltage of 2.5kV DC for 1 sec.

2.6.3.5. The VSD shall provide interfacing facilities for voltage free contacts to or from external control circuits for the following functions:

- Start / Stop control
- Combined fault indication
- Run indication

2.6.3.6. If the VSD is to be connected with a passive filter, an output will be required to control the passive filter ON/OFF state. (Eg. The filter will be switched off when the drive is not running).
2.6.3.7. Each VSD will be capable of communicating the following information to the PLC via TCP/IP:
- Run Hours (Daily, Weekly, Monthly, Total)
- Number of Starts (Daily, Weekly, Monthly, Total)
- Drive Output Frequency
- Motor Current
- Motor Voltage

The above information is to be then presented on the relative ‘Pump’ page/s of the station HMI.

2.6.4. Protection and Diagnostic Facilities

2.6.4.1. The VSD System and sub-components shall be completely protected from and apart from the rupturing of the necessary protective fuses and/or shutting down safely and/or disconnect the motor from service, suffer no damage from the following adverse conditions or faults originating from either the supply source, connected load or within the VSD system itself in either variable speed or fixed speed mode:
- Voltage transients
- Over- and under-voltage
- Short circuits
- Earth faults
- Overload
- VSD output open circuits
- Thermistor over temperature (positive temperature coefficient type)
- Single phase
- Motor stall

2.6.4.2. Test points required during maintenance procedures on the VSD shall be clearly marked. Dangerous voltages on the VSD capacitors shall be clearly indicated. A LED indicator is not sufficient for this purpose.

2.6.4.3. The VSD shall include an electronic motor overload which shall be capable of adjusting the thermal model according to the motor speed.

2.6.4.4. Facility for the connection of motor thermistor protection shall be inbuilt in the VSD for motors less than 450 kW.

2.6.5. Harmonics and Power Factor

2.6.5.1. The VSD shall be designed and adjusted to generate the minimum level of current harmonics consistent with the converter size, and pulse number. The Total Harmonic Distortion Voltage (THDv) of <2.5% at all times shall be met to meet future power authority requirements. AS/NZS 61000.3 shall be used as a guide to indicate the expected level of harmonics.
2.6.5.2. For locations where existing network THDv is Greater than 2.5% the harmonic filtering is to be sized such that no additional distortion is added to the network.

2.6.6. Acceptable filter topologies

In order to control high harmonic levels, the following topologies are deemed acceptable:

2.6.6.1. Passive Harmonic Filtering (PHF)

Should PHF devices be used the units must be sized sufficiently to ensure that the full reactive current (Ib) of each load that the filter is connected to is covered. Passive Filters are to be connected to individual loads only and are not to common-coupled to multiple loads.

2.6.6.2. Active Harmonic Filtering

Should an AHF device be specified it is to be sized to ensure the full reactive current (Ib) of the largest load (pump operational dependent) is covered with additional capacity to cater for other site based equipment to ensure the THDv is below the required level.

2.6.6.3. Hybrid Harmonic Filtering

This option allows for the use of both passive and active filters. Passive filters may be attached to discrete loads with a smaller active filter used to cater for the all other drives and equipment that produce distortion at the site to ensure the station complies with the minimum standards.

A report is to be prepared detailing the proposed topology selection and evidence provided to demonstrate that THDv will be below the required level. Report is to include details of calculated vs measured values in respect to TDHv.

2.6.7. Filter performance is required to be demonstrated over a continuous 7 day period of operation and include the following:

   a) The magnitude of input current harmonics shall be provided.
   b) Any limitations on performance or output rating of the motor load due to harmonics shall be provided.
   c) The power factor (kVar in PU) for a pump load application over the entire speed range shall be provided.

2.6.8. Electro Magnetic Interference (EMI)

Electromagnetic interference generated by electronic switching devices shall be within the limits stipulated by AS/NZS 61000 - Electromagnetic Compatibility (EMC) series of standards. The Original Equipment Manufacturer (OEM) of electronic switching devices shall provide full installation instructions for the equipment to minimise Electromagnetic Interference. There is to be no interference to the public or to Councils facilities as a result of the
operation of the electronic switching devices. The generated electromagnetic Interference shall be limited through appropriate selection of EMC filters to provide appropriate dampening of the interference. The appropriate filters shall be supplied and installed by the Contractor.

2.7. **Programmable Logic Controller**

2.7.1. The operation of both pump motors shall be facilitated by a Programmable Logic Controller (PLC).

2.7.2. The PLC shall be capable of communicating using MODBUS RTU over RS485 for integration with the Telemetry equipment (9600, 8, 1, none)*. Connection of the PLC to the Telemetry equipment will be the responsibility of the successful Contractor.  

*RTU will be set up as the Modbus Master, PLC will be required to act as a Slave on address 1. NOTE – this is ONLY applicable to Elpro telemetry equipment.

2.7.3. The control system shall be capable of communicating over MODBUS TCP/IP Protocols for integration with the LOCAL HMI, motor drives and any other IP capable components.

2.7.4. The operating voltage of the control system shall be 24VDC. It shall be powered by a set of 12VDC gel cell batteries which shall be capable of supplying critical components in the control system for a period of not less than three (3) hours after a mains power fail. Critical functionality includes:

- PLC, LOCAL HMI and telemetry
- Measurement of floats and other level indication instruments relating to the main tank and overflow tank.
- The overflow tank flowmeter, if fitted.

2.7.5. If the battery charger used with the batteries fails, it shall initiate an alarm “BATTERY CHARGER FAILED” to the control system and the telemetry system.

2.7.6. If the PLC fails it shall initiate an alarm “PLC FAILED” to the telemetry system. The PLC failed alarm shall be operated via the integrated PLC run indicator relay. This fault shall be directly wired to the telemetry system by means of a failsafe connection.

2.7.7. In the event of a malfunction and/or fault condition of any equipment associated with this the control system it will initiate appropriate alarm annunciations.

2.7.8. During any out of limit conditions, change of equipment state or alarm conditions the PLC shall automatically take steps to control the site to prevent malfunctioning and/or damage to people and equipment;

2.7.9. Interlocking, alarming and control logic for each pump motor operation shall be programmed into the PLC. The contractor shall ensure that the PLC software is suitable for the application and to the approval of the General Manager of Water and Waste Services.

2.7.10. Analogue input/output resolution for the PLC IO modules shall be 10-bit or greater.

2.7.11. All functional programming by the contractor shall be in function block language.

2.7.12. All blocks and rungs of the PLC program will have comments as to the function of the block or rung.
2.7.13. The telemetry input/output Modbus registers shall be as detailed in Appendix – C. All Modbus Alarms from the PLC to telemetry shall be in the “True”/“On” state.

2.7.14. The PLC shall be capable of detecting any out of range inputs on the 4-20 mA channels. This will result in the generation of a fault that will be sent to the HMI and SCADA system.

2.7.15. All values/set-points shall be retained by the PLC after a reboot or shutdown.

2.7.16. A complete copy of the PLC program (including program files/drivers/settings) shall be kept on an SD/Compact Flash card to allow transition of site functionality to a spare unit.

2.7.17. Steps shall be taken to ensure the memory of the PLC system is not compromised over time. This should include limitations on the sizespace of log or trend files.

2.7.18. The PLC shall monitor the internal temperature of the control cabinet and generate appropriate faults when the internal temperature exceeds 40°C.

2.8. LOCAL HMI (Where applicable)

2.8.1. The functionality of the LOCAL HMI screen is to facilitate operators controlling the site.

2.8.2. The LOCAL HMI shall be directly compatible with the PLC used and capable of withstanding the internal temperatures of the cabinet.

2.8.3. Maintenance personnel shall be able to re-range and configure instruments through the LOCAL HMI.

2.8.4. Maintenance personnel shall be able to place any analogue instrument into a 'Maintenance Mode' to simulate analogue values.

2.8.5. The screen shall be of a minimum size of length as detailed in the Appendix B.

2.8.6. The LOCAL HMI shall contain a Backup copy of the program used (SD card).

2.8.7. LOCAL HMI icons indicate the state as follows:

<table>
<thead>
<tr>
<th>Icon</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Running</td>
</tr>
<tr>
<td>Amber/Orange</td>
<td>Fault</td>
</tr>
<tr>
<td>Red</td>
<td>Stopped</td>
</tr>
<tr>
<td>Flashing</td>
<td>Unacknowledged pump alarm</td>
</tr>
</tbody>
</table>

2.8.8. Mimic designs shall be submitted to Toowoomba Regional Council for review prior to the scheduled Factory Acceptance Testing. Over-crowding of images and values on the HMI screen should be avoided.

2.8.9. The failure of the LOCAL HMI will have no impact on the Operation of the station in the Auto Mode.

2.8.10. Manual switches are to be fitted to the board in the event of a LOCAL HMI failure that will allow the station to be operated in the Manual mode. These switches will be directly wired to the starting units (VSD/SS) and the PLC such that the switch will run the pump in manual mode, should the PLC also fail.

2.8.11. Operators and Electricians/Engineers shall have a separate login and password and shall have suitable function access within the program. Username and password will be discussed during FAT/SAT.
2.8.12. Where the control cubicle is outside (not within a structure) the technology of the LOCAL HMI screen is to promote view-ability in sunlight, i.e. Super Twisted Nematic (STN) technology or approved equivalent. This will depend on the orientation of the switchboard. The HMI shall be southward facing.

2.9. **Telemetry**

2.9.1. A Telemetry system shall be installed in section 6 by the contractor as seen in the appropriate layout. Toowoomba Regional Council will supply the telemetry unit including any associated I/O module/s. *

2.9.2. A double power point shall be mounted near the telemetry unit.

2.9.3. The batteries are to be 12 V, minimum 12Amp-hour sealed lead-acid type.

2.9.4. Toowoomba Regional Council will supply the telemetry unit antenna, fly lead and RF surge arrestor.*

2.9.5. The telemetry shall be connected in accordance with the manufacture’s requirements.

2.9.6. Panel mounting space requirements for the Telemetry will be made available to the successful contractor at the time of tender. Liaising will need to be done with the appropriate telemetry vendor.

*Supply of Telemetry goods by TRC only applicable to those sites requiring Elpro telemetry.
3. Station Functions

3.1. Station Functions

3.1.1. The pump motors shall each be controlled by via the PLC under normal operation. Both pumps shall be used in an alternating cycle (unless specified otherwise).

3.1.2. If both pumps are available, the duty pump will alternate at the end of each run.

3.1.3. A selector switch shall be provided to manually control each motor. Selector positions shall be ‘Auto’, ‘Off’, and ‘Manual’. The PLC is to indicate the pump is running when operated in manual or auto.

3.1.4. The switch in the ‘Manual’ position shall bypass any function of the automatic control and run the relative pump. When the pump is operated in manual mode it shall run at full speed.

3.1.5. With the switch in the ‘Auto’ position, control of that motor is passed to the PLC.

3.1.6. With the switch in the ‘Off’ position, that pump shall be inhibited from operating.

3.1.7. The pumps are to be able to be run manually in the event of a PLC and/or LOCAL HMI and/or Telemetry failure.

3.1.8. If a pump is selected as duty and becomes unavailable the duty will be swapped to the next available pump.

3.1.9. In the case where there is only one pump, disregard statements regarding duty/standby operations.

3.2. Emergency Stop

3.2.1. The emergency stop button will stop all functions of the station. Input circuit and monitoring relay shall conform to a Category 4 level device in AS4024.1 -2006.

3.2.2. When the button is activated it shall send an alarm “EMERGENCY STOP” to the PLC and the Telemetry Unit and be displayed on the LOCAL HMI Screen.

3.2.3. The button is to be of a push lock on and twist release and must be dual acting connected to an appropriate safety relay.

3.2.4. The button is to be suitably labelled and easily identifiable in section five (5) of the switchboard.

3.2.5. The E-stop circuit is to use a contactor on the line side of the VSD/SS. The safe stop input on the VSD/SS is not to be used.
3.3. Main Tank (Wet Well)

3.3.1. The level in the main tank will be controlled by an analogue level control device that is one of the following:
- Hydrostatic Pressure Transducer (preferred)
- Ultrasonic Sensor
- Radar level Sensor

3.3.2. The analogue level control device will be the primary source of control for the pump station. The operator will have the ability to set both a duty start and duty stop set-point for the station (as well as a duty assist start and duty assist stop, if applicable).

3.3.3. Three (3) separate float switches are to be associated with the main tank (wet well) which will act as primary backup control.

3.3.3.1. One float switch shall provide a signal to the PLC for a Low Level Stop (backup) and shall be located 150mm above the manufactures ‘minimum pump level’ (in case of a transducer failure). ‘Minimum pump level’ is stated on the pump dimensions or specifications.

3.3.3.2. The second float switch shall provide a signal to the PLC for a High Level Start (backup) located 150mm above the duty start or duty assists cut in level (if applicable), but not above the gravity inflow level.

3.3.3.3. The third float switch shall provide a signal to the PLC and directly to the telemetry for a High-High Level (hardwired). This float shall be located 150mm below the inflow level to the overflow storage tank (if applicable) or prior to the emergency storage level contained within the wet-well.

3.3.4. In the case where there is no overflow storage tank available and the emergency storage is contained within the wet-well design, a 4th float will be located above the high-high level float.

3.3.4.1. This float shall be wired directly to both the Telemetry and the PLC and initiate a “STATION OVERFLOW” Alarm. This float shall be located at the approximate location where the flow from the station enters the environment but not above (within 150mm).

3.3.5. When the pumps are selected in the auto mode and the duty start level is reached it shall attempt to start the duty pump, with the stand-by pump ready to start if the duty fails. The duty or standby pump shall run until the duty stop level is reached. In the event that a duty assist system is being controlled the duty assist pump will also be ready to start after the duty pump if the duty assist start level is reached and run until the duty assist stop level is reached.

3.3.6. When the level in the main tank has reached the high level float switch (in the case of analogue control failure) and remains continually active for 5 seconds an alarm “MAIN TANK HIGH LEVEL” shall be initiated via the PLC to the telemetry and Local HMI and the duty pump shall start. The station will continue to pump down until the low level stop (float) is reached (or any critical pump fault is triggered).
3.3.7. When the level in the main tank has reached the low level float switch and remains continually active for 5 seconds an alarm “MAIN TANK LOW LEVEL” shall be initiated via the PLC to the telemetry and the operator’s panel. If the “MAIN TANK HIGH LEVEL” is seen to be active at the same time as the “MAIN TANK LOW LEVEL” the PLC is to generate a “Float control discrepancy” alarm, stopping the pumps. This stop will not occur if all floats below the “STATION OVERFLOW” level are also in the alarm state. In this situation the pumps are to start and pump for a time to be configured by the operator on the HMI.

3.3.8. Critical Float switches shall be configured to fail open and open circuit shall be the alarm state. This includes:

- Low Level
- Main Tank High-High or Station Overflow tank not empty
- Station Overflow Level

3.4. **Overflow Storage Tank (if installed)**

3.4.1. The Overflow storage Tank is to contain two (2) floats to be associated with alarm levels.

3.4.1.1. The first is to be located 150mm off the bottom of the overflow storage tank. An alarm “OVERFLOW TANK NOT EMPTY” shall be initiated via the telemetry and the PLC to the Local HMI (this alarm will be hardwired to both Telemetry and the PLC, it’s not required on Modbus). Field Terminal connections shall be provided within section 6 for this function.

3.4.1.2. A second float shall be located at the approximate location where the flow from the station enters the environment but not above (within 150mm). It shall be wired directly to both the telemetry and the PLC and initiate a “STATION OVERFLOW” Alarm (this alarm is not required on Modbus). This alarm shall be also displayed on the station HMI.

3.4.2. A flow measuring device will be used to accurately measure the volume of effluent that leaves the well during an overflow event. The arrangement of this device shall be approved by TRC. This device shall be powered from the 24VDC supply and provide the following:

- Instantaneous flow rate (via 4-20mA output to the PLC).
- Flowmeter fault (via output relay to the PLC). A closed contact shall represent a healthy state.
- kL Flow pulse (via output relay and shall be connected directly to the telemetry). This relay shall be a solid state relay.
3.5. **Pump Display**

3.5.1. When a pump motor is selected as the duty pump it shall initiate a signal “PUMP X DUTY” to the local HMI and telemetry system.

3.5.2. When a pump motor is selected in the manual or off position it shall initiate a signal “PUMP X AUTO NOT SELECTED” to the local HMI and telemetry system. If the PLC sees that both pumps have had active ‘PUMP X AUTO NOT SELECTED’ for longer than 5 minutes, a ‘STATION NOT AVAILABLE’ alarm will be generated.

3.5.3. When a pump motor is running in auto or manual it shall initiate a signal “RUNNING” to the local HMI and telemetry system.

3.5.4. The local HMI is to also display the following pump motor information:
- Motor run hours (daily, weekly, monthly, lifetime)
- Motor Voltage and Current
- Motor Frequency
- Motor starts (daily, weekly, monthly, lifetime)

3.6. **Faults**

3.6.1. Alarms associated with each pump shall be grouped together to provide a “PUMP COMMON FAULT” to the telemetry system. The alarms required are:
- Pump Overcurrent Fault
- Pump Phase Fault
- Pump Control Circuit Fault
- Pump Thermistor Fault
- Soft Starter / Variable Speed Drive Fault
- Pump Undercurrent Fault
- The pump seal failure fault is not to be grouped.

3.6.2. Station control faults are not to be grouped.

3.6.3. In the event of a loss of power to the site, a “MAINS FAIL ALARM” shall be initiated to the LOCAL HMI and Telemetry. Alarms which were present prior to loss of power may remain if active or unknown due to the loss of power. Any other alarms which are a subsequent result of the power failure shall be masked. “MAINS FAIL ALARM” shall not just rely on the 24VDC power supply alarm output, but also the phase failure relay output.

3.6.4. Should a power failure occur, the site status shall be the same after the supply has been resumed as it was prior to failure, i.e. if pump 1 was selected duty prior to power failure then pump 1 is to be duty when power has been restored. (Unless a fault developed during the power failure on the relevant pump prevents this.)

3.6.5. When the power supply has been restored there shall be a delay of 60 seconds to allow the mains to stabilise before allowing the pump to start.
3.6.6. The reset button on the operator panel LOCAL HMI is to reset the latched alarms / indicators on the pump but not to interfere with the pump if it is running. The following alarms are to be latched.

- Overload
- SS/VSD Fault (shall be automatically reset on site power failure/phase failure)
- Thermistor Alarm
- Water void
- Fail to start

3.6.7. If the duty pump becomes unavailable then the next available pump shall become the duty pump.

3.6.8. If a pump control circuit breaker trips or is turned off it shall initiate an alarm “PUMP CONTROL CIRCUIT FAULT” to the PLC and the telemetry system.

3.6.9. When a seal failure within the pump motor is detected it initiates an alarm “SEAL FAILURE” to the telemetry system and the LOCAL HMI screen. This fault shall not inhibit the operation of the pump motor nor will it activate the “PUMP COMMON FAULT”.

3.6.10. In the event of a phase loss, phase imbalance or phase reversal to a pump motor the PLC shall initiate an alarm “PHASE FAILURE” to the telemetry system. The phase failure signal shall not be derived from the Soft Starter or VSD. It shall be derived from a sensing relay located on the line side of the motor control gear. The relay shall be separately and appropriately protected, for example by 2A HRC fuses.

3.6.11. STATION INHIBIT Functionality:

3.6.11.1. Station Pumping Sewage: A telemetry signal output to the PLC shall be activated to this station and it shall inhibit this station from operating until the output is no longer active. This fault is an auto-reset type. This fault shall be displayed on the operator interface panel as “STATION INHIBITED”

3.6.11.2. Station Receiving Sewage: Should one of the below faults become active at the Receiving station

- COMMON FAULT (Both Pumps only)
- MAINS POWER FAIL
- EMERGENCY STOP
- OVERFLOW IMMINENT
- STATION OVERFLOW

An output will be generated by the PLC that shall be transmitted to inhibit any station from pumping directly to this receiving station. An alarm will be also generated “STATION NOT AVAILABLE” and will be transmitted to the Telemetry and shall be displayed on the operator interface panel.

3.6.12. A recommended station I/O list is included in Appendix C. This is not an exhaustive list and final list shall be submitted for approval by TRC.
4. Odour Control (MHL Dosing) if specified

A station may need to be fitted with specialist dosing equipment for the purposes of controlling odour and to protect civil assets from H2S attack. This section outlines the how this system shall be operate and interface with the station.

4.1. PLC Control

4.1.1. All control of the Odour control system shall be facilitated though the main station PLC
4.1.2. The use of remote I/O is acceptable to rationalise field terminations and minimise the need for additional cabling

4.2. General operation

4.2.1. The dosing solution shall operate such that chemical is dosed at a configured rate into the pump wet well during the operation of the pumps or for a defined period of time after the pump run has been initiated.
4.2.2. Where possible the level of the chemical tank shall be monitored via a non-contact method and the PLC shall generate an alarm at a configured level “CHEMICAL TANK LOW LEVEL”.
4.2.3. When the low level alarm is generated it shall stop the chemical pump(s) from operating

4.3. Alarms and Faults

4.3.1. The operation and or failure of the MHL system shall not prevent the main operation of the Pumping station in any way
4.3.2. Alarms/ Faults generated by the system are to be grouped where possible and transmitted via telemetry into the following categories
   4.3.2.1. “Chemical System Fault”
       Includes any alarms that are generated within the dosing system, Pressure sensors, Valve positions, Flow indicators, Level sensors
   4.3.2.2. “Chemical Pump(s) Not Available”
       Includes any alarms that are generated within the pumping system when a pump(s) become unavailable, should multiple pumps be installed.
4.3.3. Individual equipment faults and alarms are to be represented on the Station Control panel to assist with fault diagnosis.
5. **Documentation**

Documentation is to be provided by the contractor upon completion of construction and prior to practical completion of the job or prior to the acceptance of an “on maintenance” period by Council. Failure to supply documentation will delay acceptance of the works as complete.

5.1. **Format**

- Electronic copies, including PDF and DWG format of drawings and schematics with *as constructed* revisions. This will include *as commissioned* PLC and HMI Programs, as well as any VSD configurations.
- 1 x Paper copy in water resistant ring binder folders.

5.2. **Scope**

Documentation for the site will include the functional descriptions and operations manuals including (but not limited to):

- LOCAL HMI screen and controls
- Switches and buttons
- Faults and alarms
- Parameter listing for equipment VSD’s, programmable relays, etc.
- Site operations

5.2.1. As constructed design drawings must be certified by a suitably qualified RPEQ.

5.2.2. A factory acceptance test shall be performed by the contractor and witnessed by Council. Council reserves the right to attend additional testing inspections as required.

5.2.3. The contractor shall provide one week’s notice in writing for a TRC representative to attend any testing of the switchboard.

5.2.4. The Contractor shall be required to perform functional commissioning of the switchboard in conjunction with Toowoomba Regional Council. The Contractor shall be required to rectify any defects, make any changes to the PLC program and / or the communication network of the PLC to the telemetry system as deemed necessary by Toowoomba Regional Council.

5.2.5. The Contractor shall submit details of the cabinet layout single line diagrams and schematics before construction commences. These shall be submitted to council for approval.

5.2.6. All work is to remain the intellectual property of Toowoomba Regional Council.
6. Equipment Schedule

The selected equipment will be from the approved suppliers list or approved equivalent (Appendix A).

6.1. Free Issue Equipment

Toowoomba Regional Council will, when required, issue the following equipment to the successful contractor free of charge.

6.1.1. External door lock barrels to suite handle piece as specified the Approved Equipment Listing.

6.1.2. Telemetry equipment*.

- TLX 400 Radio
- 115-E2 IO module
- Antenna surge suppressor
- Antenna Fly lead
- Yagi Antenna

*Telemetry equipment is only free issued for Elpro sites (Rad-Tel or Kingfisher sites will require the procurement of telemetry equipment through a 3rd party vendor. The vendor must be able to interface with the existing SCADA system.
### Appendix A – Preferred Equipment list

Below is a list of equipment that is preferred by Toowoomba Regional Council for use in pumping stations applications.

<table>
<thead>
<tr>
<th>Category</th>
<th>Preferred Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit Breakers</td>
<td>NHP Terasaki, Schneider or approved equivalent;</td>
</tr>
<tr>
<td>Fuses</td>
<td>NHP, Schneider or approved equivalent;</td>
</tr>
<tr>
<td>Lightning Protection</td>
<td>Novaris, Critec, NHP or approved equivalent;</td>
</tr>
<tr>
<td>Transient Barriers</td>
<td>Novaris, Critec or approved equivalent;</td>
</tr>
<tr>
<td>Surge Reduciton Filters</td>
<td>Novaris, Precision Power or approved equivalent;</td>
</tr>
<tr>
<td>Signal isolators</td>
<td>APCS, Weidmuller or approved equivalent;</td>
</tr>
<tr>
<td>Selector Switches</td>
<td>Schneider, S&amp;S, K &amp; N or approved equivalent;</td>
</tr>
<tr>
<td>Push Buttons</td>
<td>Schneider, S &amp; S, Siemens, AB or approved equivalent;</td>
</tr>
<tr>
<td>Indicator Lights</td>
<td>Schneider, S &amp; S, Siemens, AB or approved equivalent;</td>
</tr>
<tr>
<td>Phase Failure Relay</td>
<td>Carlo Gavazzi, Crompton or approved equivalent;</td>
</tr>
<tr>
<td>Indicating Meters</td>
<td>Crompton, IME or approved equivalent;</td>
</tr>
<tr>
<td>Smart Meter</td>
<td>IME Nemo 96, Schneider PM or approved equivalent;</td>
</tr>
<tr>
<td>Current Transformers</td>
<td>Crompton, IME or approved equivalent;</td>
</tr>
<tr>
<td>Relays</td>
<td>Schneider, Finder, Omron or approved equivalent;</td>
</tr>
<tr>
<td>Timers</td>
<td>S &amp; S, Omron or approved equivalent;</td>
</tr>
<tr>
<td>PLC</td>
<td>Schneider Modicon (M340) or approved equivalent;</td>
</tr>
<tr>
<td>Soft Starter</td>
<td>NHP, Schneider or approved equivalent;</td>
</tr>
<tr>
<td>VSD</td>
<td>Schneider Altivar Process 610/630 or approved equivalent;</td>
</tr>
<tr>
<td>Contactors</td>
<td>S &amp; S, Schneider or approved equivalent;</td>
</tr>
<tr>
<td>Thermistor Relays</td>
<td>S &amp; S, Schneider or approved equivalent;</td>
</tr>
<tr>
<td>Motor Protection Relays</td>
<td>S &amp; S or approved equivalent;</td>
</tr>
<tr>
<td>LOCAL HMI</td>
<td>Schneider Magellis “Sunlight Readable” or approved equivalent;</td>
</tr>
<tr>
<td>Magflow meter</td>
<td>ABB (Watermaster range) or approved equivalent;</td>
</tr>
<tr>
<td>Radar Level Sensor and transmitter</td>
<td>VEGA PULS WL 61, or approved equivalent;</td>
</tr>
<tr>
<td>Ultrasonic Sensor and transmitter</td>
<td>VEGA (HART compatible) or approved equivalent;</td>
</tr>
<tr>
<td>Pressure Transducer and Transmitter</td>
<td>VEGA WELL 52 (HART compatible) or approved equivalent;</td>
</tr>
<tr>
<td>Float Level Switch</td>
<td>Xylem, Endress + Hauser or approved equivalent;</td>
</tr>
<tr>
<td>Energy Monitors</td>
<td>NEMO 90 HD or approved equivalent;</td>
</tr>
<tr>
<td>Communication Network</td>
<td>Modbus or Ethernet (Modbus TCP/IP) or approved equivalent;</td>
</tr>
<tr>
<td>Harmonic Filters</td>
<td>Schneider, ABB, Fuji, Rockwell or approved equivalent;</td>
</tr>
<tr>
<td>Ethernet switch</td>
<td>Moxa (industrial type) or approved equivalent;</td>
</tr>
<tr>
<td>Battery</td>
<td>NQ Batteries, GPO or approved equivalent;</td>
</tr>
<tr>
<td>Pump Control and Leakage Relay</td>
<td>Flygt Mini CASII or approved equivalent;</td>
</tr>
<tr>
<td>Terminals</td>
<td>Phoenix, ABB, S &amp; S or approved equivalent;</td>
</tr>
<tr>
<td>Wire numbers</td>
<td>Grafoplast or approved equivalent;</td>
</tr>
<tr>
<td>De-Contactors</td>
<td>Marechal, Ch or approved equivalent;</td>
</tr>
<tr>
<td>Magnetic Reed Switches</td>
<td>Schmersal, IFM or approved equivalent;</td>
</tr>
<tr>
<td>Battery Charger</td>
<td>Powerbox PB256, PULS UPS or approved equivalent;</td>
</tr>
</tbody>
</table>
Appendix B – Site Specific Details

To be completed by Council

Site Location: Refer to Site Reference Documents.

Board Type: External – Internal mounted Drives

Switchboard form: 2b (Clause 2.1.2)

Dimensions: Length: ** mm; Width: ** mm; Height ** mm (Will Vary) (Clause 2.1.4)

Switch Board colour: Sand (Satin Finish) Dulux code 51438 (Indoor Switch boards) Colourbond Wilderness C10 (Outdoor Switch boards) Escutcheons and equipment panels inside cabinet – White Dulux code 19143 (Clause 2.1.5)

PLC Spare I/O allocated: 10% for large installations Or minimum 5 Digital I/O and 3 Analogue I/O Minimum one spare slot on PLC rack

LOCAL HMI Screen Size: Minimum Diagonal Length: 7.5” (Clause 2.84)

Telemetry Make: Elpro TLX (Toowoomba, Crows Nest, Oakey) Radtel (Clifton, Millmerran, Greenmount, Pittsworth) Kingfisher (Goombungee, Yarraman)

Station Inhibited Functionality Required (Yes / No ) (Clause 3.6.11)

Odour Control (Yes / No)

Other: Any other site based requirements
## Appendix C – Station I/O List

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<thead>
<tr>
<th>Digital Input Description</th>
<th>Source (Address)</th>
<th>Float Status</th>
<th>Alarm State at terminal</th>
<th>Description</th>
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<tbody>
<tr>
<td>Overflow Flow Total Pulse</td>
<td>(DIN001)</td>
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<td>Station Pumped Flow Total Pulse</td>
<td>(DIN002)</td>
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<td>Rain Gauge Pulse</td>
<td>(DIN003)</td>
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<td>kWHr Pulse</td>
<td>(DIN004)</td>
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<tr>
<td>PLC Healthy</td>
<td>(DIN005)</td>
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<td>PLC (%M102)</td>
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<td>PLC (%M104)</td>
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<td>Battery Charger Failed</td>
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<td>Station Overflow Alarm (Flowmeter)</td>
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<td>Pump #1 Phase Fail</td>
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<td>Peer to Peer Radio Link Failure</td>
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<td>Chemical Tank Low Level</td>
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<td>TLX Output (DOT002)</td>
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<td>Reserved</td>
<td>TLX Output (DOT003)</td>
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<td>Overflow Flowrate</td>
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<tr>
<td>Station Pumped Flowrate</td>
<td>PLC (%MW102)</td>
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</tr>
<tr>
<td>Pump 1 Current</td>
<td>PLC (%MW103)</td>
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</tr>
<tr>
<td>Pump 2 Current</td>
<td>PLC (%MW104)</td>
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</tr>
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<td>Chemical Tank Level</td>
<td>PLC (%MW105)</td>
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ELECTRICAL DESIGN AND INSTALLATION SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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1 General

1.1 Preface
The purpose of this specification is to provide guidelines for the design and installation of electrical and instrumentation systems, equipment and installations for the Wirraglen and Lorrimer Street Sewerage Project.

Conformance with this specification shall result in power and control circuit designs that are safe, economical and practical, that comply with all relevant standards and regulations, and that utilise standard, proven and reliable equipment wherever practical.

At no time shall the Contractor deviate from this specification without written approval of the Principal's Representative.

1.2 Scope of Works
This document sets out the standards of work, regulations, requirements, equipment specification and reference documentation for the electrical works for the Toowoomba Regional Council Wirraglen and Lorrimer Street Sewerage Project under this contract.

Contractor shall design the main switchboard, telemetry panel and VSD panels as indicated in the switchboard and electrical design and installation specification. The Contractor shall also be responsible for the design and installation of electrical and instrumentation systems at each pump station site.

1.3 Standards, Codes and Regulations
All materials and workmanship shall be of the best standard and shall comply with the latest revision and subsequent amendments of the relevant Australian Standards, or if such do not exist, with the relevant IEC or International (ISO) Standards. Materials, equipment and installation works shall also comply with the rules and regulations of the relevant local electricity supply authority and the requirements of any other authority having jurisdiction over the installation.

All certificates of compliance and registration are to be obtained by the Contractor in the Principal's name, at no cost to the Principal. The following Acts shall be complied with without exception:

- The Queensland Electrical Safety Act
- The Queensland Electricity Act
- The Queensland Workplace Health and Safety Act
- The Queensland Environmental Protection Act.

Irrespective of any requirements shown in these documents the installation as a whole shall comply with the latest edition of the following standards in particular:

- AS 1074 Steel Tubes and Tubulars for Ordinary Service
- AS 1102 Set: Graphical symbols for Electrotechnical Documentation
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<td>Methods of Testing Soils for Engineering Purposes</td>
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<tr>
<td>AS 60529</td>
<td>Degrees of Protection provided by Enclosures.</td>
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</tbody>
</table>
1.4 Reference Documents

The following Specifications shall apply to works described in this specification:

- Technical Specification – Pump Station Functional Specification
- Technical Specification – Switchboard Specification
2 Environmental Conditions

All electrical equipment, installations and works shall be suitable for the environmental conditions set out in this section.

2.1 Atmospheric Conditions

The following atmospheric conditions shall be taken as the minimum design parameters for all equipment installed. The Contractor shall confirm the atmospheric conditions applicable to all equipment and increase these requirements accordingly.

- Mean ambient temperature: -2 - 34°C
- Yearly average temperature: 25°C
- Relative humidity: 30 – 99%
- Altitude rating Approx 400 m – 600m
- Atmospheric Corrosion: Category B, Low to AS/NZS 2312
- Pollution Concentration: Low to Medium in accordance with AS 4436 (Ambient temperature for design is -5°C to +40°C).

2.2 Service Conditions

All equipment supplied under this contract shall be of suitable construction, form and function for the intended duty of the equipment. Equipment in contact with process fluids shall be intrinsically suitable for the fluid at elevated temperatures, regardless of stated process temperature.

All equipment shall operate free from excessive vibration, noise, heating and radio frequency interference (RFI) as demonstrated by the Contractor’s design documentation and calculations.

The Contractor shall note the presence of significant concentrations of sulphur dioxide and other highly corrosive compounds like methane in gaseous form within the well. All equipment shall therefore be designed, supplied and installed to withstand this corrosive attack for the duration of the service life of the equipment.

The stated equipment maximum operating temperature shall be less than the sum of the maximum ambient temperature stated above, equipment self-heating, equipment mutual heating, radiant heating from exposure to sunlight and the heating effects of elevated temperature process fluids.

If requested the Contractor shall supply calculations, to the satisfaction of the Principal’s Representative, of expected temperature rise at equipment locations as a result of equipment losses, exposure to the sun and other factors.

Equipment installed in permanently cooled areas must be rated for operation under the atmospheric conditions stated above, such as would be encountered when temperature control units are off-line. This is especially applicable to the Starter Panels.
3 Design Requirements

The contract documents indicate the extent of the work; however the Contractor shall be responsible for all detailed electrical design including the preparation of design, calculations, drawings and other submissions. The scope of works under this contract includes this detailed design work. All design work undertaken by or on behalf of the Contractor shall be certified by fully qualified and experienced engineers with qualifications acceptable to the board of Professional Engineers Queensland.

3.1 Interpretation of the Documents

All electrical drawings supplied under this contract are intended for typical application only. The Contractor shall not in any way rely on design work inferred from the drawings or documentation.

Where the Contractor selects equipment or methods that differ from those specified in the documents (subject to the approval by the Principal's Representative), they are responsible for any associated redesign work. This includes any consequential redesign of other systems, such as cable and protection changes when motors ratings are altered. The quality, longevity, operability and maintainability of the redesigned sections of the work shall be at least equal to that original design.

All deviations from the Tender Documentation shall be submitted to the Principal’s Representative for approval.

3.2 Design Life

All electrical equipment shall be designed to operate continuously at full load for 24 hours per day, 365 days per year at the extremes of temperature and humidity specified for the installation location, in the installed environment for a period of approx 20 years.

The design life for PLC equipment shall be not less than 12 years while that of telemetry equipment shall be not less than 12 years.

3.3 Design by Contractor

The Contractor shall undertake the design of all electrical equipment, systems and processes.

The Contractor shall provide design documentation in the form of calculations, simulation results, drawings, technical datasheets and specifications to the Principal’s Representative for review prior to any manufacturing, construction or procurement.

Before installation works are carried out, all documentation shall be submitted in accordance with the relevant documentation clauses, below.

The Contractor shall demonstrate in their design documentation where each of the following design aspects has been addressed.
3.3.1 Continuity of Operation
Each specific item of plant, system and process shall be designed such that continuity of operation is the primary factor. The Contractor shall detail the systems, methods and specifications applied to ensure this functionality under the specified conditions at the installed location.

The Contractor shall also consider non-standard conditions such as power failure, operation from unstable local generation, single phasing and short circuit events in the design and specification of the equipment and systems under this contract.

3.3.2 Safety-in-Design
The Contractor shall clearly demonstrate their treatment of the requirements of Safety-in-Design with a detailed analysis of safety during the entire life cycle of the equipment including constructability, use and operation, maintenance, decommissioning and disposal as required by the Queensland Workplace Health and safety Act.

The requirements of AS4024: Safety of Machines shall be explicitly implemented.

3.3.3 Rating and Duty of Equipment
All equipment and systems shall be rated for the maximum duty as limited by the upstream protective devices. Where adjustable MCCB’s are installed, the equipment shall be rated for the maximum possible settings on the device.

Enclosed compartments shall either be of the completely sealed type or furnished with sufficient ventilation to disperse condensation. All contactors, relay coils and other devices with working metallic parts exposed to the atmosphere shall be supplied with certified conformal coatings or other approved method of tropicalisation.

3.3.4 Standardisation
All items of equipment having equal or similar functions will be of the one manufacture and of similar appearance, finish, mounting arrangement and the like. Where alternatives of equipment are permitted under this Specification and more than one item is to be supplied, all equipment shall be of the same manufacture and type. All equipment of the same type supplied under different sections of the contract or not, shall be of the same manufacturer and from a contiguous range.

Corresponding parts shall be made to gauge and shall be interchangeable wherever possible. Where required by the Principal’s Representative, the Contractor shall prove this quality by actually interchanging the various parts.

3.3.5 Corrosion Protection
All equipment and fixings shall be selected so that it is suitable for the corrosive effect of the environment in which it is installed. The equipment shall provide a service life of at least the periods nominated earlier in the Specification without excessive maintenance. Stainless steel components shall not be used in low oxygen environments that will prevent the
formation of the protective chromate layer. Fixings shall be suitable for use with the base material of the component that is fixed, and shall consist of either:

- Stainless steel
- Plated steel, with a platting thickness to suit the aggressiveness of the environment.

Where dissimilar metals are installed in moist or aggressive environments care shall be exercised to avoid the effects of galvanic corrosion. In this case the components shall be either inherently sealed from the environment, e.g., stainless steel electrically isolated from each other by separating them with either:

- A minimum 3 mm air gap
- A minimum 2 mm of UV resistant, non hygroscopic material such as rubber, PVC or polythene.

Welding of corrosion protected surfaces shall not be permitted unless specifically directed in the documents. Stainless steel components shall be thoroughly passivated after welding or being subject to any process that creates an oxide layer.

3.4 Drawings and Technical Submissions

3.4.1 General
The Contractor shall prepare detailed design drawings of the electrical works to be carried out in this Contract. All drawings submitted by the Contractor for approval pursuant to the requirements of this contract shall be amended to show in detail all mark-ups and changes as required by the Principal’s Representative. All drawings shall be to a professional standard and drawn in accordance with the relevant Australian, IEC or International (ISO) Standards. Poorly prepared or insufficiently detailed drawings will be rejected. Drawings that have not been initialled or signed by a responsible member of the Contractor’s organisation will also be rejected.

All drawings shall include the Manufacturers’ detail or serial number of all plant/equipment so that sufficient information is available for the ordering of replacement parts. Drawing schedules shall be supplied and shall list all working drawings by number and title.

3.4.2 Design Drawings
The drawing suite shall contain:

<table>
<thead>
<tr>
<th>Area</th>
<th>Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power system: Main Switchboards, Pillar Boxes, and Starter Panels</td>
<td>Switchboard layout diagrams</td>
</tr>
<tr>
<td></td>
<td>Switchboard single line diagrams</td>
</tr>
<tr>
<td></td>
<td>Switchboard schematics for each incomer, feeder and starter panel</td>
</tr>
<tr>
<td></td>
<td>Interconnection diagrams for each drive</td>
</tr>
<tr>
<td></td>
<td>Switchboard control schematics</td>
</tr>
<tr>
<td></td>
<td>Switchboard instrumentation loop diagrams</td>
</tr>
</tbody>
</table>
### 3.4.3 Drawing Submissions

The Contractor shall prepare detailed calculations covering of the whole of the works to be carried out in this Contract. In particular, if there is insufficient detail on the drawings to permit evaluation solely on the information provided then the drawings shall be accompanied by further technical submissions consisting of the Contractor's data and design documentation. The Contractor shall submit copies of all drawings to the Principal's Representative for review before any work shown on the drawings is carried out.

All drawing submissions shall be either:

- Three (3) sets of A3 sized paper prints, or
- Adobe Acrobat PDF files suitable printing at A3.

Note AutoCAD files shall not be submitted, unless they are “As Constructed” drawings.

### 3.4.4 Technical Submissions

Technical submissions, covering all equipment shall be provided:

- Where the submission of technical and other manufacturers data is specified.
- If requested by the Principal's Representative.
- Where the make and model is not indicated in the documents.
- Where the make and model differ from those indicated in the documents.
- Where detail is insufficient on the design drawings.

Technical submissions shall be provided to the Principal's Representative for review before any work utilising the equipment is carried out. Technical submission shall consist of manufacturer's data describing the item including ratings, dimensions and technical features.
The submission shall be concise and not simply be the bulk submission of manufacturer’s installation manuals. If the information is only available within a larger manual the relevant information shall be extracted from the manual for the submission, with the manual Table of Contents also forming part of the submission.

3.4.5 Design Calculations
As a minimum, the Contractor shall provide electrical design calculations including:

- Fault current analysis, detailing connection point fault levels and resultant downstream fault levels at each MSB. Three phase, line to line to ground and single line to ground faults shall all be considered, with the maximum fault situation highlighted.
- Cable calculations, detailing analysis of earth fault loop impedance, voltage drop, thermal limits, and current carrying capacity for each cable in the cable schedules.
- Earthing system design documentation, detailing geotechnical analysis results, earth grid design, earth potential rise, touch voltage analysis, step potential analysis and transfer potential analysis.
- Maximum demand and load sharing calculations for all switchboards.

3.4.6 Review of Submissions
The Principal’s Representative’s review of the Contractor's submissions will be for general compliance with the Contract, review of plant detailing and standard of drawings. It is not a design check and does not relieve the Contractor of responsibility for ensuring that the works are constructed in accordance with the specification and in a safe manner. Acceptance of the submissions does not imply acceptance of any variation from the contract documents contained thereon. Such variations must be identified and the explicit agreement of the Principal’s Representative obtained. Following completion of the review the Principal’s Representative will notify the Contractor of the results.

The Principal’s Representative will arrange for Drawings and documents to be returned to the Supplier with a status code:

<table>
<thead>
<tr>
<th>Code</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Proceed. Data containing this code shall be deemed acceptable and does not require re-submittal unless changes are made by the Supplier. The Supplier may proceed with the manufacture of the item(s) to which the data relates.</td>
</tr>
<tr>
<td>B</td>
<td>Proceed as Noted. Data containing this code requires re-submittal by the Supplier within 14 calendar days. The Supplier may proceed with the manufacture of the item(s) to which the data relates, provided that all comments are accepted and incorporated and no other changes are made.</td>
</tr>
<tr>
<td>C</td>
<td>Do Not Proceed, make corrections and re-submit. Data containing this code requires re-submittal by the vendor within 14 calendar days. The vendor may NOT proceed with the manufacture of the item(s) to which the data relates.</td>
</tr>
<tr>
<td>D</td>
<td>Information Only. Data containing this code shall be deemed for information only and does not require re-submittal.</td>
</tr>
</tbody>
</table>
Upon receiving reviewed data requiring re-submission (i.e. Status Codes B or C), the Supplier shall re-submit a new revision to the Purchaser within 14 calendar days. The Supplier shall revise the document only in accordance with the Purchaser review comments.

The Supplier shall clearly identify revisions made through the use of ‘clouding’ for drawings and other practical means for other document types.

All issues raised by the Principal’s Representative as part of this review must be resolved to the satisfaction of the Principal’s Representative prior to commencement of construction. Alterations to drawings or technical submissions between submissions shall be clouded or revision marked to clearly identify the alteration. Allow a period of 10 working days, following each submission, for review by the Principal’s Representative.

3.5 Drawing Format

3.5.1 General
The drawings shall be clearly legible when printed on A3 size sheets. Where appropriate, the drawing scale must be shown. The drawing shall also include a graphic scale to facilitate scaling when a sheet is reproduced at a different size to the original. Equipment detail drawings shall be drawn at a scale of 1:20 or larger.

3.5.2 Symbology
The drawings shall use graphical symbols in accordance with AS1102. Where the use of nonstandard symbols is unavoidable, these shall be fully detailed in the legend on the drawing accompanied by explanation and description.

3.5.3 Assembly Drawings
Drawings of assemblies of mechanical and electrical plant and machines shall include, where appropriate:

- Overall dimensions and mass (including the mass of the heaviest lift for maintenance)
- Finished sizes and tolerances of all wearing parts
- Terminal point details
- Expansion limits
- Lubrication points
- Minimum clearances
- Welding preparation and procedures
- Where plant or plant items subject to pressure and temperatures higher than ambient:
  - Design pressures and temperatures
  - Working pressures and temperatures
  - Test pressures and temperatures.
- Insets, where necessary, to ensure every item of the assembly is clearly shown
- All points of support
All points of attachment of the plant to piping, conduits or other items supplied by others
- Location of holding down bolts or other points of support or anchorage.

3.5.4 Electrical Drawings
Electrical schematics for the installation shall be drafted in accordance with AS 1102 and shall include the following:

- Ammeter scales and current transformer ratios
- Circuit breaker and fuse current ratings
- Ratings of capacitors, resistors and any other electrical devices
- A short name description of each relay, timer or control device to describe its operation
- A cross reference system that indicates where each contact for a relay or timer is located. - The system may include sheet and line numbers
- Switchboard drawings including layouts and construction details and panel wiring diagrams
- Single line diagrams
- Items shall be designated as per AS 3702
- All field wiring diagrams
- All instrument loop diagrams
- Instrumentation and control termination diagrams
- Overall system diagrams of communication systems, showing terminal strip allocation
- Cable types and system components
- Block cabling diagrams with detail frame allocation and terminals.

Electrical wiring diagrams for the installation shall be produced showing all cable terminations including cable numbers, core numbers and terminal numbers. The numbering systems shall be modular and consistent throughout the plant. Submit details of the proposed numbering systems to the Principal’s Representative for approval before use.

A wiring schedule shall be submitted showing all cable sizes and number of cores. The Contractor shall remain entirely responsible for the control logic, correct operation, performance and design.

3.5.5 As Constructed Drawings
The Contractor shall maintain one set of A1 prints of all electrical drawings on-site as the master construction set. These drawings shall be used to record all deviations from the design drawings and shall form the basis of the “As Constructed” drawings produced by the Contractor for the O&M Manuals.

3.6 Liaison with Electricity Service Provider
The Contractor shall make all necessary arrangements and applications for the full permanent power to be available at the connection point before the start of commissioning.
The Contractor shall prepare and submit to the Principal’s Representative any documents (including the Ergon connection enquiry form duly completed) requiring the signature of the Principal.

The Contractor shall make all payments required to effect connections under this contract. Certified copies of all certificates required by the electricity service provider and other authorities having jurisdiction over the site shall be provided to the Principal’s Representative.

The Contractor shall obtain from Ergon Energy all the required data and information required to suitably complete the electrical design works to conformance. This shall include but not be limited to the following: source impedances, system fault levels, etc.

The Contractor will be held responsible for any consequential damage or loss resulting from a failure to comply with the above requirements.

3.7 **Interruptions to Electrical Supply**

The Contractor shall maintain electrical supply to all installations throughout the duration of the works. Should it be necessary to interrupt electrical supply then written application shall be made to the Principal’s Representative at least two weeks beforehand. This notification shall include a description of the works to be executed, the installation affected and the projected duration and timing of the interruption. Interruptions to electrical supply are strictly at the discretion of the Principal’s Representative, and should the requested interruption not be possible, the Contractor shall reschedule the works to a time at which an interruption can be tolerated, at no additional cost.

3.8 **Quality of Materials and Workmanship**

All materials used under this Contract shall be new. Where existing equipment is specifically required to be reused it shall be removed, tested, repaired / replaced / recertified and reinstated. The Principal reserves the right to reject any materials, equipment or works if he/she deems it unacceptable for the intended duty or not undertaken in a workmanlike manner.

Repair of defective or rejected parts, materials or equipment shall not be permitted under any circumstances. Where available, vermin and fire resistant equipment and parts shall be used.

3.9 **Provision for Handling Equipment**

All heavy parts of the plant supplied under the Contract shall have provision for lifting, slinging and handling during erection and overhaul or maintenance. All parts normally lifted during periods of maintenance and weighing one tonne or over shall be marked with their weight. Eyebolts shall be provided where necessary to facilitate handling and overhaul of the various parts of the plant.
The Contractor shall provide all cranes, elevated work platforms, forklifts and handling equipment required for the works under this contract along with suitably trained and licensed operators for each item of handling equipment supplied.

3.10 Tools
The Contractor shall supply any special tools that may be necessary to complete the works under this contract. All special tools required for the mounting, disassembly, maintenance and use of installed equipment shall be supplied to the Principal’s Representative in a purpose designed box or receptacle. All Supplied tools shall be new and unused.

3.11 Packing and Transport
All Equipment shall be carefully packed and secured for transport in such a manner that it is protected from all dust and climatic conditions during loading, transport, unloading and subsequent storage in the open. Equipment shall be suitably packed and protected against vibration, movement and shock that may occur during loading and transport. Particular care in packing shall be taken when the Equipment is transported by road.

Heavy and bulky equipment shall be provided with adequate lifting fixtures to facilitate ready handling during transit and on arrival at site. Instruments, relays and fragile items shall be packed separately. All items that include delicate equipment shall be sealed in polythene sheeting and silica gel desiccant or vapour corrosion preventive shall be inserted within the polythene packing.

Contractors shall submit their proposals to the Principal’s Representative for protection of equipment during transit; however, the responsibility for safe delivery remains with the Contractor. All equipment supplied under this Contract shall be clearly identified on the outside of any case with the type and number of items contained therein and the gross weight. Large crates are to be marked on three sides, and smaller crates which can be easily manhandled are to be marked on at least two sides.

The names of haulage firms, shipping companies, shipping agents, customs authorities and any special handling firms shall be advised to the Principal’s Representative before the equipment is dispatched. One copy of each applicable shipping specification, packing list, mass note, packing note and the relevant control numbers of consignment notes, waybills, bills of loading, customs clearance certificates, tranship notes and the like shall be forwarded to the Principal’s Representative as each paper required is raised, together with expected dates of departures and arrivals en route.

All equipment shall be shipped below decks. Adequate precautions shall be taken in the packaging of all machines that have ball and/or roller bearings so as to minimise the risk of damage to the bearings. Any bearing found with “brinelling” marks shall be replaced at no cost to the Principal. Special precautions shall be taken to protect journals where they rest on supports during transport. At such points, anticorrosion fluid impregnated wrappings shall be used to protect the journals during transport.
4 Electrical Installation Technical Requirements

Installation shall also comply with the rules and regulations of the relevant local electricity supply authority and the requirements of any other Authority having jurisdiction over the installation. All certificates of compliance and registration are to be obtained by the Contractor in the Principal's name, at no cost to the Principal. Irrespective of any requirements shown in these documents the installation as a whole shall comply with all relevant standards and legislation.

4.1 Wall Mounted Cable Ladders (where applicable)

The preferred supports for cable ladder are Galpro and Unistrut. The Contractor shall use beam clamps to attach cable ladder supports to structural steel. The Contractor shall ensure that all anchor points and beam clamps are sufficient for carrying loads for cable ladder support brackets. Unbraced cantilever racking system is not permitted to be installed.

Fixings to concrete or masonry materials shall be made using 12 mm or larger 316 stainless steel dynabolts or approved equivalent complete with flat washer under nut. Support brackets or components shall be Unistrut approved equivalent.

All brackets and joints shall be hot dipped galvanised. Where the galvanising protective coating is broken during installation (ie drilling or welding), the exposed metal shall be thoroughly coated with ‘Cold Zinc’ paint to restore the finish.

The contractor is not permitted to install cable ladder support brackets under the following conditions:

- Welding to the building structural steelwork without prior approval.
- Fixed onto plant pipes and equipment
- Restricting access to valves, pipes or other equipment for maintenance (minimum 1m clearance required)
- The use of threaded rod to support cable ladder or tray (completed support structure to be rigid)
- Using explosive tools or impact type fixings

Extra supports shall be located within 600mm of cable ladder or tray bends, tees or risers.

Cable tray shall be spaced a minimum of 50mm from ceilings or walls.

Horizontal cable ladder shall be spaced vertically a minimum of 300mm between ladders and ceilings.

Cable ladders which pass through electrical room walls shall slope down on the outside in order to prevent ingress of water into the electrical room.

The installation shall contain no sharp edges or burrs.
4.2 Conduits and Pits

4.2.1 General
Conduits and Pits shall be installed as required by the Design or as shown on the Drawings and at any location where additional mechanical protection of cables is required.

Conduit material shall comply with the following:

- Underground conduits, for power circuits, shall be heavy duty, rigid PVC to AS 2053, orange in colour.
- Aboveground conduits shall be heavy-duty seamless galvanised steel screwed type to AS 2052. Where approved by the Principal’s Representative, heavy duty galvanised water pipe may be used.

All conduit fittings and junction boxes shall be of a manufacture compatible with the conduit being used. All surface conduit fittings of the inspection type shall be provided with neoprene gaskets.

For above ground installations, conduit elbows and tees shall not be used, unless otherwise approved by the Principal's Representative. Changes in directions shall be by bends, large radius sets in the conduits, or by using junction or pull in boxes.

The minimum nominal size of conduits shall be as follows:

- 25mm for lighting circuits and general purpose power and instruments.
- 32mm for all other circuits.

All underground conduits and ducts shall be buried to a minimum cover depth of 750mm or to a depth approved by the Principal's Representative.

All HDPVC/HDUPVC conduits and ducts shall be sealed with permanently plastic waterproof compound.

Conduit runs shall be installed square to the equipment as far as possible and shall have a minimum of direction changes.

Metallic conduit ends are to be suitably covered to prevent cuts or damage to cables.

For in-ground installations, changes in direction of underground conduits may only be achieved by the use of approved draw-in pits, or as otherwise approved by the Principal's Representative.

All in-ground buried conduits are to be fitted with stainless steel draw wires.

Contractor to design for additional conduits to allow for the lesser of 50% spare conduit by number or two (2) off spare conduits in each conduit trench run,. The spare conduit shall be of equal size to the largest diameter conduit in the run. All spare conduits to be capped and foam sealed.
4.2.2 Cable Culverts (if applicable)
Where cable tray routes intercept and cross roads, the cable trays shall be installed under the road surface in precast concrete culverts. The culverts shall be installed such that precast concrete covers provide a continuous, level road surface to the surrounding grade. Covers shall be load rated for the applicable traffic class.

Cable trays shall be continuous throughout the culvert and shall be supported on Unistrut or similar mountings. Where possible the culverts shall have the relevant Unistrut fittings cast into the walls. All vertical bends shall be fully supported on large radii cable tray bends. Cable tray covers shall be maintained continuously throughout the duct.

The culverts shall be installed with minimum 1:500 fall to one end and provision shall be provided to allow for the removal of water from the culvert i.e. drainpipe to adjacent drain or permanent sump for installation of transportable pump. Surrounding pit structures shall be constructed proud of the surface to prevent run-off water entering the duct.

4.2.3 Underground Conduits
Prior to commencing any works associated with the installation of underground cable conduits, the Contractor shall make arrangements to inspect the route with the Principal’s Representative.

The Contractor shall make all necessary precautions and arrange for all necessary permits to ensure that all existing services are identified prior to commencing excavation and that adequate protection is provided to same services during trenching activities.

The Contractor shall clear the area along the line of the trench to a minimum distance of 2 m on both sides of the trench. Any vegetation within the trench corridor shall be cleared and removed from the site. All stumps and roots with 1000 mm of the sides of the trench shall be grubbed to a depth of 300 mm.

Unless directed otherwise by the Principal’s Representative, all trenches shall be excavated in ground along the alignment shown on the drawings. The trench line shall be kept as straight as possible to the planned alignment.

The Contractor shall ensure that the trench profile is maintained as close as possible to the design requirements. Where trench depth exceeds the design requirement, the bottom of the trench must be filled with selected stone free material, properly compacted to the proper grade.

Where required the Contractor shall erect shoring to prevent the sides of the trench collapsing during trenching and cable installation activities. The Contractor shall be held responsible for keeping clean and the maintenance of the trenches in good order and condition between the time of excavation and cable installation. It shall be the responsibility of the Contractor to undertake works necessary to manage any water that interferes with work progress.
After completion of trenching, the Contractor shall arrange for inspection of the trench by the Principal's Representative prior to installing any cabling or conduits. Following inspection and approval to proceed, the trench shall be cleared of any sharp objects and a layer of bedding material shall be placed. The depth of bedding material shall be such that after the cable or conduit is laid, the minimum depth of bedding between the underside of the cable or duct and the trench floor is 50 mm.

Bedding material shall be free from any hard sharp or abrasive material such as rocks or stones shall be laid over the cables with a minimum cover of 50 mm. Bedding material shall have the following qualities:

- Be capable of being shaped to form a uniform support for the cable
- Pass a 10 mm sieve
- Have a liquid limit not exceeding 25%
- Have a plasticity index not exceeding 6%.

All bedding material shall be compacted to a minimum of 90% standard compaction density.

General backfill may comprise the excavated soil or imported soil provided that any material in the soil will pass through a 50 mm screen. Cable protection and marker tape shall be incorporated during backfilling.

The compaction of the backfilling shall be to a density not less than the density of the existing adjacent material and to the entire satisfaction of the Principal's Representative. Backfilling shall be carefully placed in layers not exceeding 150 mm, well watered if necessary, then packed and compacted by mechanical means. In existing paved areas the surface shall be reinstated to the original level and finish to the satisfaction of the Principal's Representative.

Cable segregation shall be as per AS/NZS3000:2010. Conduit separation shall be as per AS3008.1.1:2009. Separation minimum is to be used as separation maximum to prevent civil scope creep.

4.2.4 Cable Protection and Marker Tape

Mechanical protection shall be installed over direct buried cables for their entire route as required by AS 3000 and as shown on the drawings. Mechanic protection shall be of approved proprietary manufacture consisting of either:

- Polymeric cable protection covers manufactured from orange coloured material. Paint or other orange coatings on the covers is not acceptable.
- Precast bricks or precast concrete. Concrete covers cast on site or in situ are not acceptable.

Orange Polyethylene marker tapes, 150 mm wide and 0.1 mm, shall be laid in the trench directly over all underground cables at a depth of 150 mm or as instructed within AS/NZS 3000 to comply.
4.2.5 Cable Markers
Underground cable route concrete markers shall be installed above all underground cable joints, at every change of direction of underground cable and on straight runs at least every 30 m.

Markers shall consist of a concrete block 250 mm square 100 mm deep with an engraved brass label attached. The marker shall identify the cable and indicate its direction of lay as indicated on the drawings. Labels shall be fixed to the concrete block with screw fixings and epoxy adhesive.

4.3 Cable Pits
Where possible, cable pits shall be proprietary supplied items. Where the installation of proprietary pits is not possible the Contractor shall install cable pits as required by the installation or shown on the drawings.

Pits, lids and the method of installation shall be suitable for the maximum wheel loadings in the area in which they are installed.

Lids to electrical pits shall be marked ‘Electrical’. Lids and for communications pits shall be marked ‘Communications’.

Cable pits (including the entry to the Switchroom) shall:
- Be adequately sized for the number of cable / tray / conduit entries.
- Be adequately sized to allow personnel access to undertake maintenance activities.
- Allow for the installation of cables without contravening the Manufacturers recommended minimum bending radius of cables during both installation and setting.
- Have bell mouth fittings on all conduit entries.
- Be installed 30mm above the surrounding surface and the surrounding ground graded up to the pit for a distance of 1 m.

4.4 Cabling

4.4.1 General
All Cabling supplied under this contract shall be new. Unless otherwise indicated all cables shall have stranded copper conductors. All cabling and wiring shall be designed, supplied and installed in accordance with AS 3000 and AS 3008.

The minimum size shall be:
- Lighting 1.5 mm2
- Control 1.0 mm2
- Power 2.5 mm2

4.4.2 Sheath Colours
Cable distinguishing colours shall be as follows:
a) Single Phase:
   - Red Active
   - Black Neutral

b) Three Phase:
   - Red “A” Phase
   - White “B” Phase
   - Blue “C” Phase
   - Black “N” Neutral

c) Earth: Green / Yellow

d) Control:
   - Orange 240V AC
   - 24 V + DC Brown
   - 24V – DC Brown with Black Stripe or Purple

e) Instrumentation:
   - Thermistor White twisted pair

f) Telemetry: Grey

4.4.3 Classification
As a minimum, all internal wiring shall conform to the minimum requirements of category WSX2 to AS 3013.

All cables exposed to sunlight shall have UV stabilised sheathing insulation (where unsheathed) or shall be covered to the approval of the Principal’s Representative. Usage of double insulated cables with an outer sheathing of non UV stabilised material shall not be accepted.

4.4.4 Segregation
The following groups of cables shall be segregated from each other by continuous barriers when installed in common ladder systems or by using separate ducts or conduits:

   - 240/415V power supplies
   - 240V control supplies and systems
   - Instrumentation cabling
   - ELV control supplies, and signal and communications systems, including thermistor wiring.

Cable segregation shall be as per AS/NZS3000:2010. Conduit separation shall be as per AS3008.1.1:2009. Separation minimum is to be used as separation maximum to prevent civil scope creep.

4.4.5 Small Light and Power Cabling
For light and power installations where full protection from mechanical damage is assured, PVC/PVC or TPS cables may be used in walls and ceilings of approved installations, or where allowed otherwise by AS3000 and the BCA. Circular V-90 cables shall be offered in non-protected installations exposed to atmosphere and mechanical damage.
For building services wiring the following wiring shall be permitted:

- TPS cables in false ceiling areas and partition walls.
- TPS or TPI cables protected by conduit.

4.4.6 Single Core Cables
Single core cables forming part of a three phase system shall be clamped together in trefoil over their entire route to avoid derating. The configuration of parallel trefoil circuits shall comply with the recommendations of AS 3008 Appendix D.

The clamping of single core cables in trefoil shall be of sufficient mechanical strength to withstand the forces generated by fault currents. Single core power cables shall be fixed in close trefoil formation by metal trefoil or 4 way clamps, up to as close as practical to the cable glands.

4.4.7 Armoured Cables
Armoured cables (where required without the use of conduits) shall be 0.6/1 kV grade comprising stranded copper conductors PVC or XLPE insulated and bedded, galvanised steel wire armoured and PVC, black sheathed, UV resistant overall. Armoured cables shall comply with AS 5000.1. Armoured cables shall be terminated in heavy compression type glands having wedge type armour clamps for steel wire armouring. An earthing lock nut shall be used on all armoured cable glands.

4.4.8 LV Instrument and Control Cables
LV instrument and control cables shall be PVC insulated, screened copper conductors suitable for instrumentation applications such as Instrolex or equivalent. The cables are to be PVC, black sheathed, and UV resistant. Instrument cable pairs are to be individually and overall screened. Control cables shall be overall screened.

4.4.9 Instrument Sensor Cables
Instrument sensor cables shall be as supplied without joints or as recommended by the relevant instrument manufacturers.

4.5 Cable Installation

4.5.1 General
The Contractor shall select routes for all cables and submit the layout drawings for approval by the Principal's Representative. Cables shall be installed on the cable ladders as presented on Contractor drawings. Cable routes from cable ladders to equipment shall be submitted for approval to the Principal's Representative before installation.

Cables shall be run with all due care, which shall include the following precautions to prevent cable damage:

- Rollers including radius rollers shall be provided and used as required.
- Cables shall not be subjected to twisting and kinking or contact with sharp edges, or any other mishandling which may cause sheath or core damage.

It shall be the Contractor's responsibility to ensure that cable to be installed is the size and type required. Run lengths and cable routes shall be determined before cutting cables, with off-cuts being minimal. The bending radii of cables shall not be less than the minimum recommended by the Manufacturer.

Instrumentation, telephone and radio communication cables shall be kept separate from power and control cables by a spacing of at least 300mm, unless approved otherwise.

If termination or jointing is not immediately performed after cutting, all cables subject to potential damage due to moisture absorption or dirt ingress shall be effectively sealed by attachment of heat shrink caps or other methods as approved by the Principal's Representative.

Cables installed by methods not covered in the following clauses shall be fixed and supported in accordance with AS 3000 or as approved by the Principal's Representative.

4.5.2 Small Power and Lighting Cables
The cable routes to light fittings and GPOs shall be approved before installation. Circuit cables shall not be looped at light fittings. They shall be teed off via an approved 3 way junction box, unless allowed otherwise by the Principal's Representative.

The temperature rating of cables into light fittings shall be suitable for the temperature within the fitting. Sleeving and taping shall not be accepted as a substitute for correctly rated cables. Top entry into light fittings is not permissible. Top entry into GPOs and welding outlets is only permissible when the outlets are housed inside a suitable splash cover to the approval of the Principal's Representative. Armoured cables shall not be looped at GPOs with non-metallic enclosures.

4.5.3 Cable Winching
Winches may be used only to install armoured cables and if used, winch ropes shall be attached to the cable armouring with steel mesh sleeves. Cables shall be pulled under controlled conditions. When pulling cables, any winch used shall have automatic tension limiters and the tension shall not exceed that specified by the manufacturer for the particular cable and conditions of installation.

The cables shall be supported along the run and at deviations, by rollers spaced at 5 metres maximum. In addition to the cable roller fixing to the cable support system, an approved safety chain must be fitted to each roller to prevent a fall due to a failure of the primary fixing.

4.5.4 Specific Requirements
Where cables leave the main ladder routes they shall be supported as follows:
Electrical Design and Installation Specification

- Single, double and triple cable runs shall be supported in discrete lengths of heavy duty galvanised steel/HDPVC conduit. Each discrete length of conduit shall be bushed at each end.
- The use of galvanised water pipe, effectively reamed, with sharp edges removed and welded or saddled to structures shall be permitted, subject to the approval of the Principal's Representative.
- The Contractor shall have a full range of bending equipment on site suited to the range of conduit used. Where water pipe is used, a hydraulic bender with the range of mandrels to suit the pipe sizes shall be used.
- Four or more cables shall be run on subsidiary cable ladder-runs additional to those shown on the drawings.

The installation of single core cable shall be in clamped trefoil groups as approved by the Principal's Representative. Unless specifically approved by the Principal's Representative for temporary installations, spring clips shall not be used as a means for fastening cables.

Cables shall be protected at all times from mechanical or physical damage. Where necessary where cables are installed over or around any sharp edge, the Contractor shall provide adequate protection to prevent the outer sheath being damaged by chaffing or cutting. The type of protection used shall be submitted to the Principal's Representative for approval.

All installed cables shall be labelled in accordance with this specification.

4.5.5 Installation in Cable Tray and Ladder
Cables installed on cable ladders shall comply with the following requirements:

- Cables shall be neatly laid in parallel runs with a minimum of cross-overs.
- Motor power and control cables shall be installed per the approved layout drawings. The routing of light, general purpose power and earthing cables can be determined on site with the approval of the Principal's Representative.
- Cables laid on horizontal ladder shall be fixed with adequate cable ties to preserve a neat appearance, where there is no grouping required.
- Where grouping or spacing is required the cables shall be fixed every third rung or closer if necessary to keep grouped cables neatly together.
- Cable ties shall be stainless steel / nylon for all areas. Cable ties shall be cut with manufacturers special tools so that no sharp ends are left protruding.
- Cables run on edgewise horizontal ladder shall be tied at every rung.
- Cables run on vertical ladder shall be fixed with heavy duty stainless steel / nylon cable ties or stainless steel cable clamps, KSV or approved equivalent type, every second (2nd) rung.
- The maximum number of cables tied together shall not exceed 4 or an overall diameter of 100mm. Cables greater than 50mm outer diameter shall be fixed separately.
- When run on the same cable ladder, control cables shall be segregated from instrument analog cables by a barrier strip.
- Single core power cables shall be fixed in close trefoil formation by metal trefoil or 4 way clamps, up to as close as practical to the cable glands. Parallel trefoil circuits shall be installed with symmetric phasing.

4.5.6 Installation Underground

In-ground cables shall be installed inside conduits or ducts as approved on the Contractor drawings. Vinindex cable protective sheeting (or approved equivalent) of adequate width to fully cover and protect the cable, or its equivalent, must be used. Cables shall pass below other services.

In all locations where cables leave the ground, cables shall be installed inside heavy duty rigid UPVC ducts and conduits of 50mm minimum size, or heavy duty galvanised water pipe as approved. Conduits shall rise 500mm above and extend 500mm below finished ground level.

All backfilling shall be in layers not exceeding 150mm, each layer being separately compacted to match the ground condition prior to excavation.

Backfilling material shall be the best available. No large boulders shall be used for backfilling material. Where the excavated material is unsuitable for backfill and compaction, suitable material shall be obtained and used by the Contractor.

Backfilling under pavements and hard standing shall be compacted to a dry density not less than 95% relative compaction based on the modified method of compaction to AS 1289, Test E2.1.

Surplus excavated material shall be removed to a designated position on site. Cable route markers shall be installed at the start, finish, every 30 metres and every change in direction of all cable trenches.

In areas where top dressing or grading is to be carried out temporary cable route markers shall be installed and maintained by the Contractor until such work is complete. Temporary route markers shall be 50 x 50mm timber stakes. The top 300mm of stakes shall be painted white and a black letter 'E' painted on two opposing sides. When all grading work is complete, permanent concrete markers shall be installed where required by the installation. In rough terrain where concrete marker blocks are unsuitable, galvanised steel sign post type markers shall be installed.

4.6 Terminating

Bolts shall be fitted with Belleville washers. Once tightened, bolts must show at least two threads past the nut. Brass nuts or bolts shall not be permitted. Cable terminations shall be carried out using approved glands and gland installation method. When cable glands are installed on SWA cables, no armour shall be exposed.
Cable glands installed on gland plates other than brass shall be fitted with brass earth tags and brass locknuts. Earth tags shall be individually bonded to the equipment earth bar.

Cable glands shall be of an approved weatherproof type that is consistent with the IP rating of the enclosure and the hazardous area classification (where applicable).

Nickel plated brass glands shall not be used in conjunction with aluminium alloy boxes or Aluminium gland plates.

PVC weatherproof shrouds shall be provided and fitted for glands mounted outdoors or in readable visible areas. The shrouds shall be ALCO “SG” type or approved equivalent. All gland plates shall be drilled to the sizes required by the cable gland. The gland sizes shall conform to the manufacturer’s recommendations.

Cable entries in switchboards and pillars shall be installed in such a manner as to permit the orderly accommodation of the total potential requirement for cable glands at each location.

Lacing of cores in control panels and switchgear panels shall be carried out using an approved method (e.g. zip ties especially for flexible attachment to moveable parts & installation in slotted covered duct for fixed terminal strips etc.).

Earth conductors on XLPE cables (normally green) shall be sleeved with green and yellow coloured heat shrink sleeving.

All cable terminations shall be made using pre-insulated crimp lugs. Crimp lugs shall be crimped with an approved crimp tool. Where hand operated crimping tools are used, the tools shall be of the type which will not release until full compression is applied. Hexagonal crimping dies shall be used on all cables of 70 mm² cross section and above. Lugs shall be approved by the Principal’s Representative and shall be tinned copper.

Terminating of cables to motors and other equipment, which have a requirement to be moved for maintenance or adjustment purposes, shall be such that the motor or equipment can be moved through its range of adjustment without disconnecting or damaging the cable. Note that SWA cable must not be considered as flexible cable.

Where practicable, the motor cables are to be installed so that they can be connected to either side of the motor. Sufficient length of cable shall be left to allow for neat and safe terminations. This is to ensure that if the motor is changed out and the terminal box of the replacement motors are on the opposite side, cables do not have to be extended.

Where it is required that SWA or other large cables be connected to equipment that is too small to accommodate the gland, or if permanent wiring is provided with equipment (e.g. solenoid valves), then cables shall be terminated in a conveniently located 2-way junction box. The connection to the equipment from the junction box shall be made using steel PVC coated flexible conduit and approved fittings. Alternatively, in situations where there is a very low risk of mechanical damage, PVC cables may be used at the discretion and approval of...
the Principal’s Representative. In such instances the length of the PVC cable shall not exceed 300mm, and cables shall be terminated using glands.

Only one wire / cable core shall be crimped into each connector.

Terminal strips shall be provided within enclosures and equipment for control cable terminations. Terminal strips shall be provided with the number of terminals required on the drawings plus 10% spare rail capacity. Terminal blocks shall be coloured as follows:

- 240 V white
- 24 V grey
- Analogue yellow
- Intrinsically safe blue
- Earth green/yellow.

Where control cables and power cables (above 50 VDC) are connected to terminal strips in the same enclosure approved protective covers and warning labels shall be installed over power connections.

Each terminal shall be identified with a number in accordance with the drawings using permanent clip on non-flammable terminal markers with black characters on a white background.

4.7 Jointing
All Cables shall be supplied and installed in one length without joints except

Flowmeter cable shall be in a single continuous length and shall not be joined in any circumstances.

However, the Contractor may submit to the Principal’s Representative for approval any intention to install in-line joints in cables where the manufactured supplied cables are not of suitable length.

All joints shall be affected using an approved cable joint kit as specified in the specification for preferred electrical equipment. The following precautions shall be strictly observed when making through joints:

- Cables shall be laid so that the lay of the cores is maintained throughout the length of the cable. Crossover of conductors within cable joints will not be permitted. Any crossover shall be carried out at the termination box.
- Continuity of core numbering shall be maintained in all joints unless otherwise allowed by the Principal’s Representative (i.e. joining to existing cables).
- To ensure correct phasing out of power cables, the continuity of core throughout the cable shall be confirmed before cores are terminated.
4.8 Labelling & Identification

All cables shall be labelled. Each label shall be identified with the cable number or title as called for on the drawings. Labels shall be affixed to cables at both ends. Additionally, labels shall be affixed at cable tray junctions, at entries to and exits from trenches, walls and other obstructions, and at any point beyond which the cable may not easily be traced.

All floor mounted bottom entry equipment shall have cable identification both inside and outside the enclosure.

Cable numbers shall be read from left to right and bottom to top.

All items of equipment shall be labelled:

- GPOs and light switches shall be labelled by means of cable labelling and by a separate label adjacent to the device. Labels shall indicate the switchboard and breaker of origin for that circuit and the relevant circuit diagram drawing number.
- Field devices shall be labelled as per the drawings or directed by the Principal’s Representative (tag numbering or device numbering) and shall include the relevant circuit diagram drawing number.
- Motors shall be labelled with a 180 x 80mm label fastened with four stainless steel screws to the drive support steelwork and positioned such that it is visible from the local control unit. Label designation shall match that of the drive LCS and with letters sized to fill label.

If necessary a galvanised 3mm steel mounting plate shall be fixed in position to provide a suitable mounting.

Labelling of equipment shall be the responsibility of the Contractor performing the electrical installation (i.e. connecting to the equipment).

Switchboard circuit identification shall be by means of an individual label for each circuit breaker, fixed adjacent to the circuit breaker. Labels indicating “SPARE” or “SP” shall be installed adjacent to spare circuit breakers and circuit breaker spaces.

All labels shall be attached to the equipment with epoxy resin glue or stainless steel screws, but only if the IP rating is not lowered or reduced.

In the event that suitable tags are not already fitted, the Contractor shall record all nameplate details of the equipment to submit to the Principal's Representative. The Contractor will then arrange for suitable tags to be installed. This is subject to agreement by the Principal's Representative where applicable.

The cores of all cables shall be numbered with white engraved ferrules with black numbers to correspond to the relevant termination diagrams and equipment drawings. Wrap around adhesive markers are not acceptable. The Contractor shall ensure that the component numbers of the identifier are aligned and that the identifier is clearly visible. Ferrules shall be of a sleeve type which will not slip off the ends of the cables. Unless otherwise specified, all
control cables core terminating within switchboards, control panels, junction boxes, etc. shall be fitted with ferrules and identified in accordance with the drawings. Wire numbers for spare cores not shown on the drawings shall be labelled “SP” or “SPARE”.

4.9 Earthing

4.9.1 Earthing General
Earthing shall be strictly in conformance with the SAA Wiring Rules, (AS3000).

Radial connections to the earth grid system shall be PVC yellow/green insulated. Connection shall be with an approved heavy-duty compress-on profile “C” copper connector to the grid conductor, and lug bolted to equipment. Conductor size shall be 120mm² copper.

Connections to the earth electrodes shall be by means of stainless steel "V" bolt clamps which shall be housed in an earthenware or concrete pot or as approved by the Principal’s Representative and fitted with a lid at ground level. The connections shall be wrapped in “Denso” tape.

All earth connections, including earthing connections between dissimilar metals such as copper and stainless steel, shall be protected against corrosion by painting with zinc rich paint.

Earth connections within equipment shall be terminated at earth bars, with one conductor per screw or stud. Earth bars to have 2 screws per tunnel.

An earth conductor shall be connected to all high voltage cable glands unless otherwise required by the protection system.

Each earth wire shall be wired directly to the panel earth bar. Earth terminals, such as rail mounted terminals, are not acceptable. A common connection via the terminal mounting rail is not acceptable. Similarly, a loop of earth connections is also not acceptable.

All cable ladder runs shall be electrically continuous throughout and shall be bonded to the switchroom main earth bar with 25mm² green/yellow PVC earth cable. Similarly, any section that is not electrically continuous (i.e. hinged swivel plates, fish plates on painted ladder, etc.) shall be made continuous by bridging with a 25mm² bonding earth cable.

Contractor to consider any likely Ergon Energy earthing grid requirements within scope of contract works (if applicable).

4.9.2 Equipotential Bonding
Values for touch and step potential for all electrical installations in case of a fault shall be kept within the limits required by legislation and the relevant Australian Standard.

Conductors connecting individual equipment and cable ladder to the main equipotential conductor (branch connections) shall be minimum 35 mm² copper, with green / yellow insulation.
In exceptional situations and with prior approval by the Principal’s Representative, alternative bonding may be installed, e.g.:

- Flexible cable with green/yellow insulation or sleeving of cross-section equivalent to 35mm2.
- Smaller size flexible cable (minimum size 6 mm2) for small equipment where bonding with 35 mm2 conductor is not practical.

Connection of the branch connection conductor the main equipotential conductor shall be with approved compression profile “6” copper connections.

4.10 Specific Electrical Equipment

4.10.1 Switchboards and Feeder Pillars

Where an MSB has been transported as two or more shipping sections it shall be levelled to ensure alignment of busbar connections and uniform bolting together of sections. Fixing of MSBs to the floor shall not be carried out until the sections have been connected.

After assembly and prior to the Ductor testing, all accessible bolts shall be checked for tightness. Following checking, the bolts shall be distinctly marked to verify that they have been checked.

Field cables shall be neatly bunched or loomed within the MSB cable compartments. Cables shall be supported within the cable compartments by perforated tray and the use of PVC cable ties to avoid strain on field terminals.

To provide slack, cable cores shall be looped adjacent to field terminals. Alternatively where cable ducts are provided, cores shall be "snaked" within the ducts.

4.10.2 Feeder Pillars

The installation of a Feeder Pillar shall be taken to include all associated works including mounts / foundations, base, stands, sunhoods, equipment and enclosures.

Feeder Pillars shall be constructed of 3 mm marine grade aluminium all 5251-h34 to AS1734 with folded welded joints, stiffened where necessary to form a weatherproof enclosure to min IP65, supplied complete with sunhood.

All Feeder Pillar equipment shall be mounted on a removable gear tray. It shall be the responsibility of the Contractor to size the Feeder Pillars as the relevant Technical Specification and provide adequate clearances between items of equipment and to allow sufficient space to terminate both internal and external cables.

Where provided on the Feeder Pillars, isolators shall:

- Be rated for uninterrupted duty, utilisation category AC23B at the continuous currents nominated.
- Be gang operated fault make, load break, manually operated units with facilities for locking in the OFF position.
- Be provided on the front access door interlocked such that the door cannot be opened unless the switch is open.
- Be double break type.
- Be provided with a padlockable lockout device such that when a padlock is applied, the door cannot be opened.

Cable lengths between Feeder Pillar and pumps shall be of sufficient lengths that are adequately supported and allow removal of the pumps to the hardstand adjacent to the wet well without disconnection.

All power circuits on equipment terminations, uninsulated conductors, busbars and the like remaining live within an enclosure whilst the door is opened and the isolator is in the OFF position, shall either be effectively shielded, shrouded, sleeved or booted to the extent that a person holding a uninsulated pointed tool (e.g. screwdriver) cannot inadvertently come into contact with a live power circuit. Shielding, shrouding, sleeving or booting that is removable shall be labelled "DANGER ALIVE - ISOLATE ELSEWHERE" or other approved labelling.

The Feeder Pillars shall contain the necessary terminal strips to allow for terminal of all control or instrumentation cabling associated with the installation. All control selector switches shall be supplied complete with the appropriate escutcheon engraving clearly identifying individual actions.

Internal wiring shall be concealed in wiring ducts. Where control wiring accesses door mounted equipment the wiring shall be loomed and a loop left between the door and the terminal strip.

Where a plug and socket connection is shown on the single line diagrams, the plug socket shall be surface mounted on the side of the Feeder Pillar. The plug socket shall be or Marechal make or approved equivalent and a 60 or 90 degree model such that bending stresses from the attached cable are eliminated. Where link bolts are shown on the drawings, the Feeder Pillar shall consist of a segregated, separately lockable compartment containing the link bolt terminals.

The Feeder Pillar shall be provided with labelling. External labelling shall consist of the following:

- “Feeder Pillar Number”
- “Equipment Name & Rating”
- “Source of Supply – Main Switchboard / Starter Panel Module Number”
- “Electrical Schematic Reference”
- The Feeder Pillar shall be provided with an earth bar of satisfactory dimensions.
- Feeder Pillars shall be used for the marshalling and looping of all field cabling, and housing of field surge protection devices.
- A single Feeder Pillar shall be provided for both Pump Stations as per the technical specifications.

4.10.3 Small Power and Lighting Distribution Boards
Distribution boards shall be constructed from proprietary supplier equipment and should be not purpose built.

All distribution boards shall be fitted with a main switch comprising either a load break / fault make isolator or circuit breaker. The fault rating of the distribution board shall be suitable for the area in which it is to be installed.

All lighting and power outgoing circuits, as required by AS/NZS 3000, shall be protected by 30mA earth leakage protection on a per circuit basis.

All welding outlets shall be protected by 30mA earth leakage protection on a per circuit basis.

Provision shall be made for earth leakage test points for the testing of each individual circuit without accessing live parts of the board.

4.10.4 Lighting and General Purpose Power
Light fittings, light fitting supports and switches shall be located and installed as shown on the drawings. Lighting equipment, GPO's and welding outlets may be subject to minor relocation on site to avoid conflicts, or to suit site conditions and specification requirements, as approved.

All general purpose outlets shall be fitted with an isolating switch.

General purpose outlets shall be hose proof and weatherproof to IP56 degree of protection, high impact polycarbonate. Three phase outlets shall be hose proof, dustproof and weatherproof to IP56 degree of protection. They shall be switch interlocking plug receptacles rated at a minimum of 415 V, 3 phase, 50 Hz, 30 A, high impact polycarbonate. All outlets installed in direct sunlight shall have additional sun protection in the form of an approved sunshield.

Switched socket outlets shall be mounted 1300mm above the operating floor unless shown otherwise on the approved drawings. Outlet locations shall be generally as shown on the approved drawings. Approval shall be obtained before the location of any socket outlet is changed.

Outdoor lighting shall be PE cell controlled, the only exception being emergency lighting. Where required outdoor lighting required for maintenance activities shall be provide with a manual local over-ride of the lighting control system.

All light fixtures and accessories including circuit junction boxes shall be readily accessible for maintenance either from floors, landings, crane, machinery platforms or ladders. Prior to installation, the location of all light fittings shall be checked for interference with structures,
piping, equipment or personnel in the performance of their normal duties off the floor, platform or walkways. Approval shall be obtained before the location of any light fitting is changed.

Where Unistrut or other metal duct is used to contain and support cables and fittings, the distance between supports shall be approved by the Principal's Representative, and shall not exceed 3000mm.

4.10.5 Cranes and Hoists (where applicable)
Installation of cranes and hoists shall comply with the SAA Crane Code AS1418.

Each crane power supply isolator located near the crane access ladder shall be clearly labelled "Crane Supply Isolator". The equipment number and source of supply shall also be detailed on this sign.
5 Instrumentation Technical Requirements

5.1 General Requirements

5.1.1 Power Supply
All AC powered instruments shall be powered from mains supply as follows:

- 415 VAC, 50 Hz
- 240 VAC, 50 Hz.

All instrumentation requiring auxiliary power shall be fed via dedicated circuit breakers in instrumentation section of the MSB”s. Lighting and general purpose power distribution boards shall not be used for the purpose of supplying power for instrumentation.

For two-wire transmitters, the nominal 24VDC supply shall be supplied on an individual instrument basis from the respective analog input point of the Control System.

Where applicable all instrument power distribution boards shall contain suitably rated, DIN rail mounted, moulded case, miniature circuit breakers, each clearly and permanently labelled as to their purpose.

The circuit breakers must be capable of being locked in the off position.

Surge reduction filters shall be provided as necessary to protect all instrument power supplies against input overvoltage and mains borne sags, surges and impulses originating from lightning, switching operations or other causes. The surge reduction filters shall be placed at both ends of the instrument power cable. The surge reduction filter shall be rated at 250 VAC, 40 kA on a single shot 8/20 ms impulse and shall be capable of continuous supply of 10 A. The maximum let through voltage of the device shall be 500 V.

5.1.2 Sensors
Sensors shall be supplied such that they are compatible for the process installation and the environment in which they are to be installed.

Where sensors are remote from the transmitter, sufficient proprietary cable for connecting the two shall be provided.

Sensors shall be provided with all additional hardware required to facilitate the installation of the unit in the nominated process.

5.1.3 Transmitters
Transmitters shall be remote or integral to the primary sensor as approved by the Principal’s Representative. Preference will be given to transmitters which are capable of performing multiple diagnostic analysis through the application of different software.
Where possible, "Smart" transmitters shall be offered as an option in addition to the standard models. Communications shall utilise an internationally recognised protocol with transmission via high frequency signal superimposed on top of the 4-20 mA output signal. "Smart" communications to the transmitter shall allow remote interrogation, diagnostics and reconfiguration without interruption of the transmitters signal to the control system.

5.1.4 Accuracy
The accuracy of each instrument shall be within ± 1% of span unless otherwise specified. Accuracy shall be defined as follows.

- For primary elements and their associated signal converters/transmitters: The accuracy shall relate the analogue signal output to the physical process variable.
- For secondary instruments, accuracy shall relate the output signal, indication or pen record (as appropriate) to the analogue input signal.

All instruments shall be suitable for continuous unattended operation and shall maintain their rated accuracy with a minimum of maintenance or need for calibration and adjustment.

5.1.5 Output
The analogue output of all electronic signal converters, transmitters, controllers, etc., shall be a 4 to 20 mA signal. Each output shall be capable of operating into a load in excess of 600Ω. Discrete outputs (on/off) of all electromechanical equipment such as flow switches, level switches, relay circuits, etc., and of all electronic switching devices such as electronic level and limit switches, etc., shall be voltage free contacts rated for at least 2 A at 24 VDC unless otherwise specified.

5.2 General Field Instrumentation Requirements

5.2.1 General
Field instrumentation shall include the primary measuring elements and associated instrument transmitters for sensing of physical and analytical plant variables, and discrete process devices required for satisfactory monitoring and/or control purposes.

The Contractor shall ensure that the most suitable type of instrument is selected and installed for each application. The Contractor shall submit the proposed Instrument Supply list to the Principal’s Representative for approval prior to purchasing the same.

5.2.2 Mounting of Instruments, Controls and Accessories
Installation of instrumentation shall be in accordance with Manufacturer’s Instruction Manuals.

Except as otherwise directed by the Principal’s Representative, all equipment shall be installed as near as practicable to the position required or as shown on the approved Contractor drawings. Small variations to facilitate fixing of equipment are permitted subject to approval of the Principal’s Representative.
Instruments shall be mounted in accordance with the approved Contractor instrument drawings and detail sheets furnished by the Manufacturer. Instruments shall be rigidly supported, level and plumb, in such a manner as to provide accessibility; protection from damage; and freedom from interference with other equipment, piping and electrical work.

All instrument devices including accessories shall be located where they shall be accessible from structural platforms, permanent ladders, or final grade. Height for mounting instruments shall be 1300mm above grade or platform, to the centre of the instruments. All locally mounted instruments shall be in line of sight and within reading distance of normal operating area.

Sufficient clearance shall be provided for the removal of transmitters, level probes, floats and temperature elements.

Where sunlight or spillage on to field items is likely, these shall be fitted with shields for protection.

Mounting Restrictions - No structural member may be drilled, chipped or torch cut without specific prior approval by the Principal’s Representative. Hand rails shall not be used for mounting or supporting instruments. Where instruments are installed adjacent to hand rails, minimum of 150mm clearance shall be maintained.

All Junction Boxes shall be securely mounted in a workman like manner and shall be installed plumb with surrounding structural steel members.

No Instrument or Instrument Stand shall be mounted directly on the floor of a bunded area.

All Field Instruments are to be tagged with their relevant Instrument Tag number. The Tag name plate shall be made from stainless steel, with characters not less that 5mm high and secured with stainless steel hardware.

Tag Name Plates shall not be mounted directly on any instrument housing. Where instrument stands are required, the name plate shall be affixed to the front plate provided for this purpose.

5.2.3 Instrument Earthing
The earthing design for each instrument installation shall include for the provision of two separate earthing systems. These being:

- The electrical safety earth and
- The instrument system earth.

The instrument system earth shall be bonded to the electrical safety earth system only at the main electrical safety grid (or stake). This equipotential bond connection shall be a PVC green/yellow stripe insulated copper conductor having a minimum cross sectional area of 120 mm².
All instrument earth cables from instrument system earth bars in marshalling and equipment cabinets (where applicable) shall be connected to the instrument system earth.

All earth cables from electrical safety earth bars in marshalling and equipment cabinets (where applicable) shall be connected to the electrical safety earth grid.

Each earthing system shall be tested from each instrument earth bar and the results recorded using approved testing equipment and forms.

**Cabinet earthing**

All instrument marshalling and equipment cabinets shall have two separate earth bars as follows:

- An electrical safety earth bar for the connection of earths for mains powered equipment, earth wires from multi-core cables, cable armouring, gland plates and the cabinet frame.
- An instrument system earth bar for the connection of shield (drain) wires from shielded signal cables. The instrument system earth bar shall be isolated from the cabinet by insulated mounts.

**Cable Shield Earthing**

The shields of instrument cables shall be earthed at the marshalling cabinet only (as applicable).

The shield wire of instrument cables shall be cut off and insulated at the field instrument end of the cable. The continuity of shields of instrument cables shall be maintained through all junction boxes and terminal strips.

5.2.4 Instrument Junction Boxes (where applicable)

Junction boxes shall be fitted out to provide a fully functional assembly ready for field termination. Any instrument and control equipment specified for the box shall be wired to terminal blocks as detailed on the drawings.

All junction boxes shall be of stainless steel or hot dipped galvanised steel construction or other approved equivalent. They shall be fitted with Metal Mounting Pans and sealed with compression neoprene gasket type covers unless otherwise indicated on the drawings.

The junction box arrangement, outside dimensions and layout shall be suitable for the installation of the nominated equipment and termination of relevant cabling. All junction boxes shall be of appropriate dimensions to allow for approximately 10% spare capacity and ensure neat appearance.

Wiring between the cable entry and the terminal strips and between terminal strips shall be enclosed in closed slotted PVC cable duct. The ducting shall be supplied, sized and installed.
to carry at least double the maximum cable capacity of the adjacent terminal strip unless otherwise specified in the accompanying documentation.

Terminal rail shall be of a length to fill the useable space and not limited to the length required for the number of terminals nominated.

Cable duct, terminal rail and any other equipment that is to be mounted on the mounting pan shall use metal screws in pre-tapped holes. Screws with nuts behind the mounting pan or self tapping screws shall not be used.

Unless otherwise specified in the accompanying documentation, cable duct shall be mounted such that there is a clearance of at least 50mm between the duct and terminal strip.

5.2.5 Indicators
Indicators shall be of the digital display type of flush mounting pattern utilising a LCD or LED display. They shall be fitted with an inconspicuous front panel zero adjustment. Indication shall be sufficient to allow for accurate reading at a distance of 3 m from the unit.

Indicators shall be scaled from 0 to 100% or as otherwise specified. Indicators shall include continuously variable span and zero adjustments. Adjustment shall be provided via inconspicuous front panel controls. Each indicator shall accept a 4-20 mA signal input with a maximum input resistance of 100Ω. Each indicator shall be mounted in an enclosure to at least IP65. The enclosure is to be stainless steel or as otherwise specified.

5.2.6 Intrinsically Safe Instruments (where applicable)
Where Intrinsically Safe (IS) instruments are specified and the transmitter will be installed in a Safe Area separated from the sensor, the instrument system shall be supplied as an Integrated Certified Intrinsically Safe System. Certified equipment shall be supplied for the connection to the sensor in the Hazardous Area In all other cases, the supply of instruments as an Integrated Certified IS System is preferred. Where Intrinsically Safe Interfaces are required they shall be of the Galvanic Isolation type.

All instrumentation supplied for installation into Hazardous Areas shall be provided with current Aus Ex or IEC Ex Hazardous Area Compliance certificates. ATEX certification alone will not be accepted.

5.2.7 Instrument Tagging
Instruments and control devices shall be tagged in accordance with the approved data sheet provided by the Contractor.

Panel instruments shall be affixed with metal tags visible from the back of the panel. The metal tags shall show the instrument number. Instruments with removable chassis shall be affixed with a metal tag on the chassis and housing showing the instrument number.

The suppliers of all field instruments shall provide a permanent non-rusting metal tag attached to their equipment by metal screws, pins or stainless steel wire. The tag shall be stamped with the instrument tag number. A metal tag giving the instrument number shall be
supplied and attached by the Contractor in the event of the original tag becoming damaged or lost.

5.3 Instruments
All wetted components of the instruments, including cabling and connection manifolds as required, shall be constructed of materials where specified or otherwise suitable for the process fluids of the application.

5.3.1 Level Measurement

Level Transmitters (pressure transducer type - preferred)

Submersible level transmitters shall be loop powered and shall provide a 4-20 mA output signal proportional to the measured level.

Level Transmitters (Guided Radar Type)

Guided Radar level transmitters shall be loop powered and shall provide a 4-20 mA output signal proportional to the measured level. The transmitter or connection box shall include a digital indicator. Provision shall be made at the transmitter for independently adjustable span and zero adjustment and adjustable internal damping.

Level Transmitters (Ultrasonic Type)

Ultrasonic level transmitters which shall only be applicable with use of V-Notch flow control shall be loop powered and shall provide a 4-20 mA output signal proportional to the measured level. The transmitter or connection box shall include a digital indicator. Provision shall be made at the transmitter for independently adjustable span and zero adjustment and adjustable internal damping.

Level Sensors (Multiple Point Conductivity)

Probes shall be cable suspended PVC tube body with stainless steel sensors located at 150 mm increments along the height of the probe. Each sensor shall be wired out to allow connection of all or any level to extra low voltage control equipment. The cable sheath, probe body and sensors shall be suitable for long term operation in the environment in which it shall be installed. The probe shall be fitted with cable of sufficient length to terminate in the switchboard or Feeder Pillar without joints, suspended from a purpose built stainless steel bracket incorporating a flexible probe cleaner. Where specified, a pump controller shall operate in conjunction with the multipoint conductivity level probe. The controller shall be self contained to control two pumps and alarms, and shall feature:

- incremental bar graph indication of well level
- selectable levels for each pump start, stop, and alarm
- selection of pumps to duty, standby or alternating
- selection of fill or empty modes.
Level Switches (Float Type)

Each level switch shall be of the float activated bulkhead mounting type. Float, stem and other wetted materials shall be constructed from inherently non corrosive material and suitable for the proposed application. Each level switch shall be provided with a voltage free, changeover contact.

5.3.2 Flow Measurement

Mag Flow meter

The Magflow meter transmitter shall be separately powered from a 24V DC supply and shall provide a 4-20 mA output signal proportional to the calculated flow rate. The static pressure range and maximum working pressure of the pressure transmitter shall be as specified or as otherwise suitable for the application. Positive over range protection shall be provided.

The transmitter shall include independently adjustable zero and span adjustment and adjustable internal signal damping. A digital display shall be included at the transmitter. The differential pressure transmitter shall be supplied with a three valve manifold. Auto-calibrating type Magflow meters shall be specified.

Flowmeter cable shall be in a single continuous length and shall not be joined in any circumstances.

5.3.3 Temperature Measurement

RTD’s

Unless otherwise specified resistance thermometers shall be utilised for temperature measurement. Each resistance thermometer shall include a 3 wire platinum resistance temperature detector. The sensing element shall be sealed in a ceramic former and enclosed in a stainless steel sheath. Each RTD shall include a suitable connector head, with enclosure class equivalent to IP65 allowing cable entry via a compression type cable gland.

A "3 wire" circuit shall be used between each RTD and the associated converter. The converter shall be located in the RTD connector head. Cabling to current converters shall be of the “two wire" type deriving electrical power from the loop 24 VDC supply. Converters shall include continuously variable span and zero. The output shall be a 4-20 mA signal with respect to temperature.

Temperature Switches (Thermostats)

Temperature switches (thermostats) shall be of the mercury bulb type. Where specified or as otherwise required a copper tube protected capillary shall be provided for connecting the switch mechanism to the remote bulb installation. A calibrated adjustment for the set point shall be provided. The adjustable set point range shall be such that the noted set point falls between 30 and 70% of the adjustable range. The switch shall be of the automatic reset type with an adjustable switching hysteresis (except where noted). Wetted materials shall be
suitable for the application. Each temperature switch shall satisfy enclosure class IP65 or better and shall be provided with voltage free, changeover contact.

5.3.4 Proximity Sensors
Proximity sensors shall be either 3 wire PNP or two wire make function inductive devices. Proximity sensors shall withstand reverse polarity connections and shall incorporate short circuit protection.

5.4 Pre-Installation Testing

5.4.1 General Requirements
The Contractor shall carry out a pre-installation test on each instrument as soon as practicable after the receipt of the instrument. The tests shall be carried out in accordance with the manufacturer’s instruction manual.

The Contractor shall ensure during the pre-installation testing that each instrument has been supplied in accordance with specifications, is correctly tagged and calibrated and is functioning correctly.

The Contractor shall test all instruments in the up-scale and down-scale directions to determine the amount of hysteresis.

Electronic instruments that have been factory calibrated should only be adjusted if the “As Found” errors are significant. (The test equipment used at the manufacturer’s works is often more accurate than is available at site workshops). The Contractor shall notify the Principal’s Representative prior to making any adjustment.

The Contractor shall notify the Principal’s Representative immediately of any defects which cannot be rectified or of any instrument which cannot be calibrated within a reasonable period of time. This notification shall be confirmed in writing.

Where circumstances prevent the Contractor from carrying out of the prescribed test, a test method shall be agreed with the Principal’s Representative in writing.

The Contractor shall obtain the approval of the Principal's Representative in writing before any non-standard modifications or adjustments are made.

The Contractor shall perform tests that will simulate as closely as possible the design process conditions, by the use of manometers, potentiometers, resistance bridges, dead weight testers, test-pressure gauges, electric and pneumatic supplies.

The Contractor shall ensure that electronic instruments undergo a warm up period as per the manufacturer’s recommendations prior to any calibration tests.

The Contractor shall record all adjustments on the Instrument Calibration Report. If no adjustments are made, the comment “No adjustments made” shall be recorded. The “As Found” and “As Left” percentage errors shall be recorded.
The Contractor shall ensure that upon completion of tests, the instruments have been drained of any fluid used during testing and shipping stops replaced.

Upon completion of tests, the Contractor shall hand the signed Instrument Calibration Reports to the Principal's Representative. All evidence and records of abortive tests shall also be handed to the Principal's Representative at this time.

5.4.2 Pre-Installation Test Procedures - General
The Contractor shall ensure that each instrument type has been supplied with a manufacturer’s instruction manual that includes the calibration procedures for the instrument. The Contractor shall hand any factory calibration certificates supplied with the instrument to the Principal's Representative.

The Contractor shall ensure that all calibration equipment has been checked and approved as suitable for performing the tests.

The Contractor shall ensure that the atmosphere in the calibration room is dust free and clean.

The Contractor shall ensure that all shipping stops have been removed from the instruments before starting the procedures listed below. Miscellaneous components such as charts, mercury, oil, shall be correctly installed.

5.4.3 Pre-Installation Testing of Transmitters, Receivers and Controllers
The Contractor shall connect the test equipment to the instrument in accordance with procedures given in the manufacturer’s instruction manual.

Before starting on any tests on transmitters, controllers and so on, the Contractor shall manually ensure that instruments will give the required full output signals (100kPa or 20 mA as appropriate).

The Contractor shall check the calibration of all instruments at 0%, 25%, 50%, 75% and 100% of the instrument range (rising and falling) and record the corresponding instrument readings on the Instrument Calibration Report.

The Contractor shall check that the accuracy of the calibration meets the manufacturers quoted accuracy and the calibration is as per the data sheet for the instrument.

5.4.4 Pre-Installation Testing of Switch Instruments
The Contractor shall check all flow, temperature and level switch instruments as follows.

The Contractor shall connect the test equipment to the instrument in accordance with the manufacturer’s instruction manual.

The Contractor shall check the switching points are set as per the data sheet settings. For the instruments that have not been factory calibrated, the Contractor shall adjust as required.
The Contractor shall check the difference between set and reset values are within specified limits.

The Contractor shall record the results of the calibration tests on the Instrument Calibration Report.

The Contractor shall attach the appropriate label to the instrument to show it has been Pre-Installation Tested.
6 Inspection, Testing and Pre-Commissioning

6.1 General

The Contractor is completely responsible for the satisfactory installation testing and pre-commissioning according to the relevant Australian, IEC or other appropriate standard and to the requirements of the Principal's Representative. The Principal's Representative reserves the right to inspect at any time, the shop drawings, equipment, materials and installation called for in this Specification and on the drawings during manufacture, installation and pre-commissioning.

The Contractor shall provide the Principal's Representative with a complete dossier of all electrical testing and pre-commissioning works to be completed, including a copy of the relevant test sheets to be completed as part of the works. The Contractor shall keep testing and pre-commissioning records. Copies of these records shall be available for inspection / review by the Principals Representative immediately upon request.

Any defects identified during testing shall be rectified and documented by the Contractor. All testing shall cease while remedial work is being carried out. The Contractor shall repeat inspections and tests following completion of remedial work and document the results.

All medium and low voltage installations shall be tested by experienced qualified tradespersons who are certificated under the Electrical Safety Act.

All necessary tests shall be performed and recorded before energising any equipment or circuit. Should any dispute arise from test results so recorded, such tests shall be repeated as directed.

Equipment shall be disconnected before and during testing as required by the relevant standards and as directed. All equipment disconnected shall be recorded on the test reports. Equipment to be disconnected includes electronic equipment during megger tests.

The Contractor shall provide all temporary barriers and warning signs, including signs on switchboards, starter panels, etc., to adequately protect and warn of danger during testing and commissioning periods as directed.

6.2 Test Instruments

All test equipment shall be in good working condition and shall have a current NATA calibration certificate. Copies of calibration certificates shall be produced as requested.

The Contractor shall provide all test instruments and equipment required to carry out the complete range of tests in accordance with this specification. Test equipment shall be approved. Where equipment is found to be unsuitable during testing it shall be replaced immediately.
6.3 Testing Requirements
Statutory testing shall be carried out on every new installation and where alterations or additions have been made to existing installations.

At the minimum, the following testing and pre-commissioning shall be provided:

- Mandatory Tests in accordance with Clause 8.3.3 of AS3000.
- Optional Tests in accordance with Clause 8.3.4 of AS3000.
- The insulation resistance of every complete lighting and power circuit including all machinery, cables and apparatus forming part of or in connection with such circuits either collectively or in parts.
- The electrical continuity of all earthing conductors and metallic coverings if used as such.
- The effectiveness of all electrical safety devices and protection systems.
- The effectiveness of earth leakage protection systems.
- The earth resistance of earth electrodes and other earthing systems.
- Instrument configuration and calibration.
- Other testing and pre-commissioning procedures to be completed as per Manufacturers recommendations.

6.4 Point to Point Tests
Prior to energising of any circuits, the Contractor shall carry out point to point continuity tests of all control and power circuits. Such tests shall be carried out with all control and power fuses removed.

6.5 Testing of Current Transformers
All current transformers shall be tested by primary injection, during which turns ratio, polarity, correctness and continuity of wiring up to the protection relays, indicating devices or metering shall be checked.

6.6 Testing of Protection and Indicating Devices
All current operated protection devices shall be tested by secondary injection. The test shall be for at least three current levels widely spaced on the relay setting range. One test point shall be the final setting.

All earth leakage relay units shall be checked for correct setting and installation of wiring, and shall be tested by both primary injection and operating the test trip button.

Thermistors and connecting cables shall be tested for insulation resistance and continuity. Operation of thermistor control units shall be checked by temporary disconnection of one wire at the motor thermistor terminals.

All ammeters, transducers and other current operated metering devices shall be tested and calibrated by secondary injection testing.
6.7 Testing of Cables

All testing shall be performed prior to the energising of any cable installation. After completing the termination of the cable at each end, the cable shall be disconnected from the termination points to enable testing.

LV cables shall be subjected to the following tests:

- Inspection for damage to the cable following installation.
- Insulation resistance test at 1000V between phases and between each phase and earth before and after the high voltage withstand test.
- High voltage withstand test between phase and the other phases and earth (1 up, 2 down) at approved voltage levels. Leakage currents shall be recorded.

The megger voltage output shall be at least twice the nominal voltage between conductors when energised. The minimum acceptable reading shall be 1 (one) megohm.

The continuity of the earth conductors shall be tested. Values measured shall not exceed 2 (two) ohm.

Following insulation and voltage withstand tests the cable shall be reconnected and the following tests performed:

- Check of torque for each connection and marking of the bolt and nut position with respect to the terminal using a marker pen.
- Ductor test of each connection.

All power cables shall be checked for correct phasing.

Instrument cables shall be tested in accordance with the relevant instrument/specification.

6.8 Testing of 415V Main Switchboards (MSBs)

Insulation tests shall be performed after the installation is completed, with the main feeder cables and all outgoing circuits disconnected. All devices containing electronic components and other equipment as directed shall be disconnected during insulation tests.

Resistance tests shall be performed on all busbar joints and connections made during erection.

The following tests shall also be performed:

- Current Transformer tests to this specification.
- Protective Devices tests to this specification.
- General testing to this specification.

All thermal overloads shall be set at 100% motor full load current.

The phase rotation of incoming supplies at each MSB main circuit breaker shall be checked.
6.9 Testing of VSD Systems
Each VSD complete with ancillary shall be subjected to and satisfactory withstand the test specified in the relevant Australian Standard.

a) Type Tests
   - All new VSD’s must be type tested.
   - The Vendor may, in lieu of test, produce evidence of satisfactory completion of such tests on identical equipment for review. Where such evidence cannot be produced to TRC’s satisfaction, the equipment to be supplied shall be subjected to the type tests required by TRC at Vendors cost.

b) Routine Tests
   - All drives shall be routine tested

c) VSD Site Acceptance Test
   - Contractor shall test and measure the followings:-
     - THD at PCC to ensure that the reading less than 2.5% for 7 days.
     - Temperature rise
     - Pump performance

6.10 PLC Systems
Upon completion of each PLC installation such that the PLC System is fully assembled in its final configuration the following tests shall be completed:

   - Insulation resistance tests.
   - Testing of protective circuits.
   - Testing of all control and interlock circuits to ensure satisfactory operation.
   - Check of wiring and terminations.

Following satisfactory results of the above testing, the PLC shall be energised and the relevant PLC Programme loaded. Following successful loading of the programme the following tests shall be completed:

   - Operational check of the PLC and associated I/O.
   - Undertake functional testing of all digital and analog inputs and outputs associated with the PLC Control System.

6.11 Testing of Earthing System
All earthing systems shall be tested in accordance with the requirements of AS/NZS 3000.

The resistance to ground of every earth electrode, and of each complete earthing system shall be measured and recorded.

Sufficient testing shall be completed to ensure the earthing system designed and installed provides satisfactory levels of protection against prospective touch and step voltages, and transfer voltages if appropriate.
6.12 Testing of Batteries and Battery Chargers
The following tests shall be completed for any Battery Chargers / Battery Banks installed:

- Check and record specific gravity of batteries if applicable.
- Check voltage of each cell.
- Check the float voltage of entire battery bank.
- Check the boost voltage if applicable.
- Check all alarms indicated on the charger and output relays operate for remote alarming.
- Check load current.

6.13 Testing of Motors
The following tests shall be completed for all motors installed:

- 1000V Megger insulation test on windings with power cables connected taken at the MSB outgoing terminals. The temperature at the time of testing shall be recorded. Where required, the motor insulation shall be dried out by an approved method.
- Insulation and circuit resistance of motor heaters including connected cable shall be tested.
- The resistances of thermistor circuits shall be checked.
- Bearings shall be checked for brinelling.
- The bearing temperature shall be checked and recorded after a four hour run at no load.
- The no load current on all three phases shall be measured and recorded.

6.14 Testing of Distribution Boards
All distribution boards shall be subjected to a 1000V megger insulation check prior to energising. All load circuits shall be tested.

Tests as described in “General tests” below shall be performed.

Phase rotation of the incoming supply shall be checked.

All protection devices such as fuses, circuit breakers and the like shall be checked for correctness of type, size and application as shown on the drawings.

Circuit schedules shall be checked.

6.15 Testing of Lighting Systems
The insulation resistance of each circuit, including switch-wires shall be checked.

The continuity of the earth connections shall be tested.

The operation of all light fittings shall be checked.
A discharge test shall be carried out on all battery operated emergency units to establish the capacity of the batteries.

The operation of the daylight switched circuits shall be tested.

6.16 General Testing
All switchboard equipment shall be tested to prove the correct operation of closing and tripping mechanisms, starters, protective functions, interlocks and switching functions.

All circuit breakers, operating mechanisms, withdrawable switchgear and the like shall be checked for alignment and adjusted where required.

All alarm circuits shall be tested by operating the relevant initiating device.

All switches, pushbuttons, control devices and the like shall be tested for correct operation.

All indicating lamps shall be tested for correct operation.

6.17 Instrument Testing
The Contractor shall carry out pre-commissioning tests on installed instrumentation. Pre-commissioning tests shall include the following:

- Ensure by pressure testing that all instrument piping and tubing is pressure tight to the specified working/testing conditions.
- Check all electric and electronic instrument wiring for correct polarity, continuity and insulation resistance between conductors and earth.
- Carry out loop testing to prove that the installed instrumentation functions correctly and is in fit condition for plant commissioning to proceed.

The Contractor shall keep a record of all instrument pre-commissioning tests.
MAGNESIUM HYDROXIDE SPECIFICATION

WIRRAGLEN AND LORRIMER STREET SEWERAGE PROJECT
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1. General

1.1 Scope

This Specification shall apply to a complete magnesium hydroxide liquid (MHL) dosing system consisting of a magnesium hydroxide liquid (MHL) storage, dosing system and associated instrumentation and equipment for the Wirraglen Sewage Pump Station.

The Contractor is to provide the design, manufacture, supply, installation and commissioning of a complete magnesium hydroxide liquid (MHL) dosing system including, bunding and shed. The MHL dosing system to be supplied under this contract is to be in new and unused condition, and shall comply with the relevant drawings and schedules.

Scope of works includes, but not limited to:

- delivery to site;
- fabrication of equipment;
- installation;
- mechanical commissioning;
- packing;
- pre-commissioning;
- Process commissioning of equipment and supply of details to allow work by others to incorporate built in works and apertures.
- produce Contract documentations (details in section 1.3);
- quality control activities such as inspection, tests, etc.;

For any brands referred to in this specification, it is intended that this shall be “or approved equivalent”. All equipment and instrumentation shall be installed to the manufacturer’s recommendations.

1.2 Standards, Codes and Regulations

The following Australian Standards and Specifications shall apply unless otherwise noted. Please note that the current edition of any of the Australian Standards mentioned below shall take precedence.

AS4766-2006 Polyethylene storage tanks for water and chemicals
AS1170.2-2002 Structural design actions – Wind actions
AS1170.4-2007 Structural design actions – Earthquake actions in Australia
AS1722-1992 Pipe threads of Whitworth form
AS3500-2003  Plumbing and drainage
AS4020-2005  Testing of products for use in contact with drinking water
AS4087-2004  Metallic flanges for waterworks purposes
AS2634-1983  Chemical plant equipment made from glass-fibre reinforced plastics (GRP) based on thermosetting resins

1.3  Contract Documentation

The following technical information is required:

- data sheets for each equipment type including flow tolerances, measuring range, converter specifications, default mA settings, size, weight, temp range, description and material specification;
- Drawings and any other pertinent information;
- Equipment, valves and instrumentation lists;
- Information pertaining to the asset including recommended spares, maintenance and replacement over the lifecycle of the project;
- Installation instructions indicating assembly and mounting requirements, alignment and assembly tolerances, and
- Material of construction
- Operation and maintenance (O&M) manual - a complete description of operation together with general arrangement and detailed drawings, wiring diagrams for power and control, parts catalogues with complete list of repair and replacement parts with section drawings, illustrating the connections and the part manufacturer’s identifying numbers.
- Performance evaluation for MHL dosing equipment;
- pump specifications;
- The required ancillary equipment including but not limited to electrical and anchor bolts. The information shall provide the sizes, ratings, and any other information related to this equipment;
1.4 Drawings

The Contractor shall provide the following drawings:

- Dosing Area General Arrangement Drawing
- Electrical Drawings and Bills of Materials
- Process & Instrument Diagrams
- Pump Skid Pipework Detail Drawings
- Tank Detail Drawings

The Contractor shall submit draft drawings to Toowoomba Regional Council (TRC) for comment. Upon incorporation of TRC comments into the drawing a HAZOP will take place and equipment shall be procured, fabricated and installed based upon outcomes of the HAZOP. The HAZOP shall be organised by the Contractor.

2. Design

2.1 General

The MHL dosing systems shall be a complete chemical dosing system, comprising a storage tank, skid mounted dosing pumps, calibration tube, level sensing and bunding. All concrete and civil works shall be in accordance with Structural and Civil Specifications.

The MHL dosing system shall be fitted with:

- 1 off MHL storage tank with overflow and vent; a minimum of 2 months storage for MHL shall be provided;
- 1 off mixer inside the MHL storage tank;
- Tank access hatch and mixer access with ladders and platforms as required;
- All instrumentation to facilitate remote automatic operation including, control, level sensors in storage tank and alarms;
- all junction boxes, electrical wiring, cabling, conduits for power supply and control etc.;
- all necessary control and isolation valves including flush water control solenoid, non-return valves, ball valves, gate valves and pressure relief valves;
• all pipework including calibration column, strainer, flanges, gaskets, expansion joints, nuts bolts washers, pipe supports, grout, labelling, painting and directional arrows;
• Bunded concrete slab and surrounds;
• Connection to service water;
• Detailed control philosophy for dosing pumps operation, including MHL dosing control. The dosing is required to be synchronised with sewage pump operation and flow, with continuous dosing as a secondary option. The pump’s operation for both scenarios is to be manually adjustable within a suitable range (to suit increased flow rate during synchronised operation);
• dosing system connection points;
• Hold down and lifting lugs;
• Installation lifting points;
• lockable camlock at chemical delivery point to prevent inadvertent filling;
• MHL dosing pump;
• Quick delivery connection fill point for chemical;
• Safety signage and chemical tank labelling;
• Safety facilities, such as safety showers and eyewash stations; and
• Colour Bond Shed.

The MHL dosing systems shall be fully integrated systems complying with all relevant legislations and Australian Standards. The design shall be reviewed using a HAZOP process. Selected materials of all equipment provided by the Contractor are to be compatible with the use of magnesium hydroxide solution. Refer to the ‘information only document’ standard MHL product data sheet.

The Contractor shall include any additional equipment necessary to provide effective, safe operation and maintenance in accordance with regulatory bodies, Australian Standards and chemical Contractors.
2.2 **Design Basis**

1. A manually adjusted magnesium hydroxide liquid (MHL) dosing system, synchronised with the sewage pump station operation, is considered necessary for providing pH increase to the sewage rising main.

2. The contractor is required to demonstrate that variable dosing rates are able to be achieved by the dosing system, so that a PH of 8.5 is able to be maintained at the discharge point as the sewerage catchment develops.

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<tr>
<th>Flow Streams</th>
<th>Wirraglen SPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modelled ADWF flows catchment (ultimate)</td>
<td>1,670 kL/day</td>
</tr>
</tbody>
</table>

3. The MHL dosing pumps are to dose into the collecting manhole upstream of the Wet Well. The Contractor shall provide details of the nominated pumps and flow rate for approval to the Principal.

4. The effective volume of MHL storage tank for the Wirraglen Sewage Pumping Station is as follows:

<table>
<thead>
<tr>
<th>SPS</th>
<th>Tank</th>
<th>Minimum Storage Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wirraglen SPS</td>
<td>1 only</td>
<td>5,000L storage capacity for MHL</td>
</tr>
</tbody>
</table>

5. Three phase 415V or single phase 240V power supply for the motors of pumps and single phase 24VDC supply for instrumentation and control devices, connected via conduits from nearby sewage pump station switchboard;

6. Site ambient temperature range for design is -5 °C (min) to 40 °C (max).

7. Mechanical equipment shall have a 15 year serviceability period.

2.3 **Assembly**

Units shall be delivered pre-assembled with minimal assembly work required other than connection to interface points.

2.4 **Shipment, Protection and Storage**

All products supplied under this contract shall be delivered to site in manufacturer's Original protective packaging. The Contractor shall supply equipment required to handle the products
without damaging hardware or coatings. The Contractor shall unload and stack the products where directed in storage.

The Contractor shall provide complete short term and long term storage instructions, indicating specific requirements necessary to prevent any weathering, corrosion, contamination, mechanical damage, freezing or any other deterioration of components.

2.5 Equipment Guarantee and Warranty

The Contractor must provide equipment that meets the demands of all operational cases. Equipment must be installed in accordance with the manufacturer’s warranty requirements.

2.6 Factory acceptance Tests

Units shall undergo factory acceptance tests before delivery. The results of the tests shall be made available upon delivery of the units.

2.7 Technical Specifications

2.7.1 Storage Tank

A MHL storage tank shall be installed in a bunded area with 110% capacity of the tank volume, enabling chemical delivery and containment of any spills. The Contractor shall size as appropriate for tank volume and size and working space. The bund shall be drained back to the wet well by way of a lockable valve.

The MHL dosing system shall be located within a bunded area and housed within a colour bond shed.

The required isolation valves, drain valves, level switch and ultrasonic level transmitter shall all be supplied and installed by the Contractor. Actuated valves shall include steel shaft components and be suitable for MHL environment and operation.

2.7.1.1 Nozzle Height and Orientation

The Contractor shall size and locate nozzles as appropriate for effective dosing operation. This will need consideration of design aspects such as sump locations and level indicator visual requirements for chemical loading.

Nozzle heights will be assessed on confirmation of tank dimensions.

2.7.1.2 Agitator/ Mixer

Tank mixer shall be provided to keep solids in suspension while the slurry is in storage. Mixer shall be a top entering, pitch blade or rake-type. The mixer impeller/ blades shall be located suitably close to the bottom and at suitable intervals of the tank to ensure the agitation of the
full usable volume of the tank. Agitator shaft speed will vary depending on the impeller size and length of shaft.

Mechanical shafts shall be provided with safety grills or other means of personal protection against entanglement.

2.7.1.3 Vent

Tank vents shall be sized to avoid incurring negative pressures within the tank during chemical withdrawal. The vent shall include a vermin-proof screen.

2.7.1.4 Tank access hatch

An access hatch shall be provided on top of the tank. The hatch shall be lockable. Seals shall be provided on the access hatch to prevent the loss of moisture from the tank. A sealed inspection opening shall be provided to facilitate visual inspection of the inside of the tank. Suitable access ladders and platforms for inspection, access and working areas shall be provided for access to the tank and mixer.

2.7.1.5 Overflow pipe

The tank overflow pipe shall extend to 100mm off the floor of the bund floor.

2.7.1.6 Lifting Lugs and Hold Down Points

The MHL tank shall come with appropriate hold down points as required for stability and lifting lugs for ease of installation and removal.

2.7.1.7 Hydrostatic Tests

The installed chemical tanks shall be subjected to a hydrostatic test, by being filled by others, in a manner approved by the Contractor. The fill rate will be no greater than the operating flow rate as stated in the respective tank datasheet. The Contractor will supervise the filling of the tank.

Should any leaks or evidence of unsatisfactory performance develop, the water level shall be drawn down by others and repairs carried out by the Contractor. The water level shall then be raised again by others to ensure that the repairs are satisfactory.

If, in the opinion of the Principal’s Representative, the integrity of the tank is inadequate, the tank will be drained and shall not be filled again until directed by the Principal’s Representative. When the tank is filled with water to the specified level, it shall be allowed to stand for a period of at least twenty-four [24] hours to ensure the detection of any leaks or other defects.
The tank shall be deemed to have passed the test if, after a period of twenty-four [24] consecutive hours, no leakage or other defect is evident.

2.7.1.8 Product Certification

The Contractor shall provide details of product certification as per AS4766 or AS2634 depending on tank material of construction.

2.7.1.9 Cleaning

The Contractor shall visually inspect the tank before delivery and ensure the tank is free of loose material or rags. The inside of the tank will be rinsed with water to remove any residue.

2.8 Dosing Pumps

The contract includes the supply and installation of hose dosing pumps to handle the slurry chemical (i.e MHL) and to provide the pressure required for operating the MHL. Dosing pump are to be sized to adequately span the range of synchronised dosing rates down to continuous dosing.

An automated water flushing functionality shall be provided in the installation, and controlled by the PLC in the sewage pump station switchboard. Water flush shall come on for user defined times and periods to clean the MHL dosing pipework.

The dosing pump shall be suitable for dosing magnesium hydroxide at the appropriate injection point, provided with a variable speed drive or similar to accept a 4-20 mA analogue signal from the PLC controller. Each pump shall also be capable of running at a manually set flow control.

Dosing pumps shall be of approved manufacture and equipped with either single or three phase motors, provided with IP65 rated GPO plug-in receptacles.

The pump shall be suitable for, and of, materials of construction to suit the chemical pumped. Driving motors shall be standard units, with speed control manually set by operators in accordance with the flow. This would be based on the in-line rising main flow meter providing a flow signal, which would be averaged to produce a continuous incoming flow-rate of sewage into the collecting manhole. The contractor shall develop a control algorithm to achieve this automatic flow paced dosing control.

The dosing pump shall be flow proportional or operator adjusted set point.

The dosing pump shall be mounted on the appropriate skid/ rack using an approved bracket/mounting arrangement using corrosion resistant fasteners. The Contractor shall supply all necessary pump installation hardware required.
2.8.1 Commissioning

The Contractor shall test and commission the dosing pump units onsite and provide copies of the test certificates and calibration curves.

2.8.2 Dosing Equipment and Pipework

The Contractor shall supply and install all necessary dosing equipment and pipework from the storage tank to the dosing pumps and onto the dosing point. All dosing pipework between the tank and the discharge point shall be clear flexible hose with cam lock fittings. Rigid pipework is to be limited to straight sections only where flexible hose is demonstrated to not be practical and these sections must be able to be easily rodded, flushed and cleaned.

Due to the precipitation nature of MHL chemical and therefore, the possibility of clogging in the pipework, the Contractor shall allow facility in the sections of the pipework for high pressure flushing of the lines. All dosing pipework shall be neatly installed to minimise any dead legs or unnecessary pipework. All pipework shall be easily removed for rodding and cleaning purposes.

All dosing pipework shall be PN12 PVC-U (Vinidex Series 1 – or equivalent) / pressure rated clear flexible hose. Pipelines shall generally be constructed in accordance with AS 2032 (Code of Practice for Installation of uPVC Pipe Systems).

Where lines penetrate walls neatly make the openings by drilling and seal with sheet metal and sealant.

Labelling of pipework above ground, in accessible ducts and pipes shall be according to AS 1345 (Identification of the Contents of Pipes, Conduits and Ducts).

Tapping connection to the upstream collection man hole shall be arranged by the Contractor. The dosing piping shall be contained within a minimum 50mm PVC-U conduit for all underground service installations. 90 degree bends shall be large radius bends or a combination of 45 degree bends to prevent kinking of internal hose.

2.8.3 Instrumentation

The Contractor shall specify instrumentation constructed of materials compatible with the chemicals being used. Ultrasonic level sensors shall be used for monitoring the liquid level in storage. Ultrasonic level sensors shall be Calibrated to the full useable capacity of the storage tank and installed so that the nose of the level sensor is at a minimum 300 mm above the overflow level of the storage tank. All instrument installation requirements specified by the original equipment manufacturers shall be followed. Minimum clearances are to be provided in all instances.

Tank Level indicators and overflow pipe are to be easily visible by personnel from the chemical loading bay. Pressure gauges to be installed to indicate the rated pressure is maintained in the dosing lines.
2.9 Electrical

The Dosing System shall be designed, supplied and installed by the Contractor accordingly. Contractor shall notify the Principal’s Representative immediately if system requirements deviate from this arrangement. The Contractor shall refer Switchboard and Electrical Specification in Dosing System equipment design / selection.

MHL Dosing shed shall have its own dedicated Electrical Panel, designed and built in accordance with AS3000, which may include devices not already provided in the pump station switchboard:

- A 3 Phase Main Switch,
- Lightning Surge Protection
- IP65 rated work area lighting with wall switch.
- Individual Dosing Pump Motor isolation switches,
- Circuit breakers for local power outlets
- Control relays/logic for monitoring and alarming of chemical tank overfill
- Terminals for termination of customer cables to enable remote monitoring and control of the MHL Dosing Plant from the pump station PLC.

The MHL dosing shed and chemical storage tank shall be controlled and monitored via the Main Switch Board PLC. Status and alarms that are required to be remotely monitored by the PLC are:

- Tank Level (loop powered 4-20mA analog)
- Tank High Level Alarm (volt free contact)
- Pump Running (volt free contact)
- Pump Fault (volt free contact)
- No Flow (for each pump or common delivery line) (volt free contact)
- Mixer Running (Status Only)

Remote controls via the PLC are:

- Pump Start/Stop (volt free contact output from PLC)
• Pump Speed (4-20mA output from PLC)

• Mixer Running Timers or Start/Stop

All pumps, controllers and field instruments, including tank level instruments shall be pre-wired to the Local Control Panels.

The Local Control Panels shall be stainless steel or aluminium construction, suitable for outdoor installation (IP56), with key lockable doors.

The Contractor shall supply a complete set of circuit diagrams that clearly identify customer connections for power supply and signal cabling back to the Main Switch Board PLC.

Any instruments that require 24V DC supply, or require 4-20mA loop power shall be clearly identified on the vendor drawings.

A 3 phase 415V outlet and 240V AC outlet shall be provided on each skid for use by the tanker drivers for connection of their unloading pumps.

All electrical services, wiring, conduits and junction boxes shall be manufactured and installed in accordance with the manufacturer’s requirements and Electrical Specification.

The mixer motor/s shall be fitted with a VSD or similar device to enable speed control. This control shall be able to be modified via the main PLC control MHI.

3. Installation and Commissioning

The Contractor shall install and commission the MHL dosing system complete. This includes but is not limited to the following activities:

• Bolting down tanks to bunded slabs

• Installation of pump skids in required locations

• Installation of interconnecting pipework between tank and pump skids and chemical fill points

• Flushing and hydrostatic testing of pipework and tanks

• Calibration and working demonstration of all pumps

• Operator Training

The Contractor shall be responsible for addressing and liaising with the Principal’s Representative on all aspects associated with the site installation and commissioning which include but is not limited to the following:
MAGNESIUM HYDROXIDE SPECIFICATION

- Site Access & Induction
- Job Safety and Environmental Analyses
- Any licences or permits required to complete installation
- Site service requirements i.e. power, water supply
- Tag out measure
- Subcontractors
- Toolbox Meetings
- All other OH&S measures

The Supplier shall ensure that the equipment is installed in strict accordance with the manufacturer's recommendations to provide satisfactory service.

3.1 Inspection and Testing

Any repairs on the MHL dosing equipment are to be undertaken by the manufacturer or by a service representative approved by the manufacturer.

3.2 Performance Testing

The Supplier shall propose a Commissioning Schedule outlining the duration of the testing period and notify TRC in advance of a suitable time to witness the Performance Tests. Testing of the unit shall comply with the manufacturer’s recommendations.

3.3 Unsatisfactory Testing

The Contractor shall adjust the equipment as necessary and repeat all the proof of Performance Tests.

3.4 Operation & Maintenance Manual

The Contractor shall provide Installation, Commissioning, Operations and Maintenance Manuals (O&M). As a minimum one softcopy is to be provided on CD as unsecured interlinked PDF format and MS Word or Excel file.

The O & M manuals shall include:

a) As Constructed drawings and schematics of the installations and equipment supplied including a general arrangement drawing,
b) Installation instructions,

c) Detailed catalogue of spare parts and part numbers

d) Dismantling and reassembling instructions,

e) OH&S requirements for maintenance, and

f) Preventative maintenance schedule and procedures.

The Supplier is also to provide the Standard Operating Procedures (SOP) for operating the MHL dosing systems.
## Appendix A  Equipment Schedules

Equipment schedule for the proposed MHL dosing system

<table>
<thead>
<tr>
<th>Qty</th>
<th>System</th>
<th>Description</th>
<th>Size / Duty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>CHEMICAL TANKS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Chemical System</td>
<td>Magnesium Hydroxide Storage</td>
<td>HDPE, FRP or equivalent</td>
<td>(plastic liner to suit)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CHEMICAL DOSING PUMPS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chemical System</td>
<td>MHL Dosing Pumps</td>
<td>1 Duty Hose or Equivalent</td>
<td>pumps</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>MIXER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Chemical System</td>
<td>Slurry Mixer</td>
<td>Magnesium hydroxide</td>
<td>solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>ANCILLARY SERVICES</strong></td>
<td></td>
<td></td>
<td>Connected to mains, with RPZ</td>
</tr>
<tr>
<td>1</td>
<td>Ancillary Services</td>
<td>Service Water Packages</td>
<td></td>
<td>installation, safety showers,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and service connection hose</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>points and a duty pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pump (if required).</td>
</tr>
<tr>
<td></td>
<td><strong>INSTRUMENTATIONS</strong></td>
<td></td>
<td></td>
<td>To report MHL level in storage</td>
</tr>
<tr>
<td>1</td>
<td>Chemical System</td>
<td>Ultrasonic sensor</td>
<td></td>
<td>tank, High level and low level</td>
</tr>
<tr>
<td>2</td>
<td>Chemical System</td>
<td>Pressure indicator</td>
<td></td>
<td>in tank.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>