MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

TENDER NO 054/2024/PMID/MCWAP2/RFB

PART C3.1
SPECIFICATION

SECTION 40

CONTROL AND INSTRUMENTATION GENERAL

PART C3.1
SPECIFICATION

SECTION 40
CONTROL AND INSTRUMENTATION GENERAL

TABLE OF CONTENTS

SECTION 40

CONTROL AND INSTRUMENTATION GENERAL

40.1 SCOPE

This Section covers the design, supply, delivery, installation, testing and commissioning of the Control and Instrumentation system of Phase 2 of the Mokolo and Crocodile Water Augmentation Project. This shall be interpreted as the Employer's Requirements with regard to the system design obligations.

Phase 2 consists of:

a) Control and instrumentation at the Vlieëpoort Weir;
b) Control and instrumentation for the Low-Lift Pumping Station;
c) Control and instrumentation for the Balancing Reservoir;
d) Control and instrumentation for the High-Lift Pumping Station;
e) Control and instrumentation for the Break Pressure Tank;
f) Control and instrumentation for the Break Pressure Reservoir; and
g) Control and instrumentation at the User's Points of Supply.

The Scope of C&I work includes:

a) Instrumentation;
b) Instrumentation cabling;
c) Programmable Logic Controllers (PLC) hardware and software;
d) Supervisory Control and Data Acquisition (SCADA) hardware and software;
e) Primary Network – Fibre optic cable;
f) Secondary Network – Microwave radio;
g) Managed Layer 2 Network Switches and Layer 3 Network Routers;
h) Integration between MCWAP-2, RMS and MCWAP-1 Control Systems;
i) Any other installation materials stated or implied to provide for a complete installation in accordance with the Specification, Drawings and Schedules supplied; and
j) Complete Data Pack including "as-built" drawings, O&M Manuals, PLC and SCADA software, etc.

40.2 INSTALLATION BY OTHERS

The Control and Instrumentation Plant forming part of the River Management System (RMS) does not form part of this Contract.

The C&I control and monitoring signals of the RMS are to be integrated into the MCWAP-2 control system under this Contract.

40.3 BATTERY LIMITS

The battery limits between Employer's Design and Contractors Design is shown on the Drawings. The mechanical and electrical designers of the Contractor shall design the integrated VSD, Power Factor Correction installation, Surge Protection, Motor and Pump installation, including control and cabling to ensure compatibility and correct sizing of the Plant components.

The battery limit of the C&I Contractor is the network connection at the managed network switch.

The Contractor shall submit a detailed cable schedule for approval, before ordering any cable.

40.4 GENERAL INFORMATION

This Section shall be read in conjunction with Section 41 - Control and Instrumentation Plant and Installation. In the event of conflict, this Section shall take preference over Section 41 – Control and Instrumentation Plant and Installation.

This Section shall also be read in conjunction with the Technical Schedules of the Contract. Any deviation from the agreed Technical Schedules shall be approved by the Engineer. Any application for a concession or replacement shall be accompanied by a revised Technical Schedule.

40.5 STANDARDS AND REGULATIONS

40.5.1 Standards and Regulations

All materials and Plant shall be new, and of the standard and quality specified.

The Contractor shall ensure that he is fully acquainted with the contents of Section 41 – Control and Instrumentation Plant and Installation.

The wiring installation shall comply fully with SANS 10142, as amended.

The design and manufacture of Plant, and the complete installation, shall be carried out and tested in accordance with the latest issue or amendments of the following Regulations, as applicable:

a) SANS 10142-1 – The Code of Practice for wiring of premises as amended;

b) The Occupational, Health and Safety Act, (Act 85 of 1993);

c) The Regulations of Telkom (S.A) Ltd;

d) The Electricity Act, (Act 88 of 1996);

e) The regulations of ICASA;

f) IEEE 1613 - Substation Environment FCC Part 90;

g) IEC 61131-3 - Programming Languages;

h) IEC 61140 – Common aspects for installation and equipment;

i) IEC 60529 - 2013 degrees of Protection Provided by Enclosures (IP Code);

j) Class 1, IEC 825-1 - Safety of Laser Products;

k) IEC 60068-2-6 - Environmental Testing;

l) IEC 60068-2-27 – Shock Testing;

m) EN 61000-4-4 - Electrical Fast Transients;

n) EN 61000-4-5 - Surge Test;

o) EN 61000-4-6 - Conducted Disturbances Immunity;

p) EN 61000-4-9 - Pulse Magnetic Field Testing;

q) EN 61000-4-11 - Voltage Variations;

r) EN 61000-4-16 - Electromagnetic Compatibility 4-16;

s) EN 60950 – Low Voltage Directive;

t) IEC 61508 - Functional safety of electrical / electronic / programmable electronic safety-related systems;

u) BS EN ISO 13849-1- Requirements for Safety-related parts of Control Systems; and

v) IEC 61804 - Function Block Applications in Control Systems.

40.5.2 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

40.6 ENVIRONMENTAL AND SITE CONDITIONS

The following information pertains to the Site and Works:

- Altitude above sea level: Vary between 875 and 1105 masl.
- Maximum ambient temperature: 40.7ºC.
- Control voltage: 230 V UPS fed Transient Free.

The Contractor shall ensure that all Plant, electrical or electronic, will be suitable for continuous, reliable operation under these circumstances, and the Contractor shall ensure that all Plant is adequately protected in this regard, whether such protection has been specified in detail or not.

Failure or malfunction of any component of the installation, even if attributable to the quality of supply, will be rectified at the Contractor’s expense.

The Contractor shall determine if his Plant will fit into the spaces provided for the Plant items, prior to ordering.

40.7 MAIN SERVICES

The Contractor shall familiarise himself with the positions of the other main services, i.e. pipelines, water pipes, storm water sleeves and sewer pipes, and co-ordinate these services to ensure an unobstructed path for any cable installations.

Should obstructions exist, these must be brought to the attention of the Engineer as soon as possible.

40.8 MATERIAL

All indoor switchboards, distribution boards and control panels shall be mild steel painted, in accordance with paint system number 402 in Section 37 – Painting and Corrosion Protection.

All outdoor switchboards, distribution boards and control panels shall be 3CR12 painted, in accordance with paint system number 414 in Section 37 – Painting and Corrosion Protection.

All cable trays, conduit and cable ladders shall be hot-dip galvanized, in accordance with paint system 453 in Section 37 – Painting and Corrosion Protection.

All fixing bolts, nuts, washers, brackets, etc., shall be stainless steel.

In addition to normal operating loads, all Plant shall be designed and installed to withstand without damage, a seismic acceleration of 0.1 g.

All Plant and material to be corrosion protected, shall be protected in accordance with the corrosion protection systems specified in Section 37 – Painting and Corrosion Protection. Should a corrosion protection system not be clearly defined, the Contractor shall agree the appropriate system with the Engineer prior to ordering the product.

Cables shall be flame retardant, low toxic cable type (blue stripe). Fire barriers shall be provided at every point where cables cross walls. Pratley type Enviro glands shall be used for all cable terminations.

40.9 PLC AND SCADA

Refer to Section 41.3 and Section 41.4 as well as to the Control Philosophy covered in Clause 40.22.

A detailed Functional Specification shall be written by the Contractor from the Control Philosophy. A centralised scheme remote control room shall be built at the O&CC (Operational and Control Centre). The SCADA System required for the O&CC shall be designed to accommodate all control system information from the MCWAP-2 sites, the River Management System and the MCWAP-1 sites.

A HMI (Human Machine Interface) shall be provided in the following areas:

a) Abstraction Works and Low-Lift Pumping Station (Four);

b) Sedimentation Works and Balancing Reservoir (One);

c) High-Lift Pumping Station (Five);

d) Break Pressure Tank (One);

e) Break Pressure Reservoir (One);

f) Off-Take A (One); and

g) Off-Take B (One).

The HMI displays shall be similar to the faceplate displays in the O&CC SCADA system and shall display the status of all Plant control and monitoring signals including alarming signals, trending information, reporting information, historian information, etc.

The I/O's shall be connected to PLCs situated at predetermined points. The PLC's shall all be of the same vendor type and make.

Refer to the P&IDs specific for each section discussed below.

40.9.1 Abstraction Works and Low-Lift Pumping Station

The overall PLC design for the Low-Lift Pumping Station shall be done as follows:

a) The I/O's (Input and Output signals) associated with the Low-Lift Pumping Station shall be connected to individual PLC Units. Each Low-Lift Pump shall have its own dedicated PLC Unit. An additional PLC Unit is used for the auxiliary services like HVAC, dewatering pumps, cooling water systems, network monitoring, UPS signals, MV Switchgear signals, etc. The PLC Units shall have the following Tags:

- Pump 01: 2B-PLC-01A;
- Pump 02: 2B-PLC-02A;
- Pump 03: 2B-PLC-03A; and
- Services: 2B-PLC-04A.

b) Please refer to the MCWAP-2 Low-Lift Pumping Station Cable Block Diagram, diagram number 1B-E2.4-001.

c) Each PLC Unit shall be connected via an Ethernet-IP network to a managed network switch.

The PLC units situated near its respective pump set shall have but not be limited to the following functionality:

a) Low-Lift Pump Delivery Line Pressure;

b) Low-Lift Pump Motor DE Bearing Temperature;

c) Low-Lift Pump Motor NDE Bearing Temperature;

d) Low-Lift Pump Motor Winding Red Phase Temperature;

e) Low-Lift Pump Motor Winding White Phase Temperature;

f) Low-Lift Pump Motor Winding Blue Phase Temperature;

g) Low-Lift Pump Motor 1 NDE Bearing Vibration;

h) Low-Lift Pump Delivery Actuated Valve Signals;

i) Low-Lift Pump Delivery Line Flow Switch;

j) Low-Lift Pump Motor Variable Speed Drive Signals; and

k) Low-Lift Pump Delivery Flow Measurement.

The Services PLC unit – 2B-PLC-XXA shall be situated in the Server Room.

The PLC units shall have redundancy on the following:

a) Power Supplies; and

b) Ethernet Communications Modules.

These PLC units shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary broadband wireless network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing between the different MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3 switches are to be installed will depend on the network topology. These Layer 3 switches shall be root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the topology of the network is optimised to the traffic flows of the network. Refer to Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number – 2A-E5-004.

40.9.2 Balancing Reservoir and Sedimentation Works

The overall PLC design for the Balancing Reservoir and Sedimentation Works shall be done as follows:

a) The I/O's (Input and Output signals) associated with the Balancing Reservoir and Sedimentation Works shall be connected to a PLC Unit. The PLC Unit shall have the following Tag:

- Pump 1: 2D-PLC-1A.

b) Please refer to the MCWAP-2 Balancing Reservoir and Sedimentation Works Cable Block Diagram, diagram number 2D-E2.4-001.

c) The PLC Unit shall be connected via an Ethernet-IP network to a managed network switch.

The PLC unit – 2D-PLC-1A shall have but not be limited to the following functionality:

a) Balancing Reservoirs 1, 2 and 3 Level Measurement.

The PLC unit – 2D-PLC-1A shall have redundancy on the following:

a) Power Supplies; and

b) Ethernet Communications Modules.

This PLC unit shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary broadband wireless network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing between the different RMS, MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3 switches are to be installed will depend on the network topology. These Layer 3 switches shall be the root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the physical and logical topology of the integrated RMS, MCWAP-1 and MCWAP-2 networks are optimised to the traffic flows between the networks. Refer to Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number – 2A-E5-004.

40.9.3 High-Lift Pumping Station

The overall PLC design for the High-Lift Pumping Station shall be done as follows:

a) The I/O's (Input and Output signals) associated with each High-Lift Pump and the Pump Station ancillary equipment shall be connected to individual PLC Units. Each High-Lift Pump shall have its own dedicated PLC Unit. The PLC Units shall have the following Tags:

- Pump 01: 2E-PLC-01A

- Pump 02: 2E-PLC-02A
- Pump 03: 2E-PLC-03A
- Pump 04: 2E-PLC-04A
- Services: 2E-PLC-05A

b) Please refer to the MCWAP-2 High-Lift Pumping Station Cable Block Diagram, diagram number 2E-E2.4-001.

c) Each PLC Unit shall be connected via an Ethernet-IP network to a managed network switch.

The PLC units situated near its respective pump set shall have but not be limited to the following functionality:

a) High-Lift Pump Delivery Line Pressure;

b) High-Lift Pump Suction Pressure;

c) High-Lift Pump DE Bearing Temperature;

d) High-Lift Pump NDE Bearing Temperature;

e) High-Lift Pump Casing Temperature;

f) High-Lift Pump Motor DE Bearing Temperature;

g) High-Lift Pump Motor NDE Bearing Temperature;

h) High-Lift Pump Motor Winding Red Phase Temperature;

i) High-Lift Pump Motor Winding White Phase Temperature;

j) High-Lift Pump Motor Winding Blue Phase Temperature;

k) High-Lift Pump Motor Water Cooler Inlet Temperature;

l) High-Lift Pump Motor 1 Water Cooler Outlet Temperature;

m) High-Lift Pump DE Bearing Vibration;

n) High-Lift Pump NDE Bearing Vibration;

o) High-Lift Pump Motor 1 DE Bearing Vibration;

p) High-Lift Pump Motor 1 NDE Bearing Vibration;

q) High-Lift Pump Suction Actuated Valve Signals;

r) High-Lift Pump Delivery Actuated Valve Signals;

s) High-Lift Pump Suction Line Flow Switch;

t) High-Lift Pump Motor Variable Speed Drive Signals; and

u) High-Lift Pump Delivery Flow Measurement.

The PLC units shall have redundancy on the following:

a) Power Supplies; and

b) Ethernet Communications Modules.

These PLC units shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary broadband wireless network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing

between the different RMS, MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3 switches are to be installed will depend on the network topology. These Layer 3 switches shall be the root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the physical and logical topology of the integrated RMS, MCWAP-1 and MCWAP-2 networks are optimised to the traffic flows between the networks. Refer to Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number – 2A-E5-004.

Each PLC unit shall be responsible for the following functionality:

Pump PLC units, 2E-PLC-XXA refers:

a) The start sequence for pump 2E-PPXX;

b) The stop sequence for pump 2E-PPXX;

c) The safety interlocks for pump 2E-PPXX;

d) The process interlocks for pump 2E-PPXX;

e) The safety interlocks for the motor of pump 2E-PPXX, 2E-MOXX;

f) Control of pump 2E-PPXX using output and input signals; and

g) The I/O interface with the MV power supply circuit breaker and VSD device.

Services PLC unit, 2E-PLC-1XX refers:

a) The monitoring / control signals from the HVAC Equipment;

b) The monitoring / control signals from the Dewatering Pumps;

c) The monitoring / control signals from the Pump cooling water system;

d) The monitoring / control signals from Fire detection/suppression system; and

e) The totalizer and flow measurement signals from outlet and inlet flow meters.

Please refer to the Control Philosophy document and respective P&IDs for the operation of the High-Lift Pumping Station.

40.9.4 Break Pressure Tank

The overall PLC design for the Break Pressure Tank shall be done as follows:

a) The I/O's (Input and Output signals) associated with the Break Pressure Tank shall be connected to a PLC Unit. The PLC Unit shall have the following Tag:

- Pump 1: 2F-PLC-1A.

b) Please refer to the MCWAP-2 Break Pressure Tank Cable Block Diagram, diagram number 2F-E2.4-001.

c) The PLC Unit shall be connected via an Ethernet-IP network to a managed network switch.

The PLC unit – 2F-PLC-1A shall have but not be limited to the following functionality:

a) Break Pressure Tank inlet and outlet Pressure;

b) Break Pressure Tank outlet Actuated Valve Signals;

c) Break Pressure Tank inlet Actuated Valve Signals;

d) Break Pressure Tank Level Measurement;

e) Break Pressure Tank Inlet Flow Measurement; and

f) Break Pressure Tank Delivery Flow Measurement.

The PLC unit – 2F-PLC-1A shall have redundancy on the following:

a) Power Supplies; and

b) Ethernet Communications Modules.

This PLC unit shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary broadband wireless network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing between the different RMS, MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3 switches are to be installed will depend on the network topology. These Layer 3 switches shall be the root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the physical and logical topology of the integrated RMS, MCWAP-1 and MCWAP-2 networks are optimised to the traffic flows between the networks. Refer to Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number – 2A-E5-004.

40.9.5 Break Pressure Reservoir

The overall PLC design for the Break Pressure Reservoir shall be done as follows:

a) The I/O's (Input and Output signals) associated with the Break Pressure Reservoir shall be connected to a PLC Unit. The PLC Unit shall have the following Tag:

- Pump 1: 2G-PLC-1A.

b) Please refer to the MCWAP-2 Break Pressure Reservoir Cable Block Diagram, diagram number 2G-E2.4-001.

c) The PLC Unit shall be connected via an Ethernet-IP network to a managed network switch.

The PLC unit – 2G-PLC-1A shall have but not be limited to the following functionality:

a) Break Pressure Reservoir outlet Actuated Valve Signals;

b) Break Pressure Reservoir inlet Actuated Valve Signals;

c) Break Pressure Reservoir Level Measurement;

d) Break Pressure Reservoir Delivery Flow Measurement; and

e) Break Pressure Reservoir Inlet Flow Measurement.

The PLC unit – 2G-PLC-1A shall have redundancy on the following:

a) Power Supplies; and

b) Ethernet Communications Modules.

This PLC unit shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary broadband wireless network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing between the different RMS, MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3

switches are to be installed will depend on the network topology. These Layer 3 switches shall be the root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the physical and logical topology of the integrated RMS, MCWAP-1 and MCWAP-2 networks are optimised to the traffic flows between the networks. Refer to Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number 2A-E5-004.

40.9.6 Off-Take B - Medupi Gravity Pipeline Connection

The overall PLC design for the Medupi connection shall be done as follows:

a) The I/Os of the Medupi Connection shall be connected to their own PLC unit. Please refer to the MCWAP-2 Off-Take B Cable Block diagram, diagram number 2J-E2.4-002.

The PLC unit, 2J-PLC-1A shall have the following functionality:

a) Receive all required indication signals from the pressure transmitter;

b) Receive all required indication signals from the flow transmitters; and

c) Control the flow and receive feedback from the control valves going to Medupi.

This PLC unit shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary microwave network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing between the different RMS, MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3 switches are to be installed will depend on the network topology. These Layer 3 switches shall be the root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the physical and logical topology of the integrated RMS, MCWAP-1 and MCWAP-2 networks are optimised to the traffic flows between the networks. Refer to the Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number 2A-E5-004.

40.9.7 Off-Take A – Matimba, Exxaro and Thabametsi Gravity Pipeline Connection

The overall PLC design for the Off-Take A connection shall be done as follows:

a) The I/Os of the Off-Take A Connection shall be connected to their own PLC unit. Please refer to the MCWAP-2 Off-Take A Cable Block Diagram number 2J-E2.4-001.

The PLC unit, 2J-PLC-1A shall have the following functionality:

a) Receive all required indication signals from the pressure transmitter;

b) Receive all required indication signals from the flow transmitters;

c) Control the flow and receive feedback from the control valves going to Grootgeluk Coal Mine;

d) Control the flow and receive feedback from the control valves going to Thabametsi IPP’s; and

e) Control the flow and receive feedback from the control valves going to Matimba.

Please refer to the Control Philosophy document and respective P&IDs for the operation of the pump station.

This PLC shall have redundancy on the following:

a) Power Supply; and

b) Communications Modules.

This PLC unit shall as for all other PLC units, be connected onto a Primary fibre optic network and Secondary broadband wireless network, via a managed network switch. The selection of managed network switch shall be a Layer 2 switch. Layer 3 switches shall be used for routing between the different RMS, MCWAP-1 and MCWAP-2 local area networks (LANs). The site where the Layer 3 switches are to be installed will depend on the network topology. These Layer 3 switches shall be the root bridges and must be placed near to Network Servers and designated control equipment having high network traffic. This will ensure that the physical and logical topology of the integrated RMS, MCWAP-1 and MCWAP-2 networks are optimised to the traffic flows between the networks. Refer to the Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number 2A-E5-004.

40.10 FACTORY ACCEPTANCE TESTING (SOFTWARE)

Factory Acceptance Testing (FAT) shall be performed by the Contractor with all hardware connected to prove that the programming software is performing exactly as per the Control Philosophy document. The software shall be complete and fully tested before installation on Site.

The testing of the software programs shall only be done with the Engineer / Employer or both being present, and the procedure and method shall be as follows:

a) The software Engineer shall first ensure that the program is working exactly as per the Control Philosophy document;

b) The software Engineer shall then arrange a Pre-FAT testing session at a date and time that shall be appropriate for all included (Engineer, E&I contractor, Employer, etc.);

c) Minutes shall be kept of this Pre-FAT session and these minutes shall be distributed and commented on by all parties concerned;

d) All anomalies found at this Pre-FAT session shall be recorded in these minutes and assigned to the responsible person;

e) A two-week period shall be allowed for the changes to be made by the responsible people assigned to each item on the list;

f) This two-week period must be adhered to expedite the successful implementation of the Employer’s project plan;

g) The FAT shall then be held after this two-week period and all anomalies and corrections shall be recorded, if any, in the minutes held for this meeting;

h) If there are any anomalies or corrections that still need to be made after this FAT, then there shall be allowed a time period of between 2 – 4 working days only for these changes to be made; and

i) If no changes are required, then this FAT shall be regarded as the final FAT and the method of signing off on the final FAT of the software shall be as follows:

- Each Loop / Tag shall be tested and signed off by both the software Engineer for the E&I contractor and the consulting Engineer on behalf of the Employer;

- Each Loop / Tag shall have its own page with various parameters on it including I/O Failsafe mode, Alarms and Events, Interlocks, Functionality, Trending, Group starts, Control modes, Data entry, Dynamics, etc.; and
- There shall also be a remarks column added for comments.

Please note* - Under no circumstances shall the software Pre-FAT and FAT be done without the Engineer or the Employer or anyone designated by these two entities being present.

40.11 PRIMARY FIBRE OPTIC SINGLE MODE NETWORK

Please refer to the Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number 2A-E5-004 and latest Link Planner Profile report.

40.11.1 Scope of Work

The following sites refer:

a) Abstraction Works (AW);
b) Low-Lift Pumping Station (LLPS);
c) Sedimentation Works (SW);
d) Balancing Reservoir (BR);
e) High-Lift Pumping Station (HLPS);
f) Break Pressure Tank;
g) Break Pressure Reservoir (BPR);
h) Off-Take A; and
i) Off-Take B.

The proposed Fibre Optic links under this MCWAP-2 Project include, but are not limited to the following:

a) **LLPS** to **HLPS** (5.3 km Link);
b) **HLPS** to **BPT** (27 km Link);
c) **BPT** to **BPR** (2 km Link);
d) **BPR** to **Off-Take B** (95 km Link); and
e) **Off-Take B** to **Off-Take A** (6.3 km Link).

40.11.2 General

40.11.2.1 Purpose of the Network

The MCWAP-2 Project shall have a Fibre Optic Single Mode Network which will serve as the Primary Network. This Primary Network shall be used to for data transfer of the following network systems:

a) PLC to PLC Networks;

b) SCADA to SCADA Networks;

c) VoIP Networks;

d) CCTV Networks;

e) Intruder Detection Networks; and

f) Fire Detection Networks.

The Primary Network shall be used for the transmission / receiving of data between LAN's (Local Area Networks) or VLAN's (Virtual Local Area Networks) with regards to the MCWAP-2 Project. Additionally, the Primary Network shall be used for the transmission / receiving of certain LAN's or VLAN's of the MCWAP-1 System as well as from the RMS. These selected LAN's or VLAN's shall be integrated into the MCWAP-2 Control System. This shall be done utilizing Layer 3 Network Routers and dedicated LAN's or VLAN's, specifically setup for this purpose.

The Ethernet Standard for this Primary Network shall be based on the 1000BASE-ZX standard for Gigabit Ethernet Transmission over Single Mode 1550nm Wavelength Fibre Optic Cable. The Fibre Optic Cabling shall be a 24-core fibre optic Single mode – 8/125 µm, 1550 nm wavelength, Polyethylene outer sheath, Galvanized steel wire / tape armour, PVC bedding sheath cabling.

The fibre optic cable shall be connected as a full duplex system, meaning that one fibre core shall be used for the transmission of data and another fibre for the receiving of data. Refer to the specification C3141 - C&I Plant and Installation for details on the physical and optical properties of the Fibre Optic cable and other technical details of the Fibre Optic Cable including storage, trenching and installation requirements.

Both the Primary and Secondary Networks shall work independently of each other and both shall be transmitting / receiving data all the time between links. The Primary and Secondary Networks shall be connected at each site to a managed Layer 2 Ethernet Network Switch or Layer 3 Network Router. The network switches / routers shall have sufficient Ethernet fibre ports (1000BASE-ZX SFP's) and Ethernet copper ports (100BASE-T/1000BASE-T RJ45) as per the project requirements at each specific site.

The Primary fibre optic network shall be connected to SFP (Small Form-factor Pluggable transceiver) Ethernet ports on the managed Network Switches / Network Routers. The selection of Network Switches / Network Routers shall consider the minimum required SFP Ethernet Ports on the selected Plant. The design is for a 24-core fibre optic cable Single mode – 8/125 µm, 1550 nm wavelength, Polyethylene outer sheath, Galvanized steel wire / tape armour, PVC bedding sheath cabling. Therefore, multiple Ethernet SFP Ports shall be required to ensure all the required LAN's and VLAN's can be transmitted / received between the RMS, MCWAP-2 and MCWAP-1 sites via the Network Switches / Network Routers.

Under the section below, Microwave Radio Secondary Network the data routing is discussed between the Primary and Secondary Networks.

40.12 MICROWAVE RADIO SECONDARY NETWORK

Please refer to the Primary Fibre Optic Network and Secondary Broadband Wireless Radio Network Layout Drawing number 2A-E5-004 and latest Link Planner Profile report.

40.12.1 Scope of Work

The following sites refer:

a) Abstraction Works (AW);
b) Low-Lift Pumping Station (LLPS);
c) Sedimentation Works (SW);
d) Balancing Reservoir (BR);
e) High-Lift Pumping Station (HLPS);
f) Break Pressure Tank;
g) Break Pressure Reservoir (BPR);
h) Repeater site 1 (R1);
i) Repeater site 2 (R2);
j) Repeater site 3 (R3);
k) Radio PTA Repeater (EZT Communications);
l) Kuncura Repeater (EZT Communications);
m) Fancy Repeater (EZT Communications);
n) Tafelkop Repeater (EZT Communications);
o) Matimba Stacker Unit 1 (Eskom);
p) Zeeland WWTW;
q) Off-Take A;
r) Off-Take B;
s) Mokolo Dam Wall Hut (MDWH);
t) Mokolo Pump Station (MPS); and
u) Wolwefontein Dam (WD).

Complete and operational licenced Microwave wireless network consisting of:

a) Two microwave radios at AW and LLPS;
b) Two microwave radios at R1 (Link LLPS to HLPS);
c) Two microwave radios at SW, BR and HLPS;
d) Two microwave radios at R1 (Link HLPS to BPR);
e) Two microwave radios at BPT;
f) Two microwave radios at BPR;
g) Two microwave radios at R1 (Link BPR to Off-Takes);
h) Two microwave radios at R2 (Link BPR to Off-Takes);
i) Two microwave radios at R3 (Link BPR to Off-Takes);
j) Two microwave radios at Radio PTA Repeater (EZT Communications);
k) Two microwave radios at Kuncura Repeater (EZT Communications);
l) Two microwave radios at Fancy Repeater (EZT Communications);

m) Three microwave radios at Matimba Stacker Unit 1 (Eskom);

n) Two microwave radios at MDWH;

o) One microwave radio at MPS;

p) One microwave radio at Off-Take B – Medupi;

q) One microwave radio at Off-Take A – Grootgeluk Mine, Thabametsi IPP and Matimba;

r) Two microwave radios at Zeeland Connection;

s) One microwave radio at Mokolo Pump Station;

t) Two microwave radios at Mokolo Dam Wall; and

u) Three microwave radios at Tafelkop Repeater.

Refer to the attached Link Planner Profile report for detailed information on proposed microwave radio links. The proposed Microwave radio links under this MCWAP-2 Project include, but are not limited to the following:

a) **LLPS** to **R1** (Link LLPS - HLPS);

b) **R1** (Link LLPS - HLPS) to **HLPS**;

c) **HLPS** to **R1** (Link HLPS - BPR);

d) **R1** (Link HLPS - BPR) to **BPT**;

e) BPT to **BPR**;

f) **BPR** to **R1** (Link BPR – Off-Takes);

g) **R1** (Link BPR – Off-Takes) to **R2 (Link BPR – Off-Takes)**;

h) **R2 (Link BPR - Off-Takes) to R3 (Link BPR - Off-Takes)**;

i) **R3 (Link BPR - Off-Takes) to Radio PTA Repeater (EZT Communications)**;

j) **Radio PTA Repeater (EZT Communications) to Kuncura Repeater (EZT Communications)**;

k) **Kuncura Repeater (EZT Communications) to Tafelkop Repeater**;

l) **Tafelkop Repeater to Zeeland WWTW**;

m) **Tafelkop Repeater to Fancy (EZT Communications)**;

n) **Zeeland WWTW to Matimba Stacker Unit 1 (Eskom)**;

o) **Matimba Stacker Unit 1 (Eskom) to Off-Take A**;

p) **Matimba Stacker Unit 1 (Eskom) to Off-Take B**;

q) **Fancy Repeater (EZT Communications to Wolwenfontein Reservoirs**;

r) **Wolwenfontein Reservoirs to Mokolo Dam Wall Hut**; and

s) **Mokolo Dam Wall Hut to Mokolo Pump Station**.

Including all:

a) Upper 6GHz ODU’s;

b) CAT5e/CAT6 Outdoor Cable;

c) Grounding / Earthing Kits;

d) PoE Injectors;

e) Ground / Earth Cable for ODU's;

f) Activation Licences Keys;

g) Glands;

h) GBE Connector kits;

i) Antenna upper 6GHz type 1", 2", 3", 4" and 6";

j) OMT Kit upper 6GHz; and

k) Mast / tower lattice types: 15 m, 24 m, 33 m, 50 m, 54 m, 60 m, 64 m, 70 m.

40.12.2 General

40.12.2.1 Purpose of the Network

The Licenced Microwave Wireless System is to be used as a secondary or backup network if the primary network – Ethernet (Fibre Optic) goes down between any two links. Both the primary and secondary networks shall work independently of each other and both shall be transmitting / receiving data all the time between links. The primary and secondary networks shall be connected at each site to a managed Ethernet network switch. The network switches shall have sufficient Ethernet fibre ports (1000BASE-ZX SFP's) and Ethernet copper ports (100BASE-T/1000BASE-T RJ45).

The secondary microwave network will be connected to a RJ-45 Ethernet port on the network switch. The network switches monitor the transmitted / received data traffic on both Ethernet Ports in the network switches. The default setting in the network switch menu shall be set up as follows:

a) Enable the SFP Ethernet port connected to the fibre optic cable; and

b) Disable the RJ-45 Ethernet port connected to the microwave radio.

These default settings will ensure that no traffic loops are caused, whilst ensuring the network switch can monitor the data traffic communication on both Ethernet ports. If the data traffic communication over the primary fibre optic goes down or is interrupted (for any link between sites), the network switch will automatically disable the Ethernet port connected to the fibre optic patch lead whilst enabling the Ethernet port going to the microwave radio.

This process will happen at both network switches, situated on either side of the affected link between sites. The network switches will continue to monitor traffic over both ports. As soon as the primary fibre optic link is restored (for the affected link), the network switch will automatically enable the port connected to the fibre optic cable, whilst disabling the port connected to the microwave radio. This entire process happens seamlessly, with zero interruption of data traffic communication between the affected link.

A Network Management System (NMS) is required to give visual and/or audible indication when a link goes down between any two sites. The NMS uses graphical layouts built on a database. The database of the NMS uses MIB (Management Information Base) files received from the manufacturer of the Plant used on the project. These MIB files give detailed system information regarding the Plant. The NMS uses the information in its database for each specific make and model of Plant installed and measures the Plant performance over each fibre optic or microwave link.

If there are any Plant causing link degradation / link failures between any two sites, then the NMS will give indication of these errors. The NMS provides continuously updated information on the

status of fibre optic Plant and microwave Plant over each link. This provides an invaluable tool to a maintenance Engineer and can form an integral part of a Maintenance Management System (MMS).

40.12.2.2 Testing and Commissioning

All radio Plant offered shall come complete with a SANS test certificate for compliance with the requirements of the regulatory authority (ICASA) for the make and model of microwave radio Plant item offered. Radio Plant items offered without a SANS test certificate shall not be accepted.

The Engineer reserves the right to instruct the Contractor to submit a complete microwave radio system or relevant Plant item to the SANS to be tested for the following, before acceptance of the Plant item for incorporation into the Works:

a) Compliance with the limits on the emission of radio frequency interference as controlled in terms of the Radio Act; and

b) Satisfactory operation of the Plant at the extremes of the ambient operating conditions specified.

Refer to Clause 41.5 in this regard.

The costs for the performance of these tests shall be for the Contractor's account, as detailed in Section 48 – Tests on Completion.

The Contractor shall submit all test and calibration certificates received from specialist suppliers, to the Engineer for his approval. Such documents shall then be included in the as-built manuals.

40.13 TESTING AND PRE-COMMISSIONING

All radio Plant shall be tested at the Contractor's works before any Plant will be transferred to site. Each unit shall be tested with respect to the following:

a) Transmitter output power;

b) Transmitter modulation for -12 dBm to 0 dBm input;

c) Transmitter output frequency and frequency stability;

d) Transmitter output power, modulation and frequency variation with change in supply voltage;

e) Receiver sensitivity for 12 dBm Sinad;

f) Receiver input frequency;

g) Receiver audio output level and distortion;

h) Duplexer insertion loss and Tx/Rx isolation;

i) Repeater Station talk-through tests; and

j) Current consumption figures.

Any faults, deviations etc., discovered during the inspections at the work shall be rectified fully before any Plant is transported to site.

40.14 INSTRUMENTATION

Refer to Clause 41.1.

Refer to Technical Schedules for detail instrument specifications, document number 1A-O-144-6 for the I/O list and to Drawings for required cable connections to PLCs.

40.14.1 Abstraction Works and Low-Lift Pumping Station

The following water quality instruments shall be installed in the pipeline to the Low-Lift Pumping Station:

- Conductivity; and
- Turbidity.

Multiple or single parameter instruments can be offered by the Contractor.

40.14.2 High-Lift Pumping Station

There are four (4) High-Lift pumps in this pump station. The signals associated with each pump set are listed in the I/O List, document number 1A-O-144-6.

The following motor and pump monitoring shall be provided:

a) Vibration monitoring on both drive and non-drive ends of the Motor;

b) Vibration monitoring on both drive and non-drive ends of the Pump;

c) Temperature monitoring on Bearings on both drive and non-drive ends of the Motor – PT100 RTDs;

d) Temperature monitoring on Bearings on both drive and non-drive ends of the Pump – PT100 RTDs; and

e) Temperature monitoring on all the Windings of the Motor – PT100 RTDs. The motors shall be equipped with an extra set of RTDs per winding. This set is a standby set and shall be wired to the motor termination box, but not connected to the PLC.

Separate temperature and vibration monitoring transmitters shall be provided for each pump set. The RTDs transmitters shall be mounted in a junction box. Instrumentation on the pump sets shall be provided as shown on Drawings and specified on Technical Data sheets.

All flow meters shall have separate power supplies.

40.14.3 Balancing Reservoir and Sedimentation Works

There shall be various I/O and instrumentation installed at the Balancing Reservoir and Sedimentation Works. These shall include valve I/O, level measuring instruments and flow meters. Refer to the P&IDs for the Balancing Reservoir and Sedimentation Works.

All flow meters shall have separate power feeders supplying them.

40.14.4 Break Pressure Tank

There shall be various I/O and instrumentation installed at the Break Pressure Tank. These shall include valve I/O, pressure instruments and flow meters. Please refer to the P&IDs and corresponding part of the I/O list in document number 1A-O-144-6 for the Break Pressure Tank.

All flow meters shall have separate power feeders supplying them.

40.14.5 Break Pressure Reservoir

There shall be various I/O and instrumentation installed at the Break Pressure Reservoir. These shall include valve I/O, pressure instruments and flow meters. Please refer to the P&IDs for the Break Pressure Reservoir.

All flow meters shall have separate power feeders supplying them.

40.15 CABLING

Refer to Section 41 - C&I Plant and Installation.

Cable sizes, types and approximate lengths are as shown on the Drawings. Installation shall be done in accordance with the standard installation Specification.

40.16 LABELLING AND NUMBERING

Plant shall be marked clearly in accordance with the Drawings.

Plant not designated or numbered on the layout Drawings shall be labelled by means of a unique numbering system for ease of identification. The Contractor shall submit a numbering system as well as examples of the labels for approval by the Engineer.

All cables shall be clearly labelled at both ends. Each end shall be labelled to identify the Plant it is connected to on its other end. More than one cable of the same type shall be distinguished by a second suffix in numerical order.

All cabling and wiring shall be marked with HELAGRIP PVC cable markers. Circuit as well as cable numbers shall appear on all “as-built” (“as installed”) drawings.

Draw boxes and terminals shall be numbered and labelled.

Labels shall be permanent and indelible.

Numbering and labelling shall be such that, during maintenance, the wiring can be traced by using the ‘as-built” (“as installed”) drawings.

40.17 OPERATION AND MAINTENANCE MANUALS

Submission of O&M Manuals shall be as required under Section 48 – Tests on Completion.

40.18 SPARE PARTS REQUIREMENTS

The Contractor shall list and price the spare parts considered to be necessary as required for the continued operation of all mechanical, electrical and electronic Plant based not only on a reliability analysis of the Plant, but also on the reliability and availability of local suppliers of spare parts. The lists shall also include all long lead maintenance items and special maintenance tools that will be required during the maintenance of the Plant by the Contractor. The lists of additional critical spare parts must be submitted to the Engineer prior to achieving RFTO.

The total amount for spares derived from for each part of the Works shall be carried forward to the Bill of Quantities. A Provisional Sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.

40.19 TOOLS AND ACCESSORIES

All tools, special tools and accessories required for the normal operation and maintenance of all the Plant and systems supplied, shall be included in this Contract.

All keys, tools and special tools shall be in duplicate and handed to the Engineer upon completion. The Contract shall be deemed to be incomplete until this requirement has been met.

The Contractor shall ensure that all tools and equipment required are available during inspections and testing. This includes two-way radios, meters, keys, manhole cover removers, and conductivity meters, bridging pieces, recorders and personnel as required.

40.20 TESTS AND TESTS ON COMPLETION

Factory Acceptance Testing, Site Testing and Tests on Completion shall be as per Installation Specification in Section 41- C&I Plant and Installation and Section 48 – Tests on Completion.

40.21 MAINTENANCE AND GUARANTEE

The Plant and installation included in this Contract shall be guaranteed and maintained in all respects for the duration of the Defects Notification Period.

The Contractor shall, for the full duration of the Defects Notification Period, be responsible for all work and Plant replacements required, including labour, travelling costs, the replacement of lamps and fuses, etc. Renewals or repairs resulting from misuse, however, will not be made at the expense of the Contractor. The Contractor shall repair / replace faulty Plant within 48 hours of notification.

The Contractor shall submit full details of his maintenance and repair service facilities, including statutory holidays, weekends, after hours and normal hours.

The Contractor shall stock the spares during the Defects Notification Period. All repairs to be made to the installation due to causes not covered by the guarantees shall be done utilising the above material.

At the end of the Defects Notification Period the remaining material shall be documented and handed over to the Employer for the ongoing maintenance of the installation.

40.22 CONTROL PHILOSOPHY

40.22.1 General

The control philosophy is for an integrated fully automated system, except for activities that requires operators, e.g. cleaning, normal and preventative maintenance. Appropriate communication, monitoring and control systems shall be provided to allow for the effective and efficient control of all systems and the integration of MCWAP-1, RMS and MCWAP-2.

A new centralised Operational and Control Centre (O&CC) will be established under MCWAP-2. The O&CC will be built at the Vlieëpoort High-Lift pumping station site. Management and control of the integrated MCWAP-1, RMS and MCWAP-2 transfer system will be done via a SCADA System.

The SCADA System shall interface with Programmable Logic Controllers (PLC) at each site.

The primary communication network shall be a Primary Ethernet fibre optic single mode cable and the secondary or backup system shall be a licenced Microwave Radio system.

The following areas shall be controlled and monitored from the SCADA System situated in the centralized Operational and Control Centre (O&CC):

a) River Management System (RMS);
b) Abstraction Works and Low-Lift Pumping Station;
c) Balancing Reservoir and Sedimentation Works;
d) High-Lift Pumping Station;
e) Break Pressure Tank;
f) Break Pressure Reservoir;
g) MCWAP-1 sites;
h) Off-Take A (Grootgeluk Exxaro, Matimba and Thabametsi IPP);
i) Off-Take B (Medupi); and
j) Points of supply.

40.22.2 Control of Plant

Plant shall be controlled as follows:

40.22.2.1 Actuated Valves

All electrically actuated valves have a key operated local / remote selector switch.

(a) Local Selection

Valves can be opened, closed and controlled at the Plant (local).

Local selection will normally be chosen for maintenance purposes and during communication network or control system failures.

(b) Remote Selection

Opening, closing and control of valves can be done from the SCADA (remote from Plant).

Remote selection is the normal operating mode.

40.22.2.2 Pumps and Associated Valves

All electrically actuated valves associated with the pumps shall have a lockable local / remote selector switch.

(a) Local Selection

Local selection will normally be done for maintenance purposes only or during SCADA or network failure.

Valves can be opened and closed on the Plant (local). The following safety interlocks are provided by the pump set PLC:

- The pumps will not start unless the valves are in the Remote mode as the valves are PLC controlled during pump start up and stopping; and
- The pumps will trip if the valve open signal fails or if the valve is closed during pumping operations.

Pumps can be started in the Local mode from the HMI's on the respective pump control panels. This will be used for maintenance purposes only or during SCADA or network failure.

All the pump protection shall still be provided by means of the pump PLC.

(b) Remote Selection

Remote selection is the normal operating mode and will be done from the SCADA.

Pumps can be started in auto or manual mode from the SCADA. The pumps will be started by means of the time function and water level control in the Break Pressure Reservoir in auto mode. This is the normal mode of operation.

Pumps can be switched to manual mode on the SCADA using a password. This will only be used during commissioning and network failure.

40.22.3 Controlled Areas

40.22.3.1 Abstraction Works and Low-Lift Pumping Station

Refer to P&I Diagrams no 2B-E2.1-001, 2B-E2.1-002 and 2B-E2.1-003.

40.22.3.2 High-Lift Pumping Station

Refer to P&I Diagrams no 2E-E2.1-001 to 2E-E2.1-004.

Each pump line, including VSD's, motors, pumps and associated valves shall form part of the pump supply Contractor's design and programming. All I/O shall be wired to a dedicated PLC for that pump line. These PLCs shall be connected to each other and to the common control PLC via an Ethernet communication network.

Pumps shall be started remotely from the SCADA system in auto or manual mode.

Water quality instrument readings on the outlet pipe from the Pump Station shall be displayed on the SCADA screen.

(a) Remote Auto Mode (SCADA)

The High-Lift Pumping Station shall be controlled by level sensors in the Break Pressure Reservoir (delivery line) during auto mode (default mode) and level sensors in the Balancing Dams (suction line).

(b) Remote Manual Mode (SCADA)

The pump operation, in manual mode, shall ignore the process interlocks like the Break Pressure Reservoir levels, but still operate under the safety interlocks from the pump line. The Pump operation process interlocks shall apply and the operator shall be prohibited from operating pumps outside these process interlocks.

(c) Local Manual Mode (HMI)

Local start operation shall be selected from the HMI. The pump operation, in local mode, shall ignore the Break Pressure Reservoir levels, but still use the safety interlocks from the pump line. Pump operation process interlocks shall not apply.

40.22.3.3 Balancing Reservoir

Refer to P&I Diagram no 2D-E2.1-001. All I/O shall be wired to a PLC situated at the Balancing Dam.

Level indication in the Balancing Dams shall be displayed on the SCADA screen and used for control purposes.

40.22.3.4 Gravity Pipeline

Air valves and scour valves on the pipeline shall not be monitored.

Farmer water take offs shall be provided with battery operated magnetic flow meters with built in data logging. Data shall be manually downloaded from these flow meters and shall not be displayed on the SCADA.

Differential flow between the flow meter at the Break Pressure Reservoir and the flow meter at Off-Take B shall be used to check if allocated water to farmers is not exceeded and/or if any scour valves are left open on this section of the pipeline.

Differential flow between the flow meter at Off-Take B and the flow meter at Off-Take A shall be used to check if allocated water to farmers is not exceeded and/or if any scour valves are left open on this section of the pipeline.

40.22.3.5 Off-Take A Connection (Matimba, Exxaro and Thabametsi IPP)

Refer to P&I Diagram no 2J-E2.1-001. All I/O shall be wired to a PLC situated in this area.

Valves in this valve chamber shall be remotely controlled from the SCADA. Valve opening shall be controlled in auto mode (default mode). Valve position indication shall be displayed on the SCADA screen.

Valves can be switched to manual (remote) mode or local (at the valve) mode on the SCADA. Any water management control shall be overridden in this mode and this shall only be used for maintenance purposes.

Flow meter readings shall be displayed on the SCADA screen.

40.22.4 Water Management

Water management shall be done as follows:

a) Take water quality measurements and display on SCADA screen;

b) Monitor Balancing Dam levels;

c) Stop pumps when the Break Pressure Reservoir is full;

d) Off-Take A and Off-Take B supply valves shall be controlled;

e) Off-Take A and Off-Take B water supply flow readings shall be done with a Major Payment Flow meter and a Check Flow meter in series. Both flow meters shall be displayed on the SCADA screen. An alarm shall be raised when a difference of more than 5% is detected between the meters. Both readings shall be logged at all times by the SCADA and a monthly report shall be available if requested by the operator;

f) Minor Payment Flow meters shall be installed for the farm take-offs. These reading shall not be displayed on the SCADA;

g) Water Balance Flow meters shall be installed in the following locations:

   i) Low-Lift Pumping Station supply pipelines;

   ii) Feeding pipeline of High-Lift Pumping Station;

   iii) High-Lift Pumping Station supply pipeline;

   iv) Feeding pipeline of Break Pressure Reservoir;

   v) Break Pressure Reservoir release pipeline;

   vi) Off-Take B feed pipeline; and

   vii) Off-Take A feed pipeline.

h) Display all the Water Balance Flow meters on the SCADA screen. Log readings at all times by the SCADA and a monthly report shall be available if requested by the operator;

i) Flow meters on pipelines BPR to Off-Take B shall be used to determine and check farm water take offs;

j) Flow meters on pipelines Off-Take B to Off-Take A shall be used to determine and check farm water take offs;

k) The flow reading on pipeline Off-Take A (Grootgeluk connection) shall be used to control the maximum flow to Grootgeluk Mine. Flow shall be limited by means of a control valve in pipeline;

l) The flow reading on pipeline Off-Take B (Medupi connection) shall be used to control the maximum flow to Medupi. Flow shall be limited by means of a control valve in pipeline;

m) The flow reading on pipeline Off-Take A (Matimba connection) shall be used to control the maximum flow to Matimba. Flow shall be limited by means of a control valve in pipeline; and

n) The flow reading on pipeline Off-Take A (Thabametsi IPP connection) shall be used to control the maximum flow to Thabametsi. Flow shall be limited by means of a control valve in pipeline.

40.22.5 Low Lift Pumping Control

40.22.5.1 General

The pump start-up procedure shall be provided by pump supplier at tender stage. See battery limits for design.

The pumps shall be controlled by the levels in the Balancing Reservoir. The Low-Lift Pumps shall be VSD controlled and shall extract water out of the weir based on the level (weir level same as river level). Higher levels in the river will cause the VSD's on the Low-Lift pumps to increase whilst lower levels in the river will decrease the VSD's on the Low-Lift pumps. These Low-Lift pumps will operate on a 24/7 basis. The Balancing Dams are sufficiently sized to accommodate the 24/7 pumping from the LLPS. The pumps shall be stopped on high levels in the Balancing Reservoir respectively.

Pressure transmitters across the pump set shall be used to ensure that the pump operates on the pump curve and will trip the pump if it exceeds certain pre-defined limits.

The flow transmitter in a pipeline shall be used to ensure positive flow after a certain start-up period.

Two pump sets will start up every time with the third set being the standby set.

The duty pumps shall rotate with each pump cycle. The pump running hours shall be recorded and logged and the pumps with the least running hours will be the duty pumps with each cycle. The standby pump shall take over from duty pump if a duty pump fails to start, stopped or tripped.

A time delay of 2 minutes shall be implemented between consecutive starts of pumps.

40.22.5.2 High-Lift Pump Start up Sequence

The start-up sequence for a pump set is as follows (detail shall be provided by the Contractor):

a) Block vibration protection and high discharge pressure protection for start-up;

b) The start-up siren sounds for 15 seconds;

c) The cooling water system starts;

d) The VSD starts and ramps up to full speed;

e) Confirm discharge pressure;

f) Confirm discharge flow;

g) Unblock motor and pump vibration protection;

h) Confirm vibration levels; and

i) Confirm differential pressure across the pump for any high flow conditions.

40.22.5.3 High-Lift Pump Stop Sequence

The stop sequence for a pump set is as follows (detail shall be provided by the Contractor):

a) Block vibration and low discharge flow protection;

b) Stop VSD;

c) Close pump discharge isolating valves; and

d) Stop cooling water after time delay.

The outlet valve at the High-Lift Pumping Station will be closed and all the pumps will be stopped when a high sump level is detected in the High-Lift Pumping Station building.

40.23 QUALITY CONTROL FOR CONTROL AND INSTRUMENTATION

40.23.1 Responsibility for Quality

This part of the specification shall be read in conjunction with the Contractor's Quality Management System which shall be in accordance with ISO 9000.

The Contractor shall implement a comprehensive Quality Control Plan and accept full responsibility for the quality of his workmanship and material used, irrespective of any quality surveillance that may be carried out by the Engineer or his appointed representatives.

In keeping with the principles contained in the above-mentioned code of practice, the Contract or any nominated and approved Subcontractor(s) shall -

- Be responsible for compliance with all the Clauses of this Specification in every respect;
- Carry out all Factory Acceptance and Site inspections and tests called for in the specifications in the presence of the Engineer or his appointed representative. The cost of these inspections and tests shall be included in the tendered rates; and
- Draft a quality control plan for manufacturing indicating all the intended stages of testing during manufacture as well as hold points for independent quality surveillance and testing.

The quality control plans will not be compromised once in agreement and shall be adhered to at all times.

40.23.2 Notice of Inspection

The Engineer shall be notified at least seven days in advance, or as otherwise agreed for him to make travel plans as required, of impending inspections or testing in terms of the agreed Quality Control Plans.

40.23.3 Contractor Qualification

The Contractor and Subcontractor(s) shall satisfy the Engineer that they have the management, facilities and equipment, skilled staff, a quality control procedure and required test methods and standards to carry out quality control during manufacture.

The above-mentioned Contractors shall be subject to a Quality Audit.

40.23.4 Submission for Approval

The Contractor shall submit the following to the Engineer, including data sheets where applicable, for approval:

40.23.4.1 For Manufacture

- Drawings;
- A programme;
- A quality control plan; and
- A draft Operation and Maintenance manual.

40.23.4.2 For Corrosion Protection

- A programme;
- The Quality Control Plan for corrosion protection duly completed;
- Blast material;
- Coating products; and
- Pickling and passivating products.

40.23.5 Manufacture Programs

The manufacture programs shall state the time and place when the following will be conducted:

- Inspection of enclosures and material; and
- Testing.

40.23.6 Substandard Quality Control

All material, certification and records of the Contractor shall be subject to examination by the Engineer.

This shall include the checking and testing of the Plant. If any deviation is found, additional testing and quality surveillance shall be carried out.

If the additional testing confirms inaccurate quality control by the Contractor, all work shall be stopped and shall only proceed after remedial action has been implemented.

40.23.7 Access for Surveillance

For the purpose of carrying out quality surveillance, the Engineer or his representative shall be granted access to any part of the Contractor's premises relevant to the work being carried out, at any reasonable time.

The Contractor shall provide, at his own cost, any equipment or labour necessary to gain access to surfaces which are coated, to be coated or are in the process of being coated.

40.23.8 Cost of Quality Control

The cost for quality control shall be included in the Tender price.

When surveillance results in rejection of the lot or when notice by the Contractor results in a fruitless trip, the cost borne by the Inspector / Engineer shall be debited against the Contractor's account.

Where Plant or services fail to meet the Contract requirements but are nevertheless accepted at an agreed revised price, the costs with regard to inspections, tests and analyses shall be for the Contractor's account unless otherwise directed by the Employer.

40.23.9 Non-Compliance with the Specification

Plant, materials and services that do not conform to the requirements of this Specification shall be rejected.

Such rejected Plant shall be held at the cost and risk of the Contractor who shall, when called upon, and at his own cost, repair the defects or corrosion protection according to the Contract.

Failing satisfactory repair of rejected Plant, the Plant shall be returned to the Contractor at his cost and risk without any opportunity to substitute the rejected Plant. Alternative Plant may be purchased at the Contractor's expense or an approved Contractor may be employed to do the repair to the corrosion protection.

Should the Contractor fail to comply with the provisions of the Specification, the Taking-Over Certificate shall not be issued.

40.23.10 Acceptance

No Plant shall be accepted nor be delivered to site unless all Quality Control requirements have been complied with.

40.24 QUALITY CONTROL RECORDS

40.24.1 Coating and Material Records

Quality control, material and coating records for all stages of the work, i.e. batch numbers of materials used, environmental conditions and all test data shall be recorded on the approved Quality Control Plan for manufacture and the Quality Control Plan for corrosion protection.

Certificates for all materials used shall also be required.

40.24.2 Data sheets, Specifications and Codes of Practice

The Contractor shall have available the latest issues of the following:

- A copy of this Specification;
- Relevant Standard Specifications and Codes of Practice;
- Drawings; and
- Manufacturer's data sheets for materials to be used.

The above mentioned shall be available to all the Contractor's Quality Control and Production personnel.

40.24.3 Quality Control Records

Accurate and detailed quality control records shall be kept by the Contractor for all stages of the work.

All the quality control records shall be available for inspection by the Engineer or his representative.

Incomplete, inaccurate or inadequate records shall be regarded as non-compliance with the Specification.

The collection of documents for each item of Plant shall be collated and bound in a logical manner and retained by the Contractor as proof of quality achieved. These shall be available on demand for quality control and part payment releases. The records shall be handed over to the Engineer on completion of the work.

The records shall be bound in the Operation and Maintenance Manuals where such manuals are supplied. Refer to Section 48 in this regard.

40.24.4 Provision for Testing

The Contractor shall at no additional cost provide all material, samples, labour and the necessary calibrated instruments which may be required for the purpose of inspection, testing and analyses, unless otherwise specified.

40.25 QUALITY SURVEILLANCE BY THE ENGINEER

40.25.1 Inspection by the Engineer and/or Approved Inspection Authority (AIA)

Inspection of Plant shall be carried out by the Engineer and/or an AIA at the manufacturer’s works.

The Engineer's and AIA’s inspections shall in no way relieve the Contractor or Subcontractors of any of their obligations to design, manufacture, test, inspect and supply Plant of superior quality and workmanship in accordance with the specification.

The Engineer and AIA have the right to inspect any item covered in the Contract at any stage of execution of the Contract.

Where imported supplies are to be inspected before shipment, the Contractor shall notify his suppliers abroad of the conditions applicable to inspections and also notify the Engineer and AIA when consignments are ready so that arrangements for inspection may be made.

40.25.2 Material Tests

The Manufacturer's material test data certification and the Contractor's quality records shall be subject to examination by the Engineer or his representative.

40.26 DRAWINGS

40.26.1 Drawings Issued by the Engineer

The Drawings that were issued as part of the Tender documentation are not manufacturing drawings and the dimensions given are only sufficient for tendering purposes or to enable the Contractor to complete his working drawings.

40.26.2 Contractor's Drawings

The Contractor shall submit drawings for the following purposes:

- Concept Design : for assessment
- Manufacturing (Workshop) : for approval
- Installation : for approval
- As built : for records

40.26.3 Concept Design Drawings

a) The Contractor shall submit concept design drawings for review by the Engineer before commencing with manufacturing drawings.

b) Concept drawings submitted by the Contractor shall give sufficient information to make a proper assessment of the Plant offered together with sufficient detail to enable the dimensions and general arrangement of the Plant to be determined. All the important parts shall be shown in detail, i.e. gate body, scaling arrangements, bearing arrangements, guides, wheels, etc.

c) Drawings shall include details of parts to be built into, and loads to be transferred to, the civil engineering works, routes and sizes of cabling, cable ducts or trunking, hydraulic pipework, description of erection methods, operating and control units, position indicators and details of connections to any other Plant.

40.26.4 Manufacturing (Workshop) Drawings

a) Before commencing with fabrication, drawings in triplicate shall be submitted for approval by the Engineer. These drawings shall cover the general arrangement, assembly and supporting detailed drawings of the Plant offered and their related ancillary Plant.

b) The drawings shall provide complete information regarding thickness and types of material, finishing of surfaces, fixing and connections, standard parts, tolerances, clearances with regard to other machine parts or building faces and in general everything that may have a bearing on the satisfactory fabrication, erection and operation of the Plant shown on these drawings.

c) Electrical Plant wiring and or hydraulic diagrams for the sub-assemblies such as distribution and control boards, as well as overall integrated cabling and wiring diagrams for the complete installation, shall be prepared and submitted in a similar fashion to these drawings.

d) These drawings shall be submitted within the period(s) as indicated on the Construction Programme and agreed with the Engineer. All drawings submitted must signify authorisation by the Contractor. Submission of the Contractor's drawings shall be accompanied by one or more updated index sheets prepared on A3-size sheet, listing all drawings with numbers, titles and status of amendments.

e) Two weeks after submission by the Contractor, or 10 days in the event of re-submission, the Engineer will return one of the above-mentioned prints either with his certified approval or else with his comments regarding any amendments that may be required. A drawing returned to the Contractor for amendment purposes shall be re-submitted in its amended form within two (2) weeks of the date of receipt of the drawing by the Contractor.

f) Approval of the above drawings by the Engineer shall only signify approval of the general design and layout and shall not make the Engineer liable for any error by the Contractor.

g) Priority shall be given to those drawings regarding items that affect the concrete or other construction work of a civil engineering nature. These drawings shall detail in full, the necessary provisions to be made in the concrete or other supporting structure(s) for casting in of embedded parts and anchors for fixing of built-in parts and Plant.

h) All the foundation details and the positions and dimensions of all connecting rods, pockets, vent ducts, cable ducts, anchor bolt holes and similar items, as well as aligning, fixing, anchoring and second stage concrete requirements must be clearly indicated and detailed on these drawings with the general requirements for built-in parts.

i) The magnitudes and directions of all forces and loads, both static and dynamic, exerted by the Plant on the supporting concrete structure shall be clearly and fully detailed on the Contractor's drawings. Any special requirements to prevent transmitting possible vibrations must also be shown.

40.26.5 Installation Drawings

a) Not later than 21 days after the proposed Plant has been given approval, drawings shall be submitted to allow for adequate site preparation before the arrival of the Plant. These drawings shall offer the necessary details for the programming of civil works, including foundation details and anchor bolts.

b) The Engineer has the right to suspend manufacture until a set of drawings, calculations, a draft Operation and Maintenance Manual and Quality Control Plans (for the manufacture and corrosion protection including data sheets of paint and abrasives used) are in his possession and approved in principle.

40.26.6 "As-built" Drawings

a) On completion of the Works, the Contractor shall deliver to the Engineer's office one complete set in triplicate of high-quality paper copies together with an electronically saved version preferably on Compact Disc of the Contractor's drawings, updated to reflect the as-built information. These drawings must be clearly marked as "as built".

b) These drawings shall contain general arrangements, assemblies, parts lists (including part numbers) and complete component details as well as wiring and hydraulic diagrams. These items are required in draft form before the Tests on Completion are commenced and in final form before Taking Over in terms of the General Conditions of Contract.

c) Layout drawings shall be marked up by the Contractor showing all dimensions to buildings, including the relative positions of underground cables.

Refer to Section 48.

40.26.7 Drawing Format

a) Drawings provided by the Contractor shall be to scale size A3 produced in hard copy and electronically in .pdf format. Each drawing shall show the following particulars in the lower right hand corner:

- Name of Employer;
- Name of Engineer;
- Name of Contractor;
- Project title;
- Contract number;
- Title of drawing (Location, item and detail);
- Scale;
- Date of drawing;
- Details of electrical supply (where applicable);
- Drawing number; and
- Revision identification.

b) Dimensions on all drawings shall be metric.

c) A blank space 45 mm by 30 mm shall be provided as an extension of the title block for the Engineer's approval stamp. Provision shall be made for details of revisions to be recorded above the title block. Prints of drawings shall be in the form of black lines on a white background.

40.26.8 Notes and Part Lists

a) Notes on the drawings shall be in English and dimensions in the metric system in SI units with all scales clearly stated.

b) The Parts Lists shall be part of the assembly drawing unless otherwise agreed to by the Engineer.

40.26.9 Drawing Identification and Number

a) All drawings shall be consecutively numbered.

b) Each drawing shall be provided with a title block as per the construction Drawings issued by the Engineer. A pro-forma drawing frame and title block is available electronically from the Engineer.

40.26.10 Quality and Format of Drawings

a) The standard of draughtsmanship and detailing shall conform to the requirements of SANS 10111 and 10143. Drawings shall be clear, black line on white paper, unfolded and suitable for microfilming purposes.

b) Unless otherwise agreed to by the Engineer, the Contractor's drawings shall be prepared on A3-size (297 mm x 420 mm) high quality paper. The size of the drawing shall not compromise the clarity of the prints.

c) Drawings shall be submitted in hard copy and electronically in pdf format.

d) As-built drawings shall also be submitted in Auto CAD, .dwg format.

40.27 NOTICES AND LABELS

All notices, labels and designations shall be in English. A list of wording, terms, designations etc., shall be submitted for approval before manufacturing of labels and notices commences.

40.28 WORKMANSHIP

The Contractor shall only employ competent staff to execute the installation.

The Contract shall be executed with the best workmanship in a workmanlike manner and to the satisfaction of the Engineer.

Should any material or workmanship not be to the satisfaction of the Engineer, it shall be rectified at the cost of the Contractor and all rejected material shall be removed from site.

The Contractor shall be responsible for the correct and complete erection of the Installation. Inspections by the Engineer shall not release the Contractor from this responsibility.

40.29 SUPERVISION

The Contractor shall provide full time supervision while staff is working on the Contract.

The person nominated by the Contractor to supervise the Works shall have the authority to take instructions on behalf of the Contractor.

40.30 GENERAL

Refer to Section 41 – C&I Plant and Installation for detail of Payment Clauses on each item listed in this Section, except Telemetry Plant which follows below.

40.31 MEASUREMENT AND PAYMENT

The rates tendered under this Section shall not include for the general obligations, Contractor's Equipment and work deemed to be covered by the items provided in Section 1 – General.

40.001 Design and documentation **Unit : lump sum (Sum)**

The rates tendered shall include for full compensation of all costs incurred in the preparation of the design and calculations, detail working drawings for all items, specifications, schematic diagrams, loop diagrams and wiring diagrams, PLC layout diagrams, Control Network layout diagrams, SCADA graphic layouts, engineering software code, engineering design philosophy, control philosophy, operation and maintenance instructions, programmes of work (manufacture and on-site) and any other work as specified for the design of the complete installation. Payment will only be effected after the design and associated documentation has been approved by the Engineer.

Measurement and Payment for the preparation and submission of O&M Manuals shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

40.002 Supply and Deliver to Site **Unit : number (No)**
or: sets (Sets)
or: pairs (Pairs)
or: lump sum (Sum)

The rates tendered shall include full compensation for the supply and delivery of the Plant to Site including supply of raw materials and bought-out items and associated operating Plant items; fabrication, manufacture and assembly; quality assurance and quality control; inspection and Factory Acceptance Testing (including attendance on inspections and tests witnessed by the Engineer); type and routine tests; application of finishes (painting and corrosion protection); trial erection and dismantling; preparation and packing for transport; transport from place of manufacture to the Site; insurance, harbour dues etc., during transport; loading and unloading; storage under appropriate conditions from date of delivery until commencement of erection; and any other work as specified. Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

a) Supply and Deliver Telemetry Enclosure with Power Supply and Battery **Unit: number (No)**

The rate shall include full compensation for the supply and delivery to Site of the specified Telemetry Enclosure with Power Supply and Battery including all required material for a complete and operational installation including surge protection.

b) Supply and Deliver Managed Ethernet Network Layer 2 Switch **Unit: number (No)**

The rate shall include full compensation for the supply and delivery to Site of the specified Managed Ethernet Network Switches including all required material for a complete and operational installation including surge protection.

c) Supply and Deliver Managed Ethernet Network Layer 3 Router **Unit: number (No)**

The rate shall include full compensation for the supply and delivery to Site of the specified Managed Ethernet Network Routers including all required material for a complete and operational installation including surge protection.

d) Supply and Deliver Licenced Spectrum Microwave Radios Unit: number (No)

The rate shall include full compensation for the supply and delivery to Site of the specified Licenced Spectrum Microwave Radios including all required material for a complete and operational installation including surge protection.

e) Supply and Deliver Tower Mast with Base Unit: number (No)

The rate shall include full compensation for the supply and delivery to Site of the specified Tower Mast with Base including all required material for a complete and operational installation including surge protection.

f) Supply and Deliver Comprehensive Earth Kit Unit: number (No)

The rate shall include full compensation for the supply and delivery to Site of the specified Comprehensive Earth Kit including 20 m x 70 mm^2, 10 m x 10 mm^2, 5 x 1.2 m Spikes, 5 off Earth Clamp and Lugs and all required material for a complete and operational installation including surge protection.

40.003 Installation of Plant

Unit : number (No)
or: sets (Sets)
or: pairs (Pairs)
or: lump sum (Sum)

The rates tendered shall include for full compensation for the installation of the Plant on Site including the provision of all labour, transport, materials and Temporary Works necessary to install the complete works; on-site quality assurance and quality control, inspection, testing (including attendance at tests witnessed by the Engineer); the installation of all auxiliary Plant items; necessary for the operation of the installation until taken over by the Employer; the putting into service of the complete installation of the Plant; and any other work as specified.

The rate shall also include for all pre-commissioning testing and the provision of equipment therefore including all disruptions to installation caused by such testing. Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

Measurement and Payment for Test on Completion shall be covered under Clause 48.15 of Section 48 – Tests on Completion and paid elsewhere.

a) Install Telemetry Enclosure with Power Supply and Battery Unit: number (No)

The rate shall include full compensation for the installation, testing and pre-commissioning of the specified Telemetry Enclosure with Power Supply and Battery for a complete and operational installation as specified including surge protection.

b) Install Managed Ethernet Network Layer 2 Switch Unit: number (No)

The rate shall include full compensation for the installation, testing and pre-commissioning of the specified Managed Ethernet Layer 2 Switches for a complete and operational installation as specified including surge protection.

c) Install Managed Ethernet Network Layer 3 Router **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the specified Managed Ethernet Layer 3 Routers for a complete and operational installation as specified including surge protection.

d) Install Licenced Spectrum Microwave Radios **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the specified Licenced Spectrum Microwave Radios for a complete and operational installation as specified including surge protection.

e) Install Tower Mast with Base **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the specified Tower Mast with Base for a complete and operational installation as specified including surge protection.

f) Install Comprehensive Earth Kit **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the specified Comprehensive Earth Kit for a complete and operational installation as specified including surge protection.