APPENDIX A

DISCUSSION DOCUMENT ON

THE OPERATION AND MAINTENANCE PHILOSOPHY

MOKOLO AND CROCODILE (WEST) WATER AUGMENTATION PROJECT (MCWAP) FEASIBILITY STUDY

REPORT 10: REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER

Project No. WP9528

APPENDIX A: DISCUSSION DOCUMENT ON THE OPERATION & MAINTENANCE PHILOSOPHY

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1. INTRODUCTION

It is generally accepted that the responsible authority for owning, operating and maintaining the two transfer systems, i.e. from the Crocodile River and Mokolo Dam, is DWA. Should DWAF, however, not be in a position to fulfil this function it is recommended that this be managed by a semi-autonomous authority,

- which should be responsible to its own management board;
- be responsible for the complete operation and control of the project;
- ensure the full sustainability of the project;
- appoint its own staff/personnel, and
- propose its own water tariffs, bill its own customers, collect its own monies and acquire capital loans as required.

All subject to DWA oversight and appropriate Ministerial approvals.

This sub-report primarily deals with the Operation and Maintenance Philosophy of the MCWAP. These functions will be primarily executed by the authority responsible for the MCWAP Scheme Management Authority (MCWAP SMA).

Details of the institutional arrangements and general functions and responsibilities of the MCWAP Authority (the overseeing authority), MCWAP SMA and the respective River Management Authorities (RMAs) are provided in **Appendix E** of this Report.

2. PRINCIPAL COMPONENTS OF THE MCWAP

Water will be provided from two main sources namely:

- the Crocodile River and
- Mokolo Dam.

In essence the Crocodile River (West) Transfer Scheme will provide water to the new consumers such as Eskom and Sasol, while the Mokolo water will primarily be provided to existing consumers in the vicinity of Lephalale as well as the new Medupi Power Station (partly).

The overall layout of the MCWAP is shown in Figure 2-1 below.

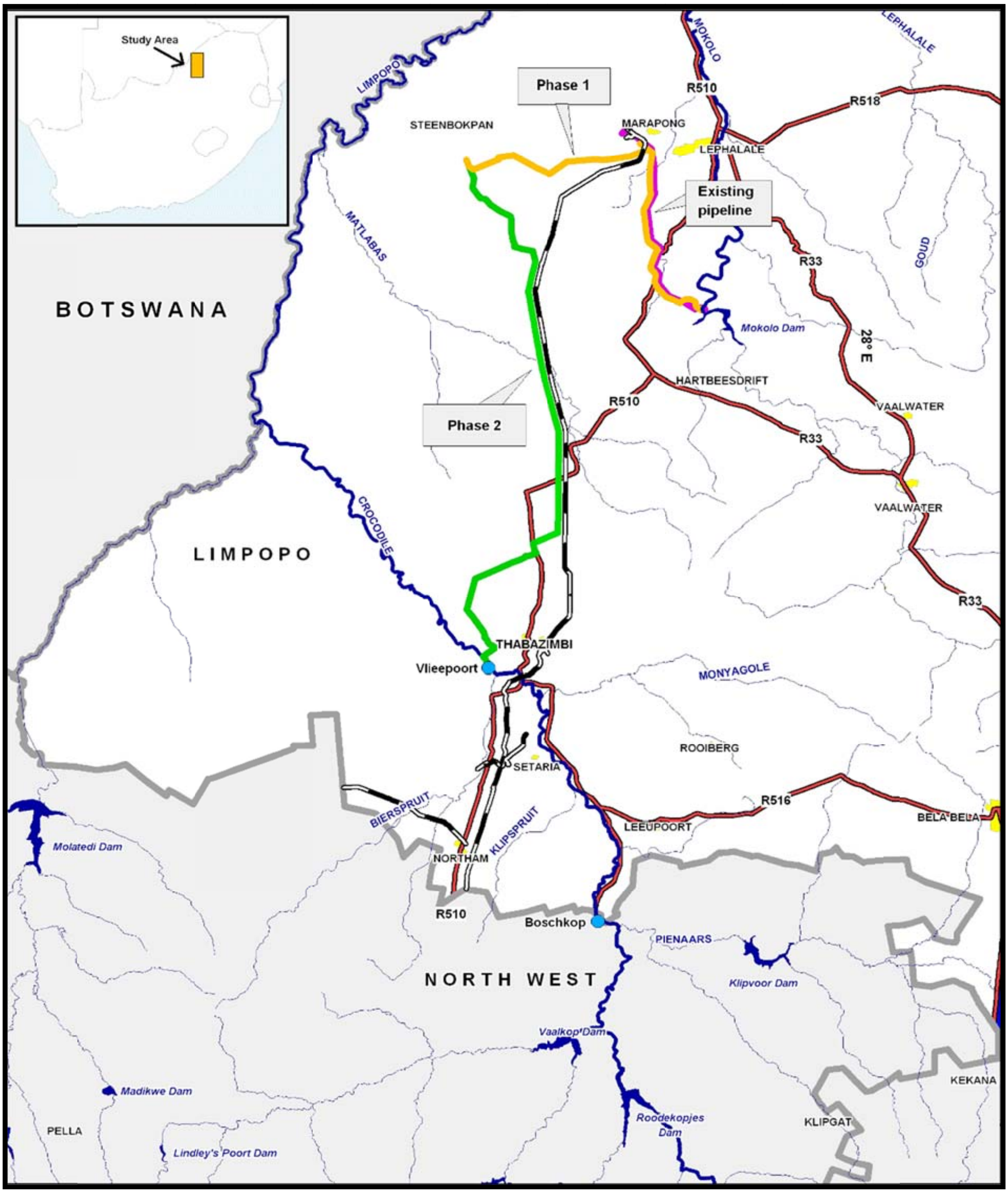

Figure 2-1: Layout of the MCWAP Scheme

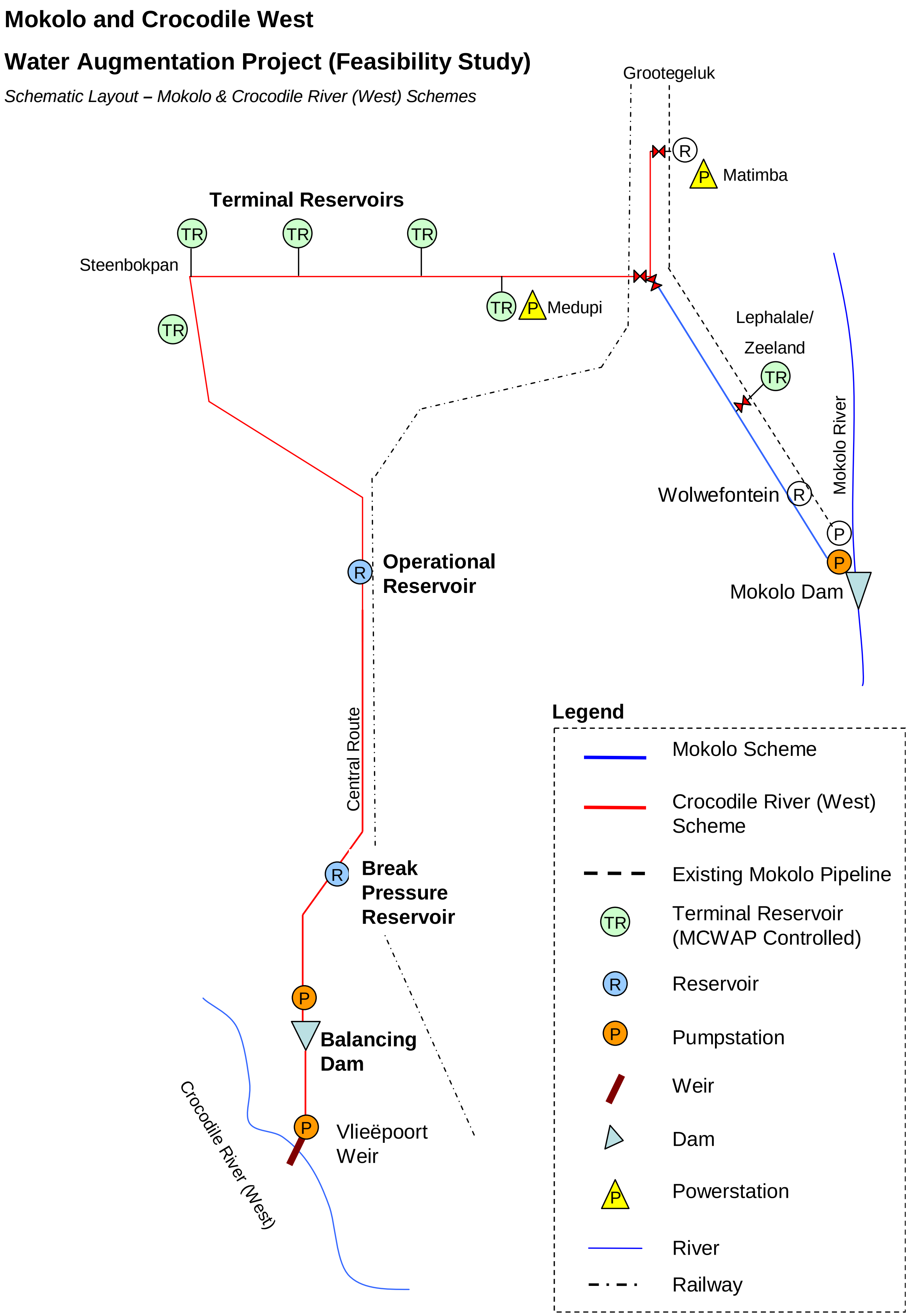

Figure 2-2: Diagrammatic Layout of MCWAP Scheme

2.1 Crocodile River (West) Transfer Scheme (Phase 2)

This will comprise the following main components, namely:

2.1.1 Supply Dams and Crocodile River (West)

The MCWAP will be supplied with water released from Klipvoor, Roodekopjes and Vaalkop Dams (and other dams further upstream of these dams). Hartebeespoort Dam/Roodekopjes Dam will however be the primary sources of supply which in turn will be augmented by return flows from the Pretoria – Johannesburg complex. An assessment of the adequacy and improvements required at the outlet works of these dams are dealt with in **Annexure B**.

Water for the MCWAP will be abstracted at the Vlieëpoort Abstraction Works, which is located some 134 km downstream of Roodekopjes Dam on the Crocodile River (West).

A River Management System will need to be implemented to manage water releases from these dams and water use along the Crocodile River (West) to ensure that the water requirements at Vlieëpoort are met at the specified assurance levels. Infrastructure that will support the river management system, include:

- Existing gauging weirs at the dams, Atlanta, Nooitgedacht and Hugo.
- New gauging weirs at Vlieëpoort and one each along the Bierspruit and Sandspruit.
- Flow meters and power consumption meters at user abstraction points along the river and at boreholes in the flood plain (in the connected alluvial aquifer).
- Instrumentation and telemetry (backed up by manual control readings) feeding a SCADA system.

2.1.2 Vlieëpoort Abstraction Works in the Crocodile River (West)

This will by its design be capable of delivering the widest range of flows at a high efficiency, and will in turn consist of the following:

- A diversion weir with de-gritting capabilities also incorporating a low lift pump station
- Downstream of the weir and above the high flood level (PMF) of the river, a de-silting works and operational storage reservoir followed by a high lift pump station.
- All appropriate monitoring for efficient operation and control, such as level and flow measurement and control.

The operational/balancing storage reservoir will provide storage for effective systems operation (6 hours annual average delivery) as well as off-channel balancing storage (approximately 1,5 days of annual average delivery) for surplus flows released from the upstream storage dams. This reservoir will be compartmentalised for normal operational and maintenance purposes (i.e. a minimum of two compartments).

All pump sets will be controlled by programmable logic controller (PLC) capable of being operated either locally or from the control centre. Also see Section 3.1 below.

Suitably positioned flow meters will be provided in the rising main from the river to the De-silting Works and in the rising main directly downstream of the High lift Pump Station.

2.1.3 Rising Main from the Vlieëpoort Abstraction Works to a Break Pressure Reservoir

The pipeline route from the Vlieëpoort Abstraction Works High-lift Pump Station crosses over a high ridge approximately 60 km from the pump station and then on to an Operational Reservoir close to the centroid of consumption at an elevation from which all the user terminal reservoirs can be commanded by gravity.

The elevation of the high ridge is such that a break pressure reservoir is required on the ridge. The section of pipeline from the High-lift Pump Station at Vlieëpoort to this break pressure reservoir will thus be a rising main. This reservoir will be known as the Break Pressure Reservoir.

The following facilities and structures normally associated with pipelines will be installed en-route:

- Air valves;
- Scour valves;
- Pipe access points;
- Road crossings;
- River crossings;
- A Cathodic protection system;
- Protective measures required to curb surge in a pipeline such as, reflux valves and surge tank(s);
- Any bulk off-takes that may be agreed on by DWA, and
- Farmers off takes.

2.1.4 Break Pressure Reservoir

The function of this reservoir will be twofold:

(i) To break the pressure at the end of the rising main, and

(ii) To feed water into the gravity pipeline between the Break-pressure and Operational reservoirs.

This reservoir will have a minimum of 4 hours storage at full demand to provide effective balancing capacity and to feed into the gravity pipeline supplying water to the operational reservoir. A minimum of two compartments will be provided for normal operational and maintenance purposes. The reservoir will furthermore:

- Have a top entry and a bottom outlet, and
- Have level indication linked to the remote control centre for normal operational purposes.

2.1.5 Gravity main between the Break Pressure Reservoir and the Operational Reservoir

This pipeline will convey the water from the Break-pressure reservoir to the Operational Reservoir by gravity. Facilities and structures normally associated with pipelines, as mentioned in Section 2.1.3 above, will be installed en-route.

2.1.6 Operational Reservoir

This reservoir, located at the edge of a plateau overlooking the consumer area, is suitable and essential for the effective operation of the system as well as distribution of water to the different consumers.

This reservoir will have a minimum of 12 hours storage at full demand to allow for effective distribution and smoothing out of variations in demand. A minimum of two compartments will be provided for normal operational and maintenance purposes. The reservoir will furthermore:

- Have a top entry and a bottom outlet;
- Have level indication linked to the remote control centre for normal operational purposes;
- An automatic altitude valve with pressure sensors at the pumps is proposed to close off the inflow to prevent the reservoir from spilling in the event of communication and computer failure, and
- Be designed to ensure that the gravity pipeline will be running full at all times.

Should couple pipes be used downstream of this reservoir, the installation of a flow control valve (flow limitation) could be considered, to protect the pipe lining from being damaged in the event of a catastrophic break in the pipeline.

2.1.7 Gravity Pipelines supplying the User Terminal Reservoirs

A gravity main will flow in an approximately northerly direction to close to the Eenzaamheid Fault where it will tee off in easterly and westerly directions to the different consumer reservoirs. Facilities and structures that are normally associated with pipelines, similar to those mentioned in Section 2.1.3 above, will be installed en-route.

2.1.8 User Terminal Reservoirs

These Terminal Reservoirs will typically be compartmentalised and have a minimum storage of 18 days of the consumers average final demand, which will be reserved for purposes of the

MCWAP operation and maintenance only, plus storage to be determined by consumers for their own internal balancing and operational requirements.

These reservoirs and possible associated pumping stations will be operated and maintained by the consumer. However there will be feed controls at each reservoir, such as an in-line isolating valve, flow measurement (for revenue purposes), flow control, etc., owned and operated by the MCWAP Authority.

Furthermore these reservoirs will:

- Have top entries (and bottom outlets)
- Have level indicators linked to the control centre for normal operational purposes
- Pressure sensors linked to the inlet control valves to prevent drainage of the gravity pipeline(s).

2.2 Mokolo Dam Transfer Scheme (Phase 1)

This will comprise the following principal components, namely:

2.2.1 Abstraction Pump Station at Mokolo Dam

This pump station which will be constructed directly downstream of the existing pump station will take water directly from Mokolo Dam via one of the two existing outlet pipes from the dam. It will have combined low lift – high lift pumps with the low lift boosters in a well, and the high lift pumps above the probable maximum flood (PMF) tail water level in the river directly downstream of the dam.

The new pump station together with the existing pump station will have to provide the total requirements until the completion of the Crocodile River (West) Transfer Scheme (March 2015). Since the capacity of the new pump station (45 Million m^3/annum) will be greater than the ultimate long term demand plus its 20% “catch-up” requirement from the dam (i.e. 33,2 Million m^3/annum; thus 35.5% greater in capacity making it more than adequate for redundancy purposes), and the fact that the existing pump station is well below the maximum tail water level in the river directly downstream of the dam making it susceptible to floods, there will be no need to keep the existing pump station in service once the Crocodile River transfer system becomes operational in 2015. The suction pipes out of Mokolo Dam will then be interlinked directly upstream of the new pump station inlet manifold.

The pump station will also by its design be capable of delivering the widest range of flows at a high efficiency by means of variable speed drives (VSD's).

As the dam will in effect act as a large settling tank, no de-silting structures will be required.

All pump sets will be PLC controlled from either locally or from the control centre.

2.2.2 Rising Mains from Mokolo Dam (new and existing)

There will be two rising mains from Mokolo Dam to Wolvenfontein balancing reservoirs, namely:

- The existing rising main will be retained. It currently has a conservatively accepted capacity of 13,5 Million m^3/annum. For permanent retention the internal lining will need refurbishment once the Crocodile River Transfer Scheme becomes operational, and
- A new pipeline resulting in a total scheme design capacity of 40 Million m^3/annum.

Since the economics of the retention of the existing rising main in the long term is not yet self-evident, it is recommended that it be investigated after the Crocodile River (West) Transfer System becomes operational. Should refurbishment of the existing rising main be warranted, the two pipelines will be interconnected so that both can be used to reduce the overall energy consumption and either used as and when necessary.

Facilities and structures that are normally associated with pipelines, similar to those mentioned in Section 2.1.3 above, will be installed en-route.

2.2.3 Wolvenfontein Balancing Reservoir (Existing)

This reservoir, with a total storage capacity of 52 000 m^3 in two compartments, implies between approximately 8,5 hours and 12 hours average annual demand active storage for the design flows before and after the commissioning of the Crocodile River (West) Transfer Scheme, respectively. This is adequate for operational purposes. The balancing reservoir has two compartments for purposes of normal operation and maintenance, and should have:

- Top entry and bottom outlets, and
- Level indication linked to the high lift pump station as well as the interim and final control rooms for normal operational purposes.

Should couple pipes be used downstream of this reservoir, it is recommended that the installation of a flow control valve be considered to protect the pipe lining from being damaged.

2.2.4 Gravity pipelines (new and existing)

The gravity pipeline system delivers water into the terminal reservoirs serving the consumers supplied from the Mokolo Dam Scheme (i.e. Lephalale/Zeeland WTW, Matimba Power Station, Medupi Power Station as well as the Steenbokpan–Eskom and – Sasol consumers).

Facilities and structures that are normally associated with pipelines, similar to those mentioned in Section 2.1.3 above, will be installed en-route.

2.3 Operational Control Centre

Since it is envisaged that both transfer systems (i.e. Crocodile River (West) and Mokolo Dam) will be managed as an integrated system by the same Authority, it is proposed that both the transfer schemes are controlled and managed from one operational control centre.

This Operational Control Centre will comprise the administration offices, a central control room, stores and workshops, and should be conveniently located more or less at the centroid of operational activities (i.e. Vlieëpoort/Thabazimbi or Lephalale). There may also be a case to be made to expand the Operational Control Centre to also include for the facilities required for the River Management.

A communications network will link the operations control room to all the main components of both transfer systems. Supporting communication systems required for security and environmental monitoring will also be provided for. The communications network is proposed to be, first and foremost, a fibre-optic cable from the control centre to each site, with a backup system such as a GSM network.

3. OPERATIONS

The control and operation of all sites will be monitored and managed by means of a SCADA (systems control and data acquisition) system from the control room of the Operational Control Centre. All sites furthermore are to be capable of local operation and have sufficient redundancy data storage capacity so that, in the event of communications or computer failure, the data will be restored automatically.

All the daily, weekly, monthly and annual reports necessary for operational and revenue purposes, will be available for extraction from the data captured by the SCADA system.

It is envisaged that the Operational Control Centre from which all the sites, together with the functions that will be monitored and controlled/operated at each site, will be manned on a 24-hour day basis.

The sites together with the relevant functions are listed below. Also refer to Figure 2-2 above for details of the layout of the MCWAP.

3.1 Operational Control Centre

The SCADA will be programmed to give planning, operational, costing and reports for a variety of purposes. The following facilities will also be available:

- Full operational control of all sites
- Monitoring of river releases and flows (as provided by a separate authority if needed. Facilities to allow cross-checking of water balance, water use and system losses will also be included.

- The control of the abstraction of surplus river flows into off-channel storage to optimize water usage.

3.2 Crocodile Transfer Scheme (Phase 2)

3.2.1 Supply Dams and Management of the Crocodile River (West)

- Monitor water levels in the supply dams (Klipvoor, Roodekopjes, Hartebeespoort and Vaalkop Dams).
- Open and close dam outlet valves and set to required release flow as directed.
- Monitor gauging weirs immediately downstream of dams to confirm flow release and adjust outlet valves as may be required.
- Monitor gauging weirs along Crocodile River (West) downstream of dams (Atlanta, Nooitgedacht, Hugo, Vlieëpoort as well as gauging weirs on Bierspruit and Sandspruit.
- Monitor water levels in aquifer downstream of Vlieëpoort Abstraction Works using specially equipped boreholes.
- Open and close low level outlet at Vlieëpoort Abstraction Weir and monitor compliance with IFR release directives.
- Monitor water use and power consumption at river and borehole abstraction points at all users along the Crocodile River (West).
- All of the above data will be used to update the water resources and river management system analysis model.
- Monitor water quality in supply dams, along river and in the aquifer.

3.2.2 Abstraction Works at Vlieëpoort

- Monitor the Crocodile River (West) water level in the weir at the Abstraction Works.
- Start and stop river pumps (Low-lift Pump Station).
- Start and stop High-lift pumps (High-lift Pump Station).
- Change the flow by means of the variable speed drives (VSD's) on the high-lift pumps.
- Monitor the operational/balancing reservoir water level at the Abstraction Works.
- Monitor the "general health" of all the mechanical & electrical equipment.
- Manually operate the de-gritting (sand trap) and de-silting channels.
- Monitor all security and control access.
- Monitor the flows from the river, as well as the High-lift pump stations.
- Monitor noise levels at Abstraction Works and High-lift Pump Station.

- Monitor water quality at Abstraction Weir and in Balancing Reservoir and monitor downstream impacts on water quality of the cleaning of the Low-lift Pump Station sand traps and de-silting channels.
- Preparation and maintenance of fire breaks around the works.

3.2.3 Rising Main from the Crocodile River to a Balancing Reservoir

- Monitor the cathodic protection (CP) system (i.e. transformer rectifier installations if installed).
- Patrolling of servitude for security and maintenance purposes.

3.2.4 Abstraction Works Balancing Reservoir, Break Pressure Reservoir and Operational Reservoir

The following will be monitored and controlled at each of the reservoirs:

- Flow into the reservoir.
- Flow out of the reservoir.
- The water level in the reservoir compartments. The operational one(s) will be used to manage the pumping rate from the High-lift Pump Station.
- Cleaning and de-silting of spare compartment as and when required.
- Monitoring of water quality in the compartments.
- Monitoring of noise levels and assessment/rectification of environmental impacts on surrounding landowners with respect to water spills and other possible sources of pollution.
- Preparation and maintenance of fire breaks around the works.
- Security of installations and controlling of access to the Works.

3.2.5 Gravity Pipelines supplying the User Terminal Reservoirs

- Read all revenue water meters.
- Read all farmer off-take water meters and inspect condition of off-take and pipework.
- Monitor the cathodic protection system (i.e. transformer rectifier installations if installed).
- Water source control. Control of the direction of flow at Medupi/Matimba T-junction (refer to Figure 2-2) to prevent or control mixing of water sourced from Vlieëpoort (Phase 2 Crocodile River (West) Transfer System) and Mokolo Dam (Phase 1). This will have a direct impact on the water quality requirements of Matimba Power Station.
- Patrolling of servitude for security and maintenance purposes.

3.2.6 Typical User Terminal Reservoir

- Monitor and control flow control valves.
- Monitor flow meters.
- Monitor and control in-line isolating valves.
- Monitor water level and water quality in each of the compartments.
- Advise the Owner on recommended maintenance activities (if short-comings are noted).

3.3 Mokolo Dam Transfer Scheme (Phase 1)

3.3.1 Abstraction Pump Station at Mokolo Dam

- Monitor the water level in Mokolo Dam.
- Start and stop the high lift and booster pumps.
- Change the flow by means of the variable speed drives (VSD's) on the high lift pumps.
- Monitor the "general health" of all the mechanical & electrical equipment.
- Monitor all security and control access.
- Monitor the flow from the high lift pump station
- Preparation and maintenance of fire breaks around the works.
- Monitoring of noise levels and assessment/rectification of environmental impacts on surrounding landowners with respect to water spills and other possible sources of pollution.

3.3.2 Rising Mains from Mokolo Dam (New and Existing)

- Monitor the CP system (i.e. transformer rectifier installations if installed).
- Open and close relevant inter-connecting valves as may be required.
- Read all farmer off-take water meters and inspect condition of off-take and pipework.
- Patrolling of servitude for security and maintenance purposes.

3.3.3 Wolvenfontein Balancing Reservoir (Existing)

- The same as for the Phase 2 Operational Reservoir above (see Section 3.2.4).

3.3.4 Gravity pipelines (New and Existing)

- Same as the gravity pipelines supplying the User Terminal Reservoirs of the Phase 2 Crocodile River Transfer System mentioned above (see Section 3.2.5).

4. MAINTENANCE PHILOSOPHY

Maintenance is generally divided into the three major engineering disciplines namely: mechanical; electrical and civil. For each of these disciplines maintenance will be categorised as follows:

- Routine planned maintenance;
- Major Breakdown repairs, and
- Minor breakdown repairs.

These are expanded on below:

4.1 Mechanical

4.1.1 Routine Planned Maintenance

A schedule of routine maintenance will be compiled to cover all mechanical components such as:

- Exchange of pump and motor unit(s);
- Bearing replacements;
- Water and oil seal adjustment and replacement;
- Servicing (lubrication, oil changing and or refilling);
- Inspection and repair of leaks;
- Painting of components such as valves, pipes and gates;
- Inspection and repair of valves and gate seals in the pump stations, weirs and the de-gritting and de-silting channels at the abstraction works;
- Inspection and repair of any hydraulic piping, and
- All gates, sluices, and valves.

In certain instances maintenance functions will be based on efficiency monitoring of pump sets and other mechanical components.

Routine maintenance will generally be done by any one or a combination of the following:

- Staff exchanging strategic spares units and taking old units in for refurbishment or replacement.
- Contractors doing maintenance repairs.
- Contractors doing SCADA maintenance on call out.
- Pump contractors servicing/maintaining units on a regular basis.

4.1.2 Major Breakdown Repairs

These repairs will include the rectification of faults shown by SCADA, such as:

- Bearing faults.
- Power supply breakdowns.
- Rectifying loss of efficiency on pump sets.

These breakdown repairs can be done by any of the methods given in Section 4.1.1 above.

4.1.3 Minor Breakdown Repairs

These repairs will cover mechanical components such as:

- Exchange of pump and motor unit(s);
- Bearing replacements;
- Water and oil seal adjustment and replacement;
- Repair of leaks;
- Repair of all gates, sluices, and valves, and
- Inspection and repair of any hydraulic piping.

Breakdowns of this nature can be done by staff or large/small contractors (i.e. mechanics, etc.)

4.2 Electrical

4.2.1 Routine Planned Maintenance

A schedule of routine maintenance will be compiled to cover all electrical components such as:

- Checking/servicing transformer oils;
- Switchgear components;
- Routine calibration of instruments, and
- Routine cleansing of equipment depending on design.

In certain instances maintenance functions could be based on efficiency monitoring of electrical motors and components.

These maintenance inspections and resulting actions can be done by any of the methods given in Section 4.1.1 above.

4.2.2 Major Breakdown Repairs

These repairs will cover the rectification of faults shown by SCADA, such as:

- Power supply breakdowns
- Motor faults.

These maintenance repairs can be done by any of the repair units given in Section 4.1.1 above.

4.2.3 Minor Breakdown Repairs

Breakdowns of the following nature can be done by staff or large/small contractors (i.e. electricians, etc.)

- Replacement of lights and bulbs.
- Repair of light and other switches.
- Faulty control units.
- Replacement of transducers and switches.
- Repair of wiring faults.

4.3 Civil

4.3.1 Routine Planned Maintenance

A schedule of routine maintenance will be compiled to cover all components such as:

- Five yearly dam safety inspections of river abstraction works and other qualifying reservoirs;
- Regular inspection and repair of pipelines and chambers including fencing, gates, access roads, road crossings, etc.;
- Regular painting of valves and pipes in chambers;
- Inspection and repair of pipe linings at intervals (say 5 years);
- Inspection and repair of all reservoir embankments, structural and other concrete elements of all the principal components mentioned above. This will include checking for leaks and leakage rates from all reservoirs;
- Inspect and repair erosion and flood damage caused at any of the principal components;
- Keeping the pipeline servitudes free of shrubs and trees;
- Painting of buildings; and
- Maintenance of building services.

These maintenance repairs can be done by any of the repair units given in Section 4.1.1 above.

4.3.2 Major Breakdown Repairs

These repairs will include aspects such as:

- Repair of leaks in reservoir linings;
- Structural repairs to the abstraction works structures;
- Fighting of veldt fires, and
- Repair major erosion damage.

These repairs can be done by any of the repair units given in Section 4.1.1 above.

4.3.3 Minor Breakdown Repairs

These repairs will include aspects such as:

- Repairs to buildings and structures (i.e. safety handrails, doors, roofs, windows, etc.).

These repairs can be done by any of the repair units given in Section 4.1.1 above.

4.4 Interfaces with Landowners and Users

4.4.1 Property Ownership

Property on which reservoirs, pump stations and other facilities required for the operation and maintenance of the MCWAP are located will be acquired by DWA. Security fencing will be erected along the property boundaries and security patrols and access control measures implemented. Only DWA, TCTA and MCWAP staff will have access to these properties.

DWA will also take ownership of the property inside the Crocodile River (West) servitude of conveyance on which structures associated with MCWAP will be built. These would include the Abstraction Weir at Vlieëpoort and gauging weirs along the river. The servitude of conveyance will be enlarged where these structures impact on the present declared servitude boundaries outside of the acquired DWA property. Access to the properties will be controlled and security fencing will be erected where appropriate.

4.5 Pipeline Servitudes

Access to pipeline servitudes will not be controlled, but restrictions will be placed on activities inside the servitudes. These will typically include the prohibiting of the erection of permanent structures and the planting of perennial crops (orchards, timber, etc.).

Servitudes will be marked with concrete servitude markers. Existing fencing will be reinstated and gates installed where these fences cross the servitude. Valve chambers will, however, be fenced.

A service road (to basic standards) will be provided along the servitude for maintenance purposes and will be patrolled on a regular basis.

Although the servitude will be rehabilitated after construction, the re-establishment of the indigenous trees (to compliment the natural Bushveld surroundings) will not be undertaken. Limited replanting of trees may be possible along the perimeter of the servitude to soften the visual impact of the servitude if sufficient environmental grounds exist to sanction such expenditure. The anticipated impacts on game farming would therefore be limited to visual impact of the servitude clearing and regular maintenance and security patrolling.

One of the primary tasks of the Local Liaison Officer that will need to be appointed to the MCWAP authority will be to ensure efficient communication with the surrounding landowners to minimise the potential long-term impacts of the servitudes and the use thereof by the MCWAP staff on the landowners.

4.5.1 User Terminal Reservoirs

Bulk Users will be required to provide their own Terminal Reservoirs. The MCWAP Authority will only guarantee the agreed flow (on the basis of an average annual delivery plus allowances for peak flows) and a minimum pressure head at the designated terminal point of the pipeline take-off to the User.

All User Terminal Reservoirs will be level controlled and monitored, not only by the User (Owner), but also by the MCWAP Authority.

Siltation may occur in the reservoirs and a cleaning system should be provided for removal of accumulated sediment. Cleaning may be expected to be required at 10-year intervals.

The MCWAP system will provide and control the following components in the gravity feed main directly upstream of the consumer's reservoir distribution pipe/manifold supplying water to the different reservoir compartments:

- An in-line isolating valve with chamber;
- An in-line revenue flow meter with chamber, and
- An in-line flow control valve (with chamber) which will limit the incoming flow to the annual average flow plus 20%.

The terminal reservoirs should be sized to provide for a minimum live storage capacity of 18 days of the maximum average annual delivery plus allowances for peak flows. The reservoir design should take cognisance of water quality and maintenance requirements.