SCADA Report

Institutional and Organisational Strengthening of WASCO Saint Lucia and Regional Water Utilities

Saint Lucia

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<table>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>CAH</td>
<td>CONSULAQUA Hamburg Beratungsgesellschaft mbH</td>
</tr>
<tr>
<td>CAWASA</td>
<td>Caribbean Water &amp; Sewerage Association Inc.</td>
</tr>
<tr>
<td>Como</td>
<td>Como Consult GmbH</td>
</tr>
<tr>
<td>FIT</td>
<td>Flow Indicator Transmitter</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GIZ</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH</td>
</tr>
<tr>
<td>HW</td>
<td>HAMBURG WASSER</td>
</tr>
<tr>
<td>LIT</td>
<td>Level Indicator Transmitter</td>
</tr>
<tr>
<td>LS</td>
<td>Level Switch</td>
</tr>
<tr>
<td>LSLL</td>
<td>Level Switch Low Low</td>
</tr>
<tr>
<td>LSL</td>
<td>Level Switch Low</td>
</tr>
<tr>
<td>LSM</td>
<td>Level Switch Medium</td>
</tr>
<tr>
<td>LSH</td>
<td>Level Switch High</td>
</tr>
<tr>
<td>LSHH</td>
<td>Level Switch High High</td>
</tr>
<tr>
<td>PIT</td>
<td>Pressure Indicator Transmitter</td>
</tr>
<tr>
<td>PS</td>
<td>Pressure Switch</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote Terminal Unit</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition (Program)</td>
</tr>
<tr>
<td>WASCO</td>
<td>Water Supply and Sewerage Company Inc., Saint Lucia</td>
</tr>
<tr>
<td>WTP</td>
<td>Water Treatment Plant</td>
</tr>
</tbody>
</table>
1 INTRODUCTION AND OBJECTIVE

This Report is one of the outcomes of the project “Institutional and Organizational Strengthening of WASCO Saint Lucia and Regional Water Utilities”. The project started on 1st of November 2018, it has a duration of 13 months and is carried out by a joint venture between CONSULAQUA Hamburg, which is a 100% subsidiary of HAMBURG WASSER, public Water Utility of Hamburg, and COMO Consult, both from Germany.

According to the project’s ToR, the deliverable B.2.2 is the “analysis and assessment of the existing SCADA system used for monitoring of the existing network (software and hardware) and recommendation of necessary updates and upgrades […]”.

During various missions, the consultant has obtained impressions of the status of SCADA at WASCO. It was observed, that the SCADA system is not, or only partly in operation and a holistic review is required. Furthermore, as part of Vieux Fort Water Supply Redevelopment Project in the southern part of the island, a completely new SCADA system will be installed for the Vieux Fort water supply system.

In consultation with WASCO, the ToR was therefore altered, and the consultant asked to provide a general assessment and draft work plan for a central SCADA system for the northern supply zone. The proposed SCADA system should be as similar as possible to the SCADA system in the south, which will be installed soon, to provide uniformity within the whole supply system.
2 CURRENT STATUS OF SCADA AT WASCO

Two SCADA systems are in place at two locations namely the Theobalds WTP and at the head office in Castries.

Additionally, a "third" SCADA system will be installed soon in the south of St. Lucia as part of a Vieux Fort Water Supply Redevelopment Project.

2.1 SCADA AT THEOBALD WTP

The Theobalds WTP has the more comprehensive and functional SCADA in comparison to the SCADA at the head office in Castries. The SCADA system itself, called 'Rockwell', is working and devices are connected by cable and radio. However, many devices cannot be connected or integrated. E.g., the meters at the treatment plant are read manually every hour.

Currently all actuators need to be exchanged (step by step) and then integrated into the system. Reportedly a programmer from AUMA is expected to visit St. Lucia and perform the initial programming.

Figure 1: Meter at Theobald
Figure 2: Screens of the SCADA System at Theobald

Figure 3: Different screens of the SCADA System at Theobald - I

Figure 4: Different screens of the SCADA System at Theobald – II
2.2 **SCADA at Central Control Room (Headquarter)**

In the control room at the head office two SCADA systems are installed, from which only one is partly in operation. The majority of tanks, pumping stations and bulk meters are not monitored or controlled by the SCADA System and need to be inspected physically. Due to licence problems, broken down meters and/or interrupted communication, the current operability of the SCADA system is very low. Only from the control room monitoring is possible to a limited extent.

2.3 **General Recommendations**

The consultant strongly recommends preparing a strategy for the development of a common SCADA system for the whole island. In general, this would lead to a more efficient operation of the supply system. Amongst others, it will help in

- Better understanding of system behaviour
- Optimisation of tank and pump management
- Reduction of required manpower in the field (bulk meter reading, pump operation, …) → cost saving

To develop a SCADA strategy, an approach along the following steps is recommended:

1. Create/update a schematic map of the network (intakes, tanks, treatment facilities, pumping stations, raw water and big mains)
2. Assess and visualize all existing devices to be integrated in the SCADA system (already available or to be added)
3. Conduct hydraulic verification of system behaviour as base for the SCADA concept
4. Investigate software options and define criteria which influence the evaluation, such as,
   - How does the existing SCADA System at Theobalds WTP compare with the new system in Vieux Fort
   - experience of staff
   - approval of GIS based System (e.g. Iconics or other) are necessary
   - Evaluate the required maintenance and operational needs
   - What are the concepts to integrate new devices (experts available?)
5. Prepare cost estimates (price hardware + software, maintenance)
6. Prepare Installation plan for devices
7. Prepare Installation plan for software

The procurement of a new SCADA system is recommended to be done through public tendering. Based on an elaborated overview of number and type of required instruments for SCADA connection of different system components, a tender for the design, supply, installation, commissioning and training shall be launched. Such a tender has recently been launched by the CDB bank for a SCADA system for St. Kitts. The specifications shall be based on the latest technical standards, preferably from global suppliers such as Siemens, Schneider or equivalent. It is further strongly recommended to have a service contract with the selected hardware and software provider to guarantee a sustainable operation of the SCADA system.
In the next paragraphs, a general layout is provided as a proposal for a new SCADA system for WASCO. In order to provide conformity of the system, the general layout is based on the planned SCADA system which will soon be implemented in Vieux Fort.

It recommends installing SCADA first in the northern supply area (separate from the ongoing measures in Vieux Fort) and then expand it to other parts of the island.
3 **OVERVIEW: NORTHERN SUPPLY SYSTEM**

The following Figure 5 presents a map of the northern part of the island and its water supply infrastructure ('northern supply system'). The most relevant parts of the northern supply system, which are to be integrated into SCADA, are:

- 2 WTPs
- 34 Pumping Stations
- 1 Chlorination Unit and 1 simple Treatment Facility
- 50 Tanks or Reservoirs

Additionally, important boundary valves and bulk water meters should also be part of SCADA.

![Figure 5: Layout of current northern supply system](image-url)
4 **RECOMMENDATIONS FOR SCADA SYSTEM**

4.1 **GENERAL SCADA SYSTEM DESIGN**

As part of the “Vieux Fort Water Supply Redevelopment Project”, a complete SCADA system will be implemented in Vieux Fort for WASCO. The system includes the two water treatment plants Beausejour and Grace including their pumping stations, and the reservoirs Augier, Laborie, La Tourney and Beanfield.

The consultant recommends using a similar system for the northern supply zone of St. Lucia. This allows for an exchange of knowledge and experiences between the responsible persons within WASCO. As the SCADA system in Vieux Fort is likely established ahead of the SCADA system in the northern supply area, first experiences in Vieux Fort can be helpful for the implementation in Castries.

Further, a modular design is recommended. The system should be implemented gradually (step-by-step), starting with the core distribution network (Water Treatment Plants, Pumping Stations, Water Tanks) and eventually the Northern Line. In the subsequent steps, further sections of the water supply system and installations regulating the network can be added incrementally to the SCADA system. This ensures a functioning SCADA system from the start.

4.2 **SCADA CONTROL SYSTEM**

The SCADA system should consist of the following sub-systems:

- A human–machine interface (HMI) presenting process data to the operator to monitor and control the process.
- A supervisory computerized system, gathering (acquiring) data on the process and sending commands (controlling) to the process.
- Programmable logic controllers (PLCs).
- Various process and analytical instruments with remote terminal units (RTUs) connected to sensors in the supply process, converting sensor signals to digital data and sending digital data to the supervisory system.

The data transfer between RTUs, PLCs and the SCADA Control Center is preferably carried out through fiber optic cables with GSM mobile provider as backup.

The control system hierarchy can be viewed as a pyramid structure with three layers:

- **First Layer:** Field Instruments (flow meters, pressure meters, level meters, kWh-meters) and Field Control Devices (valve actuators, motor starters, main power switches)
- **Second Layer:** Local RTU and PLC Panels for control/monitoring
- **Third Layer:** SCADA Control Centres for monitoring/controlling

All **controlling actions** are performed automatically by the PLCs. The host control functions are restricted to basic overriding or supervisory level intervention. The PLCs are capable of autonomously executing simple logic processes without involving the master computer.
The **SCADA system** allows operators to **change the PLC settings** and enable alarm conditions to be displayed and recorded. The feedback control loop passes through the PLCs, while the SCADA system will monitor the overall performance of the loop.

Data acquisition is provided at SCADA System level and the data is collected from the RTU or PLC levels. It includes meter readings and equipment status reports that are communicated to the SCADA. Data is then compiled and formatted in such a way that a control room operator using the HMI can make supervisory decisions to adjust or override normal RTU / PLC controls.

The **RTUs** should be located at **remote sites**, e.g. storage reservoirs, which shall be on a distance longer than 1 km from the water feeding pump station. An RTU shall collect signals from reservoir water level sensors and flow meters on the outlets of the storage reservoirs. The RTU units shall consist of small compact PLC unit, fibre optic communication port and GSM communication module as back up. The RTU units shall be equipped with communication modules to transfer the process data to PLC Panels in the pumping station, which is pumping the water to the remote reservoirs, for remote monitoring, controlling and data acquisition.

The RTUs for controlling and monitoring communicate through fibre optic cables (or GSM mobile provider as backup) with the local PLC and at the same time communicate with the SCADA Centre for data transfer, recording and reporting. For ensuring a better maintenance and better repairability, using standard cables instead of fibre optic cables can be taken into consideration.

The **HMI** system presents the information to the operating personnel in the form of a mimic diagram. Mimic diagrams consist of digital “photographs” of the process equipment overlain with animated symbols.

Data is fed to a Database Management System, to allow trending and other analytical auditing - reporting.

Alarms are displayed on the HMI and stored in the database.

The SCADA system includes a master station in the operator room. A back-up PC is provided, e.g. at the director’s office location.

### 4.3 HARDWARE / SOFTWARE REQUIREMENTS

The control system should be a modern system with a clear and easy to use interface and open to the office and process work. It is important that its functions are sophisticated and reliable, efficient to configure and scalable for simple and complex tasks. A worldwide usability and support is also essential.

Commercially available **workstations** (a powerful personal computer) should be used for all working stations. Rack mounted professional **server stations** should be used as master station of the SCADA system. The SCADA control systems software should be consisting of one complete package. It should be possible to establish the coupling to other devices and applications from various manufacturers via the standardized software interface OPC (‘open platform communications’).

The **system should be upgradable** to implement or add further components and procedures at any time. When expanding the system, it should be possible to integrate the expansions into the user interface. It is strongly recommended that a switchover between various applications using standard controls such as Alt-Tab or Ctrl-Esc is not allowed for safety reasons. The hardware and software
installed should be state of the art with latest versions of processors and software to guarantee compatibility in the future.

Process control systems must be organized in a logical control hierarchy in order to provide a standard format for 24 hours monitoring/control of the overall facilities. This shall provide operators and maintenance staff a uniform interface, which improves monitoring/controlling the equipment, the control modes the equipment can attain, and how to override the controls when necessary due to failures or when required for routine maintenance.

4.4 INSTRUMENTS REQUIRED

For the operation of the facilities with the SCADA system, field instruments need to be installed in order to control the field control devices. Among these instruments are level indicator transmitters (LIT), flow indicator transmitters (FIT), pressure indicator transmitters (PIT) level switches (LS), and pressure switches (PS). The type of instruments with analogue outputs are

- Electromagnetic flow meters
- Ultrasonic Water Level Meters
- Hydrostatic Level Meters
- Pressure sensors with transmitters

The type of instruments with digital outputs are

- Flow switches
- Level switches
- Pressure switches
- Limit switches
5 REQUIREMENTS FOR DIFFERENT SYSTEM COMPONENTS

Table 1 and the following sections give an overview of the type of instruments that are needed for controlling and monitoring pumping stations, water tanks, pressure reducing valves and DMAs.

Further equipment for operation (e.g. shut-off valves) need to be considered as well, but are not discussed with this document.

Table 1: Overview of number and type of required instruments for SCADA connection for different system components

<table>
<thead>
<tr>
<th>Installation</th>
<th>LIT</th>
<th>LS</th>
<th>Backup float valve</th>
<th>FIT</th>
<th>PIT</th>
<th>PS</th>
<th>Inlet valve</th>
<th>Outlet valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping Station</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Tank Gravity Outflow</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Tank Pump Outflow</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure Reducing Valve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary Valve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.1 PUMPING STATIONS

Each pump is protected by two PITs and two PSs as backup (one of each before and after each pump) preventing low- or high-pressure start-ups. The PIT after the pump is also used to monitor and control pump operation.

A FIT installed after the pump monitors the outflow of each pump.

Figure 6: General equipment at Pumping Stations feed by Reservoir

5.2 WATER TANK WITH GRAVITY OUTFLOW

The water tank is equipped with a LIT for indicating the water level inside the tank. As backup for the LIT there are five LS installed at five different water levels:

a. LLLL: ‘low-low’, indicating alarm for dry running
b. LSL: ‘low’, indicating inflow to begin
c. LSM: ‘medium’
d. LSH: ‘high’, indicating inflow to stop
e. LSHH: ‘high-high’, indicating alarm for overflow
The LIT is using the same settings as the LS for the five water levels. It monitors the water level and controls the motorized inlet valve. If a motorized outlet valve is installed, the LIT can also control the outlet valve.

The water levels LSLL and LSHH should never be reached. If these levels are reached, an alarm will be activated.

The inlet has a motorized inlet valve to regulate the inflow into the tank. After the inlet valve, a FIT is installed for monitoring the inflow into the tank and controlling the inlet valve.

At LSH, that means the tank is full, the motorized inlet valve closes, which stops the inlet supply. At LSM or below the motorized inlet valve opens to refill the water tank until LSH is reached.

A backup float valve is installed in the tank, which mechanically closes the inlet in case the LSH is not working.

A FIT installed at the outlet monitors the outflow of the water tank.

The outlet can be equipped with a manual outlet valve for maintenance purpose only. Under normal gravity operation, this outlet valve shall be fully opened. A FIT is installed after the outlet valve.

Figure 7: General equipment for tanks with gravity outflow

### 5.3 WATER TANK WITH PUMPED OUTFLOW

The water tank is equipped with a LIT for indicating the water level inside the tank. As backup for the LIT there are five LS installed at five different water levels:

a. LSLL: ‘low-low’, alarm for dry running
b. LSL: ‘low’, indicating inflow to begin
c. LSM: ‘medium’
d. LSH: ‘high’, indicating inflow to stop
e. LSHH: ‘high-high’, indicating alarm for overflow

The LIT is using the above settings for the five water levels. It monitors the water level and controls the pump(s) filling the water tank. If a motorized outlet valve is installed, the LIT can also control the outlet valve.
The water levels LSLL and LSHH should never be reached. If these levels are reached, an alarm will be activated.

Like every pump, the tank inflow pumps are also protected by LS (at their water source), preventing the pumps from running dry in case there is no water supply. Furthermore, each pump is protected by two PITs and two PSs as backup (one of each before and after each pump) preventing low- or high-pressure start-ups.

At LSH, which means the tank is full, the pump(s) stop, which stops the water supply. At LSM or below the pump(s) start to refill the water tank until LSH is reached.

A backup float valve is installed in the tank, which mechanically closes the inlet in case the LSH is not working.

A FIT installed at the inlet monitors the inflow of the water tank and the pump(s).

A FIT installed at the outlet monitors the outflow of the water tank.

The pumping station is equipped as explained under paragraph 5.1.

![Figure 8: General equipment for tanks with pumped outflow](image)

### 5.4 Pressure Reducing Valves

A PIT is installed in front of the pressure-reducing valve for monitoring and controlling the valve. A PIT is installed after the pressure-reducing valve for monitoring and controlling the valve.

A FIT installed after the valve monitors the flow after the pressure reduction.

![Figure 9: General equipment for pressure reducing valves](image)

### 5.5 Distribution Zone / DMA

Each distribution zone and DMA has a boundary valve at every inlet and outlet regulating the inflow and outflow of the distribution zone. Each inlet and outlet has a FIT monitoring the inflow and the outflow.

PITs can be installed inside the distribution zone at crucial points to control the valves and therefore the pressure inside the distribution zone.
5.6 SAFETY MEASURES

All electromechanical equipment are protected following the same general principle.

**Protections and alarm:**

- Protection against operation without water (LSL / LSLL), or at air - water interface for mixers (LSM).
- Alarm for high level or very high level before overflow (LSH / LSHH).
- Pumps are protected against start-up at low downstream pressure to avoid NPSH related issues (PSL or PSLL).
- Protections and alarms are PLC integrated and available in manual mode. Manual mode is integrated in the PLC.
- Emergency stop devices where applicable.

**Electrical protection:**

- Circuit breaker – Electromagnetic protection - Discordance.
- Soft-start – star/triangle – speed drives for motors according to process and power requirements.

A complete uninterruptable power supply system (UPS) should be installed for control and monitoring the system and instrumentation for critical processes (e.g. treatment plants, pumping stations).

The SCADA system should be designed in a way that the automatic controls can be overridden, and the system can be controlled manually if necessary. Manual controls are installed locally next to the field devices, which are required for daily operations.

An “Auto/0” switch should be installed at supervision PLC level and an “Auto/0/Manu” switch should be installed at local PLC level. It should be possible to operate the equipment manually at local level without permission from the supervision. Supervision (Master PLC) should be limited to “auto mode”, general “visualization”, “alarm” per zone and access to all slave PLC for “Automation” settings and control. Local levels should be integrating all functionalities including “visualization” and “default”, access to the PLC (slave PLC) for “Automation” local settings and control and activation of manual mode. Once the equipment is manually operated, information is sent to the supervision (Master PLC) for manual mode.
Once the “Auto/0” switch is on “0” at supervision level, equipment cannot be operated at local level. The supervision level should be equipped with a main “Auto/0” switch. Operation of the facility can only be initiated at supervision level in “Auto” mode. Equipment in “Manu” mode have first to be started at local level or switched to “Auto” mode before the operation of the facility is initiated. The supervision level is equipped with a general emergency stop, which stops the operation of the facility.

**Note:** If one device is switched to manual control, then all other devices at local level or standing in relationship to this device automatically switch to manual control for safety reasons. It must be prevented that a procedure, like e.g. managing the water level in a water tank, is not executed correctly because one device is switched to manual mode while others are still controlled by the automated sequence. If all relevant devices are switched to manual mode, then the whole operation of e.g. managing the tank water level must be executed and supervised manually until all relevant devices are switched back to automatic control.
6 CONCLUSIONS AND RECOMMENDATIONS

The SCADA System for the northern supply zone currently consists of two partly functional separate systems. They are located at the Theobalds WTP and at WASCO’s head office in Castries. The SCADA Systems at both locations do not include all relevant instruments installed at the locations, as many devices cannot be connected or integrated. Therefore, these instruments must be inspected and read manually. The SCADA System at Theobalds WTP is more comprehensive and functional than the SCADA System at the Head Office.

As the SCADA System for the northern supply zone is only partly functional and only for two locations, the consultant recommends introducing a new SCADA System for the northern supply zone. This SCADA System should be of modular design and should be implemented step-by-step. The implementation should start at the most important infrastructure. This guarantees a working system for the most important infrastructure from the start. To guarantee a long working SCADA, the system should consist of new hardware operating with the latest operating systems and software. The system should also be upgradable to implement further components and procedures at any time. Implementing a SCADA System similar to the SCADA System in Vieux Fort would allow for an exchange of knowledge and experiences between the responsible persons at Castries and at Vieux Fort.

For the sustainable development and operation of the future SCADA system it is recommended for WASCO to train its staff and to enter into a water operating partnership (WOP) through e.g. GWOPA (Global Water Operating Partnership) to allow for peer to peer support.

A SCADA system and SCADA operation can be compared with a piano (SCADA System) and a piano player (SCADA Operator). The experienced piano player develops the music score, likewise only with professional support by experienced water operators the operation of the water supply system can be better understood and gradually improved. This activity should not be outsourced to external private companies as this directly affects WASCO’s core business.
ATTACHMENT

Example SCADA Vieux Fort