AN INDEPENDENT INVESTIGATION AND ADVISORY ON THE ROLE OF WATER, SANITATION AND HYGIENE IN THE 2023 CHOLERA OUTBREAK IN HAMMANSKRAAL, SOUTH AFRICA

WORK PACKAGE 4: WATER AND SANITATION SAFETY ASSESSMENT AND ENVIRONMENTAL MONITORING

Part 2: Assessment of the Functionality and Compliance Status of the Temba Water Treatment Works

Final Report to the
Water Research Commission

by

E Barnard and JA Wilsenach
Virtual Consulting Engineers VCE (Pty) Ltd
Contact detail of author for correspondence:

WRC Report No. 3167/2/24
ISBN 978-0-6392-0664-6

October 2024

WATER
RESEARCH
COMMISSION

Obtainable from
Water Research Commission
Bloukrans Building, Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor
PRETORIA

hendrickm@wrc.org.za or download from www.wrc.org.za

EXECUTIVE SUMMARY

INTRODUCTION

The cholera outbreak within the Hammanskraal area has intensified the focus on the raw water source for the Temba Water Treatment Works (WTW) as well as the performance of the Temba WTW. The Water Research Commission appointed Virtual Consulting Engineers on Friday, 02 June 2023. A project kick-off meeting was held on Monday, 05 June 2023.

AIMS

The Temba water treatment works were inspected to identify the following:

1. Operational status of the various process units
2. Performance of the treatment stages
3. The capacity of the treatment works
4. Recommendations

METHODOLOGY

A walkthrough inspection was used to identify the availability of plant and equipment. The outcome was to confirm whether sufficient equipment is available to ensure raw water treatment to the required potable water standard. An inspection was conducted using a checklist, which was compiled based on best practices. Process units were measured to calculate the capacity of each process unit. Samples taken from the various process units were analysed to determine the pathogen removal through these processes.

RESULTS AND DISCUSSION

The abstraction point could not be inspected as access was unavailable. It was reported that water was taken from the middle of the dam. Only three pump sets are available of which two were in use. All four systems (Modules 3, 4, 5 and 6) produced water with turbidity exceeding 1 NTU. Only two clear water pumps were operational at the time of the inspection. There was no chlorine standby system installed, which could have resulted in an interruption in chlorine dosing, posing a major risk to the water treatment process.

RECOMMENDATIONS

The following actions must be implemented immediately at the Temba WTW to address the current situation.

1. Repair the chlorine leak, which is further damaging the remaining equipment. Implement the requirements of SANS 10298. Check the chlorine room for leaks using an ammonia solution.
2. Move the abstraction point to the highest point from the Leeukraal Dam.

3. Determine the required dosing rates and combination of strong oxidants and flocculants to treat the raw water as best as possible.
4. Ensure proper desludging of each of the clarifiers. Where desludging valves are blocked, the unit must be removed from service and cleaned.
5. Monitor the water quality on each of the clarifiers.
6. Wash each sand filter on a rotational basis and treat the filter with HTH (run the air scour blower while adding HTH over the filter surface, and allow the filter to stand for at least 8 hours before backwashing and returning to service.
7. Take samples of each filter on a rotational basis daily. Backwash filter when turbidity exceeds 1 NTU.
8. Monitor chlorine demand daily to ensure that the chlorine demand is exceeded when dosing chlorine.
9. Take chemical stock levels for all treatment chemicals daily, calculate the actual usage, and back calculate the actual dosing rates. Compare these against the requirements.

ACKNOWLEDGEMENTS

The project team thanks the following people for their contributions to the project.

Name	Affiliation
Cholera Advisory Panel	Various Institutions
Dr Eunice Ubomba-Jaswa (Research Manager)	Water Research Commission
Staff	Temba Water Treatment Works

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS & ABBREVIATIONS

DAF	Dissolved Air Flotation
DAFF	Dissolved Air Flotation Filtration (CoCo DAF)
DWQ	Drinking Water Quality
DWS	Department of Water and Sanitation
GAC	Granular Activated Carbon
HPC	Heterotrophic Plate Count
IMP	Incident Management protocol
IRIS	Integrated Regulatory Information System
LM	Local Municipality
Mℓ	Mega-litre
NTU	Nephelometric Turbidity Units
o/c	Out of commission
O&M	Operation and Maintenance
PFD	Process Flow Diagram
PPE	Personal Protective Equipment
PTS	Proficiency Testing Scheme
SANAS	South African National Accreditation System
SANS	South African National Standards
SG	Specific Gravity
SLA	Service Level Agreement
VCE	Virtual Consulting Engineers
WaSP	Water Safety Plan
WHO	World Health Organisation
WMA	Water Management Agency
WRC	Water Research Commission
WSI	Water services Institution
WTW	Water Treatment Works
WUL	Water Use License

CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

The cholera outbreak within the Hammanskraal area has intensified the focus on the raw water source for the Temba Water Treatment Works as well as the performance of the Temba Water Treatment Works. The Water Research Commission appointed Virtual Consulting Engineers on Friday, 02 June 2023. A project kick-off meeting was held on Monday, 05 June 2023.

1.2 AIMS

The Temba Water Treatment Works were inspected to identify the following:

1. Operational status of the various process units
2. Performance of the treatment stages
3. Capacity of the treatment works
4. Recommendations

1.3 SCOPE AND LIMITATIONS

The scope of the investigation was limited to:

1. The Temba Water Treatment Works
2. The water supplied by water tankers

The investigation concentrated on the Temba Water Treatment Works' ability to provide potable water, taking into consideration the existing water source and the upstream pollution of the raw water source.

CHAPTER 2: ASSESSMENT OF TEMBA WTW

2.1 TEMBA WATER TREATMENT WORKS

The Temba WTW consists of 6 modules, two of which are no longer in commission. An overview of the various modules is given below in Figure 1.

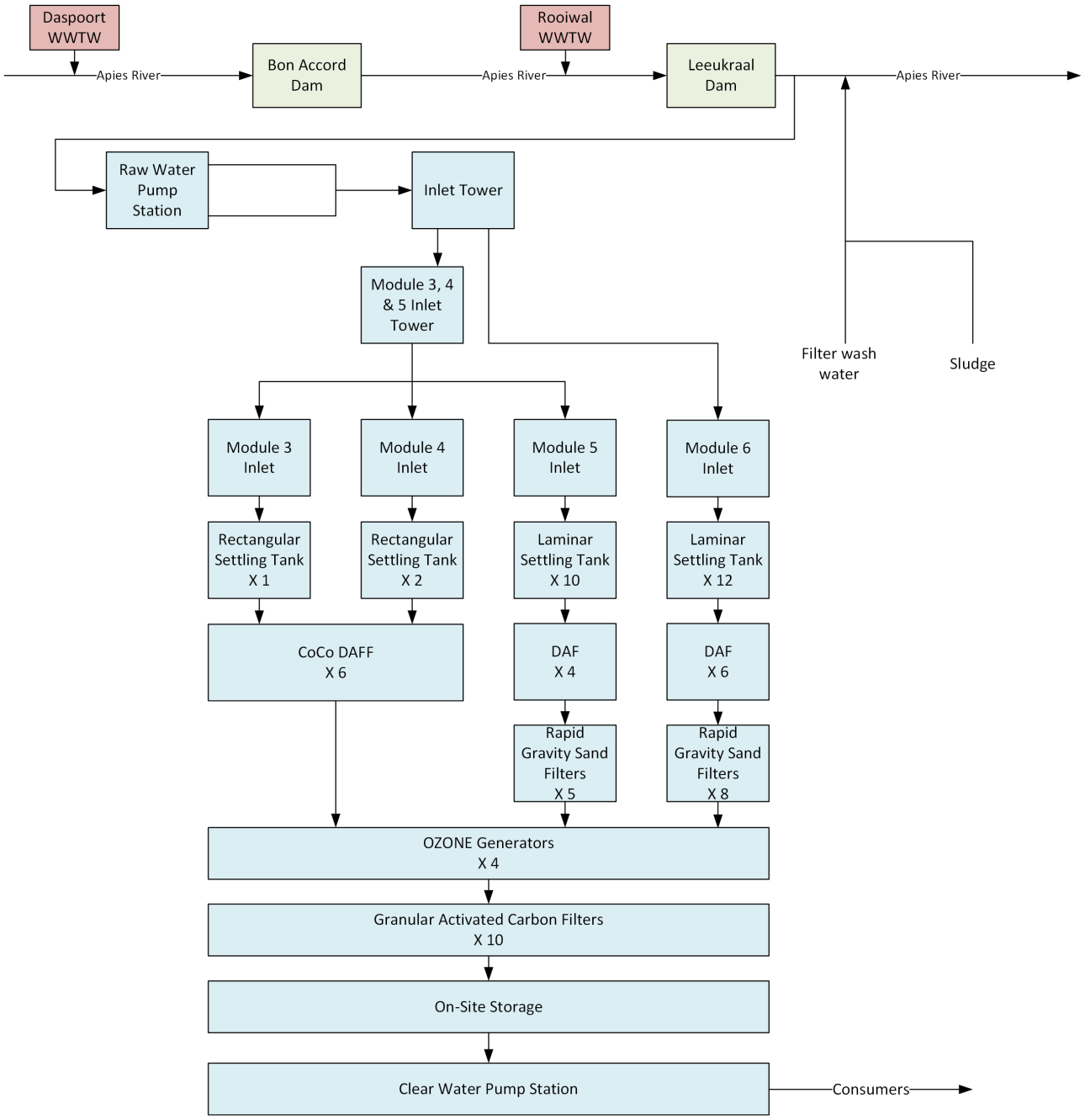


Figure 1: Temba Water Treatment Works

2.2 KUDUBE/LEEUKRAAL DAM

The overflow of the dam was foaming and was not what would be expected from surface water. The foam was similar to what is seen at the Rooiwal Wastewater Treatment Works (WWTW) discharge point. People were washing their clothes in the water while others bathed in the same water. See Figure 2 below.

Figure 2: Community washing downstream of the dam

2.3 RAW WATER PUMP STATION

The raw water abstracted from the Kudube/Leeukraal Dam is treated with a trash rack system before being pumped to the water treatment works. The trash rack system could not be inspected, as access could not be gained to the installation.

The pump station has two lines, each with three raw water pumps. Only two (2) pumps were operating, while a third pump was available as a standby pump. Only one of the flow meters was functional, but the pumps are rated at 1 249 m^3/h. The inflows from the two lines are measured at the water treatment works and was 402 ℓ/s for the old line and 408 ℓ/s for the new line. The combined inflow into the works is, therefore, 810 ℓ/s, which equates to ± 70 Mℓ/d. The flow is only 58% of the design capacity of the water treatment works.

Figure 3: Raw water pump station

2.4 INFLOW MEASUREMENT

The inflow into the Temba WTW is measured with the Magflow type of flow meters. The calibration status of the meters was not available. The meter readings are recorded daily, but the operating staff (Process Controllers) are not using the information. Raw water meter readings are changed around by swopping old and new.

2.5 FLOW SPLITTING

The incoming water is split at the inlet tower for Modules 3,4, and 5 and Module 6. The line for Modules 3, 4 and 5 later splits again at an inlet tower between the various modules.

2.6 CHEMICAL DOSING FOR SUSPENDED SOLIDS REMOVAL

The Temba WTW has several dosing points where various combinations of chemicals could be dosed based on the water quality. The Process Controller indicated that Ferric Chloride is only dosed when the raw water requires it. No jar test results were available.

During the assessment, it was unclear who decides on dosing rates and combinations of treatment chemicals. There was no Jar test equipment available to quantify dosing requirements.

2.6.1 Ferric Chloride

Ferric Chloride is stored in six (6) bulk tanks, each with an electronic level measuring device and a sight glass to measure the available stock in each bulk tank. Various sizes of dosing pumps were available with sufficient standby capacity. The sizes varied between 17 ℓ/h and 75 ℓ/h. Some pumps were, however, removed for repairs or replacement. Ferric Chloride dosing was not taking place during the site inspection. Records of actual stock and stock used are not kept. Back-calculation of dosage and a comparison against the required dosage are not performed.

2.6.2 Potassium Permanganate Dosing

Potassium Permanganate dosing is no longer used.

2.6.3 Polymer

Polymer is stored in two large concrete tanks, which are lined. The capacities of the tanks were not measured and not known by the Process Controller. The exact product number was not available and could not be identified. One of the Process Controllers mentioned that although the product is from the same supplier, the standard varies, and even colour changes occur. As no Jar Test equipment is available, the performance of the delivered product cannot be compared with that of the original proposal or existing stock. This may leave a gap in manipulating the deliveries, and the City of Tshwane will have to implement some form of Quality Control.

The polymer is transferred to three (3) day tanks, each with 2 500 ℓ capacity. Various sizes of dosing pumps are used to dose the polymer to the various pre- and post-dosing points within the process. The sizes ranged between 14 and 18 ℓ/h. The required dosing rate for the current water quality was unknown to the operational staff on shift. Records are not kept of actual stock, stock used, back-calculation of dosage and the comparison against the required-dosage.

Figure 4: Polymer Day Tanks and Dosing Pumps

2.6.4 Lime Dosing

Provision is made for lime dosing. Lime is delivered in a lime silo while mixing equipment and various peristaltic pumps are available to dose lime. The system is, however, not functional due to moisture problems, and no lime dosing was taking place on the day of the assessment.

Figure 5: Lime dosing system (not operational)

2.7 MODULE 3

Module 3 consists of:

1. Inlet structure
2. Dosing systems
3. Floc channels
4. 1 x Clarifier with an estimated surface area of 294 m^2
5. Post-dosing system (shared with Module 4)
6. Flocculation Channel (shared with Module 4)
7. 4 x Counter-Current Dissolved Air Flotation and Filtration units (shared with Module 4) with an estimated area of 216 m^2
8. Sludge and wash water pump pit and pump station (shared with Module 4)

Figure 6: Module 4 flocculation and clarification

The black foam could be seen looking like anaerobic sludge, while the intake water was not similar in nature. The filtered water from Module 3 is transferred to the Ozone contact tank and the GAC filtration plant.

2.8 MODULE 4

Module 4 consists of:

1. Inlet structure
2. Dosing systems
3. Floc channels
4. 2 x Clarifiers with an estimated surface area of 252 m^2
5. Post-dosing system (shared with Module 3)
6. Flocculation Channel (shared with Module 3)
7. 6 x Counter-Current Dissolved Air Flotation and Filtration units (shared with Module 3), with an estimated surface area of 216 m^2
8. Sludge and wash water pump pit and pump station (shared with Module 3)

The filtered water from Module 4 is transferred to the Ozone contact tank and the GAC filtration plant.

2.9 MODULE 5

Module 5 consists of:

1. Inlet structure
2. Dosing systems
3. 6 x inclined plate-type clarifiers with an estimated surface area of 600 m^2
4. Post-dosing system
5. 4 x DAF units with an estimated surface area of 216 m^2
6. 5 x Rapid Gravity Filters with an estimated surface area of 320 m^2

Figure 7: DAF unit for Module 5

The filtered water from Module 5 is transferred to the Ozone contact tank and the GAC filtration plant.

2.10 MODULE 6

Module 6 consists of:

1. Polymer dosing
2. Ferric dosing
3. Inlet structure
4. 12 x inclined plate clarifiers, each with a surface area of 1200 m^2
5. 6 x DAF units with an estimated surface area of 336 m^2
6. 8 x rapid gravity filters with an estimated surface area of 416 m^2

2.11 OZONE

Three screw pumps lift the water from the sump to the ozone treatment system. Four (4) Ozone generators are available to treat the water. Limited information is available on the capacity of the ozone generators. The

units were all out of commission, and ozone had not been dosed for an extended period due to a procurement issue.

2.12 GAC FILTERS

Water from Modules 3, 4 and 5 and Module 6 is treated with ten (10) GAC filters. Each filter has a surface area of 78 m^2. Modules 3, 4 & 5 were feeding at a flow rate of 369 ℓ/s, while Module 6 was feeding at a flow rate of 345 ℓ/s. Seven (7) GAC filters were in commission, while three (3) were out for maintenance. The filtrate from the GAC filters is collected in a collection sump and transferred with four (4) submersible pumps to the on-site storage reservoirs.

2.13 DISINFECTION

The chlorination room is unsafe and not meeting the requirements of SANS 10298. There were 15 full chlorine drums in the storage area. The empty drums were not properly prepared for transport. The protective hoods were not replaced on all the cylinders.

The chlorine room (pressure and vacuum side) is not locked, and access is freely available. Four (4) drums are connected to one of the chlorine banks, while no drums were connected to the second chlorine bank. The scales were dysfunctional; therefore, the mass of chlorine used, and the remaining mass are unknown. The transfer pump was operational at a flow rate of (1 300 ℓ/s) 4 680 m^3/h. The chlorine dosing took place at 26 kg/h, resulting in a chlorine dosing of about 6 mg/ℓ. The staff would not know when the chlorine bank is running empty. This could result in an extended period of no disinfection, as chlorine residuals are not taken every two hours, and the frequency of inspections of the chlorine dosing facility is unknown.

The vacuum room of the chlorine facility has several badly damaged carriage water pumps, and the remaining infrastructure is prone to serious damage due to a chlorine leak in the vacuum side. The Process Controller suggested that the discussions be held outside the vacuum side of the chlorine room due to the very strong chlorine smell. The staff does not understand the risk of these types of events.

The mass of chlorine escaping with the carriage water inside the room is unknown, but it was clear that not all the chlorine reached the on-site storage reservoirs. The chlorine residuals vary between 0.6 and 1.23 mg/ℓ, confirming the treatment level of the Rooiwal effluent. Records of actual stock, stock used, and back-calculation of dosing are not performed.

Based on the condition, the operating practices, and the frequency of measuring the free chlorine, water is highly likely to be distributed without being disinfected. This would pose a risk to the consumers supplied by Themba WTW.

Figure 8: Chlorine Bank 1 and Bank 2

Figure 9: Change-over system but no second chlorine bank

Figure 10: Poor condition of carriage water pumps

Figure 11: Leaking component (after chlorine injection)

2.14 CHLORAMINATION

Four bulk tanks for ammonium solution and dosing pumps are available. The system is not operational, and the condition of the equipment has not been assessed. Limited information on the capacity is known. Ammonia is stored in 4 x 10 000 ℓ storage tanks.

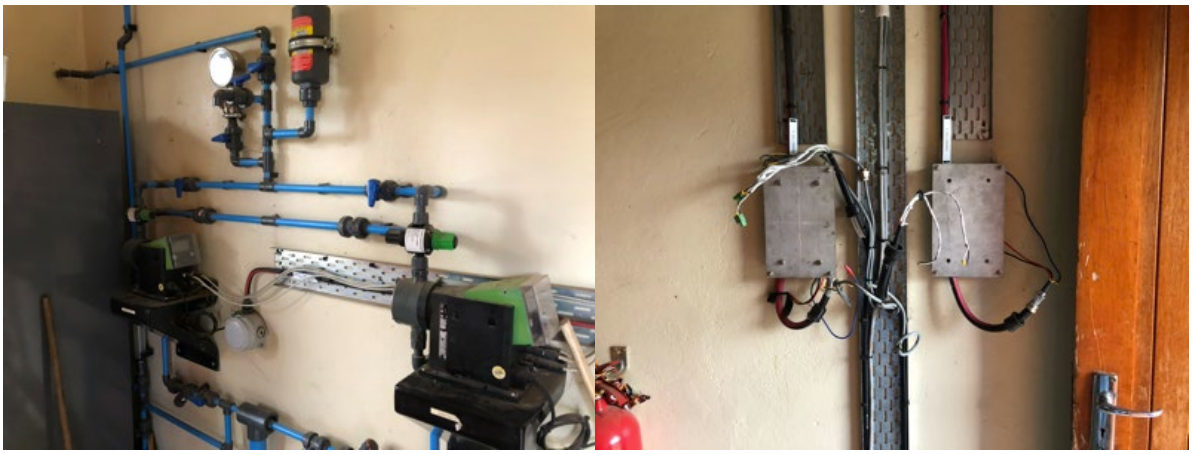


Figure 12: Ammonia dosing system

2.15 ULTRAVIOLET TREATMENT

The system is not operational, and the condition of the equipment has not been assessed. Limited information on the capacity of the two units is known.

Figure 13: Ultraviolet System

2.16 ON-SITE STORAGE

The treated water is stored in five reservoirs on-site. The estimated storage capacity is 25 Mℓ. The storage, if kept above one-quarter of the total capacity, would be sufficient to meet the 30-minute retention time for the chlorine.

Figure 14: One of the 5 reservoirs

2.17 HIGH-LIFT PUMPING STATION

The treated water is pumped to two on-site towers for supply to the areas adjacent to the water treatment works. The high-lift pumping station is used for transferring the treated water to the various storage reservoirs in the supply area of the water treatment works. There are eight (8) high lift pumps, while only two were in

operation during the site inspection. The total delivery was recorded as 800 ℓ/s. Several pumps were out of commission for maintenance.

Figure 15: High Lift Pumps

2.18 WASH WATER AND SLUDGE HANDLING

Provision is made for the sludge and backwash water to be treated by recovering the supernatant, while the sludge should be treated using a set of belt presses. The sludge handling system could not be inspected due to the unavailability of staff and access to the building not being obtained. From an inspection of the building from the outside, it was evident that the sludge is not thickened on-site, as seen below in Figure 16.

Figure 16: Skips for the disposal of thickened sludge

The Process Controller reported that the sludge is discharged back into the river just below the dam, negatively impacting downstream river water users. The filter wash water and sludge will also contain elevated levels of bacteria, and it is recommended that the sludge handling be re-instated.

2.19 ON-LINE MONITORING

On-line monitoring instruments such as pH, turbidity and chlorine are installed at several critical process units. Most of the values were not realistic, and there is no schedule to calibrate these instruments regularly. The from these units are therefore ignored most of the time.

2.20 OPERATIONAL AND MAINTENANCE MANUAL

A copy of the O&M Manual is not available in the water treatment works control room.

2.21 HOUSEKEEPING

During the inspection, it was evident that certain sections of the plant are not inspected at all. The clarification building for Module 5 was covered with spider webs, such that the clarifiers could not be inspected. There were several buildings where lights were not working. The situation results in inspections of individual clarifier outflows not being done. The filter building in Module 6 makes the inspection of the filter galleries impossible due to the light situation. Due to the lack of light in the filter building for Module 6, inspections of filter galleries cannot be performed.

2.22 PREVENTATIVE MAINTENANCE

Based on the observations at the treatment works and nearly all the defective lights in the closed buildings, maintenance is limited to major breakdowns only. No records of a preventative maintenance schedule or job cards were observed during the assessment. Work, such as replacing pumps and motors, was ongoing, but no instrument or electrical maintenance seemed to occur. Many online instruments such as turbidity meters, were not working. It could not be established during the assessment whether an instrumentation technician or a water quality technician calibrates the equipment on a regular basis.

CHAPTER 3: CAPACITY ASSESSMENT

The capacity assessment is conducted based on the information available. The capacity of each process unit is given below:

3.1 RAW WATER PUMP STATION

Only three (3) raw water pumps were available, reducing the raw water volume prior to losses due to filter washing and sludge removal, to about 95 Mℓ/day. An additional raw water pump would be required to reach the design capacity, but the works will be left without standby capacity.

3.2 CLARIFICATION

The clarification process consists of conventional clarifiers, lamella plate/tube clarifiers, CoCo DAFF and conventional DAF systems. When all units are in operation, the total available surface area is 2 346 m^2, with a treatment capacity of about 173 Mℓ/day.

3.3 FILTRATION

Filtration consists of rapid gravity filters and CoCo DAFF systems. When all units are in operation, the total available surface area is 952 m^2 and has a treatment capacity of about 114 Mℓ/day at a 5 m/h filtration rate. A slightly higher filtration rate will be able to achieve the design capacity of 120 Mℓ/day.

3.4 OZONE

The capacity of the ozone generators could not be retrieved from the information on the equipment.

3.5 GRANULAR ACTIVATED CARBON

Granular Activated Carbon filters are installed. When all units operate, the total available surface area is 1 168 m^2 with a treatment capacity of about 125 Mℓ/day.

3.6 DISINFECTION

When the chlorine installation is fully operational, the disinfection capacity is about 192 Mℓ/day. This allows for sufficient capacity. The facility would however require an urgent upgrade to ensure sufficient standby capacity and for the safety of the staff and the communities living next to the water treatment works.

3.7 TREATMENT PERFORMANCE GRAPH

A process performance graph has been compiled with the available information. The ozone generators are not included in the calculations due to the unavailability of sufficient information. The performance graph is shown below in Figure 17.

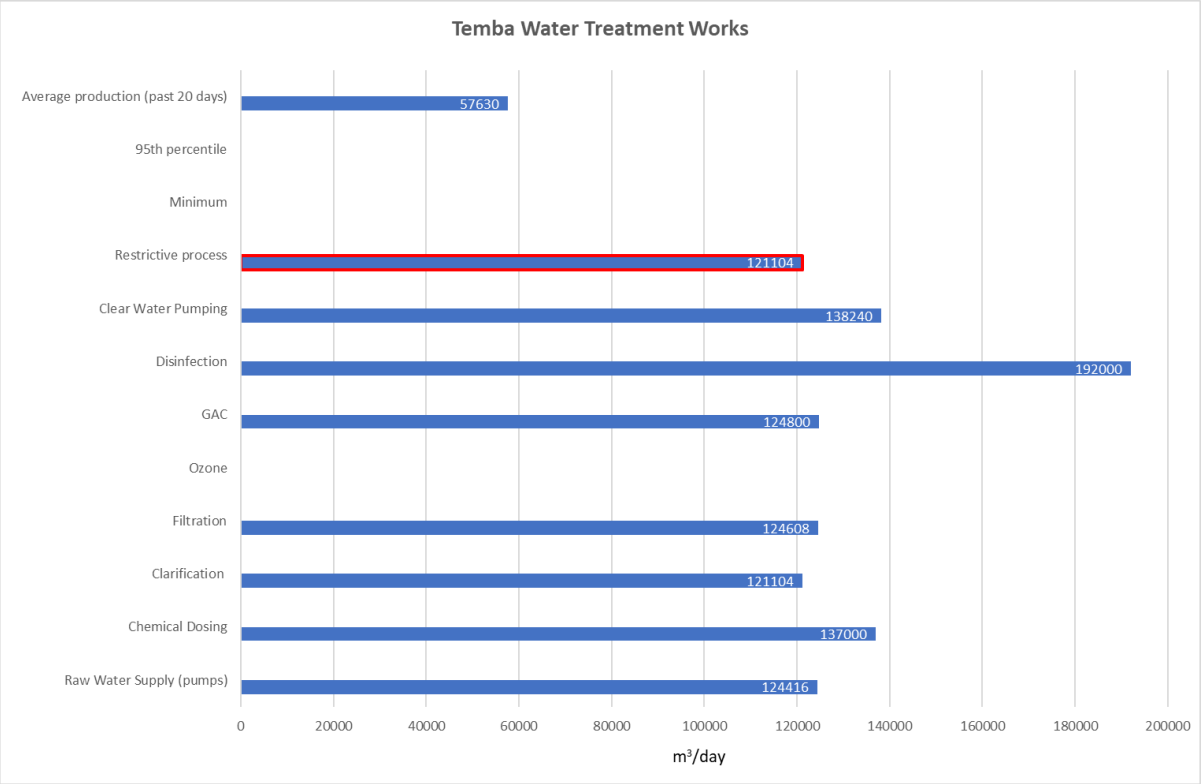


Figure 17: Performance Graph

The performance graph shows that the Temba Water Treatment works operate within the plant's capabilities. The poor water quality can, therefore, only be attributed to the chemical dosing, which is not optimised.

CHAPTER 4: PROCESS CONTROL

Process control consists of 2-hourly samples taken at the various process units. Based on the available records, sampling of all the sampling points is not conducted on a 2-hourly basis. The following testing equipment is available:

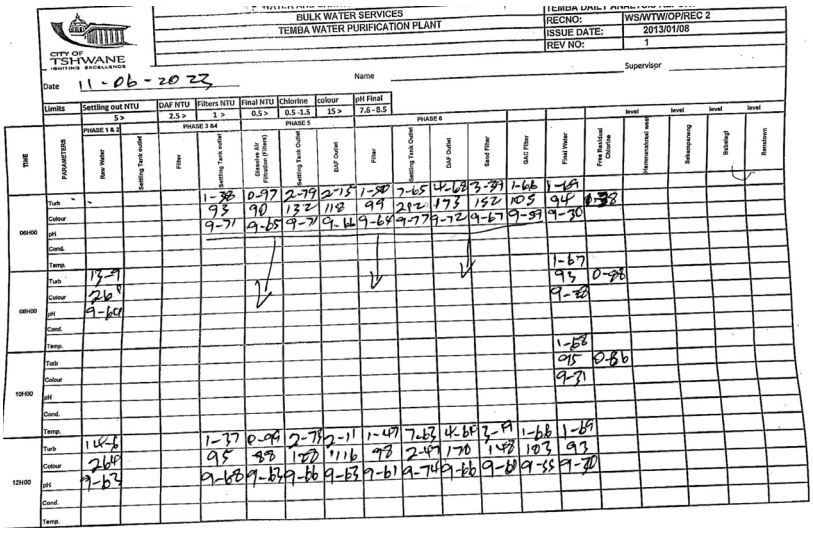
1. Combined pH and Electrical Conductivity Meter
2. Colourimeter for the testing of chlorine residuals.
3. Turbidity meter
4. Colour meter

There were no pH buffers and secondary standards for the turbidity meter. Instruments are, therefore, not checked for accuracy. A system should be implemented to confirm the accuracy of the on-site process control instruments.

Figure 18: Process Control Instrumentation

A jar tester should form part of the process control equipment available to the Process Controllers. Raw water has to be tested with various chemical dosages and combinations to achieve a final water quality which complies with the turbidity requirement of 1 NTU.

The results of the process control tests are recorded on three forms: a separate form for each of the three shifts. It was noted that final water turbidities are seldom below 1 NTU.



BULK WATER SERVICES
TEMBA WATER PURIFICATION PLANT

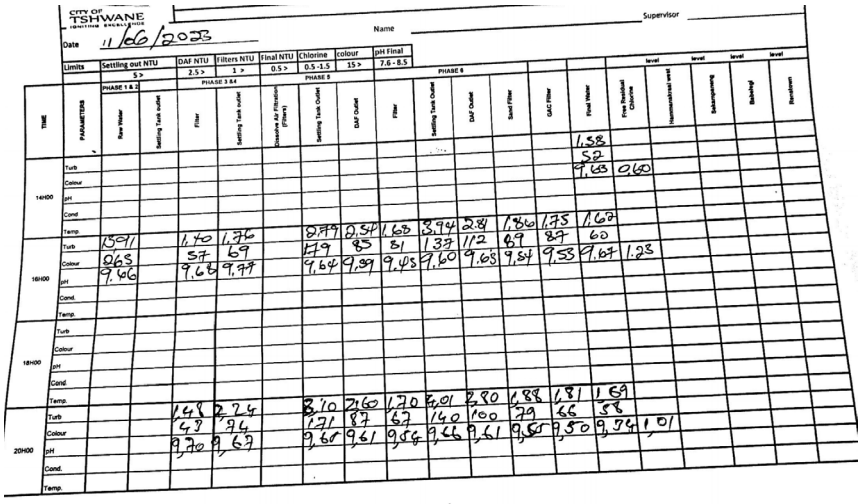
RECNO: WS/WTW/OP/REC 2
ISSUE DATE: 2013/01/08
REV NO: 1

Date 11-06-2023 Name Supervisor

Limits	Settling out NTU	DAF NTU	Filters NTU	Final NTU	Chlorine	colour	pH Final
	5 >	2.5 >	1 >	0.5 >	0.5 -1.5	15 >	7.6 - 8.5

TIME	PARAMETERS	PHASE 1 & 2: Raw Water	PHASE 1 & 2: Settling Tank outlet	PHASE 3 &4: Filter	PHASE 3 &4: Settling Tank outlet	PHASE 5: Dissolve Air Filtration (Filters)	PHASE 5: Settling Tank Outlet	PHASE 5: DAF Outlet	PHASE 6: Filter	PHASE 6: Settling Tank Outlet	PHASE 6: DAF Outlet	PHASE 6: Sand Filter	PHASE 6: GAC Filter	Final Water	level: Free Residual Chlorine	level: Hammondsbed level	level: Balancepoint	level: Backwgt	level: Rundown
06H00	Turb			1-38	0.97	2-79	2-15	1-58	7-65	44.68	3-39	1-66	1-69						
	Colour			93	90	132	118	99	282	173	152	105	94	0.38					
	pH			9-71	9-65	9-71	9-66	9-64	9-77	9-72	9-67	9-59	9-30						
	Cond.																		
	Temp.																		
08H00	Turb	13-9											1-67						
	Colour	266											93	0-78					
	pH	9-60											9-62						
	Cond.																		
	Temp.																		
10H00	Turb												1-68						
	Colour												95	0-86					
	pH												9-71						
	Cond.																		
	Temp.																		
12H00	Turb	1-45		1-37	0-99	2-78	2-11	1-49	7.63	4.68	3-19	1-66	1-69						
	Colour	266		95	88	172	116	98	2-49	170	148	103	93						
	pH	9-62		9-68	9-69	9-66	9-63	9-61	9-74	9-66	9-68	9-55	9-30						
	Cond.																		
	Temp.																		

Figure 19: Typical Water Quality per shift (morning shift, 11/06/23)

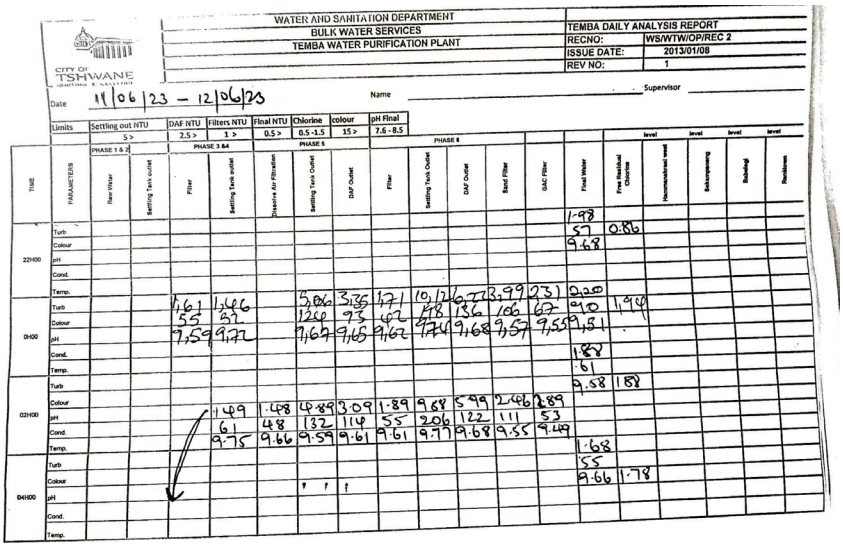


Date 11/06/2023 Name Supervisor

Limits	Settling out NTU	DAF NTU	Filters NTU	Final NTU	Chlorine	colour	pH Final
	5 >	2.5 >	1 >	0.5 >	0.5 -1.5	15 >	7.6 - 8.5

TIME	PARAMETERS	PHASE 1 & 2: Raw Water	PHASE 1 & 2: Settling Tank outlet	PHASE 3 &4: Filter	PHASE 3 &4: Settling Tank outlet	PHASE 5: Dissolve Air Filtration (Filters)	PHASE 5: Settling Tank Outlet	PHASE 5: DAF Outlet	PHASE 6: Filter	PHASE 6: Settling Tank Outlet	PHASE 6: DAF Outlet	PHASE 6: Sand Filter	PHASE 6: GAC Filter	Final Water	level: Free Residual Chlorine	level: Hammondsbed level	level: Balancepoint	level: Backwgt	level: Rundown
14H00	Turb													1.58					
	Colour													52					
	pH													9.63	0.60				
	Cond																		
	Temp																		
16H00	Turb	15.91		1.40	1.76		0.79	0.54	1.68	3.94	2.28	1.86	1.75	1.67					
	Colour	065		57	69		179	85	81	139	112	89	89	60					
	pH	9.46		9.68	9.79		9.64	9.59	9.45	9.60	9.68	9.64	9.53	9.67	1.28				
	Cond.																		
	Temp.																		
18H00	Turb																		
	Colour																		
	pH																		
	Cond.																		
	Temp.																		
20H00	Turb			1.48	2.24		3.10	2.60	1.70	4.01	2.80	1.88	1.81	1.69					
	Colour			49	94		171	87	67	140	100	79	66	58					
	pH			9.70	9.67		9.60	9.61	9.56	9.46	9.61	9.65	9.50	9.74	1.01				
	Cond.																		
	Temp.																		

Figure 20:Typical Water Quality per shift (afternoon shift, 11/06/23)



WATER AND SANITATION DEPARTMENT
BULK WATER SERVICES
TEMBA WATER PURIFICATION PLANT

TEMBA DAILY ANALYSIS REPORT
RECNO: WS/WTW/OP/REC 2
ISSUE DATE: 2013/01/08
REV NO: 1

Date 11/06/23 - 12/06/23 Name Supervisor

Limits	Settling out NTU	DAF NTU	Filters NTU	Final NTU	Chlorine	colour	pH Final
	5 >	2.5 >	1 >	0.5 >	0.5 -1.5	15 >	7.6 - 8.5

TIME	PARAMETERS	PHASE 1 & 2: Raw Water	PHASE 1 & 2: Settling Tank outlet	PHASE 3 &4: Filter	PHASE 3 &4: Settling Tank outlet	PHASE 5: Dissolve Air Filtration	PHASE 5: Settling Tank Outlet	PHASE 5: DAF Outlet	PHASE 6: Filter	PHASE 6: Settling Tank Outlet	PHASE 6: DAF Outlet	PHASE 6: Sand Filter	PHASE 6: GAC Filter	Final Water	level: Free Residual Chlorine	level: Hammondsbed level	level: Balancepoint	level: Backwgt	level: Rundown
22H00	Turb													1-98					
	Colour													57	0.86				
	pH													9.68					
	Cond.																		
	Temp.																		
0H00	Turb			1.61	1.46		5.06	3.35	1.71	10.12	6.77	3.99	2.31	0.20					
	Colour			55	57		126	93	62	248	136	106	67	090	1.94				
	pH			9.59	9.72		9.67	9.65	9.62	9.74	9.68	9.57	9.55	9.51					
	Cond.																		
	Temp.													1.88					
02H00	Turb													161					
	Colour													9.58	1.88				
	pH																		
	Cond.																		
	Temp.																		
04H00	Turb	1.49	1.48	4.89	3.09	1.89	9.68	5.99	2.66	2.89									
	Colour	61	48	132	114	55	206	122	111	53									
	pH	9.75	9.66	9.59	9.61	9.61	9.77	9.68	9.55	9.49									
	Cond.																		
	Temp.													1.68					
	Turb													155					
	Colour													9.66	1.78				
	pH																		
	Cond.																		
	Temp.																		

Figure 21: Typical Water Quality per shift (night shift, 11/06/23)

The Process Controllers record the water meter readings and the water quality. They do not calculate the actual daily volumes. A copy of the log sheet with the meter readings is shown below. There was no evidence of chemical stock levels or actual or required dosages.

City of Tshwane Metroplolitan Municiplalty's networks

	Start Date:	End Date:	Reservoir	Level (%) yesterday	Volume (kl)	Level (%) Today	Volume (kl)	Storage change (kl)	Res Capacity
			1						2750
Metering Days:			2						5500
			3						5000
			4						10000
			5						10000

Meter no:	Supply Zone	Monday	Tuesday	Wednesday	Thursday	Friday	Saterday	Sunday			Serial nc
	Date	29/5/23	30/05/2023	31/5/23	01/06/2023	02-06-23	03-06-23	04-06-23			
14 A	Unit-D Lower	189040	189175						(x)	WPD 200	9568831-(
14 B	Unit-D Lower	384167	384390	Water		Water	WC	ve	10	WPD 200	9568840-(
15 A	Unit-D Lower	177181	177241						10	WPD 150	9569455-(
15 B	Unit-D Lower	174892	174953		Water				10	WPD 150	9570967-(
16	Manyaleti Lower								10	WPD 150	9568811-(
	Manyaleti Lower	609653	610486	611319		612926	638383	639261	10	WPD 100	9568797-(
17 B	Manyaleti Lower	461803	462350	462897		463992	607860	608714	1	WPD 100	9562281-(
18 A	Rockville Lower	462061	462206	462351		462641	482892	463154	1	WPD 150	9562297-(
18 B	Rockville Lower	482161	482306	482450		482739	483209	483380	10	WPD 150	9562301-(
19 A	Rockville Lower	789379	789677	789975		790571	799777	791245	10	WPD 100	9568807-(
19 B	Rockville Lower	799534	799823	800112		800681	801137	801409	1	WPD 100	9568799-(
20 A	Dura-Built	465414	465959	466504		467593	468880	469114	1	WPD 100	9562267-(
20 B	Dura-Built	600593	601154	601715		602836	503987	504524	1	WPD 100	9562286-(
22	Sekampaneng	97498,112	97225,188	97252,091	97252,881	97272,6[illegible]	97273,469	97275,30	1	MAG 500	
25	Jubilee								1000	WPD 200	9568834-(
26 A	Unit-D Extention		321798				ve	ve	10	WPD 150	9561972-(
26 B	Unit-D Extention	water	323023	water	Water	Water			10	WPD 150	9569446-(
30	Babelegi Transfer								10	WPD 300	9549868-(
31 A	Makapaanstad	water	244011	244175	244339	244426	ve	ve	10	WPD 300	9507704-(
31 B	Makapaanstad		141620	141669	141719	141822			10	WPD 300	9550150-(
34A	Jubilee New	214443	214595	214747	214898	214878	057044	057682	10	WPD 300	9550150-(
34A	Jubilee New	108674	109530	110386	111242	111268	112980	113637	10	WPD 300	9550150-(
35A	Hammaskral west	F	F	F	F	Faulty	Faulty	Faulty	10	WPD 300	9550150-(
	Hammaskral west	48613,891	4862628		not	Faulty	Faulty	Faulty	1000	WPD 300	9550150-(
36	Chris Hani	533227	533279	533332	working	[illegible]			1000		
						TOTAL WATER DISTRIBUTED			1000		
1	Clear water 1+2			100							
24	Clear water 3+4+5		~~114883~~	100					100		
	Clear Water 6								100		
21	Back wash (Phase 3,4,5)		114883		114911	114911	114911	114911			
32	Back wash (Phase 5)	114849		114917							
27		148535	148562	148589	148607	148636	148647	148662			
Meter before raw water pumps											
Meter before raw water pumps											
28A	Raw Water	17182,6	17215,2		17272,5	43093,6	431082	431297			
28B	Raw Water	429956	42992,9		43055,2	17707,8	17322,4	17342			
Before inlet Tower											
Before inlet Tower											
Sludge dam flow											

Checked by:

Figure 22: Typical meter readings log sheet

CHAPTER 5: WATER QUALITY

Water samples of the following points were taken on 12 June 2023. The purpose was to evaluate the water treatment process regarding pathogen removal, using total coliforms as indicator organisms. The samples were submitted for analyses to Waterlab (Pty Ltd, a SANAS-accredited laboratory (T0391).

1. Raw water
2. Module 6 clarified water
3. Module 6 filtered water
4. GAC filtrate
5. Final water

The results of the water samples are given below in Table 1. A copy of the modified (signatures removed) Certificate of Analysis is attached as Appendix 3.

Table 1: Water Quality Results of Module 6 (Temba WTW)

	Module 6				
Parameter	**Raw Water**	**Clarified Water**	**Filtered Water**	**GAC Filtrate**	**Final Water**
pH, value at 25°C	7.6				7.5
Electrical Conductivity, mS/m at 25°C	80.1				79.9
Total Dissolved Solids, mg/ℓ	518				546
Suspended Solids, mg/ℓ	16.7				
Turbidity, NTU	4.4				2.6
Chloride, mg/ℓ Cl	55				66
Sulphate, mg/ℓ SO_4	46				44
Nitrate, mg/ℓ as N	0.1				3.0
Free and Saline Ammonia, mg/ℓ as N	15				10
Total Coliform Bacteria, MPN/100 mℓ	> 100 000	> 100 000	> 100 000	> 100 000	< 1
Escherichia coli, MPN/100 mℓ	31 000				< 1

The Total Coliform bacteria counts show that the expected counts in terms of pathogen removal could not be evaluated, as the initial counts were higher than expected. The coagulation, flocculation and clarification processes should achieve 4-log bacteria removal.

Additional samples from the water treatment plant were taken on 26 June 2023 and submitted to the ERWAT, SANAS-accredited laboratory (T0082). The results are given below in Table 2, Table 3 and Table 4. The purpose was to include determinants normally tested for in wastewater to evaluate the impact of the Rooiwal Wastewater Treatment Works on the source of the Temba Water Treatment Works. A copy of the modified (signatures) certificate of Analysis is attached as Appendix 3.

Table 2: Microbiological Results (Temba WTW and Temba Distribution)

Determinant	UoM	Raw Water (Temba)	Before Chlorine (Temba)	Final Water (Temba)	Temba Network	Tanker Rand Water
Total coliforms	MPN.100ml^{-1}	6.13 x 10^4	1.72 x 10^5	0	0	2
Escherichia coli	MPN.100ml^{-1}	1.08 x 10^4	3.60 x 10^3	0	0	0
Heterotrophic plate count	CFU.1ml^{-1}	3.98 x 10^5	2.18 x 10^5	1.00 x 10^2	1.68 x 10^2	1.33 x 10^2
Salmonella enterica	Positive/Negative	Negative	Positive	Negative	Negative	Negative
Shigella species and/or EIEC	Positive/Negative	Negative	Positive	Negative	Negative	Negative
Toxigenic *Vibrio cholerae* (*ctxAB*+)	Positive/Negative	Negative	Negative	Negative	Negative	Negative

NOTES:
EIEC = entero-invasive *Escherichia coli*
MPN = most probable number
CFU = colony forming units

Table 3: Chemistry Results (Temba WTW and Temba Distribution)

Determinant	UoM	Raw Water (Temba)	Before Chlorine (Temba)	Final Water (Temba)	Temba Network	Tanker Rand Water
Chemical oxygen demand (COD)	mg.L^{-1}	112.0	79.0	106.0	33.0	18.0
Filtered chemical oxygen demand (FCOD)	mg.L^{-1}	62.0	50.0	49.0	24.0	10.0
Ammonia-nitrogen (NH_3)	mg.L^{-1}	16.4	13.1	12.2	11.1	0.3
Ortho-phosphates (PO_4)	mg.L^{-1}	2.3	2.0	1.9	1.8	<0.1
Nitrates (NO_3^-)	mg.L^{-1}	0.6	3.5	3.5	3.7	0.7
Total suspended solids (TSS)	mg.L^{-1}	10.0	<10.0	<10.0	<10.0	<10.0
Total organic carbon (TOC)	mg.L^{-1}	17.3	13.7	11.9	12.1	8.1

Table 4: Trihalomethane Results (Temba WTW and Temba Distribution)

Determinant	UoM	Raw Water (Temba)	Before Chlorine (Temba)	Final Water (Temba)	Temba Network	Tanker Rand Water
Bromodichloromethane	µg.L^{-1}	<3	<3	<3	<3	20
Bromoform	µg.L^{-1}	<3	<3	<3	<3	<3
Chloroform	µg.L^{-1}	<3	<3	5	3	64
Dibromochloromethane	µg.L^{-1}	<3	<3	<3	<3	3
Total THM	µg.L^{-1}	<3	<3	5	3	87

The above microbiological results show that the total coliform count increases over the treatment process instead of the required log removal. The increase in pathogen numbers indicates insufficient treatment, while the chemistry results indicate poor water quality. Most of the parameters exceed the requirements of the General Authorisation. This will adversely impact on the water treatment process, requiring a dedicated dosing regime aligned with the raw water quality and a functional duty and standby chlorine dosing system.

REFERENCES

AWWA, 1979. *Water Treatment Plant Design.* 4th Edition ed. s.l.:McGraw-Hill Inc.

Botha, M. v. d. M., 2018. *Principles and approaches for Drinking Water Treatment Plant performance Assessment and Optimisation.* Pretoria: Water Research Commission.

Ceronio, A., 2018. *Guidance on Drinking Water Treatment Process Audits and Plant Optimisation.* Pretoria: Water Research Commission.

Degrémont, n.d. *Water treatment handbook,* s.l.: Lavoisier Publishing.

Duuren (Editor), F. v., 1997. *Water Purification Works Design.* Pretoria: Water Research Commission.

SABS, 2015. *Part 1: Microbiological, physical, aesthetic and chemical determinands,* s.l.: s.n.

Schutte (Editor), F., 2006. *Handbook for the Operation of Water Treatment Works.* Pretoria: Water Research Commission.

APPENDIX 1: TREATMENT INSPECTION LIST

Temba - Water Treatment Works Inspected on: 12/06/2023	
Raw Water Abstraction / Source Protection	Inflow Measurement
40%	17%
Pre-treatment	Chemical Dosing
0%	17%
Phase Separation	Filtration
30%	15%
Disinfection	Stabilization
27%	0%
Treated Water Storage	Water Loss
100%	0%
Storage Reservoirs	Point of Use
Not Checked	Not Checked
Operating Manual	Emergency Procedures
0%	Not Checked
General Maintenance	Residue Management
0%	25%
Sampling	Operational Monitoring
67%	9%
Compliance Monitoring	Troubleshooting
Not Checked	Not Checked
Registration, Staffing and Others	PERCENTAGE COMPLIANCE ACHIEVED FOR AUDIT
40%	22%

AUDIT CHECKLIST FOR WATER TREATMENT WORKS					
TREATMENT WORKS		Temba Water Treatment Works			
INSPECTED BY		Pierre Smit			
INSPECTED ON		12-Jun-23			
OVERALL COMPLIANCE		22%			
ITEM	REQUIREMENTS	REFERENCE	POINTS	MAX %	COMMENTS
Raw Water Abstraction / Source Protection					
1	Clean debris from raw water intake		†	0	
2	Change duty / standby pumps		0	1	
3	Raw water source levels monitored		0	1	
4	Rainfall measured and recorded		0	1	
5	Raw water pumping hours monitored		0	1	
6	Raw water pump efficiency checked		0	1	
7	Raw water pH checked regularly		1	1	Once per day
8	Raw water Turbidity checked regularly		1	1	Once per day
9	Raw water Electrical Conductivity checked regularly		0	1	
		40%	2	5	
Inflow Measurement					
1	Is the inflow measured and recorded daily to monitor treatment		0,5	0	Readings recorded, but not subtracted.
2	Is the inflow rate recorded 2-hourly to monitor flow changes		0	1	
3	Is the inflow compared against the plant's design capacity		0	1	
4	Is the inflow meter checked for accuracy		0	1	
		17%	0,5	3	
Pre-treatment					
1	Pre-treatment conducted		0	1	No pre treatment conducted.
2	Effectiveness of pre-treatment monitored as part of operational monitoring		N/A		
		0%	0	1	
Chemical Dosing					
1	Jar Test equipment available (inclusive of glassware)		0	1	No jar test equipment in process controllers office where process control tests are performed.
2	Jar tests conducted regularly		0	1	
3	Jar test results available on-site		0	1	Product name was not known and no jar test results from supplier available.
4	Jar test results used in applying chemical dosing		0	1	
5	The supplier conducts regular checks and report on dosing (reports available on-site for Process Controllers use)		0	1	
6	Duty / Standby chemical dosing pumps available		1	1	Some pumps out for maintenance, sufficient capacity available.
7	Drop / Delivery tests conducted regularly, recorded and back calculated to actual dosing in mg/ℓ		0	1	
8	Actual usage recorded (kg), based on tank levels converted to mass		0	1	No info available an actual dosages.
9	Actual dosage back calculated (mg/ℓ)		0	1	
10	Actual dosage compared to recommended dosages / Jar test results		0	1	
11	More than 30 days stock available		†	0	
12	Storage area bunded		1	1	Area is bunded.
13	MSDS / PDS available		0	1	
14	Safety Shower / Eye Wash available		†	0	
15	Treatment chemicals tested for as per SANS 241 (weekly)		†	0	
		17%	2	12	
Phase Separation					
1	Settling / Cascade tests conducted		N/A		
2	Performance checked by regular turbidity monitoring		1	1	
	Are individual units sampled		0	1	Combined sample taken, performance of individual units unknown.
3	Regular desludging		0,5	0	No records available for all the modules.
4	Time / volume calculated		0	1	
5	Desludging recorded		0	1	
6	Cleaning schedule		0	1	
		30%	1,5	5	

AUDIT CHECKLIST FOR WATER TREATMENT WORKS					
TREATMENT WORKS		Temba Water Treatment Works			
INSPECTED BY		Pierre Smit			
INSPECTED ON		12-Jun-23			
OVERALL COMPLIANCE		22%			
ITEM	REQUIREMENTS	REFERENCE	POINTS	MAX %	COMMENTS
Filtration					
1	Filters washed at least every 48 hrs		1	1	
2	Filter media inspected during backwash		0	1	
3	Any mudballs		†	0	
4	Any broken nozzles		†	0	
5	Valves Checked for leaks, while backwashing		†	0	
6	Structure Checked		†	0	
7	Media levels monitored		0	1	
8	Upwash rate checked		0	1	
9	Optimum backwash determined		0	1	
10	Media grading conducted		0	1	
11	Backwash efficiency determined		0	1	
12	Filter backwash recorded		0	1	
13	Reason for backwashing recorded		0	1	
14	Air scour time recorded		0	1	
15	Backwash water time/volume recorded		0	1	
16	Filtered water quality tested		1	1	Combined sample per module. Individual units not monitored.
17	Filtered water quality tested per individual filter		0	1	
		15%	2	13	
Disinfection					
1	Chlorine demand determined / known		0	1	
2	Duty / Standby chlorine bank available		0	1	Only 4 cylinders, not on a scale dosing at 26 kg/h
3	Automatic change-over facility available and operational		0	1	Available, but not sure of working, but no standby chlorine bank available.
4	Chlorine alarm operational		0	1	Major leak on line after chlorine injection but no warning light or siren indicating of leak. State of equipment confirm this as a regular event.
5	Windsock available		1	1	
6	Chlorine room inspected and recorded as per SANS 10298 requirements		0	1	No inspections for leaks are recorded once per shift.
7	Sample taken after on-site storage (30 min retention time)		1	1	
8	Level of on-site reservoir/s recorded		0	1	
9	Actual usage (kg) determined		0	1	No working scale.
10	Actual dosing (mg/ℓ) determined		0	1	No working scale.
11	More than 30 days stock available		1	1	15 Full Cylinders available.
		27%	3	11	
Stabilization					
1	Is stabilization required ($CaCO_3$ ppt available)		†	0	
2	Stabilization applied		0	1	
3	Guideline pH available		0	1	
4	Actual dosing back calculated		0	1	
		0%	0	3	
Treated Water Storage					
1	Reservoirs kept closed		1	1	
2	Vents in good condition		†	0	
3	Level indicator/s available and working		†	0	
4	Sampling point/s available to sample water quality		1	1	
5	Minimum of 30 minute storage time available		1	1	
		100%	3	3	

AUDIT CHECKLIST FOR WATER TREATMENT WORKS					
TREATMENT WORKS		Temba Water Treatment Works			
INSPECTED BY		Pierre Smit			
INSPECTED ON		12-Jun-23			
OVERALL COMPLIANCE		22%			
ITEM	REQUIREMENTS	REFERENCE	POINTS	MAX %	COMMENTS
Water Loss					
1	Volume of treated water measured		0	1	Not recorded.
2	Potable water production calculated		0	1	
3	Meter calibration checks done regularly		0	1	
4	Water loss calculated (volume)		0	1	
5	Water loss calculated (%)		0	1	
6	Water loss acceptable (sludge volumes calculated)		0	1	
		0%	0	6	
Storage Reservoirs					
1	Chlorine residuals measured daily		†	0	
2	Level measurement in place		†	0	
3	Cleaning programme available		†	0	
4	Cleaning programme followed		†	0	
		Not Checked	0	0	
Point of Use					
1	Coverage more than 80%		†	0	
2	Chlorine residuals measured daily		†	0	
3	Re-testing when residuals low and corrective action taken		†	0	
4	Compliance monitoring conducted		†	0	
		Not Checked	0	0	
Operating Manual					
1	Is an Operations Manual available on-site		0	1	No manual in Process Controllers office/process control lab.
2	Manual specific to site		†	0	
3	Design capacity of plant / various process units provided		†	0	
4	Process Description		†	0	
5	Start-up Procedures		†	0	
6	Process Control Procedures		†	0	
7	Shut down Procedures		†	0	
8	Mechanical, Electrical & Instrumentation detail		†	0	
		0%	0	1	
Emergency Procedures					
1	Chemical Spillage		†	0	
2	Dam Failure		†	0	
3	Fire		†	0	
4	Chlorine Leak		†	0	
		Not Checked	0	0	
General Maintenance					
1	Preventative Maintenance Schedule		0	1	
2	Logbook for maintenance defects		0	1	
3	Record of maintenance carried out		0	1	
4	Maintenance staff qualified		†	0	
		0%	0	3	
Residue Management					
1	Appropriate technology		1	1	
2	Supernatant recovery		0	1	
3	Desludging volumes / times calculated		0	1	
4	Volumes recorded		0	1	
		25%	1	4	

AUDIT CHECKLIST FOR WATER TREATMENT WORKS					
TREATMENT WORKS		Temba Water Treatment Works			
INSPECTED BY		Pierre Smit			
INSPECTED ON		12-Jun-23			
OVERALL COMPLIANCE		22%			
ITEM	REQUIREMENTS	REFERENCE	POINTS	MAX %	COMMENTS
Sampling					
1	Sampling points marked		0	1	
2	All process can be sampled		1	1	
3	Sampling equipment available		1	1	
4	Regular refresher training / methods to ensure correct sampling		†	0	
		67%	2	3	
Operational Monitoring					
1	Operational monitoring risk based?		0	1	
2	Operational monitoring program documented		0	1	
3	Guideline values for various processes documented		0	1	
4	Calibration / Calibration check procedure in place		0	1	
5	Calibration records available		0	1	
6	Comparison of own results with external lab results		†	0	
7	pH buffers changed regularly		0	1	
8	Turbidity standards valid and not expired		0	1	
9	Electrical Conductivity standards changed regularly		N/A		
10	All process units monitored		0	1	
11	Monitoring regularly		0	1	
12	Compliance reported on daily, monthly and annual reports		0	1	
13	Records readily available		1	1	
		9%	1	11	
Compliance Monitoring					
1	Compliance Monitoring Programme informed by Risk Assessment		†	0	
2	Compliance Monitoring Programme available on site		†	0	
3	Compliance Monitoring programme followed		†	0	
4	Compliance Monitoring results available on-site		†	0	
5	Full SANS 241 conducted on raw, final and point of use		†	0	
		Not Checked	0	0	
Troubleshooting					
1	Abstraction - troubleshooting available	Best Practice	†	0	
2	Chemical Dosing - troubleshooting available	Best Practice	†	0	
3	Flocculation - troubleshooting available	Best Practice	†	0	
4	Sedimentation - troubleshooting available	Best Practice	†	0	
5	Filtration - troubleshooting available	Best Practice	†	0	
6	Disinfection - troubleshooting available	Best Practice	†	0	
7	Residue Management - troubleshooting available	Best Practice	†	0	
		Not Checked	0	0	
Registration, Staffing and Others					
1	Treatment works registered and certificate displayed	Water Act	0	1	Class B works
2	Supervisor/s classified and certificates displayed	Water Act	0	1	
3	Supervisor/s meeting requirements of Reg 2834/813	Water Act	1	1	
4	Process Controllers registered and certificates displayed	Water Act	0	1	
5	All shifts manned	Water Act	1	1	
6	All shifts manned as per requirements of Reg 813	Water Act	†	0	
7	Annual Process Audit conducted		†	0	
8	Training Needs determined		†	0	
9	Staff development plan in place		†	0	
		40%	2	5	

AUDIT CHECKLIST FOR WATER TREATMENT WORKS					
TREATMENT WORKS		Temba Water Treatment Works			
INSPECTED BY		Pierre Smit			
INSPECTED ON		12-Jun-23			
OVERALL COMPLIANCE		22%			
ITEM	REQUIREMENTS	REFERENCE	POINTS	MAX %	COMMENTS
		TOTAL POINTS ACHIEVED	20		
		MAXIMUM CRITERIA SCORE		89	
		PERCENTAGE COMPLIANCE	22%		

CRITERIA USED FOR % COMPLIANCE CALCULATION	
1	Satisfactory
0,5	Partially meeting the requirements (action required)
0	Fails to meet the requirements
N/A	Not Applicable in this Case
	Not Checked

Auditor :

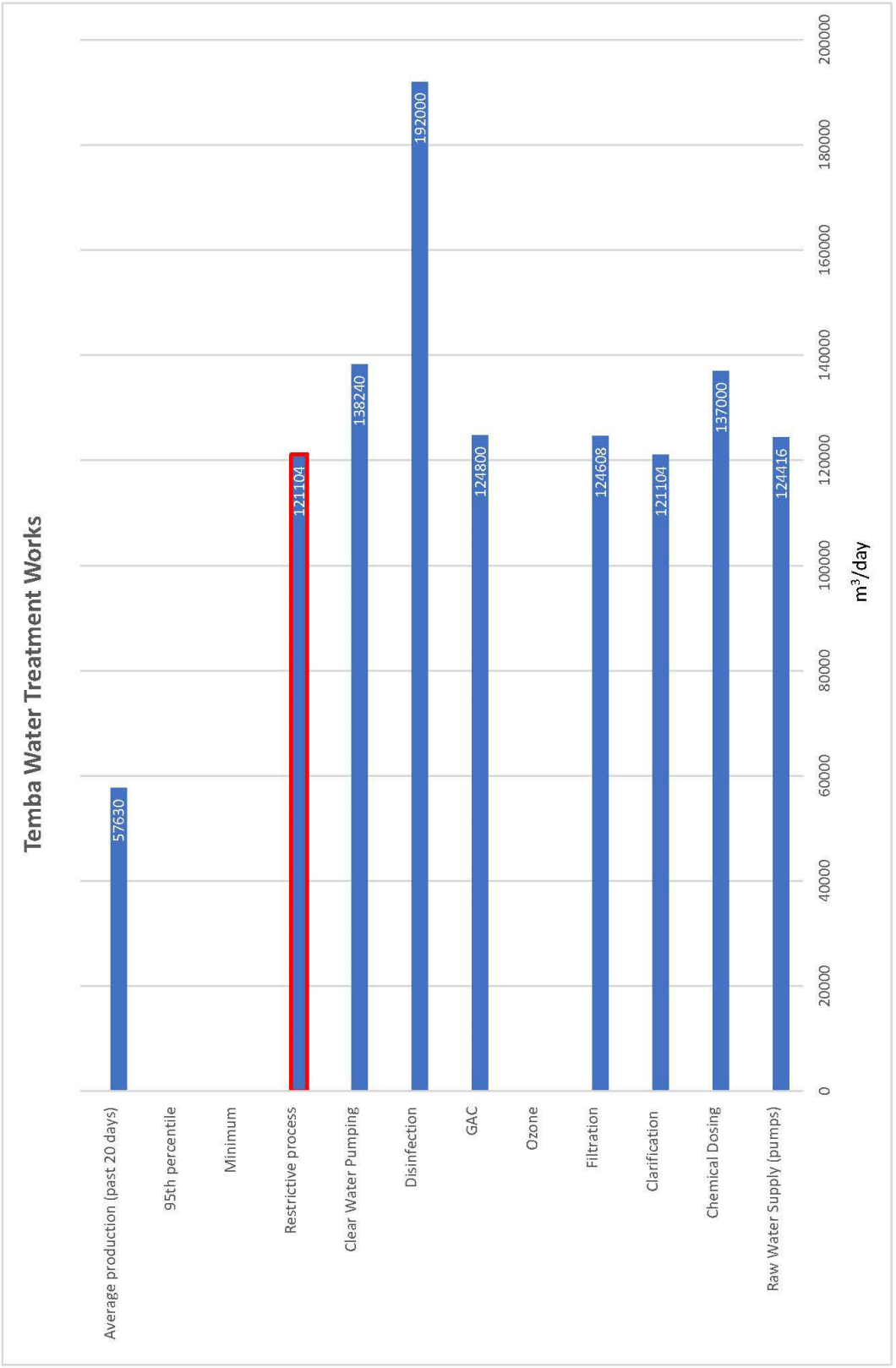
Auditee :

Date :

APPENDIX 2: BASIC PROCESS CAPACITY CALCULATIONS

Temba Water Treatment Works

					Design		
Inlet Works	Current				*360*	*ℓ/s*	
Pump 1	402	ℓ/s			*360*	*ℓ/s*	
Pump 2	408	ℓ/s			*360*	*ℓ/s*	
Pump 3		ℓ/s			*360*	*ℓ/s*	
Pump 4		ℓ/s				*ℓ/s*	
Pump 5		ℓ/s				*ℓ/s*	
Pump 6		ℓ/s			*1440*	*ℓ/s*	
Q_{in}	810	ℓ/s			*5184*	*m^3/h*	
Q_{in}	2916	m^3/h			*24*		
Hours/day	24				*124 416*	*m^3/d*	
Q_{in}/day	69984	m^3/d			***124***	***Mℓ/d***	
Qin/day	**70**	**Mℓ/d**					
Clarifiers	**Module 3**	**Module 4**	**Module 5**	**Module 6**			
Settling Area/Unit, m²	294	126	100	100			
Number	1	2	6	12			
Surface Area (Total), m²	294	252	600	1200			
Upflow rate, m/h	1,0	1,0	2,5	2,5			
Possible flow, Mℓ/d	7	6	36	72	121	Mℓ/d	
CoCo DAF							
Settling Area/Unit, m²		36					
Number		6					
Surface Area (Total), m²		216					
Filtration rate, m/h		10					
Possible flow, Mℓ/d		52					
DAF							
Area/Unit			70	56			
Number			4	6			
Surface Area (Total)			280	336			
Loading Estimated, m^3/hr/m^2			7	10			
Possible flow, Mℓ/d			47	81	128	Mℓ/d	
Filtration (Rapid Gravity)							
Filtration Area/Unit, m²			64	52			
Number			5	8			
Surface Area (Total), m²			320	416			
Filtration rate, m/h			5	5			
Possible flow, Mℓ/d			38	50			
Filtration (CoCo DAF)							
Filtration Area/Unit, m²		36					
Number		6					
Surface Area (Total), m²		216					
Filtration rate, m/h		7					
Possible flow, Mℓ/d		36					
					125	Mℓ/d	
Filtration (GAC)							
Filtration Area/Unit, m²					52		
Number					10		
Surface Area (Total), m²					520		
Filtration rate, m/h					10		
Possible flow, Mℓ/d					**125**		
					125	Mℓ/d	
Transfer Pumps							
Number			1		*2*		
$Q_{transfer}$			1300	ℓ/s	*2600*	*ℓ/s*	
$Q_{transfer}$			4680	m^3/h	*9360*	*m^3/h*	
Chlorine Dosing							
Max chlorine withdrawal					10	kg/cylinder	
Max chlorine withdrawal					40	kg/4 x cylinders	
Cylinders							
Actual Chlorine Dosing					26	kg/h	
					5,56	mg/ℓ	
Maximum Dosing					40	kg/h	
				Possible	8	mg/ℓ	
					192	**Mℓ/d**	
On-site Storage					25	Mℓ	
Volume					80	min	*40 min*


Temba Water Treatment Works
m3/day
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000
57630
121104
138240
192000
124800
124608
121104
137000
124416
Average production (past 20 days)
95th percentile
Minimum
Restrictive process
Clear Water Pumping
Disinfection
GAC
Ozone
Filtration
Clarification
Chemical Dosing
Raw Water Supply (pumps)

APPENDIX 3: LABORATORY RESULTS

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-06-13 **Date completed:** 2023-06-23
Project number: 1000 **Report number:** 121368 **Order number:**

Client name: Virtual Consulting **Contact person:** Mr. Pierre Smit
Address: P.O Box 323, Groenkloof, 0027 **e-mail:** pierre@virtualconsulting.co.za
Telephone: 012 452 0444 **Facsimile:** 012 452 0583 **Mobile:** 082 773 2156

Analyses in mg/ℓ (Unless specified otherwise)		UOM %	Method ID	Risk	SANS 241 : 2015 Limits	Sample Identification: Temba WTW Raw
Sample Number						23-09886
Date/Time Sampled						N/A
pH - Value @ 25 °C	A	7.7	WLAB065	Operational	≥5 to ≤ 9.7	7.6
Electrical Conductivity in mS/m @ 25°C	A	7.0	WLAB065	Aesthetic	≤170	80.1
Total Dissolved Solids @ 180°C	A	5.6	WLAB003	Aesthetic	≤1200	518
Suspended Solids at 105°C	A	8.6	WLAB004	---	---	16.7
Turbidity in N.T.U	A	7.6	WLAB005	Operational/Aest	≤1 / ≤5	4.4↓
Chloride as Cl	A	8.0	WLAB046	Aesthetic	≤300	55
Sulphate as SO_4	A	8.4	WLAB046	Acute health/Aest	≤500 / ≤250	46
Nitrate as N	A	4.8	WLAB046	Acute health	≤11	0.1
Total Coliform Bacteria (MPN/100 mℓ)	A	6.1	WLAB021	Operational	≤10	>100000↓
E. coli (MPN/100 mℓ)	A	5.0	WLAB021	Acute health	Not detected	31000↓
Free and Saline Ammonia as N	A	10	WLAB046	Aesthetic	≤1.5	15↓

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-06-13 **Date completed:** 2023-06-16
Project number: 1000 **Report number:** 121370 **Order number:**

Client name: Virtual Consulting **Contact person:** Mr. Pierre Smit
Address: P.O Box 323, Groenkloof, 0027 **e-mail:** pierre@virtualconsulting.co.za
Telephone: 012 452 0444 **Facsimile:** 012 452 0583 **Mobile:** 082 773 2156

Analyses in mg/ℓ (Unless specified otherwise)		UOM %	Method ID	Risk	SANS 241 : 2015 Limits	Sample Identification
						Module 6 Settled
Sample Number						23-09888
Date/Time Sampled						N/A
Total Coliform Bacteria (MPN/100 mℓ)	A	6.1	WLAB021	Operational	≤10	>100000 ↓

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-06-13 **Date completed:** 2023-06-16
Project number: 1000 **Report number:** 121371 **Order number:**

Client name: Virtual Consulting **Contact person:** Mr. Pierre Smit
Address: P.O Box 323, Groenkloof, 0027 **e-mail:** pierre@virtualconsulting.co.za
Telephone: 012 452 0444 **Facsimile:** 012 452 0583 **Mobile:** 082 773 2156

Analyses in mg/ℓ (Unless specified otherwise)		UOM %	Method ID	Risk	SANS 241 : 2015 Limits	Sample Identification
						Module 6 Filtered
Sample Number						23-09889
Date/Time Sampled						N/A
Total Coliform Bacteria (MPN/100 mℓ)	A	6.1	WLAB021	Operational	≤10	>100000

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-06-13 **Date completed:** 2023-06-16
Project number: 1000 **Report number:** 121372 **Order number:**

Client name: Virtual Consulting **Contact person:** Mr. Pierre Smit
Address: P.O Box 323, Groenkloof, 0027 **e-mail:** pierre@virtualconsulting.co.za
Telephone: 012 452 0444 **Facsimile:** 012 452 0583 **Mobile:** 082 773 2156

Analyses in mg/ℓ (Unless specified otherwise)		UOM %	Method ID	Risk	SANS 241 : 2015 Limits	Sample Identification GAC Filters
Sample Number						23-09890
Date/Time Sampled						N/A
Total Coliform Bacteria (MPN/100 mℓ)	A	6.1	WLAB021	Operational	≤10	>100000

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-06-13 **Date completed:** 2023-06-23
Project number: 1000 **Report number:** 121369 **Order number:**

Client name: Virtual Consulting **Contact person:** Mr. Pierre Smit
Address: P.O Box 323, Groenkloof, 0027 **e-mail:** pierre@virtualconsulting.co.za
Telephone: 012 452 0444 **Facsimile:** 012 452 0583 **Mobile:** 082 773 2156

Analyses in mg/ℓ (Unless specified otherwise)		UOM %	Method ID	Risk	SANS 241 : 2015 Limits	Sample Identification: Temba WTW Final
Sample Number						23-09887
Date/Time Sampled						N/A
pH - Value @ 25 °C	A	7.7	WLAB065	Operational	≥5 to ≤ 9.7	7.5
Electrical Conductivity in mS/m @ 25°C	A	7.0	WLAB065	Aesthetic	≤170	79.9
Total Dissolved Solids @ 180°C	A	5.6	WLAB003	Aesthetic	≤1200	546
Turbidity in N.T.U	A	7.6	WLAB005	Operational/Aest	≤1 / ≤5	2.6↓
Chloride as Cl	A	8.0	WLAB046	Aesthetic	≤300	66
Sulphate as SO_4	A	8.4	WLAB046	Acute health/Aest	≤500 / ≤250	44
Nitrate as N	A	4.8	WLAB046	Acute health	≤11	3.0
Total Coliform Bacteria (MPN/100 mℓ)	A	6.1	WLAB021	Operational	≤10	<1
E. coli (MPN/100 mℓ)	A	5.0	WLAB021	Acute health	Not detected	<1
Heterotrophic Plate Count (cfu/1 mℓ)	A	4.5	WLAB021	Operational	≤1 000	<10
Free and Saline Ammonia as N	A	10	WLAB046	Aesthetic	≤1.5	10↓

Certificate of Analysis

Client: Pierre Smith
Company: Virtual Consulting Engineers
Address: 57 George Storrar Drive,Groenkloof
Pretoria
0181
Tel No: (012) 452 0444

Cert No: VIRT-2023-06-2
Project No: VIRTUAL_CONSU-20230626

Date Sample Received: 2023/06/26
Certificate Date: 2023/06/30

CHEMICAL ANALYSIS

Date Analysed:		2023/06/26 - 2023/06/29				
Sample Number:		1	2	3	4	5
Sample Name:		Raw (Temba WTW)	Before Chlorination (Temba WTW)	Final (Temba WTW)	Network	Tanker
Sample Date and Time:		2023/06/26	2023/06/26	2023/06/26	2023/06/26	2023/06/26
Lab Number:		2386783	2386785	2386790	2386792	2386794
Sample Description:		Water	Water	Water	Water	Water
Sample Container:		2L sterile plastic bottle	2L sterile plastic bottle	2L sterile plastic bottle	2L sterile plastic bottle	2L sterile plastic bottle
Determinant (units)	Method Number					
Ammonia Nitrogen (mg/L N)	EL26B	16.4	13.1	12.2	11.1	0.3
Chemical Oxygen Demand (mg/L O2)	EL 18	112	79	106	33	18
Filtered Chemical Oxygen Demand (mg/L O2)	EL 18	62*	50*	49*	24*	10*
Nitrate Nitrogen (mg/L N)	EL26E	0.6	3.5	3.5	3.7	0.7
Orthophosphate (mg/L P)	EL26G	2.3	2.0	1.9	1.8	<0.1
Suspended Solids (mg/L @ 105°C)	EL2	10	<10	<10	<10	<10
Total Organic Carbon (mg/L)	EL6	17.3	13.7	11.9	12.1	8.1

Certificate of Analysis

Client: Pierre Smith
Company: Virtual Consulting Engineers
Address: 57 George Storrar Drive,Groenkloof
Pretoria
0181
Tel No: (012) 452 0444

Cert No: VIRT-2023-06-2
Project No: VIRTUAL_CONSU-20230626

Date Sample Received: 2023/06/26
Certificate Date: 2023/06/30

MICROBIOLOGICAL ANALYSIS

Date Analysed:		2023/06/26 - 2023/06/28				
Sample Number:		1	2	3	4	5
Sample Name:		**Raw (Temba WTW)**	**Before Chlorinatio n (Temba WTW)**	**Final (Temba WTW)**	**Network**	**Tanker**
Sample Date and Time:		2023/06/26	2023/06/26	2023/06/26	2023/06/26	2023/06/26
Lab Number:		2386783	2386785	2386790	2386792	2386794
Sample Description:		Water	Water	Water	Water	Water
Sample Container:		250ml sterile plastic bottle	250ml sterile plastic bottle	250ml sterile plastic bottle	250ml sterile plastic bottle	250ml sterile plastic bottle
Determinant (units)	Method Number					
E.coli (MPN/100mL)	EM 9	10800	3600	0	0	0
Heterotrophic Plate Count (cfu/1mL)	EM 3	398000	218000	100	168	1330
Total Coliforms (MPN/100mL)	EM 9	61300	17200	0	0	2

Certificate of Analysis

Client: Pierre Smith
Company: Virtual Consulting Engineers
Address: 57 George Storrar Drive,Groenkloof
Pretoria
0181
Tel No: (012) 452 0444

Cert No: VIRT-2023-06-2
Project No: VIRTUAL_CONSU-20230626

Date Sample Received: 2023/06/26
Certificate Date: 2023/06/30

PCR ANALYSIS

Date Analysed:		2023/06/26 - 2023/06/27				
Sample Number:		1	2	3	4	5
Sample Name:		**Raw (Temba WTW)**	**Before Chlorination (Temba WTW)**	**Final (Temba WTW)**	**Network**	**Tanker**
Sample Date and Time:		2023/06/26	2023/06/26	2023/06/26	2023/06/26	2023/06/26
Lab Number:		2386783	2386785	2386790	2386792	2386794
Sample Description:		Water	Water	Water	Water	Water
Sample Container:		250ml sterile plastic bottle	250ml sterile plastic bottle	250ml sterile plastic bottle	250ml sterile plastic bottle	250ml sterile plastic bottle
Determinant (units)	Method Number					
Salmonella enterica	PCR 1	Negative	Positive	Negative	Negative	Negative
Shigella species and/or Entroinvasive E. coli	PCR 3	Negative	Positive	Negative	Negative	Negative
Toxigenic Vibrio cholerae	PCR 2	Negative	Negative	Negative	Negative	Negative

Certificate of Analysis

Client: Pierre Smith
Company: Virtual Consulting Engineers
Address: 57 George Storrar Drive,Groenkloof
Pretoria
0181
Tel No: (012) 452 0444

Cert No: VIRT-2023-06-2
Project No: VIRTUAL_CONSU-20230626

Date Sample Received: 2023/06/26
Certificate Date: 2023/06/30

TRIHALOMETHANES ANALYSIS

Date Analysed:		2023/06/28				
Sample Number:		1	2	3	4	5
Sample Name:		**Raw (Temba WTW)**	**Before Chlorination (Temba WTW)**	**Final (Temba WTW)**	**Network**	**Tanker**
Sample Date and Time:		2023/06/26	2023/06/26	2023/06/26	2023/06/26	2023/06/26
Lab Number:		2386783	2386785	2386790	2386792	2386794
Sample Description:		Water	Water	Water	Water	Water
Sample Container:		2L sterile plastic bottle	2L sterile plastic bottle	2L sterile plastic bottle	2L sterile plastic bottle	2L sterile plastic bottle
Determinant (units)	Method Number					
Bromodichloromethane (µg/L)	EL 9	<3	<3	<3	<3	20
Bromoform (µg/L)	EL 9	<3	<3	<3	<3	<3
Chloroform (µg/L)	EL 9	<3	<3	5	3	64
Dibromochloromethane (µg/L)	EL 9	<3	<3	<3	<3	3
Total THM (µg/L)	EL 9	<3	<3	5	3	87

Certificate of Analysis

Client: Pierre Smith
Company: Virtual Consulting Engineers
Address: 57 George Storrar Drive,Groenkloof
Pretoria
0181
Tel No: (012) 452 0444

Cert No: VIRT-2023-06-2
Project No: VIRTUAL_CONSU-20230626

Date Sample Received: 2023/06/26
Certificate Date: 2023/06/30

Heterotrophic Plate Count results for sample 2386785 have been estimate.