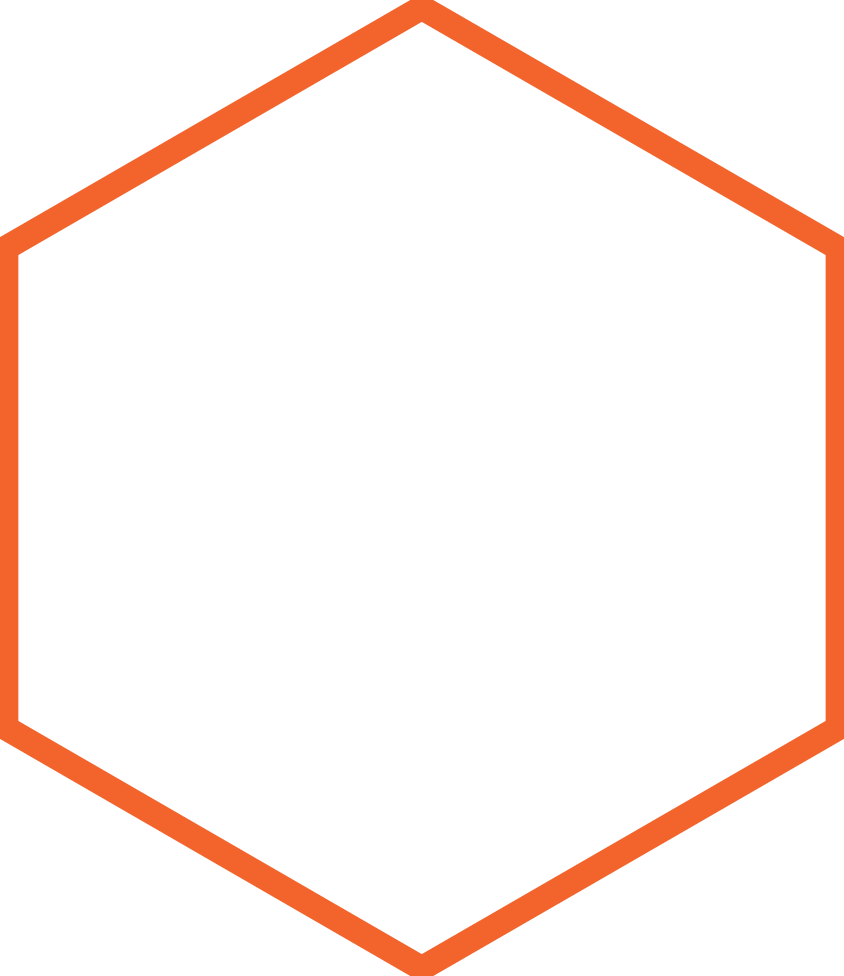
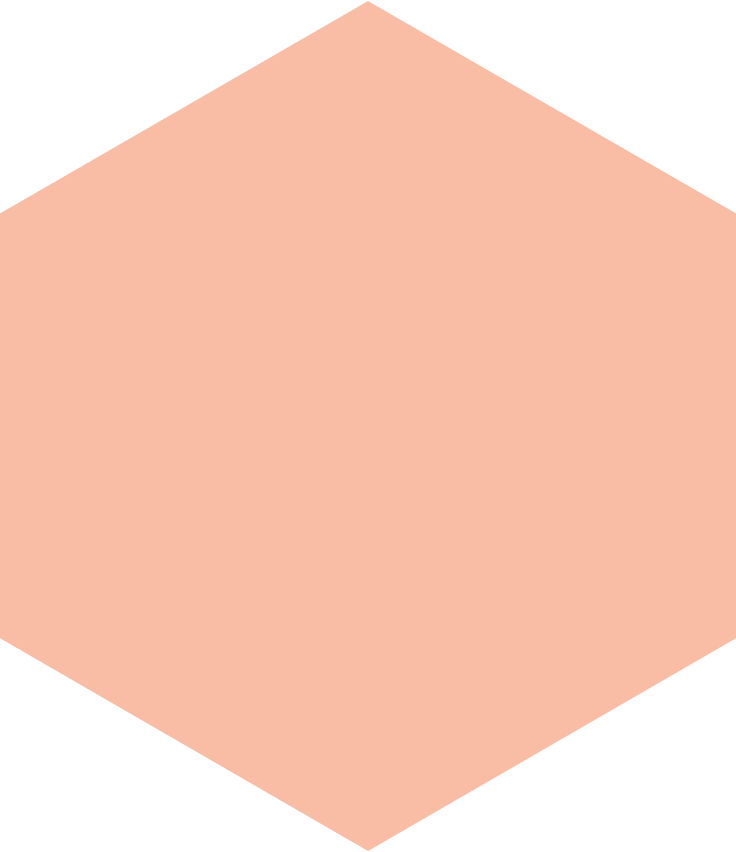
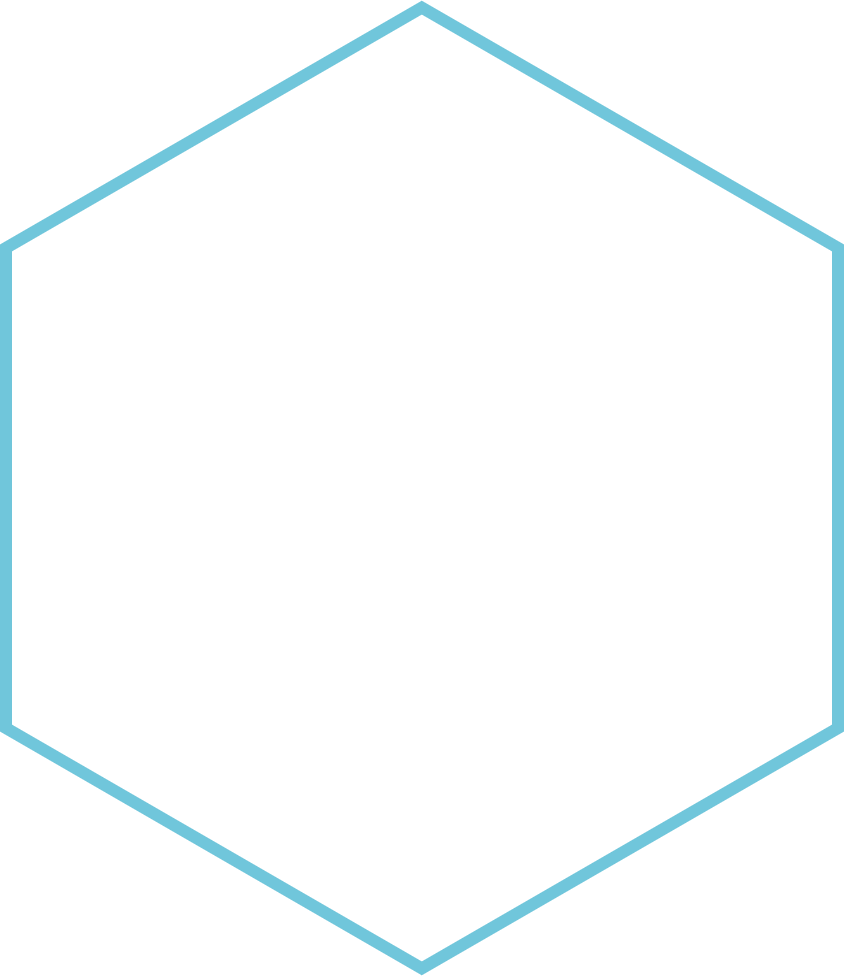
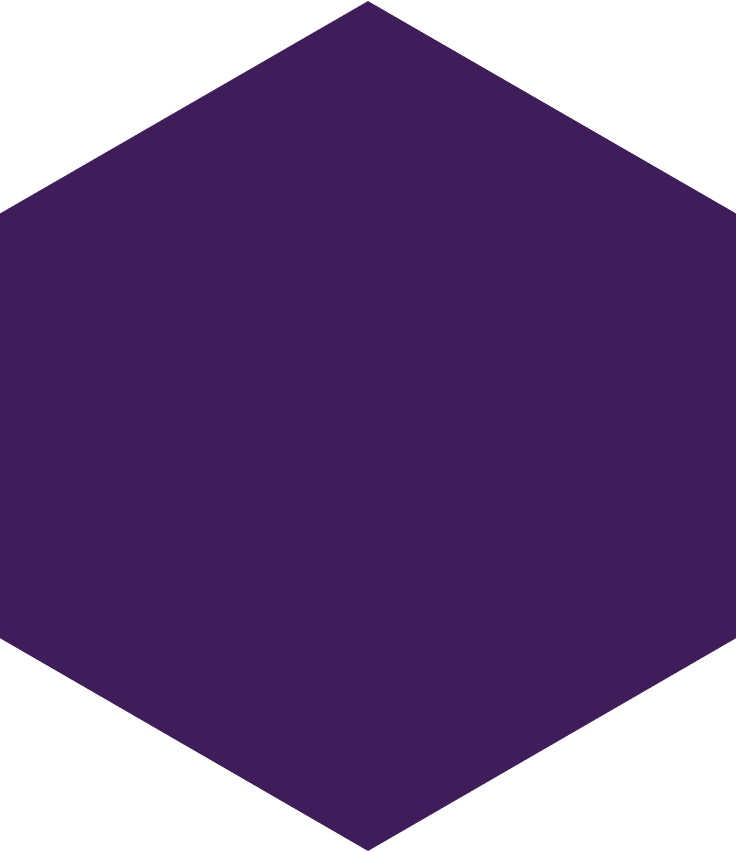
12th July 2019



|  |
| --- |
| [solar powered potable water supply systems] |
| [operations& maintenance manual] |
| [By Mlamuli Myeni – Consulting Engineer – WASH / Irrigation]  For WaterAid Eswatini) |
|  |



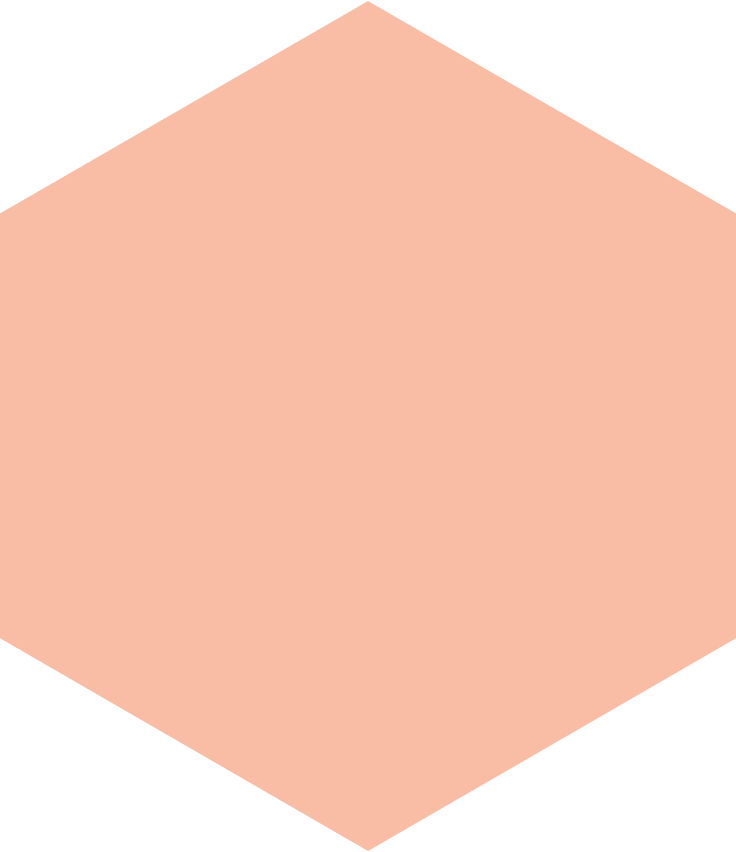
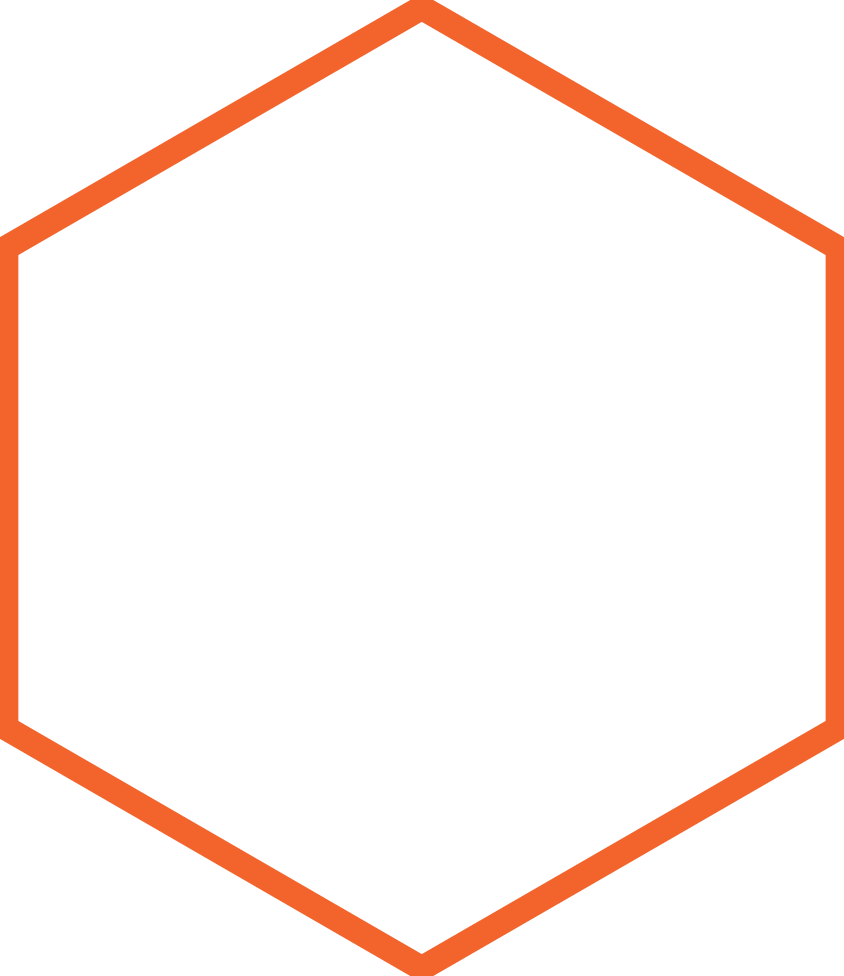
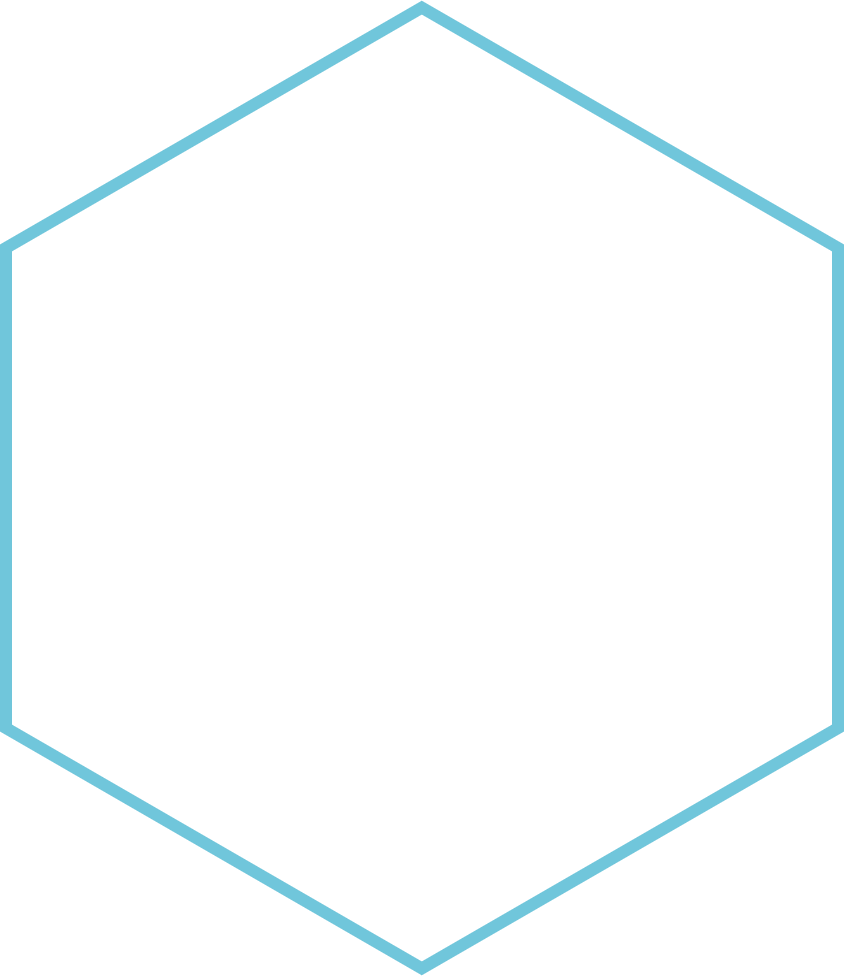


Table of Contents

[List of acronyms 4](#_Toc15895794)

[background 4](#_Toc15895795)

[introduction 5](#_Toc15895796)

[operation 6](#_Toc15895797)

[Main Components for solar powered potable water supply system 7](#_Toc15895798)

[Photovoltaic Solar 7](#_Toc15895799)

[Functions 7](#_Toc15895800)

[INVERTOR/control unit 8](#_Toc15895801)

[functions 8](#_Toc15895802)

[wiring 8](#_Toc15895803)

[Function 8](#_Toc15895804)

[pump 8](#_Toc15895805)

[functions 8](#_Toc15895806)

[pipelines 9](#_Toc15895807)

[functions 9](#_Toc15895808)

[Other Components 9](#_Toc15895809)

[Well probe 9](#_Toc15895810)

[Float switch 9](#_Toc15895811)

[Surge Protector 10](#_Toc15895812)

[Water meter 10](#_Toc15895813)

[Safety Rope 10](#_Toc15895814)

[inspection 10](#_Toc15895815)

[Inspection procedure for key Components 11](#_Toc15895816)

[Solar panels 11](#_Toc15895817)

[Submersible pump 11](#_Toc15895818)

[pipelines and fittings 12](#_Toc15895819)

[Valves 12](#_Toc15895820)

[Storage Tanks 13](#_Toc15895821)

[Inspection checklist 13](#_Toc15895822)

[SUBMERSIBLE BOREHOLE PUMP 13](#_Toc15895823)

[STORAGE TANKS 14](#_Toc15895824)

[pipeline 16](#_Toc15895825)

[Solar array and accessories 17](#_Toc15895826)

[Paperwork 22](#_Toc15895827)

[trouble shooting 22](#_Toc15895828)

[Cause or Symptom 22](#_Toc15895829)

[recommended troubleshooting 23](#_Toc15895830)

[Troubleshooting chart 25](#_Toc15895831)

[repair works 26](#_Toc15895832)

[repair worksheet 29](#_Toc15895833)

[maintenance 30](#_Toc15895834)

[Maintenance procedures 30](#_Toc15895835)

[Equipment manufacturers manual 30](#_Toc15895836)

[wire control kit 31](#_Toc15895837)

[Recommended daily operational duties/preventive maintenance 31](#_Toc15895838)

[Preventive maintenance logbook 32](#_Toc15895839)

[Spare Parts Management 34](#_Toc15895840)

[operators NOTES 37](#_Toc15895841)

[Project composition and layout 37](#_Toc15895842)

[Operators duties 38](#_Toc15895843)

[detailed regular operational duties for water operator 38](#_Toc15895844)

[Controlling nonrevenue water 41](#_Toc15895845)

[Technical losses 41](#_Toc15895846)

[Commercial losses 41](#_Toc15895847)

[Maintenance tools 43](#_Toc15895848)

[Reporting and communication 43](#_Toc15895849)

[Repair manual 44](#_Toc15895850)

[Sample repair works record or report sheet 44](#_Toc15895851)

[remove and replace a water flow meter 45](#_Toc15895852)

[Sample service agreement 46](#_Toc15895853)

[Repair toolkit 50](#_Toc15895854)

[**Table 1: Troubleshooting Table of charts** 25](#_Toc15895781)

[**Table 2: Repair or Replace Choice Table** 27](#_Toc15895782)

[**Table 3: Maintenance Contact List** 30](#_Toc15895783)

[**Table 4: Daily, Monthly and Annual operational Duties on a SPPWSS** 31](#_Toc15895784)

[**Table 5: Preventive maintenance logbook** 33](#_Toc15895785)

[**Table 6: Security assessment** 34](#_Toc15895786)

[**Table 7: Spare material management list** 36](#_Toc15895787)

[**Table 8: Water meter recordings** 39](#_Toc15895788)

[**Table 9: repair toolkit for a water supply system** 50](#_Toc15895789)

# List of acronyms

AC – Alternate Current

DC – Direct Current

DWA – Department of Water Affairs

HDPE – High Density Poly Ethylene

LED – Light Emitting Diode

NCM – Nazarene Compassionate Ministries

NDS – National Development Strategy

NRW – Non-Revenue Water

OEM – Original Equipment Manufacturers

O& M - Operations and Maintenance

PPP – Private Public Partnerships

PV – Photo Voltaic

RWSB – Rural Water Supply Branch

SPPWSS - Solar Powered Potable Water Supply System

uPVC – unPlasticised Poly Vinyl Chloride

# background

The Kingdom of Eswatini government’s National Development Strategy (NDS) and National Water and Sanitation Sector Development Plan and Monitoring Framework both have prioritized community water supply, with the former targeting 100% water and sanitation coverage by 2022. These are also backed by the DWA’s prioritization of ensuring vulnerable and poor communities have access to safe water and sanitation.

The severe lack of infrastructure and poor sustainability of services has contributed to the approximately 40% of rural communities in Eswatini that lack access to clean and safe water. A 2016 report conducted by the DWA indicates that about 25% of rural water infrastructure in Eswatini is non-functional, mainly due to user non-payments that result in a lack of funding for maintenance and repairs. Communities also often lack sufficient skills and knowledge on the maintenance of the installed systems. Due to these challenges, there is a great need to build communities’ capacity to manage and repair systems, thereby improving sustainability of services.

As water resources dry up, women and children walk long distances in search of water for their families. In many cases. These water sources are not protected and can be easily contaminated as communities are still practicing open defecation. This facilitates spread of diseases and amplifies the suffering of communities. Over the 30 months project period, WaterAid and our local partners are addressing WASH needs of 16 000 people, while building local capacity and resiliency.

Under this project, Water AID Eswatini n partnership with NCM Eswatini aims to have conducted these three core activities:

* Constructed and/or rehabilitated nine sustainable water schemes
* Constructed household latrines to improve overall community health
* Developed water supply guidelines and regulations

WaterAid and partners will utilize the private public partnership approach to ensure the sustainability of water scheme management. In each community, private water vendors will operate and manage water schemes, and a project Board comprised of community and government representatives will be established with the responsibility of managing the water vendors and ensuring compliance in service provision. WaterAid will also support overall WASH sector coordination and policy development by working with government and other key stakeholders at the local, regional, and national levels. Overall, sustainability will be ensured by addressing operational challenges and policy limitations by improving institutional frameworks & legislation and engaging local and national governments to influence change.

This project therefore aimed at introducing private–public-partnerships (PPP) in rural water management. This project shall be a pilot for PPP and Facilitated the development of regulations for the Rural Water Supply sector. This pilot will have prepaid systems which will be operated by a private vendor who will be responsible for operations and Maintenance.

# introduction

Sustainability is very crucial in ensuring project longevity. Sustainability traits are not only provided for once the project is complete and has been handed over to the beneficiaries, but from inception when the project is still a blurry and fuzzy idea. Sustainability traits are infused further during design and construction. Such is evident through adherence to recognized construction standards and methodologies, which make it easier to follow and comprehend from a user and client ‘s perspective.

An operation and maintenance manual forms part of the documents that ensure project sustainability. And is a must have document. The end user should treat the Operation and maintenance manual as a “bible” for that particular project. Every detail that may be needed for the sustainability of the project is contained in the Operations And maintenance manual. This manual should be kept safe and used properly, and its contents adhered to.

This manual will provide information on the operation, inspection, troubleshooting, repair and maintenance of Solar Powered Potable Water systems. Post construction the user will be handed over a complete and functional solar powered potable water system, which he/she has to operate and maintain for the boon of the entire populace.

On construction completion just before project handover, the project will take the resemblance of a wrapped gift to the beneficiary/end user. He/She may want an answer(s) to the following question(s) What is it? How does it Work? Is it currently working? What’s wrong with it? How can I fix it? How do I ensure that it keeps working?

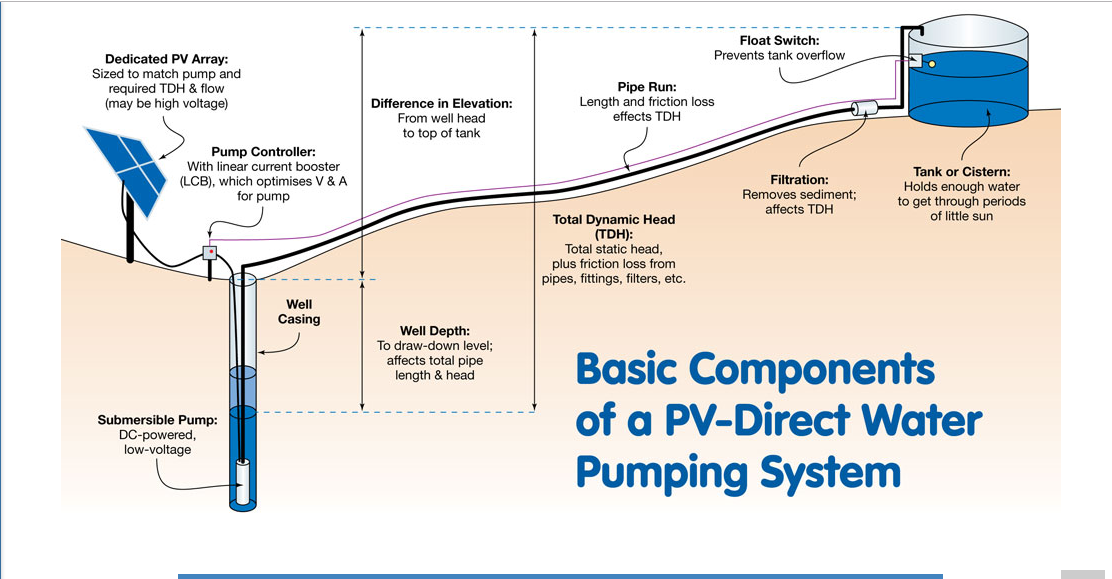
All these questions seek to establish answers to what is this system, how can it be operated, inspected, troubleshot, repaired and maintained.

The manual shall have a straight forward scope and shall cover service issues for the proper and sustainable operation of solar powered potable water supply systems. The flow diagram below shows the scope and chronology of topics that will be discussed.

# operation

The topic discusses the different components of a Solar Powered Potable Water Supply System (SPPWSS) and how it has been configured. This topic specifics will address those of the system constructed at kaBheni Community. The purpose of and operation of individual components will also be discussed, here under and/or in the rest of the manual

Diagram 1: Diagrammatic view of the Solar Powered Water Systems



# Main Components for solar powered potable water supply system

Almost all functional solar powered potable water supply systems should have the following components.

## Photovoltaic Solar

A solar powered system or water supply system is not a solar powered system without solar panels. An array of solar panels is usually erected in close proximity to the water source. All the systems in the three communities have 18 Solar panels erected on a solar Tower.

### Functions

* This is the main component of a solar powered potable water supply system.
* They absorb solar energy from the sun and convert it to Electrical energy.
* they do this by absorbing the suns photons and convert them into energy by the photovoltaic effect.
* The photovoltaic effect is a physical and chemical phenomenon

In a nutshell this is the energy hub of the system. While this is the main component there are other components which are equally important.

## INVERTOR/control unit

The pump invertor controls the speed of motors to suit the design requirements by ensuring that the pump operates within its duty point. The duty point is the combination of the head (pressure and flow rate), it is the parameter in which the pump is allowed or envisaged to operate.

### functions

* When the solar panels convert the solar energy into electrical energy, it is in DC (Direct Current) form. One key function of the invertor is to convert DC electricity to AC electricity. This conversion is important for many electrical devices like water pumps
* In advance systems it can be used as a backup power supply in the event of excess cloud cover, it comes with a Power on Demand Box, which is capable of converting extra DC and store it in 24V batteries.

## wiring

Transfer of energy in an electrical field is by means of wires. In Solar powered systems electrical wires transfer energy from one device to the other.

### Function

* Transfer electrical current through the interconnected devices

## pump

The solar pump is another extremely important component of a solar powered potable water supply system. Without the pump there wouldn’t be water in the system. In this case there is a borehole submersible water pump. Sometimes the pump runs on a DC motor and in that case an invertor is not necessary. If the pump operates on AC, an invertor is needed. The system uses a submersible pump from Grundfos.

### functions

* Draw water from the borehole well and convey it into an elevated storage reservoir/tank
* Convert static energy in water to kinetic energy, by drawing it from a well and conveying it through a pipe and discharge into a reservoir.

## pipelines

This component is used a conduit that conveys water from the source to the storage tanks and from the storage tanks to our water access points. The system uses HDPE pipes for conduits. The minimum class is class 10. This is in adherence to a guideline provided for by the DWA -RWSB.

### functions

* When pressurized they keep the system devoid of air.
* Transfers water from one part to the other within the system, especially to points of user interest.

# Other Components

## Well probe

It is a switch used that can be used to detect the water level within a well. When the water level in the well drops below the level of the well probe, the Controller will stop the pump and indicate source Low LED lighting. It is used as an anti-dry run device; it protects the pump from frying in case of dry well.

## Float switch

A float switch is a type of level sensor, a device used to detect the level of liquid within a tank. The switch may be used to control a pump, as an indicator, an alarm, or to control other devices. One type of float switch uses a mercury switch inside a hinged float. Another common type is a float that raises a rod to actuates a microswitch. One pattern uses a reed switch mounted in a tube; a float, containing a magnet, surrounds the tube and is guided by it. When the float raises the magnet to the reed switch, it closes. Several reeds can be mounted in the tube for different level indications by one assembly

*The picture below shows an example of a float switch*



## Surge Protector

is an appliance or device designed to protect electrical devices from voltage spikes

## Water meter

A device that measures the amount of water that passes through a certain point per unit time. The amount of water used by the beneficiaries will be measured by this device. It will be read off by the water attendant, and use the readings to determine the bill to be paid in the case of private connections. When fitted in the pump house, this device will measure the amount of water drawn from the borehole well. It may not necessarily translate to water used, as some may be lost in transmission due to leakages.

## Safety Rope

A safety rope is a high strength rope, made of either nylon or stainless steel, which is used to safely secure the pump in the well, should the pipe dislodge from the fittings. The safety rope should be strong enough to pull out the pipe, pump full of water.

# inspection

Every system regardless of type, must be inspected periodically. It is an important aspect for good operation of the system. System inspection should be conducted at least once a year depending on the size and intricacies of the system. Planned inspection prompt timely maintenance, and in some cases inspection and maintenance can be carried simultaneously especially when the inspectors also double up as maintainers. It also highly recommended that the inspectors also triple as repairmen of the system.

# Inspection procedure for key Components

## Solar panels

* ***Check the solar panels for dirt and cracks***,
  + dirt accumulates on the solar panels over time, as they are exposed to the environment. Cracks may be due to vandalism or heavy hailstorm.
  + If there are cracks on the panels, one should consider replacing those panels
  + Dirt can be cleaned off the surface using clean water and cloth, Soap should not be applied.
* ***Electrical cables*** 
  + Check to see if all electrical cables are still intact, loose cables should be tightened up.
* ***Tilt Angle***
  + In fixed solar array this may not be necessary, unless there is suspicion of tilt on angle if inclination. This should be corrected, to avoid dust accumulation of flatter inclines, and reduced solar absorption on steeper inclines.

## Submersible pump

The installation of a new pump brings with it the expectation that it will operate consistently. More often that that is the true case, but operators find it rather hard to draw the line.

Most operators are content with starting a pump and observing it run, like that is enough to see that the pump is operational. It is very vital to inspect the pump immediately on start-up, and also do frequent inspections on it. Inspections assist in picking up faults early, when they occur before they become catastrophic.

Routine preventive maintenance inspections can help address possible issues before they become major (or even catastrophic) events.

In most cases, three major components should be inspected in submersible pumps.

* Alarm monitoring
* Pressure Flow checks
* Visual Inspection
  + Inspect for clogging debris on suction inlet
  + Check pump exterior for dents, corrosion and abrasion

## pipelines and fittings

The inspection procedure outlined here, is a visual inspection. The procedure includes all fittings and accessories associated with pipelines.

* Identify the pipeline section to be inspected and note it down on the checklist book.
* Inspect the pipeline for labels, if any are visible on exposed sections.
* Inspect the pipelines for leaks, if leaks are spotted repair should ensue
* Inspect backfilling on pipelines
* Check or inspect pipe lines for erosion after events of rainfall
* Inspect pipe supports, for loose brackets, pipe support if they are still intact.
* Inspect pipeline for vibrations, if excessive schedule for attendance
* Inspect pipe insulation against corrosion, pipes especially steel pipes usually corrode when they leak.

## Valves

These are classified as part of system appurtenances. They are used to isolate certain sections of the system, from the rest. Isolation is usually done when there is ongoing maintenance in one section, where water flow is not required at the time.

* ***Leaks***
  + Valves should be inspected for leaks, that is if they are still water tight, leaks on valves should be attended to, to curb prolonged leakages on the system.
* ***Blockages***
  + Debris collection in the system may cause valves to let water through even though they are shut. All debris should be cleaned off valves, especially gate valves.
  + Grit collection also affects operation of gate valves, hence they should be stripped during preventive maintenance and cleaned off.
* ***Corrosion***
  + Inspect valve threads for signs of corrosion, all corrosion when spotted should be attended.

## Storage Tanks

* ***Tank***
  + Inspect for leak on the tanks, if leaks are spotted schedule for repairs
  + Inspect leaks on pipes and fittings connecting to tank/reservoir
  + Check for accumulation of algae inside tank, and schedule for cleaning if spotted
* ***Valves and Fittings***
  + Inspect for leaks and breakages on valves. consider changing valves or repairing them leaks are spotted.
  + Inspect for dirt collection inside valve chambers, and clean overgrowth of grass in chambers.
* ***Float Valves***
  + Inspect float valves for function, adjust float valves accordingly

# Inspection checklist

## SUBMERSIBLE BOREHOLE PUMP

* Check electrical condition of insulation on power cable(s) and on all phases of the motor.
* Check for any loose or faulty electrical connections within the control panel.
* Measure resistance between stator windings (in ohms).
* Check voltage supply between all phases of the electrical control panel.
* Check voltage balance between all phases on the load side of the pump / mixer control panel with pump / mixer running (vac).
* Check amperage draw on all phases of the motor (in amps).
* Check condition and operation of the motor thermal protection control system (if equipped).
* Remove pump / mixer from the lift station for physical inspection.
* Check condition of upper and lower shaft seals (inspect condition of motor / stator housing, if applicable).
* Check condition and operation of leakage and bearing sensors (if equipped).
* Check for worn or loose impeller or propeller.
* Check impeller wear rings (rotating & stationary)
* Check for any unusual noise in the upper and lower bearings.
* Clean, reset and check operation of the level control system (if equipped).
* Check for physical damage of power and control cables.
* Check for correct shaft rotation.
* Check operation of valves and associated equipment.

## STORAGE TANKS

The table below presents a checklist of item that ought to be inspected in a reservoir, a Yes or No answer should be given after an inspection and jotted down against that item. A comment usually sheds more light on the inspection findings.



## pipeline



## Solar array and accessories











## Paperwork

In all inspections the importance of paperwork and record keeping cannot be over emphasized. It is prudent upon every inspector to keep and maintain a good record of the system, as this will form a major part of maintenance decision making.

|  |  |  |  |
| --- | --- | --- | --- |
| Status | | Item | |
| Available | **Not Available** | Description | Comments |
|  |  | Operation and maintenance manual for system on site or available |  |
|  |  | Service record for system on site or available |  |
|  |  | Flow diagram and sequence of operation on site or available |  |
|  |  | Photographs taken and placed in service record |  |
|  |  | This inspection record filed in service record |  |

# trouble shooting

This section of the manual contains information that may be used to determine what is wrong with a solar powered water supply system. Troubleshooting chart will be discussed in this section. Troubleshooting techniques will also be explored.

Troubleshooting a Solar Powered Water Supply System should involve more than looking for an obvious problem, or replacing components at random in an attempt to get the system working again. This is particularly true of Solar Powered Water Supply System. What is required is a systematic procedure that carefully “troubleshoots” the system until the problem is located and repaired

## Cause or Symptom

What may appear to be the cause of a problem may actually be a symptom of another problem. For example, if a pump is not pumping water you can replace a pump while the problem is the electric cable that supplies current and voltage to the pump.

Replacing the pump, will not solve the problem but wasting money and time for a simple problem. Never assume that a system is completely without faults after correcting a problem. Spend a few more minutes observing and inspecting the system. This will save time doing a return job. Or even a bigger job caused by an escalated problem which could have been spotted on the first visit.

## recommended troubleshooting

Good troubleshooters follow the below listed steps or a variation of them. The steps include

* Planning
  + Planning takes off with brainstorming the possible causes of the problem.
  + This includes the tools and materials used to diagnose the fault.
  + It also includes the resource to be allocated for finding and fixing the fault, such as money, time and Labour.
* Cause /Source Finding
  + This is the investigation /diagnosis phase
  + Start with checks that will have low impact on the system
  + Proceed in a systematic, organized and logical manner
  + Isolate the results of testing to the component being tested
  + Sometimes the only way to determine if a component is working properly or not is to replace it and see what happens. Remember that this may fix the symptom but it can fail to turn up the real cause of a problem.
* Repairing
  + Repairs can be made on a “band-aid” basis, doing as little as possible to get the system running again.
  + Another approach is to replace major portions of the system to be absolutely certain the problem is gone.
  + The correct approach is to determine what the real cause of a problem is, and make repairs that solve that problem so it does not happen again. Whether to repair or replace defective components depends on the cost and availability of the component.
  + Generally, the more expensive and difficult it is to obtain something, the more appropriate the repair of the component.
  + If the part is cheap and readily available, it generally will be replaced.
  + If repairs can be made to the defective component, it can become the new replacement the next time this same component fails in this or other systems.
* Testing
  + After the cause of a problem has been identified and corrected, inspect and test the entire system.
  + This confirms that the new components are working, and that no other problems exist.
  + The defective components should be tested as well. The best time is usually before rebuilding. As an example, if a control works fine on a test bench, but not at all at the site, a problem exists at the site that will not let the new control work there either.
  + If the part is truly defective, look for the reason it failed. For example, did the pump control unit get wet? Will the new control unit also get wet and fail?
* Recording
  + The last part of troubleshooting is record-keeping.
  + Maintenance and repair records are kept to maintain a history of each system.
  + Troubleshooting records should be part of that written history. In addition, writing down the troubleshooting process preserves that information for the person who found the problem.

## Troubleshooting chart

**Table 1: Troubleshooting Table of charts**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Item | Problem(s) | Symptom(s) | Cause(s) | Action(s) | Comments |
| Solar Tower and Accessories | * Performance decline in Solar powered system * Low water pressure | * Solar not producing initial Power * Reduced flow rate in transmission | * Loose wiring * Dirty or damaged solar panels * System overheating | * Replace terminals and attend to lose wiring * Clean solar panels and replaced damaged panels * Check heat fade |  |
| Pipeline | leakages | * Water seeping out from the pipe * Soil showing wetness | * Broken pipe * Broken valve | * Replace pipe * Replace valve |  |
| Storage Tank | leakages | Water flowing through plastic tank sides | Broken tank | Fix or replace tank |  |
|  |  |  |  |  |  |
| Submersible Borehole Pump | Pump not working | Pump will not start | * Blown fuses * Fried breakers * disconnected splice connection * Motor fried   Pump not turning | * Replace fuses * Replace breakers * Install new splice * Replace motor/fix motor   Fix pump |  |
|  |  |  |  |  |  |
| Valves | Leakages | Water seeping out of valve | * Broken valve   Loose fitting | * Replace valve   Tighten valve |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

# repair works

This section includes information on the repair or replacement of solar powered potable water supply system components. The first section lists common components and whether to repair or replace them. Then, specific procedures for particular components are described. The section ends with a sample repair record sheet.

During repair works we normally ask questions of whether to repair or replace. Some components, such as Solar Panels, can never be repaired, and must be replaced. Others, such as mounting racks and supporting steels, are usually repaired rather than replaced. However, most components can be repaired or replaced. In general, the decision to repair or replace is based on:

* availability of replacement parts
* lead time for replacement parts
* cost of replacement parts
* difficulty of repair

**Table 2: Repair or Replace Choice Table**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Component | Repair | Replace | Rationale | Comments |
| Solar Panels |  | x | For optimum performance and warranty coverage damaged solar panels ought to be replaced | It is important to replace panels with similar new panels. |
| Solar Tower | X |  | Normally this is fabricated, and repair works are sufficient when defects are spotted. | Re weld broken welds and prime or paint with oil-based pain to prolong life of the weld. |
| Wiring |  | X | Worn out wires should be replaced to avoid short circuiting | Wiring and splicing kits should be replaced. |
| Invertor | X | X | If invertor has suffered minor damaged it can be fixed, but If major it should be replaced. Adhere to warranty provisions | The invertor has a shorter life than the Solar Panels. So, at some point it will have to be replaced |
| Motor | X |  | Motors should either be repaired or replaced depending on gravity of damage, attempting to fix it should be first priority. |  |
| Pumps | X | X | If pumps are broken, they can be fixed, but if they dropped into the well and can’t be fished out, they should be replaced |  |
| Pipelines | X |  | Broken sections should be repaired, depending on the nature of the damage, and type of pipe, sometimes the pipelines can be repaired by replacing a number of lengths |  |
| Valves | X | X | Repair when leaking, and replace when broken and can’t be repaired. |  |
| Pump Control Unit | X | X | If components are faulty the unit can be repaired, if the fault is major like a lightning strike, the whole unit ought to be replaced |  |

## repair worksheet



# maintenance

This is the most important section; it answers the question of how can the system be kept working. To the layman it is perceived as the only section that ought to be given attention and disregard all the other sections. It cannot be overemphasized how important preventive maintenance can be. It involves a great deal of proactiveness. every system ought to have a regular maintenance schedule that is appraisable.

Some information on minor repairs is given; however, if major repairs are necessary, use Chapter 5, Repair. If a system has not been maintained, or has not been operational for some time, we suggest you perform a system inspection, using Chapter 3, and make necessary repairs, using Chapter 5, before starting a regular schedule of maintenance.

## Maintenance procedures

Preventative Maintenance activities are the core element of the maintenance services to a Reticulated solar powered potable water supply system. It comprises regular visual and physical inspections, as well as verification activities with a specific task periodicity of all key components which are necessary to comply with the operating manuals and recommendations issued by the Original Equipment Manufacturers (OEMs). It must also maintain the equipment and component warranties in place and reduce the probability of failure or degradation. This maintenance will be carried out at predetermined intervals or according to prescribed OEM manuals. These are included in a detailed Annual Maintenance Plan which provides an established time schedule with a specific number of iterations for carrying out the maintenance.

The tables below are some of the tools that will be used.

**Table 3: Maintenance Contact List**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company | Artisan Name | Position/Trade | Telephone | Cellphone | email |
| Sivene Pumps & Irrigation | Mduduzi Vilakati | Plumber | 25373024 | 76031512 | sivenepumps@gmail.com |
| Sicelo Zulu | Plumber | 25373024 | 76241637 | sivenepumps@gmail.com |
| Richard Tsabedze | Builder | 25373024 | 76035903 | sivenepumps@gmail.com |

The maintenance contact list (Table 4) is easy to use at local level as it only outlines contacts of responsible maintenance team. As such it can be used by the water system committee for further details of maintenance appendix B provides supplies of equipment of the system.

## Equipment manufacturers manual

The equipment manufacturers manuals shall and will be attached in this section. The manuals should be used by the operations/maintenance team as reference. Preventive maintenance can be scheduled periodically from weekly to monthly and annually. The tables below outline the steps to be taken and tools used in performing preventive maintenance exercises.

### wire control kit

## Recommended daily operational duties/preventive maintenance

Based on the layout and operation of the system, several parameters for inspection and action were developed and set to respond to routine challenges of the system. Some of these actions to be performed can be categorized to daily, weekly, monthly and annually:

The weekly preventive maintenance has been skipped because it is similar to the daily tasks

**Table 4: Daily, Monthly and Annual operational Duties on a SPPWSS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Schedule | Component | Action Items | Status | Date | Comments |
| DAILY | Water Transmission | * Record water meter readings * Calculate daily volume/production |  |  |  |
| Pump Station | * Inspect pump operation * Inspect pump control unit |  |  |  |
| Storage Tanks | * Check and record tank water levels * Inspect tank for leaks |  |  |  |
| Security | * Conduct and complete a daily security inspection * Investigate and attend to customer complaints * Inspection for evidence of vandalism on the property * Inspect fence enclosure and gates |  |  |  |
| MONTHLY | cleaning | * Clean solar panels array * Flush water system |  |  |  |
| security | * Check all system alarms for proper operation * Check for loose cable connections on solar array. * Check all air valves on system * Check entire system for leaks |  |  |  |
| Quality inspection | * Take all water samples for testing * Check and record all monthly water production * Check monthly reports * Inspect and maintain entire system. |  |  |  |
| valves | * Maintain valves for leaks or when spotted |  |  |  |

## Preventive maintenance logbook

All maintenance activities should be written down on a maintenance log book or log sheet. The logbook below should be used to keep records of the maintenance on the system.

**Table 5: Preventive maintenance logbook**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Category | Action to be done | Frequency | Last service (Date) | This service (Date) | Preventive maintenance procedure |
| Solar Panel Array | Clean solar panel array | Monthly |  |  | Use pressurized spray washer to clean solar panels |
| Inspect solar panel array | Weekly |  |  | Walk around solar tower |
| Inspect electric wire cable connection | Monthly |  |  | Check cables by touching and feeling for loose connections and damages |
| Inspect structural Integrity of tower | Monthly |  |  | Look for structural damage to tower, check for corrosion/oxidation. Remove rust with wire brush and paint off tower to coat against rust |
| Inspect invertor and control unit | Weekly |  |  | Read fault lights on invertor if any. |
| Water Access Tap | Inspect water access point for leaks | Monthly |  |  | Observe leaks on access point, they should be visible with the naked eye. Use hemp and the correct tolls to fix leaks on threaded fittings. |
| Check and remove mud around access point | Monthly |  |  | Use a digging spade and wheel barrow to clean off mud. |
| Remove rubbish around access point | Monthly |  |  | Take rubbish on the wheel barrow |
| Storage Tank | Inspect tanks for sanitary conditions | Monthly |  |  | Disinfect tanks with chlorine if need be, adhere to correct dosages of chlorine |
| Inspect air vents and inlets for damage | Monthly |  |  | Remove cobwebs on air vents |
| Check security of fittings on tank | Monthly |  |  | Secure lids on tanks to avoid, microbes encroachment |
| Clean tanks | Half yearly |  |  | Clean and disinfect with chlorine |
| Pipeline | Check and maintain all valves | Annually |  |  |  |
| Flush dead ends at scour valves and valleys | Tri -Monthly |  |  | Scour off debris within system by open scour valves |
| Repair non-working valves | Annually |  |  | Repair or replace now working valves with new approved valves |
| De corrode corroded valves | annually |  |  | Use wire brush to de-corrode and prime off threads on valves |

Ensuring security of the system may require conducting an assessment of the security within the system. The table below can be used to do an assessment check.

**Table 6: Security assessment**

|  |  |  |
| --- | --- | --- |
| Item No: | Activity description | Yes /No |
| 1.0 | Are all critical facilities fenced, including control houses, solar panel tower, and are gates locked when appropriate? |  |
| 2.0 | Are warning signs erected/non tampering signs |  |
| 3.0 | Do you have a neighborhood watch program for your water system? |  |
| 4.0 | Are your wellheads sealed properly? |  |
| 5.0 | Are well vents and caps screened and securely attached? |  |
| 6.0 | Are observation, test, and abandoned wells properly secured to prevent tampering? |  |
| 7.0 | Is your surface water source secured with fences or gates? |  |
| 8.0 | Do water system personnel visit the source? |  |
| 9.0 | Are tank ladders, access hatches, and entry points secured? |  |
| 10.0 | Are vents and overflow pipes properly protected with screens and/or grates? |  |

## Spare Parts Management

Spare Parts Management is an inherent and substantial part of O&M. it shall be used throughout the lifespan of the system. The table below is the tool that will be used to record available spares for the system by the maintenance team. From the water sales 10 percent of the revenue generated from the system shall be kept as a reserve to purchase the spare parts. The major components like PUMPS, Solar Panel array, Solar Controller, Water meter can be insured for damage and vandalism and it elaborated in the risk management under management guidelines.

**Table 7: Spare material management list**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Item No: | Spare Material | Sub Description | In Stock | Utilized | Remaining/Balance | Comments |
| 1.0 | Pipes -HDPE | 75mm HDPE class 10 |  |  |  |  |
|  |  | 63mm HDPE class 10 |  |  |  |  |
|  |  | 50mm HDPE Class 10 |  |  |  |  |
|  |  | 40mm HDPE class 10 |  |  |  |  |
|  |  | 32mm HDPE class 10 |  |  |  |  |
| 2.0 | Fittings (Couplings) | 75mm |  |  |  |  |
|  |  | 63mm |  |  |  |  |
|  |  | 50mm |  |  |  |  |
|  |  | 40mm |  |  |  |  |
|  |  | 32mm |  |  |  |  |
| 3.0 | Adaptors | 75mm |  |  |  |  |
|  |  | 63mm |  |  |  |  |
|  |  | 50mm |  |  |  |  |
|  |  | 40mm |  |  |  |  |
|  |  | 32mm |  |  |  |  |
| 4.0 | Reducers | 75mm x 63mm |  |  |  |  |
|  |  | 63mm x 50mm |  |  |  |  |
|  |  | 50mm x 40mm |  |  |  |  |
|  |  | 40mm x 32mm |  |  |  |  |
| 5.0 | Bends | 75mm |  |  |  |  |
|  |  | 63mm |  |  |  |  |
|  |  | 50mm |  |  |  |  |
|  |  | 40mm |  |  |  |  |
|  |  | 32mm |  |  |  |  |
| 6.0 | Solar Panels | Poly crystalline 320 Watts Grundfos |  |  |  |  |
|  |  |  |  |  |  |  |
| 7.0 | Solar Controller |  |  |  |  |  |
| 8.0 | Pump | Grundfos Submersible pump |  |  |  |  |
| 9.0 | Water Meter | Kent Water meter |  |  |  |  |
| 10.0 | Isolation Valves | Cobra gate valves |  |  |  |  |
|  |  | 80mm |  |  |  |  |
|  |  | 65mm |  |  |  |  |
|  |  | 50mm |  |  |  |  |
|  |  | 40mm |  |  |  |  |
| 11.0 | Air valves |  |  |  |  |  |

# operators NOTES

This section of the manual is intended for the use of the PROJECT (Water System Operator) who is in charge of operating the potable water supply project to guide them through the tasks of Operator. It gives explanation of the facility structure, and then explains the tasks of the operators, and things to bear in mind when operating facilities. It also provides in part trouble shooting information.

## Project composition and layout

This project consists of a borehole well as a water source, solar panel array as an energy source, transmission pipeline, storage tanks, distribution pipeline, water access points, valves and air release valves. In this project water is pumped from the borehole by a submersible pump, transmitted into the storage tanks. From the storage tanks it then gravitates to the water access points/station. The customer will access water at the water access points

**Figure 1: KaBheni Solar Powered Potable Water Supply System**

**Figure 2: Njojane 1 Solar Powered Potable Water Supply System**

**Figure 3: Siweni 1 Solar Powered Potable Water Supply System**

## Operators duties

The operator is the key person in the operation of the system. He has important roles that he/she has t execute on a daily basis. The roles encompass the following

* Operate the system properly or as designed
* Patrol and inspect system daily and weekly
* To write the operation records, this consists of operation data etc.
* To correspond with the Business manager
* Be a link between the customers and the business manager
* Collect and collate issues from the customers

The sustainability of the system hinges mainly on the management aptitude of the operator. The operator is expected to safeguard the system and keep all records of the system operation.

### detailed regular operational duties for water operator

#### Solar Panel Array

* Inspect cable wiring interconnecting solar panels
* Inspect invertor
* Inspect dirt /dust accumulation on solar panels
* Inspect structural integrity of solar panels tower

#### Water Control Unit and pump

* Check control unit for fault reporting
* Observe sound and performance of submersible pump
* Inspect pump for leaks
* Observe water meter and record readings off it.

**Table 8: Water meter recordings**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Operators Name & Surname | Meter Readings of different Sections of the water System | | | | | | | | | | | |  | Time | | |
|  |  | | | | | | | | | | | |  |  | | |
| Date | Bulk Water Meter Reading (litres) | | Water Access Point 1 | | Water Access Point 2 | | Water Access Point 3 | | Water Access Point 4 | | Water Access Point 5 | | Balance on Storage | Start | Stop | |
| Open | Close | Open | Close | Open | Close | Open | Close | Open | Close | Open | Close |  |  |  |
| *31/05/19* | *0* | *43200* | *0* | *8000* | *0* | *8000* | *0* | *8000* | *0* | *8000* | *0* | *8000* | *3200* | *0600* | *0800* |
| *01/06/2019* | *43200* | *86400* | *8000* | *16000* | *8000* | *16000* | *8000* | *16000* | *8000* | *16000* | *8000* | *16000* | *6400* | *0600* | *1800* |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

#### Transmission Pipeline

* Inspect pipe for leaks
* Inspect trench for erosion
* Inspect pipe for tapering or vandalism

#### Storage Tanks

* Inspect tank for leaks
* Inspect tanks for vandalism
  + Ensure scour and bypass valves are fully shut
  + Ensure outlet and inlet valves are fully open
  + Clean manholes/inspection chambers if clogged with debris or rubbish
  + Ensure all valves are in their correct operational positions
  + Clean tank half yearly or if the need arises

#### Kiosks Station

* Inspect surroundings for security breaches
* Inspect fence enclosure
* Inspect gates for tampering and vandalism
* Check kiosk structure for defects and signs of vandalism
* Check plumbing on kiosk structure for leaks
* Clean kiosk house and toilets
* Inspect toilets/latrines for cleanliness and check air vents for breakages

#### Water Access points

* Inspect fence enclosure for tampering and vandalism
* Inspect water access points for leaks
* Inspect soak pits for clogging
* Check gates and padlocks for security breaches
* Check if access point/tap is in good operation condition
* Surroundings should be kept clean

#### Distribution Pipeline

* Inspect pipeline for leaks, is there any damage to the pipes
* Inspect pipeline for erosion and pipe exposure
* Inspect pipeline for vandalism, illegal tapping

#### valves

* Inspect valves for corrosion and leaks, record and report leaking valves to maintenance team

## Controlling nonrevenue water

By definition this is the difference between the amount of water produced and measured and the amount of revenue collected for produced water. Non-Revenue Water (NRW) can be categorized into Physical/technical and Commercial losses. A combination of the two makes up non-revenue water. Technical losses are mainly due to leaks in the water supply system and commercial losses are mainly due to incorrect billing, especially underbilling.

### Technical losses

The causes of technical losses may be due to

* Installation/use of substandard materials in the system
* Loose pipe fittings
* Shallow trench excavation
* Poor workmanship on construction and maintenance of system (infrequent maintenance or lack of technical skills)
* Aging system
* Human influence on the system

### Commercial losses

Commercial losses are mainly caused by

* Illegal tapings
* Inaccurate or broken meters
* faulty meter readings recording
* Incorrect billing

Teamwork between the accountant and meter reader is vital to be able to establish non-revenue water and the cause of it. If a water access point shows changes in the amount of water it discharges, it may be due to blockages in the system or illegal tapping or even another fault may be on the meter itself.

The first step towards managing NRW is to have a functioning metering system; this means that the production point and all water access points have working meters. The following data must be collected in order to calculate NRW:

* The amount of water produced (recorded by a bulk meter);
* The amount of water distributed in each particular water access point

The difference between the collective water access points readings (metered consumption) and the bulk meter reading (production) will show you the amount of water that is ‘lost’

Example Given (e.g.)

Statement

For kaBheni, the borehole submersible pump abstracts water at a rate of 1.5 liters per second and continues pumping for 8hrs. the water is then distributed to six water access points or stations. Each of these stations draws about 9000 liters of water per day. Determine the amount of water

* Produced per month
  + Given that 1m³ = 1000l
  + 1.5 l/s x 3600s/hr. x 8hr/day x 30days/month

= 1 296 000 liters = 1296m³

* Consumed/drawn per month
  + 8000 l/day x 30days/month x 5 Water Access Points

= 240 000 liters x 5 = 1 200 000= 1200m³

* NRW per month
  + 1296m³ - 1200m³ = 96m³
* The ratio of NRW per month
  + 96m³/1296m³ = 0.074 = 7.4%

This translates to 7.4% of NRW per month or water lost.

Reducing water losses can be achieved by regular inspections on the water network. Such an exercise is normally done to

* Detect leakages.
* Identify illegal collections.
* Identify unacceptable human activities around network infrastructures.

While it is the plumbers/operators’ duty to carry out network inspections regularly, the customers can play a responsible role in reporting leaks, illegal collections and other inappropriate or illegal behaviour (such as vandalism). Reports can be made to the business man. The Business man must act fast after reports have been filed to ensure that action is taken against water thieves and leaks are plugged within a reasonable time. If action is taken slowly or if anonymity is not respected, the customers may lose confidence and trust in the Water Business Man.

The following three tasks may help the plumber/operator/treasurer to identify sources of NRW:

* Walking around and inspect the network on a regular basis to identify any problems.
* Establishing regular check-points on junctions and areas with frequent problems and checking these regularly.
* Establishing good relationships with customers so they will provide tips on leaks and water theft.

## Maintenance tools

Maintenance tools should be kept inside the kiosk house and locked. A tool inventory should be conducted every month to establish the condition of the tools and also establish any lost tools. The plumbers should pay for lost tools. The tools should be used in maintaining the water project and should not be used for any other work outside the project. This practice prolongs the tool lifespan. Generally, tools should be used for the job they were designed for, wrong tools should not be used for any job.

## Reporting and communication

Reports are major sources of the information. In implementing the projects, reports are pre-requisite in order to know the implementation status and make a rational decision timely if the need arises. Operator needs to record Operational status of the system daily. The data will form a part of the project O&M monthly report. When faults are detected, it should be communicated to the Business Man immediately. The Business man then coordinates repair work, depending on the type of repair required.

The steps below outline the communication chronology in the project

* The water customers or water operator discover or notice a breakdown in the water supply system
* They notify the business man swiftly
* The water operator request for a repair on the system
* The water operator notifies the businessman of the parts that are required to repair the breakdown
* The business man avails funds for fixing the breakdown
* The business man procures the materials needed to attend to the breakdown.
* The business man provides spare parts to the plumber to expedite repairs.
* The plumber then expedites works on the repairs
* The plumber then prepares and submits a repair report to the business man
* The Business man avails money and pays the plumber for the repairs
* The system is back to operation again

# Repair manual

In this section of the O&M manual discussion will be based on repair procedures for certain components of the water system.

## Sample repair works record or report sheet

Under this topic there is a sample of a record sheet on any repair works that ought to be done on the system. It is very important to know the name of the technical person who attended to the fault. Date on which the fault was attended. The location of the repair is also important in order for the operators to pick up trends if any, on fault re occurrences.

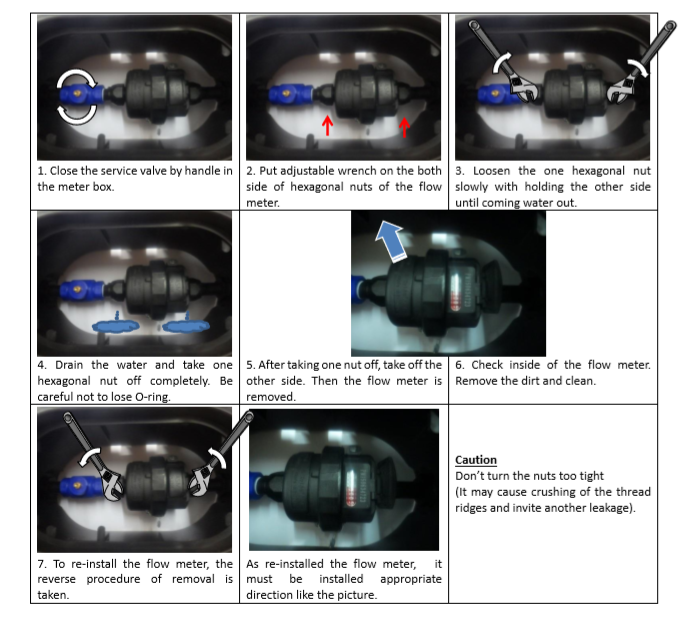
|  |  |
| --- | --- |
| Name…………………………………………………………. | Name of Project…………………………………………………. |
| Surname…………………………………………………. | **Name of Section…**……………………………… |

|  |  |  |  |
| --- | --- | --- | --- |
| ITEM: | DATES (dd/mm/yyyy) | | |
| Date of Breakdown  ………………………………….. | Date Reported  ………………………………….. | Repair works Executed  …………………………………. |
| **ISSUES** | | |
| Specific issues with the item  …………………………………………  ……………………………………….. | Cause (s) of the issues  ………………………………….  …………………………………. | |
| **REPAIRS** | | |
| What kind of repair works have been done on this system?  …………………………………………. | | |
| **SUMMARY** | | |
| Is the system functional again |  |  |
| **FINANCES** | | |
| How Much was paid for the service and recorded | Labour Only E………………………………………….  In words………………………………………………………………. | |
|  |  |  | |
|  |  |  | |
|  |  |  | |
|  |  |  | |
|  |  |  | |
|  |  |  | |
|  |  |  | |
|  |  |  | |

## remove and replace a water flow meter

Once in a while the operator may experience a water no flow in the standpipe. This may be due to blockages. Sometimes there may be leakages on the meter and a need to fix them shall arise. The procedure outlines the steps that ought to be taken in fixing a leak in a water meter.

|  |  |
| --- | --- |
| Facility: Public Access Point | Purpose of the task |
| Task: Cleaning the Flow meter |  |
| Frequency of Task |  |



# Sample service agreement

This topic here outlines a sample service contract for major works, that can be undertaken in a water supply project/scheme.

**GENERAL SERVICE AGREEMENT**

This General Service Agreement (the “Agreement”), dated \_\_ (date) \_\_ of \_\_ (month) \_\_, 2019, has been discussed and agreed upon by

*KaBheni/Njojane / Siweni 1 Water Project* in the Lubombo Region under Mkhiweni/Dvokodvweni Inkhundla (the Customer/Client)

**- AND -**

*Sivene Pumps and Irrigation, Sidvokodvo M216, Swaziland* (the “Service Provider”)

**BACKGROUND**:

A. the Customer is of the opinion that the Service Provider has the necessary qualifications, experience and abilities to provide services to the Customer.

B. The Service Provider is agreeable to providing such services to the Customer on the terms and conditions set out in this Agreement.

In consideration of the matters described above and of the mutual benefits and obligations set forth in this Agreement, the receipt and sufficiency of which consideration is hereby acknowledged, the Customer and the Service Provider (individually the “Party” and collectively “Parties” to this Agreement) agree as follows:

**TERMS AND CONDITIONS:**

**Services Provided 1.**

The Customer hereby agrees to engage the Service Provider to provide the Customer with services (the “Services”) consisting of:

* Repair and Replacement of Piped water schemes within ………………. days of notification of conditions by the Customer.
* Inspection visits at \_\_\_\_\_\_\_\_\_ intervals to perform operation and maintenance services for the Customer’s Piped Water Supply Schemes. This includes the completion of any required reports to be submitted to \_\_\_\_\_ the Customer. (Optional, as agreed with the Customer on intervals and amount)
* Completion of a report summarizing the service performed, any conditions which may require additional attention, any corrections made, and any recommendations.
* Provision of a copy of all the paperwork to the Customer.

2. The Services will also include any other tasks which the Parties may agree on. The Service Provider hereby agrees to provide such Services to the Customer.

3. The Services will be provided and completed in accordance with the terms and conditions attached to this agreement.

**Customer’ obligation**

4. The Customer must promptly notify the Service Provider of any known defects, problems that cannot be dealt within the community.

**Term of Agreement**

5. The term of this Agreement (the “Term”) will begin on the date of this Agreement and will remain in full force and effect until \_\_\_ (date, month, year) \_\_. The term of the Agreement may be extended by mutual agreement of the Parties.

6. In the event that either Party wishes to terminate the Agreement, the Party shall provide formally written \_\_\_\_\_\_\_\_\_\_ days termination notice to the other Party.

**Compensation**

7. For the Services provided by the Service Provider under the Agreement, the Customer will provide compensation (the “Compensation”) of the agreed amount upon notification of the condition by the Customer.

8. For standard repair work, price list should be provided by the Service Provider.

9. The Service Provider must provide at least 30 days’ notice of rate changes.

10. For non-standard repairs, the amount of repair shall be advised through estimation by the Service Provider.

11. The Compensation will be payable upon completion of the Services within \_\_\_\_\_\_\_\_\_\_\_ days.

12. The Compensation advised shall include Value Added Tax (VAT)which is currently at 15%.

13. All fees for any service, installation, or replacement parts shall be discussed and agreed upon before it is performed. Payment Penalties

14. In the event that the Customer does not comply with the payment amount within the agreed dates, the Service Provider may refuse further provision of Services until payments are made.

**Performance Penalties**

15. If the Service Provider does not perform the Services within the time frame provided by this Agreement, the penalty charge of agreed amount of SZL shall be deducted from the Compensation.

16. The Service Provider shall not be liable for delays in performance caused by circumstances beyond control. Such events include but are not limited to acts of nature, war, invasion, revolution, insurrection or other acts of a similar nature or force.

17. In case the Customer finds any defect or failure of the facility related to the repair work within days of the

repair work, which is not caused by negligence or intentional damage by the Customer or any other party other than the Service Provider, the Service Provider shall provide a corrective repair work free of charge.

**Dispute Resolution**

18. In the event a dispute arises out of or in connection with this Agreement, the Parties will attempt to resolve the dispute through friendly consultation.

19. If the dispute is not resolved within a reasonable period then any or all outstanding issues may be submitted to mediation in accordance with any statutory rules of mediation. If mediation is unavailable or is not successful in resolving the entire dispute, any outstanding issues can be submitted by either Party to final and binding arbitration in accordance with the laws of the Kingdom of Eswatini. All items must be fully documented.

**Modification of Agreement**

20. Any amendment or modification of this Agreement or additional obligation assumed by either party in connection with this Agreement shall be proposed in writing, agreed and signed by each Party.

**Severability**

21. If any term or provision of this agreement is deemed to be invalid or unenforceable, such a determination will not affect any of the remaining terms and provisions. All such remaining terms and provisions will remain in full force and effect.

IN WITNESS WHEREOF the Parties have duly affixed their signatures under hand on this \_ (date) \_\_ of \_\_ (month) \_\_, 2019.

**SIGNED in the presence of:**

Witness Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Witness Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Organization \_\_\_\_\_\_\_\_\_\_

Position: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**The Customer:**

Kaben Water Project

Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Full Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Position: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Full Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Position: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**The Service Provider:**

Sivene Pumps and Irrigation (pty) ltd.

Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Full Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Position: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Repair toolkit

**Table 9: repair toolkit for a water supply system**

|  |  |  |
| --- | --- | --- |
| Item Number | Tool | General use |
| 1 | Adjustable Wrench/Shifting Spanner | Hex shaped nuts fastenings and tightening compression fittings with hex edges |
| 2 | Pipe Wrench | Tighten and loosen threaded pipes and fittings |
| 3 | Working Shovel | Digging in the ground to expose pipes and fittings |
| 4 | Digging Spade | Digging in the ground |
| 5 | Thread seal tape | Sealing off leaks between fittings and pipe treads. |
| 6 | Hemp | Same as above |
| 7 | Bucket | Removing a pool of water from a leaking pipe pit |
| 8 | Wire Brush | Cleaning threads of pipes off any corrosion |
| 9 | Propane torch | Sweating copper pipes and fittings |
| 10 | Metal file | Remove burrs and smoothens edges on pipes |
| 11 | Hacksaw | Cut through metal, polyvinyl pipe, screws and related fittings |