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BIDDING DOCUMENTS

For

Supply, Installation and Maintenance of Solar PV Pumping Systems for Community Facilities

Volume II

Part 2, Section VII, Schedule of Requirements

Project: Kenya Off-grid Solar Access Project (KOSAP)

Purchaser: Rural Electrification and Renewable Energy Corporation (REREC).

July 2022

PART 2 – SUPPLY REQUIREMENTS

Section VII. Schedule of Requirements

Contents

1. List of Goods and Delivery Schedule

Line Item N°	**Description of Goods**	**Quantity**	**Physical unit**	**Final (Project Site) Destination as specified in BDS**	**Delivery Date** *following the date of effectiveness the Contract*	**Bidder's offered Delivery date *[to be provided by the bidder]***
1	Delivery of Samples for Approval as detailed in the specification	As defined in Lot contract	*Per Lot*	Nairobi	*Within twenty eight (28) days*	
2	Delivery of equipment for Pilot Installation sites	One systems for each Lot	*Per Lot*	At sites in project area acceptable to Purchaser in each Lot	*Within seventy-seven (77) days*	
3	Shipment of First Tranche of equipment for first sites	Per Lot	*Per Site*	Project Areas per Lot	*Within seventy-seven (77) days*	
4	Delivery of First Tranche of equipment for first sites	Per Lot	*Per Site*	Project Areas per Lot	*Within one hundred-thrrty-three (133)) days*	
5	Delivery on site of final tranche of equipment for remaining sites, including spares	Final equipment	*Per Site*	Project Areas per Lot	*Within one-hundred sistxy-one (161)days*	

2. List of Related Services and Completion Schedule

Service	Description of Service	Quantity	Physical Unit	Place where Services shall be performed	Final Completion Date(s) of Services *following the date of effectiveness the Contract*
1	Inception report	One per Lot	Per Lot	At selected installation sites	Within forty-two (42) days
2	Completed Installation Services for Pilot /Test Facilities	One per Lot	Per Lot	At pilot installation sites	Within ninety-one (91) days
3	Establishment of necessary management facilities, physical facilities for installation services, and trained staffing for Installation Services	One per Lot	Per Lot	Project area	Within ninety-one (91) days
4	Training of staff as per *Chapter 3 Section B.2.7.1*	One per Lot	Per Lot	Pilot installation site	Within 100 days
5	Training of staff as per *Chapter 3 Sections B.2.7.2*	2-3 per Lot	Per county	On site	1st training within 180 days
6	Commencement of installation services for PVP systems in all project areas	First tranche of installations in each Lot	Per Lot	In Project Lot/Lots	Within one hundred-thrrty-three (133)) days
7	Installation services for final tranche of PV systems for PVP in all project areas	Remainder of all installations	Per Lot	In Project Lot/Lots	Within two-hundred-eighty (280) days)

8	Final documentation for commissioning for final tranche of PV systems for PVP in all project areas	Remainder of all installations	Per Lot	In Project Lot/Lots	Within three-hundred-ten (310) days)
9	Provision of After Sales Services including the Warranty Period till end of contract period	All equipment supplied and all installations, plus spares supplied	Per lot	Project area	Period being thirty-six (36) months after Acceptance of final installation.
10	Warranty support for individual components	All components under warranty	Per lot	Project area	End of component warranty period

For details see following Scope of Work and Technical Specifications.

3. Scope of Work and Technical Specifications

List of Tables

Abbreviations

AC	Alternating current
BoQ	Bill of quantities
CBK	Central Bank of Kenya
CBO/WRUAs	Community-based Organisation/Water Resources Users Association
DB	Distribution board
DC	Direct current
ELP	Earth leakage protection unit
ESMF	Environmental and Social Management Framework
ESMP	Environmental and Social Management Plan
FFL	Finished floor level
GoK	Government of the Republic of Kenya
IEC	International Electro-technical Commission
IECEE	International Commission of rules for approval of electrical equipment (IEC)
IVA	Independent Verification Agent
LED	Light emitting diode
KOSAP	Kenya Off-grid Solar Access Project
KPLC	Kenya Power and Lighting Company
kWh	kilowatt hour
MCB	Miniature circuit breakers
MWSI	Ministry of Water and Sanitation and Irrigation
O&M	Operation and maintenance
PVP	Photovoltaic pump system
REREC	Rural Electrification and Renewable Energy Corporation
RCD	Residual current device
TDH	Total Dynamic Head
VSD	Variable speed drive
W	Watt
Wh	Watt hour
WRA	Water Resource Authority
EPRA	Electricity and Petroleum Regulatory Authority
WASREB	Water Services regulatory Board
WSPs	Water Service Providers
WAJWASCO	Wajir Water and Sewerage Company Ltd
LAWASCO	Lamu Water and Sewerage Company Ltd
GAWASCO	Garissa Water and Sewerage Company Ltd
MANDWASCO	Mandera Water and Sewerage Company Ltd

A: Information on Tender and Project Area

A.1. Introduction

This Chapter 3 contains the complete ***Technical Specifications*** for supply, installation, commissioning and maintenance of Solar PV pumping systems (herein referred to as packages), for use in a structured tender process. The complete documentation comprises of:

Part A: Information on Tender and Project Area
Part B: Scope of Work
Part C: Technical Specifications and Standards for PV pump systems
Part D: Technical Specification: After sales service

Chapter 4: ***Technical Bid Submission Forms, Declaration of Performance and BoQ***
Chapter 5: ***Schedule of Drawings***
Chapter 6: ***Schedule of Tables***
Chapter 7: ***Inspection and Commissioning Tests***

A.2. Location of project area

The purpose of this tender is to convert existing diesel water-pumping facilities to solar water pumping systems with diesel back-up, in community-based schemes. The schemes are operated by water service providers (WSPs) who are county government owned water utility companies or Community-based Organisation (CBO) or Water Resources User Associations (WRUAs) working in collaboration with the county governments, in the Counties of **Kilifi, Kwale, Isiolo, Samburu, West Pokot, Turkana, Tana River, Lamu, Marsabit, Mandera, Garissa, Wajir, Taita Taveta and Narok in the Republic of Kenya.**

The electrification of these water pumping installations will be using stand-alone photovoltaic water pumpijng systems together with diesel back-up. The scope of work covers design, supply, installation and commissioning of the equipment for existing functional water schemes in proper working order, a warranty period covering quality of workmanship, the provision of equipment warranties, spare parts, and training. Three years compulsory maintenance services shall be provided by the Supplier during the warranty period, optionally extendable to seven years at discretion of Purchaser. The project area is divided into six (6) lots as follows:

Lot 1: Garissa, Lamu & Tana River	**(Approximate size is 639.8 kWp)**
Lot 2: Wajir & Mandera	**(Approximate size is 623 kWp)**
Lot 3: Kilifi & Kwale	**(Approximate size is 649 kWp)**
Lot 4: Isiolo, Samburu & Marsabit	**(Approximate size is 493 kWp)**
Lot 5: West Pokot & Turkana	**(Approximate size is 359 kWp)**
Lot 6: Taita Taveta & Narok	**(Approximate size is 499 kWp)**

For maps of the project area please see ***Appendix 1***. Detailed locations of sites and overall quantities are provided in *Appendix 3*.

A.3. Completing the technical documentation

Chapter 4: Technical Bid Submission Form and BoQ provides all the forms for the technical information that is required to be completed. Each of these forms form an integral part of the bid, and the failure to complete them adequately may result in the rejection of the bid.

Form 1: Technical Compliance Submission Forms

(to be completed for each major component)

- Technical Form 1: Compliance with standards and warranties
- Form 1.1 Solar PV Panel
- Form 1.2 Pump controller / inverter
- Form 1.3 Pump / motor
- Form 1.4 Diesel generator
- Form 1.5 Data-logging and on site display
- Form 1.6 Remote Monitoring Software and Dashboards
- Form 1.7 Laptop

Form 2: Ssytem Diagram and Sub-System Performance Curves

(to be completed for each motor/pump/Pumpcontroller combination)

- Form 2.1 Ssytem Diagrams
- Form 2.2 Performance Curves - Daily Output Curves
- Form 2.3 Performance Curves - Instantaneous Output Curves

Form 3: Schedules of Information for Solar Pumping System

(*To be completed for each system)*

- Form 3.1 General site and system information
- Form 3.2 Table of declaration of system water output vs. solar radiation and head

Form 4: Bill of Quantities for Solar Pumping System

(*To be completed for each system)*

- Form 4.1 Main equipment BoQ
- Form 4.2 Diesel genset BoQ
- Form 4.3 Additional Minor Works BoQ

(*To be completed for each Lot)*

- Form 4.3 (A) Schedule of Variation Prices for Additional Minor Works
- Form 4.4 Mandatory Spares
- Form 4.5 Maintenance Kit

Form 5: Recommended Spare Parts Schedule

(*To be completed for Lot)*

- Form 5 Recommended spares schedule

Form 6: Maintenance Activity Schedule

(*To be completed for Lot)*

- Form 6 Maintenance activity schedule

Appendix 1: Detailed explanation on *Schedule Technical Proposal*

A.4. General environmental conditions in project area

Solar radiation and design data

Solar radiation information available indicates variable solar resource throughout Kenya. There are also many sources of solar radiation data. All systems in this tender must be designed using solar radiation figures which are most generally applicable to the Region. Refer to ***Appendix 2.***

Temperatures

Ambient temperatures in targeted regions of Kenya are high. Refer to ***Appendix 2.*** High ambient temperatures, also affect electronic component life. Electronic component life decreases by approximately 50% for every 10º Celsius above 25ºC. Components are to be de-rated for high temperature life expectancies, to ensure compliance with the component warranties.

Lightning risk issues
The targeted region of Kenya is a medium risk area for lightning strikes. Refer to ***Chapter 6, Table 5 2.***Systems should be designed with moderate Class II lightning protection only. Sound earthing practice must be followed as detailed in the specification.

A.5. General conditions on site

Storage facilities for each Lot
The supplier is responsible for the organization of secure centralized storage depot for all equipment for each Lot. The supplier is responsible for the security of all goods till after comissioning.

Operational community facilities
Note that systems shall be installed in operational facilities serving the rural population. The Supplier is obliged to ensure minimal disruption to the rendering of water services by Water Service Provider (WSP)

The supplier is responsible for secure storage of equipment that will be delivered to site prior to commencement of the installation. The Supplier will also be responsible for arrangement of sleeping and other facilities for their installation technicians on the project site. The Suppliers shall ensure that all staff respect the local customs of affected communities and comply with Kenya national laws when interacting with stakeholders and that at all stages during the execution of project works adhere to associated safeguards procedures.

Electricity and water
No electricity supply is available on site and supplier is required to take care of own energy needs. Supplier may not assume to use any existing diesel generators used for water pumping on site, without prior arrangement with the facility, in writing.

Interface with other works
The solar PVP installations shall interface with the existing diesel water pumping systems – in a hybrid configuration so that the existing diesel generator can be used as back-up on the solar pump.

- The solar pump shall connect into the existing water storage and reticulation system.
- In all cases the existing pumps shall be withdrawn and replaced.
- Water storage repair works shall be required, and reticulation system repair shall be required.

The supplier shall be provided with a clear scope of work for each site after the supplier has taken a careful inventory of existing works at the *Inception Stage (section B.2.4)* prior to commencing the new installations.

Note that no existing water pumping equipment may be removed from site.

Environmental and Social Code of Practice
The Supplier, all contractors and subcontrators shall ensure that all staff respect the local customs of beneficiary communities and comply with national laws when interacting with stakeholders. The Supplier, at all stages during the execution of project works, must adhere to associated safeguards procedures outlined in the project’s documents (refer Volume III)

B: Scope of Work

B.1. Scope of Contract

The tender is for **design, supply, installation, commissioning, warranties, spares, training of operators and technicians, and provision of after-sales-service for solar photovoltaic pumping (PVP) systems**, without batteries, with diesel generator interface and new diesel generators (for ALL sites), and remote performance monitoring, to specification and in proper working order, for pre-identified village community water supply facilities. Suppliers are required to remove existing water pump systems in each case.

The total duration of the contract is 10 **months for supply and installation** (3 months preparation, 6 months installation and 1 month inspections and verification)**,** followed by 36 **months of operation and maintenance after-sales service**.

1. Provision of Solar PVP system installations for community facilities, to specification, with components trackable using barcode system, and remote performance monitoring system.
2. A period of procurement, installation and commissioning for all community facilities of a maximum as stated in ***Section VII -Chapters 1 and 2. Delivery Schedule*****.**
3. The Supplier shall visit sites with the Purchaser representative and shall produce *an Inception Report* based on the visits. The Supplier will conduct due diligence of the Lot(s) and areas awarded to it to determine whether the conditions and situation in the project area and the status of the facilities are materially different from those stated in the bidding document. The Supplier will report on the activities and results of the due diligence. The Purchaser may issue Change Orders based on the results of the due diligence.
4. *Samples for approval***:** the Supplier is required to provide samples for approval prior to the Pilot Installations and bulk manufacturing or shipping.
5. *Pilot installations*: At least one PVP system in a project area acceptable to the Purchaser shall be installed in one village, then, commissioned and accepted by Purchaser prior to proceeding with the other installations. The Pilot Installations will be completed within ***Section VII -Chapters 1. and 2.Delivery Schedule*****.** The Pilot installations serve as the "Blueprint" for all the subsequent installations under this contract. The installation requirements and procedures (not the price) may be adjusted based on the results of Pilot installations and mutual agreed.
6. Installation of the remainder of PVP should be completed within the time frames in ***Section VII-Chapters 1. and 2.Delivery Schedule,*** concurrent with removal of existing pump systems.
7. Practical Completion, Commissioning, Inspection and Acceptance as per this scope of work.
8. Training of staff of the WSPs and government technicians as per specification shall be conducted by the Supplier.
9. *Warranties* on quality of work provided by the Supplier during the twelve (12) month Warranty Period and the Component Warranty Period after Acceptance of each system. Manufacturer's Authorization for warranties on equipment shall be provided by the Supplier as detailed in this scope of work. During the Warranty Period the Supplier shall attend to all defects without additional cost for both the system and components.
10. *Maintenance Period* of thirty six (36) months, commencing after Acceptance of the Final installation in the Lot, as specified in ***Section VII-Chapters 1 and 2. Delivery Schedule***. The Supplier has maintenance obligations for both routine preventative maintenance, and breakdown repair (callouts) as specified in this scope of work. After the Maintenance Period the Purchaser may optionally procure additional long term maintenance there-after.
11. *Spares management* shall be conducted by the Supplier. At end of the Contract Period obligations the Supplier shall hand-over the spares in good working order to the Purchaser.

B.2. Supply and Installation of Solar PVP systems

B.2.1. System descriptions

Solar PVP systems are to be supplied and installed at selected facilities and villages within the project area, according to the procedures outlined below.

The community facilities shall receive PVP systems depending on their existing functional situation on site with regards to their water supply infrastructure (See ***section B.2.2*** for exact details of what systems are to be supplied to each specific facility). The PVP systems are detailed in ***Section C: Technical Specifications and Standards for PVP Systems -*** *n*ote that ***Section C*** takes precedence over these short descriptions.

Functional description of PVP system comprising of:

Submersible borehole pump powered by solar PV array, sized to meet the specified water demand for the specified season. PVP system is to include diesel engine for back-up operation for low solar radiation or increased water demand.

Refer to schematic of the systems in to ***Schedule of Drawings: DWG.SCH.2.:Schematic of PVP configuration.***

B.2.2. Location of systems and overall quantities

Each Lot encompasses a number of community facilities, as identified in ***Table 1***.The approximate size of each Lot is indicated by kWp of PV required.

Table 1: Identification of Lots and summary data

Lot	County	No of sites	Aproximate Total kWp / County	Aproximate Total kWp / Lot
1	Garissa	27	451	639.8
	Lamu	21	12.8	
	Tana River	26	176	
2	Wajir	35	384.6	623
	Mandera	30	238.4	
3	Kilifi	33	429	649
	Kwale	30	220	
4	Isiolo	18	160	493
	Samburu	23	252	
	Marsabit	11	81	
5	West Pokot	32	58	359
	Turkana	38	301	
5	Taita Taveta	19	287	499
	Narok	37	212	
TOTAL		**380**	**3,262.8**	**3,262.8**

The village location and the number of facilities where the PVP systems are to be placed for each Area/Lot are set out in the ***Appendix 3*** in detail, with further sizing and costing data.

The number, location and sizing of each PVP system provided in the bidding document provides the basis for pricing. The bidder shall provide unit cost of each system in the BoQ. Final numbers may be adjusted before signing of the contract.

GPS co-ordinates of the sites are in the detailed lists are provided in ***Appendix 3***.

B.2.3. Delivery schedule

The delivery of the systems shall be in four stages as per the time frames in ***Section VII -Chapters 1. and 2. Delivery Schedule*** (and in case of discrepancy, the Chapters 1 and 2 take precedence):

1. Inception report, Samples for Approval, and Pilot installations

1.1 ***Inception Report*** shall commence on contract execution and be finalised within **forty-two (42) days**.

1.2 ***Samples for approval*** shall be requested on contract award and submitted within **twenty-eight (28) days**.

1.3 ***Pilot Installations*** shall be supplied and installed for inspection and approval by the Purchaser as **per ninety-one (91) days** of contract signature.

2. Establishment of facilities for installation services

The Supplier shall set-up the necessary management infrastructure, facilities, outlets and staffing to provide quality installation services, within **ninety-one (91) days** of contract signature.

3. Balance of installations

After the approval of the Pilot installations, then commencement of the balance of installations may proceed. First tranche of systems installation must be within ***one-hundred tjhrity=three (133) days*** of signature. All systems identified above must be delivered, installed and ready for commissioning within two-***hundred eighty (280) days*** of contract signing. Commissioning is to be completed by 310 ***days.***

4. Warranty, after sales service and maintenance

The Supplier shall provide after sales service for all systems and maintain the community systems installed (see ***Section B.3***), for a period ending of a minimum of **thirty six (36) months** after commissioning of the last system in the lot.

B.2.4. Inception report

Immediately after signature of the contract, the Supplier together with the Purchaser's representative shall conduct inception missions to every site in each Lot. Supplier shall also make detailed assessments of the sites, villages, access and logistical issues. In particular Supplier shall confirm and report the hydraulic conditions.

The Supplier shall provide the necessary qualified staff to lead the tasks, including an Electrical Engineer and a Project Manager. During the inception mission to these facilities, final clarifications will be made on the positioning of PV modules, the manner in which they are installed, placement of the outline of the wiring. The Supplier will provide drawings of all proposed installations, including wiring diagrams, construction drawings and typical placement of components in the Inception Report.

The final Inception Report shall contain at least the following sections:

- Validation of listed facilities, and facility status, in conjunction with REREC and WSP office:
    - Confirmation of hydraulic design conditions on site
        - existing pump and generator size and operational condition
        - existing storage tank sizes, condition, rehabilitation needs
        - existing borehole internal diameter

        - existing diesel engine size, condition
        - yield under test using existing pump (with supplementary / portable generator as required)
        - TDH calculation comprising of: static head, pipe diameters, lengths (***Chapter 4, Form 3.3: Hydraulic information and pumping head calculation sheet***)
    - PVP systems and scope of works to be installed at each facility per site,
    - Requirement for additional works to integrate supplementary storage tanks per site
    - Confirmation of minor additional components necessary site

- List of all sites with
    - proposed PV system(s) type to be installed at each,
    - proposed diesel genearator size,
    - minor works required, including repairs to tanks and reticulation networks
    - Updated BoQ for each/all sites site with site specific additional work (DB, new cabling routes, additional rooms, etc), showing total cost implications per facility. Use the same format as the BoQ provided.
    - Site plan for location of solar PV array, buildings, fencing at each site.

- Proposed Solar PV types
    - DC-AC Wiring diagrams for each system type, showing in addition, earthing, lighting protection (internal and external), and monitoring sensors
    - Detailed construction drawings for PV module mounting structures
    - Functional description of the operation and variables of the data logging and remote monitoring system
    - Communication wiring diagrams for each PV system type

- Implementation Approach and Staffing
    - A description of the installation method if different from ***Volume 1, Section IV, PQ Form 3*** of the proposal
    - Staffing approach if different to proposal
    - Schedules for implementation and related assumptions
    - Final Gantt chart

- Support requirements from Purchaser, to be agreed
    - Itemised support required (i.e. permissions from country government/WSP for access to certain areas project)
    - Responsibilities and schedule for the support.

The Supplier shall finalise the Inception Report and submit to the Purchaser as per time frames in ***Section VII -Chapter 1 and 2. Delivery Schedule.*** The Supplier will be informed about approval of the final Inception Report within ***fourteen (14) days*** weeks after submission, and any change-orders necessary.

B.2.5. Samples for approval

Once the contract is awarded and at the time of the *Inception stage*, the successful bidder shall provide documemtation for verification together with samples for approval or factory inspection reports prior to placement of orders, bulk manufacturing or shipping.

The Supplier shall provide selected components from each system type on this project, for inspection. In general the samples inspection shall entail visual inspection, to ensure that samples correspond with the documentation offered at time of bidding. However, in case of doubt the Purchaser may require testing of the samples by a nominated certified laboratory.

The Supplier shall replace any components or systems which do not meet the requirements of the applicable specification at their own expense. These samples shall be held over after scrutiny, until handover of the project to ensure that the same items as tested or inspected are installed.

Samples of one of each type of the following equipment for approval should be provided prior to the Pilot installations:

- PV modules
- Pump controller / inverter of each type
- Pump of each type
- Array structure (s)
- Any other components requested
    - water meters, valves, connectors
- Diesel engine
- Change-over mechanism (from PV to diesel)
- Remote monitoring transducers
- Demonstration of remote monitoring system
- Demonstration of barcoding system

(Since this tender requires rationalisation of models of pumps and controllers, implication is rationalisation of numbers of samples required. Assuming all systems offered are from same brand and same “family of components” (with only size variations), then this would reduce the numbers of samples required.)

Sample approval does not release the supplier from obligations with respect to quality and component performance this is a process to verify that the product proposed in the bids are same in the sample and final delivery.

B.2.6. Pilot installations

The Supplier shall install at least one complete PVP installation to be approved by the Purchaser, in each Lot. (The Pilot installation shall include the entire hardware for a complete functional installation to be signed off as acceptable, covering all major equipment and all minor and balance of systems equipment for installations; array structures, fencing, remote monitoring systems, etc.)

The Pilot installations will benchmark the installation practice to be used, and will serve as the approved "blueprint" for the standard of installation. The Purchaser will review the quality and functionality of components, individually and as a system, and the quality of installation against requirements stated in this document; and revise, as needed, based on the benchmark pilot installations - any equipment changes, installation or procedural changes required for this blueprint will become mandatory for the balance of the installations. The supplier shall provide the necessary qualified staff to lead the tasks, including an Electrical Engineer and a Project Manager.

The Pilot installations shall follow the process below:

1. The Supplier shall expedite delivery of the equipment for the installations, as soon as practical after approval of the Inception Report and Samples.
2. The Supplier shall agree a date with the Purchaser for completion of the Pilot Installations and for the Blueprint inspections, within the project schedule as in ***Section VII -Chapters 1 and 2. Delivery Schedule.***
3. The Supplier shall provide technical and managerial staff on site capable of and authorised to make any necessary decisions on site.
4. The Supplier shall install the equipment according the installation guidelines agreed in the Inception Report.
5. The supplier shall give the Purchaser at least three days’ notice to inspect the Pilot works.

6. The Purchaser shall inspect the Pilot installations and equipment at the agreed date, and make recommendations for modifications to improve quality with respect to equipment quality, locations of key equipment and installation planning, cabling and wiring, plugs and sockets, light locations, installation methods, labelling, and functionality of the remote monitoring system, etc.
7. Any necessary changes shall be implemented while the Supplier and Purchaser are on site, with the objective of approving the Pilot Installations.
8. If the modifications required are of a major nature, then a second Inspection visit shall be scheduled with the same Supplier team, within 2 weeks.
9. Once the installations are to standard, then the Pilot Installations will be accepted according to the process in ***Section B.2.9***.
10. The Supplier shall update electrical diagrams, instructions to installers based on the approved Pilot Installations.
11. The Purchaser will issue an *Authorization to Proceed* with balance of installations.
12. The Supplier will train all his supervision and installation staff to undertake installations to the standards agreed at the Blueprint.
13. The Supplier will commence the balance of installations to the same standards.

At the Pilot installation, the component documentation, commissioning procedures, manuals and other documentation will also be tested and validated against the specific equipment provided. The Supplier may confirm that the procedures and forms for Practical Completion, Commissioning Inspections and Acceptance and other steps are practicable, and propose any revisions that may make them more effective and efficient.

B.2.7. Training requirements

B.2.7.1. ***National level REREC Engineers***

The Supplier will conduct a training to key member of technical engineering staff at the national level. Key staff (electrical engineers or similar) at REREC engineers will be designated by the Purchaser.

The objectives of this training will be to ensure that the selected trainees master the key installations points : functioning principle of each key components, local display unit, distance monitoring system, routine maintenance and repair tasks, supervision using remote monitoring, and finally how to upgrade a system.

This training will take place at first pilot sites are installed), once it has accepted (after Final acceptation). Between 2-3 REREC engineers, in charge of supervision of future systems will be part of the trainees. This training session shall not last less than 3 days.

B.2.7.2. ***County Water Engineers***

Atnother training session will be conducted under the supervision of the Supplier, with the assistance of key REREC and county staff (that have been trained see above). The target group will be the County water engineners in charge of the future systems, once several other systems are installed. Duration of training will also be at least 3 days with a maximum of 10 participants per each training session and will be conducted also at a pilot installation (or a PV system that has been accepted). The total of engineers to train is 24. Therefore, 2-3 training sessions will be required per LOT.

The teaching content of these above described trainings will be proposed by the Supplier and agreed upon by the Purchaser. It will be theorical and practical (60% of practical exercices)

This training will take place at the first pilot system in a County after Final acceptaance).

B.2.7.3. Operators of community facility systems

Operator-training and provision of documentation for the systems installed at the community facilities is required. Training shall be conducted in English and Swahili languages. Training is directed at the WSPs operators and the administrators of the community public facilities systems in the villages. These include the following specific components:

- Basic use of solar PVP systems – operating principles, basic operating modes and practices, safety issues, energy and power limitations of solar PV systems, change-over to diesel mode (were applicable)
- The uses and limitations of the system installed;
- Basic fault diagnosis and key indicators of system or component failure
- Operator-maintenance responsibilities, administration of maintenance visits and completion of user-sections of maintenance log sheets
- Safety procedures and precautions, including handling of heavy components;
- Contact information for queries and break-down maintenance service.
- Warranty support

Operator training in the system operation shall be provided at each system installed, to at least two WSP pump operators appointed by the WSP. Training in the system operation shall be provided to the operators at each system installed for a duration of at least 3 hours

B.2.7.4. On site and follow-up training

County engineers /super-technciain in each countty shall nominate qualified technicians to be responsible to liaise with the WSP for long term technical support, general maintenance supervision and upgrading of systems required during and after the initial warranty/maintenance period of the systems.

For each site, the Supplier shall be responsible for providing on the job maintenance training to operators and WSP technician with its own maintenance kits in the course of the warranty/maintenance period. In other words, routine maintenance and repair job will be done by the Supplier technician and while doing so, this will include training of users and to the WSP technician. The follow-up training should target i) operators and staff that received the first training and ii) new operators and staff. Technicians within WSP must be trained to provide this level of support to the users.

Maintenance report and/or repair job report, indicating clearly the training time for users and WSP technicians, will have to be cosigned by the Supplier, the WSP technician, the operators and head of health facilities and submitted to the Purchaser

B.2.8. Documentation to be provided

B.2.8.1. Operator Poster

A Poster intended for the operator must be provided with each system. The Poster shall be specific to each system type, and shall be approved, in English, during the Pilot Installations, and later translated to Swahili language. The Purchaser shall review and provide the final version of the manual to be used by all suppliers. The final version of User's Manual shall be printed in both English and Swahili languages, after approval by the purchaser.

The documentation should be simple and easy to understand. Use of sketches or graphics should be used to make the manual easier to use. The documentation is to include the following:

- Simple explanation of how the PVP indicator lights work:
- Indications of available water supplied by the system, in seasons.
- Emergency shutdown procedures and recommendations for extended periods of system non-use.
- A simple user trouble shooting guide.
- Basic maintenance to be done by user, including frequent cleaning of the panel especially during dry season to remove dust, deal with array shading,
- Name address and telephone number of call-centre for fault reporting, and to be contacted if dealer/supplier does not meet its obligations.

- Name address and telephone number of dealer/ supplier and the technician(s) responsible for warranty and service claims

B.2.8.2. O&M technical manual

The Supplier must provide an Operations and Maintenance Manual to be used by the service technicians. The copy shall always remain on site after Acceptance of the system. The O&M Booklet is a pre-requisite for Acceptance Tests and inspections.

The O&M Booklet shall be written in English and must be graphically illustrated for unambiguous interpretation and understanding by operators and maintenance staff. Special attention must be drawn to fault finding and remedial action.

All drawings shall be annotated in English. All drawings shall comply with BS 308. All drawing symbols must be standardised according to BS, DIN or IEC symbols and must be consistently used.

A booklet shall be provided. Each section shall be partitioned with labelled plastic dividers. The main sections are outlined below:

- ***Operator section***
  - The Operator Section shall include:
  - Introduction
  - Instructions on safety techniques
  - Operating and serving instructions with details of service schedules, with start-up and shut-down procedures, functional description and interpretation of status and error indicators
  - Fault finding instructions, normal and fault indicators
  - Rules for action in error situations
  - Repair of minor faults
  - Regular maintenance procedures, plant care and cleaning, maintenance schedule (NBNB)
  - Schematic description in the form of an overview drawing with references to the relevant detail drawings, indicator lights etc.
- ***Contacts for backup***
  - Local agents
  - Installer
  - Manufacturer
  - Purchaser (if relevant)
- ***Maintenance required***
  - Taken from ***Chapter 4: Technical Bid Submission, Form 6, Maintenance Schedule.***
- ***Log book and maintenance section***
  - Records of date and water meter reading , and reservoir level if relevant
  - Forms to enable the keeping of a log book and collection of data and maintenance records.
- ***Spare parts list***
  - Parts list in agreement with the graphical documents quoting all the data necessary for ordering as required in section.
- ***Performance section***
  - Commissioning sheet/Acceptance certificates (ex project Purchaser) and Performance Test Sheets.
  - Performance requirements (from *Project Specification*)
  - Performance tendered (completed by Bidder, from ***Chapter 4: Technical Bid Submission Form 3.2***)
  - System performance section (as detailed in ***Section C.2.11 System Performance***

Information, and ***Chapter 4: Technical Bid Submission Form 2***).

- Daily output curves - water delivery for system at different radiation levels and heads.
- Instantaneous output curves - water delivery for system at different radiation levels and heads.
- Array curves - different radiation levels (and at operating temperature).
- Power conditioning - instantaneous efficiency over the full range of operating conditions expected.
- Pump curves, motor curves.

- ***As-built' drawings***
  - A set of "As-built" drawings of the new installation shall be furnished. The set shall consist of separate drawings of each of the following:
    - Single line diagram / system schematic.
    - General assembly drawing of the motor / pumping system, including exploded drawings of the pump unit with particular attention paid to the labelling of working parts operation instructions.
    - General assembly drawing of the array mounting structure.
    - Detailed electrical layout drawings, electrical circuit and regulatory diagrams, implementation plans, wiring and terminal diagrams, including wiring sizes, lengths, etc.

- ***Technical section***
  - Detailed technical servicing for trained/specialist technical staff.
  - Complete parts list (to be supplied by the Bidder)
  - Component specifications (from ***Chapter 4: Technical Bid Submission Form*** *1*), submitted by Bidder), including:
    - Module certification, degradation, and all component data-sheets.

- ***Upgrade path***
  - Upgrade path (if applicable, the performance achievable by simple upgrade, costs etc)

- ***Installation***
  - Installation instructions

B.2.8.3. Equipment documentation

The Supplier is required to supply certain documentation with the equipment. This documentation shall include:

Softcopy database <u>for each major component</u> supplied including the following fields:

- Unique barcode, manufacturer name, model number, serial number, supplier name, date of purchase

The Purchaser reserves the right and discretion to require pre-shipment inspections by the Purchaser or Purchaser’s nominated independent inspection agent. The pre-shipment inspections will occur at the premises of the Supplier or the manufacturers of the Supplier. The cost of these inspections would be borne by the Purchaser.

B.2.8.4. Claims documentation for systems installed

For payments related to installation services, periodic (monthly or longer) claims shall be submitted by the Supplier. The claims documentation shall comprise of the following documents linked to each site, whetherr in formal MIS provided by the Purchaser (for example *Odyssey*^{TM} or *Edison*^{TM} platforms), or a simple sharefolder, with one directory per site.

1. Practical completion sheet for each site
2. Certificate of Electrical Compliance (for each site where relevant)

3. Spreadsheet with equipment inventory:

- System number and name (i.e. 1..CDS-1)
- Dated Practical Completion / Acceptance Receipt signed by HC staff
- Province, district, village,
- Location for verification purposes (i.e. GPS co-ordinate).
- Key equipment supplied and installed
    - Technical Manual, user poster
    - Module type, rating, qty, serial numbers, barcode serial numbers
    - Pump type and capacity, qty, barcode numbers
    - Inverter type, capacity, barcode serial number

4. As-built site layouts

- Layout of PV array, platform, DBs
- Overall of entire site with cabling routes.

5. Photos

- WSP facility members
- Array location, lack of shading, solar arrays,s tructure
- Control enclosure
- Safety signage
- Model and serial numbers of each major component excl modules.
- Minor works undertaken (control room, etc)
- Operator Poster, Manuals,
- Site fencing

B.2.9. Procedures for Practical Completion, Commissioning Inspections and Acceptance of the Systems

Note that the risk passes from the Supplier to the Purchaser only on satisfactory inspection and commissioning of the public facilities and hand over to the client along with complete Acceptance Certificates to ensure that equipment is on site and fully functional. The Purchaser acknowledges that there may be risk of theft and/or vandalism between the period of completion of installation and Acceptance. The Supplier should carry insurance or other means of safeguarding the PV systems until the Acceptance Certification is signed by the Purchaser. It is expected that any costs associated with insurance or other means of safeguarding the PV installations will be paid for under this Contract.

Practical Completion

1. The Supplier shall satisfy himself that the installations are completed in accordance with the Specifications, the Pilot Installation standards and any variations that have been issued before requesting an inspection by the Purchaser.
2. The Supplier will complete the Practical Completion Log-sheet.
3. The Supplier will train the facility staff in basic operational procedure and first line maintenance before commissioning. The system may be used by the staff.
4. The Supplier shall capture each system data, and Practical Completion Log-sheet, to spreadsheet.
5. After checking, the Supplier shall submit the uploaded data in the MIS, in a Claims Batch. This Claims Batch will form the softcopy database to the specified format, of the sites completed and ready for inspection in the Claims Batch (***section B.2.8.4***). Claims batches must be made up of

facilities located in one geographic area of the Lot. Otherwise inspections will occur at a frequency of not more than once every month.

Acceptance, Commissioning and Verification

6. Sometime after Practical Completion of the installation the systems will be subject to Acceptance/Commissioning/Verification Inspection by the Purchaser.
7. Prior to inspection, the Supplier shall hand over to the Purchaser all technical and other necessary Claims Documentation.
8. The Acceptance/Commissioning/Verification Inspection by the Purchaser will occur in Claims Batches, within 15 days of notification and handing over submission of the Claims Batch and the necessary documentation.
9. The Purchaser will determine whether the staff has been adequately trained in basic operational procedure and first line maintenance.
10. The Supplier and Purchaser will be present at the Commissioning Tests.
11. At the Acceptance Inspection the Supplier will be issued with a certificate stating all defects of the installation or part at that time.
12. If the defects are minor and of fewer than the agreed number, then the installation will be handed over by the Purchaser using the Acceptance Certificate. If defects are of a major nature, or large quantity of a minor nature, then the Supplier will correct these defects and request a further inspection.

Acceptance Certificate

13. An Acceptance Certificate will only be issued once major defects mentioned above have been rectified and inspected, and staff have been trained satisfactorily.
14. The acceptance of the Claims Batches will determine the payment for the complete claims batch. Payments shall be withheld proportionally for systems found to be un-Acceptable, on a pro-rata basis. Payments for those shall only be released after further verification.
15. The Warranty Period will commence from the date of Acceptance of the last installation in the Lot, as dated in the ***Acceptance Certificate.***

B.2.10. Commissioning tests

Draft commissioning process is given as ***Chapter 7***. These will be updated to meet the requirements of the Supplier's specific products at the time of the "Pilot installations":

1. The commissioning document is an initial record after the system has been installed and made operational, and contains pertinent data on condition and performance of the system. These measurements are necessary for future servicing, repair and warranty issues of the system.
2. The technical documents referred to as ***Section B.2.8*** should be an integral part of the commissioning document as well as other design documents from the supplier as these are the reference documents of this "Commissioning Document".
3. The commissioning officer should be qualified to measure voltage and current parameters required in this document, in a safe manner, and should have read and understood in detail the above-mentioned annexes and supplier design data. The commissioning officer will have been trained on a Pilot installation.

B.3. After-Sales Services for Solar PVP systems

The Supplier shall maintain a Service Center in the project area (Lot) to serve the support needs of the solar PVP systems. The period of after-sales services is from commencement of the Warranty period until end of Contract Period.

Activities covered under after-installation services are:

- *Warranty period* on quality of workmanship and all parts
- *Component warranty* on key system components
- *System performance guaranty*
- *Routine maintenance* services
- *Break-down repair* services
- *Spare parts* support
- Provision of maintenance services to be purchased after the contract

The supplier shall maintain the Service Center on its own or through business partners, at least at Regional level, and preferably within 12 hours travel (600km) from any site. Service Center shall provide adequately skilled and trained staff to perform any maintenance services, repair or component replacements likely to be necessary over the system lifetime, and should carry a stock of spares for any components which are likely to need replacing over the system lifetime. The names of the accredited local agency shall be provided in the schedules in the ***Volume 1, Section IV Bidding forms, Schedule PQ No.3.***

B.3.1. Warranty period

The Supplier shall provide a twelve (12) month unconditional Warranty Period on the installation from the date of Acceptance of the last installation in the Lot, as per ***section B.2.9 clause 15.***

The Warranty Period shall cover all materials, components and quality of workmanship for each system. Should any faults arise, this warranty will provide for the necessary repair or component replacement in order for full functionality to restore full functionality within time period of reported fault in ***Table 6.***

B.3.2. Component warranties

The warranties on the individual components for installations shall meet the following requirements:

- 25 years on PV modules (performance not less than 80% of name plate output), and 10 years against manufacturing defects
- 5 years warranty on Pump controller/Inverter/Converters
- 5 years warranty on Pump/motor
- 2 years warranty on diesel generator
- 3 years for all other PV system components
- 1 year on all unspecified hydraulic components.

Specific Manufacturer Warranties shall be provided signed by an authorized official of the manufacturer with company seal, on the company's letterhead with specific reference to this procurement. Standard/nominal printed documentation without the signed warranty commitment is not acceptable. Manufacturers' Warranties must be transferable to the "Purchaser or nominee" after the Contract Period.

The Supplier shall be responsible for the managing the Component Warranties till the end of Contract.

B.3.3. System performance guaranty

Overall system performance guarantee of 36 months shall be provided, during which time average monthly water output from the solar PVP system (without diesel back-up) shall not drop below that of the specification performance level required. System efficiency indicators as defined in ***Section C.10,*** as declared by Supplier and as measured during commissioning (***Chapter 7***) shall not show measurable decrease.

B.3.4. Spares management

The Supplier shall supply all ***Mandatory Spare*** part for inspection, and may utilize these on an exchange and repair basis during the Maintenance Period. At end of the Maintenance Period the Supplier shall hand-over and replace all used Mandatory Spares in good working order to the Purchaser.

The Bidder shall also submit a list of additional ***Recommended Spare*** parts, i.e. in addition to the Mandatory Spares (***Section C.2.12***), for components which may require replacement caused by normal 'wear and tear' within the initial Maintenance Period after handover, as required in ***Chapter 4: Technical Bid Submission Form 5 Recommended Spares Schedule*. **

The above does not obligate the system owner or other responsible party to order the spares scheduled in the list at the prices stated during or after the contract.

B.3.5. Maintenance and service, reporting and tracking

The Supplier shall provide on-site maintenance services for PVP systems from the date of Acceptance of the last installation in the Lot, as per ***Section B.2.9 clause 15.*** (i.e. date of commencement concurrent with commencement the Warranty Period).

Maintenance is the responsibility of the Supplier until end of Contract Period. During this time the contractor will inspect, maintain and service the installation as part of the contract. The Maintenance services should be undertaken by the Service Center for the system

The Supplier will ensure that maintenance is conducted as follows:

- A routine maintenance regime will be implemented according to the technical specifications provided in ***Sections D.1 and D.2.*** The routine maintenance will be undertaken for every solar PV system installed at community facilities in accordance with this scope of work;
- In addition, a break-down repair service operated by the Supplier shall be available to users in accordance with ***Section D.3.***
- Supplier shall manage Warranty period ***(Section B.3.1)*** Component warranty (***Section B.3.2***), System performance guarantee (***Section B.4.3***) and Spares ***(Section B.3.4)***.
- Declaration by the contractor stating that the maintenance work and any repair work has been completed and accurately recorded, co-signed by the community system operator or water committee chairperson on site.
- Forwarding of copies of the Maintenance Form to the relevant parties specified on the Maintenance Form.

The Supplier will maintain organizational, staffing, logistical, inventory, recording and reporting capabilities and other arrangements sufficient to meet the managerial and technical requirements of providing the maintenance and other post installation services to comply with the requirements established in ***Sections D.1 to D.5***.

A Maintenance period may be renewed thereafter, or may be awarded to another maintenance contractor.

Fault reporting

The fault reporting channels shall be established to be unchanged from time of installation till completion of the contract and handover to Purchaser. Fault reporting shall be via a call center operated by Purchaser.

The Purchaser shall provide a call center for customer support (WSP, not individual customers). The call centre shall log PDWS system related faults and complaints, and shall used to draw up job cards for action, including all customer related details, the nature of the complaint, with a unique reference number. Each logged complaint and notification of system failure shall be recorded by the Fault Report Call-centre, forwarded to Supplier (and copied to WSP). Feedback from Supplier job cards will be used to assess customer perception of the system performance and assess speed of response to problems.

For ease of reporting, each User manual, and each system shall include a label:

- Name address and telephone number of call center for fault reporting, and to be contacted if dealer/supplier does not meet its obligations.
- Name address and telephone number of dealer/ supplier and the technician(s) responsible for warranty and service claims
- Users shall be instructed to first contact the call centre, and to follow-up with complaints to call centre if the repair is not addressed within 3 working days.

B.3.6. Rejection of faulty equipment

If, within the first twelve (12) months of the Warranty period, ten percent (10%) of more of any class of equipment fails based on record-keeping tracking tools, the Purchaser may, at his sole discretion, have the right to demand the replacement of all of that class of component or material throughout the entire set of equipment supply or tender installations awarded to that Supplier.

C: Technical Specifications and Standards for PVP systems

C.1. General

This specification is intended for solar PV water pumping systems in the range 400Wp to 50kWp. The configuration would generally be stand-alone systems, without batteries, but with back-up electrical generator.

Many modern solar pumps can be operated selectively from different power supplied, for instance one of solar, or even grid supply. These hybrid solar/diesel configuration systems are considered in the commissioning and acceptance procedures as pure solar systems.

C.1.1. Introduction

The ***Standard Technical Specification*** details the general system requirements, standard of design and workmanship, and quality of material for the installation, and is supported by the drawings listed in the ***Chapter 5: Schedule of Drawings***, and tables in the ***Chapter 6: Schedule of Tables***.

Project-specific data are given in the ***Project Specification* (Appendix 3)**. .

C.1.2. Scope of standard specification

The scope of this specification covers the following items: supply, installation, testing, commissioning, hand-over in proper working order and maintenance. Any cost or other requirements for coordination and liaison with other contractors or relevant parties is also included in this contract.

The scope of the contract includes, but is not limited to, the following:

Major equipment

- Photovoltaic Modules
- Pump controller (Maximum power point tracking devices, DC/DC converters, DC/AC inverters, etc.)
- Water pump(s) and motors (as specified in the ***Project Specification***).
- Diesel generator and change-over interface to operate the pump efficiently
- Remote monitoring, data-logging and remote control (as specified in the ***Project Specification***).

Minor equipment

- Borehole riser pipes
- Borehole head
- Pump mountings for sumps where required
- Non-return and control valves, strainers
- Water flow and pressure meters
- Complete balance-of-systems (BOS) equipment including array supports, bypass diodes, fuses, wiring, connectors, junction boxes, isolators and switchgear.
- Earthing and bonding
- Lightning protection against induced surges, but not direct strikes (as specified in the ***Project Specification***).
- Additional water storage tanks (as specified in the ***Project Specification***).
- All other materials and labour to install, test, commission and hand over the systems in terms of the Specification and Schedules.
- Spares for the number of years operation

C.2. System Performance Requirements and Design

C.2.1. General design requirements

The purpose of this specification is to maximise the following system characteristics:

- robustness and reliability of the installation
- security of the system
- consistent and adequate performance of the system
- cost-effectiveness of water output over the system lifetime
- low maintenance of the system
- operation, maintenance and fault-finding simplicity (able to be performed by community operator without specialised tools)
- long life of the system
- adequate attention to backup services and parts availability over the system lifetime
- upgrade-ability
- minimal environmental impact and aesthetically pleasing

These characteristics will constitute the key criteria whereby tenders are evaluated, and are at the core of the system acceptance test. The onus rests on the bidder/contractor/supplier/installer to ensure that systems are optimally designed, configured, installed and supported in accordance with the above requirements.

The systems, including all supporting infrastructure, shall be designed and constructed to operate normally under the environmental conditions summarised in table below.**Error! Reference source not found.**

Table 2: Environmental conditions

Criteria	Condition
Minimum Ambient Temperature (oC)	15 ºC
Maximum Ambient Temperature (oC)	40 ºC
Humidity (%)	85%
Wind Speed (m/s)	Up to 35m/s or 120km/h
Altitude (m)	1,500 m AMSL
Corrosion	Compliance with ISO-12944, C5M

C.2.2. System configurations

This Standard Specification is intended to cover one configuration of PV pump, being solar PV with change-over to generator back-up.

Refer to schematic of the systems in to ***Schedule of Drawings: DWG.SCH.1. and DWG.SCH.2.:Schematic of PVP configuration***.

The specific design parameters and configurations required are presented in the ***Project Specification.***

C.2.3. Design parameters

The system performance requirements are defined by the following design parameters:

- Pump rating (kW) (see ***Project Specification***)
- Array size (kWp) (see ***Project Specification***)
- Pump controller rating (kW) (see ***Project Specification***)
- Borehole characteristics: (see ***Project Specification***)
- System lifetimes: 20 years
- Component lifetimes: 10 years

System performance will be confirmed in the Acceptance Test before the system is deemed acceptable (see ***Chapter 7 Acceptance Test Procedures for Solar PVP Systems***).

Unless provided in the ***Project Specification***, final site, water source, and hydraulic characteristics must be assessed on site by the supplier before ordering equipment.

C.2.4. Maximum allowable performance degradation

Maximum acceptable performance degradation over the system lifetime is to be 10% of the output required in the Project Specification. If greater degradation is expected, systems should be oversized to ensure that the acceptable lifetime degradation level is not exceeded.

Zero performance degradation is allowed within the first year of operation.

C.2.5. Theft and vandalism resistance

Systems shall be designed, configured and installed such that they are subject to reduced risk of theft and vandalism. The risk applies primarily to solar panels. The risk of the systems to vandalism and theft has a principal effect on their viability, and hence this specification focuses on technical measures in the system configurations to minimise the effects of theft and vandalism.

Other technical measures (such as alarms, fencing, and very secure solar panel mounting) and social measures (via strong community participation and allocation of responsibility to watch over panels) will need to be well considered to reduce the instances of theft and vandalism.

C.2.6. Fault-finding and user friendliness

The system design and configuration shall allow for easy fault-finding by system operators. This may include the use of LEDs or volt/amp meters to determine whether various components or groups of components are performing as per specification, or are faulty.

C.2.7. Maintenance

Systems should be as maintenance free as possible, and maintenance requirements should be predictable. System operation and routine maintenance should be within the capabilities of community pump operators, but would exclude withdrawing of deep borehole pumps. Where special tools are required, they are to be supplied as a part of the contract, and included in the tender price.

C.2.8. System efficiency

Since high system efficiencies are critical to minimize system initial costs, the system is to be configured such that overall daily efficiency is maximized.

Performance data for each of key components and sub-system components shall be provided as per ***Section C.2.10 System Performance Information, & Chapter 4: Technical Bid Submission Form 2***).

C.2.9. System performance information

In relation to the System Efficiency data to be provided. Since high system efficiencies are critical to minimize system initial costs, the system is to be configured such that overall daily efficiency is maximized.

C.2.9.1. Array performance data

Array performance curves shall be provided. This data shall be used for assessing system performance during bid evaluation, and Acceptance Testing (see ***Chapter 7: Acceptance Test Procedure***.

The performance curves shall reflect the maximum power available at the power conditioner input (assuming maximum power point tracking), and shall include all diode and wiring losses:

- instantaneous DC power output at maximum power point (MPP) versus instantaneous solar irradiation. The power output shall be for typical operating temperatures for that irradiation (NOCT), and the operating temperature shall be declared on the curves.
- average daily DC energy versus daily solar insolation. The energy shall be determined at NOCT.

The curves shall be used as input to the *Subsystem Performance Data curves ('wire-to-water' curves).*

C.2.9.2. Power conditioner performance data

Power conditioning throughput efficiency curves shall be provided for the range of operating conditions expected of the system.

Instantaneous electrical efficiencies should preferably be above 95% over the full range of operating conditions.

Refer to ***Schedule of Tables: 2 Power Conditioner Performance Data*** for the data typically required. Note that any reduction in array power output caused by the power conditioner operating off the array maximum power point (i.e. tracking inefficiencies) shall be specifically excluded from the power conditioner efficiency, as this is likely to be both array and power conditioner specific. In other words, the input to the subsystem performance data ('wire-to-water' curves below) shall be the maximum array power achievable at NOCT, together with a further separate allowance for >tracking efficiency=.

C.2.9.3. Motor performance data

Motor manufacturer test certificates may be requested by the Purchaser. Sufficient data to meet the requirements stated in ***Section C.2.10 System Performance Information*** shall be provided.

C.2.9.4. Pump performance data

A set of curves indicating pump output under a range of head and RPM shall be provided. More detailed curves (i.e. pump output vs. kW & rpm / motor torque & speed / etc, and head starting torque) shall also be offered. Sufficient data to meet the requirements stated **in *Section C.2.11 System Performance Information*** shall be provided.

C.2.9.5. Sub-system performance data ('wire-to-water' curves)

Performance curves for the complete sub-system comprising 'Power Conditioner/ Motor/ Pump' shall be furnished. These will be used in evaluating system performance during *Acceptance Testing* (see ***Chapter 7: Acceptance Test Procedure***), in conjunction with the *Array Performance Data*, and an estimate of the >tracking efficiency=.

Refer to ***Schedule of Tables: 1: Sub-system Performance Data*** for typical data required.

The sub-system performance curves shall show the >wire to water= conversion, but shall specifically exclude the >tracking efficiency= by the power conditioner of the PV array maximum power point:

- instantaneous water output versus DC input power to the power conditioner at various heads
- average daily water delivery versus daily DC energy input to the power conditioner at various heads.

While the curves shall be constructed from actual measured data for the complete sub-system, sufficient data on the individual components in the subsystem shall be provided to enable construction and checking the curves from a theoretical perspective.

C.2.9.6. System efficiency

C.2.10.6.1 Instantaneous sub-system power efficiency: η(Instantaneous sub-system)

This is defined as the *instantaneous 'wire-to-water' efficiency*, from the DC power input measured to the power conditioner, to the power output of water delivered by the pump at the working head and pressures.

η(Instantaneous sub-system) = η(Power conditioner) x η(motor) x η(pump) x η(losses)

= hydraulic power / DC input power

Where:

Hydraulic power (kW) = flow (m^3/hour) x pumping head (m) x 9.8 /3,600

DC input Power (kW) = Irradiation(kW/m^2) x Array STC power(kWp) x η(array tracking)

C.2.10.6.2 Average daily sub-system energy efficiency: η(average daily sub-system)

This is defined as the *average daily 'wire-to-water' Efficiency*, from the DC energy input to the power conditioner, to the energy output of water delivered by the pump at the working head and pressures. It is usually determined by integrating energy and water delivery over the duration of a complete operating day.

η(average sub-system) = Σ [η(Instantaneous sub-system)]

= Σ [η(Power conditioner) x η(motor) x η(pump) x η(losses)]

= hydraulic energy / DC input energy

Where:

Hydraulic energy (kWh) = volume (m^3/day) x pumping head (m) x 9.8 /3,600

DC input energy (kWh) = Insolation (kWh/m^2/day) x Array STC power(kWp) x η(array tracking)

An estimate of the *Daily Energy Efficiency* for the electrical subsystem shall also be given (power to water efficiency, excluding the array).

C.2.10.6.2 Instantaneous water output

The instantaneous water output (m^3/hour) shall be estimated by calculating:

= Irradiation(kW/m^2) x Array STC power(kWp) x η(array tracking) x η(Instantaneous sub-system)

/ [pumping head (m) x 9.8 /3,600]

C.2.11.6.2 Average daily water output

The average daily water volume deliverable (m^3/day) for any month shall be estimated by calculating:

= Insolation(kWh/m^2/day) x Array STC power(kWp) x η(array tracking) x η(average daily sub-system$_{month}$)

/ [pumping head (m) x 9.8 /3,600]

C.2.10. Spares

Sets of spares are required to maintain immediate spares stocks for the number and type of systems in each project Area. The bidders shall price for both *Mandatory Spares,* and *Recommended Spares*.

Each LOT requires at least the minimum number of spares specified below. The Supplier shall supply the following *Mandatory Spares,* and compose and deliver at the end of the Warranty Period an optimal package of spare parts typically comprising the following items. **See *Chapter 4: Technical Bid Submission Form 4.4.***

In addition, the Bidder shall draw up a list of *Recommended Spares,* comprising of high-usage and high-value items of components and spare parts, for usage in the initial period of operation specified in the Maintenance Period, and to cost for these items. **See *Chapter 4: Technical Bid Submission Form 5.*** Failure to cost for these recommended spares will result in an incomplete bid.

C.3. Code of Practice for Installation of Solar Pumping Systems

C.3.1. Installation Standards

The AC elements of installations shall comply with the *British Wiring Standards BS 7671*. The other relevant international standard for wiring of buildings is **IEC 60364.**

Kenyan electrical installation personnel shall be registered with an installation license issued by Electricity and Petroleum Regulatory Authority (EPRA), relevant to the type of installation, who shall sign off the works.

As noted in ***Section B.2.6***, the installation requirements may be revised based on the benchmarks established during the Pilot installations.

C.3.2. Protection against theft and vandalism

Solar PV systems are inherently at risk to theft and vandalism. Bidders shall provide specific descriptions of the measures which are included in the supply and installation of the systems to minimize the risks of theft and vandalism. These anti-theft and anti-vandalism measures must be based on an understanding and analysis of the modes of theft or vandalism which are possible in the service areas. For instance, location of the array in an inaccessible position, use of tamper proof modules screws, and nuts and bolts on array frames spot-welded after installation.

C.3.3. PV array mounting

C.3.3.1. Structure assembly

The structure for large installations shall be designed for mounting on the ground onto a concrete base. Pole-mount structures are acceptable for installations of small sub-arrays (further below).

The array mounting structure will hold the photovoltaic module(s). The module(s) must be mounted on a support structure made of corrosion resistant material that assures stable and secure attachment.

The structure shall be corrosion resistant; and shall be hot-dipped galvanized steel in accordance with IEC-ISO 1461(2009), or anodized aluminium. All nuts, bolts and washers shall be stainless steel, and any other mounting material shall be of corrosion resistant material. Any welding, holes drilled, or surface damage to galvanising shall be treated with Galvadip™, Adensotape™ or Petrotape™ systems, or other approved cold-galvanising treatments substantially equivalent to those.

The method of fixing the PV modules to the support structure and the support structure to the base shall reduce the risk of theft and vandalism (e.g. using stainless steel rivets rather than aluminium rivets or bolts). The suggested method is to weld array security frames onto the structure after module installation. The security frame assembly should be designed to integrate as part of the total original structure and take into consideration the actual modules used.

Refer to ***Schedule of Drawings: DWG.STR 2: Array and module structure security assembly***.

The structure and mounting arrangements shall be compatible with the earthing requirements called for in ***Section C.3.14.1 Array grounding***. Specifically, the structure shall make provision for earthing of the each module frame, see ***Schedule of Drawings: DWG.STR.6. Array frame flange grounding for module earth.***

PV array and support structure shall be designed to withstand loads from wind gusts of 120 km/hour.

Bidders are to provide detailed drawings of their proposed structure for each system type, including foundations, pole base mounting arrangements, and wind loading calculations.

Pole mount structures are suitable for individual sub-arrays of up to 2.5 m^2 in area. The vertical pole shall be supported by means of a concrete base without guy wires. The assembled array structure installed on top of the pole shall be reasonably balanced, and the lowest part shall be at least 2m above ground level. The selected array tilt angle shall be maintained and secured by multiple bolts and lateral bracing (tensioning by a single axial bolt is unacceptable). Detailed drawings of mounting structures shall be submitted.

Ground mount structures: large installations shall utilize ground mount lattice array structures, secured onto concrete bases. The lowest part of any modules mounted on the structure shall be at least 2m above ground level to reduce access and minimize vandalism. Detailed drawings of mounting structures shall be submitted.

C.3.3.2. Selection of the PV site

In all cases, the design of the mounting structure shall to ensure compliance with the requirements of:

- Orientation: array shall face the equator, and in cases where this is not possible the a deviation of ±45° from equator orientation is acceptable.
- Shading: array location shall be chosen such that there will be no shading from trees, antennas, other building parts, etc. onto the PV modules between 08:30 and 16:00, in all seasons of the year.
- Concrete plinths of the structures may not damage or interfere with any existing structures nor interfere with local activities, plans or services. Structures must themselves be protected from mechanical damage.
- Lowest part of any module from the ground shall be 2m to reduce vandalism risk, and to prevent shading by grass or other vegetation and to minimise settling of dust on the modules. Consideration should be given to possible future shading by vegetation growth (e.g. the position of young trees) over the system lifetime.
- Sufficient space around the array mounting shall allow for additional structures should the system be upgraded in the future. Particular attention should be given to future shading from fencing or from the new array structures.
- Sufficient space around the array mounting shall allow for solar PV cleaning and maintenance

No deviations from these requirements will be tolerated, and no claims for additional costs will be entertained.

C.3.4. Array cabling and PV module interconnection

The installation of the large and higher voltage PV arrays shall comply with the standard of

- *IEC 62548 Ed.1: Design requirements for photovoltaic arrays*
- *IEC 60364-9-1: Low-voltage electrical installations - Part 9-1: installation, design and safety requirements for photovoltaic systems (PV).*

Wiring shall be permanently shaded from UV radiation. Wiring shall be *'Flexible multi-strand copper conductor cables in flexible UV resistant (e.g. Neoprene) sheath compatible with gland seals',* with any array junction boxes as may be required.

Modules shall be interconnected using professional PV array quick connectors available for array fly-leads cables in the 2-4mm2 range, for example Multi-Contact™, Tyco™, SunClix™.

- the array junction boxes, alternatively quick-connector Y connectors may be used to parallel strings.

C.3.5. Security Enclosure

A security enclosure or lockable room shall house the control cubicle, with power conditioner, switchgear and controls, and remote monitoring systems.

The security enclosure shall be vandal resilient, secure and with no exposed bolts to enable it to be tampered with. It shall be lockable, and locks recessed and inaccessible to vandals.

The enclosure need not provide more environmental protection more than IP13 as its primary purpose is to provide security. Key components within the security enclosure shall include the control cubicle (which should provide IP54 or higher protection), and the power conditioner which may also be installed within the control cubicle.

Refer to ***Schedule of Drawings: DWG.STR.2:Security enclosure around the control cubicle and power conditioner***

C.3.6. Control cubicle and controls

C.3.6.1. General

The water pumping system shall be managed by an operator. The layout, general safety features and labelling shall enable the operator to control the system without any damage either to the system, or individual components or to themselves.

It is recognised that some features mentioned below may be integrated into power conditioners. In instances when required features are not integrated into the power conditioner, then a separate control cubicle shall be provided. Where practical, the power conditioner may then be integrated into the control cubicle design.

The control cubicle shall be IP54 at least, and insect-proof. It shall be lockable even though within the Security Enclosure. Where practical, all required indicators shall be visible without unlocking the control cubicle.

If both DC and AC circuits are routed through the control cubicle, then these shall be clearly physically separated and necessary safety precautions taken in system design and layout, with necessary warning notices posted.

C.3.6.2. Operational configuration of the control cubicle

The control cubicle shall include the following features and control gear, which shall be clearly labelled:

- *Array isolator* (array feed to control cubicle): A manual override switch shall be provided to disconnect the power conditioning from the array (unless the power conditioning and modules are integral units, in which case a switch shall be provided to disconnect the motor from the power source).
- *Pump/motor isolator* (power conditioner feed to pump motor): pump and motor must be manually controllable B manual switch B marked MANUAL ON/OFF (should be left on usually)@.
- *Hi-level cut-off relay* (if required in ***Project Specification***): to cut-off when tank is full, and to reset only when tank level drops below pre-determined level again. Indicator light to show this has happened, and an override switch shall be included.
- *Low level cut off relay* (if required in ***Project Specification***): to cut-off when the well or borehole level becomes low, and to reset when borehole or well rises to predetermined level. Indicator light and an override switch shall be included
- *Indicators & electronic meters*: diagnostic equipment to be considered: Voltmeters, Ammeters, Indicator lights for fault diagnosis and state diagnosis (cut off, run dry, component failure, etc)
- *Generator CB*: 2 pole of 4 pole as required
- *Lightning surge arrestor protection* with indicators on the following cables (where required in the ***Project Specification***):
    - DC inputs from array
    - AC/ DC outputs to motor
    - DC cables to level switches

  Lightning protection requirements are specified in ***Section C.3.15. Lightning protection***.

Refer to ***Schedule of Drawings: DWG.SCH.4: Schematic of the control cubicle, with isolators & optional lightning protection*** and ***DWG.SCH.1 and 2: Schematic of solar PVP configurations***

Diagram for control cubicle to be provided with submission.

C.3.6.3. Component specification within the control cubicle

Overload protection circuit breakers

Overload protection Circuit-breaker's shall be rated as follows:

Mounting	Modular DIN rail mounting (same cutout as MCB)
Type:	Thermal-magnetic current limiting circuit-breaker
Breaking capacity:	at least 3kA at AC 220V
Trip characteristic:	10 to 14 x I rated (trip time <0.1 s)
	1 to 1.5 x I rated (trip time <10 s)
Rating:	full operating current plus 50%

Array breaker

A conventional single or dual-pole DC rated breaker for the array input.

Pump/motor breaker

A conventional multi-pole breaker, to ensure power conditioner has additional over-current or short-circuit protection. DC pump systems should include dual-pole isolation or dual-pole breakers.

High-level cut out relay (& low-level)

A logic-linked circuit which automatically prevents pumping when a signal is received from the three-wire electronic/mercury float switches in the header tank, sump or borehole. The circuit may be integral to the power conditioner. Manual over-ride or bypass switches are required.

The over-ride switches to the cables shall be breakers, and isolators are not acceptable. The cables to the level switches are a primary source of induced lightning surges and power conditioner faults, and for this reason they shall always be protected by breakers.

Refer to ***Schedule of Drawings: DWG.SCH.4: Schematic of the control cubicle, with isolators & optional lightning protection***

Generator CB

A conventional dual, or 3, or 4 pole AC-rated breaker for input from generator.

Generator change-over switch or system (where there is existing generator)

A break-before-make change-over switch rated for generator and pump start currents, and for necessary number of poles, and in N-PE earthing arrangement, neutral shall not be switched.

Alternatively, an integrated VSD or electronic change-over system shall be provided as a power conditioning component (refer *Section C.4.3*).

C.3.7. Pump and motor

C.3.7.1. General

Non-return valves to be installed where pump type and header pipe volumes are such that significant backflow can occur, i.e. more than 2% of the daily water delivery.

At sites where freezing is a possibility, positive displacement pumping systems must be installed with suitable pressure relief valves fitted to prevent damage in the event of pipe freezing. Refer to ***Section C.3.8.5 Pressure-relief valves.***

Manufactures installation instructions are to be followed.

C.3.7.2. Submersible pumps

Pumps are to be suspended at least 1.5 meters from the bottom of the borehole or sump to avoid silting up of pump. Project Specification will stipulate exact depth. The additional weight of water in the rising main to be taken into account when the pipe and support cables are fully extended.

Straining wire to be used for lowering all submersible pumps (either stainless wire for large pumps, or non-degradeable rope for small pumps), with the exception of units installed with steel riser pipes or line shafts, or with 'Boreline™' or similar flexible hosing. Straining wire is to be strapped to the riser pipes every 5m, while the power cable is to be unstressed and taped every 3m. At the borehole head, a bore-cap to be used to support the weight of the entire submersible installation on the borehole head.

C.3.7.3. Installation of motor

Surface mount motors to be bolted onto a single stable concrete plinth, and protected against direct sunlight and rain by a removable shield and to add to theft resistance.

C.3.8. Rising pipes and valves

C.3.8.1. General

All pipes and fittings shall be constructed of suitable corrosion resistant materials. Water quality tests (see ***Project Specification***) are to be considered in this regard.

Surface pipes shall be smooth, with low relative roughness, to minimise dynamic pressure losses. High Density Polyethylene (HDPE) or drawn galvanised steel pipes shall be used.

Borehole riser pipes shall be 'Boreline' or similar flexible material for ease of access for submersible pump servicing.

Rising pipes, joins and valves are to be installed leak-free, using accepted joining methods. PTFE tape is to be used for high pressure joins.

Where it is important that pipes are vertical (as with line-shaft systems), spacers are to be used at suitable intervals.

C.3.8.2. Dynamic head pressure losses

The dynamic head loss of pipework from pump to borehole head water-meter outlet shall not exceed the static head by more than 10%.

The total dynamic head loss of the entire system from pump to water tanks shall be reduced should this be deemed critical within the ***Project Specification***.

Maximum flowrate for sizing

The maximum flow rate for calculating the dynamic head shall be calculated as follows:

$$Q_{MAXIMUM} = V_{DESIGN} / 5 \text{ hour pumping period x } 110\%$$

Note: that the design flowrate may be required to be higher by a specified percentage to cater for future expansion of the system.

Rating of pipes and fittings

The pressure ratings for pipes and fittings selected shall be for continuous operation at least 150% of the total head. The piping and fittings shall be rated for operation at 20^{o}C.

The wall thicknesses of all pipes shall comply with 10MPa design stress. 18MPa design stress pipes not suitable, as they are designed primarily for irrigation and are not appropriate for reticulation purposes.

Minimum ratings for piping

- For total head < 10m - use at least Class 6 pipe i.e. rated for 600kPa or 6 bar
- For total head > 10m - use at least Class 10 pipe i.e. rated for 1,000kPa or 10 bar
- For steel galvanised piping in general, pipes of OD >25mm shall be of Medium Wall Thickness.

Minimum ratings for fittings

- at least 1,000kPa rating (10 bar), but preferably 1,600kPa (16 bar)

Calculation of dynamic head

Dynamic head losses may be calculated from the charts included in ***Schedules of Tables 3 (a,b). Pressure losses through pipe fittings***. The following charts shall be the basis of the total head calculation:

- pipe losses
- pipe elbows
- non-return valves
- globe/gate valves
- water meters

Where Bidders offer particular components that perform better than the typical, those performance curves may be included for consideration. However, the charts shall take precedence for design flow calculations.

If performance for any particular component is likely to be worse than the losses expected from the data in the charts, then the Bidder shall be obliged to mention this specifically in **the *Chapter 4: Technical Bid Submission Form 1***, and those figures shall then form the basis for the pressure drop calculation.

C.3.8.3. Gate & globe valves

Gate or globe valves shall be installed to enable servicing and isolation of main components. See ***Schedule of Drawings: DWG.STR.3: Location of main valves and metering*** for the typical layout:

- at the manometer, to enable removal or replacement, or to enable or disable readings
- between the pump and the water meter, but after the manometer, usually at the borehole head
- at any other locations in the riser and transmission pipe that may be required to facilitate servicing.

All valves shall have the facility to be locked into the relevant open/closed or partially open positions to prevent damage to the system caused by unauthorised tampering or inadvertent valve closure.

Valves shall be selected with minimum K factor in open position to minimise dynamic head losses.

C.3.8.4. Non-return valves

All external non-return valves should be of stainless-steel material, and further the plastic check valves offered as integral to some centrifugal pumps should be replaced with stainless-steel types.

In general, non-return valves are supplied integral with the specific pumps that require them to optimize performance. This is usually where the pump type is such that backflow can occur, i.e. certain submersibles. The issue is most important to system efficiency in instances where large volumes are water are stored in the riser and transmission pipes. See ***Schedule of Drawings: DWG.STR.3 Location of main valves and metering*** for the typical layout.

- A non-return valve is to be located as close to the pump outlet as is practically possible to minimise daily backflow losses.

Valves shall be selected with minimum K factor in open position to minimise dynamic head losses.

C.3.8.5. Pressure-relief valves

In general, pressure relief valves are not required. However, at sites where control/globe or gate valves have been installed in combination with sensitive diaphragm pumps, and where sudden closure of such valves could cause pump damage, suitable pressure relief valves are to be installed at the control/gate valve inlet.

Further, at sites where water freezing is a possibility, positive displacement pumping systems must be installed with an additional, suitably rated pressure relief valve fitted to the pump to prevent damage to the pump in the event of pipe freezing. See ***Schedule of Drawings: DWG.STR.3. Location of main valves and metering*** for the typical layout.

C.3.9. Water-meter

C.3.9.1. General

The water meters shall be a flow totaliser of a mechanical nature. The meter shall be robust and protected against external damage by a suitable cover. It shall be constructed of suitable corrosion resistant materials against internal damage. Water quality tests (see ***Project Specification***) are to be considered in this regard.

The water meter at borehole head shall be pulse output type, compatible with logging system.

C.3.9.2. Accuracy and resolution

Diameter to be as per pipework, and to minimise pressure losses.

The meter should be operational relative to the *design flow rate* in the pump systems.

- Q_{min} < 2% x design flow,
- Q_t (transitional) > 10% x design flow
- Q_n < design flow < Q_{max} , where Q_{max} >150% x design flow

Where

Q_n	is the designated flow of the meter
Q_{max}	is the maximum flow with maximum permitted error
Q_{min}	is the lowest flow within maximum permitted error
Qt	is the low at which maximum error changes

In general a Class B meter will suffice. The accuracy of the meter shall be at worst

- 5% at Q_t
- 2% at Q_n

C.3.9.3. Dynamic-head pressure drop

Valves shall be selected with minimum K factor in open position to minimise dynamic head losses.

Refer to ***Schedule of Tables: 3 (a,b) Pressure losses through pipe fittings***

C.3.10. Manometer pressure gauge

C.3.10.1. General

The pressure gauge shall be a manometer type. The manometer shall be robust, suitable for outdoor use, and protected against external damage by a suitable cover. It shall be manufactured from suitable corrosion resistant material against internal damage. The gauge shall be operational over the entire pressure range of 10% of total head to 150% of the design head.

C.3.10.2. Accuracy and resolution

The accuracy of the meter shall be 3% at 10% of the design head. Full scale of the meter shall be no more than 150% and not less than 120% of the design head.

C.3.10.3. Installation

The unit shall be installed on a T-piece and shall be isolated from the system by a gate or globe valve. The meter shall be located as close to the pump as practical. Refer to ***Schedule of Drawings: DWG.SR.3 Location of main valves and metering*** for the typical location.

C.3.11. Borehole /well head

The borehole /well head is to be closed with a concrete plinth and lockable baseplate. The baseplate is to be galvanised, and have an attachment for the submersible pump safety cable.

At the borehole head, a bore-cap or base-plate, to be used to support the weight of the entire submersible installation on the borehole head. The entire baseplate is to be sealed with protection for the pump power cable against chafing.

C.3.12. Supplementary water storage tanks

Any supplementary storage required shall be high quality UV-resistant polyethylene, similar to Kiboko™ or SimTank™ tank, and each additional tank shall be of minimum volume 10,000 litres.

The supplementary tanks shall be stored adjacent to the main storage tank. They shall be installed at a level so that the useable supplementary volume required in the specification is achieved by simple interconnection to the main storage tank (without any additional controls). All necessary interconnections to main storage shall be provided.

Additional earthworks or structures required shall be provided by the supplier under change-order after Inception Visits. Should additional supplementary storage tanks be required due to achieve the specified usable supplementary storage volumes, then these shall be treated as change-orders after Inception Visits.

Water tanks shall be supplied and installed on 6m tall tank stands (for purposes of bidding).

C.3.13. Chlorinator

Prime cost pricing for component similar to *WaterMissions™ Potable Water Chlorinator* to be provided in ***Chapter 4: Technical Bid Submission, Form 4.3 BoQ for Additional works***.

The chlorinator(s) shall be installed adjacent to the main storage tank on the incoming water main. It shall be installed in a shaded environment protected out of direct sunshine and protected from elements, and from tampering. All necessary interconnections to water main shall be provided. The manufacturer’s installation requirements shall be followed and it shall be accessible for operational adjustments.

C.3.14. Diesel generator installation

All diesel generators, whether existing units or new units, shall be installed on a concrete plinth, under cover and protected from elements, in a secure and lockable building or security enclosure. The exhaust shall be vented direct to outside the building. This is in addition to their enclosed canopy.

C.3.15 Cables, wires and electrical connectors

C.3.15.1 General

All external wiring, cabling, insulation material and junction boxes must be UV-resistant and terminals protected against dust and moisture (IP rating: 54). Refer to ***Schedule of Tables:4. Degrees of protection provided by enclosures***.

With the exception of steel wire armoured (SWA) cable, or array cables, no exposed wiring shall be permitted. Submersible pump cable shall be not be exposed except within the borehole. All wiring shall be inside galvanised conduit, galvanised kick-pipes, within junction boxes or control cubicles. The wiring installation shall be both physically robust against bumping and tugging, and electrically robust.

All wiring and connectors should have a design lifetime of 20 years.

All wiring shall be colour-coded and/or labelled, as follows:

- DC circuits
  - Red = positive (however PV single conductor cable wiring can be black)
  - Black or blue = negative
  - Green-yellow = earth
- AC 1-phase circuits
  - Red only = live
  - Bluek only = neutral
  - Green -yellow = earth
- AC 3-phase circuits
  - Brown = L1
  - Black = L2
  - Grey = L3
  - Blue = neutral
  - Green-yellow = earth

In addition, where a mix of AC and DC circuits are used within any enclosure or building, the circuits shall be clearly labelled on each wire.

C.3.15.2 Electrical connectors and cable-ends

All wiring must be neatly done and secured by means of appropriate fasteners at regular intervals. Wiring lengths shall be sufficiently looped to allow ease of connection and disconnection in the case of component replacement, and for maintenance.

Conductor lugs should be used to terminate all wiring. Lugs and connectors should be crimped or soldered, and mechanically and electrically sound. Critical connections of less than 16A connections may be made using terminal blocks. Higher current DC connections shall be ferruled.

Any wiring connections (with the exception of borehole or underground connections), whether internal, external, high voltage or low voltage shall be inside accessible junction boxes.

Borehole connections and underground connections shall be avoided by using correct wiring lengths, but where they cannot be avoided then they shall be made using recognised and approved wiring splicing kits.

C.3.15.3. Junction boxes

All junction boxes shall be rated to IP54 with bottom entry glands. They shall be located to facilitate inspections with sufficiently long wiring loops.

Any medium and high voltage junction boxes shall be labelled as such, and shall be lock-able or accessible only with a special key. These junction box shall be also be clearly numbered, and shall include a relevant wiring diagram inside the lid or the wiring shall be clearly numbered, and cross-referenced to the ‘as-built’ drawings.

C.3.15.4. Underground cables

All buried cables shall be steel wire armoured (SWA). Any underground cable connections must be approved watertight corrosion resistant types.

Cables crossing roads or driveways should be protected by steel or concrete pipes buried in the ground, or suspended by brackets and strain reliefs at a suitable height above the ground.

- Wires must be clearly labelled with the circuit number at each end
- Underground cable runs to buried 600 mm below ground level.

C.3.15.5. Submersible pump/motor cables

Underwater joints in submersible cables shall be avoided Where they are used, they are to be of high quality, using splicing kits rated for this purpose and with an extended lifetime.

Submersible cables are to conform to *EN 50525-2-21 and VDE 0298-300* standards.

C.3.15.6. Wiring losses and allowed voltage drops

Wire gauges shall be selected to minimise energy losses or system performance problems through wire degradation.

Source circuits

> (i.e. array - power conditioning) shall be designed to limit round trip voltage drops between array junction-box and power conditioning terminals to 2% of the nominal wiring voltage for peak array current ratings at 25ºC ambient temperature and 1,000 W/m^2 solar radiation. Voltage drops to include connector losses. (Voltage drop would be the difference between voltages measured simultaneously at the array junction box (positive and negative) and power conditioner input (positive and negative)).

Load circuits

> (i.e. power conditioning - motor) circuits shall be designed to limit round trip voltage drops between power conditioning terminals and the motor to 5% of the nominal wiring voltage for full load current ratings. Voltage drops to include connector losses.

The cables shall be insulated copper wires. The minimal cross section shall be

$$S = \frac{0{,}023 * L * I_m}{V * \Delta V\%}$$

where

S	is the cable cross section area (mm$^{2)}$
L	is the one-way cable length for a single cable (m)
Im	is the maximum current (A)
V	is the nominal voltage of the appliance (V)
ΔV%	is the maximum allowed voltage drop (%)

Notwithstanding the above calculations, the minimum wire size requirements below shall apply.

C.3.15.7. Wiring types and specific installation requirements

The following minimum wiring guidelines shall apply, over and above the previous requirements:

All cables exposed to outdoors shall be UV resistant sunlight, damp and heat resistant.[1]

- ***PV module interconnection:*** *'Flexible multi-strand copper single conductor cables in flexible UV resistant sheath (e.g Neoprene) compatible with gland seals'*. Minimum 2.5mm^2 XSA conductor

- ***Array (JB) to Power Conditioner/Control Cubicle:*** *'Flexible multi-strand copper conductor, with single conductor in flexible UV resistant sheath (e.g. Neoprene), with polarity indication'*. Minimum 4.0mm^2 XSA conductor [Preferably installed within galvanised conduit for protection].
- ***Power conditioner/control cubicle to surface pump:*** either
  - *Steel Wire armoured* **(SWA):** 'high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC; insulated cores are PVC bedded and SWA and PVC sheathed*'. Minimum 2.5mm^2 XSA conductor*
    or
  - *Correctly rated wire within galvanised conduit:* 'high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC*'. Minimum 2.5mm^2 XSA conductor, installed within galvanised conduit.*
- ***Submersible pump cable:*** '*high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC; insulated cores are PVC nitrile sheathed, water resistant*'. Minimum 3.0mm^2 XSA conductor
- ***Power conditioner/control cubicle to submersible pump:*** either
  - SWA with junction box at borehole head changing to submersible pump cable: ***SWA:*** '*high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC; insulated cores are PVC bedded and SWA and PVC sheathed*'. Minimum 2.5mm^2 XSA conductor
    or
  - Submersible pump cable protect in galvanised conduit buried underground.
- ***Sense cables (remote water level switch at sump or primary storage):*** Any underground cable runs SWA with junction box connection to level switch cable. ***SWA*:** '*high conductivity stranded plain copper conductors, insulated and coded with general purpose PVC. These insulated cores are PVC bedded and SWA and PVC sheathed*'. Minimum 1.5mm^2 XSA conductor.

C.3.16. System grounding

C.3.16.1. Ssytem equipotential bonding

As a rule, all metallic parts of the installations must be at the same potential.

The array structures of all systems require grounding. The systems shall be provided with an equipment ground where the PV array metal structure and the roof structure if metal are connected to an earth electrode via insulated stranded copper earth wire 6 mm^2 minimum). The maximum allowable earth cable resistance between array frame and earth electrode shall be 2.0 Ohms, including earth electrode connection (but excluding the earth electrode earth impedance

C.3.16.2. Electrical earthing

Neither the positive nor the negative DC conductors are grounded.

C.3.16.3. Earth electrode

The maximum earth electrode earth impedance target is 100 ohms. This figure is sufficient to fulfil functions of (i) array lightning surge earth path, (ii) system bonding and equipment protection, and (iii) enable earth leakage device fault tripping.

In sites with high earth contract resistances, then the following additional steps shall be taken towards this target:

- Electrodes shall be buried with activated charcoal or salt to improve contact resistance
- Up to three electrodes may if necessary be inter-connected (OR increased in length) to minimize

the earth contact resistance.

No additional steps shall be required hereafter.

C.3.16.4. Submersible Pump Motor Earthing

The pump supplier may specify special requirements for submersible pump earthing which are compatible with its power conditioner. The pump itself may not be used as a systems or equipment earth electrode.

The electrical configuration of the power conditioner and its specifications must be checked, together with specific supplier's requirements for earthing. The Bidder shall supply information relating to power conditioner galvanic isolation and internal earthing in the ***Chapter 4: Technical Bid Submission Form 1.2***.

C.3.17. Lightning Protection

C.3.17.1. Locations Requiring Additional Lightning Protection

Where there is an increased risk of lightning activity, either direct strikes or nearby lightning strikes which will cause induced surges in cables, then additional protection precautions must be taken. ***Schedule of Tables:5.Lightning ground flash density*** indicate approximate distribution of lightning activity.

If the ***Project Specification*** does not stipulate the level of lightning protection required, then the Ground Flash Density map will apply. Risks of lightning damage to electronic components are serious at locations where the Ground Flash Density is greater than 3.5. For detailed calculations of the actual frequency of strikes expected, refer to http://lightningsafety.com/nlsi_info.html

C.3.17.2. General

The lightning protection devices are not designed to prevent damage caused by direct strikes. Direct strikes will usually be destructive.

However, the lightning protection devices are designed to prevent any voltage spikes induced in buried or overhead wires from reaching any of the system components via the power cable conductors, by offering a controlled path to earth under surge conditions. Lightning surge protection devices are generally placed between the system components and the sources of induced surge. Lightning protection devices are generally located on cables between:

- array junction box and power conditioner
- pump power conditioner output and motor
- control cubicle and float level switches
- any other any long distribution power or signal cables.

C.3.17.3. DC side lightning protction

DC lightning protection in the form of a SPD Class 2 (using metal oxide varistor and internal deconnection) at the input to the inverters is obligatory as specified in *section C.4.5* as a minimum on all systems, irrespective of PV system size.

More sophisticated power conditioners already incorporate some or high levels of DC and AC lightning protection.

- Class 2 protection requirements
    - if Class 2 devices are contained within the power conditioner, then this protection shall suffice for Class 2 protection.
    - if not included within the power conditioner, then Class 2 protection shall require this external components as per below:

C.3.17.4. Additional Protection Requirements (Class 1 & Class 2)

Class 1& Class 2 combined protection shall always require this additional protection, and the requirements stated below are in-addition to any internal protection devices.

The following additional protection specifications shall apply unless similar specification protection devices are included and integrated within the power conditioner:

- ***Lightning protected array junction box***: as per specification for External DC lightning protection system (***Section C3.17.5***), and shall be located near the array structure earth point or stud (Class 2 or Class 1&2 as required).
- ***Lightning protected power conditioner DC input*** (often integral to power conditioner): When the power conditioner is located physically far away from the array or separated by underground cable, then a separate external protection system shall be installed (as for array JB), located near the power conditioner (Class 2 or Class 1&2 as required).
- ***Lightning protected power conditioner AC output*** (often integral to power conditioner): (Class 2 or Class 1&2 as required).
- ***Lightning protected earth point at motor or wellhead***. Any long power cable runs between power conditioner and borehole head shall be separately protected, (as for relevant DC/AC lightning protection), in a junction box located at the wellhead for submersible pumps (Class 1 or Class 1&2 as required), or at surface motor earth point.

Refer to ***Schedule of Drawings: DWG.SCH.5: Lightning protection system for PV pumping system*** of a complete lightning protection system.

C.3.17.5. Specifications of the Lightning Protection System

External DC lightning protection systems (array junction box)

As per ***Schedule of Drawings: DWG.SCH.6. Over-voltage protected circuitry for junction box for DC circuits***,

Device breakdown voltage to be maximum of 5 times the nominal wire voltage.

- Class 2 protection lightning surge arrestors with visual fault indication, 25kA according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *SALTEK™ PV 500V Class 2, or Cirprotec™ PSM3-40/600PV Class2*
- Class 1 protection lightning surge arrestors with visual fault indication, 25kA according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *Cirprotec™ PSC3-12.5/600PV Class 1&2.*

AC lightning protection systems

As per ***Schedule of Drawings: DWG.SCH.7. Over-voltage protected circuitry for junction box for AC circuits***, . Device breakdown voltage to be maximum 5 times the nominal wire voltage.

- Class 2 protection lightning surge arrestors with visual fault indication, 25kA (8/20) according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *Dehnguard™ Class 2 952110.*
- Class 2 protection lightning surge arrestors with visual fault indication, 25kA (8/20) according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Similar to *Dehnguard™ Class I&2 951110.*

C.3.18. Safety signs, labels and notices

C.3.18.1. General

Industrial quality signs shall be used, complying with the general requirements of *ISO 3864-2: 2004*.

In particular, all signs, labels and notices are to be made of weather resistant material and shall be properly secured by means which will not decay with moisture or sunlight over the period of the system lifetime.

Signs shall be of a size that they can be easily read, and shall make use of good use of colour for clarity, and shall follow the SABS guidelines for use of colour.and shapes. Refer to ***Schedule of Tables:6(a,b,c,d) Safety sign conventions*** for an extract from the *ISO 3864-2: 2004* documentation.

While standard industrial signage may be available, the exact meaning of the sign shall be accessible and appropriate to the level of understanding of the operators and persons likely to come into contact with the system. If necessary, modified signs shall be developed using the general guidelines for shapes and colours.

Samples of all signs, labels and notices shall be available for inspection, discussion with and approval by the Purchaser prior to manufacture.

C.3.18.2. Signs Required

The following mandatory signs are to be attached in the relevant places:

Danger /warning signs

- **Electrical Danger - High Voltage DC!** Signs located on power conditioner and any DC junction boxes where voltages are 100V DC or above. The system voltage is to be clearly displayed inside the cover of the junction box.

Electrical safety information

- Separate trunkings shall be used for DC cables, AC cables, and instrument or communication cables. These trunking shall be clearly labelled.
- All cables inside junction boxes, enclosures and trunking are to be numbered, and the numbers shall cross-refer to the wiring diagrams.

Prohibition signs

- Clear signage shall be displayed to caution against any specific instances where action may cause damage or injury. For example: if sudden valve closure may damage the pump; or if extreme high pressure water may be released; or if change-over from solar to diesel generator requires specific cautions.

Instruction signage

A single A4 sheet shall be posted to describe each of the following operations:

- Emergency switch off procedures
- Basic start-up procedures
- Change-over from solar power to diesel generator back-up (where relevant)
- Daily and weekly reading and measurements

Information signs

- General notice: regarding information around the pumping system implementation: i.e. Community name, date, funding agency, implementation agency.
- Installation contractor: A notice with the local pumping system agent contact details and the installers contact details if different (including contact person, telephone number and postal address) must also be suitably located on the system.
- Wiring connection diagrams are to be attached inside main enclosures, and in the manuals.

Safety signs

- **First aid signage**, shall be displayed if appropriate, including treatment for electrical burns and shock if system voltages are over 220V in any location.

Additional signage may be required for specific systems or installations.

C.3.19. Compliance with Regulations and Codes

The entire contract must be carried out in accordance with the latest revisions and amendments of the following:

- *IEC 60364-1:2005,Low voltage electrical installations,* and the latest amendments.
- *IEC 60364-9-1: Low-voltage electrical installations - Part 9-1: installation, design and safety requirements for photovoltaic systems (PV).*

C.3.20. Maintenance kits

The supplier shall supply:

- 1 x (one) complete maintenance kit for each site.
- 1 x (one) enginener maintenance kit for LOT

The kits shall include the minimum components listed below. Please refer to ***Chapter 4: Technical Bid Submission Form and BoQ form 4.5***:

Table 3: Maintenance kit components

		Maintenance per LOT engineer	**Maintenance kit per site**
		Qty	**Qty**
Item	**Description**		
Laptop	Refer *Tech form 1.7*	3	0
Digital clamp . Multi-meter	(minimum range 0-600V DC, 0-300 V AC, accuracy min 1%, 0.01V resolution)	3	1
Current clamp meter	(range 0-40A, accuracy 1%, resolution 0.1A for AC and DC 40 A, including thermocouple and leads. Recommended model: TCM 02 DC/AC clamp meter – 600 VDC	3	1
Basic tool kit	Including set of insulated screwdrivers to fit all terminals on DIN rail/inverter/power conditioner; small/narrow pliers, wire cutters/strippers, crimp tool with set of lugs, insulating tape, etc.	3	1
Stop watch	digital	0	1
Step ladder	to reach solar array	0	1
Water bucket		0	1
Squeegee	to clean solar array	0	1
Marker pens		0	5

C.4. Component Technical Specifications and Standards

These specifications and standards provide the overall specifications for main components and materials supplied within the bid. Individual components must comply with the technical specification and technical standard(s) indicated in the sections below (*sections C.4.1 to C.4.5*).

Specific technical details regarding the solar PVP systems minor component are set out in ***Section "C.3. Code of Practice for Installation"***.

C.4.1. Accredited laboratories

Individual components must comply with the technical specification and technical standard(s) indicated in the sections below (*sections C.4.2 to C.4.5*).

The systems and components to be used under this procurement, must have valid test certificates for their qualification as per specified IEC or equivalent standards[2], from ISO 17025[3] certified or equivalent accredited test center. An accredited test center is one of (a) Test Center accredited by ILAC Full Member or Associate (b) one of National Accreditation Board for Testing & Calibration Laboratories (NABL)-Accredited Test Centers in India; (c) one of the China National Accreditation Service for Conformity Assessment (CNAS)-Accredited Test Centers in China; (d) laboratories under the Hydraulic Institute Pump Test Laboratory Approval Programme. ***A copy of the accreditation certificate issued to the Test Center authorizing it to conduct and certify the specific tests in the standard under consideration must be provided[4].***

C.4.1.1. IEC Standard certificate

In general the full standard of the International Electro-technical Commission (IEC) is applied. Specifically, a certified quality test certificate is required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered complies with the entire referenced technical standard, based on the sampling approach of that technical standard.

- A certified copy of the **component's Compliance Certificate** shall be required from the ISO17026 accredited Certification Body corresponding to the accredited Test Center.
- A copy of the **Test Center's accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results may be requested for the specific tests in the standard.
- This form of accreditation is required for the following components only:
    - PV modules - all certificates
- This form is but is also accepted for all required component certificates as below:
    - Power conditioner / inverters /converters (Safety; Efficiency / performance; Noise and emissions)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

[2] The equivalence is to be provided by the bidder in order for the equivalence standard to be acceptable. Examples of equivalent standards include those under BS, IS, DIN, IECEE etc,

[3] ISO/IEC 17025:2005 - General requirements for the competence of testing and calibration laboratories.

[4] Certification Organisation links:

- http://ilac.org/about-ilac/
- http://www.nabl-india.org/index.php?option=com_content&view=frontpage&Itemid=123, https://www.cnas.org.cn/english/index.shtml

C.4.1.2. Test result certification based on testing to partial IEC standard, without Certification

The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. Therefore provision is made for testing to only the relevant parts of the standard. Certified test results are required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered have been tested to referenced test procedure in the standard, based on the sampling approach of that technical standard.

- A copy of the **Test Center accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results shall be provided for the specific tests conducted in the standard for all the samples tested.
- This form of accreditation is acceptable for the following component certificates only:
    - Power conditioner / inverters / converters
        - Safety, Efficiency / performance, Noise and emissions
    - Pumps and motors
        - Safety, Performance characterisation
    - Monitoring systems
        - Performance

C.4.1.3. ISO9001 In-house certifications based on in-house R&D test results

The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. In addition many manufacturers perform rigorous in-house testing of their components before going to market. Therefore the ISO9001 Declaration of Compliance Form was developed to qualify components of ISO9001 certified manufacturers which are tested in their in-house ISO9001 research and development laboratories, to either full or partial standard. The ISO9001 Declaration certificate may only be used for components manufactured by ISO9001 company, AND tested to the relevant full standard (or partial standard procedures) referenced in the bid document. The Declaration must be supported by the test results for all the samples tested.

- See ***Section IV: Bid Forms: Statement of Compliance for Components by ISO 9001 Certified Manufacturer*** .
- Proof of the manufacturer's ISO9001 accreditation from an approved accreditation agency is required.
- **Proof of competence of the manufacturer's testing facility**: its existence, equipment and equipment calibrations, staffing, and suitability to undertake the specific tests. This competence shall preferably be **via inspection and reference from a National Certification Body**[5].
- Presentation of detailed **supporting test results** is required for all samples tested, complemented by reference to the standard test method or detailed alternative **test methodology** where standards do not exist, and supported by an **inventory of test equipment** used.
- This form of accreditation is acceptable for the following component certificates only:
    - Power conditioner / inverters/ converters
        - Efficiency, performance
    - Pumps and motors
        - Safety, Performance characterisation
    - Monitoring systems
        - Performance

Bidders must submit detailed documentation for each component proving that the products offered comply with the technical standards via one of the means set out above. Products or components that do not comply with any of the above quality certification requirements will not be acceptable.

C.4.2. Photovoltaic (PV) modules

C.4.2.1. Certification standards

Compulsory certifications for crystalline modules::

- *IEC 61215 (2005-04): Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*
- *IEC 61730-1:2016: Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction and related test method in Part 2.*
- *IEC 61701 Ed.2: Salt mist corrosion testing of photovoltaic (PV) modules*

PV modules shall meet the following requirements:

C.4.2.2. Particular requirements

a) The photovoltaic (PV) array shall consist of mono-crystalline or poly-crystalline modules. Note that thin film modules are not acceptable.

b) High-power high-voltage modules are favoured over low power low-voltage modules

c) Only a maximum of two standard size of module (one manufacturer) shall be used to facilitate spares and parts management.

C.4.2.3. General requirements

a) All PV modules within an array shall be of the same type and hence interchangeable.

b) Each module must be factory equipped with 14 to 12 AWG (2.0 to 4mm^2) fly-leads length approximately 800mm with weather-proof connectors for interconnection of modules into strings without any additional wiring. There are a multitude of professional PV array quick connectors available for array fly-leads cables in the 2-4mm2 range, for example Multi-Contact™, Tyco™, SunClix™. The connectors shall have the following features:

- Class II rating for fly-leads and connectors
- system voltage 1,000V maximum,
- IP65 protection rating
- temperature up to 90oC
- 20A current rating
- 2.5-4mm2 cables
- Snapping locking system

c) The module framing should be such that it permits secure connection to the mounting structure, prevents edge damage and has the longevity to withstand environmental factors for the duration of the module warranty period.

C.4.2.4. Electrical performance

a) The tolerance of rated output of the PV modules offered shall be positive only. Negative tolerances are not allowed.

b) Module warranty: 25 years: The PV modules shall be warranted to retain at least 80 percent of its nominal rated output measured at STC for at least twenty-five years.

C.4.2.5. Labelling and documentation

a) Labelling: Each module must be labelled indicating at a minimum:

- Manufacturer, Model Number, Serial Number,
- Maximum Power Point Watt Rating (Wp ± tolerance),
- Maximum Power Point Current,

- Maximum Power Point Voltage,
- Open Circuit Voltage and Short Circuit Current of each module.

b) The supplier is required to provide for each PV Module offered the following data: Equipment Origin, Type of Certification, and the following general data
- I-V Curves at AM1.5, NOCT,
- Electrical data
  - Maximum Power Point Watt Rating (Wp ± tolerance),
  - Maximum Power Point Current,
  - Maximum Power Point Voltage,
  - Open Circuit Voltage and Short Circuit Current of each module.
- Dimensions,
- Warranty,
- Product brochure

c) The supplier is required to provide for each Panel supplied the following test data
- Flash test information for each individual module shall be provided.

C.4.3. Power conditioners / inverters/ converters

C.4.3.1. Certification standards

The required safety standard:

- *IEC 62109 Safety of power converters for use in photovoltaic (PV) power systems - Part 1: General requirements. Part 2: Particular requirements for inverters.*

Compulsory performance standard:

- *IEC 61683 Ed. 2.0: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency*

For noise and emission the following shall apply:

- *IEC CISPR 22 Radio disturbance characteristics – limits and methods of measurement.*
- *IEC 61000-4-2 Electromagnetic compatibility (EMC) Testing and measurement techniques – electrostatic discharge immunity test.*
- *IEC 61000-4-3 Electromagnetic compatibility (EMC) Testing and measurement techniques - radiated, radio frequency, electromagnetic field immunity test.*

In addition power conditioners shall meet the following requirements:

C.4.3.2. Particular requirements

a) Variations of *power conditioning* equipment are applicable to solar water pumping, including those listed below. Whichever power conditioning is offered, it shall be well matched with the array and motor such that overall system efficiency is maximised.
- DC systems: linear current boosters, sometimes included within each module terminal box
- DC/AC inverter, variable frequency inverter, either single phase or three phase
- Maximum power point trackers (MPPT), often used in conjunction with inverters
- Stand-alone programmable variable speed drives (VSD)
- Powerpack converters: allowing automatic changeover between DC solar array power and AC diesel generator power; or simultaneous parallel operation from both DC solar arrays and AC diesel generators for sites with existing generators.

b) Power conditioning should maximize water delivery, dealing with pump start-up torque requirements, and should start pumps early in the day even in inclement weather conditions. Inherent inefficiencies in the power conditioner through the day should be offset by the gains made in early pump starting and water delivery.

c) The electrical outputs of the power conditioner shall preferably be fully galvanically isolated from the DC. The state of galvanic isolation between power conditioner input and output shall be declared in the ***Chapter 4: Technical Bid Submission Form 1.2***.

d) Power conditioners shall be capable of operating the solar pump from diesel generator power as back-up, either directly or via additional componentry, without reprogramming of the power conditioner. Simultaneous solar power and diesel operation is not required.

e) Only one brand of each power conditioner type shall be used to facilitate spares and parts management.

C.4.3.3. General requirements and electrical performance

a) Rated output power (kVA) shall be at temperature of at least 25ºC

b) High conversion efficiency devices are required with the following minimum requirements when measured according to *IEC 61683 Ed. 2.0: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency*. The conversion efficiency shall be supplied.

c) Easy to service: easy to repair or replace in the field by the service technicians.

C.4.3.4. Electrical protection

a) Protection must include at least the following sustained normal conditions without cut-out:

- output current overload and starting surge capacity before cut-out (300% of maximum capacity for 20 seconds is desirable, or soft-start ability,
- maximum array open circuit voltage on the input terminals (cold clear weather) - normal operation without cut-out

b) Protection must include at least the following sustained fault conditions without damage:

- output current overload - sustained fault condition
- short circuit on input or output terminals - sustained fault condition
- under-or over-voltage conditions - sustained fault condition
- lightning-induced surges on all or any input or output terminals: all terminals subject to common and differential mode surges of 5kV for 50 micro-seconds.
- electronic overload/cut-out above 200% of the rated output and short-circuit protection on its output. A fused output is not acceptable.
- reverse polarity protection on DC input terminals.
- thermal overload protection.
- protection against N-E and L-E grounding downstream of conditioner.

C.4.3.5. Noise and emissions

a) Quiet operation: Acoustic noise generated by the inverter shall not exceed 35 dBA at a distance of 1m from the power conditioner under all loading conditions.

b) Electromagnetic interference: The power conditioner shall not cause conducted or radiated e.m.i. over the entire power range at a distance greater than 1m, when measured according to the requirements of IEC CISPR 22 for class B and IEC 61000-4-3.

c) Electrostatic discharge: The inverter shall comply with the requirements of the test procedures given in IEC 61000-4-2.

C.4.3.6. Documentation and labelling

a) Each power conditioner / inverter must be labelled with the minimum information:

- Manufacturer name and model
- Serial number
- Input and output voltage and rated power
- Array, supplementary power and load connection points and polarity

b) The supplier is required to provide the following data for each power conditioner offered:

- System rating (kW/kVA) with temperature de-rating curves/tables
- Input Voltage (DC) range for solar
- Supplementary input range (V, kW) for generator/grid
- Output Voltage (DC/AC)
- Output Frequency and Waveform
- Efficiency versus Power output graph
- Warranty
- Product brochure

C.4.4. Electric pump & motor

C.4.4.1. Certification standards

The required performance tests standards are one of

- *IEC 62253 Ed.1: Photovoltaic pumping systems - Design qualification and performance measurements*
- *ISO 9906: 2012: Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1, 2 and 3*
- *ANSI/ HI 14.6: 2011: Rotodynamic pumps for hydraulic performance acceptance tests (*Hydraulic Institute of North America)
- *ANSI/HI 11.6:2012: Rotodynamic* submersible pumps for hydraulic performance, hydrostatic pressure, mechanical, and electrical acceptance tests. *(*Hydraulic Institute of North America)

The required safety standards are one of

- *IEC 60034-18-41: Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control tests*
- *IEC 60034-18-42: Rotating electrical machines - Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters - Qualification tests.*

In addition the motor/pumps have to meet the following requirements:

C.4.4.2. Particular requirements

a) The motor/pump performance should match the system head/flow characteristics for optimum system performance.

b) The motor/pump at system design operating point, must have capacity for production of at least 15% more water by application of additional power to the motor. Motor/pump should be sized to handle the maximum power that can be produced by the array and power conditioning, plus at least 15%.

c) Any motor types are allowed provided that they meet system performance and system maintenance requirements.

d) Any pump types are allowed provided that they meet system performance and system maintenance requirements.

e) Only one brand of motor and one brand of pump shall be used to facilitate spares and parts management. Additionally the number of models should be minimised: a maximum of 5 models or sizes each of motor and pump is allowed. (Bidders which cannot meet the system performance requirements without introducing additional models should clearly state so in their offer (in the ***Technical Bid Submission Form***), and should also tabulate the models of motor/pumps offered and number for each.)

C.4.4.3. Mechanical requirements

a) Submersible motors shall be constructed of corrosion resistant materials suitable for permanent total immersion in water. In general, stainless-steel pump shall be used at a minimum (EN/DIN 1.4301 or AISI 304). Water quality tests (see *Project Specification*) are to be considered in this regard. In high water salinity (>1,000 ppm Cl) and high water temperature (> 20ºC) environments then stainless steel of EN/DIN 1.4401 / AISI 316 and even EN/DIN 1.4539 / AISI 904L shall be used.

b) Surface mount motors shall be to at least IP43 ratings against water, sand and dust penetration and damage. Surface motors shall be corrosion resistant, both the casing and windings shall be treated, and any flow of moist corrosive air shall not cause expansion of windings into the stator.

c) Motors/pump units should be constructed such that any failure of a pump component (diaphragms etc) does not cause damage to the motor.

d) The casings of both surace and submersible motors shall have earth points suitable for bonding to other equipment. The motor shall be fully electrically isolated from the casing.

e) The expected motor and pump lifetime shall be declared.

f) Pumps / motors requiring regular routine and preventative maintenance, such as brush replacement on DC motors, or diaphragms on some positive displacement pumps, should have maintenance requirements are to be specifically noted in the ***Chapter 4: Technical Bid Submission Form 1.3 and Appendix 2, and recommended spares in Appendix 3***.

g) Pumps shall be able to handle up to 5% suspended solids (50mg/litre) without damage and should have a 1mm screen around the inlet. Water quality tests (see ***Project Specification***) are to be considered in this regard, for up to 15% suspended solids (150mg/litre). To minimise the effects of silting and wear of impellers on system performance, impellers should generally be manufactured from stainless steel, rather than from plastic/elastomer, but where necessary FKM rubber wear rings may be specified to achieve the long life. In all cases, impellors are to be changeable as they wear, preferably in the field.

h) Submersible pumps must be able to operate at different submergence levels, since seasonal groundwater level variations can be significant in some parts of the country. Exact maximum depth of submergence is specified in the ***Project Specification***.

C.4.4.4. General requirements and electrical performance

a) Pumps are to be high efficiency with certified performance curves (***Section C.2.11.3, C.2.11.4 and C.2.11.5)***

b) Variable speed pumps or with soft-start are preferred.

C.4.4.5. Electrical protection

a) Running dry protection shall be provided, and the motor shall not restart until the motor/pump/inlet is again fully submersed as required. Indicator lights on the control cubicle shall be provided showing that the dry-running cut-out is effective. Refer also to ***Section C.3.6 High & Low Level Cut-out relays***.

b) Pump / motor protection must include at least the following sustained fault conditions without damage:

- output current overload - sustained fault condition
- short circuit on input or output terminals - sustained fault condition
- under-or over-voltage conditions - sustained fault condition
- lightning-induced surges on all or any input or output terminals: all terminals subject to common and differential mode surges of 5kV for 50 micro-seconds.
- Electronic overload/cut-out above 200% of the rated output and short-circuit protection on its output. A fused output is not acceptable.
- reverse polarity protection
- thermal overload protection.
- protection against N-E and L-E grounding downsteam of conditioner.

C.4.4.6. Documentation and labelling

a) Each pump / motor must be labelled with the minimum information:

- Manufacturer name and model
- Serial number/barcode

- Input voltage and rated power

b) The supplier is required to provide for each motor offered the following data:
- Rating (kW/kVA) with temperature de-rating curves/tables
- Input Voltage (DC/AC) range
- Certified motor and pump performance curves (***Section C.2.11.3, C.2.11.4 and C.2.11.5****)*
- Warranty
- Product brochure

C.4.5. Remote monitoring, data-logging and remote control

C.4.5.1. Certification standards

The required standard is:

- *IEC 61724 Ed 1: PV System Performance Monitoring Guidelines for measurement, data exchange and analysis* (to be superseded by Ed 2).

C.4.5.2. Introduction

The facility to remotely monitor PV pump system operational status is a significant advantage when operating multiple pumps in remote locations. Further, developments in electronic data-interfaces and improved cellphone internet coverage make this a totally achievable goal.

There are five levels of system monitoring and tiers of data access required are:

Local display

1. ***On-site display for user & operator interface***
    - Overall real-time display of system status and energy and power flows, across major components groups and too loads
        - PV generation (total)
        - Dieel generation)
    - Real-time current operational status / error notificaions
    - Access to individual electronic components, paramerters, performance and error-codes.
    - Historical trends data-logging of key performance parameters and operational status
    - Password protection "View access" and "Control access" tier accreditation required

Remote Access

2. ***Dashboard providing remote overview for <u>all sites:</u>***
    - Web-based interface (compatible with 2G coverage)
    - Overview of all sites with operational status, key parameters, and any error warnings.
    - Ideally compatible with AMMP^{TM} or Odyssey^{TM} or similar.
    - "Overiew access" tier accreditation required
3. ***Detailed performance remote access for <u>each site:</u>***
    - Drill down access via Dashboard to each site
    - Remote real-time monitoring of current operational status and some performance parameters
    - Historical trends data-logging of key performance parameters and operational status
    - API accessible to AMMP^{TM} or Odyssey^{TM} or similar.
    - On-site display for operator interface
    - Password protect "View access" and "Control access" tier accreditation required

4. ***Detailed remote status for <u>each component:</u>***
    - Drill down access from each site to each sites's component
    - Access to individual electronic components, paramerters, performance and error-codes.
    - "Site access" tier accreditation required, password protected.
5. ***Remote control***
    - If provided, shall be "Control access" tier accreditation required, password protected.

This section describes each of these, as well as the minimum parameters required to be useful.

It is noted that different PV pump manufacturers have different approaches to remote data monitoring, and so the specification if intended to be non-prescriptive, but to establish set a minimum standard of functional specification.

C.4.5.3. *C.4.5.3 Communication*

To enable real time performance tracking of PV system, the required components and transducers shall be provided as a system with an interface to communicate with base station data-logger. Communication between main components and with logger may be via RS485 /Ethernet. The logger shall communicate with the outside world via GSM/GPRS or other cloud-based connection, depending on the available coverage.

The logger shall store data at short time intervals for long time-durations, and routinely upload to a cloud-based server which is easily accessible for data analysis of performance trends.

Ideally data above should be:

- recorded, aggregated at maximum 10 minute intervals, and stored on the on-site logger
- uploaded at least once daily to the cloud based information system, preferably more frequently
- accessible on the cloud-based system at any time.

Integrated hardware systems which provide the transducers and communication interface are for example:

- Grundfos™ CIU GRM SQFlex models CIU270 to CIU273, and Grundfos GO APP
- Lorentz™ PS Data-module and PumpScanner APP, and PS Communicator

C.4.5.4. Remote monitoring and key parameters

Pump system information may variously include the following outputs in real-time:

- ***Pump status***
    - Pump status (running / waiting/ fail /stopped)
    - Pump electrical power (kW) and other electrical parameters (V,A)
    - Pump speed (rpm)
    - Flow rate (m^3/hr)
    - Pump temperature (^oC)
    - Power source (solar or diesel)
    - Solar irradiation (kW/m^2)
    - Water depth in borehole and drawdown
    - Pump operating pressure (kPA) (optional)

- ***Status indicators***
    - Level control information (water tank full)
    - Alarms
        - Dry running alarm
        - Service needed alarms (overvoltage, overload, over-temperature)
    - Message log

- ***Cumulative performance***
    - kWh consumed (kWh)
    - Water meter reading (cumulative m^3 total delivered)
    - Operating hours (hrs)
    - Number of starts (qty)
    - Cumulative solar radiation (kWh/m^2)
    - kWh generated by solar
    - kWh generated by diesel, and diesel runtimes

This system information should be accessible on web-based system, either on computer software or cellphone App, for example:

- Grundfos™ GO App or Grundfos Remote Management (GRM)
- Lorentz™ PumpScanner App.

Both of these apps also allow remote control of the pump system.

C.4.5.5. Transducers

The logging system shall include all necessary transducers, and shall specifically include the following:

- Water meter of pulse type matched to max flow at borehole head
- Transducer for borehole water depth (hydro-static level sensor 4-20mA, submersible pressure sensor), or equivalent;
    - Units similar to SensorsOne™ units: https://www.sensorsone.com/borehole-water-level-transducer-recharge-rates/ or https://www.sensorsone.com/imcl-low-cost-submersible-pressure-sensor/
- Pressure sensor at borehole head (optional)
- Solar radiation reference cell for instantaneous measurement and integration
- Pump power measurement
- Genset controller (AGS) or interface to determine power source (solar or diesel).

C.4.5.6. Historical trends data-logging of key performance parameters and operational status

The requirement (or not) for off-site historical trend data-logging is specified in ***Project Specification***.

The transducer interface in shall record the short term performance data, and may or may not store much long-term performance data. Ideally performance data should be stored at short time intervals for long time-durations, and routinely uploaded to a cloud-based server which is easily accessible for data analysis of performance trends.

Ideally data above should be:

- recorded, aggregated at maximum 10 minute intervals, and stored on the on-site logger
- uploaded at least once daily to the cloud based information system, preferably more frequently
- accessible on the cloud-based system at any time.

This system information should be accessible via cloud based data, using a dedicated data manager for PV pump performance viewing, for example:

- Lorentz™ PumpManager App.
- Grundfos™ GO App or Grundfos Remote Management (GRM)

The data manager should provide summations to facilitate viewing and comparison of performance data for the key variables over the following time periods:

- Hourly (i.e. compare and see the performance for sequences of several hours)
- Daily (i.e. compare performance for sequences of several days)

- Monthly (i.e. compare months)
- Annual (i.e. compare years)

The data manager should allow tracking of fleets of pumps, providing active reporting of status and problems, which greatly facilitates maintenance planning and remote diagnosis.

C.4.5.7. *Compatibilility, agility & longevity*

The monitoring system for each site shall be provided with a single dashboard enabled for all sites.

Furthermore, hardware and software is be proven and supported for 10 years. Manufacturer to have proven history of long lasting software historical support (5 years historical operation with backward compatibility of versions).

C.4.5.8. Documentation and labelling

a) The supplier shall provide information on software data-logging user interface for each pump system:
- Product brochure
- Technical specifications (comms, storage, software requirements, hardware requirements)
- Graphical interface; functional description, variables logged, summations
- Description of custom software requirements for this project
- Web-link to web-portal with demonstration of the features

b) The supplier is required to provide for each hardware logging set the following data:
- Product brochure
- Technical specifications (comms interfaces, data interfaces, power supply options, memory, firmware etc.)
- Operational costs of data transfer
- Warranty

C.4.6. Diesel generator

C.4.6.1. Certification standards

The required standard is:

- *ISO 8528-1: 2005: Reciprocating internal combustion engine driven alternating current generating sets: Part 1: Application, ratings and performance..*
- *ISO 8528-6: 2005: Reciprocating internal combustion engine driven alternating current generating sets: Part 6: Test methods.*

The required safety standards are one of

- *IEC 60034-18-41: Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control tests.*

  IEC 60034-18-42: Rotating electrical machines - Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters - Qualification tests.

C.4.6.2. Particular requirements

a) Generator performance shall be optimised to match requirements of the pump head/flow and power characteristics. The operational capacity shall include capacity for production of at least 15% more water by application of additional power to the motor from design operating point.

b) Sizing of the generator to meet the starting requirements of the pump controller / pump under design conditions is entirely the responsibility of the Supplier. General rules of thumb include kVA of:
- 2.5 x pump power for non-soft-start systems
- 1.5 x pump power for soft-start systems

c) Only one brand of generator shall be used to facilitate spares and parts management. A maximum of 5 models or sizes is allowed.

C.4.6.3. Mechanical requirements

a) Generator is required to include enclosed canopy, electric start with battery, and integrated fuel tank.

b) Casing of generator shall have earth points suitable for bonding to other equipment.

c) Expected lifetime of generator shall be declared, together with service requirements and fuel consumption curves. Local service centre and support.

C.4.6.4. Electrical protection

a) Rated at: frequency 50Hz, voltage 230Vac single phase, or 400Vac 3 phase

b) Generator protection must include at least the following sustained fault conditions without damage:
- output current overload - sustained fault condition
- short circuit on output terminals - sustained fault condition
- under-or over-voltage conditions - sustained fault condition
- electronic overload/cut-out – fused output is not acceptable.

c) Compatibility with PVP electrical earthing, i.e. Neutral shall be isolated from casing.

C.4.6.5. Documentation and labelling

a) Each generator must be labelled with the minimum information:
- Manufacturer name and model
- Serial number/barcode
- Output voltage, phases, frequency, rated power

b) The supplier is required to provide for each motor offered the following data:
- Rating (kW/kVA) with temperature de-rating curves/tables
- Warranty
- Product brochure
- Expected lifetime of generator, with service requirements and fuel consumption curves.
- Local service centre and support in Kenya.

D: Technical Specifications: Maintenance Services

The maintenance of the solar PVP systems installed at facilities during the after-sales period is an integral part of the requirements to ensure the full benefits of the systems. Maintenance shall be carried out by the Supplier according to the following GUARANTEED maintenance regimes.

- System performance reporting using remote monitoring
- Routine preventative maintenance
- Breakdown repair maintenance service

D.1. System performance tracking using remote monitoring

The Supplier, as part of the monthly routine maintenance, shall monitor the PVP system performance using the remote monitoring software. The supplier shall report on each system monthly as follows:

- System performance tracking and reporting based on the remote monitoring system for each installation. The information shall be reported for
  - each month
  - each day in the month
- Operational statistics to be reported monthly and daily include, but are not limited to:
  - Total water volume delivered
  - Water delivered using solar PVP
  - Water delivered when powered by diesel,
  - Solar hours pumped
  - Diesel hours operated
  - Total insolation
  - System efficiency
  - Average borehole water level
- System performance guarantee: confirmation that the system is operating within the specification for meeting the system performance guaranty, based on the remote data logging.
- Reporting on system performance degradation and suggested interventions.

D.2. Routine maintenance

Each PVP system should be visited according the following schedule for routine maintenance:

Table 4: Routine maintenance schedule

Routine visit no.	Within Maintenance Period	Outside of Maintenance Period
Maintenance Interval	Every 6 months	Ideally every 6 months, but outside of this scope of works

At each routine maintenance visit, the following actions should be undertaken:

Coordination tasks

- Confirm maintenance visit with responsible WSP/REREC member.
- Meet the responsible WSP/REREC on site

- Check status of the system WSP/REREC member and obtain feed-back on performance since the last maintenance visit.

Technical tasks

- Perform visual inspection – starting with appliances and working back towards the array. Check for corrosion, rust and physical damage to installation.
- Perform measurements of system status and performance – do not disconnect any wires or components, i.e. these measurements must be 'non-invasive' to avoid creating new problems.
- Diagnoses of any problems identified, check all array wiring and all connections, repair of any loose connections, corroded parts, or electrical cabling problems;
- Ensure that array is not shaded and that panel surfaces are clean.
- Check status of all isolating switches and set correctly.
- Checking pump performance wrt irradiation, head, and flow.
- Confirm functionality, calibration and reliability of the remote monitoring system.
- Pulling of pump if recommended in the maintenance schedule of the supplier ***(Chapter 4: Form 6)***, and undertaking any maintenance actions
- Check level of spares on site and make replacements as required.
- Replacement of any faulty or damaged equipment.

Administration tasks

- Record status and measurements on the maintenance log sheets
- Obtain signature of the staff member on log sheets
- Complete hard copy documentation
    - Place one copy of the completed log sheet in the O&M manual stored at site
    - Retain one copy of the log sheet for storage at solar PV company office
    - Retain one copy for submission with the annual report to the Purchaser
- Capture the maintenance activity to spreadsheet. This shall include at least the following:
- Dated Maintenance;
    - Verification of system identifier
        - Name of purchaser,
        - System unique number,
        - Region, district, village,
        - Location for verification purposes (i.e. GPS co-ordinate)
    - Items checked
    - Components replaced and new component information:
        - Module type, rating, qty, serial numbers
        - Inverter controller type, capacity, serial number
        - Pump type, capacity, serial number

- In the event of a breakdown, the maintenance tasks will be focused on the specific problem as identified by a fault diagnosis procedure. The maintenance staff must again complete a maintenance log sheet and store a copy both at the site and at the company office.

Training tasks

- Based on communications with WSP/REREC assess staff member understanding and responsibility for systems. Check whether there has been staff change and whether new staffs are on site.
- Provide follow-training to staff as part of the maintenance tasks. The follow-up training should target i) end-users and staff that received the first training and ii) new end-users and staff.

D.3. Breakdown repair maintenance service

Over the course of the Maintenance period, a breakdown repair service, defined below, will be available to deal with system breakdowns. Users at each of the solar PVP systems installed in accordance with this scope of work will have access to this breakdown repair service.

During the Warranty Period all callouts shall be unconditionally for the Supplier's account.

Table 5: Breakdown repair maintenance services

Warranty Period (Defects and maintenance)	Maintenance Period after Warranty period
As many as necessary, unconditionally for Supplier account	Supplier to budget for breakdown repairs

Breakdowns may be identified through complaint reported through the Fault Report call-center, or via the remote monitoring and reporting of system performance.

Breakdowns and faults are defined and layered in terms of responses required:

Table 6: Breakdown repair response times

Breakdown Type	Results and impact	Response Time for Making Good
Tier 1: no water delivered at all for one (1) working day, likely due to electrical, mechanical or communication faults with both Solar pump.	No water access for scheme.	24 hours for diagnosis, including remote monitoring. 48 hours after Supplier receives Fault Report.
Tier 2: limited water supply, due to failure of the PV pump system, with reliance on water storage	Failure is limiting and restricting water supply, with dependency on water stirage	5 working days after Supplier receives Fault Report

A response to a recorded enquiry or complaint should be provided within (48) forty-eight hours and the system should be restored to full functional capability within the period specified in ***Table** 6.*

Each logged complaint and notification of system failure shall be recorded by the Fault Report Call-centre, forwarded to Supplier (and copied to REREC), and the actions taken and action time should be recorded using the log sheet provided in ***Section D.5****.*

D.4. Maintenance/breakdown log sheets

A pair of templates for maintenance log sheets are presented below for routine maintenance and breakdown maintenance. Three copies of these log sheets must be completed for each system at the time of each routine maintenance or breakdown visit. One copy should be inserted in the O&M manual on site, one should be retained for submission semi-annually to the Purchaser; and the third should be kept by the Supplier.

Table 7: Routine maintenance log sheet

<table>
<tr><td colspan="4">Site details
Customer ID
System ID</td></tr>
<tr><td>Site name:</td><td></td><td>Starting time:</td><td></td></tr>
<tr><td>Date:</td><td></td><td>Finishing time:</td><td></td></tr>
<tr><td>Weather conditions:</td><td colspan="3"></td></tr>
<tr><td>Type of system:</td><td colspan="3"></td></tr>
<tr><td colspan="4">System status on arrival</td></tr>
<tr><td colspan="2">Inverter
Status?
Power output?</td><td colspan="2">Array
Status?
Current and voltage?</td></tr>
<tr><td colspan="2">Pump
Status?
Water output?</td><td colspan="2"></td></tr>
<tr><td colspan="4">Maintenance tasks (tick each box as complete)
☐ Clean PV array and check for damage
☐ Trim vegetation so PV array not shaded
☐ Check for corrosion, rust and physical damage to installation
☐ Check all array wiring connections
☐ Check array earthing connections and continuity *(make check-box for readings)
☐ Check array electrical isolation and resistance readings *(make check-box for readings)
☐ Check status of all isolating switches and set correctly
☐ Check status of all time switches and set correctly
☐ Check lightning protection systems and indicators in all locations
☐ Check pump status and operation
☐ Check water quality output and take sample for future testing reading *(make check-box for readings)
☐ Check remote monitoring system, and compare outputs to on-site meter reading *(make check-box for readings)
☐ Download remote monitoring system readings to laptop, check wifi and internet ability
☐ Remove pump from borehole
☐ Replace pump components *(make check-box for readings)
☐ Replace pump into borehole
☐ Confirm system operational *(make check-box for readings)
☐ Conduct system performance tests as per specification *(make check-box for readings)</td></tr>
<tr><td colspan="4">Register of equipment replaced: Note each item & serial number of equipment replaced during this visit</td></tr>
<tr><td colspan="2">Existing equipment removed:</td><td colspan="2">Replacement equipment provided:</td></tr>
<tr><td colspan="2">Responsible staff member</td><td colspan="2">Maintenance technician</td></tr>
<tr><td colspan="2">Signature:</td><td colspan="2">Signature:</td></tr>
<tr><td colspan="2">Name:</td><td colspan="2">Name:</td></tr>
<tr><td colspan="2">Date</td><td colspan="2">Date</td></tr>
</table>

Table 8: Breakdown maintenance log sheet

<table>
<tr><td colspan="4">Site details
Customer ID
System ID</td></tr>
<tr><td>Site name:</td><td></td><td>Starting time:</td><td></td></tr>
<tr><td>Date:</td><td></td><td>Finishing time:</td><td></td></tr>
<tr><td>Weather conditions:</td><td colspan="3"></td></tr>
<tr><td>Type of system:</td><td colspan="3"></td></tr>
<tr><td colspan="4">Description of problem(s)
What problems are reported by the customers / users ?</td></tr>
<tr><td colspan="4">Description of repair(s)
Describe all the repairs which have been made.
Complete routine maintenance checklist also.</td></tr>
<tr><td colspan="4">Register of equipment replaced: Note each item & serial number of equipment replaced during this visit</td></tr>
<tr><td colspan="2">Existing equipment removed:</td><td colspan="2">Replacement equipment provided:</td></tr>
<tr><td colspan="2">Responsible staff member</td><td colspan="2">Maintenance technician</td></tr>
<tr><td colspan="2">Signature:</td><td colspan="2">Signature:</td></tr>
<tr><td colspan="2">Name:</td><td colspan="2">Name:</td></tr>
<tr><td colspan="2">Date</td><td colspan="2">Date</td></tr>
</table>

D.5. Maintenance reporting and tracking

The Supplier will maintain organizational, staffing, logistical, inventory, recording and reporting capabilities and other arrangements sufficient to meet the managerial and technical requirements of providing the maintenance and other post installation services to systems installed in public facilities.

The Supplier will establish and maintain clear, accessible communications channels for the users and managers of PVP facilities to report faults and other problems.

The Supplier will maintain recording and reporting systems within a database that enables:

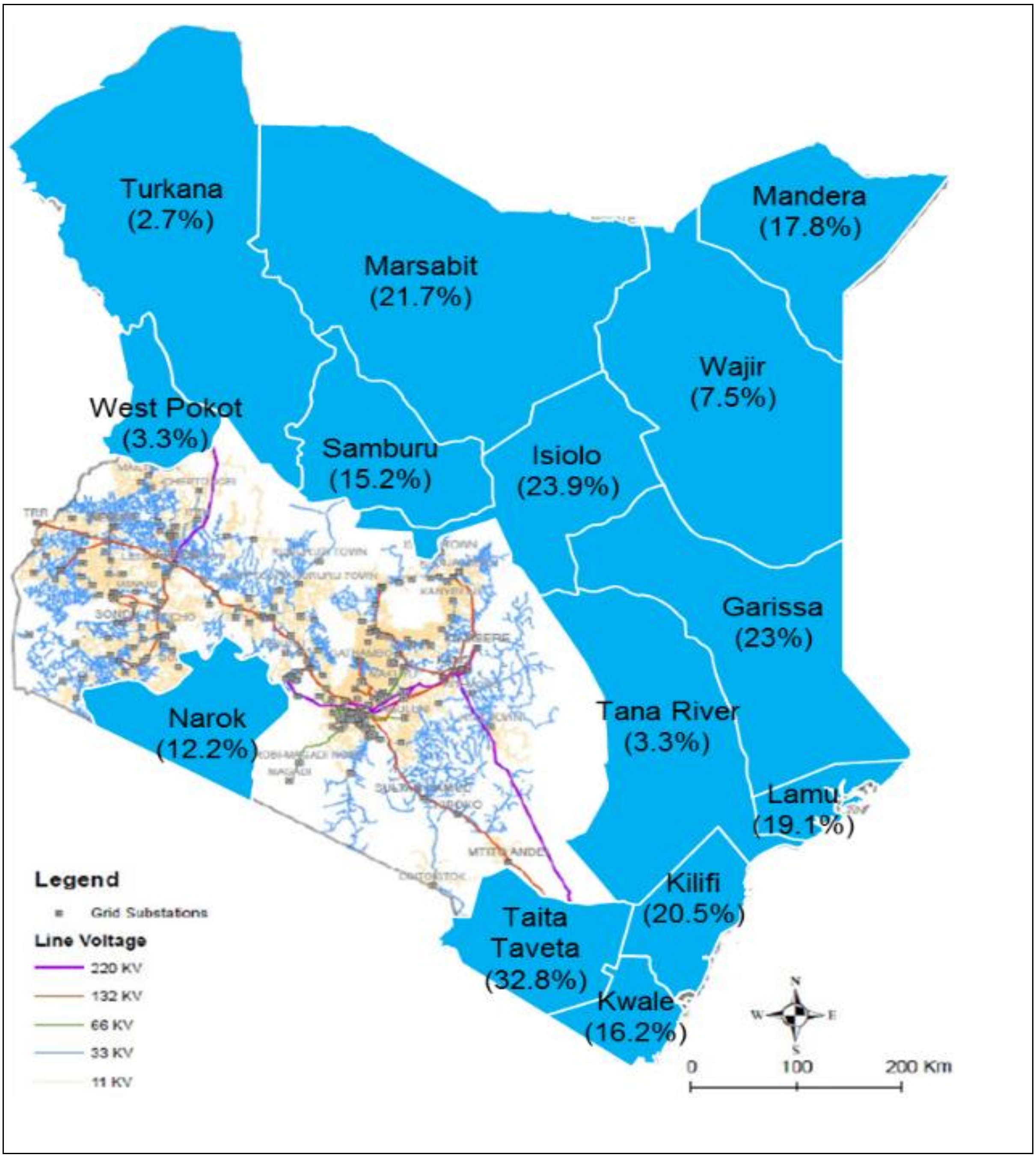
- accurate tracking of component and system performance and maintenance services, including records of complaints, repairs, component or system failures, downtimes and component replacements.
- capture the maintenance activities to spreadsheet . This shall include at least the following:
    - Dated Maintenance;
    - Verification of system identifier
        - Name of purchaser,
        - System unique number,
        - Region, district, village,
        - Location for verification purposes (i.e. GPS co-ordinate)
    - Items checked
    - Components replaced and new component information:
        - Module type, rating, qty, serial numbers
        - Inverter controller type, capacity, serial number
        - Pump type, capacity, serial number
- Access by the Purchaser to current electronic records and systems for tracking repair requests, responsiveness and status of systems.
- Accurate reporting by the Supplier on a bi-annual basis to the Purchaser.

The Supplier will submit bi-annual reports to the Purchaser that provide details on the status of the systems and the maintenance activities conducted. The reports will include the log sheets. The information to be provided will include complaints, repairs, component or system failures, downtimes and component replacements.

END

Appendix 1: Project Area Maps

Project being implemented in the Counties marked in colour blue in the Kenya Map hereunder



Appendix 2: Project Site Data

The following solar data have been used for this functional design (source *Homer Pro™*: *NASA Predictor of Worldwide Energy Resource [22 year period Jun 1983-Jun 2005]*).
The design month shall be September for all lots. The tilt angle shall be 15 degrees.

	Global solar horizontal radiation (GHI) ($kWh/m^2/day$)													
	Lot 1			Lot 2		Lot 3		Lot 4			Lot 5		Lot 6	
Month	Garissa	Lamu	Tana River	Wajir	Mandera	Kilifi	Kwale	Isiolo	Samburu	Marsabit	West Pokot	Turkana	Taita Taveta	Narok
Jan	5.53	5.55	5.44	6.11	6.54	5.71	5.8	6.47	6.49	6.13	6.2	6.18	6.18	6.1
Feb	6.05	5.96	5.94	6.51	6.98	6.2	6.07	7.05	6.98	6.62	6.67	6.58	6.57	6.58
Mar	6.02	5.95	5.98	6.17	6.57	5.95	5.7	6.71	6.68	6.49	6.44	6.39	6.04	6.49
Apr	5.76	5.47	5.69	5.62	5.46	5.43	5.15	6.18	6.2	5.96	5.94	5.8	5.32	5.95
May	5.48	4.79	5.16	5.46	5.25	4.75	4.58	6.07	6.2	5.84	5.76	5.79	4.59	5.69
Jun	5.1	4.57	4.76	5.01	4.68	4.56	4.49	5.75	5.94	5.55	5.38	5.66	4.32	5.53
Jul	5.24	4.72	4.84	5.03	4.65	4.61	4.58	5.72	5.89	5.86	5.21	5.71	4.37	5.48
Aug	5.57	5.16	5.13	5.38	5.15	4.87	4.86	6.08	6.26	6.2	5.55	6.17	4.7	5.81
Sep	6.15	5.7	5.77	5.87	5.82	5.51	5.46	6.86	6.9	6.79	6.34	6.62	5.58	6.3
Oct	6.07	5.8	5.93	5.48	5.1	5.76	5.56	6.24	6.29	6.14	5.97	6.06	5.85	6.08
Nov	5.36	5.54	5.44	5.08	5.06	5.55	5.55	5.45	5.65	5.54	5.54	5.68	5.57	5.6
Dec	5.25	5.41	5.32	5.43	5.88	5.54	5.63	5.86	6.05	5.67	5.88	5.87	5.79	5.82
Mean	**5.63**	**5.39**	**5.45**	**5.60**	**5.60**	**5.37**	**5.29**	**6.20**	**6.29**	**6.07**	**5.91**	**6.04**	**5.41**	**5.95**

Major wet season **Dry season**

	Ambient Temperature (ºC)													
	Lot 1			Lot 2		Lot 3		Lot 4			Lot 5		Lot 6	
Month	Garissa	Lamu	Tana River	Wajir	Mandera	Kilifi	Kwale	Isiolo	Samburu	Marsabit	West Pokot	Turkana	Taita Taveta	Narok
Jan	28.9	28.0	28.6	28.8	28.0	27.4	27.5	21.7	21.7	26.9	23.9	29.1	24.2	19.1
Feb	29.9	28.3	29.6	30.1	29.3	27.7	28.0	22.8	22.8	28.1	25.0	30.2	25.1	19.8
Mar	30.3	28.8	29.5	30.6	30.7	28.0	27.8	23.5	23.5	28.6	25.6	30.7	25.1	19.7
Apr	28.7	28.3	27.6	28.7	29.2	27.4	26.6	22.9	23.3	27.4	24.7	29.7	23.9	18.3
May	27.1	27.1	26.4	27.5	28.1	26.3	25.4	22.3	22.9	27.0	23.8	29.2	22.6	17.0
Jun	26.1	25.9	25.5	26.6	27.4	25.1	24.2	21.6	22.2	26.1	22.8	28.3	21.3	16.0
Jul	25.5	25.2	24.9	26.2	26.8	24.4	23.7	21.0	21.5	25.7	22.1	27.9	20.8	15.7
Aug	25.9	25.2	25.2	26.8	27.3	24.4	23.8	21.4	21.7	26.1	22.5	28.4	21.2	16.6
Sep	27.1	25.9	26.4	28.1	28.7	25.0	24.7	22.4	22.7	27.2	23.7	29.5	22.4	17.9
Oct	28.0	26.7	27.0	28.6	28.7	25.9	25.7	22.6	22.9	27.5	24.0	29.8	23.4	18.7
Nov	27.7	27.4	26.7	27.7	27.6	26.7	26.4	21.5	21.8	26.2	23.1	28.8	23.6	18.5
Dec	28.0	27.8	27.4	27.7	27.3	27.2	26.9	21.2	21.3	26.2	23.1	28.7	23.5	18.7
Mean	**27.8**	**27.0**	**27.1**	**28.1**	**28.3**	**26.3**	**25.9**	**22.1**	**22.4**	**26.9**	**23.7**	**29.2**	**23.1**	**18.0**

Appendix 3: Locations of sites and overall quantities (Project Specification)

Appendix 3.1: PVP Project requirements for all sites

Reference	Item	Requirement
C.3.3.1	Array security frames	*Y*
C.3.5	PVP switchgear enclosure or room	Y
C.4.6	Diesel generator	Y Bidders to cost to replace all generators
C.3.14	Diesel Generator Room	Y If not pre-existing
C.3.13	Chlorinator	No
	Fencing and gate around array	Y
C.3.17	Lightning protection Class II	Y
	Float switch at tank	Y
C.4.5	Remote data logging online	Y
C.4.5.6	Remote control of pump	Not mandatory

Appendix 3.2 PVP DESIGN DATA

Appendix 3.2.1 Lot 1: Garissa County

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m³/day)*	*Solar design volume (m³/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
001_GAR_BAL	Abdisamad	111	45	257	267	September	15.8	9.0	252	247	6	2	300	Submersible/ Borehole	15
002_GAR_BAL	Shimbirey 1	60	12	173	174	September	2.9	2.5	168	163	6	2	300	Submersible/ Borehole	6
003_GAR_DAD	Abdisugow	384	79	115	145	September	15.2	16.0	110	105	6	2	300	Submersible/ Borehole	15
004_GAR_DAD	AP Camp	115	89	125	162	September	19.2	18.0	120	115	6	2	300	Submersible/ Borehole	19
005_GAR_DAD	Godlie Farm	150	64	173	193	September	16.5	13.0	168	163	6	2	300	Submersible/ Borehole	11
006_GAR_DAD	Hagarbul	258	104	155	162	September	22.3	21.0	150	145	6	3	300	Submersible/ Borehole	25
007_GAR_DAD	Kadaqso	247	89	157	162	September	19.1	18.0	152	147	6	3	300	Submersible/ Borehole	19
008_GAR_DAD	Kwanjayarey	240	50	205	218	September	14.3	10.0	200	195	6	2	300	Submersible/ Borehole	15
009_GAR_DAD	Sheldub	326	74	114	141	September	13.8	15.0	109	104	6	2	300	Submersible/ Borehole	15
010_GAR_FAF	Alanjugur	258	119	161	170	September	26.7	24.0	156	151	6	3	300	Submersible/ Borehole	15
011_GAR_FAF	Amuma	227	94	175	181	September	22.5	19.0	170	165	6	3	300	Submersible/ Borehole	19
012_GAR_FAF	Fafi	235	99	137	143	September	18.8	20.0	132	127	6	3	300	Submersible/ Borehole	19
013_GAR_FAF	Jambele	48	10	85	86	September	1.1	2.0	80	75	6	2	300	Submersible/ Borehole	6
014_GAR_FAF	Nanigi	100	37	19	26	September	1.3	7.5	14	9	6	2	300	Submersible/ Borehole	11

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m^3/day)*	*Solar design volume (m^3/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
015_GAR_FAF	Ruqa	144	30	137	142	September	5.6	6.0	132	127	6	2	300	Submersible/ Borehole	11
016_GAR_FAF	Warable	50	26	110	114	September	3.9	5.2	105	100	6	2	300	Submersible/ Borehole	11
017_GAR_FAF	Welmarer	275	149	153	166	September	32.7	30.0	148	143	6	3	300	Submersible/ Borehole	19
018_GAR_HUL	Hulugho 1	465	140	158	170	September	31.5	28.3	153	148	6	3	300	Submersible/ Borehole	15
019_GAR_HUL	Hulugho 2	192	40	127	135	September	7.1	8.0	122	117	6	2	300	Submersible/ Borehole	11
020_GAR_HUL	Sangailu	338	138	188	200	September	36.5	27.9	183	178	6	3	300	Submersible/ Borehole	15
021_GAR_IJA	Handaro	563	206	201	225	September	61.5	41.6	196	191	6	3	300	Submersible/ Borehole	44
022_GAR_IJA	Hara	400	121	19	28	September	4.5	24.4	14	9	6	3	300	Submersible/ Shallow Well	6
023_GAR_IJA	Kotile	240	50	31	44	September	2.9	10.0	26	21	6	2	300	Submersible/ Borehole	15
024_GAR_LAG	Baraki 1	384	79	165	195	September	20.5	16.0	160	155	6	2	300	Submersible/ Borehole	15
025_GAR_LAG	Dehle	228	47	180	191	September	11.9	9.5	175	170	6	2	300	Submersible/ Borehole	6
026_GAR_LAG	Gurufa	192	40	149	157	September	8.3	8.0	144	139	6	2	300	Submersible/ Borehole	11
027_GAR_LAG	Shanta Abaq	264	54	185	200	September	14.4	11.0	180	175	6	2	300	Submersible/ Borehole	15

Appendix 3.2.2 Lot 1: Lamu County

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m^3/day)*	*Solar design volume (m^3/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
001_LAM_LAM	Kiwayuu well no.1	20	16	16	16	September	0.3	3.3	6	6	6	3	300	Submersible / Well	13.75
002_LAM_LAM	Kiwayuu well no.2	20	16	16	16	September	0.3	3.3	6	6	6	3	300	Submersible / Well	13.75
003_LAM_LAM	Kiwayuu well no.3	20	16	15	15	September	0.3	3.3	5	5	6	3	300	Submersible / Well	none
004_LAM_LAM	Kizingitini	78	16	15	16	September	0.3	3.3	5	5	6	3	900	Submersible / Well	45
005_LAM_LAM	Mulei Well	20	16	15	15	September	0.3	3.3	5	5	6	3	300	Submersible / Well	none
006_LAM_EAS	Mkokoni well no.1	20	16	15	17	September	0.4	3.3	5	5	6	2	300	Handpump/ Wells	none
007_LAM_LAM	Mkokoni well no.2	20	16	15	15	September	0.3	3.3	5	5	6	3	300	Handpump/ Wells	none
008_LAM_EAS	Rasini well no.1-5	80	80	15	45	September	4.8	16.3	5	5	6	2	300	Submersible/Surface Pump/ Wells	13.75
009_LAM_WES	Amkeni Primary Sch	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none
010_LAM_LAM	Bomani Pri	20	20	15	15	September	0.4	4.5	5	5	6	3	300	Handpump/ Wells	none
011_LAM_LAM	Hongwe AP camp	20	20	15	15	September	0.4	4.5	5	5	6	3	300	Handpump/ Wells	none
012_LAM_LAM	Kangaja Pri	20	20	15	15	September	0.4	4.5	5	5	6	3	300	Handpump/ Wells	none
013_LAM_WES	Kipungani	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none
014_LAM_WES	Kwa Guyo	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none
015_LAM_WES	Matondoni	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none
016_LAM_LAM	Mkunumbi pri	20	20	15	15	September	0.4	4.5	5	5	6	3	300	Handpump/ Wells	none
017_LAM_LAM	Ndeu pri	20	20	15	15	September	0.4	4.5	5	5	6	3	300	Handpump/ Wells	none
018_LAM_LAM	Ngoi Pri	20	20	15	15	September	0.4	4.5	5	5	6	3	300	Handpump/ Wells	none
019_LAM_WES	Poromoko Pri	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none
020_LAM_WES	Rehema Pri.	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none
021_LAM_WES	Thaku Thaku Teee nursery	20	20	15	17	September	0.5	4.5	5	5	6	2	300	Handpump/ Wells	none

Appendix 3.2.3 Lot 1: Tana River County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_TAN_RIV	Tana River	Maroni	50	30	46	51	Sept.	2.17	5	36	31	6	2	20	Hand Pump	No Genset
002_TAN_RIV	Tana River	Haroresa	70	42	120	125	Sept.	7.44	7	110	105	6	2	20	Submersible	15
003_TAN_RIV	Tana River	Kone Kaliti	180	108	115	120	Sept.	18.38	18	105	100	6	3	20	Hand Pump	No Genset
004_TAN_RIV	Tana River	Rhoka	40	24	30	35	Sept.	1.19	4	20	15	6	2	20	Hand Pump	No Genset
005_TAN_RIV	Tana River	Laini	50	30	28	33	Sept.	1.40	5	18	13	6	2	20	Hand Pump	No Genset
006_TAN_RIV	Tana River	Ghalamani	80	48	44	49	Sept.	3.33	8	34	29	6	2	20	Hand Pump	No Genset
007_TAN_DEL	Tana Delta	Maziwa	40	24	40	45	Sept.	1.53	4	30	25	6	2	20	Hand Pump	No Genset
008_TAN_DEL	Tana Delta	Gadeni Sec School	140	84	32	37	Sept.	4.41	14	22	17	6	3	20	Hand Pump	No Genset
009_TAN_DEL	Tana Delta	Assa	30	18	170	175	Sept.	4.47	3	160	155	6	2	20	Hand Pump	No Genset
010_TAN_DEL	Tana Delta	Kone	80	48	79	84	Sept.	5.72	8	69	64	6	2	20	Submersible	15
011_TAN_DEL	Tana Delta	Ngao Hospital	20	12	32	37	Sept.	0.63	2	22	17	6	2	20	Hand Pump	No Genset
012_TAN_DEL	Tana Delta	Tarasaa Secondary	40	24	90	95	Sept.	3.23	4	80	75	6	2	20	Submersible	11
013_TAN_DEL	Tana Delta	Kipini Secondary	40	24	30	35	Sept.	1.19	4	20	15	6	2	20	Hand Pump	No Genset
014_TAN_DEL	Tana Delta	Arap Moi Primary Ngao	40	24	35	40	Sept.	1.36	4	25	20	6	2	20	Submersible	6
015_TAN_DEL	Tana Delta	Baomo	50	30	34	39	Sept.	1.66	5	24	19	6	2	20	Hand Pump	No Genset
016_TAN_DEL	Tana Delta	Onwardei	30	18	24	29	Sept.	0.74	3	14	9	6	2	20	Hand Pump	No Genset
017_TAN_DEL	Tana Delta	Manano	30	18	26	31	Sept.	0.79	3	16	11	6	2	20	Hand Pump	No Genset
018_TAN_DEL	Tana Delta	Tumaini Sch	40	24	26	31	Sept.	1.05	4	16	11	6	2	20	Hand Pump	No Genset
019_TAN_DEL	Tana Delta	Majiweni	50	30	30	35	Sept.	1.49	5	20	15	6	2	20	Hand Pump	No Genset
020_TAN_NOR	Tana North	Maramtu A	40	24	26	31	Sept.	1.05	4	16	11	6	2	20	Hand Pump	No Genset
021_TAN_NOR	Tana North	Maramtu B	40	24	20	25	Sept.	0.85	4	10	5	6	2	20	Hand Pump	No Genset
022_TAN_NOR	Tana North	Sombo	30	18	21	26	Sept.	0.66	3	11	6	6	2	20	Hand Pump	No Genset
023_TAN_NOR	Tana North	Chewele	40	24	20	25	Sept.	0.85	4	10	5	6	2	20	Hand Pump	No Genset

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	Sub-county	Site name	Total Design volume (m^3/day)	Solar Design volume (m^3/day)	Static head (m)	TDH estimate (m)	Design month	Indicative Array (kWp)	Borehole yield (m^3/h)	Pump installed depth (m)	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Pump installed type	Existing genset (Y/NP)/ kW
024_TAN_DEL	Tana Delta	Wema	70	42	30	35	Sept.	2.08	7	20	15	6	2	20	Hand Pump	No Genset
025_TAN_DEL	Tana Delta	Ozi	80	48	20	25	Sept.	1.70	8	10	5	6	2	20	Hand Pump	No Genset
026_TAN_DEL	Tana Delta	Katsangani	50	30	20	25	Sept.	1.06	5	10	5	6	2	20	Hand Pump	No Genset

Appendix 3.2.4 Lot 2: Wajir County

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	Site name	Design volume (m^3/day)	Solar design volume (m^3/day)	Static head to tank (m)	TDH estimate (m)	Design month	Indicative design array (kWp)	Borehole yield (m^3/h)	Pump installed depth (m)	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	Pump installed type	Existing Genset (kW)
001_WAJ_ELD	Areswaji	36	17	192	194	September	4.2	3.0	187	182	6	2	300	Submersible/ Borehole	11
002_WAJ_ELD	Basir	30	14	92	93	September	1.7	2.5	87	82	6	2	300	Submersible/ Borehole	11
003_WAJ_ELD	Eldas-Anole B/hole	120	55	45	60	September	4.4	10.0	40	35	6	2	300	Submersible/ Borehole	11
004_WAJ_ELD	Eldas town	120	55	40	55	September	4.0	10.0	35	30	6	2	300	Submersible/ Borehole	11
005_WAJ_ELD	Kilkiley	96	44	34	44	September	2.6	8.0	29	24	6	2	300	Submersible/ Borehole	11
006_WAJ_ELD	Masalale	120	55	20	35	September	2.6	10.0	15	10	6	2	300	Submersible/ Borehole	11
007_WAJ_TAR	Bojigaras	108	50	107	120	September	7.8	9.0	102	97	6	2	300	Submersible/ Borehole	15
008_WAJ_TAR	Kabatula	108	50	147	159	September	10.4	9.0	142	137	6	2	300	Submersible/ Borehole	15
009_WAJ_TAR	Mansa	96	44	140	150	September	8.8	8.0	135	130	6	2	300	Submersible/ Borehole	15
010_WAJ_TAR	Mashin Ben	60	28	150	154	September	5.6	5.0	145	140	6	2	300	Submersible/ Borehole	11

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m^3/day)*	*Solar design volume (m^3/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
011_WAJ_TAR	Wargadud	336	154	110	124	September	25.4	28.0	105	100	6	3	300	Submersible/ Borehole	44
012_WAJ_EAS	Boji Garas	180	83	145	149	September	16.3	15.0	140	135	6	3	300	Submersible/ Borehole	25
013_WAJ_EAS	Khorof harar 2	144	66	140	161	September	14.1	12.0	135	130	6	2	300	Submersible/ Borehole	19
014_WAJ_EAS	Konton	360	165	45	61	September	13.4	30.0	40	35	6	3	300	Submersible/ Borehole	19
015_WAJ_EAS	Qarsa	144	66	195	216	September	18.9	12.0	190	185	6	2	300	Submersible/ Borehole	31
016_WAJ_NOR	Batalu	36	17	176	178	September	3.9	3.0	171	166	6	2	300	Submersible/ Borehole	11
017_WAJ_NOR	Beramo	72	33	70	76	September	3.3	6.0	65	60	6	2	300	Submersible/ Borehole	11
018_WAJ_NOR	Bosicha	396	182	68	88	September	21.1	33.0	63	58	6	3	300	Submersible/ Borehole	31
019_WAJ_NOR	Buna 2	216	99	46	52	September	6.9	18.0	41	36	6	3	300	Submersible/ Borehole	11
020_WAJ_NOR	Danaba	66	30	178	184	September	7.4	5.5	173	168	6	2	300	Submersible/ Borehole	11
021_WAJ_NOR	Qaranri	24	11	208	209	September	3.0	2.0	203	198	6	2	300	Submersible/ Borehole	11
022_WAJ_NOR	Qarsabula	60	28	210	214	September	7.8	5.0	205	200	6	2	300	Submersible/ Borehole	15
023_WAJ_SOU	Alan us	108	50	200	212	September	13.9	9.0	195	190	6	2	300	Submersible/ Borehole	19
024_WAJ_SOU	Arablow	240	110	160	168	September	24.4	20.0	155	150	6	3	300	Submersible/ Borehole	44
025_WAJ_SOU	Banane Shant Aral	276	127	132	142	September	23.8	23.0	127	122	6	3	300	Submersible/ Borehole	44
026_WAJ_SOU	Buruka	76	35	153	159	September	7.3	6.3	148	143	6	2	300	Submersible/ Borehole	11

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m³/day)*	*Solar design volume (m³/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
027_WAJ_SOU	Eyrib	144	66	128	149	September	13.1	12.0	123	118	6	2	300	Submersible/ Borehole	19
028_WAJ_SOU	Furmati	288	132	110	121	September	21.1	24.0	105	100	6	3	300	Submersible/ Borehole	31
029_WAJ_SOU	Lagdub	132	61	94	112	September	9.0	11.0	89	84	6	2	300	Submersible/ Borehole	15
030_WAJ_WES	Athibohol	138	63	155	175	September	14.7	11.5	150	145	6	2	300	Submersible/ Borehole	19
031_WAJ_WES	Baragothey	120	55	200	215	September	15.7	10.0	195	190	6	2	300	Submersible/ Borehole	25
032_WAJ_WES	Barmil	36	17	235	237	September	5.2	3.0	230	225	6	2	300	Submersible/ Borehole	11
033_WAJ_WES	Lagdima	288	132	156	167	September	29.2	24.0	151	146	6	3	300	Submersible/ Borehole	44
034_WAJ_WES	Shanta Abak	42	19	187	189	September	4.8	3.5	182	177	6	2	300	Submersible/ Borehole	11
035_WAJ_WES	Wara	120	55	107	122	September	8.9	10.0	102	97	6	2	300	Submersible/ Borehole	15

Appendix 3.2.5 Lot 2: Mandera County

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m³/day)*	*Solar design volume (m³/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
001_MAN_BAN	Eymole	144	30	175	180	September	7.4	6.0	170	165	6	2	300	Submersible/ Borehole	15
002_MAN_BAN	Hullow	80	20	235	237	September	6.4	4.0	230	225	6	2	300	Submersible/ Borehole	15

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m^3/day)*	*Solar design volume (m^3/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
003_MAN_BAN	Malka Mari	96	20	215	217	September	5.8	4.0	210	205	6	2	300	Submersible/ Borehole	19
004_MAN_LAF	Bubo	192	40	155	163	September	8.7	8.0	150	145	6	2	300	Submersible/ Borehole	15
005_MAN_LAF	Fino	168	35	155	161	September	7.6	7.0	150	145	6	2	300	Submersible/ Borehole	15
006_MAN_LAF	Lafey 1	240	50	175	188	September	12.3	10.0	170	165	6	2	300	Submersible/ Borehole	15
007_MAN_LAF	Sala 1	65	74	45	72	September	5.9	15.0	40	35	6	2	300	Submersible/ Borehole	15
008_MAN_LAF	Warankara	88	30	185	190	September	7.8	6.0	180	175	6	2	300	Submersible/ Borehole	15
009_MAN_EAS	Arabia 1	192	40	125	133	September	7.1	8.0	120	115	6	2	300	Submersible / Borehole	15
010_MAN_EAS	Arabia Boys	23	35	125	131	September	6.2	7.0	120	115	6	2	300	Submersible / Borehole	15
011_MAN_EAS	Bella	68	59	29	47	September	3.4	12.0	24	19	6	2	300	Submersible / Borehole	11
012_MAN_EAS	Hareri Hosle	54	30	185	190	September	7.8	6.0	180	175	6	2	300	Submersible / Borehole	15
013_MAN_EAS	Libehiya	192	40	125	133	September	7.1	8.0	120	115	6	2	300	Submersible / Borehole	15
014_MAN_EAS	Odha 1	96	20	165	167	September	4.5	4.0	160	155	6	2	300	Submersible / Borehole	11
015_MAN_EAS	Omar Jillo	170	40	155	163	September	8.7	8.0	150	145	6	2	300	Submersible / Borehole	15
016_MAN_NOR	Darab Adadi	70	25	145	148	September	5.0	5.0	140	135	6	2	300	submersible/ Borehole	15
017_MAN_NOR	Guticha	34	74	165	192	September	18.3	15.0	160	155	6	2	300	submersible/ Borehole	15
018_MAN_NOR	Kubi	92	25	165	168	September	5.6	5.0	160	155	6	2	300	submersible/ Borehole	15

		Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Site name*	*Design volume (m^3/day)*	*Solar design volume (m^3/day)*	*Static head to tank (m)*	*TDH estimate (m)*	*Design month*	*Indicative design array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	*Dynamic water depth (m)*	*Borehole diameter (inches)*	*Rising main diameter (inches)*	*Borehole to tank distance (m)*	*Pump installed type*	*Existing Genset (kW)*
019_MAN_NOR	Shirshir	48	20	175	177	September	4.8	4.0	170	165	6	2	300	submersible/ Borehole	15
020_MAN_SOU	Brewu 11	96	20	145	147	September	4.0	4.0	140	135	6	2	300	Submersible/ Borehole	11
021_MAN_SOU	Dawder	127	30	165	170	September	7.0	6.0	160	155	6	2	300	Submersible/ Borehole	15
022_MAN_SOU	Elele 1	48	10	125	126	September	1.7	2.0	120	115	6	2	300	Submersible/ Borehole	11
023_MAN_SOU	Garsesala	63	15	165	166	September	3.4	3.0	160	155	6	2	300	Submersible/ Borehole	11
024_MAN_SOU	Kobadadi	45	15	165	166	September	3.4	3.0	160	155	6	2	300	Submersible/ Borehole	11
025_MAN_SOU	Kutayu 1	120	25	165	168	September	5.6	5.0	160	155	6	2	300	Submersible/ Borehole	15
026_MAN_SOU	Kutulo 1	120	25	165	168	September	5.6	5.0	160	155	6	2	300	Submersible/ Borehole	15
027_MAN_SOU	Shimbir Fatuma	105	25	165	168	September	5.6	5.0	160	155	6	2	300	Submersible/ Borehole	15
028_MAN_WES	Darwed	303	99	185	191	September	27.1	20.0	180	175	6	3	300	Submersible/ Borehole	19
029_MAN_WES	Hamasa 2	144	30	205	210	September	8.6	6.0	200	195	6	2	300	submersible/ Borehole	15
030_MAN_WES	Wangai Dahan	105	99	185	191	September	27.1	20.0	180	175	6	3	300	Submersible/ Borehole	44

Appendix 3.2.6 Lot 3: Kilifi County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_KIL_SOU	South Kilifi	Tsalu	400	240	20	25	Sept.	8.51	40	10	5	6	3	10	Surface	55
002_KIL_GAN	Ganze	Palakumi	400	240	20	25	Sept.	8.51	40	10	5	6	3	5	Surface	55
003_KIL_GAN	Ganze	Mweza	250	150	20	25	Sept.	5.32	25	10	5	6	3	5	Surface	40
004_KIL_GAN	Ganze	Mwaeba Mbonga	450	270	20	25	Sept.	9.57	45	10	5	6	3	5	Surface	150
005_KIL_GAN	Ganze	Dungicha	250	150	20	25	Sept.	5.32	25	10	5	6	3	5	Surface	55
006_KIL_MAL	Malindi	Msabaha kwa Mwasaha	78	46.8	45	50	Sept.	3.32	7.8	35	30	6	2	20	Submersible	None
007_KIL_MAL	Malindi	Sea Breeze-Msamaha wa juu BH	50	30	50	55	Sept.	2.34	5	40	35	6	2	20	Submersible	None
008_KIL_MAG	Magarini	Gahaleni	48	28.8	45	50	Sept.	2.04	4.8	35	30	6	2	20	Submersible	None
009_KIL_MAL	Malindi	Musoloni, Kwa Jasho	48	28.8	55	60	Sept.	2.45	4.8	45	40	6	2	20	Submersible	None
010_KIL_MAL	Malindi	Takaye centre (Kwa chiguba) BH	62	37.2	55	60	Sept.	3.16	6.2	45	40	6	2	20	Submersible	None
011_KIL_MAG	Magarini	Magarini Mamburui (7 BOREHOLES)	150	90	65	70	Sept.	8.93	15	55	50	6	3	20	Submersible	25
012_KIL_SOU	South Kilifi	Kolewa chonyi	400	240	20	25	Sept.	8.51	40	10	5	6	3	20	Surface	55
013_KIL_SOU	South Kilifi	Bicharo yaa Mzambaraoni	50	30	80	85	Sept.	3.62	5	70	65	6	2	20	Submersible	None
014_KIL_KAL	Kaloleni	Nyalani Jibana	50	30	140	145	Sept.	6.17	5	130	125	6	2	20	Submersible	None
015_KIL_NOR	North Kilifi	Tezo	50	30	55	60	Sept.	2.55	5	45	40	6	2	20	Submersible	None
016_KIL_NOR	North Kilifi	Roka Youth Polytechnic chumani	40	24	50	55	Sept.	1.87	4	40	35	6	2	20	Submersible	None
017_KIL_NOR	North Kilifi	Wesa Ngerenya	35	21	55	60	Sept.	1.79	3.5	45	40	6	2	20	Submersible	None

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
018_KIL_NOR	North Kilifi	Mkunguni chumani	50	30	55	60	Sept.	2.55	5	45	40	6	2	20	Submersible	None
019_KIL_NOR	North Kilifi	Roka Maweni	25	15	55	60	Sept.	1.28	2.5	45	40	6	2	20	Submersible	None
020_KIL_NOR	North Kilifi	Mtondia Well Kwa Ngonyo	30	18	65	70	Sept.	1.79	3	55	50	6	2	20	Submersible	None
021_KIL_SOU	South Kilifi	Sharian BH (kwa Akida)	30	18	70	75	Sept.	1.91	3	60	55	6	2	20	Submersible	None
022_KIL_NOR	North Kilifi	Kwa William Shida BH	25	15	45	50	Sept.	1.06	2.5	35	30	6	2	20	Submersible	None
023_KIL_SOU	South Kilifi	Kwa Kadenge wa Kavumbi BH	30	18	45	50	Sept.	1.28	3	35	30	6	2	20	Submersible	None
024_KIL_NOR	North Kilifi	Kwa Katana wa Chome Majaoni BH	30	18	55	60	Sept.	1.53	3	45	40	6	2	20	Submersible	None
025_KIL_GAN	Ganze	Migodomani Well tsangatsini BH	25	15	180	185	Sept.	3.93	2.5	170	165	6	2	20	Submersible	11
026_KIL_NOR	North Kilifi	Samson Mumbo Nyanje BH	30	18	60	65	Sept.	1.66	3	50	45	6	2	20	Submersible	None
027_KIL_KAL	Kaloleni	Mkangani Mwakanga Walea BH	50	30	280	285	Sept.	12.12	5	270	265	6	2	20	Submersible	None
028_KIL_NOR	North Kilifi	Mwambani Kwa Mundu BH	30	18	65	70	Sept.	1.79	3	55	50	6	2	20	Submersible	None
029_KIL_NOR	North Kilifi	Kwa muye BH	30	18	45	50	Sept.	1.28	3	35	30	6	2	20	Submersible	None
030_KIL_NOR	North Kilifi	Kadenge paka BH	30	18	55	60	Sept.	1.53	3	45	40	6	2	20	Submersible	None
031_KIL_MAL	Malindi	Takaye kwa Diiwani - ponda BH	50	30	55	60	Sept.	2.55	5	45	40	6	2	20	Submersible	None

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
032_KIL_RAB	Rabai	Masaani BP	400	240	20	25	Sept.	8.51	40	10	5	6	3	5	Surface	55
033_KIL_MAG	Magarini	Majengo Centre BH	400	240	20	25	Sept.	8.51	40	10	5	6	3	20	Surface	55

Appendix 3.2.7 Lot 3: Kwale County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_KWA_LUN	Lunga Lunga	Mwamose	50	30	50	55	Sept.	2.34	5	40	35	6	2	50	Hand pump	No Genset
002_KWA_LUN	Lunga Lunga	Ganda Pri School	65	39	55	60	Sept.	3.32	6.5	45	40	6	2	50	Hand pump	No Genset
003_KWA_LUN	Lunga Lunga	Mabafweni(school)	50	30	80	85	Sept.	3.62	5	70	65	6	2	50	Hand pump	No Genset
004_KWA_MSA	Msambweni	Mwendo wa bure	50	30	60	65	Sept.	2.76	5	50	45	6	2	50	Hand pump	No Genset
005_KWA_MAT	Matuga	Chivyogo	30	18	75	80	Sept.	2.04	3	65	60	6	2	50	Not installed	No Genset
006_KWA_MSA	Msambweni	Vumilia	70	42	60	65	Sept.	3.87	7	50	45	6	2	50	Hand pump	No Genset
007_KWA_MAT	Matuga	Mwananyahi	20	12	120	125	Sept.	2.13	2	110	105	6	2	50	Hand pump	No Genset
008_KWA_MAT	Matuga	Chanyiro Primary	30	18	70	75	Sept.	1.91	3	60	55	6	2	50	Hand pump	No Genset
009_KWA_MAT	Matuga	Simanya	25	15	120	125	Sept.	2.66	2.5	110	105	6	2	50	Hand pump	No Genset
010_KWA_LUN	Lunga Lunga	Kikonde	50	30	55	60	Sept.	2.55	5	45	40	6	2	50	Hand pump	No Genset

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
011_KWA_LUN	Lunga Lunga	Mwambalazi	60	36	50	55	Sept.	2.81	6	40	35	6	2	50	Hand pump	No Genset
012_KWA_MAT	Matuga	Mbegani	20	12	50	55	Sept.	0.94	2	40	35	6	2	50	Hand pump	No Genset
013_KWA_MAT	Matuga	Mwamnyuti	50	30	86	91	Sept.	3.87	5	76	71	6	2	50	Hand pump	No Genset
014_KWA_LUN	Lunga Lunga	Mwajiate	40	24	84	89	Sept.	3.03	4	74	69	6	2	50	Hand pump	No Genset
015_KWA_MSA	Msambweni	Funzi	20	12	25	30	Sept.	0.51	2	15	10	6	2	50	Hand pump	No Genset
016_KWA_LUN	Lunga Lunga	Kilimangodo	80	48	110	115	Sept.	7.83	8	100	95	6	2	50	Hand pump	No Genset
017_KWA_LUN	Lunga Lunga	Chindi	30	18	85	90	Sept.	2.30	3	75	70	6	2	50	Not installed	No Genset
018_KWA_LUN	Lunga Lunga	Kiwambale	150	90	70	75	Sept.	9.57	15	60	55	6	3	50	Not installed	No Genset
019_KWA_MAT	Matunga	Mtsangatamu Primary School	80	48	100	105	Sept.	7.15	8	90	85	6	2	50	Hand pump	No Genset
020_KWA_LUN	Lunga Lunga	Godo	20	12	88	93	Sept.	1.58	2	78	73	6	2	50	Hand pump	No Genset
021_KWA_MSA	Msambweni	Mali yanuka	20	12	90	95	Sept.	1.62	2	80	75	6	2	50	Hand pump	No Genset
022_KWA_LUN	Lunga Lunga	Mahuruni	35	21	50	55	Sept.	1.64	3.5	40	35	6	2	50	Hand pump	No Genset
023_KWA_MAT	Matuga	Madibwani	80	48	88	93	Sept.	6.33	8	78	73	6	2	50	Hand pump	No Genset
024_KWA_MAT	Matuga	Mwanamkuu	80	48	60	65	Sept.	4.42	8	50	45	6	2	50	Hand pump	No Genset
025_KWA_LUN	Lunga Lunga	Kifuku	68	40.8	75	80	Sept.	4.63	6.8	65	60	6	2	50	Hand pump	No Genset
026_KWA_MAT	Matuga	Kidiani ECD	50	30	50	55	Sept.	2.34	5	40	35	6	2	50	Hand pump	No Genset

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
027_KWA_MSA	Msambweni	Kijembe	100	60	55	60	Sept.	5.10	10	45	40	6	2	50	Hand pump	No Genset
028_KWA_MSA	Msambweni	Darigube	50	30	82	87	Sept.	3.70	5	72	67	6	2	50	Hand pump	No Genset
029_KWA_MSA	Msambweni	Vukani	40	24	85	90	Sept.	3.06	4	75	70	6	2	50	Hand pump	No Genset
030_KWA_MSA	Msambweni	Bumamani	60	36	50	55	Sept.	2.81	6	40	35	6	2	50	Hand pump	No Genset

Appendix 3.2.8 Lot 4: Isilolo County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_ISI_MER	Merti	Yamicha	70	42	185	190	September	11.31	7	175	170	6	2	70	Submersible	15
002_ISI_MER	Merti	Lafe	96	57.6	190	195	September	15.93	9.6	180	175	6	2	70	Submersible	15
003_ISI_MER	Merti	Dogogicha	60	36	142	147	September	7.50	6	132	127	6	2	70	Submersible	15
004_ISI_GAR	Garbatulla	Duse	160	96	76	81	September	11.03	16	66	61	6	3	70	Submersible	11
005_ISI_MER	Merti	Alango BH	80	48	179.5	184.5	September	12.56	8	169.5	164.5	6	2	70	Submersible	15
006_ISI_MER	Merti	Merti Community BH 1(main)	90	54	100	105	September	8.04	9	90	85	6	2	70	Submersible	11
007_ISI_MER	Merti	Merti Community BH 2(main)	50	30	80	85	September	3.62	5	70	65	6	2	70	Submersible	6
008_ISI_MER	Merti	Bulesa(Old)	256	153.6	52	57	September	12.41	25.6	42	37	6	3	70	Submersible	25

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
009_ISI_GAR	Garbatulla	Yaqbarshadi	25	15	142	147	September	3.13	2.5	132	127	6	2	70	Submersible	11
010_ISI_ISI	Isiolo	LMD-kilimani	100	60	40	45	September	3.83	10	30	25	6	2	70	Submersible	21
011_ISI_GAR	Garbatulla	Kinna(Jillo Dima)	150	90	125	130	September	16.59	15	115	110	6	3	70	Submersible	11
012_ISI_GAR	Garbatulla	Mogore	130	78	100	105	September	11.61	13	90	85	6	2	70	Submersible	11
013_ISI_MER	Merti	Goda	100	60	82	87	September	7.40	10	72	67	6	2	70	Submersible	15
014_ISI_MER	Merti	Taiboto	51	30.6	60	65	September	2.82	5.1	50	45	6	2	70	Submersible	6
015_ISI_GAR	Garbatulla	Modogashe BH2	90	54	90	95	September	7.27	9	80	75	6	2	70	Submersible	15
016_ISI_GAR	Garbatulla	Kulamawe barrier	30	18	142	147	September	3.75	3	132	127	6	2	70	Submersible	6
017_ISI_GAR	Garbatulla	Iresaboru Bh 2	102	61.2	34.3	39.3	September	3.41	10.2	24.3	19.3	6	2	70	Submersible	11
018_ISI_GAR	Garbatulla	Muchuro Bh	80	48	80	85	September	5.78	8	70	65	6	2	70	Submersible	15

Appendix 3.2.9 Lot 4: Samburu County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_SAM_CEN	Samburu Central	Simiti bore hole	20	12	200	205	Sept.	3.49	2	190	185	6	2	50	Submersible	11
002_SAM_NOR	Samburu North	Mbukoi borehole	120	72	124	129	Sept.	13.17	12	114	109	6	2	50	Submersible	31
003_SAM_NOR	Samburu North	Natiti	25	15	160	165	Sept.	3.51	2.5	150	145	6	2	50	Submersible	11
004_SAM_NOR	Samburu North	Loruko	150	90	200	205	Sept.	26.16	15	190	185	6	3	50	Submersible	50

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
005_SAM_CEN	Samburu Central	Seketet primary school b/h	30	18	200	205	Sept.	5.23	3	190	185	6	2	50	Submersible	11
006_SAM_NOR	Samburu North	Baragoi Boys Sec. borehole	20	12	150	155	Sept.	2.64	2	140	135	6	2	50	Submersible	6
007_SAM_CEN	Samburu Central	Nkenju Emuny B/H - 2	80	48	130	135	Sept.	9.19	8	120	115	6	2	50	Submersible	21
008_SAM_CEN	Samburu Central	Sirata Oirobi B/H	26	15.6	150	155	Sept.	3.43	2.6	140	135	6	2	50	Submersible	11
009_SAM_CEN	Samburu Central	Lolmolok bore hole	25	15	75	80	Sept.	1.70	2.5	65	60	6	2	50	Submersible	6
010_SAM_CEN	Samburu Central	Loltulelei bore	50	30	43	48	Sept.	2.04	5	33	28	6	2	50	Submersible	6
011_SAM_CEN	Samburu Central	Pura bore hole	36	21.6	43	48	Sept.	1.47	3.6	33	28	6	2	50	Submersible	6
012_SAM_CEN	Samburu Central	Lorian bore hole	40	24	150	155	Sept.	5.27	4	140	135	6	2	50	Submersible	11
013_SAM_NOR	Samburu North	Nkirenyi bore hole	120	72	200	205	Sept.	20.93	12	190	185	6	3	50	Submersible	50
014_SAM_CEN	Samburu Central	Ngambo Borehole	150	90	150	155	Sept.	19.78	15	140	135	6	3	50	Submersible	40
015_SAM_EAS	Samburu East	Lderkesi b/hole	40	24	150	155	Sept.	5.27	4	140	135	6	2	50	Submersible	11
016_SAM_CEN	Samburu Central	Luai	140	84	150	155	Sept.	18.46	14	140	135	6	3	50	Submersible	40
017_SAM_CEN	Samburu Central	Kitobor bore hole	140	84	200	205	Sept.	24.41	14	190	185	6	3	50	Submersible	50
018_SAM_CEN	Samburu Central	Lpartuk b/h no. 5	150	90	82	87	Sept.	11.10	15	72	67	6	3	50	Submersible	25
019_SAM_EAS	Samburu East	Loijuk borehole	30	18	100	105	Sept.	2.68	3	90	85	6	2	50	Submersible	6
020_SAM_CEN	Samburu Central	Lemisigiyo	90	54	150	155	Sept.	11.87	9	140	135	6	2	50	Submersible	25

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
021_SAM_EAS	Samburu East	Leng'ei bore hole	20	12	110	115	Sept.	1.96	2	100	95	6	2	50	Submersible	6
022_SAM_CEN	Samburu Central	Lcheng'ei Bore hole	140	84	130	135	Sept.	16.08	14	120	115	6	3	50	Submersible	40
023_SAM_NOR	Samburu North	Tangar bore hole	30	18	150	155	Sept.	3.96	3	140	135	6	2	50	Submersible	11

Appendix 3.2.10 Lot 4: Marsabit County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_MAR_LAI	Laisamis	Ririma	60	36	150	155	Sept.	7.91	6	140	135	6	2	70	Submersible	21
002_MAR_MOY	Moyale	Rawana	30	18	120	125	Sept.	3.19	3	110	105	6	2	70	Submersible	11
003_MAR_MOY	Moyale	Ambalo I	50	30	130	135	Sept.	5.74	5	120	115	6	2	70	Submersible	11
004_MAR_MOY	Moyale	Laffen	50	30	150	155	Sept.	6.59	5	140	135	6	2	70	Submersible	15
005_MAR_MOY	Moyale	Dambala Fachana	20	12	150	155	Sept.	2.64	2	140	135	6	2	70	Submersible	6
006_MAR_MOY	Moyale	Godoma	120	72	150	155	Sept.	15.82	12	140	135	6	2	70	Submersible	31
007_MAR_MOY	Moyale	Qolob	50	30	150	155	Sept.	6.59	5	140	135	6	2	70	Submersible	15
008_MAR_MOY	Moyale	Adadi/Kobb	60	36	150	155	Sept.	7.91	6	140	135	6	2	70	Submersible	21
009_MAR_MOY	Moyale	Dabel II	152	91.2	150	155	Sept.	20.04	15.2	140	135	6	3	70	Submersible	40
010_MAR_MOY	Moyale	Mudam	80	48	120	125	Sept.	8.51	8	110	105	6	2	70	Submersible	21
011_MAR_SAK	Saku	Dirib gombo	30	18	210	215	Sept.	5.49	3	200	195	6	2	70	Submersible	11

Appendix 3.2.11 Lot 5: West Pokot County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_WES_KOD	Kodich	Reretiang borehole	10	6	180	185	September	1.57	1	170	165	6	2	50	Submersible	None
001_WES_SUA	Suam	Lokii Ecd	35	21	94	99	September	2.95	3.5	84	79	6	2	50	Submersible	None
001_WES_SAU	Saum	Kopulio Primary Borehole	30	18	147	152	September	3.88	3	137	132	6	2	50	Submersible	None
001_WES_SAU	Saum	Lochidangole Borehole-	30	18	138	143	September	3.65	3	128	123	6	2	50	Submersible	None
001_WES_SAU	Saum	Kaskuroi Ecd Borehole	15	9	162	167	September	2.13	1.5	152	147	6	2	50	Submersible	None
001_WES_MAS	Masol	fr. Leo girls sec.	30	18	97	102	September	2.60	3	87	82	6	2	50	Submersible	None
001_WES_CHE	Chepareria	Chelombai	50	30	100	105	September	4.47	5	90	85	6	2	50	Submersible	11
001_WES_CHE	Chepareria	Senetwo	50	30	110	115	September	4.89	5	100	95	6	2	50	Submersible	11
001_WES_ALA	Alale	Kakoliong	60	36	180	185	September	9.44	6	170	165	6	2	50	Submersible	None
001_WES_KIW	Kiwawa	Mbaru Borehole	30	18	156	161	September	4.11	3	146	141	6	2	50	Submersible	None
001_WES_KIW	Kiwawa	Katumkale Borehole	35	21	150	155	September	4.62	3.5	140	135	6	2	50	Submersible	None
001_WES_KIW	Kiwawa	Kaingeny Borehole	28	16.8	165	170	September	4.05	2.8	155	150	6	2	50	Submersible	None
001_WES_KOD	Kodich	Koyolo Borehole	50	30	140	145	September	6.17	5	130	125	6	2	50	Submersible	None
001_WES_ALA	Alale	Narwaro Borehole	50	30	110	115	September	4.89	5	100	95	6	2	50	Submersible	None
001_WES_ALA	Alale	Oron Primary Borehole	30	18	130	135	September	3.45	3	120	115	6	2	50	Submersible	None
001_WES_KAP	Kapchok	Katuwot Borehole	38	22.8	135	140	September	4.53	3.8	125	120	6	2	50	Submersible	None

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_WES_KAP	Kapchok	Kodera Borehole	30	18	170	175	September	4.47	3	160	155	6	2	50	Submersible	None
001_WES_KAP	Kapchok	Losam Borehole	40	24	130	135	September	4.59	4	120	115	6	2	50	Submersible	None
001_WES_KAS	Kasei	Morkorio Borehole	30	18	170	175	September	4.47	3	160	155	6	2	50	Submersible	None
001_WES_RIW	Riwo	katikomor Borehole	50	30	140	145	September	6.17	5	130	125	6	2	50	Submersible	None
001_WES_RIW	Riwo	Katukumwok Borehole	55	33	155	160	September	7.49	5.5	145	140	6	2	50	Submersible	None
001_WES_RIW	Riwo	Lodupup Primary School	25	15	145	150	September	3.19	2.5	135	130	6	2	50	Submersible	None
001_WES_MNA	Mnagei	Pser Borehole	30	18	175	180	September	4.59	3	165	160	6	2	50	Submersible	None
001_WES_MNA	Mnagei	Chetuya Borehole	40	24	160	165	September	5.61	4	150	145	6	2	50	Submersible	None
001_WES_SOO	Sook	Katimaril Borehole	35	21	170	175	September	5.21	3.5	160	155	6	2	50	Submersible	None
001_WES_SOO	Sook	Tamugh Borehole	30	18	165	170	September	4.34	3	155	150	6	2	50	Submersible	None
001_WES_END	Endugh	Rukei Borehole	40	24	175	180	September	6.13	4	165	160	6	2	50	Submersible	None
001_WES_END	Endugh	Kapkata Primary	32	19.2	165	170	September	4.63	3.2	155	150	6	2	50	Submersible	None
001_WES_LOM	lomut	Kokwomeses Primary Borehole	50	30	105	110	September	4.68	5	95	90	6	2	50	Submersible	None
001_WES_WEI	Wei Wei	Dungdung Borehole	25	15	150	155	September	3.30	2.5	140	135	6	2	50	Submersible	None
001_WES_CHE	Chepareria	Tumoi Borehole	30	18	140	145	September	3.70	3	130	125	6	2	50	Submersible	None

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_WES_BAT	Batei	Seretow bOREHOLE	40	24	150	155	October	5.27	4	140	135	6	2	50	Submersible	None

Appendix 3.2.12 Lot 5: Turkana County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_TUR_EAS	East Turkana	Lotubae	45	27	38	43	Sept.	1.65	4.5	28	23	6	2	70	Submersible	6
002_TUR_EAS	East Turkana	katilia girls	100	60	50	55	Sept.	4.68	10	40	35	6	2	70	Submersible	11
003_TUR_EAS	East Turkana	Nakwamomwa	45	27	43	48	Sept.	1.84	4.5	33	28	6	2	70	Submersible	None
004_TUR_WES	West Turkana	Loteteleit	40	24	90	95	Sept.	3.23	4	80	75	6	2	70	Submersible	11
005_TUR_WES	West Turkana	Lokichoggio UN compound	50	30	76	81	Sept.	3.45	5	66	61	6	2	70	Submersible	None
006_TUR_WES	West Turkana	Lochoriangamor	40	24	94	99	Sept.	3.37	4	84	79	6	2	70	Submersible	None
007_TUR_WES	West Turkana	Akalaliot	60	36	100	105	Sept.	5.36	6	90	85	6	2	70	Submersible	None
008_TUR_WES	West Turkana	Nakwangat 2	70	42	100	105	Sept.	6.25	7	90	85	6	2	70	Submersible	None
009_TUR_WES	West Turkana	Oropoi ws	70	42	100	105	Sept.	6.25	7	90	85	6	2	70	Submersible	15
010_TUR_SOU	South Turkana	Katilu	40	24	35	40	Sept.	1.36	4	25	20	6	2	70	Submersible	6

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
011_TUR_SOU	South Turkana	Lokichar (Chines Bore hole)	50	30	55	60	Sept.	2.55	5	45	40	6	2	70	Submersible	6
012_TUR_SOU	South Turkana	Kapelbok	35	21	55	60	Sept.	1.79	3.5	45	40	6	2	70	Submersible	None
013_TUR_SOU	South Turkana	Lomeleku	420	252	37	42	Sept.	15.01	42	27	22	6	3	70	Submersible	None
014_TUR_SOU	South Turkana	Kasuroi	30	18	60	65	Sept.	1.66	3	50	45	6	2	70	Submersible	None
015_TUR_SOU	South Turkana	Lomoonyang	30	18	60	65	Sept.	1.66	3	50	45	6	2	70	Submersible	None
016_TUR_SOU	South Turkana	Loupwala	240	144	13	18	Sept.	3.68	24	3	-2	6	3	70	Submersible	None
017_TUR_NOR	North Turkana	Napeto	50	30	130	135	Sept.	5.74	5	120	115	6	2	70	Submersible	None
018_TUR_NOR	North Turkana	Lokumwae	30	18	55	60	Sept.	1.53	3	45	40	6	2	70	Submersible	None
019_TUR_NOR	North Turkana	Karioworeng	40	24	46	51	Sept.	1.74	4	36	31	6	2	70	Submersible	None
020_TUR_NOR	North Turkana	Nimwae	50	30	130	135	Sept.	5.74	5	120	115	6	2	70	Submersible	None
021_TUR_NOR	North Turkana	Lowarengak	50	30	130	135	Sept.	5.74	5	120	115	6	2	70	Submersible	None
022_TUR_NOR	North Turkana	Murueris	30	18	80	85	Sept.	2.17	3	70	65	6	2	70	Submersible	None
023_TUR_NOR	North Turkana	Naurkorio	18	10.8	55	60	Sept.	0.92	1.8	45	40	6	2	70	Submersible	None
024_TUR_NOR	North Turkana	Natedelim	30	18	58	63	Sept.	1.61	3	48	43	6	2	70	Submersible	None
025_TUR_NOR	North Turkana	Loitangule	30	18	113	118	Sept.	3.01	3	103	98	6	2	70	Submersible	None

			Basic PVP Design Data					Design Constraints								Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
026_TUR_SOU	South Turkana	Nagetei	50	30	80	85	Sept.	3.62	5	70	65	6	2	70	Submersible	None
027_TUR_LOI	Loima	Kanyangapus	45	27	75	80	Sept.	3.06	4.5	65	60	6	2	70	Submersible	None
028_TUR_LOI	Loima	Natuntun	35	21	85	90	Sept.	2.68	3.5	75	70	6	2	70	Submersible	None
029_TUR_TUR	Turkan West	Alab lab	30	18	85	90	Sept.	2.30	3	75	70	6	2	70	Submersible	None
030_TUR_LOI	Loima	Lokatul	30	18	75	80	Sept.	2.04	3	65	60	6	2	70	Submersible	None
031_TUR_LOI	Loima	Kochuch-Tiya	40	24	100	105	Sept.	3.57	4	90	85	6	2	70	Submersible	None
032_TUR_LOI	Loima	Lomilo	40	24	75	80	Sept.	2.72	4	65	60	6	2	70	Submersible	None
033_TUR_LOI	Loima	Namoruakwak	60	36	85	90	Sept.	4.59	6	75	70	6	2	70	Submersible	None
034_TUR_CEN	Central Turkana	Nasulut water supply	100	60	80	85	Sept.	7.23	10	70	65	6	2	70	Submersible	None
035_TUR_CEN	Central Turkana	Narengelop	60	36	85	90	Sept.	4.59	6	75	70	6	2	70	Submersible	None
036_TUR_CEN	Central Turkana	Ewoi Egole	40	24	70	75	Sept.	2.55	4	60	55	6	2	70	Submersible	None
037_TUR_CEN	Central Turkana	Kadinyangole	180	108	85	90	Sept.	13.78	18	75	70	6	3	70	Submersible	None
038_TUR_CEN	Central Turkana	Naotin water Point	50	30	75	80	Sept.	3.40	5	65	60	6	2	70	Submersible	None

Appendix 3.2.13 Lot 6: Taita Taveta County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_TAI_TAV	Taveta	Njukini borehole	100	60	84	89	Sept.	7.57	10	74	69	6	2	3km	Submersible	21

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
002_TAI_TAV	Taveta	Chumvini	120	72	118	123	Sept.	12.56	12	108	103	6	2	1.5km	submersible	21
003_TAI_TAV	Taveta	Eldoro	200	120	100	105	Sept.	17.86	20	90	85	6	3	1km	Submersible	21
004_TAI_MWA	Mwatate	Alia	60	36	95	100	Sept.	5.10	6	85	80	6	2	5m	Submersible	21
005_TAI_MWA	Mwatate	Mwachawaza	110	66	90	95	Sept.	8.89	11	80	75	6	2	2.5km	No pump	No Genset
006_TAI_VOI	Voi	Uthiani	100	60	90	95	Sept.	8.08	10	80	75	6	2	1km	No pump	No Genset
007_TAI_MWA	Mwatate	Malukiloriti (A)	130	78	94	99	Sept.	10.95	13	84	79	6	2	500m	submersible	21
008_TAI_TAV	Taveta	Mahandakini/wololo	130	78	94	99	Sept.	10.95	13	84	79	6	2	5m	No pump	No Genset
009_TAI_TAV	Taveta	Kitivo ghazi	50	30	84	89	Sept.	3.79	5	74	69	6	2	5m	submersible	15
010_TAI_TAV	Taveta	Talio nyika	100	60	101	106	Sept.	9.02	10	91	86	6	2	5m	submersible	21
011_TAI_VOI	Voi	Kisimenyi	30	18	190	195	Sept.	4.98	3	180	175	6	2	5m	submersible	21
012_TAI_VOI	Voi	Kighombo	240	144	90	95	Sept.	19.40	24	80	75	6	3	500	submersible	25
013_TAI_VOI	Voi	Kakimwaita	50	30	104	109	Sept.	4.64	5	94	89	6	2	5m	submersible	11
015_TAI_WUN	wundanyi	Msau polytechnic	110	66	80	85	Sept.	7.95	11	70	65	6	2	200M	submersible	21
016_TAI_VOI	Voi	Nyolo bh	70.1	42.06	60.1	65.1	Sept.	3.88	7.01	50.1	45.1	6	2	50M	Submersible	6
018_TAI_MWA	Mwatate	Rekeke booster pump	2000	1200	20	25	Sept.	42.53	200	10	5	6	3	18M	submersible	21
019_TAI_MWA	Mwatate	Modambogho	20	12	15	20	Sept.	0.34	2	5	0	6	2	2km	submersible	11
020_TAI_TAV	Taveta	Mvita/Kwa scaver	307	184.2	104	109	Sept.	28.47	30.7	94	89	6	3	702M	submersible	40
021_TAI_MWA	Mwatate	Mramba	100	60	200	205	Sept.	17.44	10	190	185	6	2	1.5kM	submersible	11

Appendix 3.2.14 Lot 6: Narok County

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
001_NAR_EAS	Narok East	Oloikumkum Community b/h	90	54	97	102	Sept.	7.81	9	87	82	6	2	70	Submersible	15
002_NAR_SOU	Narok South	Morijo Loita b/h water project	72	43.2	130	135	Sept.	8.27	7.2	120	115	6	2	70	Submersible	6
003_NAR_ SO	Narok south	Iltirben b/h Water Project	60	36	75	80	Sept.	4.08	6	65	60	6	2	70	Submersible	6
004_NAR_WES	Narok West	Aitong Water b/h Project	50	30	72	77	Sept.	3.28	5	62	57	6	2	70	Submersible	11
005_NAR_SOU	Narok South	Ntuka (Oloisurwa) b/h W/P	20	12	255	260	Sept.	4.42	2	245	240	6	2	70	Submersible	6
006_NAR_WES	Narok West	Oldonyo Rasha SDA Pry school b/h	125	75	50	55	Sept.	5.85	12.5	40	35	6	2	70	Hand pump	No Genset
007_NAR_WES	Narok West	Parmolile W/P	120	72	190	195	Sept.	19.91	12	180	175	6	2	70	Submersible	11
008_NAR_EAS	Narok East	Kitororonyi B/h W/P	100	60	198	203	Sept.	17.27	10	188	183	6	2	70	Submersible	15
009_NAR_WES	Narok West	Lemesigio b/h W/P	20	12	187	192	Sept.	3.27	2	177	172	6	2	70	Submersible	6
010_NAR_WES	Narok West	Enkejuarro b/h W/P	20	12	225	230	Sept.	3.91	2	215	210	6	2	70	Submersible	6
011_NAR_ WE	Narok West	Kishermoruak b/h W/Project	30	18	200	205	Sept.	5.23	3	190	185	6	2	70	Submersible	6
012_NAR_SOU	Narok South	Ole Pariata b/h Water Project	20	12	199	204	Sept.	3.47	2	189	184	6	2	70	Submersible	6
013_NAR_SOU	Narok South	Iladuru b/h Water Project	150	90	128	133	Sept.	16.97	15	118	113	6	3	70	Submersible	21
014_NAR_SOU	Narok South	Ichangipusi b/h water project	130	78	130	135	Sept.	14.93	13	120	115	6	3	70	Submersible	6

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m^3/day)*	*Solar Design volume (m^3/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m^3/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
015_NAR_SOU	Narok South	Letukunyi b/h water project	80	48	97	102	Sept.	6.94	8	87	82	6	2	70	Submersible	6
016_NAR_SOU	Narok South	Osero Lempere b/h water project	20	12	198	203	Sept.	3.45	2	188	183	6	2	70	Submersible	6
017_NAR_SOU	Narok South	Olkirankawuo b/h water project	30	18	125	130	Sept.	3.32	3	115	110	6	2	70	Submersible	6
018_NAR_WES	Narok West	Mpuaai b/h water project	70	42	138	143	Sept.	8.52	7	128	123	6	2	70	Submersible	6
019_NAR_SOU	Narok South	Nkoseremai b/h water project	90	54	116	121	Sept.	9.26	9	106	101	6	2	70	Submersible	11
020_NAR_SOU	Narok South	Intalala b/h Water Project	40	24	90	95	Sept.	3.23	4	80	75	6	2	70	Hand pump	No Genset
021_NAR_EAS	Narok East	Oloolturot b/h W/P	47	28.2	136	141	Sept.	5.64	4.7	126	121	6	2	70	Submersible	6
022_NAR_NOR	Narok North	Enesampulai b/h W/P	100	60	139	144	Sept.	12.25	10	129	124	6	2	70	Submersible	6
023_NAR_NOR	Narok North	Sabbath Keeping Church b/h water project	30	18	200	205	Sept.	5.23	3	190	185	6	2	70	Submersible	6
024_NAR_TRA	Transmara East	Emurua Dikirr b/h W/P	200	120	146	151	Sept.	25.69	20	136	131	6	3	70	Submersible	6
025_NAR_SOU	Narok South	Olobaai community b/h	50	30	160	165	Sept.	7.02	5	150	145	6	2	70	B/H not equipped with Power	No Genset
026_NAR_SOU	Narok South	Nkairuwuani community b/h	100	60	180	185	Sept.	15.74	10	170	165	6	2	70	B/H not equipped with Power	No Genset
027_NAR_SOU	Narok South	Intasati B/h	40	24	130	135	Sept.	4.59	4	120	115	6	2	70	Hand pump	No Genset

			Basic PVP Design Data					Design Constraints							Existing Equipment	
Site code	*Sub-county*	*Site name*	*Total Design volume (m³/day)*	*Solar Design volume (m³/day)*	*Static head (m)*	*TDH estimate (m)*	*Design month*	*Indicative Array (kWp)*	*Borehole yield (m³/h)*	*Pump installed depth (m)*	Dynamic water depth (m)	Borehole diameter (inches)	Rising main diameter (inches)	Borehole to tank distance (m)	*Pump installed type*	*Existing genset (Y/NP)/ kW*
028_NAR_SOU	Narok south	Koseka Community B/h	60	36	180	185	Sept.	9.44	6	170	165	6	2	70	Hand pump	No Genset
029_NAR_TRA	Transmara East	Mugenyi/Njipship/Emuruadikkir B/h W/P	200	120	154	159	Sept.	27.05	20	144	139	6	2	70	Submersible	11
030_NAR_SOU	Narok South	Narosura B/h	29	17.4	148	153	Sept.	3.77	2.9	138	133	6	2	70	Submersible	6
031_NAR_WES	Narok West	Omomet (Enerelai)	50	30	108	113	Sept.	4.81	5	98	93	6	2	70	Submersible	6
032_NAR_WES	Narok West	Empora/ Olomonira Community	40	24	118	123	Sept.	4.19	4	108	103	6	2	70	Submersible	6
033_NAR_TRA	Transmara East	Simutwet water project	30	18	150	155	Sept.	3.96	3	140	135	6	2	70	Hand pump	No Genset
034_NAR_EAS	Narok East	Enobalbal B/h	100	60	166	171	Sept.	14.55	10	156	151	6	2	70	Submersible	11
035_NAR_NOR	Narok North	M.O.W.D. Nkaleta	36	21.6	94	99	Sept.	3.03	3.6	84	79	6	2	70	Submersible	6
036_NAR_WES	Narok West	Ndonyo Narasha Well	20	12	40	45	Sept.	0.77	2	30	25	6	2	70	Hand pump	No Genset
037_NAR_WES	Narok West	Nkaimurunya B/h	50	30	180	185	Sept.	7.87	5	170	165	6	2	70	Not Equipped	No Genset

Appendix 3.3: ADDITIONAL MINOR WORKS

Appendix 3.3.1 Lot 1: Garissa County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Engine enclosure*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_GAR_BAL	Balambla	Abdisamad	-	3	-	-	-	-	1	-	1
002_GAR_BAL	Balambla	Shimbirey 1	-	1	-	-	-	-	1	-	1
003_GAR_DAD	Dadaab	Abdisugow	-	-	-	-	-	-	1	-	1
004_GAR_DAD	Dadaab	AP Camp	-	-	-	-	-	-	1	-	1
005_GAR_DAD	Dadaab	Godlie Farm	-	-	-	-	-	-	1	-	1
006_GAR_DAD	Dadaab	Hagarbul	-	-	-	-	-	-	1	-	1
007_GAR_DAD	Dadaab	Kadaqso	-	2	-	-	-	-	1	-	1
008_GAR_DAD	Dadaab	Kwanjayarey	-	2	-	-	-	-	1	-	1
009_GAR_DAD	Dadaab	Sheldub	-	-	-	-	-	-	1	-	1
010_GAR_FAF	Fafi	Alanjugur	-	-	-	-	-	-	1	-	1
011_GAR_FAF	Fafi	Amuma	-	5	-	-	-	-	1	-	1
012_GAR_FAF	Fafi	Fafi	-	-	-	-	-	-	1	-	1
013_GAR_FAF	Fafi	Jambele	-	-	-	-	-	-	1	-	1
014_GAR_FAF	Fafi	Nanigi	-	-	-	-	-	-	1	-	1
015_GAR_FAF	Fafi	Ruqa	-	-	-	-	-	-	1	-	1
016_GAR_FAF	Fafi	Warable	-	-	-	-	-	-	1	-	1
017_GAR_FAF	Fafi	Welmarer	-	4	-	-	-	-	1	-	1
018_GAR_HUL	Hulugho	Hulugho 1	-	5	-	-	-	-	1	-	1
019_GAR_HUL	Hulugho	Hulugho 2	-	-	-	-	-	-	1	-	1
020_GAR_HUL	Hulugho	Sangailu	-	5	-	-	-	-	1	-	1
021_GAR_IJA	Ijara	Handaro	-	5	-	-	-	-	1	-	1
022_GAR_IJA	Ijara	Hara	-	4	-	-	-	-	1	-	1
023_GAR_IJA	Ijara	Kotile	-	-	-	-	-	-	1	-	1
024_GAR_LAG	Lagdera	Baraki 1	-	-	-	-	-	-	1	-	1
025_GAR_LAG	Lagdera	Dehle	-	-	-	-	-	-	1	-	1
026_GAR_LAG	Lagdera	Gurufa	-	-	-	-	-	-	1	-	1
027_GAR_LAG	Lagdera	Shanta Abaq	-	-	-	-	-	-	1	-	1

Appendix 3.3.2 Lot 1: Lamu County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Engine enclosure*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_LAM_LAM	Lamu East	Kiwayuu well no.1	1	1	-	-	-	-	1	1	1
002_LAM_LAM	Lamu East	Kiwayuu well no.2	1	2	-	-	-	-	1	1	1
003_LAM_LAM	Lamu East	Kiwayuu well no.3	1	1	-	-	-	-	1	1	1
004_LAM_LAM	Lamu East	Kizingitini	1	-	-	-	-	-	1	1	1
005_LAM_LAM	Lamu East	Mulei Well	1	2	-	-	-	-	1	1	1
006_LAM_EAS	Lamu East	Mkokoni well no.1	1	2	-	-	-	-	1	1	1
007_LAM_LAM	Lamu East	Mkokoni well no.2	1	2	-	-	-	-	1	1	1
008_LAM_EAS	Lamu East	Rasini well no.1-5	1	-	-	-	-	-	1	1	1
009_LAM_WES	Lamu West	Amkeni Primary Sch	1	2	-	-	-	-	1	1	1
010_LAM_LAM	Lamu West	Bomani Pri	1	2	-	-	-	-	1	1	1
011_LAM_LAM	Lamu West	Hongwe AP camp	1	2	-	-	-	-	1	1	1
012_LAM_LAM	Lamu West	Kangaja Pri	1	2	-	-	-	-	1	1	1
013_LAM_WES	Lamu West	Kipungani	1	2	-	-	-	-	1	1	1
014_LAM_WES	Lamu West	Kwa Guyo	1	2	-	-	-	-	1	1	1
015_LAM_WES	Lamu West	Matondoni	1	2	-	-	-	-	1	1	1
016_LAM_LAM	Lamu West	Mkunumbi pri	1	2	-	-	-	-	1	1	1
017_LAM_LAM	Lamu West	Ndeu pri	1	2	-	-	-	-	1	1	1
018_LAM_LAM	Lamu West	Ngoi Pri	1	2	-	-	-	-	1	1	1
019_LAM_WES	Lamu West	Poromoko Pri	1	2	-	-	-	-	1	1	1
020_LAM_WES	Lamu West	Rehema Pri.	1	2	-	-	-	-	1	1	1
021_LAM_WES	Lamu West	Thaku Thaku Teee nursery	1	2	-	-	-	-	1	1	1

Appendix 3.3.3 Lot 1: Tana River County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_TAN_RIV	Tana River	Maroni	Nil	1	0	0	0	1	1	Nil	1
002_TAN_RIV	Tana River	Haroresa	Nil	2	0	0	0	0	1	Nil	1
003_TAN_RIV	Tana River	Kone Kaliti	Nil	3	0	0	0	1	1	Nil	1
004_TAN_RIV	Tana River	Rhoka	Nil	1	0	0	0	1	1	Nil	1
005_TAN_RIV	Tana River	Laini	Nil	1	0	0	0	1	1	Nil	1
006_TAN_RIV	Tana River	Ghalamani	Nil	2	0	0	0	1	1	Nil	1
007_TAN_DEL	Tana Delta	Maziwa	Nil	1	0	0	0	1	1	Nil	1
008_TAN_DEL	Tana Delta	Gadeni Sec School	Nil	3	0	0	0	1	1	Nil	1
009_TAN_DEL	Tana Delta	Assa	Nil	1	0	0	0	1	1	Nil	1
010_TAN_DEL	Tana Delta	Kone	Nil	2	0	0	0	0	1	Nil	1
011_TAN_DEL	Tana Delta	Ngao Hospital	Nil	1	0	0	0	1	1	Nil	1
012_TAN_DEL	Tana Delta	Tarasaa Secondary	Nil	0	0	0	0	0	1	Nil	1
013_TAN_DEL	Tana Delta	Kipini Secondary	Nil	0	0	0	0	1	1	Nil	1
014_TAN_DEL	Tana Delta	Arap Moi Primary Ngao	Nil	1	0	0	0	1	1	Nil	1
015_TAN_DEL	Tana Delta	Baomo	Nil	1	0	0	0	1	1	Nil	1
016_TAN_DEL	Tana Delta	Onwardei	Nil	1	0	0	0	1	1	Nil	1
017_TAN_DEL	Tana Delta	Manano	Nil	1	0	0	0	1	1	Nil	1
018_TAN_DEL	Tana Delta	Tumaini Sch	Nil	1	0	0	0	1	1	Nil	1
019_TAN_DEL	Tana Delta	Majiweni	Nil	1	0	0	0	1	1	Nil	1
020_TAN_NOR	Tana North	Maramtu A	Nil	1	0	0	0	1	1	Nil	1
021_TAN_NOR	Tana North	Maramtu B	Nil	1	0	0	0	1	1	Nil	1
022_TAN_NOR	Tana North	Sombo	Nil	1	0	0	0	1	1	Nil	1
023_TAN_NOR	Tana North	Chewele	Nil	1	0	0	0	1	1	Nil	1
024_TAN_DEL	Tana Delta	Wema	Nil	2	0	0	0	1	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
025_TAN_DEL	Tana Delta	Ozi	Nil	2	0	0	0	1	1	Nil	1
026_TAN_DEL	Tana Delta	Katsangani	Nil	2	0	0	0	1	1	Nil	1

Appendix 3.3.4 Lot 2: Wajir County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Engine enclosure*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_WAJ_ELD	Eldas	Areswaji	-	-	-	-	-	-	1	-	1
002_WAJ_ELD	Eldas	Basir	-	-	-	-	-	-	1	-	1
003_WAJ_ELD	Eldas	Eldas-Anole B/hole	-	-	-	-	-	-	1	-	1
004_WAJ_ELD	Eldas	Eldas town	-	-	-	-	-	-	1	-	1
005_WAJ_ELD	Eldas	Kilkiley	-	-	-	-	-	-	1	-	1
006_WAJ_ELD	Eldas	Masalale	-	-	-	-	-	-	1	-	1
007_WAJ_TAR	Tarbaj	Bojigaras	-	-	-	-	-	-	1	-	1
008_WAJ_TAR	Tarbaj	Kabatula	-	-	-	-	-	-	1	-	1
009_WAJ_TAR	Tarbaj	Mansa	-	-	-	-	-	-	1	-	1
010_WAJ_TAR	Tarbaj	Mashin Ben	-	-	-	-	-	-	1	-	1
011_WAJ_TAR	Tarbaj	Wargadud	-	-	-	-	-	-	1	-	1
012_WAJ_EAS	Wajir East	Boji Garas	-	-	-	-	-	-	1	-	1
013_WAJ_EAS	Wajir East	Khorof harar 2	-	-	-	-	-	-	1	-	1
014_WAJ_EAS	Wajir East	Konton	-	-	-	-	-	-	1	-	1
015_WAJ_EAS	Wajir East	Qarsa	-	-	-	-	-	-	1	-	1
016_WAJ_NOR	Wajir North	Batalu	-	-	-	-	-	-	1	-	1
017_WAJ_NOR	Wajir North	Beramo	-	-	-	-	-	-	1	-	1
018_WAJ_NOR	Wajir North	Bosicha	-	-	-	-	-	-	1	-	1
019_WAJ_NOR	Wajir North	Buna 2	-	-	-	-	-	-	1	-	1
020_WAJ_NOR	Wajir North	Danaba	-	-	-	-	-	-	1	-	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Engine enclosure*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
021_WAJ_NOR	Wajir North	Qaranri	-	-	-	-	-	-	1	-	1
022_WAJ_NOR	Wajir North	Qarsabula	-	-	-	-	-	-	1	-	1
023_WAJ_SOU	Wajir South	Alan us	-	-	-	-	-	-	1	-	1
024_WAJ_SOU	Wajir South	Arablow	-	-	-	-	-	-	1	-	1
025_WAJ_SOU	Wajir South	Banane Shant Aral	-	-	-	-	-	-	1	-	1
026_WAJ_SOU	Wajir South	Buruka	-	-	-	-	-	-	1	-	1
027_WAJ_SOU	Wajir South	Eyrib	-	-	-	-	-	-	1	-	1
028_WAJ_SOU	Wajir South	Furmati	-	-	-	-	-	-	1	-	1
029_WAJ_SOU	Wajir South	Lagdub	-	-	-	-	-	-	1	-	1
030_WAJ_WES	Wajir West	Athibohol	-	-	-	-	-	-	1	-	1
031_WAJ_WES	Wajir West	Baragothey	-	-	-	-	-	-	1	-	1
032_WAJ_WES	Wajir West	Barmil	-	-	-	-	-	-	1	-	1
033_WAJ_WES	Wajir West	Lagdima	-	-	-	-	-	-	1	-	1
034_WAJ_WES	Wajir West	Shanta Abak	-	-	-	-	-	-	1	-	1
035_WAJ_WES	Wajir West	Wara	-	-	-	-	-	-	1	-	1

Appendix 3.3.5 Lot 2: Mandera County

				Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Engine enclosure*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_MAN_BAN	Banisa	Eymole	-	-	-	-	-	-	1	-	1
002_MAN_BAN	Banisa	Hullow	-	-	-	-	-	-	1	-	1
003_MAN_BAN	Banisa	Malka Mari	-	-	-	-	-	-	1	-	1
004_MAN_LAF	Lafey	Bubo	-	-	-	-	-	-	1	-	1
005_MAN_LAF	Lafey	Fino	-	-	-	-	-	-	1	-	1
006_MAN_LAF	Lafey	Lafey 1	-	-	-	-	-	-	1	-	1
007_MAN_LAF	Lafey	Sala 1	-	-	-	-	-	-	1	-	1
008_MAN_LAF	Lafey	Warankara	-	-	-	-	-	-	1	-	1

				Supplementary storage	**Minor works required**		**New civil works required**				**Electrical Works**
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Engine enclosure*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
009_MAN_EAS	Mandera East	Arabia 1	-	-	-	-	-	-	1	-	1
010_MAN_EAS	Mandera East	Arabia Boys	-	-	-	-	-	-	1	-	1
011_MAN_EAS	Mandera East	Bella	-	-	-	-	-	-	1	-	1
012_MAN_EAS	Mandera East	Hareri Hosle	-	2	-	-	-	-	1	-	1
013_MAN_EAS	Mandera East	Libehiya	-	-	-	-	-	-	1	-	1
014_MAN_EAS	Mandera East	Odha 1	-	1	-	-	-	-	1	-	1
015_MAN_EAS	Mandera East	Omar Jillo	-	-	-	-	-	-	1	-	1
016_MAN_NOR	Mandera North	Darab Adadi	-	-	-	-	-	-	1	-	1
017_MAN_NOR	Mandera North	Guticha	-	1	-	-	-	-	1	-	1
018_MAN_NOR	Mandera North	Kubi	-	-	-	-	-	-	1	-	1
019_MAN_NOR	Mandera North	Shirshir	-	-	-	-	-	-	1	-	1
020_MAN_SOU	Mandera South	Brewu 11	-	-	-	-	-	-	1	-	1
021_MAN_SOU	Mandera South	Dawder	-	-	-	-	-	-	1	-	1
022_MAN_SOU	Mandera South	Elele 1	-	-	-	-	-	-	1	-	1
023_MAN_SOU	Mandera South	Garsesala	-	-	-	-	-	-	1	-	1
024_MAN_SOU	Mandera South	Kobadadi	-	1	-	-	-	-	1	-	1
025_MAN_SOU	Mandera South	Kutayu 1	-	-	-	-	-	-	1	-	1
026_MAN_SOU	Mandera South	Kutulo 1	-	-	-	-	-	-	1	-	1
027_MAN_SOU	Mandera South	Shimbir Fatuma	-	-	-	-	-	-	1	-	1
028_MAN_WES	Mandera West	Darwed	-	-	-	-	-	-	1	-	1
029_MAN_WES	Mandera West	Hamasa 2	-	-	-	-	-	-	1	-	1
030_MAN_WES	Mandera West	Wangai Dahan	-	-	-	-	-	-	1	-	1

Appendix 3.3.6 Lot 3: Kilifi County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_KIL_SOU	South Kilifi	Tsalu	Nil	0	0	0	0	0	1	Nil	1
002_KIL_GAN	Ganze	Palakumi	Nil	0	0	0	0	0	1	Nil	1
003_KIL_GAN	Ganze	Mweza	Nil	0	0	0	0	0	1	Nil	1
004_KIL_GAN	Ganze	Mwaeba Mbonga	Nil	0	0	0	0	0	1	Nil	1
005_KIL_GAN	Ganze	Dungicha	Nil	0	0	0	0	0	1	Nil	1
006_KIL_MAL	Malindi	Msabaha kwa Mwasaha	Nil	3	0	0	0	1	1	Nil	1
007_KIL_MAL	Malindi	Sea Breeze- Msamaha wa juu BH	Nil	2	0	0	0	1	1	Nil	1
008_KIL_MAG	Magarini	Gahaleni	Nil	2	0	0	0	1	1	Nil	1
009_KIL_MAL	Malindi	Musoloni, Kwa Jasho	Nil	2	0	0	0	1	1	Nil	1
010_KIL_MAL	Malindi	Takaye centre (Kwa chiguba) BH	Nil	3	0	0	0	1	1	Nil	1
011_KIL_MAG	Magarini	Magarini Mamburui (7 BOREHOLES)	Nil	6	0	0	0	0	1	Nil	1
012_KIL_SOU	South Kilifi	Kolewa chonyi	Nil	3	0	0	0	0	1	Nil	1
013_KIL_SOU	South Kilifi	Bicharo yaa Mzambaraoni	Nil	2	0	0	0	1	1	Nil	1
014_KIL_KAL	Kaloleni	Nyalani Jibana	Nil	2	0	0	0	1	1	Nil	1
015_KIL_NOR	North Kilifi	Tezo	Nil	2	0	0	0	1	1	Nil	1
016_KIL_NOR	North Kilifi	Roka Youth Polytechnic chumani	Nil	1	0	0	0	1	1	Nil	1
017_KIL_NOR	North Kilifi	Wesa Ngerenya	Nil	1	0	0	0	1	1	Nil	1
018_KIL_NOR	North Kilifi	Mkunguni chumani	Nil	2	0	0	0	1	1	Nil	1
019_KIL_NOR	North Kilifi	Roka Maweni	Nil	1	0	0	0	1	1	Nil	1
020_KIL_NOR	North Kilifi	Mtondia Well Kwa Ngonyo	Nil	1	0	0	0	1	1	Nil	1
021_KIL_SOU	South Kilifi	Sharian BH (kwa Akida)	Nil	1	0	0	0	1	1	Nil	1
022_KIL_NOR	North Kilifi	Kwa William Shida BH	Nil	1	0	0	0	1	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
023_KIL_SOU	South Kilifi	Kwa Kadenge wa Kavumbi BH	Nil	1	0	0	0	1	1	Nil	1
024_KIL_NOR	North Kilifi	Kwa Katana wa Chome Majaoni BH	Nil	1	0	0	0	1	1	Nil	1
025_KIL_GAN	Ganze	Migodomani Well tsangatsini BH	Nil	1	0	0	0	1	1	Nil	1
026_KIL_NOR	North Kilifi	Samson Mumbo Nyanje BH	Nil	1	0	0	0	1	1	Nil	1
027_KIL_KAL	Kaloleni	Mkangani Mwakanga Walea BH	Nil	2	0	0	0	1	1	Nil	1
028_KIL_NOR	North Kilifi	Mwambani Kwa Mundu BH	Nil	1	0	0	0	1	1	Nil	1
029_KIL_NOR	North Kilifi	Kwa muye BH	Nil	1	0	0	0	1	1	Nil	1
030_KIL_NOR	North Kilifi	Kadenge paka BH	Nil	1	0	0	0	1	1	Nil	1
031_KIL_MAL	Malindi	Takaye kwa Diiwani - ponda BH	Nil	2	0	0	0	1	1	Nil	1
032_KIL_RAB	Rabai	Masaani BP	Nil	4	0	0	0	0	1	Nil	1
033_KIL_MAG	Magarini	Majengo Centre BH	Nil	3	0	0	0	0	1	Nil	1

Appendix 3.3.7 Lot 3: Kwale County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_KWA_LUN	Lunga Lunga	Mwamose	Nil	2	0	0	0	1	1	Nil	1
002_KWA_LUN	Lunga Lunga	Ganda Pri School	Nil	2	0	0	0	1	1	Nil	1
003_KWA_LUN	Lunga Lunga	Mabafweni(school)	Nil	2	0	0	0	1	1	Nil	1
004_KWA_MSA	Msambweni	Mwendo wa bure	Nil	2	0	0	0	1	1	Nil	1
005_KWA_MAT	Matuga	Chivyogo	Nil	1	0	0	0	1	1	Nil	1
006_KWA_MSA	Msambweni	Vumilia	Nil	2	0	0	0	1	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
007_KWA_MAT	Matuga	Mwananyahi	Nil	0	0	0	0	1	1	Nil	1
008_KWA_MAT	Matuga	Chanyiro Primary	Nil	1	0	0	0	1	1	Nil	1
009_KWA_MAT	Matuga	Simanya	Nil	0	0	0	0	1	1	Nil	1
010_KWA_LUN	Lunga Lunga	Kikonde	Nil	2	0	0	0	1	1	Nil	1
011_KWA_LUN	Lunga Lunga	Mwambalazi	Nil	2	0	0	0	1	1	Nil	1
012_KWA_MAT	Matuga	Mbegani	Nil	0	0	0	0	1	1	Nil	1
013_KWA_MAT	Matuga	Mwamnyuti	Nil	1	0	0	0	1	1	Nil	1
014_KWA_LUN	Lunga Lunga	Mwajiate	Nil	2	0	0	0	1	1	Nil	1
015_KWA_MSA	Msambweni	Funzi	Nil	0	0	0	0	1	1	Nil	1
016_KWA_LUN	Lunga Lunga	Kilimangodo	Nil	2	0	0	0	1	1	Nil	1
017_KWA_LUN	Lunga Lunga	Chindi	Nil	1	0	0	0	1	1	Nil	1
018_KWA_LUN	Lunga Lunga	Kiwambale	Nil	4	0	0	0	1	1	Nil	1
019_KWA_MAT	Matunga	Mtsangatamu Primary School	Nil	2	0	0	0	1	1	Nil	1
020_KWA_LUN	Lunga Lunga	Godo	Nil	0	0	0	0	1	1	Nil	1
021_KWA_MSA	Msambweni	Mali yanuka	Nil	0	0	0	0	1	1	Nil	1
022_KWA_LUN	Lunga Lunga	Mahuruni	Nil	1	0	0	0	1	1	Nil	1
023_KWA_MAT	Matuga	Madibwani	Nil	2	0	0	0	1	1	Nil	1
024_KWA_MAT	Matuga	Mwanamkuu	Nil	2	0	0	0	1	1	Nil	1
025_KWA_LUN	Lunga Lunga	Kifuku	Nil	2	0	0	0	1	1	Nil	1
026_KWA_MAT	Matuga	Kidiani ECD	Nil	2	0	0	0	1	1	Nil	1
027_KWA_MSA	Msambweni	Kijembe	Nil	3	0	0	0	1	1	Nil	1
028_KWA_MSA	Msambweni	Darigube	Nil	2	0	0	0	1	1	Nil	1
029_KWA_MSA	Msambweni	Vukani	Nil	1	0	0	0	1	1	Nil	1
030_KWA_MSA	Msambweni	Bumamani	Nil	2	0	0	0	1	1	Nil	1

Appendix 3.3.8 Lot 4: Isilolo County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/ room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_ISI_MER	Merti	Yamicha	Nil	0	0	0	0	0	1	Nil	1
002_ISI_MER	Merti	Lafe	Nil	3	0	0	0	0	1	Nil	1
003_ISI_MER	Merti	Dogogicha	Nil	1	0	0	0	0	1	Nil	1
004_ISI_GAR	Garbatulla	Duse	Nil	1	0	0	0	0	1	Nil	1
005_ISI_MER	Merti	Alango BH	Nil	4	0	0	0	0	1	Nil	1
006_ISI_MER	Merti	Merti Community BH 1(main)	Nil	2	0	0	0	1	1	Nil	1
007_ISI_MER	Merti	Merti Community BH 2(main)	Nil	2	0	0	0	1	1	Nil	1
008_ISI_MER	Merti	Bulesa(Old)	Nil	0	0	0	0	0	1	Nil	1
009_ISI_GAR	Garbatulla	Yaqbarshadi	Nil	1	0	0	0	0	1	Nil	1
010_ISI_ISI	Isiolo	LMD-kilimani	Nil	4	0	0	0	1	1	Nil	1
011_ISI_GAR	Garbatulla	Kinna(Jillo Dima)	Nil	0	0	0	0	1	1	Nil	1
012_ISI_GAR	Garbatulla	Mogore	Nil	0	0	0	0	0	1	Nil	1
013_ISI_MER	Merti	Goda	Nil	0	0	0	0	1	1	Nil	1
014_ISI_MER	Merti	Taiboto	Nil	2	0	0	0	0	1	Nil	1
015_ISI_GAR	Garbatulla	Modogashe BH2	Nil	0	0	0	0	0	1	Nil	1
016_ISI_GAR	Garbatulla	Kulamawe barrier	Nil	1	0	0	0	0	1	Nil	1
017_ISI_GAR	Garbatulla	Iresaboru Bh 2	Nil	1	0	0	0	0	1	Nil	1
018_ISI_GAR	Garbatulla	Muchuro Bh	Nil	3	0	0	0	0	1	Nil	1

Appendix 3.3.9 Lot 4: Samburu County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_SAM_CEN	Samburu Central	Simiti bore hole	Nil	0	0	0	0	0	1	Nil	1
002_SAM_NOR	Samburu North	Mbukoi borehole	Nil	4	0	0	0	0	1	Nil	1
003_SAM_NOR	Samburu North	Natiti	Nil	0	0	0	0	0	1	Nil	1
004_SAM_NOR	Samburu North	Loruko	Nil	4	0	0	0	0	1	Nil	1
005_SAM_CEN	Samburu Central	Seketet primary school b/h	Nil	1	0	0	0	0	1	Nil	1
006_SAM_NOR	Samburu North	Baragoi Boys Sec. borehole	Nil	0	0	0	0	0	1	Nil	1
007_SAM_CEN	Samburu Central	Nkenju Emuny B/H - 2	Nil	4	0	0	0	0	1	Nil	1
008_SAM_CEN	Samburu Central	Sirata Oirobi B/H	Nil	0	0	0	0	0	1	Nil	1
009_SAM_CEN	Samburu Central	Lolmolok bore hole	Nil	0	0	0	0	0	1	Nil	1
010_SAM_CEN	Samburu Central	Loltulelei bore	Nil	2	0	0	0	0	1	Nil	1
011_SAM_CEN	Samburu Central	Pura bore hole	Nil	1	0	0	0	0	1	Nil	1
012_SAM_CEN	Samburu Central	Lorian bore hole	Nil	1	0	0	0	0	1	Nil	1
013_SAM_NOR	Samburu North	Nkirenyi bore hole	Nil	3	0	0	0	0	1	Nil	1
014_SAM_CEN	Samburu Central	Ngambo Borehole	Nil	4	0	0	0	0	1	Nil	1
015_SAM_EAS	Samburu East	Lderkesi b/hole	Nil	1	0	0	0	0	1	Nil	1
016_SAM_CEN	Samburu Central	Luai	Nil	4	0	0	0	0	1	Nil	1
017_SAM_CEN	Samburu Central	Kitobor bore hole	Nil	4	0	0	0	0	1	Nil	1
018_SAM_CEN	Samburu Central	Lpartuk b/h no. 5	Nil	4	0	0	0	0	1	Nil	1
019_SAM_EAS	Samburu East	Loijuk borehole	Nil	1	0	0	0	0	1	Nil	1
020_SAM_CEN	Samburu Central	Lemisigiyo	Nil	2	0	0	0	0	1	Nil	1
021_SAM_EAS	Samburu East	Leng'ei bore hole	Nil	0	0	0	0	0	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
022_SAM_CEN	Samburu Central	Lcheng'ei Bore hole	Nil	4	0	0	0	0	1	Nil	1
023_SAM_NOR	Samburu North	Tangar bore hole	Nil	1	0	0	0	0	1	Nil	1

Appendix 3.3.10 Lot 4: Marsabit County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_MAR_LAI	Laisamis	Ririma	Nil	1	1	1	0	1	1	Nil	1
002_MAR_MOY	Moyale	Rawana	Nil	0	0	0	0	0	1	Nil	1
003_MAR_MOY	Moyale	Ambalo I	Nil	0	0	0	0	0	1	Nil	1
004_MAR_MOY	Moyale	Laffen	Nil	2	0	0	0	0	1	Nil	1
005_MAR_MOY	Moyale	Dambala Fachana	Nil	1	0	0	0	0	1	Nil	1
006_MAR_MOY	Moyale	Godoma	Nil	3	0	0	0	1	1	Nil	1
007_MAR_MOY	Moyale	Qolob	Nil	1	0	0	0	0	1	Nil	1
008_MAR_MOY	Moyale	Adadi/Kobb	Nil	1	0	0	0	0	1	Nil	1
009_MAR_MOY	Moyale	Dabel II	Nil	3	0	0	0	0	1	Nil	1
010_MAR_MOY	Moyale	Mudam	Nil	2	0	0	0	0	1	Nil	1
011_MAR_SAK	Saku	Dirib gombo	Nil	1	0	0	0	1	1	Nil	1

Appendix 3.3.11 Lot 5: West Pokot County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_WES_KOD	Kodich	Reretiang borehole	Nil	0	0	0	0	1	1	Nil	1
001_WES_SUA	Suam	Lokii Ecd	Nil	1	0	0	0	1	1	Nil	1
001_WES_SAU	Saum	Kopulio Primary Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_SAU	Saum	Lochidangole Borehole-	Nil	1	0	0	0	1	1	Nil	1
001_WES_SAU	Saum	Kaskuroi Ecd Borehole	Nil	0	0	0	0	1	1	Nil	1
001_WES_MAS	Masol	fr. Leo girls sec.	Nil	1	0	0	0	1	1	Nil	1
001_WES_CHE	Chepareria	Chelombai	Nil	1	0	0	0	0	1	Nil	1
001_WES_CHE	Chepareria	Senetwo	Nil	1	0	0	0	0	1	Nil	1
001_WES_ALA	Alale	Kakoliong	Nil	2	0	0	0	0	1	Nil	1
001_WES_KIW	Kiwawa	Mbaru Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_KIW	Kiwawa	Katumkale Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_KIW	Kiwawa	Kaingeny Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_KOD	Kodich	Koyolo Borehole	Nil	2	0	0	0	1	1	Nil	1
001_WES_ALA	Alale	Narwaro Borehole	Nil	2	0	0	0	1	1	Nil	1
001_WES_ALA	Alale	Oron Primary Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_KAP	Kapchok	Katuwot Borehole	Nil	2	0	0	0	1	1	Nil	1
001_WES_KAP	Kapchok	Kodera Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_KAP	Kapchok	Losam Borehole	Nil	2	0	0	0	1	1	Nil	1
001_WES_KAS	Kasei	Morkorio Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_RIW	Riwo	katikomor Borehole	Nil	2	0	0	0	1	1	Nil	1
001_WES_RIW	Riwo	Katukumwok Borehole	Nil	2	0	0	0	1	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_WES_RIW	Riwo	Lodupup Primary School	Nil	1	0	0	0	1	1	Nil	1
001_WES_MNA	Mnagei	Pser Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_MNA	Mnagei	Chetuya Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_SOO	Sook	Katimaril Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_SOO	Sook	Tamugh Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_END	Endugh	Rukei Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_END	Endugh	Kapkata Primary	Nil	1	0	0	0	1	1	Nil	1
001_WES_LOM	lomut	Kokwomeses Primary Borehole	Nil	2	0	0	0	1	1	Nil	1
001_WES_WEI	Wei Wei	Dungdung Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_CHE	Chepareria	Tumoi Borehole	Nil	1	0	0	0	1	1	Nil	1
001_WES_BAT	Batei	Seretow bOREHOLE	Nil	1	0	0	0	1	1	Nil	2

Appendix 3.3.12 Lot 5: Turkana County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_TUR_EAS	East Turkana	Lotubae	Nil	0	0	0	0	1	0	Nil	1
002_TUR_EAS	East Turkana	katilia girls	Nil	2	0	0	0	1	1	Nil	1
003_TUR_EAS	East Turkana	Nakwamomwa	Nil	1	0	0	0	1	1	Nil	1
004_TUR_WES	West Turkana	Loteteleit	Nil	1	0	0	0	1	0	Nil	1
005_TUR_WES	West Turkana	Lokichoggio UN compound	Nil	1	0	0	0	0	1	Nil	1
006_TUR_WES	West Turkana	Lochoriangamor	Nil	1	0	0	0	1	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
007_TUR_WES	West Turkana	Akalaliot	Nil	2	0	0	0	1	1	Nil	1
008_TUR_WES	West Turkana	Nakwangat 2	Nil	2	0	0	0	1	1	Nil	1
009_TUR_WES	West Turkana	Oropoi ws	Nil	2	0	0	0	1	1	Nil	1
010_TUR_SOU	South Turkana	Katilu	Nil	0	0	0	0	0	1	Nil	1
011_TUR_SOU	South Turkana	Lokichar (Chines Bore hole)	Nil	0	0	0	0	0	1	Nil	1
012_TUR_SOU	South Turkana	Kapelbok	Nil	1	0	0	0	1	1	Nil	1
013_TUR_SOU	South Turkana	Lomeleku	Nil	4	0	0	0	1	1	Nil	1
014_TUR_SOU	South Turkana	Kasuroi	Nil	1	0	0	0	1	1	Nil	1
015_TUR_SOU	South Turkana	Lomoonyang	Nil	1	0	0	0	1	1	Nil	1
016_TUR_SOU	South Turkana	Loupwala	Nil	4	0	0	0	1	1	Nil	1
017_TUR_NOR	North Turkana	Napeto	Nil	2	0	0	0	1	1	Nil	1
018_TUR_NOR	North Turkana	Lokumwae	Nil	1	0	0	0	1	1	Nil	1
019_TUR_NOR	North Turkana	Karioworeng	Nil	1	0	0	0	1	1	Nil	1
020_TUR_NOR	North Turkana	Nimwae	Nil	2	0	0	0	1	1	Nil	1
021_TUR_NOR	North Turkana	Lowarengak	Nil	2	0	0	0	1	1	Nil	1
022_TUR_NOR	North Turkana	Murueris	Nil	1	0	0	0	1	1	Nil	1
023_TUR_NOR	North Turkana	Naurkorio	Nil	0	0	0	0	1	1	Nil	1
024_TUR_NOR	North Turkana	Natedelim	Nil	1	0	0	0	1	1	Nil	1
025_TUR_NOR	North Turkana	Loitangule	Nil	1	0	0	0	1	1	Nil	1
026_TUR_SOU	South Turkana	Nagetei	Nil	1	0	0	0	1	1	Nil	1
027_TUR_LOI	Loima	Kanyangapus	Nil	2	0	0	0	1	1	Nil	1
028_TUR_LOI	Loima	Natuntun	Nil	2	0	0	0	1	1	Nil	1
029_TUR_TUR	Turkan West	Alab lab	Nil	1	0	0	0	1	1	Nil	1
030_TUR_LOI	Loima	Lokatul	Nil	1	0	0	0	1	1	Nil	1
031_TUR_LOI	Loima	Kochuch-Tiya	Nil	1	0	0	0	1	1	Nil	1
032_TUR_LOI	Loima	Lomilo	Nil	1	0	0	0	1	1	Nil	1
033_TUR_LOI	Loima	Namoruakwak	Nil	2	0	0	0	1	1	Nil	1
034_TUR_CEN	Central Turkana	Nasulut water supply	Nil	3	0	0	0	1	1	Nil	1
035_TUR_CEN	Central Turkana	Narengelop	Nil	2	0	0	0	1	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
036_TUR_CEN	Central Turkana	Ewoi Egole	Nil	1	0	0	0	1	1	Nil	1
037_TUR_CEN	Central Turkana	Kadinyangole	Nil	4	0	0	0	1	1	Nil	1
038_TUR_CEN	Central Turkana	Naotin water Point	Nil	2	0	0	0	1	1	Nil	1

Appendix 3.3.13 Lot 6: Taita Taveta County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_TAI_TAV	Taveta	Njukini borehole	Nil	0	0	0	0	1	1	Nil	1
002_TAI_TAV	Taveta	Chumvini	Nil	0	0	0	0	1	1	Nil	1
003_TAI_TAV	Taveta	Eldoro	Nil	0	0	0	0	0	1	Nil	1
004_TAI_MWA	Mwatate	Alia	Nil	4	0	0	0	0	1	Nil	1
005_TAI_MWA	Mwatate	Mwachawaza	Nil	0	0	0	0	0	1	Nil	1
006_TAI_VOI	Voi	Uthiani	Nil	0	0	0	0	0	1	Nil	1
007_TAI_MWA	Mwatate	Malukiloriti (A)	Nil	1	0	0	0	0	1	Nil	1
008_TAI_TAV	Taveta	Mahandakini/wololo	Nil	4	0	0	0	0	1	Nil	1
009_TAI_TAV	Taveta	Kitivo ghazi	Nil	4	0	0	0	0	1	Nil	1
010_TAI_TAV	Taveta	Talio nyika	Nil	5	0	0	0	0	1	Nil	1
011_TAI_VOI	Voi	Kisimenyi	Nil	5	0	0	0	0	1	Nil	1
012_TAI_VOI	Voi	Kighombo	Nil	4	0	0	0	0	1	Nil	1
013_TAI_VOI	Voi	Kakimwaita	Nil	5	0	0	0	0	1	Nil	1
015_TAI_WUN	wundanyi	Msau polytechnic	Nil	3	0	0	0	0	1	Nil	1
016_TAI_VOI	Voi	Nyolo bh	Nil	3	0	0	0	0	1	Nil	1
018_TAI_MWA	Mwatate	Rekeke booster pump	Nil	0	0	0	0	0	1	Nil	1
019_TAI_MWA	Mwatate	Modambogho	Nil	1	0	0	0	0	1	Nil	1
020_TAI_TAV	Taveta	Mvita/Kwa scaver	Nil	1	0	0	0	0	1	Nil	1
021_TAI_MWA	Mwatate	Mramba	Nil	1	0	0	0	0	1	Nil	1

Appendix 3.3.14 Lot 6: Narok County

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
001_NAR_EAS	Narok East	Oloikumkum Community b/h	Nil	1	0	0	0	0	1	Nil	1
002_NAR_SOU	Narok South	Morijo Loita b/h water project	Nil	0	0	0	0	0	1	Nil	1
003_NAR_ SO	Narok south	Iltirben b/h Water Project	Nil	2	0	0	0	0	1	Nil	1
004_NAR_WES	Narok West	Aitong Water b/h Project	Nil	2	0	0	0	0	1	Nil	1
005_NAR_SOU	Narok South	Ntuka (Oloisurwa) b/h W/P	Nil	0	0	0	0	0	1	Nil	1
006_NAR_WES	Narok West	Oldonyo Rasha SDA Pry school b/h	Nil	4	0	0	0	1	1	Nil	1
007_NAR_WES	Narok West	Parmolile W/P	Nil	4	0	0	0	0	1	Nil	1
008_NAR_EAS	Narok East	Kitororonyi B/h W/P	Nil	3	0	0	0	0	1	Nil	1
009_NAR_WES	Narok West	Lemesigio b/h W/P	Nil	0	0	0	0	0	1	Nil	1
010_NAR_WES	Narok West	Enkejuarro b/h W/P	Nil	0	0	0	0	0	1	Nil	1
011_NAR_ WE	Narok West	Kishermoruak b/h W/Project	Nil	0	0	0	0	0	1	Nil	1
012_NAR_SOU	Narok South	Ole Pariata b/h Water Project	Nil	0	0	0	0	0	1	Nil	1
013_NAR_SOU	Narok South	Iladuru b/h Water Project	Nil	5	0	0	0	0	1	Nil	1
014_NAR_SOU	Narok South	Ichangipusi b/h water project	Nil	4	0	0	0	0	1	Nil	1
015_NAR_SOU	Narok South	Letukunyi b/h water project	Nil	3	0	0	0	0	1	Nil	1
016_NAR_SOU	Narok South	Osero Lempere b/h water project	Nil	0	0	0	0	0	1	Nil	1
017_NAR_SOU	Narok South	Olkirankawuo b/h water project	Nil	0	0	0	0	0	1	Nil	1
018_NAR_WES	Narok West	Mpuaai b/h water project	Nil	2	0	0	0	0	1	Nil	1
019_NAR_SOU	Narok South	Nkoseremai b/h water project	Nil	2	0	0	0	0	1	Nil	1
020_NAR_SOU	Narok South	Intalala b/h Water Project	Nil	1	0	0	0	1	1	Nil	1
021_NAR_EAS	Narok East	Oloolturot b/h W/P	Nil	1	0	0	0	0	1	Nil	1
022_NAR_NOR	Narok North	Enesampulai b/h W/P	Nil	3	0	0	0	0	1	Nil	1
023_NAR_NOR	Narok North	Sabbath Keeping Church b/h water project	Nil	1	0	0	0	0	1	Nil	1

			Chlorinator	Supplementary storage	Minor works required		New civil works required				Electrical Works
Site code	*Sub-county*	*Site name*	*Qty*	*Qty new 10,000 liter tanks*	*Masonary tank repair*	*Valves & fittings*	*Control room / enclosure*	*Diesel Genset enclosure/room*	*Fencing*	*Chlorinator enclosure at tank*	*Float switch at tank and cabling*
024_NAR_TRA	Transmara East	Emurua Dikirr b/h W/P	Nil	4	0	0	0	0	1	Nil	1
025_NAR_SOU	Narok South	Olobaai community b/h	Nil	1	0	0	0	0	1	Nil	1
026_NAR_SOU	Narok South	Nkairuwuani community b/h	Nil	3	0	0	0	0	1	Nil	1
027_NAR_SOU	Narok South	Intasati B/h	Nil	1	0	0	0	1	1	Nil	1
028_NAR_SOU	Narok south	Koseka Community B/h	Nil	2	0	0	0	1	1	Nil	1
029_NAR_TRA	Transmara East	Mugenyi/Njipship/Emurua dikkir B/h W/P	Nil	4	0	0	0	0	1	Nil	1
030_NAR_SOU	Narok South	Narosura B/h	Nil	0	0	0	0	0	1	Nil	1
031_NAR_WES	Narok West	Omomet (Enerelai)	Nil	1	0	0	0	0	1	Nil	1
032_NAR_WES	Narok West	Empora/ Olomonira Community	Nil	1	0	0	0	0	1	Nil	1
033_NAR_TRA	Transmara East	Simutwet water project	Nil	1	0	0	0	1	1	Nil	1
034_NAR_EAS	Narok East	Enobalbal B/h	Nil	1	0	0	0	0	1	Nil	1
035_NAR_NOR	Narok North	M.O.W.D. Nkaleta	Nil	2	0	0	0	0	1	Nil	1
036_NAR_WES	Narok West	Ndonyo Narasha Well	Nil	0	0	0	0	1	1	Nil	1
037_NAR_WES	Narok West	Nkaimurunya B/h	Nil	1	0	0	0	0	1	Nil	1

Appendix 3.3 SITE LOCATIONS

Appendix 3.3.1 Lot 1: Garissa County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Garissa	Balambla	001_GAR_BAL	Abdisamad	0.0431	39.0615
Garissa	Balambla	002_GAR_BAL	Shimbirey 1	0.0431	39.0615
Garissa	Dadaab	003_GAR_DAD	Abdisugow	0.0926	40.3191
Garissa	Dadaab	004_GAR_DAD	AP Camp	0.0926	40.3191
Garissa	Dadaab	005_GAR_DAD	Godlie Farm	0.0926	40.3191
Garissa	Dadaab	006_GAR_DAD	Hagarbul	0.0926	40.3191
Garissa	Dadaab	007_GAR_DAD	Kadaqso	0.0926	40.3191
Garissa	Dadaab	008_GAR_DAD	Kwanjayarey	0.0926	40.3191
Garissa	Dadaab	009_GAR_DAD	Sheldub	0.0926	40.3191
Garissa	Fafi	010_GAR_FAF	Alanjugur	0.0321	40.4581
Garissa	Fafi	011_GAR_FAF	Amuma	0.3425	40.9156
Garissa	Fafi	012_GAR_FAF	Fafi	0.3938	40.3266
Garissa	Fafi	013_GAR_FAF	Jambele	1.0142	39.9167
Garissa	Fafi	014_GAR_FAF	Nanigi	0.6683	39.8227
Garissa	Fafi	015_GAR_FAF	Ruqa	1.4838	40.4313
Garissa	Fafi	016_GAR_FAF	Warable	0.6683	39.8227
Garissa	Fafi	017_GAR_FAF	Welmarer	0.4527	40.8659
Garissa	Hulugho	018_GAR_HUL	Hulugho 1	1.0590	41.0797
Garissa	Hulugho	019_GAR_HUL	Hulugho 2	1.0630	41.0886
Garissa	Hulugho	020_GAR_HUL	Sangailu	1.2146	40.5534
Garissa	Ijara	021_GAR_IJA	Handaro	1.4631	40.6956
Garissa	Ijara	022_GAR_IJA	Hara	0.4532	39.6461
Garissa	Ijara	023_GAR_IJA	Kotile	1.9765	40.2578
Garissa	Lagdera	024_GAR_LAG	Baraki 1	0.5524	39.4450
Garissa	Lagdera	025_GAR_LAG	Dehle	0.0431	39.0615
Garissa	Lagdera	026_GAR_LAG	Gurufa	0.0431	39.0615
Garissa	Lagdera	027_GAR_LAG	Shanta Abaq	0.0926	40.3191

Appendix 3.3.2 Lot 1: Lamu County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Lamu	Lamu East	001_LAM_LAM	Kiwayuu well no.1	-1.9976	41.2829
Lamu	Lamu East	002_LAM_LAM	Kiwayuu well no.2	-1.9976	41.2829
Lamu	Lamu East	003_LAM_LAM	Kiwayuu well no.3	-1.9973	41.2801
Lamu	Lamu East	004_LAM_LAM	Kizingitini	-2.0718	41.1430
Lamu	Lamu East	005_LAM_LAM	Mulei Well	-2.4178	40.7354
Lamu	Lamu East	006_LAM_EAS	Mkokoni well no.1	-1.9666	41.2971
Lamu	Lamu East	007_LAM_LAM	Mkokoni well no.2	-1.9666	41.2973
Lamu	Lamu East	008_LAM_EAS	Rasini well no.1-5	-2.0591	41.0838
Lamu	Lamu West	009_LAM_WES	Amkeni Primary Sch	-2.3846	40.4434
Lamu	Lamu West	010_LAM_LAM	Bomani Pri	-2.3743	40.6576
Lamu	Lamu West	011_LAM_LAM	Hongwe AP camp	-2.3495	40.6642
Lamu	Lamu West	012_LAM_LAM	Kangaja Pri	-2.3841	40.7654
Lamu	Lamu West	013_LAM_WES	Kipungani	-2.2954	40.8369

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Lamu	Lamu West	014_LAM_WES	Kwa Guyo	-2.3098	40.8220
Lamu	Lamu West	015_LAM_WES	Matondoni	-2.2711	40.8369
Lamu	Lamu West	016_LAM_LAM	Mkunumbi pri	-2.3341	40.7101
Lamu	Lamu West	017_LAM_LAM	Ndeu pri	-2.1981	40.7905
Lamu	Lamu West	018_LAM_LAM	Ngoi Pri	-2.3872	40.7640
Lamu	Lamu West	019_LAM_WES	Poromoko Pri	-2.1981	40.7905
Lamu	Lamu West	020_LAM_WES	Rehema Pri.	-2.3870	40.4408
Lamu	Lamu West	021_LAM_WES	Thaku Thaku Teee nursery	-2.3055	40.7027

Appendix 3.3.3 Lot 1: Tana River County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Tana River	Tana River	001_TAN_RIV	Maroni	S 010 50.998’	E 0400 6.001’
Tana River	Tana River	002_TAN_RIV	Haroresa	S 01º 42' 24.46''	E 39º 53; 56.13''
Tana River	Tana River	003_TAN_RIV	Kone Kaliti	S 01º 21' 58.62'';	E 39º 59; 29.40''
Tana River	Tana River	004_TAN_RIV	Rhoka	S 01º 14' 30.88'';	E 39º 55; 11.01''
Tana River	Tana River	005_TAN_RIV	Laini	S 01º 21' 58.62''	E 39º 59; 29.40''
Tana River	Tana River	006_TAN_RIV	Ghalamani	1.10000 S	39.9300 E
Tana River	Tana Delta	007_TAN_DEL	Maziwa	S 02º 11' 06.84''	E 40º 08; 00.50''
Tana River	Tana Delta	008_TAN_DEL	Gadeni Sec School	S 02º 14' 04.23'';	E 40º 10; 48.73''
Tana River	Tana Delta	009_TAN_DEL	Assa	S 02º 16' 10.12''	E 40º 06; 38.55''
Tana River	Tana Delta	010_TAN_DEL	Kone	S 02º 16' 10.12''	E 40º 06' 38.55''
Tana River	Tana Delta	011_TAN_DEL	Ngao Hospital	S 02º 24' 43.92''	E 40º 12; 03.96''
Tana River	Tana Delta	012_TAN_DEL	Tarasaa Secondary	S 02º 28' 43.29''	E 40º 05; 01.72''
Tana River	Tana Delta	013_TAN_DEL	Kipini Secondary	S 02º 29' 28.83''	E 40º 32; 12.75''
Tana River	Tana Delta	014_TAN_DEL	Arap Moi Primary Ngao	S 02º 24' 46.19'';	E 40º 12; 09.16''
Tana River	Tana Delta	015_TAN_DEL	Baomo	S 01º 54.775';	E 40º 07.037'
Tana River	Tana Delta	016_TAN_DEL	Onwardei		
Tana River	Tana Delta	017_TAN_DEL	Manano		
Tana River	Tana Delta	018_TAN_DEL	Tumaini Sch	S 01º 13' 24.83''	E 39º 50; 30.72''
Tana River	Tana Delta	019_TAN_DEL	Majiweni	2.4300 S	40.4000 E
Tana River	Tana North	020_TAN_NOR	Maramtu A	0.5665 S	39.5071 E
Tana River	Tana North	021_TAN_NOR	Maramtu B	0.5665 S	39.5071 E
Tana River	Tana North	022_TAN_NOR	Sombo	S 0º 35' 43.25''	E 39º 41; 51.35''
Tana River	Tana North	023_TAN_NOR	Chewele	S 0º 44' 09.18''	E 34º 34; 39.92''
Tana River	Tana Delta	024_TAN_DEL	Wema	S 2º 13' 20.98''	E 40º 10; 33.58''
Tana River	Tana Delta	025_TAN_DEL	Ozi	S 2º 31' 15.91''	E 40º 28; 37.82''
Tana River	Tana Delta	026_TAN_DEL	Katsangani	S 2º 40' 14.86''	E 40º 13; 14.05''

Appendix 3.3.4 Lot 2: Wajir County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Wajir	Eldas	001_WAJ_ELD	Areswaji	1.7471	40.0573
Wajir	Eldas	002_WAJ_ELD	Basir	1.7471	40.0573
Wajir	Eldas	003_WAJ_ELD	Eldas-Anole B/hole	2.4977	39.6498
Wajir	Eldas	004_WAJ_ELD	Eldas town	2.4924	39.5669
Wajir	Eldas	005_WAJ_ELD	Kilkiley	2.3203	39.4689
Wajir	Eldas	006_WAJ_ELD	Masalale	2.5497	39.5925
Wajir	Tarbaj	007_WAJ_TAR	Bojigaras	2.6615	40.5280
Wajir	Tarbaj	008_WAJ_TAR	Kabatula	1.7471	40.0573
Wajir	Tarbaj	009_WAJ_TAR	Mansa	2.5315	40.2214

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Wajir	Tarbaj	010_WAJ_TAR	Mashin Ben	1.7471	40.0573
Wajir	Tarbaj	011_WAJ_TAR	Wargadud	2.3102	40.3622
Wajir	Wajir East	012_WAJ_EAS	Boji Garas	1.7471	40.0573
Wajir	Wajir East	013_WAJ_EAS	Khorof harar 2	2.2020	40.7540
Wajir	Wajir East	014_WAJ_EAS	Konton	2.0179	40.9068
Wajir	Wajir East	015_WAJ_EAS	Qarsa	2.0781	40.7478
Wajir	Wajir North	016_WAJ_NOR	Batalu	1.7471	40.0573
Wajir	Wajir North	017_WAJ_NOR	Beramo	1.7471	40.0573
Wajir	Wajir North	018_WAJ_NOR	Bosicha	1.7471	40.0573
Wajir	Wajir North	019_WAJ_NOR	Buna 2	2.7886	39.5000
Wajir	Wajir North	020_WAJ_NOR	Danaba	3.3395	39.7858
Wajir	Wajir North	021_WAJ_NOR	Qaranri	1.7471	40.0573
Wajir	Wajir North	022_WAJ_NOR	Qarsabula	1.7471	40.0573
Wajir	Wajir South	023_WAJ_SOU	Alan us	1.7471	40.0573
Wajir	Wajir South	024_WAJ_SOU	Arablow	1.7471	40.0573
Wajir	Wajir South	025_WAJ_SOU	Banane Shant Aral	0.7167	40.4840
Wajir	Wajir South	026_WAJ_SOU	Buruka	0.6510	40.1262
Wajir	Wajir South	027_WAJ_SOU	Eyrib	1.1537	40.0208
Wajir	Wajir South	028_WAJ_SOU	Furmati	0.8786	39.9703
Wajir	Wajir South	029_WAJ_SOU	Lagdub	1.7471	40.0573
Wajir	Wajir West	030_WAJ_WES	Athibohol	1.0168	39.4837
Wajir	Wajir West	031_WAJ_WES	Baragothey	1.3914	39.3092
Wajir	Wajir West	032_WAJ_WES	Barmil	1.6249	39.7145
Wajir	Wajir West	033_WAJ_WES	Lagdima	1.7471	40.0573
Wajir	Wajir West	034_WAJ_WES	Shanta Abak	1.6863	39.8918
Wajir	Wajir West	035_WAJ_WES	Wara		#VALUE!

Appendix 3.3.5 Lot 2: Mandera County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Mandera	Banisa	001_MAN_BAN	Eymole	4.0364	40.1986
Mandera	Banisa	002_MAN_BAN	Hullow	4.1817	40.8008
Mandera	Banisa	003_MAN_BAN	Malka Mari	4.2372	40.6964
Mandera	Lafey	004_MAN_LAF	Bubo	3.1517	41.1847
Mandera	Lafey	005_MAN_LAF	Fino	3.3775	41.4156
Mandera	Lafey	006_MAN_LAF	Lafey 1	3.1489	41.1872
Mandera	Lafey	007_MAN_LAF	Sala 1	3.9319	41.2775
Mandera	Lafey	008_MAN_LAF	Warankara	3.4098	41.0100
Mandera	Mandera East	009_MAN_EAS	Arabia 1	3.5603	41.5053
Mandera	Mandera East	010_MAN_EAS	Arabia Boys	3.5592	41.5061
Mandera	Mandera East	011_MAN_EAS	Bella	3.9503	41.6517
Mandera	Mandera East	012_MAN_EAS	Hareri Hosle	3.8028	41.7125
Mandera	Mandera East	013_MAN_EAS	Libehiya	3.8306	41.5275
Mandera	Mandera East	014_MAN_EAS	Odha 1	3.5369	41.3486
Mandera	Mandera East	015_MAN_EAS	Omar Jillo	3.7544	41.6647
Mandera	Mandera North	016_MAN_NOR	Darab Adadi	3.8731	40.8386
Mandera	Mandera North	017_MAN_NOR	Guticha	3.5897	40.8350

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Mandera	Mandera North	018_MAN_NOR	Kubi	3.5544	40.8028
Mandera	Mandera North	019_MAN_NOR	Shirshir	3.5333	40.7389
Mandera	Mandera South	020_MAN_SOU	Brewu 11		#VALUE!
Mandera	Mandera South	021_MAN_SOU	Dawder	3.2808	40.4217
Mandera	Mandera South	022_MAN_SOU	Elele 1	3.2723	40.7071
Mandera	Mandera South	023_MAN_SOU	Garsesala	2.5389	40.9386
Mandera	Mandera South	024_MAN_SOU	Kobadadi		#VALUE!
Mandera	Mandera South	025_MAN_SOU	Kutayu 1	2.6614	40.6908
Mandera	Mandera South	026_MAN_SOU	Kutulo 1	2.4081	40.5961
Mandera	Mandera South	027_MAN_SOU	Shimbir Fatuma	3.0256	40.5092
Mandera	Mandera West	028_MAN_WES	Darwed	3.4559	40.2319
Mandera	Mandera West	029_MAN_WES	Hamasa 2	3.4492	40.0792
Mandera	Mandera West	030_MAN_WES	Wangai Dahan	3.3681	40.2775

Appendix 3.3.6 Lot 3: Kilifi County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Kilifi	South Kilifi	001_KIL_SOU	Tsalu	37m,0579247E UTM 9587438N	37m,0579247E UTM 9587438N
Kilifi	Ganze	002_KIL_GAN	Palakumi	37m,0616562E,UTM9639634N	37m,0616562E,UTM9639634N
Kilifi	Ganze	003_KIL_GAN	Mweza	37M,0573674E,UTM9614013N	37M,0573674E,UTM9614013N
Kilifi	Ganze	004_KIL_GAN	Mwaeba Mbonga	37M,0576328E,UTM 9602979N	37M,0576328E,UTM 9602979N
Kilifi	Ganze	005_KIL_GAN	Dungicha	37M,0569096E,UTM9615775N	37M,0569096E,UTM9615775N
Kilifi	Malindi	006_KIL_MAL	Msabaha kwa Mwasaha	37M,0616558E,UTM9639628N	37M,0616558E,UTM9639628N
Kilifi	Malindi	007_KIL_MAL	Sea Breeze- Msamaha wa juu BH	37M,0618032E,UTM9639316N	37M,0618032E,UTM9639316N
Kilifi	Magarini	008_KIL_MAG	Gahaleni	37M,062982E,UTM9638294N	37M,062982E,UTM9638294N
Kilifi	Malindi	009_KIL_MAL	Musoloni, Kwa Jasho	37M,0622236E,UTM,963945N	37M,0622236E,UTM,963945N
Kilifi	Malindi	010_KIL_MAL	Takaye centre (Kwa chiguba) BH	37m,062244E,UTM9440606N	37m,062244E,UTM9440606N
KILIFI	Magarini	011_KIL_MAG	Magarini Mamburui (7 BOREHOLES)	37m,0628016E	37m,0628016E
KILIFI	South Kilifi	012_KIL_SOU	Kolewa chonyi	37M, 0583855 E, UTM 9580567 N	37M, 0583855 E, UTM 9580567 N
KILIFI	South Kilifi	013_KIL_SOU	Bicharo yaa Mzambaraoni	37M, 0583007 E, UTM 9564670 N	37M, 0583007 E, UTM 9564670 N
KILIFI	Kaloleni	014_KIL_KAL	Nyalani Jibana	37M, 0575570 E, UTM 9578358 N	37M, 0575570 E, UTM 9578358 N
KILIFI	North Kilifi	015_KIL_NOR	Tezo	37m,061e,utm 963962N	37m,061e,utm 963962N
KILIFI	North Kilifi	016_KIL_NOR	Roka Youth Polytechnic chumani	37m,0603011,UTM 9625244N	37m,0603011,UTM 9625244N
KILIFI	North Kilifi	017_KIL_NOR	Wesa Ngerenya	37M,0661635E,UTM9614818N	37M,0661635E,UTM9614818N
KILIFI	North Kilifi	018_KIL_NOR	Mkunguni chumani	37,0615370E,UTM 9614193N	37,0615370E,UTM 9614193N
KILIFI	North Kilifi	019_KIL_NOR	Roka Maweni	37m,0603036E UTM9618761N	37m,0603036E UTM9618761N
KILIFI	North Kilifi	020_KIL_NOR	Mtondia Well Kwa Ngonyo	37M, 0596453 E, UTM, 9604365	37M, 0596453 E, UTM, 9604365
KILIFI	South Kilifi	021_KIL_SOU	Sharian BH (kwa Akida)	37M, 0591655 E, UTM 9581156 N	37M, 0591655 E, UTM 9581156 N
KILIFI	North Kilifi	022_KIL_NOR	Kwa William Shida BH	37M, 0603010 E, UTM 9625245 N	37M, 0603010 E, UTM 9625245 N
KILIFI	South Kilifi	023_KIL_SOU	Kwa Kadenge wa Kavumbi BH	37M, 0602055 E, UTM 9618233 N	37M, 0602055 E, UTM 9618233 N

Site Data				Location	
County	Sub-county	Site code	Site name	Latitude	Longitude
KILIFI	North Kilifi	024_KIL_NOR	Kwa Katana wa Chome Majaoni BH	37M, 0596350 E, UTM 9606373 N	37M, 0596350 E, UTM 9606373 N
KILIFI	Ganze	025_KIL_GAN	Migodomani Well tsangatsini BH	03D26.603" S 039D46.62" E	03D26.603" S 039D46.62" E
KILIFI	North Kilifi	026_KIL_NOR	Samson Mumbo Nyanje BH	37M, 0571019 E, UTM 957858 N	37M, 0571019 E, UTM 957858 N
KILIFI	Kaloleni	027_KIL_KAL	Mkangani Mwakanga Walea BH	37M, 0571019 E, UTM 9578358 N	37M, 0571019 E, UTM 9578358 N
KILIFI	North Kilifi	028_KIL_NOR	Mwambani Kwa Mundu BH	37m,0597868E,UTM 961195N	37m,0597868E,UTM 961195N
KILIFI	North Kilifi	029_KIL_NOR	Kwa muye BH	37,0601224E,UTM96155552N	37,0601224E,UTM96155552N
KILIFI	North Kilifi	030_KIL_NOR	Kadenge paka BH	37M,0600081E,UTM 9620260N	37M,0600081E,UTM 9620260N
KILIFI	Malindi	031_KIL_MAL	Takaye kwa Diiwani - ponda BH	37M,0621942E,UTM 9640783N	37M,0621942E,UTM 9640783N
KILIFI	Rabai	032_KIL_RAB	Masaani BP	3.9454 S	39.5588 E
KILIFI	Magarini	033_KIL_MAG	Majengo Centre BH	1.2861 S	36.8425 E

Appendix 3.3.7 Lot 3: Kwale County

Site Data				Location	
County	Sub-county	Site code	Site name	Latitude	Longitude
KWALE	Lunga Lunga	001_KWA_LUN	Mwamose	4.6607 S	39.2194 E
KWALE	Lunga Lunga	002_KWA_LUN	Ganda Pri School	4.5348 S	39.2483 E
KWALE	Lunga Lunga	003_KWA_LUN	Mabafweni(school)	4.5500 S	39.3500 E
KWALE	Msambweni	004_KWA_MSA	Mwendo wa bure	4.5205 S	39.4094 E
KWALE	Matuga	005_KWA_MAT	Chivyogo	4.2384 S	39.5950 E
KWALE	Msambweni	006_KWA_MSA	Vumilia	4.3780 S	39.5071 E
KWALE	Matuga	007_KWA_MAT	Mwananyahi	4.1816 S	39.4606 E
KWALE	Matuga	008_KWA_MAT	Chanyiro Primary	4.3392 S	39.2550 E
KWALE	Matuga	009_KWA_MAT	Simanya	4.3475 S	39.2203 E
KWALE	Lunga Lunga	010_KWA_LUN	Kikonde	4.4289 S	39.2168 E
KWALE	Lunga Lunga	011_KWA_LUN	Mwambalazi	4.4706 S	39.3205 E
KWALE	Matuga	012_KWA_MAT	Mbegani	4.3500 S	39.1833 E
KWALE	Matuga	013_KWA_MAT	Mwamnyuti	4.2384 S	39.5950 E
KWALE	Lunga Lunga	014_KWA_LUN	Mwajiate	4.5500 S	39.3500 E
KWALE	Msambweni	015_KWA_MSA	Funzi	4.5205 S	39.4094 E
KWALE	Lunga Lunga	016_KWA_LUN	Kilimangodo	4.2377 S	38.8624 E
KWALE	Lunga Lunga	017_KWA_LUN	Chindi	4.2377 S	38.8624 E
KWALE	Lunga Lunga	018_KWA_LUN	Kiwambale	4.5716 S	39.3840 E
KWALE	Matunga	019_KWA_MAT	Mtsangatamu Primary School	4.2981 S	39.2168 E
KWALE	Lunga Lunga	020_KWA_LUN	Godo	4.261 S	39.1244 E
KWALE	Msambweni	021_KWA_MSA	Mali yanuka	4.5205 S	39.4094 E
KWALE	Lunga Lunga	022_KWA_LUN	Mahuruni	4.5387 S	39.1549 E
KWALE	Matuga	023_KWA_MAT	Madibwani	4.1232 S	39.6063 E
KWALE	Matuga	024_KWA_MAT	Mwanamkuu	4.1744 S	39.4602 E
KWALE	Lunga Lunga	025_KWA_LUN	Kifuku	4.4500 S	39.3000 E
KWALE	Matuga	026_KWA_MAT	Kidiani ECD	4.4000 S	39.3833 E
KWALE	Msambweni	027_KWA_MSA	Kijembe	4.3780 S	39.5071 E
KWALE	Msambweni	028_KWA_MSA	Darigube	4.5205 S	39.4094 E
KWALE	Msambweni	029_KWA_MSA	Vukani	4.2715 S	39.5847 E
KWALE	Msambweni	030_KWA_MSA	Bumamani	4.3780 S	39.5071 E

Appendix 3.3.8 Lot 4: Isilolo County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Isiolo	Merti	001_ISI_MER	Yamicha	1.73215	38.60898
Isiolo	Merti	002_ISI_MER	Lafe	1.40509	38.90793
Isiolo	Merti	003_ISI_MER	Dogogicha	1.21860	38.48280
Isiolo	Garbatulla	004_ISI_GAR	Duse	0.32162	38.20610
Isiolo	Merti	005_ISI_MER	Alango BH	1.40461	39.06838
Isiolo (R)	Merti	006_ISI_MER	Merti Community BH 1(main)	1.06176	38.67032
Isiolo	Merti	007_ISI_MER	Merti Community BH 2(main)	1.06176	38.67032
Isiolo(R)	Merti	008_ISI_MER	Bulesa(Old)	1.06120	38.66610
Isiolo	Garbatulla	009_ISI_GAR	Yaqbarshadi	0.57258	38.08011
Isiolo(R)	Isiolo	010_ISI_ISI	LMD-kilimani	0.35689	37.56021
Isiolo(R)	Garbatulla	011_ISI_GAR	Kinna(Jillo Dima)	0.31975	38.21319
Isiolo	Garbatulla	012_ISI_GAR	Mogore	0.98301	38.73330
Isiolo(R)	Merti	013_ISI_MER	Goda	0.35460	37.58220
Isiolo	Merti	014_ISI_MER	Taiboto	1.06559	37.45120
Isiolo (R)	Garbatulla	015_ISI_GAR	Modogashe BH2	0.88150	39.07110
Isiolo	Garbatulla	016_ISI_GAR	Kulamawe barrier	0.82813	38.50660
Isiolo	Garbatulla	017_ISI_GAR	Iresaboru Bh 2	1.06588	38.74131
Isiolo	Garbatulla	018_ISI_GAR	Muchuro Bh	0.96209	38.62027

Appendix 3.3.9 Lot 4: Samburu County

Site data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Samburu	Samburu Central	001_SAM_CEN	Simiti bore hole	1.6602 N	36.9574 E
Samburu	Samburu North	002_SAM_NOR	Mbukoi borehole		
Samburu	Samburu North	003_SAM_NOR	Natiti	1.7999 N	36.7743 E
Samburu	Samburu North	004_SAM_NOR	Loruko	1.9763 N	36.8902 E
Samburu	Samburu Central	005_SAM_CEN	Seketet primary school b/h	1.1400 N	36.600 E
Samburu	Samburu North	006_SAM_NOR	Baragoi Boys Sec. borehole	1.7827 N	36.7922 E
Samburu	Samburu Central	007_SAM_CEN	Nkenju Emuny B/H - 2	1.0276 N	36.6888 E
Samburu	Samburu Central	008_SAM_CEN	Sirata Oirobi B/H	1.0475 N	36.6510 E
Samburu	Samburu Central	009_SAM_CEN	Lolmolok bore hole	0.9513 N	36.6062 E
Samburu	Samburu Central	010_SAM_CEN	Loltulelei bore	0.8776 N	36.8360 E
Samburu	Samburu Central	011_SAM_CEN	Pura bore hole	1.1300 N	36.5300 E
Samburu	Samburu Central	012_SAM_CEN	Lorian bore hole	1.2817 N	36.6957 E
Samburu	Samburu North	013_SAM_NOR	Nkirenyi bore hole	1.2981 N	36.6664 E
Samburu	Samburu Central	014_SAM_CEN	Ngambo Borehole	0° 30' 6" N	36° 3' 47" E
Samburu	Samburu East	015_SAM_EAS	Lderkesi b/hole	0.6560 N	37.6576 E
Samburu	Samburu Central	016_SAM_CEN	Luai		
Samburu	Samburu Central	017_SAM_CEN	Kitobor bore hole	0.9635 N	36.6564 E
Samburu	Samburu Central	018_SAM_CEN	Lpartuk b/h no. 5	1.09806 N	36.6559 E
Samburu	Samburu East	019_SAM_EAS	Loijuk borehole	0.7381 N	37.4164 E
Samburu	Samburu Central	020_SAM_CEN	Lemisigiyo	1.0769 N	36.6472 E
Samburu	Samburu East	021_SAM_EAS	Leng'ei bore hole	0.7994 N	37.01886 E
Samburu	Samburu Central	022_SAM_CEN	Lcheng'ei Bore hole	0.7994 N	37.01886 E
Samburu	Samburu North	023_SAM_NOR	Tangar bore hole	1.1667 N	36.6667 E

Appendix 3.3.10 Lot 4: Marsabit County

Site data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Marsabit	Laisamis	001_MAR_LAI	Ririma		
Marsabit	Moyale	002_MAR_MOY	Rawana	2.8282 N	38.6949 E

Site data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Marsabit	Moyale	003_MAR_MOY	Ambalo I	3.0348 N	38.7510 E
Marsabit	Moyale	004_MAR_MOY	Laffen		
Marsabit	Moyale	005_MAR_MOY	Dambala Fachana	3.3307 N	38.8624 E
Marsabit	Moyale	006_MAR_MOY	Godoma	3.3983 N	39.2895 E
Marsabit	Moyale	007_MAR_MOY	Qolob		
Marsabit	Moyale	008_MAR_MOY	Adadi/Kobb		
Marsabit	Moyale	009_MAR_MOY	Dabel II	3.0835 N	39.2661 E
Marsabit	Moyale	010_MAR_MOY	Mudam		
Marsabit	Saku	011_MAR_SAK	Dirib gombo	2.2972 N	38.0843 E

Appendix 3.2.11 Lot 5: West Pokot County

					Location	
County	*Sub-county*	*Site code*		*Site name*	*Latitude*	*Longitude*
West Pokot	Kodich	001_WES_KOD		Reretiang borehole	1.6436 N	35.0608 E
West Pokot	Suam	001_WES_SUA		Lokii Ecd	1.5172 N	34.9727 E
West Pokot	Saum	001_WES_SAU		Kopulio Primary Borehole	1.3910 N	34.8845 E
West Pokot	Saum	001_WES_SAU		Lochidangole Borehole-	1.3910 N	34.8845 E
West Pokot	Saum	001_WES_SAU		Kaskuroi Ecd Borehole	1.3910 N	34.8845 E
West Pokot	Masol	001_WES_MAS		fr. Leo girls sec.	1.4935 N	35.4659 E
West Pokot	Chepareria	001_WES_CHE		Chelombai	1.1300 N	35.1900 E
West Pokot	Chepareria	001_WES_CHE		Senetwo	1.3200 N	35.1700 E
West Pokot	Alale	001_WES_ALA		Kakoliong	2.2766 N	35.0038 E
West Pokot	Kiwawa	001_WES_KIW		Mbaru Borehole	2.0100 N	5.0300 E
West Pokot	Kiwawa	001_WES_KIW		Katumkale Borehole	1.9982 N	35.0608 E
West Pokot	Kiwawa	001_WES_KIW		Kaingeny Borehole	1.9982 N	35.0608 E
West Pokot	Kodich	001_WES_KOD		Koyolo Borehole	1.6438 N	35.0606 E
West Pokot	Alale	001_WES_ALA		Narwaro Borehole	2.2473 N	5.0113 E
West Pokot	Alale	001_WES_ALA		Oron Primary Borehole	2.2480 N	5.0113 E
West Pokot	Kapchok	001_WES_KAP		Katuwot Borehole	1.7878 N	35.0829 E
West Pokot	Kapchok	001_WES_KAP		Kodera Borehole	1.7879 N	35.0830 E
West Pokot	Kapchok	001_WES_KAP		Losam Borehole	1.7881 N	35.0830 E
West Pokot	Kasei	001_WES_KAS		Morkorio Borehole	1.9667 N	35.2000 E
West Pokot	Riwo	001_WES_RIW		katikomor Borehole	1.3035 N	34.8735 E
West Pokot	Riwo	001_WES_RIW		Katukumwok Borehole	1,4206 N	35.0168 E
West Pokot	Riwo	001_WES_RIW		Lodupup Primary School	1.4500 N	34.9600 E
West Pokot	Mnagei	001_WES_MNA		Pser Borehole	1.2344 N	35.0247 E
West Pokot	Mnagei	001_WES_MNA		Chetuya Borehole	1.2516 N	35.0195 E
West Pokot	Sook	001_WES_SOO		Katimaril Borehole	1°36'14.3" N	35°17'25.5"E
West Pokot	Sook	001_WES_SOO		Tamugh Borehole	1.5768 N	35.2660 E
West Pokot	Endugh	001_WES_END		Rukei Borehole	1.6802 N	35.1745 E
West Pokot	Endugh	001_WES_END		Kapkata Primary	1.6278 N	35.2781 E
West Pokot	lomut	001_WES_LOM		Kokwomeses Primary Borehole	1.3352 N	35.6181 E
West Pokot	Wei Wei	001_WES_WEI		Dungdung Borehole	1.4794 N	35.4671 E
West Pokot	Chepareria	001_WES_CHE		Tumoi Borehole	1.4942 N	35.0472 E
West Pokot	Batei	001_WES_BAT		Seretow bOREHOLE	1.3634 N	35.2660 E

Appendix 3.3.12 Lot 5: Turkana County

				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Turkana	East Turkana	001_TUR_EAS	Lotubae	2.02739	36.13847
Turkana	East Turkana	002_TUR_EAS	katilia girls	2.1447 N	36.1342 E

				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Turkana	East Turkana	003_TUR_EAS	Nakwamomwa	2.00233	36.08295
Turkana	West Turkana	004_TUR_WES	Loteteleit	1.50027	35.91740
Turkana	West Turkana	005_TUR_WES	Lokichoggio UN compound	4.20671	34.36516
Turkana	West Turkana	006_TUR_WES	Lochoriangamor		
Turkana	West Turkana	007_TUR_WES	Akalaliot		
Turkana	West Turkana	008_TUR_WES	Nakwangat 2	3.75082	34.85153
Turkana	West Turkana	009_TUR_WES	Oropoi ws	3.78394	34.44433
Turkana	South Turkana	010_TUR_SOU	Katilu	2.27144	35.42542
Turkana	South Turkana	011_TUR_SOU	Lokichar (Chines Bore hole)	2.38072	35.64442
Turkana	South Turkana	012_TUR_SOU	Kapelbok	2.10192	35.42066
Turkana	South Turkana	013_TUR_SOU	Lomeleku	2.35689	35.92991
Turkana	South Turkana	014_TUR_SOU	Kasuroi	2.47711	35.65914
Turkana	South Turkana	015_TUR_SOU	Lomoonyang	2.34112	35.48997
Turkana	South Turkana	016_TUR_SOU	Loupwala	2.57029	36.24099
Turkana	North Turkana	017_TUR_NOR	Napeto		
Turkana	North Turkana	018_TUR_NOR	Lokumwae		
Turkana	North Turkana	019_TUR_NOR	Karioworeng	4.40270	35.58996
Turkana	North Turkana	020_TUR_NOR	Nimwae		
Turkana	North Turkana	021_TUR_NOR	Lowarengak	4.27304	35.89293
Turkana	North Turkana	022_TUR_NOR	Murueris		
Turkana	North Turkana	023_TUR_NOR	Naurkorio		
Turkana	North Turkana	024_TUR_NOR	Natedelim		
Turkana	North Turkana	025_TUR_NOR	Loitangule		
Turkana	South Turkana	026_TUR_SOU	Nagetei	2.70772	35.63646
Turkana	Loima	027_TUR_LOI	Kanyangapus	2.8702 N	34.9507 E
Turkana	Loima	028_TUR_LOI	Natuntun	2.8702 N	34.9507 E
Turkana	Turkan West	029_TUR_TUR	Alab lab	2.45342	35.33201
Turkana	Loima	030_TUR_LOI	Lokatul	2.8702 N	34.9507 E
Turkana	Loima	031_TUR_LOI	Kochuch-Tiya	2.98011	35.36709
Turkana	Loima	032_TUR_LOI	Lomilo	2.77588	35.13948
Turkana	Loima	033_TUR_LOI	Namoruakwak	2.64179	35.10196
Turkana	Central Turkana	034_TUR_CEN	Nasulut water supply	3.43361	35.61607
Turkana	Central Turkana	035_TUR_CEN	Narengelop	33.44150	35.75537
Turkana	Central Turkana	036_TUR_CEN	Ewoi Egole	3.37725	35.67834
Turkana	Central Turkana	037_TUR_CEN	Kadinyangole	3.09111	35.66083
Turkana	Central Turkana	038_TUR_CEN	Naotin water Point	2.99856	35.70276

Appendix 3.3.13 Lot 6: Taita Taveta County

				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Taita Taveta	Taveta	001_TAI_TAV	Njukini borehole	3.2114 S	37.7557 S
Taita Taveta	Taveta	002_TAI_TAV	Chumvini	3.2095 S	37.7078 E
Taita Taveta	Taveta	003_TAI_TAV	Eldoro	3.48000	37.6900 E
Taita Taveta	Mwatate	004_TAI_MWA	Alia	3.333 S	38.2500 E
Taita Taveta	Mwatate	005_TAI_MWA	Mwachawaza	3.4376 S	38.3850 E
Taita Taveta	Voi	006_TAI_VOI	Uthiani	37M355261	9647699.00000
Taita Taveta	Mwatate	007_TAI_MWA	Malukiloriti (A)	3.3600 S	37.7100 E
Taita Taveta	Taveta	008_TAI_TAV	Mahandakini/wololo	3.2463 S	37.7297 E
Taita Taveta	Taveta	009_TAI_TAV	Kitivo ghazi	37M356540/9641512	37M356540/9641512
Taita Taveta	Taveta	010_TAI_TAV	Talio nyika	37M0454140/9606665	37M0454140/9606665
Taita Taveta	Voi	011_TAI_VOI	Kisimenyi	3.7226 S	38.6449 E
Taita Taveta	Voi	012_TAI_VOI	Kighombo	37M0438247/9624900	37M0438247/9624900
Taita Taveta	Voi	013_TAI_VOI	Kakimwaita	37M0420606/9640124	37M0420606/9640124
Taita Taveta	wundanyi	015_TAI_WUN	Msau polytechnic	3.4198 S	38.3975 E
Taita Taveta	Voi	016_TAI_VOI	Nyolo bh	3.4657 S	38.3162 E

Taita Taveta	Mwatate	018_TAI_MWA	Rekeke booster pump	3.4200 S	37.7300 E
Taita Taveta	Mwatate	019_TAI_MWA	Modambogho	37M431743/9616417	37M431743/9616417
Taita Taveta	Taveta	020_TAI_TAV	Mvita/Kwa scaver	37M435541/9622287	37M435541/9622287
Taita Taveta	Mwatate	021_TAI_MWA	Mramba	37M401315/9632549	37M401315/9632549

Appendix 3.3.14 Lot 6: Narok County

Site Data				Location	
County	*Sub-county*	*Site code*	*Site name*	*Latitude*	*Longitude*
Narok	Narok East	001_NAR_EAS	Oloikumkum Community b/h	01 24'05"	36⁰05'35"E
Narok	Narok South	002_NAR_SOU	Morijo Loita b/h water project	1.69988	35.80149
Narok	Narok south	003_NAR_ SO	Iltirben b/h Water Project	-0.972331°	35.598521°
Narok	Narok West	004_NAR_WES	Aitong Water b/h Project	-1.21795	35.19744
Narok	Narok South	005_NAR_SOU	Ntuka (Oloisurwa) b/h W/P	.-1.463318°	35.921702°
Narok	Narok West	006_NAR_WES	Oldonyo Rasha SDA Pry school b/h	-1.23278	35.78648
Narok	Narok West	007_NAR_WES	Parmolile W/P	-1.76151	35.45656
Narok	Narok East	008_NAR_EAS	Kitororonyi B/h W/P	.-1.3469510	36.04646
Narok	Narok West	009_NAR_WES	Lemesigio b/h W/P	01 46'43"	35 35'42"
Narok	Narok West	010_NAR_WES	Enkejuarro b/h W/P	.-1.785378	35.75889
Narok	Narok West	011_NAR_ WE	Kishermoruak b/h W/Project	01 24'40"	35 40'52"
Narok	Narok South	012_NAR_SOU	Ole Pariata b/h Water Project	01 22'25"	35 50'45"
Narok	Narok South	013_NAR_SOU	Iladuru b/h Water Project	-1.15996	35.68025
Narok	Narok South	014_NAR_SOU	Ichangipusi b/h water project	01 10.9'16	35 45'48.8"
Narok	Narok South	015_NAR_SOU	Letukunyi b/h water project	01 28'7.5	35 44'52"
Narok	Narok South	016_NAR_SOU	Osero Lempere b/h water project	01 26'0.5	35 47'56.6"
Narok	Narok South	017_NAR_SOU	Olkirankawuo b/h water project	-1.19611	35.75083
Narok	Narok West	018_NAR_WES	Mpuaai b/h water project	01 12'9.8	35 12'9.8"
Narok	Narok South	019_NAR_SOU	Nkoseremai b/h water project	.-1.85109	35.66128
Narok	Narok South	020_NAR_SOU	Intalala b/h Water Project	-1.35958	35.73668
Narok	Narok East	021_NAR_EAS	Oloolturot b/h W/P	.-1.318162	36.02117
Narok	Narok North	022_NAR_NOR	Enesampulai b/h W/P	-0.81588	36.11871
Narok	Narok North	023_NAR_NOR	Sabbath Keeping Church b/h water project	.-1.121899	35.78632
Narok	Transmara East	024_NAR_TRA	Emurua Dikirr b/h W/P	01 20'17	35 25'25"
Narok	Narok South	025_NAR_SOU	Olobaai community b/h	1 38'3.1"	35 36'58.6"
Narok	Narok South	026_NAR_SOU	Nkairuwuani community b/h	-1.18257	35.58307
Narok	Narok South	027_NAR_SOU	Intasati B/h	-1.61012	35.82886
Narok	Narok south	028_NAR_SOU	Koseka Community B/h	.-1.545499,	35.86555
Narok	Transmara East	029_NAR_TRA	Mugenyi/Njipship/Emurua dikkir B/h W/P	01 20'17"	35 25'25"
Narok	Narok South	030_NAR_SOU	Narosura B/h	-1.54071	35.858597°
Narok	Narok West	031_NAR_WES	Omomet (Enerelai)	1° 0'37.83"	35°24'45.29"
Narok	Narok West	032_NAR_WES	Empora/ Olomonira Community	35°35'56''E	35°35'56''E
Narok	Transmara East	033_NAR_TRA	Simutwet water project	-1.01017	35.19722
Narok	Narok East	034_NAR_EAS	Enobalbal B/h	-1.26707	36.08935
Narok	Narok North	035_NAR_NOR	M.O.W.D. Nkaleta	-0.979556°	35.736877°
Narok	Narok West	036_NAR_WES	Ndonyo Narasha Well	-1.25950	35.50042
Narok	Narok West	037_NAR_WES	Nkaimurunya B/h	-1.21612	35.47541

Chapter 4. The Technical Bid Submission Form and BoQ

Contents

FORM 1: TECHNICAL COMPLIANCE SUBMISSION FORMS

Provide the necessary supporting documentation to show that equipment provided complies with the standards and warranties set out in the Scope of Work and Technical Specifications. **Complete the Technical Submission Form on the following pages, and sign the declaration, and attach the supporting documentation listed below.**

PV modules

- Data sheet for solar modules
- IV curves of modules at 100, 500, 1000 W/m^2 and 25ºC (STC)
- IV curves as above for Normal Operating Cell Temperature (NOCT)
- IEC Standard Certificate for the solar modules

Power conditioner / inverters/ converters

- Data sheets for the power conditioner
- Efficiency curves
- Certification based on one of:
    - IEC Standard Certificate
    - Test result certification based on testing to partial IEC standard
    - ISO9001 In-house certifications based on in-house R&D test results

Motor / pump

- Data sheets for the motor / pump (separate if they are physically separate)
- Pump curves
- Certification based on one of:
    - IEC Standard Certificate
    - Test result certification based on testing to partial IEC standard
    - ISO9001 In-house certifications based on in-house R&D test results

Remote monitoring, data-logging and remote control

- Data sheets for the remote monitoring, transducers, data-logger, communication
- Data sheet for App and data manager
- App link for example of system
- Certification based on one of:
    - IEC Standard Certificate
    - Test result certification based on testing to partial IEC standard
    - ISO9001 In-house certifications based on in-house R&D test results

Sundry components: i.e. ball valves, non-return valves, manometer, water-meter, lightning protection, any te equipment

- Brochure and data sheets

Maintenance schedule

- A maintenance schedule for the motor/pump combination, detailing the work required and spares required.

Notes

- **Brochures and manufacturer's data sheet.** Detailed manufacturers data sheets to be provided for each component
- **Declaration of compliance.** Suppliers general declaration of compliance that systems overall, and individual components too, comply, or will be replaced or corrected at no cost to the project.
- **Manufacturer's Authorisation to Bid.** Certificate of Manufacturer's Authorization to bid for this specific bid offering the specific components, signed by the manufacturer.
- **Manufacturer's Authorisation for Warranty.** For compliance with warranties: Manufacturer's Warranty Certificates are required, bid for this specific bid offering the specific components, signed by the manufacturer. Since the warrantee periods are much longer than the contract period, these warranties shall be transferable to the eventual owner.

Notes on certificarions (from *Chapter 3, Section C.4.1*), options:

C.4.1.1. IEC Standard certificate: In general the full standard of the International Electro-technical Commission (IEC) is applied. Specifically, a certified quality test certificate is required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered complies with the entire referenced technical standard, based on the sampling approach of that technical standard.

- A certified copy of the **component's Compliance Certificate** shall be required from the ISO17026 accredited Certification Body corresponding to the accredited Test Center.
- A copy of the **Test Center's accreditation certificate**, **to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results may be requested for the specific tests in the standard.
- This form of accreditation is required for the following components:
    - PV modules - all certificates
- This form is but is also accepted for all required component certificates as below:
    - Power conditioner / inverters /converters (Safety; Efficiency / performance; Noise and emissions)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

C.4.1.2. Test result certification based on testing to partial IEC standard: The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. Therefore provision is made for testing to only the relevant parts of the standard. Certified test results are required from an accredited testing and certification organization acceptable to the Purchaser to confirm that the specific model of products or components offered have been tested to referenced test procedure in the standard, based on the sampling approach of that technical standard.

- A copy of the **Test Center accreditation certificate, to conduct and certify the specific tests in the standard** under consideration must be provided.
- Detailed test results d shall be provided for the specific tests conducted in the standard for all the samples tested.
- This form of accreditation is acceptable for the following component certificates only:
    - Power conditioner / inverters /converters (Safety; Efficiency / performance; Noise and emissions)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

C.4.1.3 ISO9001 In-house certifications based on in-house R&D test results: The testing of components in ISO17025 certified laboratories to the full IEC standard using the required sampling is both time-intensive and expensive. In addition many manufacturers perform rigorous in-house testing of their components before going to market. Therefore the ISO9001:2015 Declaration of Compliance Form was developed to qualify components of ISO9001:2015 certified manufacturers which are tested in their in-house ISO9001:2015 research and development laboratories, to either full or partial standard. The ISO9001 Declaration certificate may only be used for components manufactured by ISO9001:2015 company, AND tested to the relevant full standard (or partial standard procedures) referenced in the bid document. The Declaration must be supported by the test results for all the samples tested.

- See ***Section IV: Bid Forms: Statement of Compliance for Components by ISO 9001 :2015 Certified Manufacturer*** .
- Proof of the manufacturer's ISO9001:2015 accreditation from an approved accreditation agency is required.
- **Proof of competence of the manufacturer's testing facility**: its existence, equipment and equipment calibrations, staffing, and suitability to undertake the specific tests. This competence shall preferably be **via inspection and reference from a National Certification Body**[6].
- Presentation of detailed **supporting test results** is required for all samples tested, complemented by reference to the standard test method or detailed alternative **test methodology** where standards do not exist, and supported by an **inventory of test equipment** used.
- This form of accreditation is acceptable for the following component certificates only:
    - Power conditioner / inverters /converters (Efficiency / performance)
    - Pumps and motors (Safety; Performance characterisation)
    - Monitoring systems (Performance)

Technical Form 1: Compliance with standards and warranties

Chapter 3 clause	Clause Title	Manufacturer and model	Minimum data to be provided by bidder	Brochures	Declaration of compliance	Certification and supporting documents	Manufacturers Authorisations and supporting documents
Section C.4.2	PV Modules		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to standards, from laboratories accredited under ISO 17025. *Refer Tech Form 1.1.*	Y	Y	Y	Y
Section C.4.3	Power conditioner / inverter /converter		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to the required standards, from laboratories accredited under ISO 17025. *Refer Tech Form 1.2.*	Y	Y	Y	Y
Section C.4.4	Pump and motor		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to the required standards, from laboratories accredited under ISO 17025. *Refer Tech Form 1.3.*	Y	Y	Y	Y
Section C.4.6	Diesel generator		Specification sheet and documentation to be provided in bid submission. IEC Certifications of Compliance to the required standards, f *Refer Tech Form 1.4.*	Y	Y	Y	Y
Section C.4.5	Remote monitoring and data logging system		Full brochures, user manuals and documentation of capabilities, interconnection requirements, IEC Certifications of Compliance to the required standards Component list for the complete system. *Refer Tech Form 1.5.*	Y	Y	Y	Y
Section C.4.5	Remote software		Brochure, user manual, demonstration software and links to demonstration systems *Refer Tech Form 1.6.*	Y	Y	Y	Y

Chapter 3 clause	Clause Title	Manufacturer and model	Minimum data to be provided by bidder	Brochures	Declaration of compliance	Certification and supporting documents	Manufacturers Authorisations and supporting documents
Section C.4.5	Laptop computer		Brochure, user manual, demonstration software and links to demonstration systems *Refer Tech Form 1.7.*	Y	Y	N	Y
Section C.3.3	Module mounting structure		Specification sheet and documentation to be provided in bid submission showing the array mounting superstructure, extrusions, clamp mounting fasteners and bolts, and module earthing details. Bidders are to provide detailed drawings of their proposed structure for each system type, including foundations, pole base mounting arrangements, and wind loading calculations.	Y	Y	N	N
Section C.3.4	Array quick connectors		Specification sheet and documentation for cables and wiring quick interconnection to be provided in bid submission.	Y	Y	N	N
Section C.3.5	Security enclosure		Bidders are to provide detailed drawings of their proposed enclosure.	Y	Y	N	N
Section C.3.6	Control Cubicle		Bidders are to provide detailed drawings of their proposed enclosure.	Y	Y	N	N
Section C.3.8	Valves and pipework		Specification sheet to be provided for each type	Y	Y	N	N
Section C.3.9, Section C.3.10	Metering		Specification sheet to be provided for each type	Y	Y	N	N
Section C.3.12	Water tanks		Specification sheets for each component to be provided.	Y	Y	N	N
Section C.3.12	Water tank stand		Bidders are to provide detailed drawings of their proposed enclosure.	Y	Y	N	N
Section C.3.15	Cables and connectors		Specification sheet to be provided for each type	Y	Y	N	N
Section C.3.16	Earthing		Specification sheets for each component to be provided.	Y	Y	N	N
Section C.3.17	Lightning protection		Specification sheet to be provided for each type	Y	Y	N	N

Tech form 1.1: Solar PV Module				
Technical description	**Specification offered by Bidder**			**Remarks**
Manufacture and model				
Panel type, cell size				
Total Wp and tolerance				
Panel voltage and number of cells				
Junction box and IP protection				
Cable Connector type (MC4)				
Module dimensions (mm x mm x mm)				
Thicknes of glass (mm)				
Performance guaranty (years and % of STC power)				
Supporting documentation				
Product brochure				
Component compliance accreditation	***IEC 61215***	***IEC 61730***	***IEC 61701***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)				
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)				
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards				
Test results from ISO 17025 Laboratory (incl Y/N)				
Authorisation to bid				
Manufacturer’s Authorisation - to bid				
Manufacturer’s Warranty Certificate				

Tech form 1.2: Power conditioner / inverter / converter

Technical description	**Specification offered by Bidder**			**Remarks**
Manufacture and model				
Type (DC-DC, DC-AC etc)				
Output power (kW) • voltage(V) & phases • frequency (Hz) • rating temperature (ºC)				
Number of array inputs and MPPT's				
Array voltages and power				
Auxiliary power inputs: number • voltage (AC/DC) • power • Automatic array / genset / grid changeover (Y/N)				
Efficiency curves				
Max humidity (%), max temperature (ºC) enclosure IP rating,				
Display and functions: (i.e. operating parameters: frequency, voltage,amperage,input power: pump speed) (i.e. historical data: PV energy generation, maximum power and operating times, faults)				
Programable functions: (i.e. mini/max frequency, VoC)				
Lighting and surge protection (DC and AC)				
Warranty number of years at capacity				
Supporting documentation				
Product Brochure				
Component compliance accreditation	***IEC 62109***	***IEC 61683***	***Noise / emissions***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)				
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)				
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards				
Test results from ISO 17025 Laboratory (Y/N)				
In-house laboratory – Laboratory Accreditation				
Test results from in-house laboratory				
Authorisation to bid				
Manufacturer's Authorisation - to bid				
Manufacturer's Warranty Certificate				
ISO9001 Manufacturer - Declaration of Compliance				
ISO9001 Manufacturer Certificate				

Tech form 1.3: Pump / motor			
Technical description	**Specification offered by Bidder**		**Remarks**
Manufacture and model			
Configuration (submersible /surface/line shaft)			
Pump type (positive displacement / progressive cavity / multistage centrifugal)			
Motor type (DC /permanent magnet / AC / phases)			
Test report and IEC standard(s)			
Input power, voltage and phases			
Pump power (kW), head (m), flow (m^3/hr)			
Pump materials: • impeller material • shaft material • diffuser material • bearing material			
Pump/motor power vs flow v head curves			
Protection • dry running • thermal motor protection • other			
Earthing system			
Warranty number of years at capacity			
Supporting documentation			
Product Brochure			
Component compliance accreditation	***Performance***	***IEC 60034-81-41/42***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)			
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)			
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards			
Test results from ISO 17025 Laboratory (Y/N)			
In-house laboratory – Laboratory Accreditation			
Test results from in-house laboratory			
Authorisation to bid			
Manufacturer's Authorisation - to bid			
Manufacturer's Warranty Certificate			
ISO9001 Manufacturer - Declaration of Compliance			
ISO9001 Manufacturer Certificate			

Tech form 1.4: Diesel generator			
Technical description	**Specification offered by Bidder**		**Remarks**
Manufacture and model			
Test report and IEC standard(s)			
Engine: • kVA, kW • rated temperature • speed (rpm)			
Cooling: water/ air			
Alternator: • kVA, kW • voltage(V) & phases • frequency (Hz) • rating temperature (ºC)			
Other features • Electric start • Enclosed unit Integrated fuel tank			
Electrical Protection:			
Fuel consumption: litres/hour • 50% capacity • 75% capacity • 100% capacity			
Expected lifetime (hrs)			
Warranty number of years			
Supporting documentation			
Product Brochure			
Component compliance accreditation	***ISO 8528-1/6***	***IEC 60034-18-41/42***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)			
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)			
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards			
Test results from ISO 17025 Laboratory (Y/N)			
In-house laboratory – Laboratory Accreditation			
Test results from in-house laboratory			
Authorisation to bid			
Manufacturer’s Authorisation - to bid			
Manufacturer’s Warranty Certificate			
ISO9001 Manufacturer - Declaration of Compliance			
ISO9001 Manufacturer Certificate			

Tech form 1.5: Data-logging and on site display		
Technical description	**Specification offered by Bidder**	**Remarks**
Manufacture and model		
Power supply and back-up		
Variables: • solar radiation • pump status • pump power • pump speed • flow rate • pump temperature • pump pressure • diesel runtime		
External transducer provided (list)		
Status indicators • level • alarms		
Cumulative performance daily/monthly / totals • kWh used • water delivered • etc		
Communications interface on site (RS485 /Canbus / other)		
Communication hardware for remote access: (explain)		
Communcation protocol and requirement: (2G, 3G, other)		
Supporting documentation		
Product Brochure		
Component compliance accreditation	***IEC 61724***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)		
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)		
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards		
Test results from ISO 17025 Laboratory (incl Y/N)		
In-house laboratory – Laboratory Accreditation		
Test results from in-house laboratory		
Authorisation to bid		
Manufacturer's Authorisation - to bid		
Manufacturer's Warranty Certificate		
ISO9001 Manufacturer - Declaration of Compliance		
ISO9001 Manufacturer Certificate		

Tech form 1.6: Remote Monitoring Software and Dashboards				
Technical description	**Specification offered by Bidder**			**Remarks**
Manufacture and model				
Years of proven operation (years)				
Years of proven backward compatibility of versions (years)				
Web-link to web-portal with demonstration of the features				
Warranty term				
Supporting documentation				
Product Brochure				
Component compliance accreditation	***NA***	***NA***	***NA***	
IEC Standard Certificate for component from Certification Body (Cert number, date, expiry)				
ISO 17025 Laboratory – Laboratory Accreditation (Name and CB number)				
ISO 17025 Laboratory – Certificate to conduct the specific tests and standards				
Authorisation to bid				
Manufacturer's Authorisation - to bid				
Manufacturer's Warranty Certificate				
ISO9001 Manufacturer - Declaration of Compliance				
ISO9001 Manufacturer Certificate				

Tech form 1.7: Laptops for Monitoring System

LAPTOP SPECS	SPECIFICATION REQUIRED
Display	15" anti-glare display, up to FHD (1920 x 1080)
Processor	7th Generation Intel® Core™ i7 or similar
Memory	16 GB DDR$
Storage	1 TB PCIe NVMe SSD or 2 TB HDD Storage
Graphics and Video Support	Intel® HD Graphics 620 or NVIDIA GeForce® 940MX (2GB 2.5GHz GDDR5 memory) or similar
Connections and Expansion	2 x USB 3.2 1 x USB C port 3.5 mm Combo Audio Jack 1 x HDMI™ 1 x RJ45 Gigabit LAN 1 x Media Card Reader (SD 3.0, UHS-I) 1x Micro SIM
Keypad and Trackpad	Precision Keyboard with Number Pad
Electrical Requirements	Line voltage: 240V AC Frequency: 50Hz
Software	64-bit Microsoft® Windows® 10 (minimum)

FORM 2: SYSTEM DIAGRAM AND SUB-SYSTEM PERFORMANCE CURVES

The Bidder shall provide the following information and output curves for each combination offered for

- Power conditioner / motor /pump

Form 2.1: System Electrical diagram

The Bidder shall provide a system diagram for each system type hsowing clearly:

- DC-AC Wiring diagram for each system type, showing in addition
  - earthing, lighting protection internal to any components, lighting protection added within any components, and external lighting protection
  - location of sensors for monitoring system, with communcation cables to data-logger.

Form 2.2: Performance Curves – Instantaneuous Output Curves

The Bidder shall provide the following instantaneous output curves for:

- DC power output of the PV array (W) vs Insolation (kWh/m^2) on the tilted surface in the plane of array
- controller-pump-piping subsystem: water output (litres/second) versus DC input power (W)

These curves shall be used to assess credible instantaneous performance of the system offered. It should also be possible to derive the 'Daily Water Output curves' from these instantaneous curves

Form 2.3: Performance Curves – Daily Output Curves

.The Bidder shall provide the following daily output curves for:

- DC energy output of the PV array (kWh/day) vs Insolation (kWh/m^2/day) on the tilted surface in the plane of array
- controller-pump-piping subsystem: water output (m^3/day) versus DC input energy (kWh/day).
- Average array tracking efficiency.
- Average sub-system wire-to-water efficiency.

These curves shall be used to assess credible daily performance of the system offered.

Note that the data in provided shall be used to assess and measure the system performance and acceptance during the tests under non-design conditions.

FORM 3: SCHEDULES OF INFORMATION FOR SOLAR PUMPING SYSTEM

The Bidder shall provide the following data for each site:

*NOTE: If the Manufacturers Pump sizing software produces all the required variables in a Sizing Report, then this may be submitted as **FORM 3.1**, and shall be clearly labelled as such.*

Form 3.1: Solar Pump System Summary

a) General Site Data

1.	Name of site or project	
2.	Geographic location (region / district)	
3.	Site Number	

b) Array Configuration

Item	Description	Data
1.	Module model and Wp	
2.	Array Wp	
3.	Modules in series strings and VoC strings	
4.	Strings in parallel	

c) Pump controller

Item	Description	Data
1.	Manufacturer and Model	
2.	Rating (kW, voltage, phases)	

d) Pump / Motor Configuration

Item	Description	Data
1.	Manufacturer and Model	
2.	Motor rating (VA, voltage, phases)	
3.	Design head	
4.	Design flow	
5.	Max head	
6.	Max flow	

e) Diesel Generator Configuration (may be provided as separate table if necessary)

Item	Description	Data
1.	Manufacturer and Model	
2.	Motor rating (kW)	
3.	Alternator rating (kVA, voltage, phases)	

Form 3.2: Declaration of system water output vs. solar radiation and head

The Bidder shall provide the following data for each site:
*NOTE: If the Manufacturers Pump sizing software produces all the required variables in a Sizing Report, then this may be submitted as **FORM 3.2**, and shall be clearly labelled as such.*

Site name:………………………………………………………….. Site unique number:……………………………………………………………

This table is a declaration of the system output under the design conditions listed below. The following information shall be provided to assess the system performance during adjudication and on acceptance, by using the sub-system wire-water efficiency provided for each month.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	Water output required (m^3/day)												
B	Total Pumping head (m)												
M	Average Water Delivery from System offered (m^3/day) (from sizing software)												
	Design check												
C	Array tilt angle used for each month												
D	Average daily insolation on the array for each month at above tilt angle. (kWh/m^2/day)												
E	Nominal array power (kWp)												
F	Array tracking efficiency (%) (% of STC output including array losses, wiring losses, typically 77.4%).												
G	***Average Daily Sub-system wire-to-water efficiency*** (%) (to be declared) (typically 30-50%) *= (M x B x 9.8 / 3,600) / (D x E x F)*												
	Commissioning test requirements												
H	Required water delivery (m^3/day) under commissioning conditions: $= D_{meas} \times E \times F \times G / (B \times 9.8 / 3,600)$												
	Declaration: We declare the performance precicion to be accurate based on the site and solar data used. Sites which do not perform shall eb corrected at no cost to project Signed												

Form 3.3: Hydraulic information and pumping head calculation sheet

Not required to be completed for bidding.

Please refer to this form and referenced drawing for any notation queries.

This form shall be completed during *Inception Stage*, and prior to request for commissioning of each system.

	Abbreviation	Name / description	Formula or Constraint	Data	Units of data
Static head data	Hs	Static Water Level below ground level at source			M
	H e	Elevation difference from ground level at source to base of primary storage tank			M
	H t	Height of Tank Inlet from base			M
	H static	Total Static Head	= Hs+He+Ht		M
Dynamic head data	H d	Dynamic water level			M
	D	Drawdown	= Hd-Hs		M
	H m	Head loss in Watermeter (use charts supplied)	< 2 m max. losses allowed		M
	H nr	Head loss in Non-Return Valve(s) (use charts supplied)	< 2 m max. losses allowed		M
	H r	Head loss in Riser Pipe (use charts supplied)	< 5% of Static head max losses allowed		M
	H p	Head loss in Transmission Pipe (use charts supplied)	< 5% of Static head max losses allowed		M
	H dymanic	Dynamic head losses	=D+Hm+Hnr+Hr+Hp <10% of Hstatic		M
Total	H total	Total design pumping head	=Hdynamic + Hstatic		M
Check	H pump	Depth of Pump-Intake			M
	H immers	Maximum allowed pump submersion on site (submersible pumps only)	< H pump – Hs		M
	H suction	Maximum allowed suction head on site (surface pumps only)	< Hd		M
Site data	H w	Total depth of well or sump			M
	D w	diameter of well casing			M
	D r	diameter of riser pipe			Mm
	D p	diameter of transmission pipe			Mm
	L p	length of transmission pipe			M
	V	Volume of primary storage			M^3

Refer to ***Schedule of Drawings: DWG 4a,b:*** **the diagrammatic illustration of the variables**.

FORM 4: BILLS OF QUANTITIES

The Bidder shall complete the BoQ for each site.

a) For each site provide a bill of quantities in a format similar to that provided below. (structure of "items" and "descriptions" may be changed to fit bid), as outlined in the Scope of Work and Technical Specifications).

b) Bidders shall provide BoQ information and unit prices for each component for each packages included in each Lot. This table will be used for ensuring completeness of the systems. If any component is found missing, unit price presented in this table may be used for making adjustments to the ***price schedules in Vol I, Section IV***. After contact award, if variation orders or change orders are required due to adjust component or system quantities on site (either plus or minus), then the unit/system prices supplied in the BoQ shall be used.

c) For each Lot, provide a complete bill of quantities for Spares (see ***Chapter 3, Section C.2.10*** requirements for Mandatory spares).

Presented below is an **illustrative** bill of quantities (BOQ) for the PVP System. **Bidders are required to use this format, but component sizes and quantities may be adjusted to suite the specific components offered.** Bidders shall provide BoQ information and unit prices for each component for each package included in each Lot.

- *Form 4.1. Solar PV Pump BoQ (per site)*
- *Form 4.2. Diesel Generator Set replacement (per site)*
- *Form 4.3. Additional Minor Works BoQ (per site)*
  The above Forms 4.1 to 4.3 maybe submitted per site as one continuous flowing form, provided sections are clearly divided as per illustrations.

- *Form 4.3(A) Schedule of Variation Prices process for Additional Minor Works*
- *Form 4.4. Mandatory Spares Schedule (per Lot)*
- *Form 4.5. Maintenance kit (per Site)*

Form 4.1: PV Pump BoQ

		Use Separate Bill of Quantities for each Lot		**Unit cost (USD)**		**Site 1**		**Site 2**		**Site 3**	
		LOT number: __________				**Qty**	**USD**	**Qty**	**USD**	**Qty**	**USD**
		Item	**Description**		**Units**						
FORM 4.1 Solar PV Pump BoQ	Array	PV modules	**Total kWp**			**7.5**		**15.0**		**25.0**	
			Wp module (V)		Ea					1	
		PV array mounting super-structure	Pole mount structure up to 400 Wp, including foundations		Ea						
			Ground mount frame, up to 1 kWp, including foundations		Ea						
			Module mounting security frames		Ea						
		Module earthing clamps	per 1 kWp		Set						
		Array interconnects			Ea					1	
		Array junction box	IP65 with terminals and glands		Ea	0		0		0	
	Main control system	Power conditioner	Size 1:		Ea					1	
			Size 2:		Ea						
			Size 3:		Ea						
			Size 4:		Ea						
			Size 5:		Ea						
		Submersible pump	Size 1:		Ea					1	
			Size 2:		Ea						
			Size 3:		Ea						
			Size 4:		Ea						
			Size 5:		Ea						
		Security enclosure	for containing Control Cubcle, power conditioner, and remote data logger system		Ea	1					
		Control Cubicle	with circuit breakers, indicators, change-over switches, but exl lightnign protection								
			Size 1:		Ea	1		1			
			Size 2:		Ea	1		1			
			Size 3:		Ea	1		1			
			Size 4:		Ea	1		1			
			Size 5:		Ea	1		1			
		Remote data logger	System		Set	1				1	
			Transducers		Set	1					
			Cabling and conduit		Set	1					
			Communications module		Set	1					
			Remote montoriing software		Set	1					
		Lightning protection (AC and DC)	AC Surge arrestors (class 2 1PH + N)		Ea	1		0		0	
			AC Surge arrestors (class 1&2 1PH + N)		Ea	0		0		0	
			DC Surge arrestors (class 2)								
			enclosure		Ea	0					
	Hydrau- lic pipe-work	Riser pipe (pump to borehole head)	Flexible pipe to spec		m	100					
			fittings to pump		Ea	1		0		1	
			Non-return valve		Ea	1					
			Strain relief cable		meter	100					
		Borehole head	Borehole cap		Ea	1				1	
			Rising main pipe fittings		Set	1		1			
		Instrumentation	Water meter (pulse type)		Ea	1		1		1	
			Pressure guage		Ea	1		1		1	
			Valves		Ea	1		1		1	
			Pipework and mountings		Set	1		1		1	
		Chlorinator	Passive flow	750	Set	1	750	1	750	1	750

		Use Separate Bill of Quantities for each Lot LOT number: __________		Unit cost (USD)		Site 1		Site 2		Site 3	
						Qty	**USD**	**Qty**	**USD**	**Qty**	**USD**
		Item	**Description**		**Units**						
FORM 4.1 Solar PV Pump BoQ	Cabling	Submerisible pump cable	4mm2 3 core		meter	110		0		0	
			6mm2 4 core		meter	110		0		0	
			10mm2 4 core		meter	110		0		0	
			Splice kit		Ea	1					
		SWA cable	4mm2 3 core		meter	20					
			6mm2 4 core		meter	20					
			10mm2 4 core		meter	20					
		Sense cables	Level switches		Ea	1					
			Sense cables		meter	50					
		Array grounding and Electrical earthing	Ø16 mm x 1500 mm earth spike		Set	0		0		1	
			16mm^2 bare copper earth conductor		Set	0		0		1	
		Other	bidder to specify								
		Warning signs	as per specification		Ea	1		1		1	
		User manual			Ea	1		1		1	
		O&M manual	for customers and technicians		Ea	1		1		1	
		Sub-total Equipment									
		Sub-total Transport and clearances, insurance									
		Sub-total Equipment (to Price Schedules: Goods, Item 2)									
		Sub-total Installation, Inspection. MIS data capture, commissioning etc (to Price Schedules: Related Services, Item 3)									
		Total unit costs for Supply and Installation of Solar Pump System									

Form 4.2: Diesel Genest Replacement BoQ

FORM 4.2: Diesel Genset Replacement BoQ

Use Separate Bill of Quantities for each Lot		Unit cost (USD)		Site 1		Site 2		Site 3	
LOT number: __________				Qty	USD	Qty	USD	Qty	USD
Item	**Description**		**Units**						
Existing diesel engine	**kVA**			**10.0**		**19.0**		**40.0**	
Alternator	Size 1: kW / kVA		Ea						
	Size 2: kW / kVA		Ea						
	Size 3: kW / kVA		Ea						
Control Panel 3phase	Size 1: kVA		Ea						
	Size 2: kVA		Ea						
	Size 3: kVA		Ea						
Base frame	Size 1:		Ea						
	Size 2:		Ea						
	Size 3:		Ea						
Mounting adaptors	Rubber mountings 75mm diameter		Ea						
	Control panel frame		Ea						
Battery MF	65-100Ah MF		Ea						
Fuel guage	c/w float system		Ea						
Electrical Adaptors	Bayonet coupling LR-180mm		Ea						
	Coupling adpator		Ea						
Other	Miscelleneous bolts, cables, etc								
Warning signs	as per specification		Ea						
User manual			Ea						
O&M manual	for customers and technicians		Ea						
Sub-total Equipment									
Sub-total Transport and clearances, insurance									
Sub-total Equipment (to Price Schedules: Goods, Item 3)									
Sub-total Installation (to Price Schedules: Related Services, Item 3)									
Total unit costs for Supply and Installation of Diesel component									

Form 4.3: Additional Minor Works BoQ

						1		2		3	
		Use Separate Bill of Quantities for each Lot		**Unit cost (USD)**		**Site 1**		**Site 2**		**Site 3**	
		LOT number: __________				**Qty**	**USD**	**Qty**	**USD**	**Qty**	**USD**
		Bidders are to provide *Unit Costs* for all items below. These shall be used as indicative prices. For pricing of each site, bidders are to use the *Prime Cost* amounts shown.									
		Item	**Description**		**Units**						
FORM 4.3 Additional Minor Works BoQ	**Supplementaty storage**	Water Tank	Water tank 10,000 litres		Ea						
			Valves and fittlings for interconnection		Ea						
			Installation of tank and fittings		Ea						
		Foundation	Conctrete and sand foundation per tank		Set						
		Elevation	6m elevated platform, steel per 1 tank								
			6m elevated platform, steel per 2 tanks								
			Installation		Ea						
	Minor Work required	Masonary Tank repair (parts and labour)		**PRIME COST**			**1,200**		**1,200**		**1,200**
		Bulk water meter at pump house (supply and install)		**PRIME COST**			**1,000**		**1,000**		**1,000**
		Bulk water meter at tank (supply and install)									
		Gate valve (supply and install)									
		Sluice valve (supply and install)									
		Bleed valve (supply and install)									
		Non-Return Valve on rising main (supply and install)									
		Pressure gauge (supply and install)									
		other									
	New Civil Works	Control room (new), materials	Materials	**bidder to cost**							
			Labour								
		Diesel Engine enclosure (new)	Materials	**bidder to cost**							
			Labour								
		Fencing of entire site (new)	Materials	**PRIME COST**			**3,000**		**3,000**		**3,000**
			Labour								
		Chlorinator enclosure ar tanks (new)		**NA**			-		-		-
	Elect rical	Sense cables	Level switches	**PRIME COST**			**200**		**200**		**200**
			Sense cables (SWA) (200m)								
		Sub-total Equipment									
		Sub-total Transport and clearances, insurance									
		Sub-total Equipment (to Price Schedules: Goods, Item 4)									
		Sub-total Installation (to Price Schedules: Related Services, Item 4)									
		Total unit costs for Supply and Installation of Minor Additional Works									

Form 4.3 (A): Schedule of Variation Prices for Additional Minor Works

		Use Separate Schedule for each Lot		**Unit cost (USD)**	
		LOT number: __________			
		Bidders are to provide UNIT COSTS for all items below. These shall be used for ***Variation Pricing***			
		Item	**Description**		**Units**
FORM 4.3 (A) Variation Pricing	**Minor Components**	Bulk water meter at pump house (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Bulk water meter at tank (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Gate valve (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Sluice valve (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Bleed valve (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Non-Return Valve on rising main (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		Pressure gauge (supply and install)	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
		other	Size 1: 1.5 inches		Ea
			Size 2: 2 inches		Ea
			Size 3: 4 inches		Ea
			Size 4: 6 inches		Ea
	New Civil Works	Control room (new)	Materials		Set
			Labour		Set
		Diesel Engine enclosure (new)	Materials		Set
			Labour		Set
		Fencing of entire site (new)	Materials		Set
			Labour		Set
		Chlorinator enclosure ar tanks (new)	Materials		Set
			Labour		Set
	Electrical	Sense cables	Level switches		Ea
			Sense cables (SWA)		meter

<table>
<tr><td></td><td></td><td colspan="2">Use Separate Schedule for each Lot
LOT number: __________</td><td>Unit cost (USD)</td><td>Unit cost (USD)</td><td>Unit cost (USD)</td><td>Unit cost (USD)</td><td>Unit cost (USD)</td></tr>
<tr><td></td><td></td><td colspan="2">Bidders are to provide UNIT COSTS for all items below. These shall be used for Variation Pricing</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="5">Raiser height (m)</td></tr>
<tr><td></td><td></td><td>Item</td><td>Tank size (m³)</td><td>0</td><td>3</td><td>6</td><td>9</td><td>12</td></tr>
<tr><td rowspan="21">FORM 4.3 (A) Variation Pricing</td><td rowspan="21">Masonary tank repair (materials and labour)</td><td rowspan="7">Ceiling replacement</td><td>25</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>30</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>40</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>60</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>80</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>100</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>125</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">Ceiling repair</td><td>25</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>30</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>40</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>60</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>80</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>100</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>125</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">Minor external cracks</td><td>25</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>30</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>40</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>60</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>80</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>100</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>125</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Form 4.4: Mandatory Spares

Each LOT requires at least the minimum number of spares. The Supplier shall supply the following *Mandatory Spares,* and compose and deliver at the end of the Warranty Period an optimal package of spare parts typically comprising the following items.

	Use Separate Bill of Quantities for each Lot		Unit cost (USD)		Requirement		Mandatory Spares	
	LOT number: __________				% of total supplied	Minimum qty	Qty	USD
	Item	Description		Units				
Arra	PV modules	Wp module (V)		Ea	1%	**10**		
Main control system	Power conditioner	Size 1:		Ea	1%	1		
		Size 2:		Ea	1%	1		
		Size 3:		Ea	1%	1		
		Size 4:		Ea	1%	1		
		Size 5:		Ea	1%	1		
	Submersible pump	Size 1:		Ea	1%	1		
		Size 2:		Ea	1%	1		
		Size 3:		Ea	1%	1		
		Size 4:		Ea	1%	1		
		Size 5:		Ea	1%	1		
	Control Cubicle / Power packs	with circuit breakers, indicators, change-over switches, but exl lightnign protection						
		Size 1:		Ea	1%	1		
		Size 2:		Ea	1%	1		
		Size 3:		Ea	1%	1		
		Size 4:		Ea	1%	1		
		Size 5:		Ea	1%	1		
	Remote data logger	System		Set		1		
		Transducers		Set		2		
		Cabling and conduit		Set		1		
		Communications module		Set		2		
		Remote montoriing software		Set		1		
	Lightning protection (AC and DC)	AC Surge arrestors (class 2 1PH + N)		Ea	5%	6		
		AC Surge arrestors (class 1&2 1PH + N)		Ea	5%	6		
		DC Surge arrestors (class 2)			5%	6		
		enclosure		Ea	2%	2		
	Diesel generator	Size 1:		Ea		1		
		Size 2:		Ea		1		
		Size 3:		Ea		1		
		Size 4:		Ea		1		
		Size 5:		Ea		1		
	Change-over devices	Size 1:		Ea		1		
		Size 2:		Ea		1		
		Size 3:		Ea		1		
	Sub-total Equipment							
	GRANT TOTAL							

Form 4.5: Maintenance kits

Each SITE shall be supplied with one Maintenance Kit per site and one Engineer Kit per LOT.

Use Separate Bill of Quantities for each Lot LOT number: __________		Unit cost (USD)		Maintenance per LOT enginener		Maintenance kit per site	
				Qty	USD	Qty	USD
Item	**Description**		**Units**				
Laptop	Refer *Tech form 1.7*		Ea	3		0	
Digital clamp . Multi-meter	(minimum range 0-600V DC, 0-300 V AC, accuracy min 1%, 0.01V resolution)		Ea	3		1	
Current clamp meter	(range 0-40A, accuracy 1%, resolution 0.1A for AC and DC 40 A, including thermocouple and leads. Recommended model: TCM 02 DC/AC clamp meter – 600 VDC			3		1	
Basic tool kit	Including set of insulated screwdrivers to fit all terminals on DIN rail/inverter/power conditioner; small/narrow pliers, wire cutters/strippers, crimp tool with set of lugs, insulating tape, etc.		Set	3		1	
Stop watch	digital		Ea	0		1	
Step ladder	to reach solar array		Ea	0		1	
Water bucket			Ea	0		1	
Squeegee	to clean solar array		Ea	0		1	
Marker pens			Ea	0		5	
Sub-total Equipment							
GRANT TOTAL							

FORM 5: RECOMMENDED SPARE PARTS SCHEDULE

The Bidder shall recommend all the necessary major spare parts for operating the systems for the duration of the Maintenance Period. The bidder may utilise these spares.

The Bidder shall draw up a list of *Recommended Spares*, comprising of high-usage and high-value items of components and spare parts, for usage in the initial period of operation specified in the Maintenance Period, and to cost for these items.

Form 5: Recommended Spare Parts Schedule

	Use Separate Bill of Quantities for each Lot		**Unit cost (USD)**		**Recommended Spares**	
	LOT number: __________				**Qty**	**USD**
	Item	**Description**		**Units**		
Arra	PV modules	Wp module (V)		Ea		
Main control system	Power conditioner	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Submersible pump	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Control Cubicle / Power packs	with circuit breakers, indicators, change-over switches, but exl lightnign protection				
		Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Remote data logger	System		Set		
		Transducers		Set		
		Cabling and conduit		Set		
		Communications module		Set		
		Remote montoriing software		Set		
	Lightning protection (AC and DC)	AC Surge arrestors (class 2 1PH + N)		Ea		
		AC Surge arrestors (class 1&2 1PH + N)		Ea		
		DC Surge arrestors (class 2)				
		enclosure		Ea		
	Diesel generator	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
		Size 4:		Ea		
		Size 5:		Ea		
	Change-over devices	Size 1:		Ea		
		Size 2:		Ea		
		Size 3:		Ea		
	Sub-total Equipment					
	GRANT TOTAL					

FORM 6: MAINTENANCE ACTIVITY SCHEDULE

The Bidder shall complete the Routine Maintenance Activity Schedule for each system type. The schedule shall detail the preventative maintenance activities required or recommended each motor/pump combination,

The activities in this Schedule shall be priced in the *Maintenance Contract Price Schedule in the Volume 1*, and assumed included in price form for years 1-7.

Form 6: Maintenance Activity Schedule.

Year 1	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Year 2	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Year 3	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Year 4	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Year 5	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Year 6	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Year 7	**Specific activities required**	**Parts replaced**	**Time required on site**
Visit 1, month	i.e. withdraw pump from borehole	i.e. replace impellors	
Visit 2, month			

Appendix 1: Detailed explanation on Bid Form Technical Proposal

This information shall be evaluated under ***Volume I Section III.2.1 (ii) (b) of Qualification.***

The bidder shall provide a technical proposal of approach and method statement per ***Volume I Section IV, Schedule Technical Proposal*** that will include

- Work organisation
- Method statement
- Mobilization Schedule
- Installation schedule
- Personnel
- Equipment
- Training

1. Inception phase

Describe the approach, staffing, logistical arrangements and schedule for conducting the due diligence and preparing the Inception Report as per the requirements of ***Chapter 3 Section B.2.3, Section B.2.4*** and ***Section B.2.5.***

2. Pilot installation phase

Describe the approach, staffing, logistical arrangements and schedule for Pilot Installations as per the requirements of ***Section B.2.6***.

3.Supply and installation phase

Describe the approach, staffing plan, logistical arrangements and schedule for the supply and installations of the systems as per the requirements of ***Section B.2.3, B.2.4, B.2.8, B.2.9, B.2.10 and C.3,*** with adequate detail to permit verifying:

- the completeness and realism of approach, methodology and logistics for the supply, including procurement and delivery, and installation of the Goods, including the Pilot installations.
- Installation practices, commissioning tests and initial user-training comply with specifications.
- delivery schedule is consistent with the required time-frame. If bidders are bidding for more than one Lot, describe the additional capacity and availability that will ensure that time-frames for completion will be met if more than one Lot is awarded to the bidder.
- adequate managerial competence, including for supervision and financial controls. The description and plan should cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.
- adequate technical competence, including for quality assurance, installation and maintenance support services. Cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.
- describe the Supplier's own arrangements and procedures for quality control of the equipment supply and installations.

Include a detailed work breakdown and GANTT chart. Also, provide qualification requirements, job descriptions and names of the principal staff that will provide management, installation and maintenance support to the project areas. Include an organogram indicating the organizational structure and location of key staff and organizational units.

- **Specific numeric data to be provided for each LOT**
  - **Key management staff:** list of tasks, qty people,
  - **Key logistics staff and vehicles: list of tasks, qty people, qty vehicles**
  - **Installation teams per Lot:**
    - qty PVP installation teams,

        - qty MIS inspection teams
    - **per PVP installation team;**
        - list of tasks,
        - qty people/team,
        - qty PVP installed/team/day
    - **Per MIS team**
        - list of tasks,
        - qty people/team,
        - qty PV systems captured/team/day

    - **Key assumptions per village**
        - **Time for movement between village**
        - **Time for site establishment (P&G) per village**

    - **Spreadsheet: For each lot, show schedule demonstrating**
        - **District P&G time**
        - **Village (for each village)**
            - **Time for movement to village**
            - **Village P&G time**
            - **Works required**
                - qty PVP
            - **Resources allocated per village**
                - qty PVP teams, qty MIS teams
            - **Time to complete the works in village** based on
                - allocation of qty PVP teams, MIS teams
                - number of installations per team per day.

4. Warranty/Maintenance phase

This phase includes maintenance, continued user training, reporting, other after-sales services and staffing.

Describe the plan and approach to ensure responsive maintenance, continued user training and after-sales services to meet the standards established in ***Sections B.2.8, B.3, and D.1- D.5***.

Describe in sufficient detail to permit verification:

- the completeness and realism of approach, methods and logistics for maintenance and breakdown services that meet the specifications established at ***Sections D.1-D.5***.
- facilities for facility managers and staff to communicate with the Supplier to report failures and request repairs.
- Post-installation user training for system use and upkeep, both refresher training and training for new facility staff and local technicians.

Describe staffing plan to demonstrate:

- adequate qualification requirements and job descriptions for the personnel that will provide these after-sales services
- adequate managerial competence of the personnel proposed to provide the services, including for supervision and financial controls. Cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.
- adequate technical competence of the personnel proposed to provide the services, including for quality assurance, for the maintenance and other support services in accordance with the maintenance specifications. Cover the provision of the appropriate skills at offices serving the project area, as well as back-up support from other offices.

- **Specific numeric data to be provided for each LOT**

    - **Key maintenance management staff:** list of tasks, qty people,
    - **Key logistics staff and vehicles: list of tasks, qty people, qty vehicles**
    - **Maintenance teams per Lot:**

        - qty PVP maintenance teams,
        - qty MIS inspection teams
    - **per Maintenance team;**
        - qty people/team,
        - qty systems maintained/team/day
    - **per MIS inspection team;**
        - qty people/team,
        - qty systems MIS captured/team/day

Describe the scheduling, management, recording and reporting systems that will be deployed that will enable:

- real time tracking of complaints and responses, repair requests and responses, faults and responses, component replacements, warranties and status of systems
- access by the Purchaser to the records and systems for tracking the complaints, repair requests, faults, component replacements, maintenance and status of systems
- accurate reporting by the Supplier on a bi-annual basis to the Purchaser.

Describe the reporting and barcode systems

- Suppliers system for tracking equipment supply, system installation, claims and maintenance, (supported by suppliers MIS in see ***sections B.2.9.3 and B.2.9.4*)**,
- Barcoding method, data collection and reporting requirements, data records to be recorded,
- Software selected for processing and reporting, including sample database and sample reports.

5.Training

Describe the approach to training as required in ***Section B.2.7.1-B.2.7.3.*** for

- Operators of community facility systems training (on-site training),
- Technical training
- Follow-up training during routine maintenance (on-site)

Note: training is priced as Related Services (***Volume I Section IV Bidding Forms, Related Services)***

- Operator training (included in *Item 3: Installation services*)
- Technical training (*Item 5: Technical training*)
- Follow-up training (included in *Items 6,7,8,9 After sales*)

6.Other qualifications

- Experience from the region, and working in dispersed project sites within rural communities in low income developing countries is important, as is experience in East Africa as indicated by the experience of the Bidder, sub-contractors, or local-partners or staff. Bidders are encouraged to partner with established local solar PV companies to develop local capacity for ongoing support and market development.
- If at the time of bidding, a bidder does not have local presence in Tanzania, the bidder must categorically indicate the strategy as to how they wish to establish local presence in Tanzania if they win the contract(s). This strategy and other information (if any) should be submitted with the bid.

The bidder shall furnish a list of Key-staff including their qualification and experience for the following positions (including Joint Venture and sub-contractor staff) for each lot using ***Schedule PQ no 4: Schedule of Key Staff*** and ***Schedule PQ no 5: Schedule of Named Sub-contractor*** forms provided.

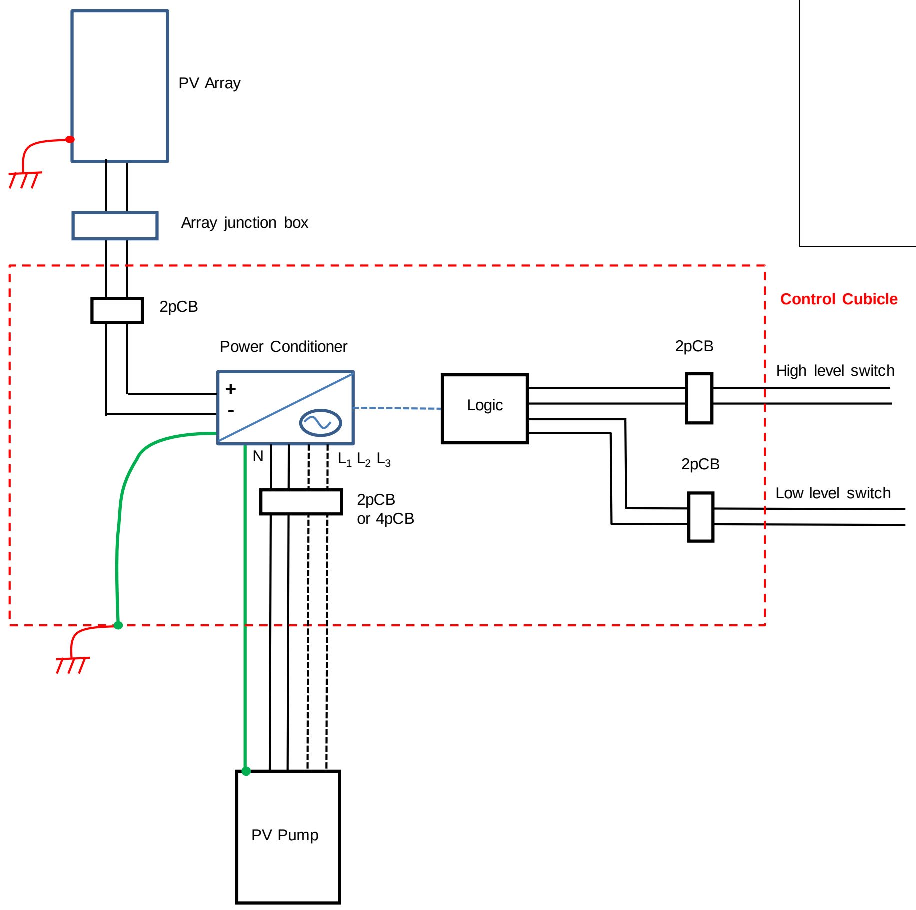
5. Schedule of Drawings

The Bidding Documents include the following drawings.

List of Drawings

	Drawing Name	Purpose
System typical electrical diagrams		
DWG SCH.1.	Electrical diagram for typical solar DC PV packages	Electrical schematic
DWG SCH.2.	Electrical diagram for typical solar AC PV packages	Electrical schematic
DWG SCH.3.	Interconnection of PV array, blocking diodes, by-pass diodes and array junction box	Electrical schematic
DWG SCH.4.	Schematic of control cubicle, showing isolators and optional lightning protection	Electrical schematic
DWG SCH.5.	Diagram of full lightning protection system	Electrical schematic
DWG SCH.6.	Typical diagram of overvoltage protection circuitry in external junction box for DC circuits	Electrical schematic
DWG SCH.7.	Typical diagram of overvoltage protection circuitry in external junction box for AC circuits	Electrical schematic
System typical structural diagrams		
DWG-STR.1	Array and module structure security assembly	Diagram of typical structure
DWG.STR.2	Security enclosure around the control cubicle and power conditioner	Diagram of typical structure
DWG.STR.3	Location of main valves and metering	Diagram of typical structure
DWG.STR.4	Hydraulic information - line-shaft / submersible pump system	Diagram of typical structure
DWG.STR.5	Hydraulic information - surface pump system	Diagram of typical structure
DWG STR.6.	Array frame flange grounding for module earth	Diagram of typical structure
Site layout drawings (A4 or A3)		
DWG 1.A4	Typical site plan - top view	Schematic of site layouts
DWG 2.A4	Typical site plan – profile	Schematic of site layouts

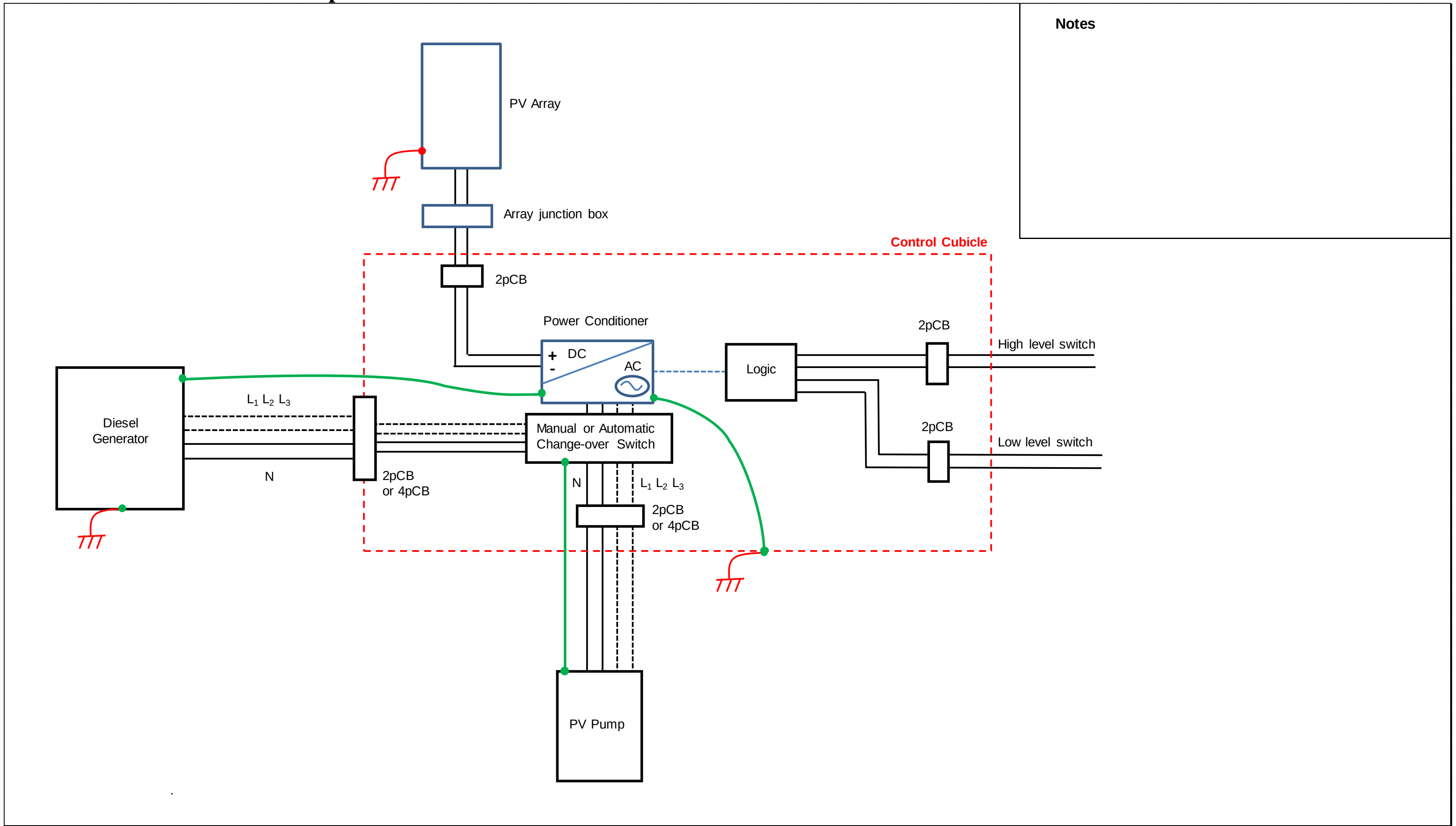
DWG SCH.1. Electrical diagram for typical solar PVP system without back-up



Notes

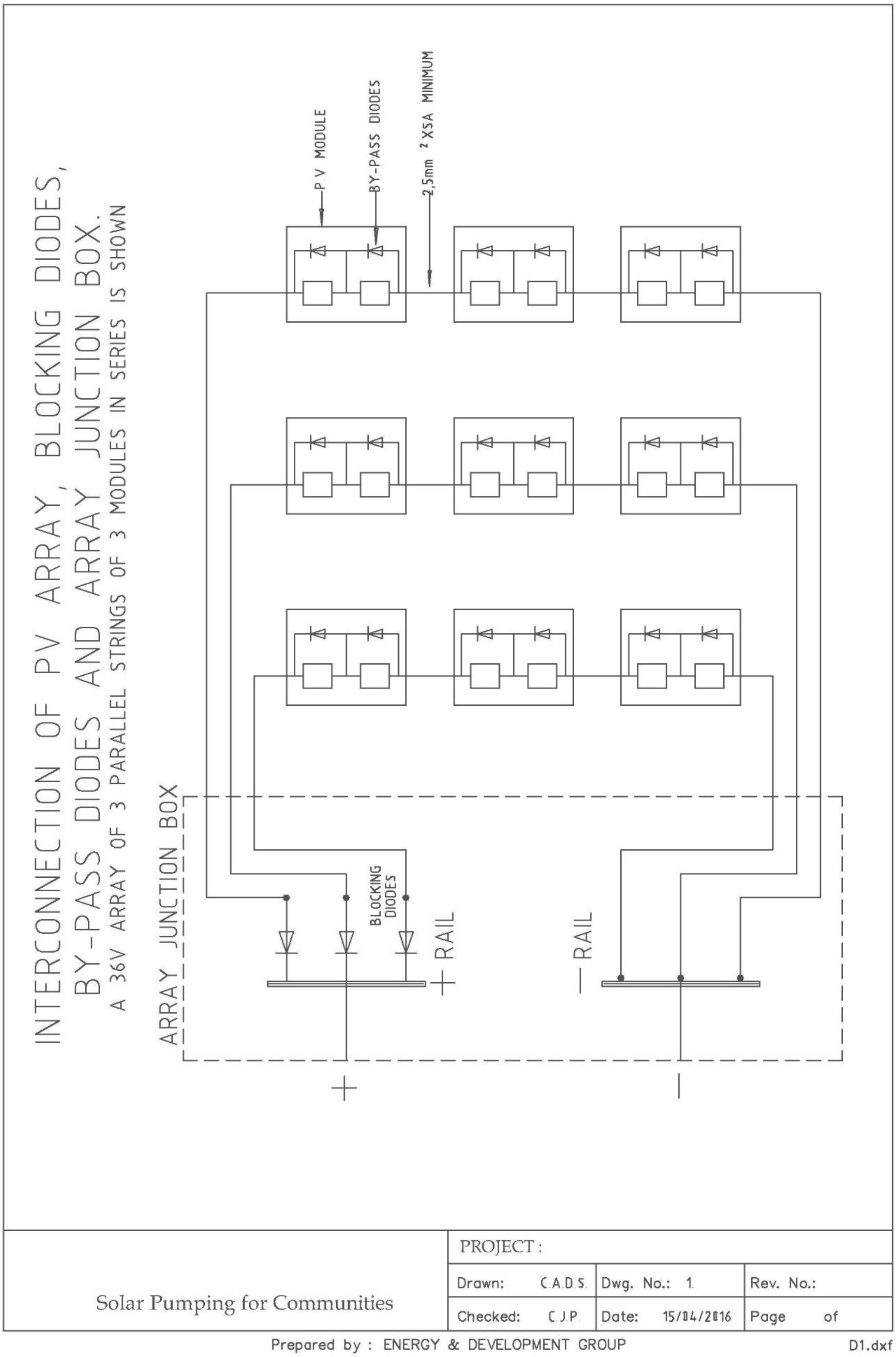
Solar Pumping for Communities	Description **Electrical diagram for typical solar PVP system without back-up**	**DWG SCH.1**	Scale
			Drawn by: NCL
			Date: February 2017
			Job no. EDG 2015-163

DWG SCH.2. Electrical diagram for typical solar PVP system with generator back-up

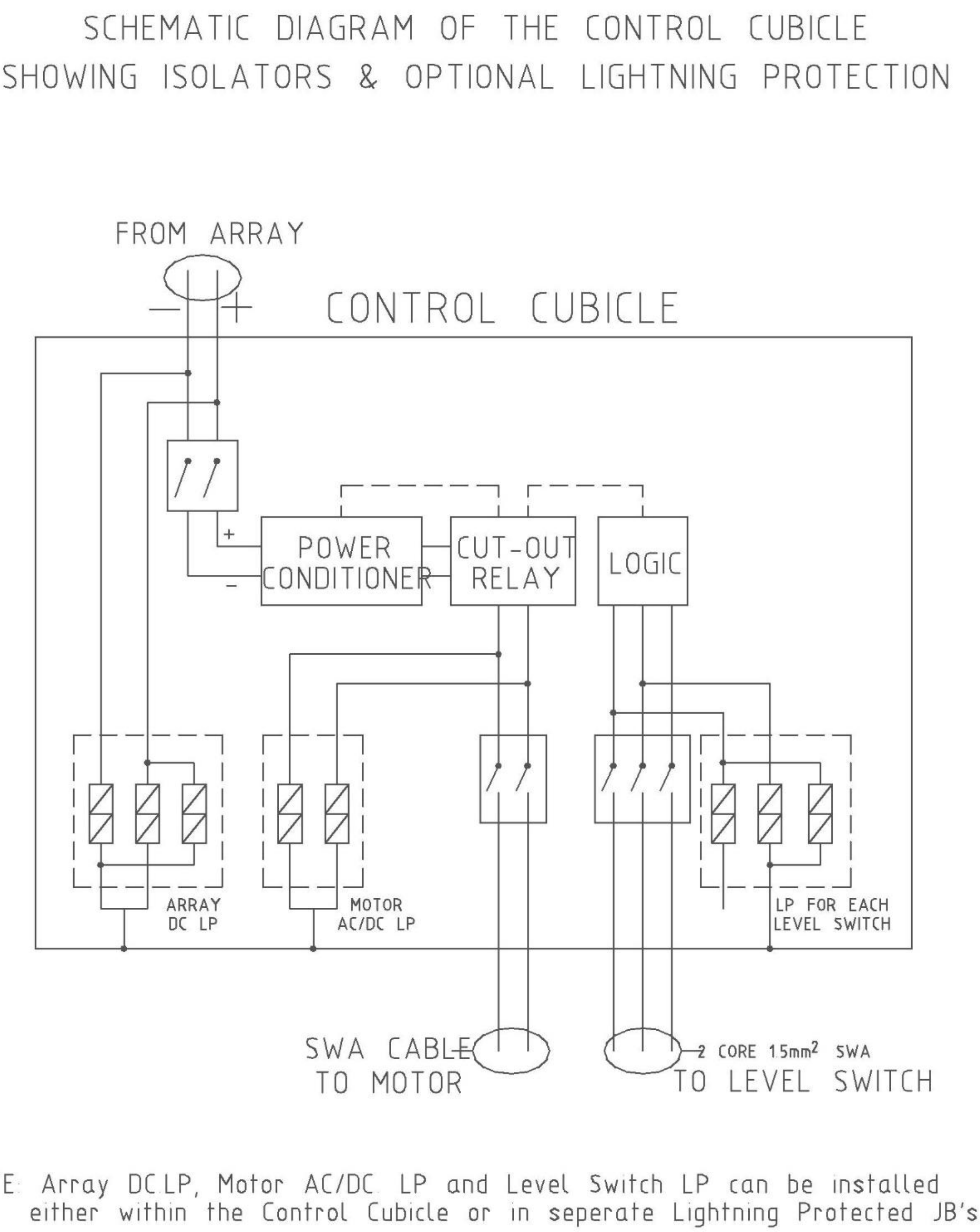


Solar Pumping for Communities	Description **Electrical diagram for typical solar PVP system with generator back-up**	**DWG SCH.2**	Scale
			Drawn by: NCL
			Date: February 2017
			Job no. EDG 2015-163

DWG.SCH.3. Interconnection of PV array, blocking diodes, by-pass diodes and array junction box



DWG.SCH.4. **Schematic of control cubicle, showing isolators and optional lightning protection**



Solar Pumping for Communities	PROJECT :		
	Drawn: C.A.D.S.	Dwg. No.: 4	Rev. No.:
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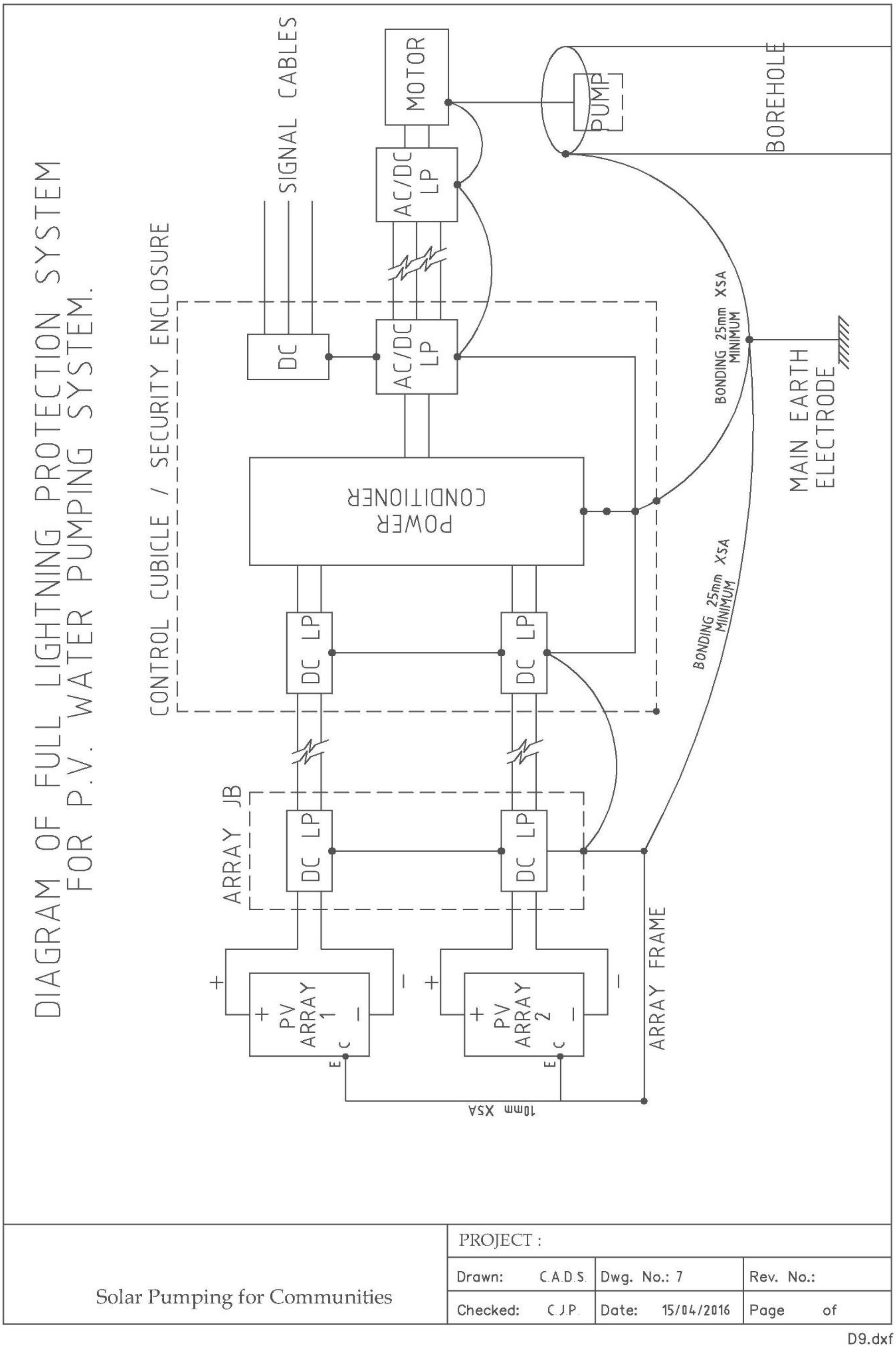
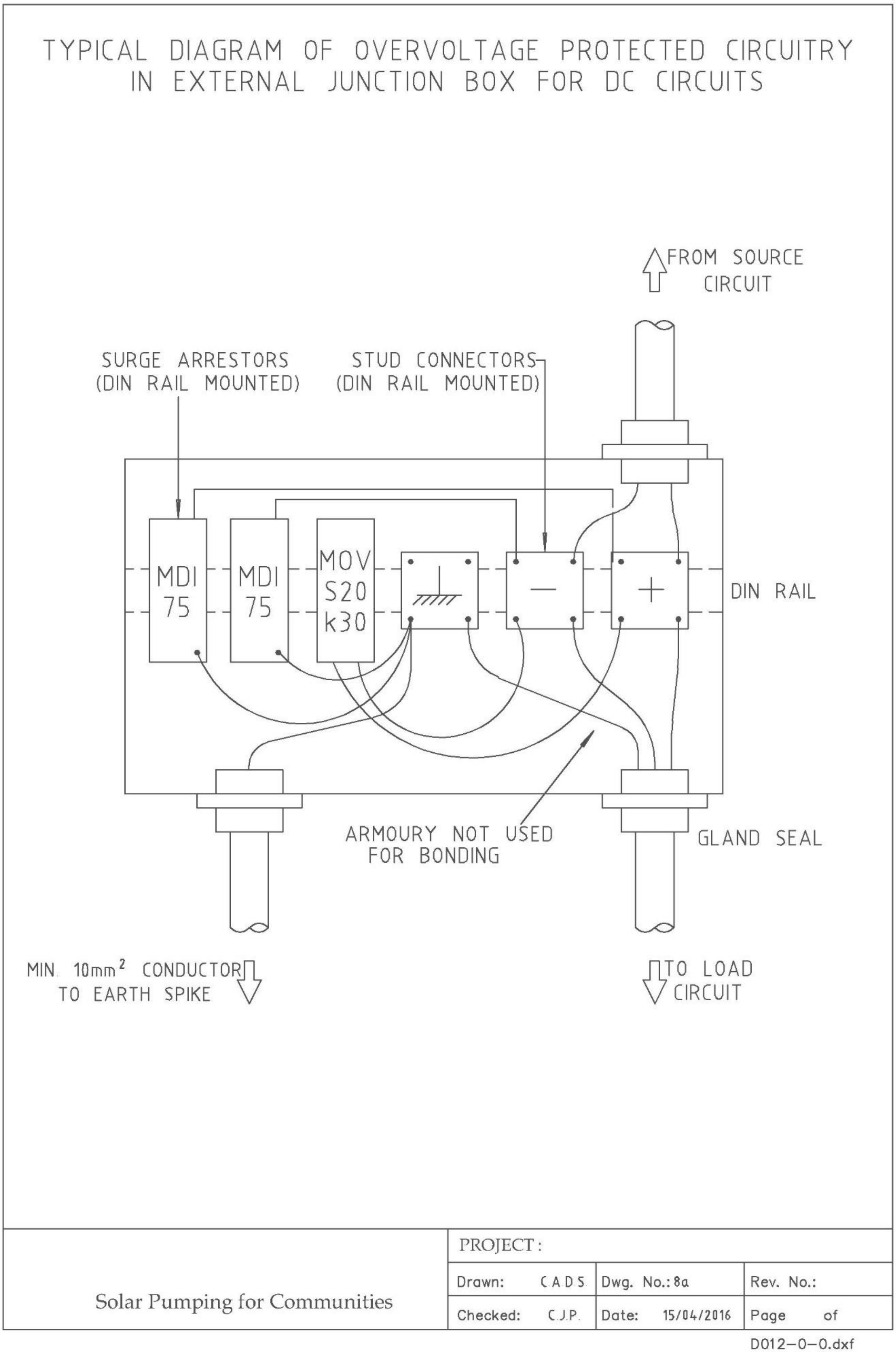
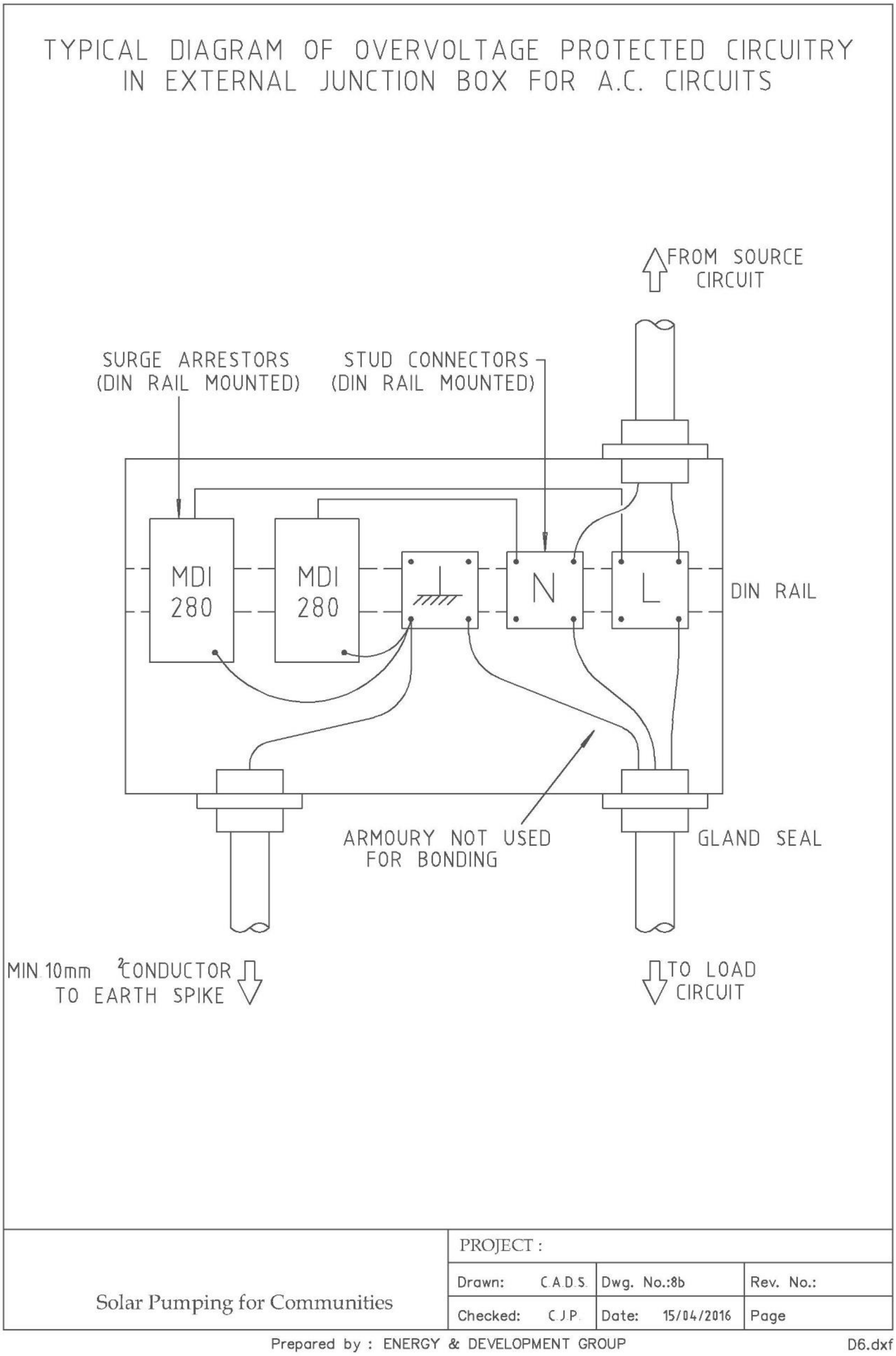
DWG.SCH.5. Diagram of full lightning protection system



DWG.SCH.6. Typical diagram of overvoltage protection circuitry in external junction box for DC circuits



DWG.SCH.7. Typical diagram of overvoltage protection circuitry in external junction box for AC circuits



DWG-STR.1 Array and module structure security assembly

Ideal arrangement of fence and array

Detail of security frames enclosing modules onto structure

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DWG.STR.2 **Security enclosure around the control cubicle and power conditioner**

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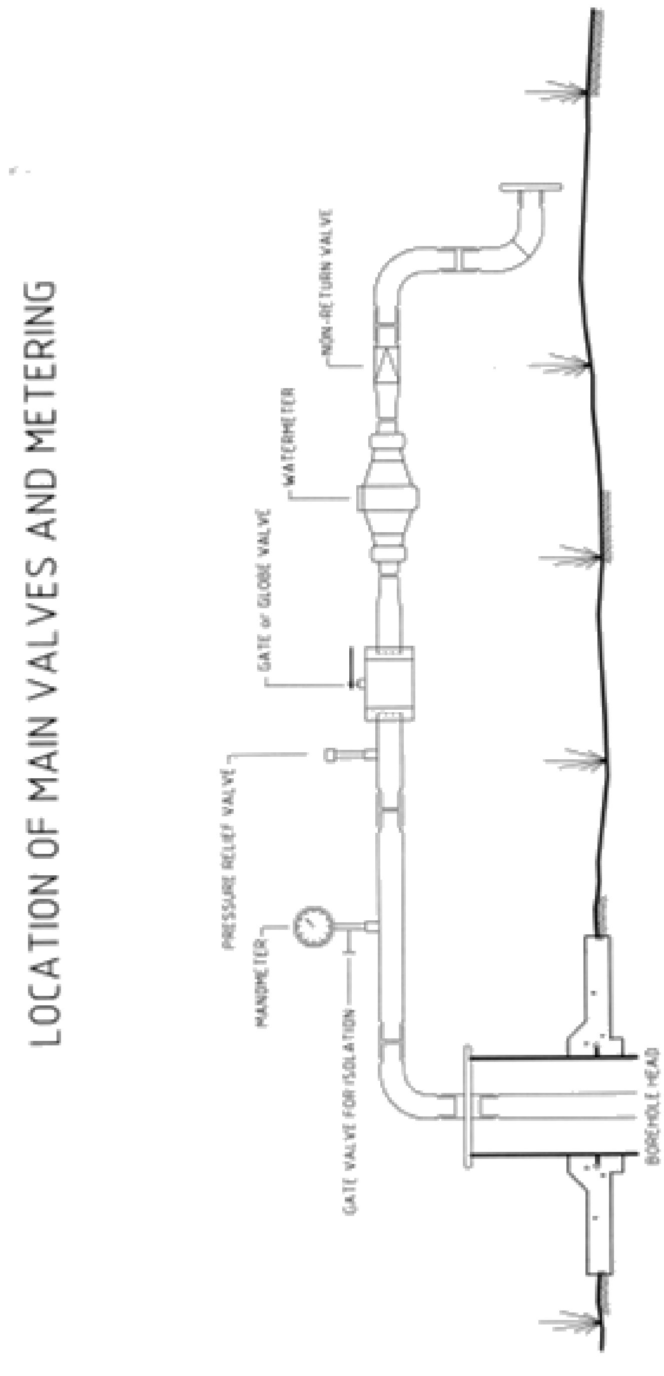
DWG.STR.3 Location of main valves and metering



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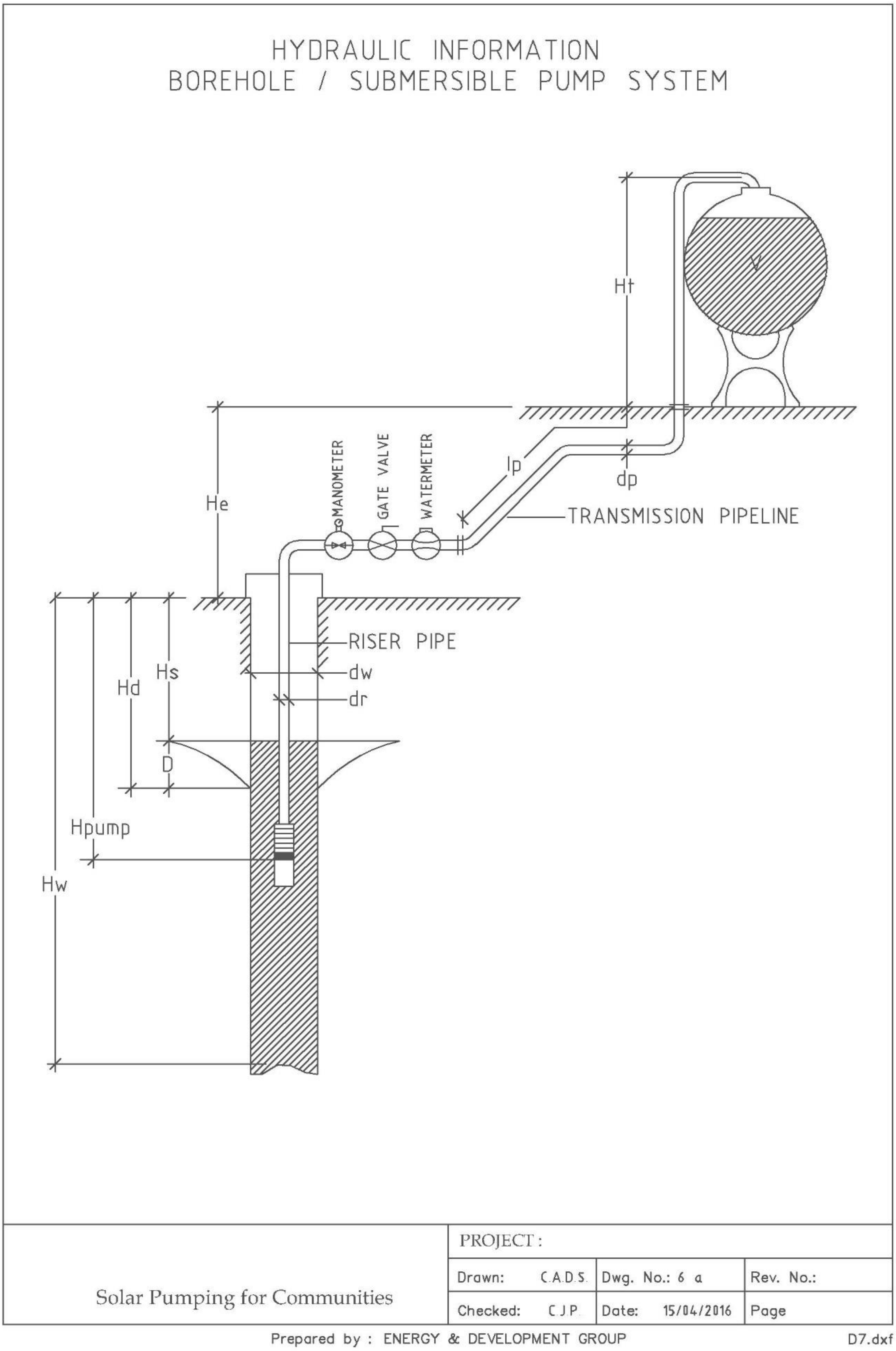
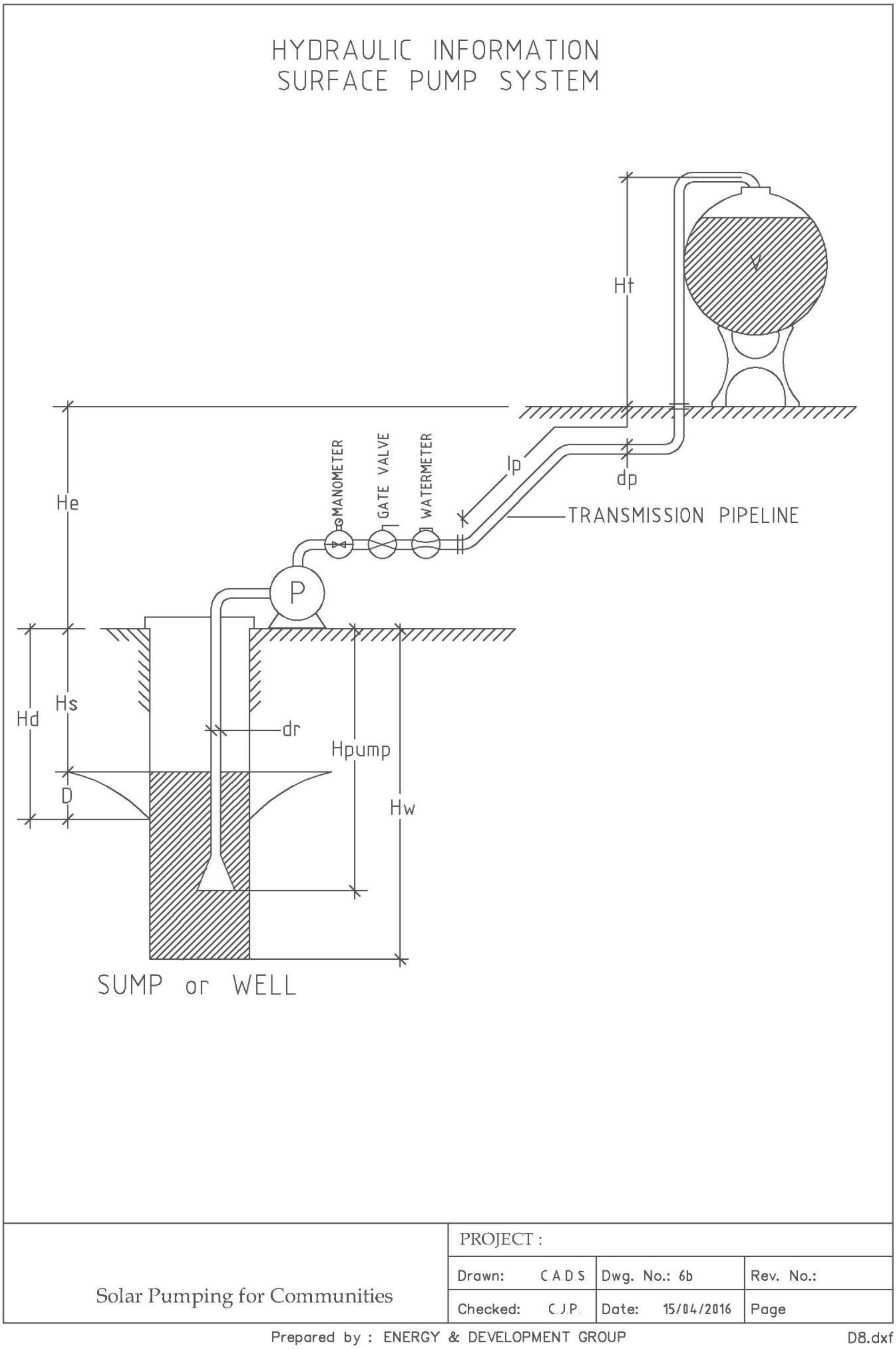
DWG.STR.4 Hydraulic information - line-shaft / submersible pump system



DWG.STR.5 Hydraulic information - surface pump system

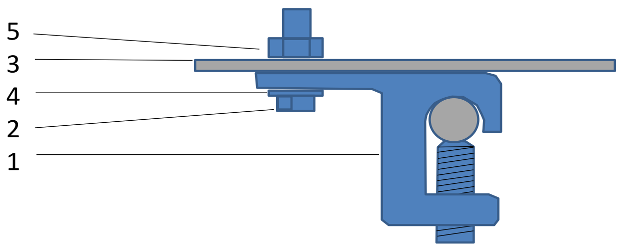


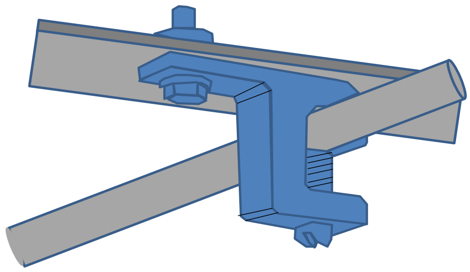
DWG-STR.6 Array frame flange grounding for module earth

Notes

1 Modules to face equator as aligned with roof

2 Space left for access for cleaning

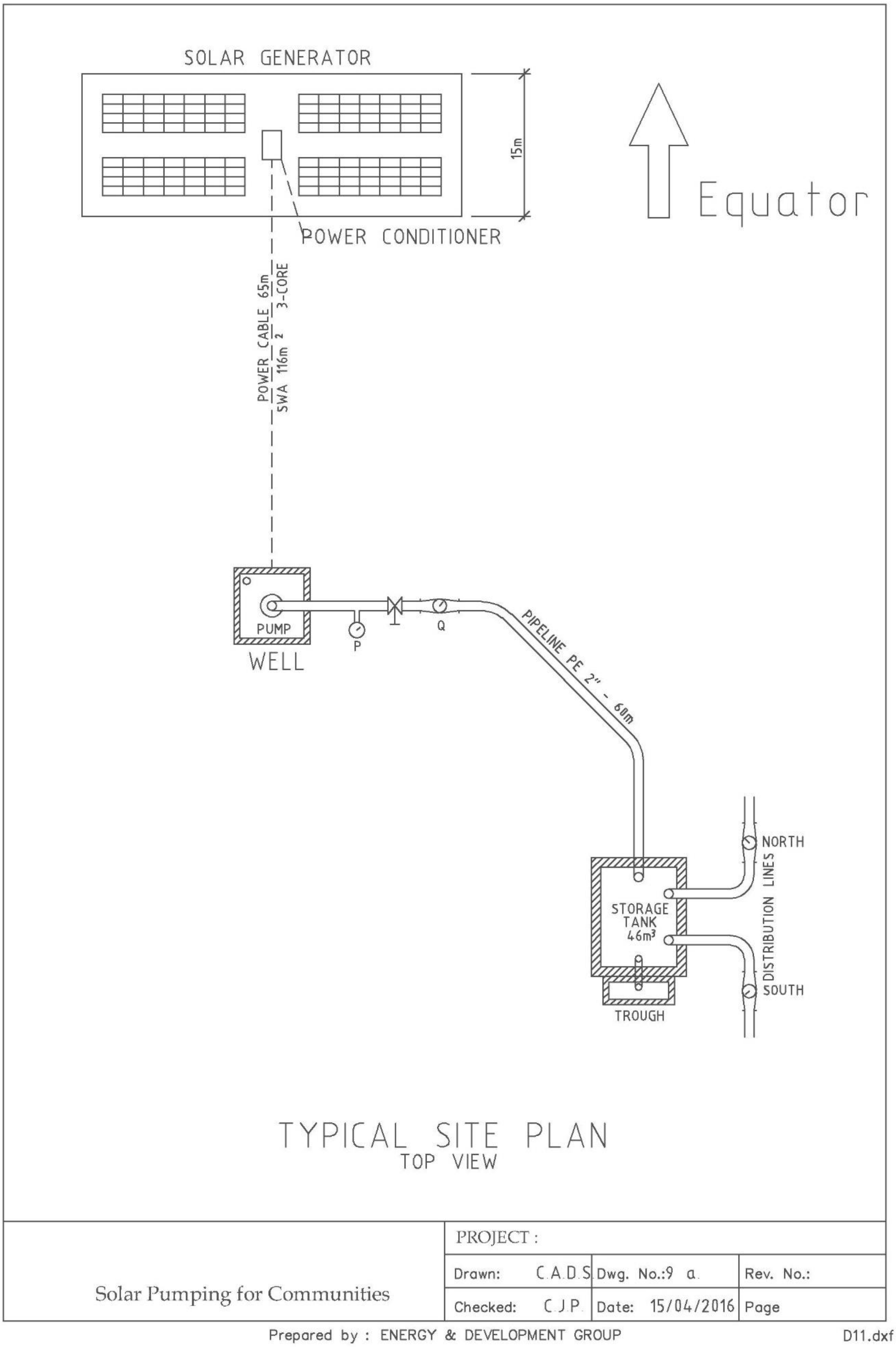




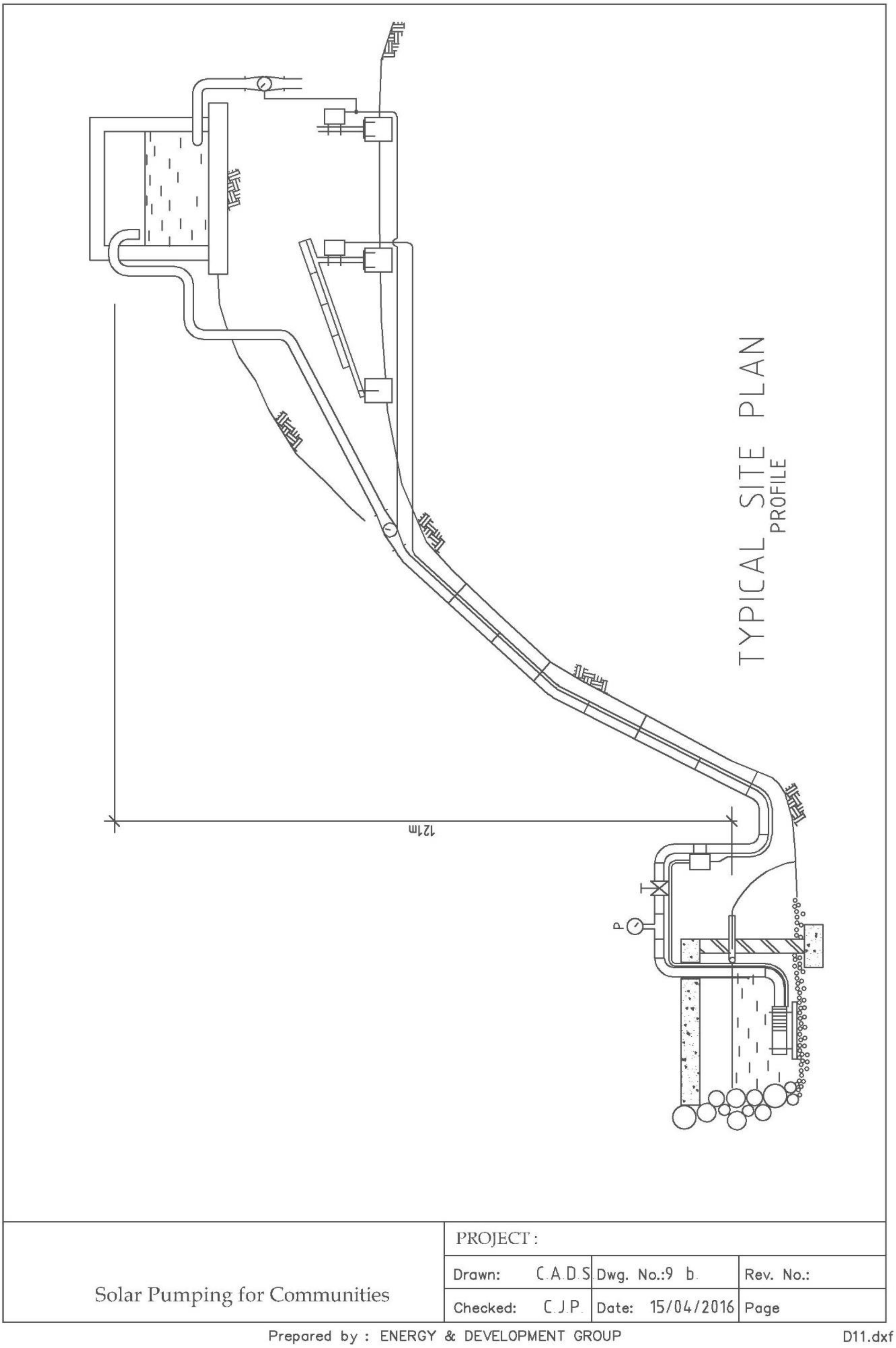
1) Lay-in Lug 2) Bolt 3) Serrated washer 4) Washer 5) Nut

Solar Pumping for Communities	Description **Array frame flange grounding for module earth**	**DWG STR.6**	Scale
			Drawn by: NCL
			Date: February 2017
			Job no. EDG 2015-163

DWG 1.A4 Typical site plan - top view



DWG 2.A4 Typical site plan – profile


TYPICAL SITE PLAN
PROFILE
121m
P
Solar Pumping for Communities
PROJECT :
Drawn: C.A.D.S
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D11.dxf

6. Schedule of Tables

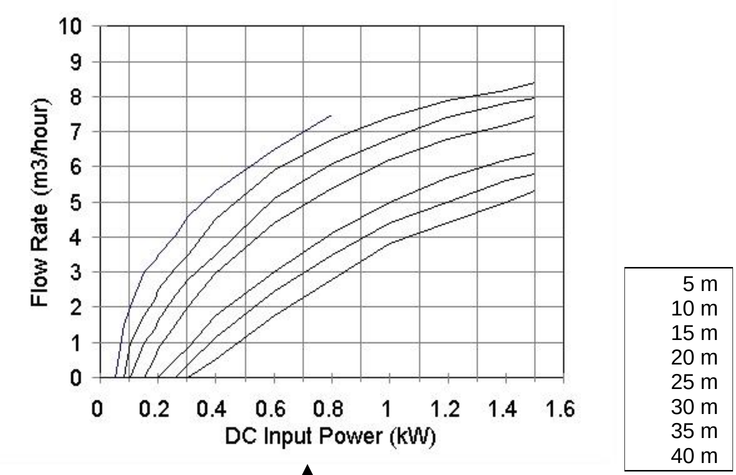
The Bidding Documents include the following tables.

List of Tables

TABLE 1 Sub-system performance data

Instantaneous Sub-system Performance Data

Water Output versus Maximum Power Available (at input to the Power Conditioner)



Note:
This graph represents the measureable "Wire to Water" power conversion.
It includes:

- Power conditioner conversion losses
- Motor / pump loses
- Any mechanical transmission losses

but excludes any array MPP tracking inefficiencies.
Power conditioner tracking is accounted for outside of the graph.

↑

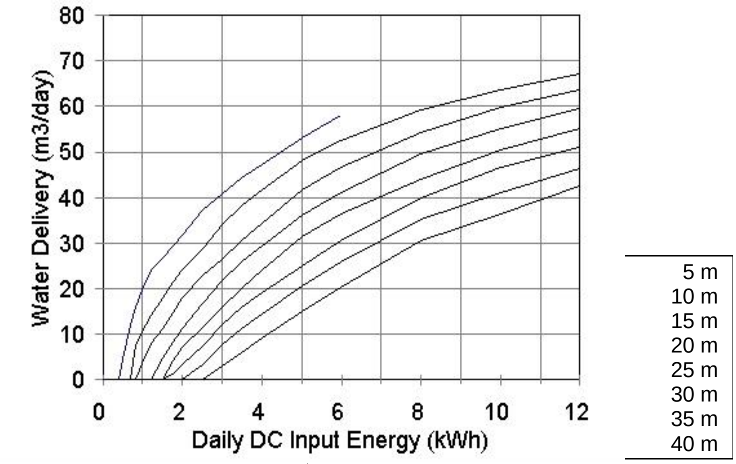
Power Conditioner Power Tracking Efficiency
(often module or array-specific)
typically 98% for MPPT
93% for CV controller
85% for no tracking

↑

MPP Power available from the PV Array

Daily Sub-system Performance Data

Daily Water Output versus Energy Available (at input to the Power Conditioner)



Note:
This graph represents the measureable "Wire to Water" power conversion.
It includes:

- Power conditioner conversion losses
- Motor / pump loses
- Any mechanical transmission losses

but excludes any array MPP tracking inefficiencies.
Power conditioner tracking is accounted for outside of the graph.

↑

Power Conditioner Power Tracking Efficiency
(often module or array-specific)
typically 98% for MPPT
93% for CV controller
85% for no tracking

↑

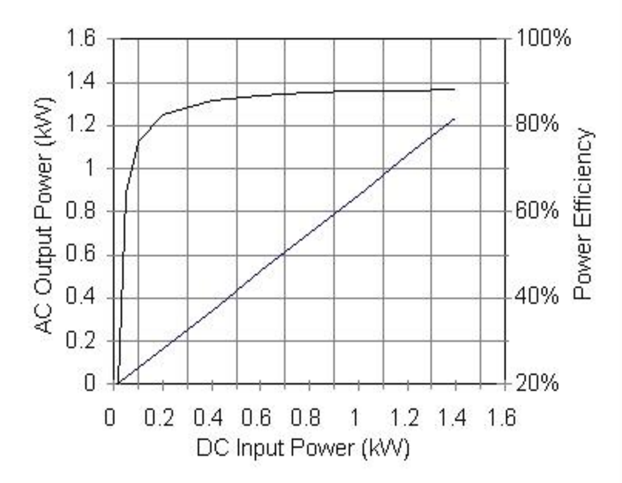
MPP Power available from the PV Array

TABLE 2 Power conditioner performance data

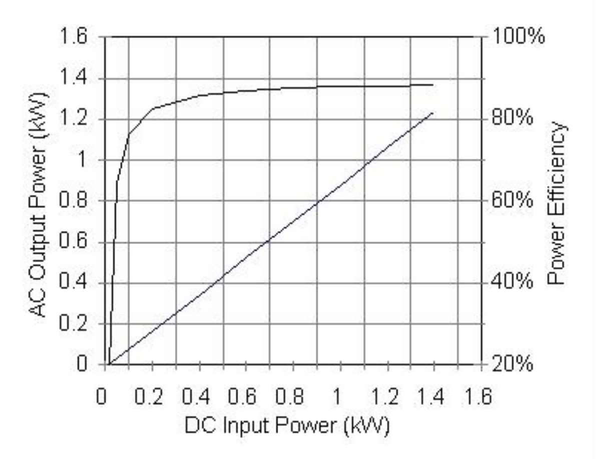
Instantaneous Power Conditioner Conversion Efficiencies

Note that Array Tracking Efficiencies are excluded, and are to be separately accounted for.

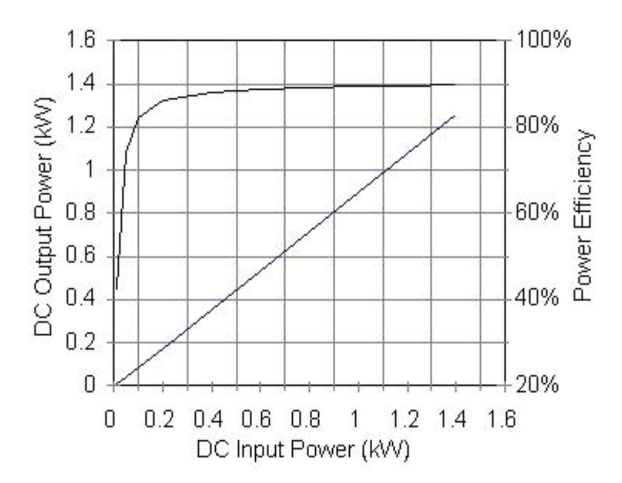
1. Variable speed inverter with MPPT



2. Variable speed inverter with CV operation



3. DC/DC converter with MPPT



4. CV DC/DC converter

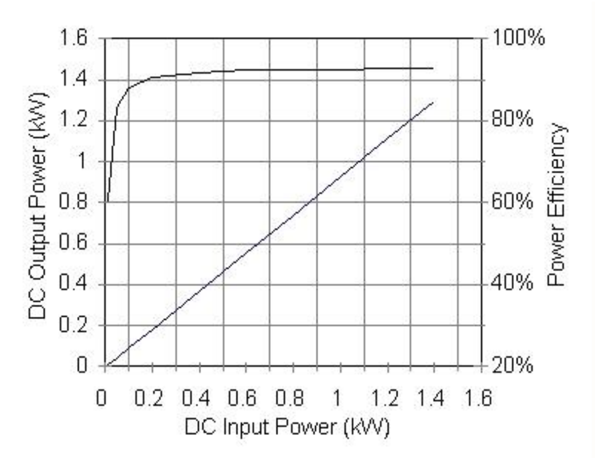
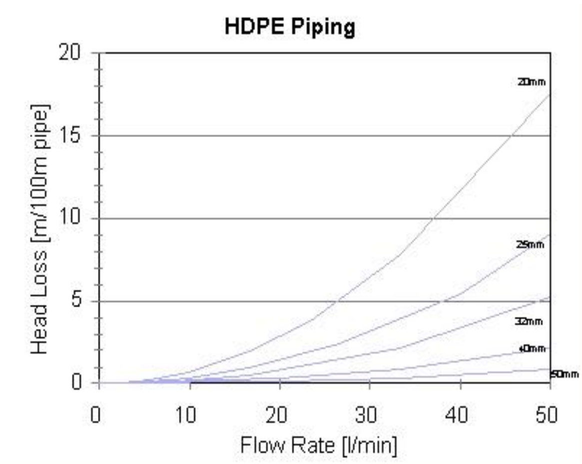
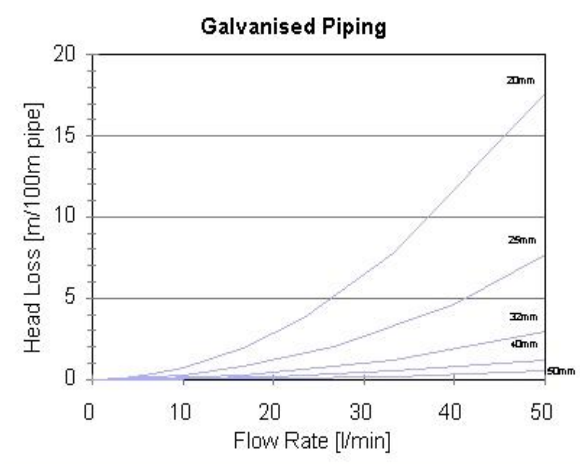
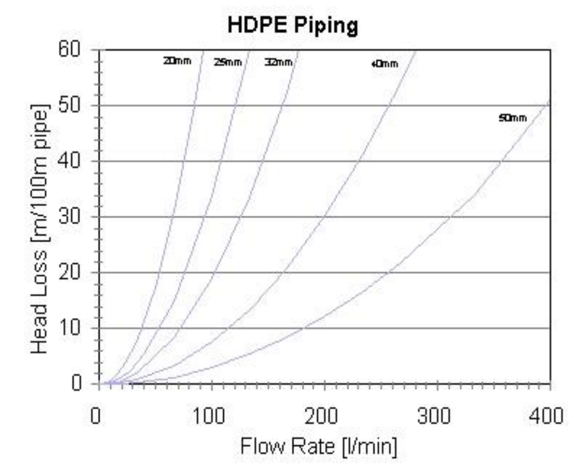


TABLE 3 A Head losses in pipes







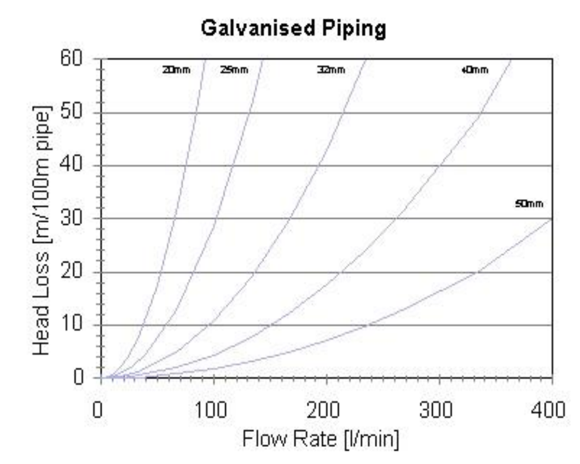
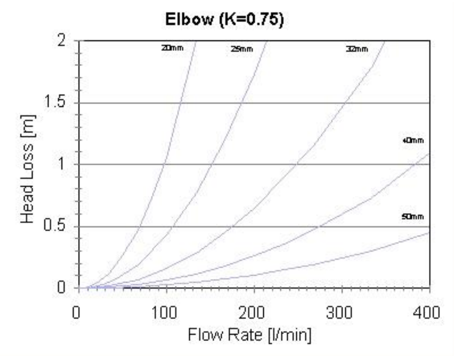
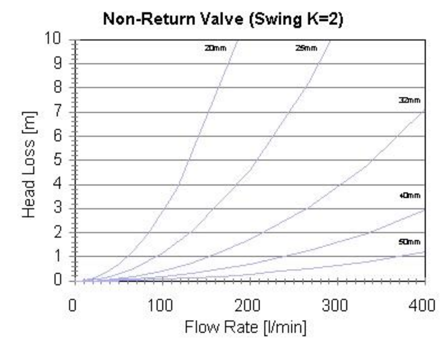
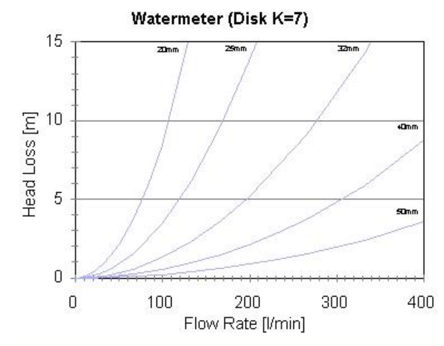
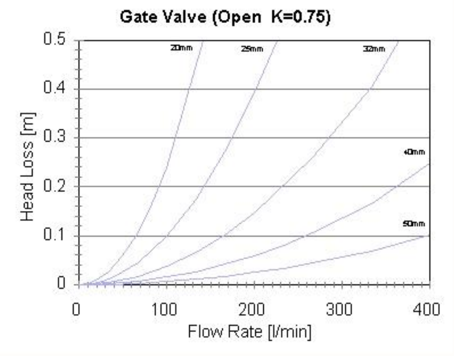


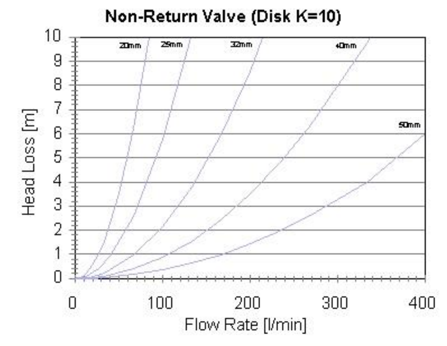
TABLE 3 b **Head losses in fittings**

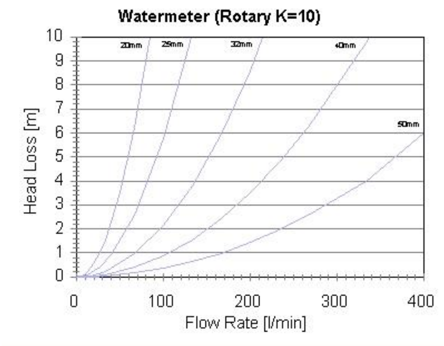


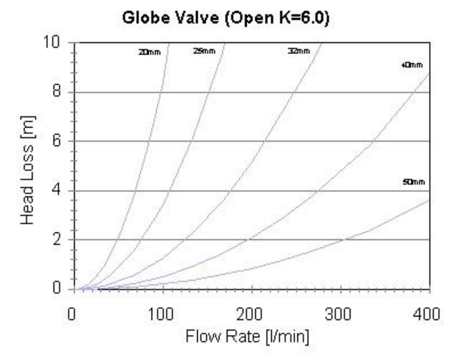


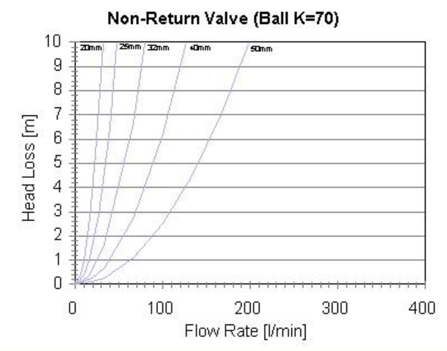












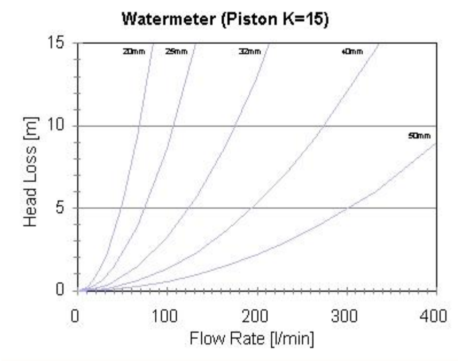


TABLE 4 Degrees of protection provided by enclosures (IP),
(from IEC 60529:2013 Degrees of protection provided by enclosure)

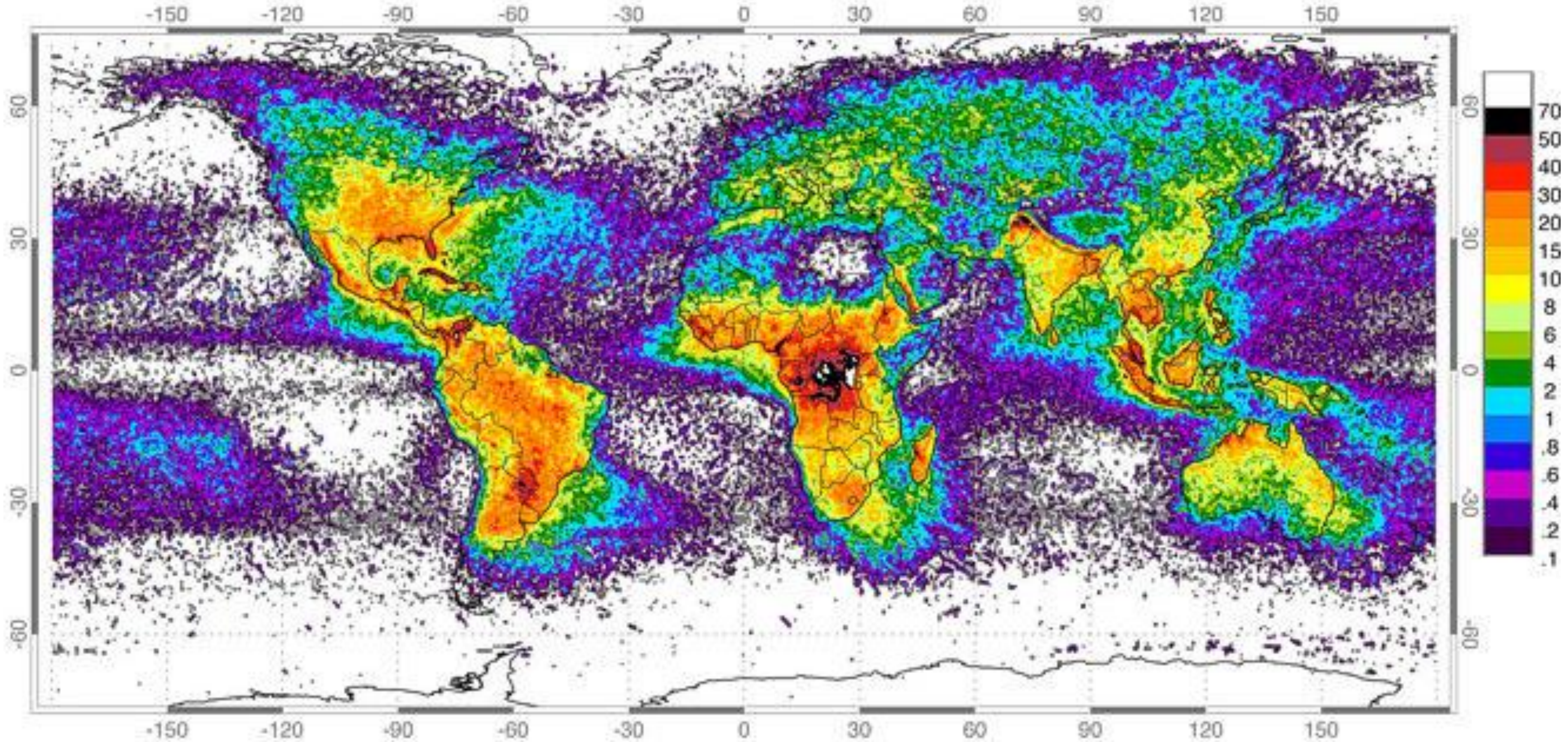
First Digit: Degree of Protection Against Contract and Foreign Bodies

1st Code No.	Extend of Protection	
	Designation	**Comment**
0	No Protection	No special protection against direct contact by persons with energized or moving parts.
1	Proof against large foreign bodies	Protection against accidental extensive contact with energized parts or internal moving parts, e.g. hand contact, but no protection against intentional access to these parts. Protection against penetration by solid foreign bodies with a diameter greater than 50 mm.
2	Proof against medium-sized foreign bodies	Protection against finger-contact with energized parts or internal moving parts. Protection against penetration by solid foreign bodies with a diameter greater than 12 mm.
3	Proof against small foreign bodies	Protection against contact with energized parts or internal moving parts by tools, wires or similar objects with a thickness greater than 2.5 mm. Protection against penetration by solid foreign bodies with a diameter greater than 2.5 mm.
4	Proof against granular foreign bodies	Protection against contact with energized parts or internal moving parts by tools, wires or similar objects with a thickness greater than 1 mm. Protection against penetration by solid foreign bodies with a diameter greater than 1 mm.
5	Proof against dust deposits	Complete protection against contact with energized parts or internal moving parts. Protection against harmful dust deposits. Dust penetration is not completely prevented, but dust may not penetrate in quantities sufficient to affect the proper functioning of the equipment.
6	Fully dustproof	Complete protection against contact with energized parts or internal moving parts. Full protection against dust penetration.

Second Digit: Degree of Protection Against Water

2nd Code No.	Extend of Protection	
	Designation	**Comment**
0	No Protection	No special protective measures.
1	Proof against vertical dripping	Vertical drips may not produce any damaging effects.
2	Proof against oblique dripping	Drips falling at an angle of up to 15º to the vertical may not produce any damaging effects.
3	Spray-proof	Water falling at any angle up to 60º may not produce any damaging effects.
4	Splash-proof	Water splashing against the equipment from any direction may not produce any damaging effects.
5	Water-jet-proof	A jet of water playing on the equipment from any direction may not produce any damaging effects.
6	Flood-proof	Temporary flooding, for example due to heavy seas, may not cause water in damaging quantities to penetrate the equipment.
7	Immersion-proof	No damaging quantities of water may penetrate the equipment if it is immersed in water for a fixed time at a fixed pressure.
8	Submersion-proof	No damaging quantities of water may penetrate the equipment if it is submerged.

TABLE 5 **Lightning ground flash densities**
http://www.weather.gov/images/pub/lightning/hirez_world_annual_flashrate_72dpi.jpg



High Resolution Full Climatology Annual Flash Rate

Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments

TABLE 6 General requirements for safety signs

Table 6a – Signage Conventions - General Meaning of Safety Colours and Shapes

	MEANING	SHAPE & COLOUR	SYMBOLS are put inside the safety shape. These are used in all EEC Countries		
PROHIBITION	You must not. Do not do. Stop.	RED means STOP	No admittance	No smoking	No dirty clothes
MANDATORY	You must do. Carry out the action given by the sign.	BLUE means OBEY	Keep clear	Head protection must be worn	Wear gloves
WARNING	Caution. Risk of danger. Hazard ahead.	YELLOW means risk of DANGER	Danger high voltage	Danger mind your head	Danger fork lifts in operation
SAFE CONDITION	The safe way. Where to go in an emergency	GREEN means GO	First aid station	Emergency phone	Emergency exit

(from ISO 3864-2: 2004: Graphical symbols –safety colours and safety signs)

(from IEC 80416-1: 2008: Basic principles for graphical symbols for use on equipment – Part 3: Guidelines for the application of graphical symbols)

Table 6b – DC Junction Box and PV enclosures

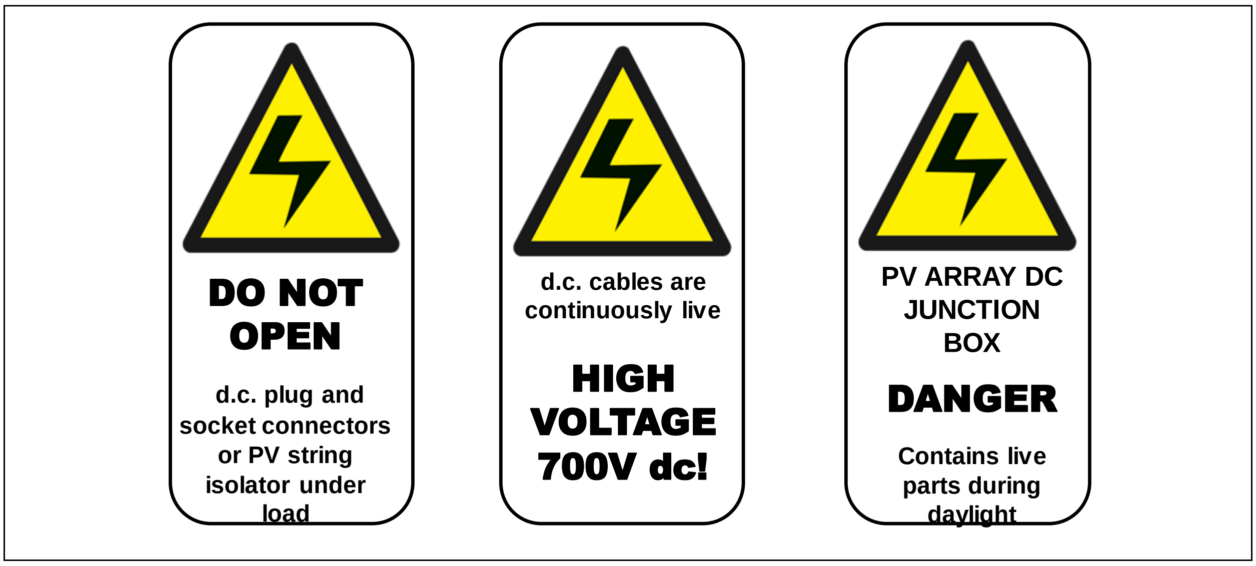


Table 6c – Generator / Fuel storage

Table 6d – Safety signage

Chapter 7. Acceptance Test Procedures for Solar PVP Systems

The Inspection and Commissioning Tests Procedures and Forms shall be updated by the Supplier to meet the specific requirements of the components and systems to be provided and installed, within one month of contract effectiveness. These revised Commissioning Procedures will be tested and approved by a commissioning officer of the Purchaser or Blue Print Consultant at the "Test" or "Blueprint" installations prior to full roll-out.

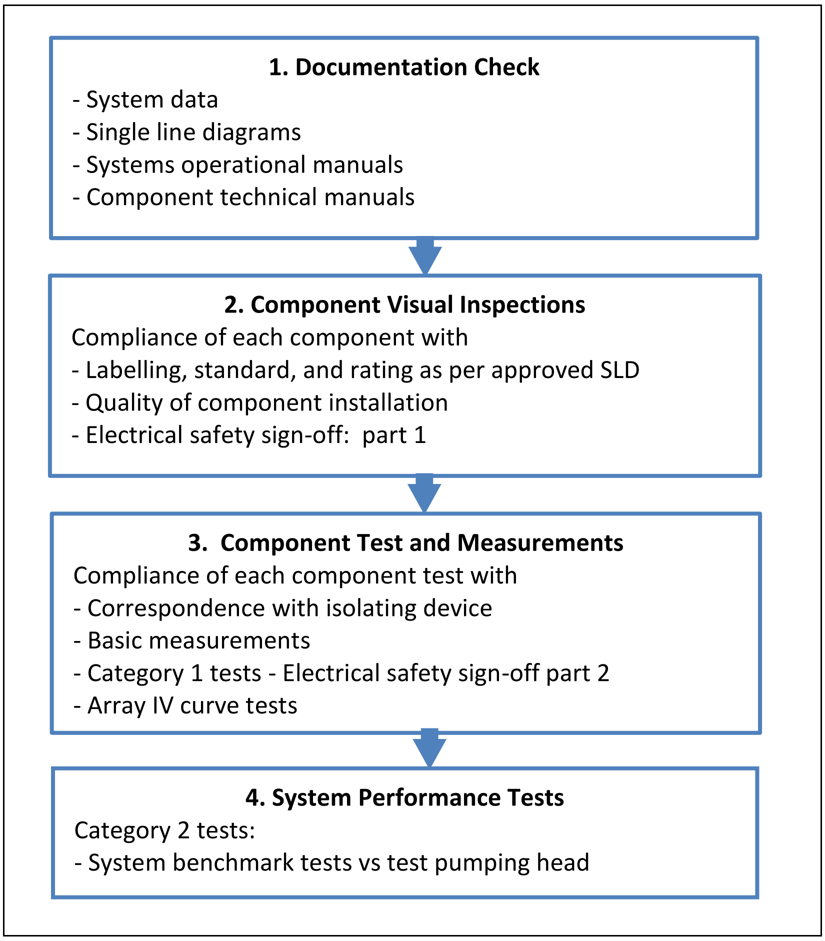
A proposed procedure, subject to revision by the Supplier to comply with requirements specific to the products supplied, is given below.

Acceptance Test Procedures for Solar Pumping Systems

1. ACCEPTANCE PROCEDURE

Acceptance checks are an important part of quality control and assurance procedures designed to ensure that systems are performing to specification, and will continue to function well after the maintenance and guarantee period, and that they will be economically viable to operate. Acceptance process comprises of the following:

Figure 1: Flow of acceptance tests



The Contractor shall allow for/facilitate such tests as described in the ***Project Specification***.

2. DOCUMENTATION CHECK

A check for all required documentation and data, and correspondence of this with the specification.

2.1 Operations and Maintenance booklet

Check the requisite sections, and specifically:

- ***System information***
  - Project identification reference (where applicable)
  - Rated (nameplate) system power (kW DC and kVA AC)
  - PV modules, MPPT, batteries and inverters - manufacturer, model and quantity
  - Installation date
  - Customer name
  - Site address

- ***System supplier information:*** As a minimum, the following information shall be provided for all bodies responsible for the supply and warranty of the system. Where more than one company has responsibility for the design of the system, the following information should be provided for all companies together with a description of their role in the project.
  - System supplier, company
  - System supplier, contact person
  - System supplier, postal address, telephone number and e-mail address.

- ***System installer information*** As a minimum, the following information shall be provided for all bodies responsible for the installation of the system. Where more than one company has responsibility for the installation of the system, the following information should be provided for all companies together with a description of their role in the project.
  - System installer, company
  - System installer, contact person
  - System installer, postal address, telephone number and e-mail address

- ***Wiring single line diagram:*** As a minimum, a single line wiring diagram shall be provided. This diagram shall be annotated to include the information detailed in the following sub-clauses.
  - Array electrical details
  - DC-AC system
  - Earthing and overvoltage protection

- ***Technical datasheets:*** All component data-sheets and operation manuals. As a minimum, datasheets must be provided for the following system components
  - Module datasheet for all types of modules used in system
  - Inverter datasheet, installation and operation manuals
  - MPPT datasheet, installation and operation manuals
  - Battery datasheet, installation and operation manuals

3. VISUAL INSPECTIONS

A general visual inspection shall be performed. The inspections are undertaken prior to testing. The inspections include system configuration and safety of earthing inspections, basic correspondence of key component and quantities with SLD and labelling, quality of installation, inspection for damage during installation.

3.1 Electrical Safety Sign-off - Part 1

The objective is to sign-off on the items numbered *3.1.1 –3..1.7* for the system as a whole. Practically this requires at least a visual inspection of each component and checking the items.

3.1.1 System design is appropriate

a) SLD are approved (i.e. the DC system has been designed, specified and installed to the requirements of IEC 60364 in general and IEC 60364-9-1 in particular.)

b) System has been mechanically designed to standard and conditions on site, including wind, temperature and corrosion.

3.1.2 System components are suitable for purpose

Confirm that components are suitable for purpose as per SLD, and appropriately installed:

a) Main components installed and comply with ratings as per *approved SLD*,

b) All necessary switching components are installed as per SLD to comply with IEC 60349-9-1

c) Wiring systems have been selected and erected to with stand external influences such as wind, temperature, UV radiation, and general tampering.

d) Connectors of appropriate nature are used and comply with IEC60349-9-1

3.1.3 DC system - Protection against the effects of insulation faults

Inspection of the DC installation shall include, as a minimum, verification of the measures in place for protection against the effects of insulation faults, including:

a) Galvanic separation in place inside the inverter/MPPT or on the AC

b) Functional earthing of any DC conductor

NOTE: knowledge of the galvanic separation and functional earthing arrangements are necessary in order to determine if the measures in place to protect against the effects of insulation faults have been correctly specified.

c) That a PV Array Earth Insulation Resistance detection and alarm system is installed – to the requirements of IEC 60364-9-1

d) That a PV Array Earth Residual Current Monitoring detection and alarm system is installed
   - to the requirements of IEC 60364-9-1

3.1.4 DC system - Protection against overcurrent

Inspection of the DC installation shall include, as a minimum, verification of the measures in place for protection against overcurrent in the DC circuits:

a) For systems with array / sub-array over-current protective devices: verify that:
   - over-current protective devices are fitted and correctly specified to the requirements of IEC 60364-9-1.

b) For systems without string over-current protective device: verify that:
   - $I_{MOD\_MAX\_OCPR}$ (the module maximum series fuse rating) is greater than the possible reverse current;
   - string cables are sized to accommodate the maximum combined fault current from parallel strings

   Note: see IEC60364-9-1 for calculation of array reverse currents

c) For systems with string over-current protective device: verify that:
   - string over-current protective devices are fitted and correctly specified to the requirements of IEC 60364-9-1.

3.1.5 DC system – earthing and bonding arrangements

Inspection of the DC installation shall include, as a minimum, verification of:

a) Array frame bonding arrangements have been specified and installed to the requirements of IEC 60364-9-1

b) Where protective earthing and/or equipotential bonding conductors are installed, verify that they are parallel to, and bundled with, the DC cables

c) Array structure earth spike(s) connected to ground. This should be clearly marked on the SLD.

d) NO earthing of the DC side of the electrical installation- or only one DC earthing location

e) Where the PV system includes functional earthing of one of the DC conductors, the functional earth connection has been specified and installed to the requirements of IEC 60364-9-1. And clearly marked in SLD.
f) Where a PV system has a direct connection to earth on the DC side, a functional earth fault interrupter must be provided to the requirements of IEC 60364-9-1 and clearly marked in the SLD.

3.1.6 DC system - Protection against the effects of lightning and overvoltage

Inspection of the DC installation shall include, as a minimum, verification of:

a) To minimise voltages induced by lightning from the array circuits, verify that the area of all incoming wiring loops has been kept as small as possible
b) Measures are in place to protect long DC cables (e.g. screening or the use of DC-rated Surge Protection Devices (SPD)
c) Where DC-rated SPDs are fitted, check that they have been installed to the requirements of IEC 60364-9-1, and are clearly marked in the SLD.

3.1.7 AC system - Protection against the effects of lightning and overvoltage

Inspection of the AC installation shall include, as a minimum, verification of:

d) To minimise voltages induced by lightning from the AC load circuits, verify that the area of all wiring loops been kept as small as possible
e) Measures are in place to protect long AC cables and underground cables (e.g. screening or the use of AC-rated SPDs)
f) Where AC-rated SPDs are fitted (underground cables or long overhead cables, they have been installed to the requirements of IEC 60364-9-1 in the AC DB, and are clearly marked on the SLD.

3.2 Component Inspection Sequence

These visual inspections descriptions highlight the important items to be checked. The full details should be on individual component inspection checklist sheets.

3.2.1 Array structure - visual inspection

a) Check for mechanical soundness of structure, including upper structure quality, foundation quality, corrosion resistance and galvanisation quality. Confirm module mounting using stainless bolts, and avoidance of contact between dissimilar metals or confirm module clamping location against manufacturer specification. Check for obvious torsional stress on modules.
b) Check cable tray quality, to same standards as per structure.
c) Check orientation, tilt angle, possible shading.
d) Check for anti-theft measures and quality of the measures (array frames, tamper-proof bolts, high mast etc), and confirm they do not affect panel shading or performance.
e) Confirm array structure earthing, including connection quality to module frames, continuity between arrays, and check for dissimilar metals (future corrosion). Verify that array frame and/or module frame protective earthing conductors have been correctly installed i.e. ground wire attachment with nut and bolt combination including star washer or WEEB clip installation, and are connected to earth. Confirm earth spike location

3.2.2 Array - visual inspection

a) Check for correspondence of each array labelling with SLD, arrangement and numbering including substring numbering. Check module type. Check quantity of arrays, modules per array, series and parallel connections.
b) Confirm each module has serial numbers for scanning, and correct product labelling with specifications for warranty support.
c) Check for any damage: surface and glass damage, back-plate and EVA damage, torsional stress on modules.

3.2.3 Array Junction Box - visual inspection

a) Check for correspondence of labelling with SLD, especially arrangement and numbering.
b) Check quality: Combiner Box is outdoor rated, IP65 and gland seals, internal CB and rating compared with SLD, internal Lightning Protection (LP) devices.
c) Check and inspect “strain reliefs” and gland seals to ensure cables cannot be pulled or chaffed against knockouts

d) Check cable routing, and quality and consistency of MC connectors.
e) Confirm earthing arrangement of internal LP devices. Confirm absence/presence of array conductor cable earthing. Confirm cable labelling.

3.2.4 Array cable entry & combiner - visual inspection

a) Check correspondence of labelling with SLD: arrangement and numbering, combiner box numbering
b) Check quality: Combiner Box is outdoor rated, internal CB and rating compared with SLD.
c) Confirm absence/presence of array conductor cable earthing. Confirm cable labelling.
d) Check cable entries to room, and quality of entry. Check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts

3.2.6 Power Conditioner / Inverters - visual inspection

a) Check for correspondence of labelling with SLD: inverter type and model, arrangement and numbering, quantities.
b) Check that sufficient space for ventilation surrounding the inverter has been left.
c) Check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts
d) Check earthing arrangement and configuration: chassis earthing and earth cabling connection, and confirm DC positive or negative cables are unearthed at inverter.
e) For functional earth leakage protection, confirm inverter ELP compatibility and N-E bridge location.
f) Check for provision of LP on incoming DC cables from array and note whether Class 1 or Class 2. Check for LP on DC cables to float switches and external relays and note Class 1 or 2. Check for continuity in LP device, and earthing connections and earth path.
g) Check for provision LP on outgoing DC cable to pump, or check for provision of SPD on outgoing AC cables to pump and note Class 1 or 2. Check continuity of LP or SPD device, and earthing connections and earth path.

3.2.7 Pump - visual inspection

This inspection is possible only for surface pumps, or pumps that have not yet been installed:

a) Check for correspondence of labelling with SLD: pump type and model, arrangement.
b) Check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts.
c) Check earthing arrangement and configuration: chassis earthing and earth cabling connection, and confirm DC positive or negative cables are unearthed.
d) Check strain cable length attachment and compare with borehole depth, to ensure pump is suspended at least 1.5m above borehole base.
e) Check pump riser pipe attachment at pump, check quality of fittings.

3.2.8 Cables and connectors - visual inspection

This visual inspection checks cables types, and general cable routing practices. Visual inspections to confirm cabling types are appropriate:

a) PV array cabling
b) Submersible pump cable
c) AC cable types

Check cable routing by opening conduits and cable trays:

d) For all enclosures, check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts
e) DC cables are separated from AC cables, and separated from COMMS cables at all routings.
f) Where protective earthing and/or equipotential bonding conductors are installed, verify that they are parallel to, and bundled with, the DC cables (IEC 60364-7-712.54:2002).
g) to minimize voltages induced by lightning, verify that the area of all wiring loops has been kept as small as possible (IEC 60364-7-712.444.4:2002).
h) Inspect for any joins and splicing of cables hidden underneath cable trunking, inside conduits or in cable trays. All wiring joining and splicing should be avoided. All cable connections, especially high power DC ones, should be INSIDE INSPECTION ENCLOSURES. Splicing and joins with ferrules and heat shrink are UNACCEPTABLE! And will heat up over time.

3.2.8 Pipework, metering and valves

a) Check and compare arrangement with borehole heard drawing, noting gate valves, pressure release, water metering, pressure metering, and non-return valves.

b) All labelling is in correspondence with the SLD
c) Check pump riser pipe attachment at pump, check quality of fittings.
d) Check borehole head concrete finish and metallic borehole head lock.
e) Check for quality of connections.

3.2.9 Generator - visual inspection

a) Check for correspondence of labelling with SLD: inverter type and model, arrangement and numbering, quantities.
b) Check Main load CB rating compared with SLD.
c) Check and inspect "strain reliefs" and gland seals to ensure cables cannot be pulled or chaffed against knockouts.
d) Earthing and bonding compatibility: Check for N-E bridge location in Genset DB or within generator.
e) Confirm whether own equipment bonding spike and location. Confirm whether own AC Electrical earth spike and location.
f) Confirm Generator Change-Over switch earthing is clearly marked in SLD, and if earth is switched, that this is not in conflict with any N-E bonding.

3.2.10 Signage and labelling - visual inspection

The signage and labelling installed on site is critical. Inspection of the PV system shall include, as a minimum, verification that:

a) Approved single line wiring diagram is displayed on site
b) All labelling is in correspondence with the SLD
c) All circuits, protective devices, switches and terminals are suitably labelled to the requirements of IEC 60364 in general and IEC 60364-9-1 in particular
d) All long cable runs are labelled as necessary
e) All DC junction boxes (PV generator, PV array boxes, PV combiner boxes, DC DB and busbars) carry a warning label indicating that active parts inside the boxes are fed from a PV array and may still be live after isolation from the PV inverter.
f) Means of isolation on the AC side is clearly labelled
g) Installer details displayed on site
h) Shutdown procedures displayed on site
i) Emergency procedures displayed on site (where relevant)
j) All signs and labels suitably affixed and durable
NOTE: the requirements for signs and labelling of the PV system are detailed in IEC60364-9-1

3.2.11 Remote monitoring, data-logging and remote control

The communications components cover those for interlinking the major power components within the site, as well as a link to the outside world.

- Confirm presence of integrated comm package as per SLD.
- Confirm presence of presence of at least one ComBox.

4. SAFETY AND COMPONENT TESTS

The objective is to sign off on basic functional switching, electrical safety tests vis-à-vis polarities, earthing continuity and insulation resistances, and cabling. The following checks will be undertaken:

- Correspondence of all CB and isolators, and labels thereof, with the switched equipment,
- Electrical Safety Sign-off - part 2
  - continuity of earthing and equipotential bonding conductors
  - polarity tests
  - junction and combiner box tests
  - V_{oc} and basic voltage range checks
  - PV string short circuit tests
  - PV insulation resistance tests
- Cable distance measurements for voltage drop calculations
- Terminal torque settings for main connections

4.1 Correspondence of isolators and labels with switched devices

Check functional correspondence of all CB and isolators and labels with switched devices: i.e. check which isolators turn on which devices. This is best achieved before system switch on by measuring resistances – however some components can be checked simply by switching.

4.2 Electrical Safety Sign-off - Part 2

These tests are used to confirm measurements of basic electrical safety before system switch on.

4.2.1 Continuity of earthing and equipotential bonding conductors

Where protective earthing and/or equipotential bonding conductors are fitted on the DC side, such as bonding of the array frame, chassis of MPPT and inverters, electrical continuity tests shall be made on all such conductors. The connection to the main earthing terminal should also be verified.

4.2.2 Polarity tests

The polarity of all DC cables shall be verified using suitable test apparatus (i.e. Seaward Solar PV150, which can be used for testing Isc, Rpe and Riso tests along with Voc and Polarity in this section.) Once polarity is confirmed, cables shall be checked to ensure they are correctly identified and correctly connected into system devices such as switching devices or inverters.

NOTE: For reasons of safety and for the prevention of damage to connected equipment, it is extremely important to perform the polarity check before other tests and before switches are closed or string over-current protective devices inserted. If a check is made on a previously connected system and reverse polarity of one string is found, it is then important to check modules and bypass diodes for any damage caused by this error.

4.2.3 Junction and combiner box tests

The purpose of combiner box test (or indeed any junction box where paralleling of connections occurs) is to ensure all strings interconnected at the combiner box are connected correctly, before switching on the combiner breakers or fuses. The following test sequence indicates a reverse connection through a substantially different voltage reading. The test procedure is as follows and shall be performed before any string fuses are inserted for the first time:

- Use a volt meter with voltage range at least twice the maximum system voltage.
- Ensure all strings share a common negative bus (as per SLD)
- Ensure all positive CB are off for the test.
- Measure the open-circuit voltage of the first string, positive to negative, and ensure it is an expected value.
- Leave one lead on the positive pole of the first string tested, and put the other lead on the positive pole of the next string. Because the two strings share a common negative reference, the voltage measured should be near-zero, with an acceptable tolerance range of +/-15 volts
- Continue measurements on subsequent strings, using the first positive circuit as the meter common connection.
- A reverse polarity condition will be very evident if it exists - the measured voltage will be twice the system voltage.

4.2.4 PV string -current measurement

The purpose of PV string current measurement test is to verify that there are no major faults within the PV array wiring. These tests are not to be taken as a measure of module / array performance.

The short circuit current of each PV string should be measured using suitable test apparatus. (i.e. Seaward Solar PV150, which can be used for testing Isc, Rpe and Riso tests along with Voc and Polarity) .The making / interruption of string short circuit currents is potentially hazardous and a suitable test procedure, such as that described below, should be followed.

Measured values should be compared with the expected value. For systems with multiple identical strings and where there are stable irradiance conditions, measurements of currents in individual strings shall be compared. These values should be the same (typically within 5% of the average string current, for stable irradiance conditions).

Short circuit test procedure

A temporary short circuit shall be introduced into the string under test. In these procedures[7] this is achieved use of a test instrument with a short circuit current measurement function (eg a specialised PV tester), with an irradiance meter reading or visual appraisal of the sunlight conditions may be used to consider the validity of the current readings, for on-stable irradiance conditions[8].

- Ensure that all switching devices and disconnecting means are open and that all PV strings are isolated from each other.
- Ensure that the test instrument has a rating greater than the potential short circuit current and open circuit voltage. It shall also be ensured that where a switching device and/or short circuit conductor is utilised to form the short circuit, that these are rated greater than the potential short circuit current and open circuit voltage.
- The short circuit current can then be measured using test instrument with a short circuit current measurement function.

4.2.5 PV array - insulation resistance tests

PV array DC circuits are live during daylight and, unlike a conventional AC circuit, cannot be isolated before performing this test. Performing this test presents a potential electric shock hazard (150-600Vdc in this case), it is important to fully understand the procedure before starting any work. It is recommended that careful safety measures are followed.

The test should be repeated for each PV Array as minimum. It is also possible to test individual strings if required.

Where the structure/frame is bonded to earth, the earth connection may be to any suitable earth connection or to array frame (where the array frame is utilised, ensure a good contact and that there is continuity over the whole metallic frame).

For installations where the array frame is not bonded to earth (i.e. class II installation) the commissioning engineer may choose to do two tests: i) between Array cables and Earth and an additional test ii) between Array cables and Frame.

Insulation resistance test procedure

It is assumed that the test shall be done using a test device such as Seaward Solar PV150 (which can be used for testing Isc, Rpe and Riso tests along with Voc and Polarity in this section).

- Before commencing with the test:; isolate the PV array from MPPT/inverter (typically at the array switch disconnector); and disconnect any piece of equipment that could have impact on the insulation measurement (i.e. overvoltage protection) in the junction or combiner boxes.
- The insulation resistance test device shall be connected between earth and the array cable(s) as appropriate to the test method adopted. Test leads should be made secure before carrying out the test.
- Follow the insulation resistance test device instructions to ensure the test voltage is according to table below and readings in MΩ.

- For PV arrays of up to 10kWp, the insulation resistance shall be measured with the test voltage indicated in Table below.
- The result is satisfactory if each circuit has insulation resistance not less than the appropriate value given in Table below.

- Ensure the system is de-energised before removing test cables or touching any conductive parts.

Table 1: Minimum values of insulation resistance – PV arrays up to 10kWp

System Voltage (Voc_{stc}x1.25)	Test voltage	Minimum insulation resistance
<120V	250V	0.5MΏ
120V-500V	500V	1MΏ
>500V	1000V	1MΏ

4.2.8 Terminal torque settings

Check connection quality of a broad selection of random locations which are critical to system performance, and which indicate consistency in quality of installation:

4.3 Array IV tests

The IV curve test on an array benchmarks the overall performance against nameplate, of the array comprising of:

- modules performance under measured temperature and insolation regime
- correct module interconnection
- array junction box and combiner box performance
- array cabling losses up to the MPPT / PV INV input

IV curves can provide detailed information on:

- measurements of string open circuit voltage (V_{oc}) and short circuit current (I_{sc})
- measurements of max power voltage (V_{mpp}), current (I_{mpp}), and max power (P_{max})
- measurement of array performance
- Identification of module / array defects or shading issues

Ideally, IV curves shall be done on all arrays at each site.

If this is impractical, then IV curves can be done for at least 2 arrays, and the acceptable performance of those arrays confirmed. Thereafter the MPPT / PV INV performance on those arrays can be confirmed. Subsequent array performance can be benchmarked by comparing MPPT performance (identical input current, input voltage, and output power). However if there are significant discrepancies, then further IV curve measurements on those arrays shall be required to isolate the problems quickly and effectively.

4.3.1 IV Curve test procedure

The suppliers of the specific IV test equipment such as SEALINK™ or TriKA™ provide detailed test procedures to follow and may differ slightly from product to product. The procedures that follow are therefore for completeness only.

The procedure for undertaking the IV curve test shall be as follows:

- PV string and array performance measurements shall be performed at stable irradiance conditions of at least 400W/m^2 as measured in the plane of the array.
- The IV test instrument should be programmed with the characteristics, type and quantity of modules under test. And with details of the cabling lengths and type from the modules to the IV tester.
- Ensure PV system is shut down and that no current is flowing.
- The string(s)/array under test should be isolated and connected to the IV curve test device. The location of this connection could be at the combiner box for strings, or at MPPT or PV INV input for complete array.
- The irradiance meter paired with the IV curve tester should be mounted in the plane of the array and not subject to any localised shade or reflected light (albedo). Where a reference cell device is used, this shall be checked to ensure it is of the same cell technology as the array under test, or suitably corrected for the difference in technologies.

- Where the IV curve tester utilises a cell temperature probe, this shall be in firm contact with the rear of the module and in the centre of a cell towards the centre of a module. Where temperature corrections are calculated by the IV curve test device, a check shall be undertaken to ensure that the correct module characteristics are inputted into the device and that the string Voc value is within the range expected.

NOTE: A check of Voc is performed to ensure that the string has the correct number of modules – the wrong number would cause an error in determining temperature.

- Prior to commencing the test, the irradiance levels shall be checked to ensure they are greater than 400 W /m² in the plane of the array.

On completion of the test, the measured maximum power value should be compared to the rated (nameplate) value of the array under test (corrected for cable losses where relevant). The measured value should lie within the stated power tolerance for the modules under test (together with an allowance for the accuracy of the IV curve test equipment).

4.3.2 Interpretation of IV test curve shape

The IV curve shape is also useful for troubleshooting defects such as:

- Damaged cells/modules
- Shirt circuited bypass diodes
- Local shading
- Module mismatch
- Shunt resistance
- Excessive series resistance (cables losses)

On recording an IV curve, the shape shall be studied for any deviation from the predicted curve. Deviations to IV curves demand particular attention as they can signal otherwise undetected and significant faults within the PV array. Information on interpreting deviations to an IV curve is contained in Annex 2.

For systems with multiple identical strings and where there are stable irradiance conditions, curves from individual strings shall be compared (overlaid). Curves should be the same (typically within 5% for stable irradiance conditions).

5. SYSTEM PERFORMANCE TESTS

The System Performance Tests shall determine whether the system is able to perform to specification in terms of water delivery relative to available solar resources on site, and pumping head conditions on site. The tests are intended to be relatively simple checks of system performance, and use the techniques of power balance (instantaneous) and energy balance (over half a day of full day).

The longer duration *energy balance tests* over full day or half day are more generally credible and reliable as they account for variability during the day, including cloud cover and pump stop/starts.

The *power balance* is more difficult to conduct, requiring greater dexterity and requires greater experience with PV and pump as well as better equipment, but are much faster.

In the event of any uncertainty in results, or in even of a dispute, then a long term energy balance test will be required as the power balance test is simply less accurate.

5.1 Test Equipment Required for the Performance Tests

5.1.1 Energy balance tests

- Stop watch / watch with second hands
- Kipp & Zonen Class 3 Solarimeter or calibrated reference cell or equivalent, plus multi-meter capable of measurement, with integrator
- Water flow meter at borehole head: to the requirements of the Standard Specification will be sufficiently accurate to measure water quantity in the above time interval. Alternatively an ultrasonic water flow meter similar to *GREYLINE INSTRUMENTS(USA) Portable Doppler flow meter PDFM5.1™* (http://www.greyline.com/index.php/2015-05-10-23-47-35/agricultural/flow-ultrasonic-flow-meters-3/pdfm-5-1-portable-doppler-flow-meter-1-detail)
- Borehole depth: .a plump-line system with meter to sense the water level using conductivity. Lazer tape water depth measurement, similar to *SOLINST Water level indicator (Model 102)*™ (http://www.solinst.com/products/level-measurement-devices/102-water-level-indicator/datasheet/)
- *Manometer gauge:* Manometers fitted to the system should enable an estimate of static and dynamic head losses. It may be necessary to estimate borehole water levels using appropriate methods.
- Digital multi-meter: minimum range 0-1,000 VAC / VDC, accuracy minimum 1%, 0.1V resolution)
- Current clamp-meter: for current measurement of each array input to the power conditioner. Range to be range sufficient to meet current and voltage requirements. (Range 0-50A, 0-200A, accuracy 1%, resolution 0.1A).
- Functional and operational ***"Remote monitoring and data-logging system"*** as specified in ***Technical Specification section 18***. Ideally, the test measurements will also be calibrated against the reading from this system.

5.1.2 Power balance tests

- All of the previous equipment plus additional equipment
- Power meter (single of three phase), capable of measuring AC or DC power from the power conditioner (alternatively another clamp-meter and voltmeter set with suitable range for power conditioner outputs).
- Container and mass measurement scale (sufficient to contain and measure 10 minute flow output at maximum flow rate)

5.2 Test set-up

- Stop watch in hand
- Solarimeter, mounted in plane of array
- Manometer gauge at borehole head
- Borehole depth measurement at borehole head
- Water meter /flowmeter at borehole head

- DC current clamp-meter, on array output or power conditioner input
- DC voltmeter, on array output or power conditioner input
- AC/DC current clamp-meter, on power conditioner output or pump motor input
- AC/DC voltmeter, on power conditioner output or pump motor input

5.3 Conditions Required

A worksheet is provided for the each Short Test for the Pumping System Performance Tests *(see **Annexure B.2.1.**)*

5.3.1 Energy balance tests / full day test

- The performance variables shall be recorded preferably over a whole day, from sunrise to sunset. Alternatively for at least half a day starting at sunrise, till midday; or from midday sunset.
- The solar predictions for the day should be typical for the month. i.e. totally clear skies for the whole day, or totally overcast days, that might be atypical should be avoided if possible.
- Radiation levels and weather conditions should be stable for at least each measurement period if any instantaneous readings are to be taken. If conditions are very variable then only the integrated values can be used.
- Reservoir level switches are over-ridden or disconnected.

5.3.2 Power balance tests / Short test

- The performance variables shall be recorded carried out for at least 3 different radiation levels over the course of the day.
- Instantaneous radiation levels should be close to: 200, 500, and greater than 800 W/m$^{2.}$ The greater the difference in radiation levels the better, ranging from close to sunrise or sunset, to midday.
- Radiation levels and weather conditions should be stable for at least each measurement period.
- Reservoir level switches are over-ridden or disconnected.

5.4 Record (over each measurement period)

Record the following on the record sheet in ***Annexure B.2.1***.

- Event (*line 1a*) (i.e. pump starts turning, water starts being delivered etc.)

Record these for energy balance inputs, at regular time intervals (30 minutes)

- Time (*line 1b*)
- Cumulative flow water meter reading (*line 1n*) (litres)
- Insolation (*line 1d*): the cumulative irradiance over the test period (Wh/m2)
- Manometer pressure (*line 1e*) (kPa)
- Borehole water level below manometer (*line 1f*) (m)

For power balance, quickly record the following within a 30 second interval, to make them as simultaneous as possible!! Take several reading sets at each irradiation level as close to 200, 400 and 800 W/m^2 as possible.

- Time (*line 1b*)
- Irradiation (*line 1c*) : Instantaneous radiation levels (W/m^2)
- Array current (*line 1h*) (A dc)
- Array voltage (*line 1i*) (V dc)

- Power conditioner output current (*line 1j*) (A ac/dc)
- Power conditioner output voltage (*line 1k*) (V ac/dc)
- Water flowrate (*line 1l*) (litres/minute)

5.5 Performance Check based on Instantaneous Measurements

5.5.1 Calculations based on Instantaneous measurements

This is to identify unusually low efficiencies and possibility of mismatched components. These can be calculated while doing the longer term tests. Calculate the following on the sheet:

- Total head (m) = dynamic head above borehole head + borehole water level

  1g = 1e/9.8 + 1f
- hourly flowrate (litres/hr) = litres / minute x 60

  1m = 1l x 60
- Expected STC array power (W) = qty modules x module (Wp) x irradiation (W/m^2)

  2d = 2b x 2c x 1c/1000
- Measured array power (W) = measured array current (A) x voltage (V)

  2f = 1h x 1i
- Array tracking efficiency (%) = measured array power / expected STC array power

  2e = 2f / 2d
- Measured power to pump (W)= measured current to pump (A) x measured voltage to pump (V)

  2h = 1j x 1k
- Controller throughput efficiency (%) = power out/power in = measured power to pump / measured array power

  2g = 2h / 2f
- Hydraulic power (W) = hourly flowrate (m^3/hr) x total dynamic head (m) x 9.8/3.6

  2k = 1m /1000 x 1f x 9.8/3.6
- Pump efficiency (%) = hydraulic power (W) / measured electrical power to pump (W)

  2j = 2k / 2h
- Instantaneous sub-system efficiency (%)= hydraulic power (W) / measured array power (W)

  2l = 2k / 2f

5.5.2 Check of instantaneous efficiency performance figures

Array tracking efficiency

Should be close to 77%. If it is too low, then either:

- the pumping head very much lower than design, and array tracking is possibly reduced,
- or panel output is much lower than expected. If there is still a query then check whether the instantaneous DC array power matches the array power output curves provided by the supplier? (Should be within 10%. If not, find the array problem: check each sub-array for output.)

Converter efficiency

Should be close to 95% plus. If it is lower, it suggests a problem.

Combined motor/pump efficiency

Depends on the pump configuration, but the following are guidelines. Figures provided which are much higher than these below should be cause for further enquiry, and validation.

System type	Expected pump/motor efficiency.
AC centrifugal pump	35%-83% depending on pump size

AC/DC/permanent magnet centrifugal pump	55%-85%
DC positive displacement pump	70%

Subsystem efficiency

Depends on the system and pump configuration:

System type	**Expected system wire-to-water efficiency.**
AC centrifugal pump	30%-65%
AC/DC/permanent magnet centrifugal pump	55%-70%
DC positive displacement pump	60%

Check that the instantaneous sub-system efficiency is approximately equal to:

$$\eta(\text{Instantaneous sub-system}) = \eta(\text{Power conditioner}) \times \eta(\text{motor}) \times \eta(\text{pump}) \times \eta(\text{losses})$$

5.5.3 Check of water output estimates

Instantaneous water delivery

- Determine whether the calculated water flowrate output matches the actual water output at this irradiation level,

  If the water flow-rate is within 10% of the specified supply rate, then accept. If not, then reject.

  Look for faults, voltage drops, and note that an explanation is required.
- From the instantaneous water output curves (wire to water), check the expected water delivery at the measured DC array power determined above. If within 10%, then the power-conditioner subsystem appears to be performing fine, if not then correct the power-conditioner/pump problem.

The instantaneous water output (m^3/hour) shall be estimated by calculating:

$$= [\text{Irradiation}(kW/m^2) \times \text{Array power}(Wp) \times \eta(\text{array tracking}) \times \eta(\text{Instantaneous sub-system})] / [\text{pumping head (m)} \times 9.8/3.6]$$

5.5.4 Comparison of instantaneous measurement with supplier data supplied

Calculate flowrate from manufacturer's performance curves in each interval :
From the instantaneous water output curves (*Instantaneous Array and Sub-system Performance Data* supplied at tender time and which form the basis of technical compliance).

Calculate

- Hourly flowrate (litres/hr)

  3f = 3e x 60
- Hydraulic power (W) = hourly flowrate (m^3/hr) x total dynamic head (m) x 9.8/3.6

  3h = 3f /1,000 x 1c x 9.8 / 3.6
- Sub-system efficiency (%) = hydraulic power(W) / measured array power(W)

  3i = 3h / 3b

5.6 Performance Check based on Energy Balance Measurements

These calculations are based on either on full day test, or half day test which includes either sunrise or sunset.

5.6.1 Calculate Expected Water Delivery at test conditions

This is based on test condition measurements and declared sub-system efficiency.

η(declared daily sub-system), declared for each month by the bidder is read from ***Chapter 4: Schedules of Technical Information: Form 3.2(G),*** corresponding to the same month as the test conditions.

Array power STC (Wp) is the installed capacity Wp.

η(declared tracking), declared for each month by the bidder is read from ***Schedules of Technical Information: Form 3.2(F),*** corresponding to the same month as the test conditions.

Expected Test Daily Water Output deliverable ($m^{3/}$day) shall be estimated by calculating:

= [Insolation(kWh/m^2/day) x Array STC (Wp) x η(Declared tracking) x η(Declared daily sub-system)] / [pumping head (m) * 9.8/3.6]

Q: Is measured water output less than expected water output?

5.6.2 Calculate Subsystem Efficiencies at test conditions

Measured subsystem efficiency based on test conditions, and compare with declared figures.

Insolation(kWh/m^2) – is the measured solar insolation in the test

Measured water output (m^3) – is the measured water delivered in the test

η(measured tracking) x η(measured daily sub-system)

= [Measured water output (m^3) x pumping head (m) x 9.8/3.6] / [Insolation(kWh/m^2) x Array power STC (Wp)]

Q: Is this substantially less than the declared figures in ***Schedules of Technical Information: Form 3.2(F and G):***

η(Declared tracking) x η(Declared daily sub-system)

5.6.3 Calculate Commissioning Water Delivery based on test results

Commissioning Water Delivery based on design conditions based on test conditions performance

Commissioning Daily Water Output deliverable (m^3/day) shall be estimated by calculating:

= [Design kWh/m^2/day) x Array STC (Wp) x η(measured tracking) x η(measured daily sub-system)] / [Design pumping head (m) x 9.8/3.6]

Q: Is this substantially less than design month declared output (***Schedules of Technical Information: Form 3.2(M)?***

5.7 Calibration of the Remote Monitoring System

The readings taken over the course of the day during the Energy Balance Test (section 3.4) should be taken in parallel and onto a separate sheet, directly from the Monitoring System. This will enable comparison of results and inspire confidence in the Remote Monitoring System.

It shall also make clear which critical variables are not accurately recorded by the Monitoring System, or which critical variables might be missing.

5.8 Long Term Monitoring

The absolute test for acceptance is long term monitoring of the system. It is critical that some form of long term monitoring is done, and that the range of operational conditions is also tracked and design assumptions validated (water demand, pumping head, solar radiation).

As demonstrated in the performance tests, it is possible to assess system performance under non-design conditions to ensure that value for money is provided.

5.8.1 Remote Monitoring

Ideally, long term monitoring can be done via remotely, using a calibrated Remote Monitoring System which tracks ALL the requisite variables for performing doing an energy balance (including pumping head, solar radiation, water delivered). Daily energy balances can be done to assess performance compared with design.

This can be used for dispute resolution if required.

5.8.2 Operator record keeping

If a Remote Monitoring System is not installed, then the long term evaluation will require operator intervention. This is likely to be a severely limiting as the only variable recorded would likely be water output, and therefore no system performance tests can be benchmarked.

Long term: Ensure that the operator records daily water output and reservoir level for on a daily basis. T

END

ANNEXURE B.2.1: OUTLINE FOR TEST DATA (BLANK)

B.2.1.1. Electronic performance data collected

1a	1b		1c	1d	1e	1f	1g	1h	1i	1j	1k	1l	1m	1n	1p
Event data			Solar data measured in the Plane of array		Pumping head data			Electrical data				Water flow data From water meter			
Event	Time				Pressure at borehole head gauge (kPa)	Borehole water level (m)	Total Pumping head (m)	Array		Pump 1		Flow rate		Meter reading (litres)	Total water delivery (litres)
			Radiation (W/m^2)	Insolation (Wh/m^2)				Current (AC/DC) (A)	Voltage (AC/DC) (V)	Current (AC/DC) (A)	Voltage (AC/DC) (V)	(l/min)	(l/hr)		

Formulae
1g = 1e / 9.8 + 1f
1m = 1l x 60

B.2.1.2. Analysis (identification of problem components, or problems with the test)

2a	2d	2e	2f	2g	2h	2i	2j	2k	2l	2m
Time	Expected Array Power @ MPP Wp (= 2b) Qty (= 2c)	Tracking efficiency Operating point derated wrt MPP (>80% acceptable)	Measured Array Power (W)	Controller thoughput eff Energy % (>90% acceptable	Measured Pump Power (W)	Measured Water flow (l/hr)	Pump Efficiency Elec to water Energy % (>25% expected)	Hydraulic power (W)	System Efficiency Elec to water eff Power % (+- 50% expected)	Comparison of instantaneous measurement of eletrical to water efficiency, with manufacturer's spec.

Formulae
2d = 1c x 2b x 2c
2f = 1h x 1i
2e = 2f / 2d
2h = 1j x 1k
2g = 2h / 2f
2i = 1m
2k = 2i /1000 x 1g x 9.8/3.6
2j = 2k / 2h
2l = 2k / 2f

B.2.1.3. Analysis of instantaneous water output (from Manufacturer spec sheets)

3a	3b	3c	3d	3e	3f	3g	3h	3l
Time	Measured Array power (W) 0.85	Pumping Head (m)	Measured Pump Power (W) 0.9	Spec water flow rate from manufacturers curves		Total water delivered (litres)	Hydraulic Power calculated (W)	Elec to water eff expected from manufacturers curv
				(l/min)	(l/hr)			

Formulae
3b = 2f
3c = 1g
3d = 2h
3e = from curves
3f = 3e x 60
3h = 3f/1000 x 3c x 9.8 /3.6
3l = 3h / 3b

B.2.1.4. Estimate of Daily Water Delivery

Variable	Unit	Declared			Test Conditions			Normalised to design conditions		
			Formula	Value		Formula	Value		Formula	Value
Nominal installed array power (STC) (Wp)	Wp	4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***	
Insolation	**kWh/m²**	4b	***Form 3.2 (D)***		4c	Measured 1d		4b	***Form 3.2 (D)***	
Pumping head at which estimates where made	Metres	4d	***Form 3.2 (B)***		4e	Average of 1g		4d	***Form 3.2 (B)***	
Average array tracking efficiency: η(tracking)	%	**4f**	***Form 3.2 (F)*** η(declared tracking)		4g	η(measured tracking) x η(measured daily sub-system) = 4g x 4i = [4e x 4k x 9.8 /3.6] / [4a x 4c]		4g	= η(measured tracking) x η(measured daily sub-system) = 4g x 4i	
Average daily subsystem efficiency: η(daily sub-system)	%	**4h**	***Form 3.2(G)*** η(declared daily sub-system)		4i			4i		
Measured Water output	m^3		NA		4k	Measured 1p		4l	***Commissioning Water Output*** = [4a x 4b x 4g x 4i] / [4d x 9.8/3.6]	
Expected Water output	m^3	**4j**	***Form 3.2 (H)***		4m	***Expected Test Water Output*** = [4a x 4c x 4f x 4h] / [4e x 9.8/3.6]		4j	***Form 3.2 (H)***	
Measured Water Output exceeds Expected Water Output?	logical		NA		**YES / No**			**YES / No**		

Notes*: taken from ***Chapter 4: Schedules of Technical Information: Form 3.2 Declaration of system performance***

ANNEXURE B.2.2: OUTLINE FOR TEST DATA (DEMO SHEET)

Kuile mono
30 October 1999
Array Tilt: 1:30 deg
Orientation: True North

Mono solar S4M with 30xm55

B.2.2.1. Electronic performance data collected

1a	1b		1c		1d	1e	1f	1g	1h	1i	1j	1k	1l	1m	1n	
Event data			Solar data measured in the Plane of array		Pumping head data			Electrical data				Water flow data From water meter				
								Array		Pump 1						
Event	Time		Radiation (W/m²)	Insolation (Wh/m²)	Pressure at borehole head gauge (kPa)	Borehole water level (m)	Total Pumping head (m)	Current (AC/DC) (A)	Voltage (AC/DC) (V)	Current (AC/DC) (A)	Voltage (AC/DC) (V)	Flow rate (l/min)	(l/hr)	Meter reading (litres)	Total water delivery (litres)	
Test start	06:15AM	6.25	21	0												
	06:35AM	6.58	40	10	1200	5	125	0.24	88	2.50	4	0	0		0	
Turn fast	07:05AM	7.08	152	58	1200	5	125	1.07	87	4.60	18	0	0		0	
± 80rpm	07:20AM	7.33	190	101	1200	5	125	1.55	88	4.80	28	0	0		0	
	07:35AM	7.58	163	145	1200	5	125	2.22	88	5.00	37	0	0		0	
water begins	07:50AM	7.83	262	198	1200	5	125	3.00	87	5.15	50	4	240		30	
	08:15AM	8.25	451	347	1200	5	125	4.23	87	5.33	67	8	480		280	
	08:35AM	8.58	530	510	1200	5	125	4.89	92	5.40	80	12.5	750		485	
	09:00AM	9.00	631	752	1200	5	125	6.00	111	5.89	111	20	1200		891	
	09:10AM	9.17	662	860	1200	5	125	6.12	145	6.00	145	21	1260		1096	
	09:15AM	9.25	700	917	1200	5	125	6.12	162	6.00	162	22	1320		1204	
	09:45AM	9.75	789	1289	1200	5	125	6.57	168	6.00	168	20	1200		1834	running dry
	09:50AM	9.83	796	1355	1200	5	125	6.70	168	5.70	168	18	1080		1929	running dry

Formulae
1g = 1e / 9.8 + 1f
1m = 1l x 60

B.2.2.2. Analysis (identification of problem components, or problems with the test)

2a	2d	2e	2f	2g	2h	2i	2j	2k	2l	2m
Time	Expected Array Power @ MPP 55 Wp (= 2b 30 Qty (= 2c	Tracking efficiency Operating point derated wrt MPP (>80% acceptable)	Measured Array Power (W)	Controller thoughput eff Energy % (>90% acceptable)	Measured Pump Power (W)	Measured Water flow (l/hr)	Pump Efficiency Elec to water Energy % (>25% expected)	Hydraulic power (W)	System Efficiency Elec to water eff Power % (+- 50% expected)	Comparison of instantaneous measurement of eletrical to water efficiency, with manufacturer's spec.
06:15AM	35	80.0%	0	ERR	0	0.0	ERR	0.00	ERR	**ERR**
06:35AM	66	32.0%	21	47.3%	10	0.0	0.0%	0.00	0.0%	**ERR**
07:05AM	251	37.1%	93	88.9%	83	0.0	0.0%	0.00	0.0%	**ERR**
07:20AM	314	43.5%	136	98.5%	134	0.0	0.0%	0.00	0.0%	**ERR**
07:35AM	269	72.6%	195	94.7%	185	0.0	0.0%	0.00	0.0%	**ERR**
07:50AM	432	60.4%	261	98.7%	258	240.0	31.7%	81.67	31.3%	**ERR**
08:15AM	744	49.5%	368	97.0%	357	480.0	45.7%	163.33	44.4%	**ERR**
08:35AM	875	51.4%	450	96.0%	432	750.0	59.1%	255.21	56.7%	**ERR**
09:00AM	1041	64.0%	666	98.2%	654	1200.0	62.5%	408.33	61.3%	**ERR**
09:10AM	1092	81.2%	887	98.0%	870	1260.0	49.5%	428.75	48.3%	More than 25% higher than Manuf.Spec
09:15AM	1155	85.8%	991	98.0%	972	1320.0	46.2%	449.17	45.3%	More than 25% higher than Manuf.Spec
09:45AM	1302	84.8%	1104	91.3%	1008	1200.0	40.5%	408.33	37.0%	Within 25% of Manuf.Spec
09:50AM	1313	85.7%	1126	85.1%	958	1080.0	38.4%	367.50	32.6%	More than 25% higher than Manuf.Spec

Formulae
2d = 1c x 2b x 2c
2f = 1h x 1i
2e = 2f / 2d
2h = 1j x 1k
2g = 2h / 2f
2i = 1m
2k = 2i /1000 x 1g x9.8/3.6
2j = 2k / 2h
2l = 2k / 2f

B.2.2.3. Analysis of instantaneous water output (from Manufacturer spec)

3a	3b	3c	3d	3e	3f	3g	3h	3I
Time	Measured Array power (W) 0.85	Pumping Head (m)	Measured Pump Power (W) 0.9	Spec water flow rate from manufacturers curves (l/min)	(l/hr)	Total water delivered (litres)	Hydraulic Power calculated (W)	Elec to water eff expected from manufacturers curv
06:15AM	0	0	0	0	0	0	0.00	ERR
06:35AM	21	125	10	0	0	0	0.00	0.0%
07:05AM	93	125	83	0	0	0	0.00	0.0%
07:20AM	136	125	134	0	0	0	0.00	0.0%
07:35AM	195	125	185	0	0	0	0.00	0.0%
07:50AM	261	125	258	0	0	0	0.00	0.0%
08:15AM	368	125	357	0	0	0	0.00	0.0%
08:35AM	450	125	432	0	0	0	0.00	0.0%
09:00AM	666	125	654	0	0	0	0.00	0.0%
09:10AM	887	125	870	5.00	300	25	102.08	11.5%
09:15AM	991	125	972	13.33	800	71	272.22	27.5%
09:45AM	1104	125	1008	18.33	1100	546	374.31	33.9%
09:50AM	1125	125	958	12.50	750	623	255.21	22.7%

Formulae
3b = 2f
3c = 1g
3d = 2h
3e = from curves
3f = 3e x 60
3h = 3f/1000 x 3c x 9.8 /3.6
3I = 3h / 3b

B.2.2.4. Estimate of Daily Water Delivery

Variable	Unit	Declared			Test Conditions			Normalised to design conditions		
			Formula	Value		Formula	Value		Formula	Value
Nominal installed array power (STC) (Wp)	Wp	4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***		4a	***Form 3.2 (E)***	
Insolation	**kWh/m²**	4b	***Form 3.2 (D)***		4c	Measured 1d		4b	***Form 3.2 (D)***	
Pumping head at which estimates where made	Metres	4d	***Form 3.2 (B)***		4e	Average of 1g		4d	***Form 3.2 (B)***	
Average array tracking efficiency: η(tracking)	%	**4f**	***Form 3.2 (F)*** η(declared tracking)		4g	η(measured tracking) x η(measured daily sub-system) = 4g x 4i = [4e x 4k x 9.8 /3.6] / [4a x 4c]		4g	= η(measured tracking) x η(measured daily sub-system) = 4g x 4i	
Average daily subsystem efficiency: η(daily sub-system)	%	**4h**	***Form 3.2(G)*** η(declared daily sub-system)		4i			4i		
Measured Water output	m³		NA		4k	Measured 1p		4l	***Commissioning Water Output*** = [4a x 4b x 4g x 4i] / [4d x 9.8/3.6]	
Expected Water output	m³	**4j**	***Form 3.2 (H)***		4m	***Expected Test Water Output*** = [4a x 4c x 4f x 4h] / [4e x 9.8/3.6]		4j	***Form 3.2 (H)***	
Measured Water Output exceeds Expected Water Output?	logical		NA		**YES / No**			**YES / No**		

Annex C (Informative) - Interpreting IV curve shapes (IEC 62246)

1 General

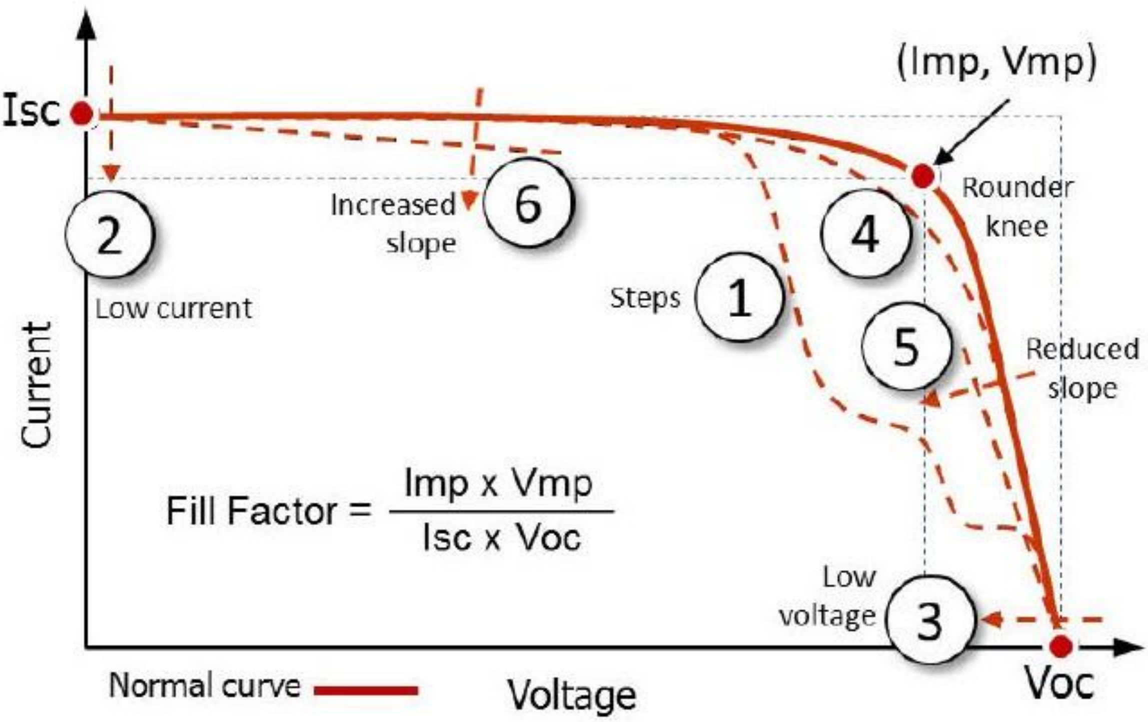
A normal I-V curve has a smooth shape with three distinct parts:

- A "horizontal leg" (slightly sloping down)
- A "downward leg" (approaching vertical)
- A bend or "knee" in the curve between these two regions

In a normal curve, these three parts are smooth and continuous. The slopes and the shape of the knee depend on cell technology and manufacture. Crystalline silicon cells have sharper knees; thin film modules usually have rounder gradual knees.

A number of factors can influence the shape of an IV curve. The following diagram illustrates the main types of deviation that may be present. These shape variations may be present individually or in combination.

Figure 2: IV curve shapes



Small deviations between the measured and predicted I-V curves are to be expected, given the normal uncertainties associated with the measurement of irradiance, temperature and voltage. Small variations between PV modules, even of a given manufacturer and model, will also have an effect. Shading and soiling, will also impact the shape of the curve.

When deviations are seen, a check should first be made to ensure that difference in shape between the measured curve and that predicted is not due to measurement errors, instrument set-up problems or due to an incorrectly entered module / string data.

2 Variation 1 - Steps or notches in curve

Steps or notches in the IV curve are indications of mismatch between different areas of the array or module under test. The deviation in the curve indicates that bypass diodes are activating and some current is being bypassed around the internal cell string protected by the diode (string unable to pass the same current of other strings). This can be due to a number of factors including:

- Array or module is partially shaded
- Array or module is partially soiled or otherwise obscured (snow etc)
- Damaged PV cell / module
- Shorted circuited bypass diode

NOTE: Partial shading of even just one cell in a module can cause the associated bypass diode to turn on and cause a notch in the curve.

3 Variation 2 – Low current

A number of factors can be responsible for a variation between the expected current and the measured current. These are summarised below

Array causes

- Uniform soiling
- Strip shade (modules in portrait orientation)
- Dirt dam (modules in portrait orientation)
- PV modules are degraded

NOTE: Strip shade and dirt dam effects have an effect similar to uniform soiling, because they reduce the current of all cell groups by approximately the same amount.

Modelling causes

- PV module data incorrectly entered
- Number of parallel strings incorrectly entered

Measurement causes

- Irradiance sensor calibration or measurement problem
- Irradiance sensor not mounted in the plane of the array
- Irradiance changed between irradiance and I-V curve measurements
- Albedo effects cause irradiance sensor to record overly high irradiance
- Irradiance is too low or sun is too close to the horizon

NOTE: While the variation shown on the diagram above is a current lower than expected, it is also possible to find that measured value is above that predicted by the model IV curve.

4 Variation 3 – Low voltage

Potential causes for a variation in voltage include:

Array causes

- Conducting or shorted bypass diodes
- Wrong number of modules in PV string
- Potential Induced Degradation (PID)
- Significant and uniform shading to whole cell / module / string

Modelling causes

- PV module data incorrectly entered
- Number of modules in string incorrectly entered

Measurement causes

- PV cell temperature different to measured value

As cell temperature affects the voltage from the PV module, a disparity between the actual cell temperature and that measured (or assumed) by the IV curve tracer will cause this shape defect. In such cases a check of the cell temperature measurement method should be instigated before proceeding (eg checking a temperature sensor is still attached to the module).

A group of strings measured in close succession will often exhibit slightly different amounts of deviation compared with the predictions of the PV model. This is to be expected given that the temperature is usually sensed at a single module and the temperature profile of the array is non-uniform and varying with time. However, if a single string shows substantially more deviation than the others, this is an issue, particularly if the deviation corresponds to module Voc/N where the modules have N bypass diodes

NOTE: While the variation shown on the diagram above is a voltage lower than expected, it is also possible to find that measured value is above that predicted by the model IV curve.

5 Variation 4 – Rounder knee

Rounding of the knee of the IV curve can be a manifestation of the aging process. Before concluding that this is the case, check the slopes of the horizontal and vertical legs of the IV curve. If they have changed, it can produce a visually similar effect in the shape of the knee.

6 Variation 5 – Shallower slope in vertical leg

The slope of the latter portion of the IV curve between the maximum power point (Vmpp) and Voc is influenced by the series resistance to the circuit under test. An increased resistance will reduce the steepness of the slope in this portion of the curve.

Potential causes of increased series resistance include:

- PV wiring damage or faults (or cables insufficiently sized)
- Faults at module or array interconnects (poor connections)
- Increased module series resistance

When testing arrays with long cable runs, the resistance of these cables will influence the curve shape and can have an impact on the curve as described here. If this is suspected, either the model can be adjusted to allow for these cables; or the test can be repeated closer the array (bypassing the long cables)

Where this error is noticed on a curve, special attention should be taken of the quality of the wiring and interconnections within the solar circuit. This error can indicate a significant wiring fault or subsequent damage or corrosion affecting the array circuit.

Increased module series resistance can be due to high resistance faults within cell interconnects or within the module junction box – due to degradation, corrosion or manufacturing error.

An IR scan, as described in the Category 2 test sequence, can be a useful tool to identify high resistance faults.

7 Variation 6 - Steeper slope in horizontal leg

A variation in slope in the upper portion of the IV curve is likely due to:

- Shunt paths in PV cells
- Module Isc mismatch
- Tapered shade or soiling (eg dirt dams)

Shunt current is any current that bypasses the solar cell – usually due to localised defects in either cell or cell interconnects. Shunt currents can lead to localised hot spots which may also be identified through IR testing.

Differences in Isc between modules in a string can be due to manufacturing discrepancies. If the mismatch is small and randomly distributed across the string, steps or notches may not be present.

While more significant shading will cause steps or notches in the IV curve, minor shade on some modules in a string or some tapered shade patterns can cause this effect.

END