

## **Annex 21: OPERATIONS AND MAINTENANCE PLAN**

**Project information:** Enhancing community resilience and water security in the Upper Athi River Catchment Area, Kenya

**Approval Date of the Operations and Maintenance Plan:**

**Date of General Operations and Maintenance Notice:**

**Period covered by this Operations and Maintenance plan:** 2020-2050

## **1.0 Introduction**

This Operations and Maintenance Plan describes the operations, inspection and maintenance activities that will be undertaken to ensure effective functioning and sustainability of the assets, infrastructure, tools, instruments and equipment under the project. An Operations and Maintenance (O&M) Plan is the most important reference for management of the proposed water assets i.e. hydro and telemetric stations, water pans, boreholes and springs. The Plan will describe the components and will outline the operation, inspection and maintenance activities necessary to maintain the dependability of the water system. This manual is intended to cover normal operating conditions.

The objective of operation and maintenance of water supply systems to provide sustainable, equitable, consistent, safe and adequate water. Operation of system means ensuring effective routine running of system in a timely manner. Maintenance means up keep of structures/system including planned, preventive or corrective maintenance and repairs.

### **1.1 Operations and Maintenance (O&M) responsibility**

The hydrological and meteorological monitoring systems established shall be handed over to the Executing Entities i.e. KMD and WRA that will have annual budgetary allocations for the broader Operation and Maintenance strategy for assets during project life span.

The adaptation assets investments which include water pans, springs, and boreholes, shall be handed over to the County Governments at project close up. The County Governments are the main project beneficiaries and will perform operation and maintenance of the rehabilitated adaptation assets for project life span. The County Governments are responsible for water supply at county level as per the Water Act 2016 and they have annual financial allocations for water works development and maintenance. As part of local level governance, community committees shall be set up for all the water assets and shall be trained on overall management of the structures to ensure sustainability of access and use. To ensure sustainability, the communities shall have a minimum fee for use and the kitty shall be used to carry basic Operation and Maintenance activities to supplement the County Governments role in the maintenance works of the adaptation investments.

WRA has an average annual budget for ground water and surface water O&M as 300,000 USD and 500,000 USD respectively. Additionally, the beneficiary County Governments have confirmed and committed to conduct O&M of the project adaptation investments through the project life span and beyond as they have an annual allocation for the O&M of water works. The average annual allocation for O&M in the counties is 830,000 USD, 480,000 USD and 400,000 USD for Machakos, Kiambu and Nyandarua county respectively.

NEMA, in its capacity as the AE will endeavor to mobilize resources for sustainable O&M of the adaptation investments by closely liaising with the Executing Entities and the beneficiary counties to ensure adequate allocation of O&M resources throughout the project life span and beyond.

### **1.2 Plan Organization**

The Operations and Maintenance (O&M) plan is intended to be used by O&M personnel as a guide for operating, inspecting, maintaining infrastructure, tools, instruments and equipment

in the project area. As such, it is presented in sections specific to each system component and/or necessary activity. The Plan is organized according to the water assets; each sections details the water asset description, the operations of the general system components of the water asset, instruments and instruction for monitoring the water asset, inspection recommendation and maintenance activities and procedures for each system

## 1. Water pans

### a) Introduction

Standard facilities for an embankment earth water pan include:

- a) embankment
- b) spillway
- c) inflow channel
- d) water level instrumentation
- e) draw-off works
- f) compensation flow pipe

Standard facilities for a water pan include:

- a) inflow channel
- b) spillway and outflow channel
- c) draw-off works

### ▪ Summary Form of pertinent Data of a water pan

ITEM	DESCRIPTION
<b>General</b>	
Water pan/ Water Pan Name	
Water pan Owner	
Water pan Users	
Year of Construction	
GPS Coordinates (Latitude, Longitude)	
Location (County, Subcounty, Ward)	
Water pan Class (A, B, C)	
<b>Inflow</b>	
Type/ Size/ Configuration	
Outlet	
<b>Embankment</b>	
Water pan Type	
Water pan height	
Water pan Length	
Minimum Net Freeboard	
Normal Water Level	
Design Flood Water Level	
Crest Width	
Upstream Slope and Slope protection	
Downstream Slope and Slope protection	
Toe Drain	
<b>Spillway</b>	
Location & Type of spillway	
Geometry of spillway sill (width and height)	
Inflow channel geometry (slope, length, width and height)	
Outflow channel geometry (slope, length, width and height)	
NWL, FWL, Minimum Freeboard, Gross Freeboard	
<b>Reservoir</b>	
Normal Storage	

Maximum Storage	
Surface Area	
HVA Curve	
<b>Draw-off Works</b>	
Type/ Size/ Configuration	
Control location	
Conduit type, size and invert	
Intake control	
<b>Scour/ Compensation flow</b>	
Type/ Size/ Configuration	
Control location	
Conduit type, size and invert	

## b) Operations

During the operations of a water pan, a Community Management Committee shall be constituted which shall oversee the day-to-day operations of the facility as well as carry out minor maintenance works. Water pan committee members shall receive basic training in operation and maintenance aspects of the water pan/ water pan.

### ▪ Water Levels

Operational tasks related to the staff gauges include making regular observations of the water level and keeping proper records.

### ▪ Draw-off works

The draw-off system consists of:

- a) intake structure
- b) draw-off pipe
- c) outlet works

Draw-off system delivers water from the reservoir to watering points below the water pan to avoid the risk of pollution of the reservoir from human or livestock contamination. Fittings are placed on the draw-off pipe for purposes of controlling and directing the flow of water to consumer points. The arrangement of pipes and valves also allows for the flushing/ removal of any sediments.

## c) Instrumentation and Monitoring

### ▪ Instrumentation

Instrumentation installed at each of the water pan locations is primarily 2No Manual Water Level Stations mainly at the inlet to the reservoir and along the spillway which also acts as the main water pan outlet.

### ▪ Water Level Station

Water level gauges are useful for estimating the volume of water entering, stored and exiting the reservoir. They are constructed from ceramic plated gauges each 1.0m - 1.5m in height.

Careful attention should be given to the datum level for the staff gages to get the maximum benefit out of the staff gauges. The zero level can be set either at the lowest point of the inlet channel, reservoir and outlet channels.

It is advisable for the owners and/ or users of water pans and pans to maintain proper records of regular readings of the water levels.

#### **d) Inspection**

Regular inspection of the structure is required to ensure problems are identified early and remedial action taken. The WRM Rules 2007 (4<sup>th</sup> Schedule) imposes the frequency and expertise required for inspection of water pans according to the class of water pan. For Class A (Low Risk) water pans, they should be inspected once in every 5 years. Emergency inspections may also be scheduled in events where the water pan has experienced any unusual events.

Unusual events during which special inspections may be conducted include:

- a) High water conditions
- b) Post flood
- c) Post-earthquake

#### **▪ Water pan Inspection Form**

<b>Water pan Name:</b>		<b>Date of Inspection:</b>	
<b>Monitored By:</b>		<b>Water Level:</b>	
<b>ITEM</b>	<b>CONDITION</b>	<b>ACTION REQUIRED</b>	<b>BY WHOM</b>
<b>a) CATCHMENT AREA</b> (existing land use/ land cover status)			
Erosion			
<b>b) EMBANKMENT</b>			
Crest			
Downstream Slope			
Upstream Slope			
Lining Material			
<b>c) SPILLWAY</b>			
Sill Area			
Culverts Under Roads			
Channel			
River Confluence			
<b>d) DRAW-OFF WORKS</b>			
Status of pump/ water meter/ piping and valves/ Cattle troughs or ramps			
<b>e) WATER QUALITY</b>			
Colour/ Turbidity			
Smell			
Bio-chemical Analysis Results			
<b>f) ENVIRONMENT</b>			
Details of any animals			

Details of any plants			
Accessibility to water pan			
<b>SIGNED BY:</b>			

▪ **Major items to look out for during inspection include:**

<b>WATER PAN ELEMENT</b>	<b>INSPECTION NOTES</b>
Access	1) Condition of gates and locks 2) Condition of signage 3) Evidence of vandalism 4) Condition of crest toad
Inflow Channel	1) Obstructions or blockage impeding flow 2) Erosion or sedimentation in inlet channel 3) Flow rate in channel
Embankment	1) Settlement, depressions, cracking, sloughing, erosion, crest and downstream toe seepage 2) Piping, low spots on the crest, boils 3) Unauthorized activity (e.g. farming) on or adjacent to the embankment 4) Excessive vegetation 5) Rodent activity
Spillway	1) Erosion or lining water panage 2) Sloughing or cracking on side slopes 3) Displacement of riprap 4) Erosion or scour of upstream or downstream ends 5) Rodent activity 6) Excessive vegetation growth
Reservoir Area	1) Evidence of siltation (e.g. growth of reeds) 2) Land use/ cover changes to the upstream catchment area
Staff gauges	1) Water panage or deterioration

d) Maintenance

<b>Component</b>	<b>Maintenance Activity</b>	<b>Responsibility</b>	
		<b>Person 1</b>	<b>Person 2</b>
Inlet Channel	Removal of sediment that has accumulated to maintain capacity of the channel	County Govt	
	Vegetation shall be maintained and trees and brush controlled	County Govt	
Outlet/ Draw-off works	Exercise gate valve regularly	Water pan Committee	
	Repair deteriorated concrete as soon as possible	Water pan Committee	
Embankment	Fill rills and gullies that occur on the embankment slopes and in the vegetated spillway and reseed the filled areas	Water pan Committee	
	When animal burrows are found, remove the burrowing animals, replace the embankment materials and reseed	Water pan Committee	
	Prevent trees and brush from growing on embankment slopes, crest, or toes. Control tree and bush growth by hand cutting, mowing, or chemicals. Avoid water damaging grass with herbicides sprays.	Water pan Committee	
	Maintain a fence to keep livestock off the embankment where applicable	Water pan Committee	
Spillway	Fill rills and gullies that occur in the vegetated spillway and reseed the filled areas	Water pan Committee	
	Maintain a vigorous sod in the spillway by regular mowing and fertilization. Remove excess growth. Do not burn or overgraze. Protect spillway from water damage by farm equipment and vehicles. Do not use spillway as a road and practice	County Govt	

	care when crossing to prevent tillage marks or wheel tracks		
	Prevent trees and brush from growing in the spillway. Control tree and bush growth by hand cutting, mowing, or chemicals. Avoid water damaging grass with herbicide sprays	Water pan Committee	
	Reestablish vegetative cover immediately where scour erosion has removed established seeding	Water pan Committee	
	Where there is rock lining, replace any dislodged rock and fill back to grade if displacement or settlement occurs	County Govt	
Staff gauges	Promptly repair or replace damaged components	WRA	
	Ensure staff gauges are level	WRA	

Summary Water Pans O&M chart

S/No.	Infrastructure /Equipment	Responsible	Contact	Normal Operating Procedure	Frequency	Common Operating Problems	Causes	Control/Preventive Measures	Cost (Amount in Kshs)		
									Estimated cost per year	Source of funds	Responsible Institution
1.	Water Pans	WRA, NEMA	PMU	<ul style="list-style-type: none"><li>• Be accessible from any direction/should have a common entry point.</li><li>• Should be constructed away from human settlements/sighting.</li><li>• Should not be constructed where there is a likelihood of pollution occurring.</li><li>• Should have a spillway to evacuate excess water</li><li>• Should not exceed 5m but not be below 2.5m</li></ul>	All these are done at inception	<ul style="list-style-type: none"><li>• Breaching of banks leading to floods</li><li>• Silting/excessive sedimentation</li><li>• Not filling</li><li>• Controlling livestock access</li><li>• Excessive seepage</li><li>• Poor water quality, difficulty in extracting the water,</li></ul>	<ul style="list-style-type: none"><li>• Small catchment area will cause the water pan not to fill</li><li>• Highly porous soils/fracture</li><li>• Lack of/poor fencing</li><li>• Catchment degradation and contamination</li><li>• Lack of a spillway/outlet/excess rain/sedimentation</li><li>• Lack of draw off points</li></ul>	<ul style="list-style-type: none"><li>• Measure the soil seepage during initial construction/use lining material to counter seepage e.g. polythene or bentonite clay</li><li>• Test soil texture before construction</li><li>• Provide fencing for the water pans</li><li>• Provide spillways and draw off points</li><li>• Test water quality</li></ul>	2.5M	GoK	WRA
		County Government, Management committee	Director Water, Committee chair	Constitute and strengthen a Management Committee – the locals/beneficiaries and they will oversee the best practices of the project based on the provided bylaws. The committee will be run under the supervision of the county ward administrators	Committees will be established during implementation of the water pans or on need basis for existing water pans				1M	County Government (CG)	CG
		WRA, NEMA	Project Management Unit (PMU)	Supervise and oversee the construction of the water pans including the fencing, provision of draw-off points, construction of silt traps	At inception, during planning, implementation and handing over of water pans to community and county governments				4.8M	GoK	NEMA/WRA
		County Government	Director Water	Undertake the periodic desilting	When need arises				6M	CG	CG
		WRA, NEMA, County	PMU	Relevant and regular field inspections including monitoring	Relevant and regular field inspections				5M	GoK	WRA/NEMA/CG
		WRA	Respective Sub Region Office	Enforcement to ensure that permits are renewed and compliance with the permit conditions	Monthly & Quarterly basis				4.8M	GoK	WRA
		WRA, NEMA	PMU	Training and capacity building of the WRUAs and community members	At beginning of activity				2M	GoK	WRA, NEMA
		WRA, NEMA	PMU	Contract a reputable consultant to provide detailed designs of the water pans	At inception				2M	GoK	WRA, NEMA
		WRA, NEMA	PMU	A monitoring tool to be developed to ensure that the management committee meets regularly (quarterly/biannually/monthly	At inception (generic tool)				1M	GoK	WRA, NEMA

## 2. Springs

### a) Introduction

Springs are found in areas of impervious strata

Springs are natural groundwater outflows. There are two types of springs, namely gravity and artesian springs. The main parts of a spring water protection are:

1. A **drain** under the lowest natural water level. The drain usually is placed in a gravel pack covered with sand and may lead to a conduit or a reservoir.
2. A **protective structure** providing stability and may be made of concrete or masonry
3. A **seal** to prevent surface water from leaking in and is usually made of puddle clay and sometimes plastic.
4. A **screened overflow pipe** guarantees that the water can flow freely out of the spring at all times.
5. A **ditch**, known as the interceptor drain, diverts surface water away from the spring box and prevents contamination as a result of infiltration from the surface.
6. A **fence** keeps animals out of the spring area.

There are many types of spring protection depending on topography, the structure of the ground and the characteristics of the spring source. It is recommended that whatever method is employed should be feasible, simple and not complex.

### b) Operation

Water should flow out freely all the time. In order to prevent contamination and leakages, the following activities should be undertaken

- ❖ Ensure the surrounding is clean and properly fenced.
- ❖ Protect vegetative cover in the recharge area and immediate surroundings of the spring.
- ❖ Prevent roots from clogging the spring.
- ❖ Regularly monitor water flow from spring box (colour, amount of flow) and take water samples for analysis.
- ❖ Wash out accumulated silt annually.
- ❖ Prevent soil erosion and maintain storm drain.
- ❖ Maintain spring box, valves and pipes regularly.
- ❖ Conduct Participatory Health & Hygiene Education to enhance hygienic practices

### c) Maintenance

Activity	Frequency	Human resources	Materials & spare parts	Tools & equipment
Clean spring surroundings	Weekly	Local		Broom, bucket, hoe, machete
Check colour (turbidity)	After each flood	Local		
Check water quantity	Occasionally	Local		Bucket, watch
Repair fence and clean surface drains	Occasionally	Local	Wood, rope, wire	Machete, axe, knife, hoe, spade, pick axe
Check water quality	Regularly	District	Laboratory reagents	Laboratory equipment
Wash and disinfect spring	Annually	Local	Chlorine	Bucket, wrench, brush
Repair piping and valves	Occasionally	Local or district	Spare pipes and valves, cement, sand, gravel	Bucket, trowel, wrench, flat spanners
Repair cracks	Annually	Local	Cement, sand, Gravel, clay	Bucket, trowel, hoe, spade, wheel barrow

#### ❖ Common Problems and Remedies

Problem	Causes	Remedy
1. Decreased flow of water	• Clogged collection system	• Unblock (clean collection pipes, take out gravel / filter media and replace it).
	• Spring drying up	• Try increasing size of catchment
	• Blocked supply pipe	• Unblock and clean supply pipes
	• Leakage or bypass	• Repair leaks
	• Silted spring box	• Scour and clean spring box
2. Clogged water collection system	• Siltation	• Dig out catchment, clean pipes, ensure pipes are laid at 2 degrees gradient.
	• Plant roots	• Dig out catchment, remove roots
3. Contamination of spring water.	• Cracks in the seal	• Mend cracks
	• Human activities that promote pollution	• Conduct Participatory hygiene education
	• Animal activity	• Repair fence
	• Wrong design	• Redesign spring catchment

4. Erosion and/ or collapse of spring box	• Construction errors	• Employ skilled labour force and increase supervision during reconstruction
	• Large surface runoff flows	• Provide adequate drainage system
	• Animal tramping	• Repair fence
5. Damaged piping	• Faulty construction	• Provide adequate cover (bunty pipe)
	• Animal tramping	• Repair fence
	• Corrosion	• Use appropriate pipes (PVC)
	• Vandalism	• Enforce security measures / education

Summary Water Springs O&M chart

S/No.	Infrastructure /Equipment	Responsible	Contact	Normal Operating Procedure	Frequency	Common Operating Problems	Causes	Control/Preventive Measures	Cost (Amount in Kshs)		
									Estimated cost per year	Source of funds	Responsible Institution
2.	Springs	WRA; County Government	Respective WRA sub-regional offices and the respective WRUAs in each region	<div>-The water quality of the spring should be checked</div> <div>-Check to ensure that the spring box is not eroding and that the uphill diversion ditch is adequately diverting surface runoff away from the spring box</div> <div>- The animal fence should be kept in a good state always to ensure that the water is not contaminated by soil compaction which could result in decreased flow rates.</div> <div>- For hillside collection boxes, it is important to check that the uphill wall is not eroding and is maintaining structural integrity. Check the cover frequently and ensure that it is in place and is watertight.</div> <div>- Ensure that the water isn't seeping out from the sides or from underneath the spring box, and check that the screening is in place on the overflow pipe.</div> <div>-The system should be disinfected, the sediment removed from the spring box and the interior walls washed with a chlorine solution.</div>	<div>-Water quality should be checked yearly.</div> <div>-At inception</div> <div>-Disinfect once a year</div>	<div>-Seepage in the springs</div> <div>-Land ownership</div>	<div>-Seepage occurs when shallow groundwater oozes or seeps from the ground over a large area</div>	<div>-Provide polythene/bentonite clay</div> <div>- Drawing up an agreement on public access to the spring on privately owned land.</div>	3M	GoK/CG	WRA/CG

### **3. Borehole**

#### **a) Introduction**

Boreholes are machine-bored wells into the ground to penetrate the water bearing formation. Generally, the diameter ranges from 100mm to 250mm. It is lined and protected against contamination and equipped with an appropriate water-lifting device. The life of a borehole will be limited unless it is constructed in a manner which permits both, a high initial efficiency and the possibility of periodical redevelopment, and only if it is pumped at the proper design rate. Some production wells under continuous heavy pumping eventually become partially clogged. With the use of appropriate materials and with careful maintenance, a borehole may be productive for 50 years or more. Production may decline as a response to:

- i) Lowering of water table levels;
- ii) Inefficient pump operation caused by worn, corroded or plugged parts;
- iii) Deposits of scale, corrosion products or micro-organism growth on the screens and casing;
- iv) Clogging of the screens by mud, silt or sand.

#### **b) Operation**

The borehole needs to be run properly to give the intended benefits to the community. Day to day running of the borehole facility involves paying attention to the borehole so that breakdowns are minimised. In order to achieve this the following guidelines should be adhered to:

When all preparations have been made after construction of the borehole the management committee will draw up preventive maintenance schedules. These will include

- Scheduling of when the water point will be opened and closed
- Preparation of duty rosters for general cleaning
- Programming of community based health and hygiene education related to the use of the borehole
- Setting up mechanisms for the enforcement of rules on the use of the borehole

#### **c) Maintenance**

##### **Daily O&M:**

- Operate pump starter and isolation valve.
- Check reading on ammeter is normal – stop pump if electric motor is drawing too much current.
- Verify whether adequate water is being delivered.
- Continue to check voltmeter and ammeter readings during the day.

##### **Monthly/quarterly:**

- Clean the pump house.
- Check for leaks in the rising main.
- Testing water quality using a Field Test Kit.

##### **Annual O&M:**

- Remove the pump and rising main from the well and inspect.
- Check pipe threads and re-cut corroded or damaged threads.
- Replace badly corroded pipes.
- Inspect electric cables and check insulation between cables.
- Record servicing and maintenance in log book.
- De-silt borehole if required.
- Check screen and clear as needed.

#### **❖ Preventive Maintenance of Pumps**

##### **Monthly/Quarterly Maintenance**

- Clean the pump, motor and other accessories.
- Check coupling bushes/rubber spider.
- Check stuffing box, gland etc.
- Records of pressure, voltage and current.
- Check and repair of leakage from mechanical seal.
- Check and repair in case of sparks in motor.
- Check for free movement of the gland of the stuffing box.
- Check gland packing and replace if necessary.
- Clean and apply oil to the gland bolts.
- Inspect the mechanical seal for wear and replacement, if necessary.
- Check condition of bearing oil and replace or top up, if necessary.

##### **Six Months Maintenance**

- Verify and rectify alignment of pump and drive.
- Clean oil lubricated bearings and replenish with fresh oil.
- Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame.
- Check vibration level with instruments if available; otherwise by observation.
- Clean flow indicator, other instruments and appurtenances in the pump house.

Yearly Maintenance

- Clean and flush bearings with kerosene and examine for flaws developed like corrosion, wear and scratches.
- Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
- Clean bearing housing and examine for flaws like wearing, grooving etc. Change oil or grease in bearing housing.
- Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packings should be examined for wear.
- Check stuffing box, glands, lantern ring, mechanical seal and rectify if necessary.
- Check clearances in wearing ring.
- Check impeller hubs and vane tips for any pitting or erosion.
- Check interior of volute, casing and diffuser for pitting, erosion, and rough surface.
- All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter, wattmeters, frequency meter, tachometer, flowmeter etc. should be calibrated.

Preventive Maintenance Activities

Period	Activity
Daily	Cleaning of surrounding and apron
	Carry out an early morning test to check if the foot valve holds water in the rising main overnight
	Check whether the pump delivery is normal or low.
	Check if the hand pump is firmly fixed in place.
	Check for loose nuts and bolts on the hand pump.
	Clean the platform and drain.
	Check the fence is in sound condition and the gate will close.
Weekly	Carry out daily checks
	Tighten all the above ground nuts and bolts with a spanner.
	Clean the accessible moving parts.
Monthly	Conducting PHHE to enhance hygienic practices
	Carry out the weekly checks.
	Collect* and record contributions to the water committee
	Grease the chain
Yearly	Dismantle the pump head parts.
	Remove the connecting rods, piston assembly and foot valve.
	Inspect all the parts.
	Replace worn or defective parts.
	Replace piston seals.
	Straighten bent connecting rods, or replace.
	Replace rods with badly corroded threads.
	Replace corroded or missing connecting rod lock nuts.
	If connecting rods show severe corrosion, remove the rising main.
	Check the rising main and replace badly corroded pipes - check the threads in particular.
	Clean pipe threads and install the rising main.
	Re-assemble and replace the below-ground parts.
	Assemble the pump head.
	Check the pump operation and pump until the water delivered is clean.
	Record all significant actions.
Irregular	Landscape the area around the borehole
	Prevent soil erosion around the apron by laying bricks around perimeter of the apron and drain and ensure that the bricks remain in place.
	Prevent the construction of sources of contamination within distance of 30 m from the borehole
	Organise fundraising activities for the maintenance of the borehole
	Repair cracks with cement mortar in the pump platform and drain.
	If pump mounting bolts become loose in the concrete platform, remove pump, breakout old bolts, and remount in fresh concrete.
	Arrange to clean the borehole if the pump delivers cloudy water with silt.

Trouble shooting of borehole

Problem	Probable Cause	Remedies
Silting of the tube Decrease of water yield Mechanical failure	<ul style="list-style-type: none"><li>❖ Over pumping, adverse aquifer conditions, incrustation of screens and aquifers,</li><li>❖ falling of foreign objects in the bore,</li><li>❖ damage of mild steel screens due to corrosion</li></ul>	<ul style="list-style-type: none"><li>❖ Deepening to appropriate level,</li><li>❖ Repair/replacement of damaged parts</li><li>❖ Cleaning by chemicals</li></ul>

O&M of Pumping machinery

Pumping machinery is mainly subjected to wear, tear, erosion and corrosion. Normally, major failure and interruptions in water supply system occur due to problems in pumping machinery. Hence, it is necessary to have timely and effective operation and maintenance of pumping machinery, up keep of pumping stations and records

- ❖ Record maintenance for O&M of pumping machinery
- Pump operation timings (start and end time daily).
- Voltage in all three phases.

- Current drawn by each pump unit and total units.
- Frequency of operation.
- Readings of vacuum and pressure gauges.
- Bearing temperature for pump and motor.
- Water level in intake/sump.
- Flowmeter reading.
- Any specific problem or event in the pumping installation or pumping system.

#### ❖ Basics on Operation of Pumps

- Avoid dry running of pumps.
- Centrifugal pumps needs to be primed before starting.
- Pumps should be operated only within the recommended range on the head-discharge and characteristics of the pump.
- Increase in distance between duty point and point away reduces the efficiency of pump.
- Operation near shut off causes re-circulation within pump, thus over heating of pump.
- Voltage during operation of pump-motor set should be within + 10 percent of rated voltage.
- Similarly, current should be below the rated current of the motor.
- For water supply schemes, pumps are started against closed delivery valve in order to reduce starting load on motor. Pumps with high specific speed should be started with open delivery valve.
- The delivery valve should be operated gradually to avoid sudden change in flow velocity which can cause water hammer pressures.
- Control the opening of delivery vale during pipeline filling period to avoid overloading on pumps.
- The running of the duty pumps and the standby should be scheduled so that no pump remains idle for long period and all pumps are in ready-to run condition. Similarly,
- If any over vibration or noise is noticed, pump should be stopped immediately.
- Bypass valves of all reflux valve, sluice valve and butterfly valve should be closed during normal operation of the pumps.
- Avoid frequent starting and stopping of pumps for reducing over loading.

Summary Boreholes O&M chart

S/No.	Infrastructure /Equipment	Responsible	Contact	Normal Operating Procedure	Frequency	Common Operating Problems	Causes	Control/Preventive Measures	Cost (Amount in Kshs)		
									Estimated cost per year	Source of funds	Responsible Institution
3.	Boreholes and monitoring wells	WRA/County Government	WRA Sub regional office in the respective County	<p>-Regular examination of GW quality so as to monitor its corrosive levels which affect the cable suspending the logger.</p> <p>-Fishing of logger to retrieve it whenever it drops.</p> <p>-Monitoring of the water level in the borehole to ensure the logger is always inside a safe water column</p> <p>-The number of downloading cables should be sufficient to ensure efficiency.</p> <p>-Cleaning the outside casing of the Logger which is dependent on several aspects of the monitored water quality. In freshwater with good to excellent water quality, the Level logger cleaning requirements will be very minimal; amounting to a seasonal or even annual maintenance inspection</p> <p>-Make requisite payments to the mobile service provider for the Telemetric Loggers.</p> <p>-In-case data transmission fails (due to e.g. depletion of batteries, sensors not responding to commands, water ingress, excessive power consumption, poor contact of the communication cable between data logger and the Data Retrieval System, limitations of the software and its user interface), diagnosis should be done to resolve the issue</p> <p>-In the case of privately owned boreholes, WRA has an MOU with the borehole owners to allow for manual (using an electric water level dipper) water level monitoring. Data obtained by WRA is shared with the borehole owner.</p>	<p>-As need arises</p> <p>-As need arises</p> <p>-Monthly and quarterly</p> <p>- On a need basis</p> <p>-As need arises</p> <p>-As need arises</p> <p>-Monthly</p>	<p>-Corrosive water</p> <p>-Logger breaking and dropping</p>		<p>-Replace corroded pipes as soon as they are detected.</p> <p>-Frequent inspections in order to record any issues needing attention.</p>	3M	GoK	WRA
	Electric Water Level dippers			<p>-Replacement of batteries</p> <p>-Replacement of the steel tape in case its tampered-with</p>	-As need arises				0.2M	GoK	WRA
	Terramètres			Have designated ABEM dealers in each country to contact in case of malfunction of the equipment. Charges will depend on the diagnosis.	As per need				2M	Gok	WRA
	Borehole Cameras -			<p>-Replacement of lost or worn out parts</p> <p>-Training of the WRA staff by the suppliers is recommended</p>	<p>-As need arises</p> <p>-Twice a year</p>				1M	Gok	WRA

4. Roof water harvesting Tanks

O&M Storage Tanks

- Remove all foreign floating materials quarterly.
- Care should be taken to dump the removed silt away from pump house.
- Dewater and tank once a year, clean it and disinfect it. For cleaning, brush the walls, column, ladders, and other parts of the tank to remove dirt and algae, if any. For disinfecting the tank, fill the tank with 50 mg/litre chlorine solutions and allow the solution to stand for 24 hours before draining it to waste. Rinse the tank with clean water once and then use the tank again.
- Undertake leakage test once a year and carry out rectification if needed with epoxy coating, cement concreting, painting etc.

Summary Roof water harvesting Tanks O&M chart

S/No.	Infrastructure /Equipment	Responsible	Contact	Normal Operating Procedure	Frequency	Common Operating Problems	Causes	Control/Preventive Measures	Cost (Amount in Kshs)		
									Estimated cost per year	Source of funds	Responsible Institution
4.	Roof Water Harvesting Tanks	WRA, NEMA Communities	PMU	<p>-The overflow pipe and draw pipe tap should not pour water directly near the building or on the ground nearby to avoid water logging</p> <p>-The gutters should be well supported and maintained so that they don't sag and pour water on the walls.</p> <p>-Leaves from nearby trees should be removed from the roofs.</p> <p>-The first water (water captured after the first 10 minutes of intense rainfall) after the first rainfall should be diverted from the tank.</p> <p>-The storage tank should be checked and cleaned i.e. scrubbing of the inner walls and floors. Use of a chlorine solution is recommended for cleaning, followed by thorough rinsing</p> <p>-Keep rainfall collection surfaces covered, to reduce the likelihood of frogs, lizards, mosquitoes, and other pests using the tank/cistern as a breeding ground.</p> <p>-If the water is to be used for drinking and domestic purposes, the cisterns or storage tanks should be chlorinated using the dosages found at chemists or WRA offices countrywide.</p> <p>-Inspect gutters and downpipes carefully. The pumps used to lift water into the house or building should also be periodically maintained.</p> <p>-Creation of a community organization /committee to maintain community systems effectively. Similarly, households must establish a maintenance routine that will be carried out by family members.</p> <p>-For community catchments, the water quality must be maintained at levels where health risks are minimized. This mostly involves chlorination of the supplies at frequent intervals.</p> <p>-Issues of lack of availability of chemicals required for appropriate treatment and the lack of adequate funding that face community systems should be addressed.</p>	<p>-As need arises</p> <p>-As need arises</p> <p>-Periodically</p> <p>-Regularly</p> <p>- Committee will be established during implementation or on need basis</p>	<p>- Certain roof types seep chemicals or animal droppings further contaminating the water.</p> <p>-Storage limits of the tanks</p> <p>-Unpredictable rainfall patterns; the tanks may stay empty for long periods of time and thus be susceptible to vandalism</p> <p>- Wear and tear due to elements of weather</p>	<p>-Unpredictable rainfall patterns.</p> <p>-Wrong roof types</p> <p>-Vandalism</p> <p>-Extreme weather elements causing frequent wear and tear</p>	<p>-Encourage tank installation on galvanized tin/roof tops.</p> <p>-Provide protective shades for the tanks</p> <p>-Clean the storage tanks regularly</p>	5M	GoK	WRA

S/No.	Infrastructure /Equipment	Responsible	Contact	Normal Operating Procedure	Frequency	Common Operating Problems	Causes	Control/Preventive Measures	Cost (Amount in Kshs)		
									Estimated cost per year	Source of funds	Responsible Institution

[illegible]

6. Laboratory Equipment

Summary of Laboratory Equipment O&M chart

S/No.	Infrastructure /Equipment	Responsible	Contact	Normal Operating Procedure	Frequency	Common Operating Problems	Causes	Control/Preventive Measures	Cost (Amount in Kshs)		
									Estimated cost per year	Source of funds	Responsible Institution
6.	Laboratory Equipment	WRA	WRA Technicians  WRA Technicians  WRA Technicians  WRA Technicians  External consultancy	<b>-Instrument health status, quality control, change of applicable consumables:</b> this involves performing checks on instrument conditions, changing applicable consumables and carrying out quality control procedures (calibration) for respective instruments in line with the operational manuals. <b>-Routine visual inspections:</b> Carrying out visual checks on instruments and instrument environment for any changes that may affect instrumental operation e.g. power cables, sockets... <b>-Routine maintenance of equipment:</b> Carrying out minor maintenance and troubleshooting procedures according to the manufacturer's manual. Such procedures include cleaning of parts, oiling of moveable parts of individual equipment, replacement of short term consumables. <b>-Instrument calibration:</b> External experts calibrate measuring instruments such as analytical balances. <b>-Major equipment overhaul:</b> External experts carry out major maintenance procedure on various equipment such as replacement of worn out parts.	-Daily    -Daily   -Varies as per instrument  -One to two years  -Varies as per instrument and manufacturer's directions				1M	GoK	WRA

7. Motor Vehicles

Summary of Motor Vehicles O&M chart

7.	Motor Vehicles	WRA, NEMA, KMD	Sub-Regional Manager in the respective WRA office,  Transport office in NEMA and KMD	The vehicle will be serviced as per the manufacturer's schedule	As indicated in the manufacturer's manual				1M	GoK	WRA
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**Notes:**

- The estimated costs provided refer to yearly operations and maintenance for the specified activities. This O&M plan will be reviewed every five years to take into consideration any changes in pricing of the equipment, tools, instruments, materials, procurement of consultancy services and any other costs related to the successful execution of the O&M plan.
- The O&M Plan will be used together with applicable manuals including but not limited to:
  1. Practice Manual for small dams, pans and other water conservation structures in Kenya, 2<sup>nd</sup> Edition, 2015. Ministry of Water and Irrigation
  2. Guide to Hydrological processes, WMO-No. 168
  3. ISO 1100-1, Measurement of liquid flows in open channels
  4. RGS Maintenance Schedule
  5. Guidelines for maintenance of RGS

1. Machakos County



REPUBLIC OF KENYA  
MACHAKOS COUNTY GOVERNMENT  
MINISTRY OF WATER, IRRIGATION, ENVIRONMENT, CLIMATE CHANGE &  
NATURAL RESOURCES

TEL: +254 (0) 44 – 20246/21158  
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KITUI ROAD,  
P. O. BOX 1996- 90100,  
MACHAKOS

REF: MWIECCNR/EN/VOL.1./152

14<sup>TH</sup> JULY 2021

The Director General  
National Environment Management Authority  
P.O BOX 67839 – 00200  
NAIROBI

**REF: COMMITMENT TO UNDERTAKE OPERATION AND MAINTENANCE FOR THE  
PROPOSED ADAPTATION INVESTMENTS IN MACHAKOS COUNTY**

The County Governments are responsible for water supply at county level as per the Water Act 2016 and have annual financial allocations for water works development and maintenance. Machakos County Government as one of the main project beneficiaries of the funding proposal titled “**Enhancing community resilience and water security in the Upper Athi River Catchment Area, Kenya**”, will perform operation and maintenance of the rehabilitated adaptation assets for project life span in line with Annex 21: Operation and Maintenance Plan.

The proposed assets are as outlined;

No	Longitude	Latitude	Name	Type	No. of Beneficiaries
1.	-1.399305556	37.398055556	Musaalani	Water pan	9000
2.	-1.209666667	37.209138889	Kwale dam	Water pan	300000
3.	-1.465333333	37.285722222	Kailo spring	Spring	1200
4.	-1.434361111	37.319111111	Muooni Dam	Water pan	6000
5.	-1.407228000	37.170124000	Mithatini Community	Borehole	18000
6.	-1.493138889	37.513500000	Muthutheni dam	Water pan	15000

7.	-1.602972222	37.237083333	Kwa Katheke	Water pan	9000
8.	-1.579388889	37.328583333	Miwani	Water pan	9000
9.	-1.657888889	37.270750000	Muumandu	Water pan	9000
10.	-1.388277778	37.756055556	Mekilingi Dam	Water pan	9000
11.	-1.270194444	37.697750000	Ikombe sand dam	Sand dam	9000
12.	-1.212111111	37.289166667	Kwa Matinga dam	Water pan	51000
13.	-1.436411000	36.994351000	Gimu	Borehole	10800



Hon. Eng. Morris Aluanga, Hsc  
CEC -WATER, IRRIGATION, ENVIRONMENT, CLIMATE CHANGE & NATURAL  
RESOURCES

CC

His Excellency the Deputy Governor

County Secretary

Chief of Staff

Chief Officer -Water, Irrigation, Environment, Climate Change & Natural  
Resources



REPUBLIC OF KENYA



COUNTY GOVERNMENT OF NYANDARUA  
DEPARTMENT OF WATER, ENVIRONMENT,  
TOURISM AND NATURAL RESOURCES.

TELEPHONE: 0202660859

P.O BOX 740-20303: ILKALOU

Email: info@nyandarua.go.ke

REF: NYA/CNT.GOV/WATER/5/132

DATE: 14<sup>th</sup> July 2021

The Director General  
National Environment Management Authority  
P.O BOX 67839 – 00200  
NAIROBI

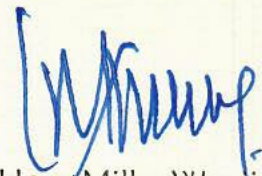
RE: COMMITMENT TO UNDERTAKE OPERATION AND MAINTENANCE FOR THE  
PROPOSED ADAPTATION INVESTMENTS IN NYANDARUA COUNTY.

The County Governments are responsible for water supply at county level as per the Water Act 2016 and have annual financial allocations for water works development and maintenance. Nyandarua County Government as one of the main project beneficiaries of the funding proposal titled “Enhancing community resilience and water security in the Upper Athi River Catchment Area, Kenya”. Once the Projects are handed over to the County Government we will perform operation and maintenance of the rehabilitated adaptation assets for project life span in line with Annex 21: Operation and Maintenance Plan.

The proposed assets are as outlined:

No	Longitude	Latitude	Name	Type	No. Beneficiaries
1.	- 0.871250000	36.598111111	Kariani	Water pan	3000

2.	-0.892111111	36.567444444	Githwe	Borehole	3000
3.	-0.865944444	36.560333333	Kahora	Water pan	1200
4.	-0.828250000	36.576527778	Mutonyora	Water pan	1800
5.	-0.786916667	36.559388889	Heni	Water pan	6000
6.	-0.699833333	36.548388889	Karanja Wanaina	Water pan	6000
7.	-0.717194444	36.573527778	Wanyeki	Water pan	600
8.	-0.723777778	36.533138889	Koinange	Borehole	3300
9.	-0.754972222	36.641222222	Wachira Waheni	Water pan	4200
10.	-0.798305556	36.614694444	Mbiru	Water pan	3000
11.	-0.778000000	36.661472222	Kahungura	Spring	1200
12.	-0.728500000	36.671888889	Ebrahim Koikai	Water pan	300
13.	-0.693527778	36.640972222	Kwa Musa	Water pan	1800
14.	-0.678000000	36.655166667	Gachuchu Spring	Spring	30000
15.	-0.714805556	36.629861111	Warungana	Water pan	3600
16.	-0.755444444	36.654972222	Churiri	Water pan	300



Hon. Milka Wanjiru

**CECM- WATER, ENVIRONMENT, TOURISM AND NATURAL RESOURCES**

**C.C H.E THE GOVERNOR**



**OFFICE OF THE COUNTY EXECUTIVE  
COUNTY GOVERNMENT OF KIAMBU**

DEPARTMENT OF WATER, ENVIRONMENT, ENERGY AND NATURAL RESOURCES  
P.O Box 2344 - 00900 Kiambu, Kenya

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CGK/WENR/NEMA/VOL 1/018 (44)

July 14, 2021


The Director General  
National Environment Management Authority  
P.O BOX 67839 - 00200  
NAIROBI

**RE: COMMITMENT TO UNDERTAKE OPERATION AND MAINTENANCE FOR THE  
PROPOSED ADAPTATION INVESTMENTS IN KIAMBU COUNTY**

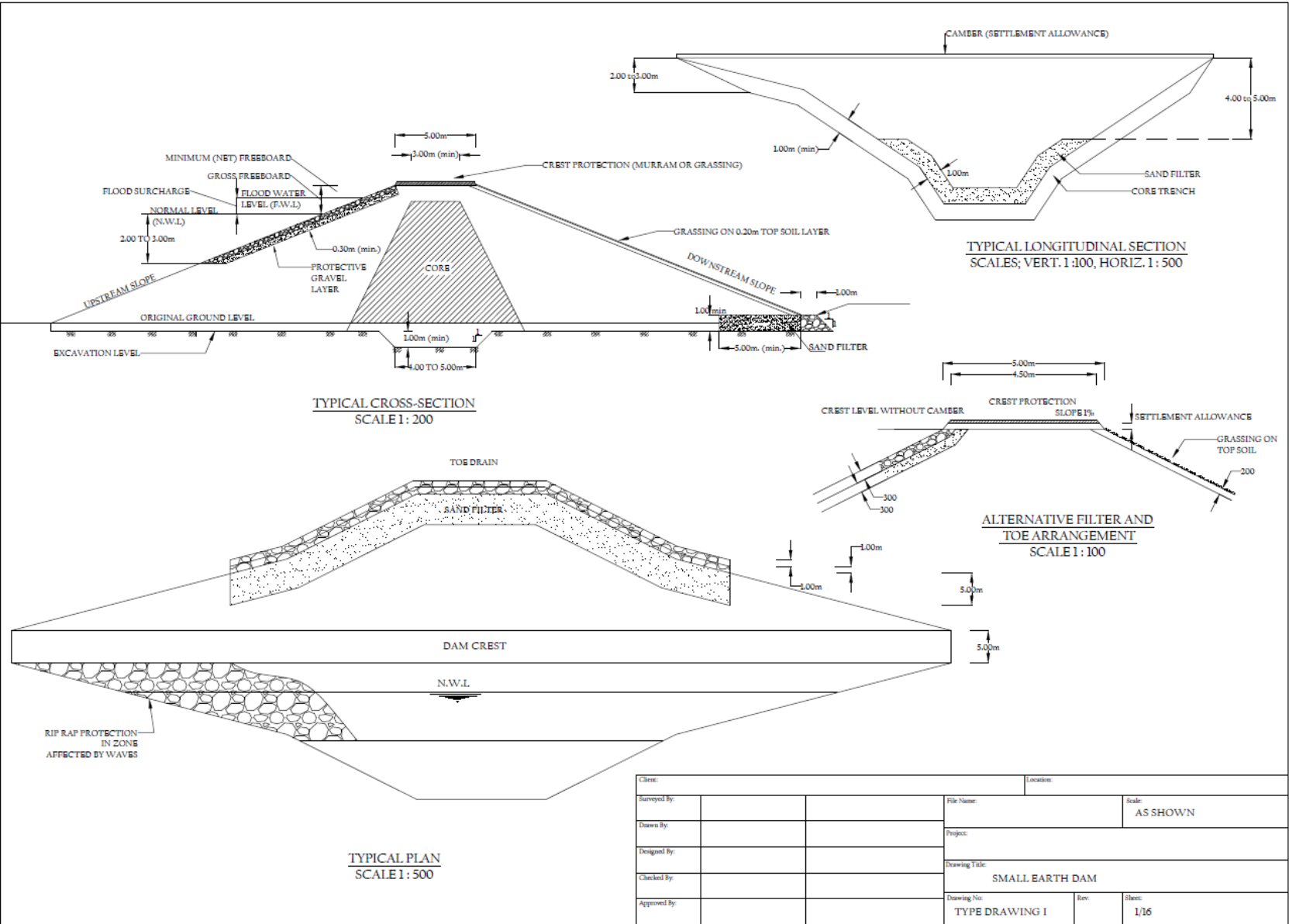
The County Governments are responsible for water supply at county level as per the Water Act 2016 and have annual financial allocations for water works development and maintenance. Kiambu County Government as one of the main project beneficiaries of the funding proposal titled **Enhancing Community Resilience and Water Security in the Upper Athi River Catchment Area Kenya** will perform operation and maintenance of the rehabilitated adaptation assets for the life span in line with Annex 21: Operation and maintenance plan.

The proposed assets are as outlined;

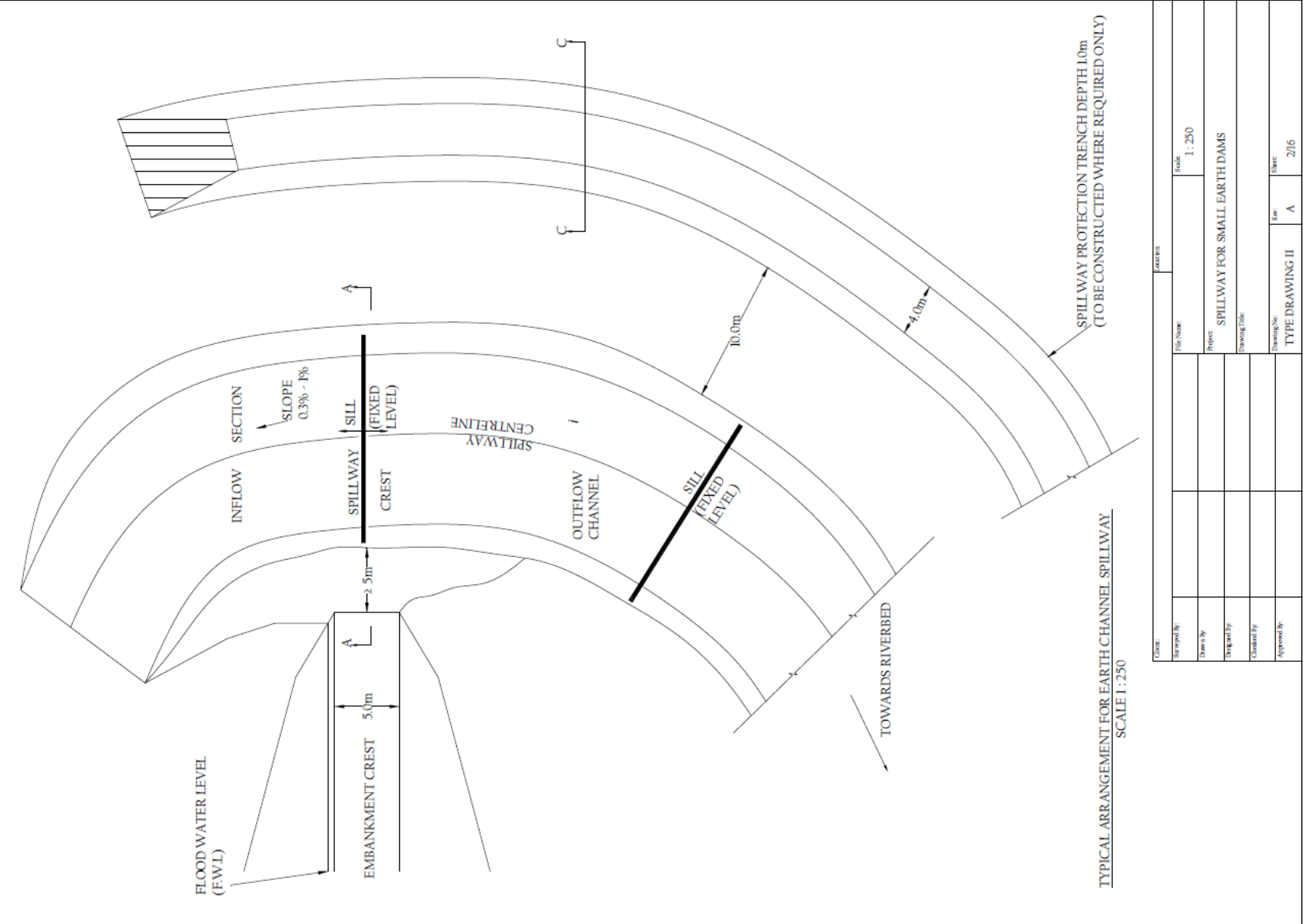
No	Longitude	Latitude	Name	Type	No. Beneficiaries
1.	-1.183583333	36.753000000	Karia - Kambara	Spring	15000
2.	-1.188888889	36.760388889	Gathiri	Spring	15000
3.	-1.159888889	36.753944444	Ite dam	Water pan	18000
4.	-1.065722222	36.649361111	Romo	Borehole	10,800
5.	-1.197916667	36.592250000	Nguirubi	Borehole	12000
6.	-1.207555556	36.570194444	Kiriri	Borehole	12000
7.	-1.250138889	36.670722222	Kikuyu	Spring	1200
8.	-1.243277778	36.669972222	Rugita	Borehole	18000
9.	-1.183583333	36.753000000	Karia - Kambara	Spring	15000
10.	-1.188888889	36.760388889	Gathiri	Spring	15000
11.	-1.242972222	36.670250000	Rungiri	Water pan	18000

  
**Hon David Kuria**  
**County Executive Committee Member**  
**Water, Environment, Energy and Natural Resources**  
**CC:**

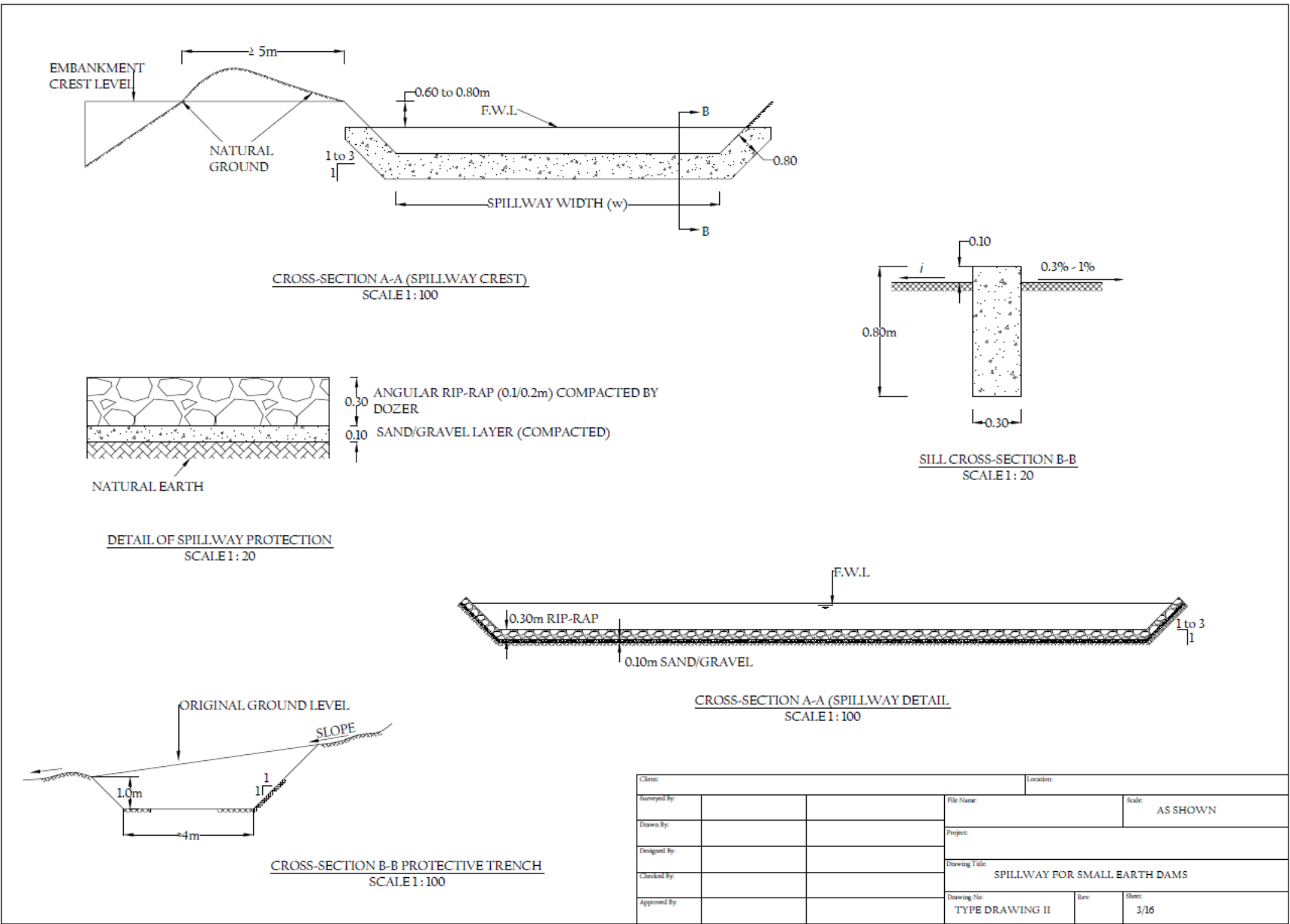
1. H.E The Governor
2. County Secretary & Head of Public Service
3. Chief Officer- Water, Sanitation, Natural Resources and Forestry



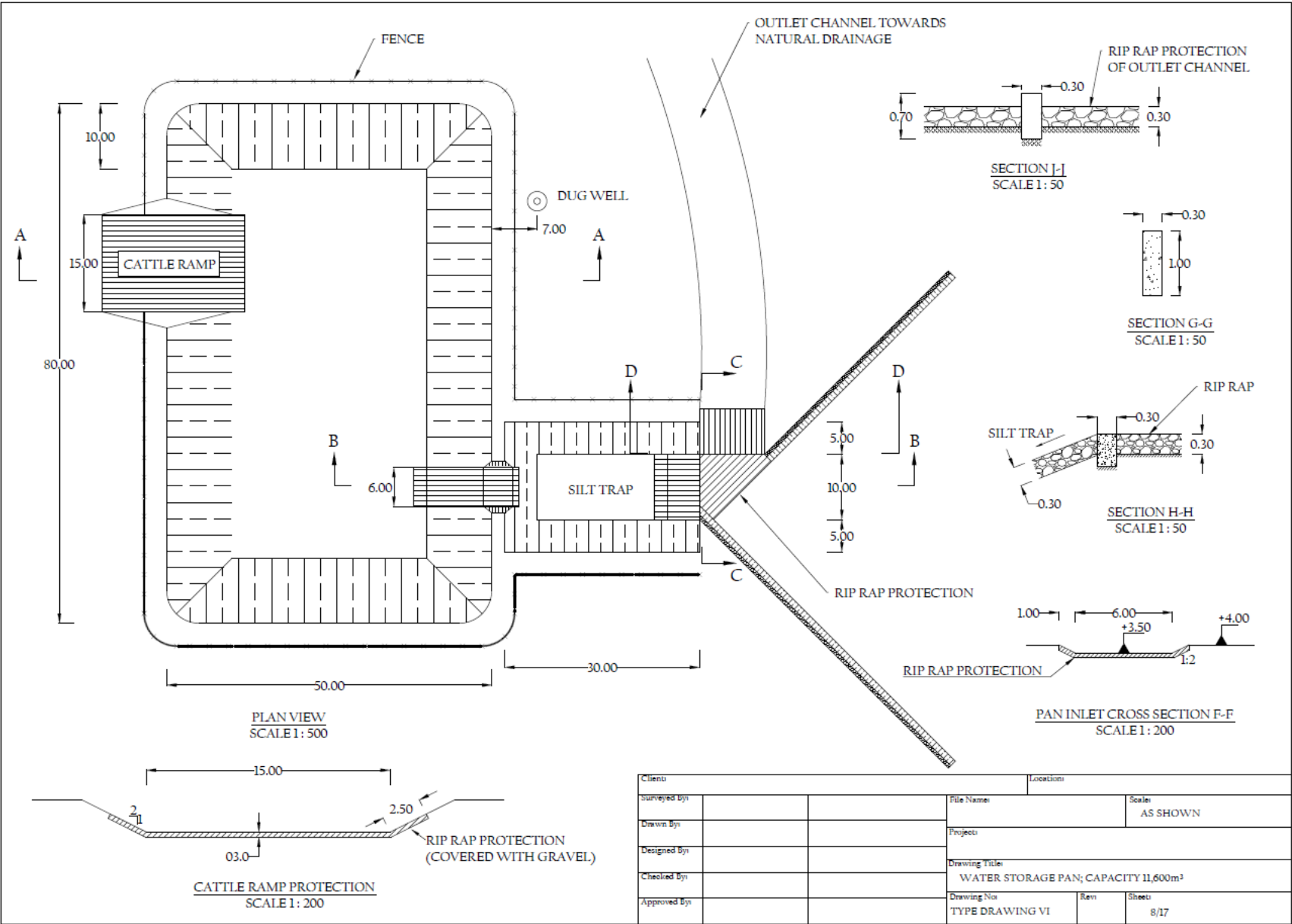
Embankment cross-section and typical plan details



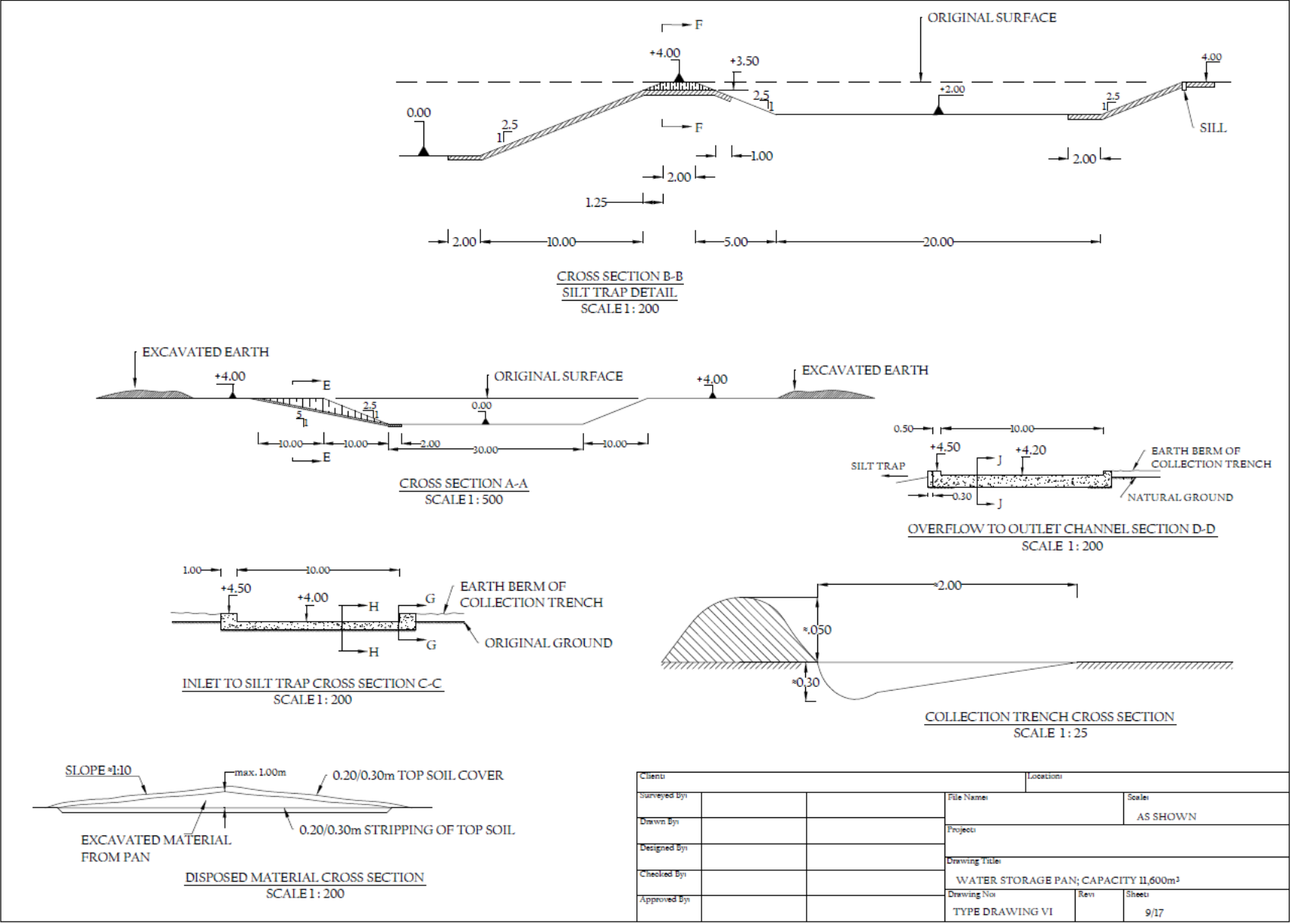
Typical spillway plan details



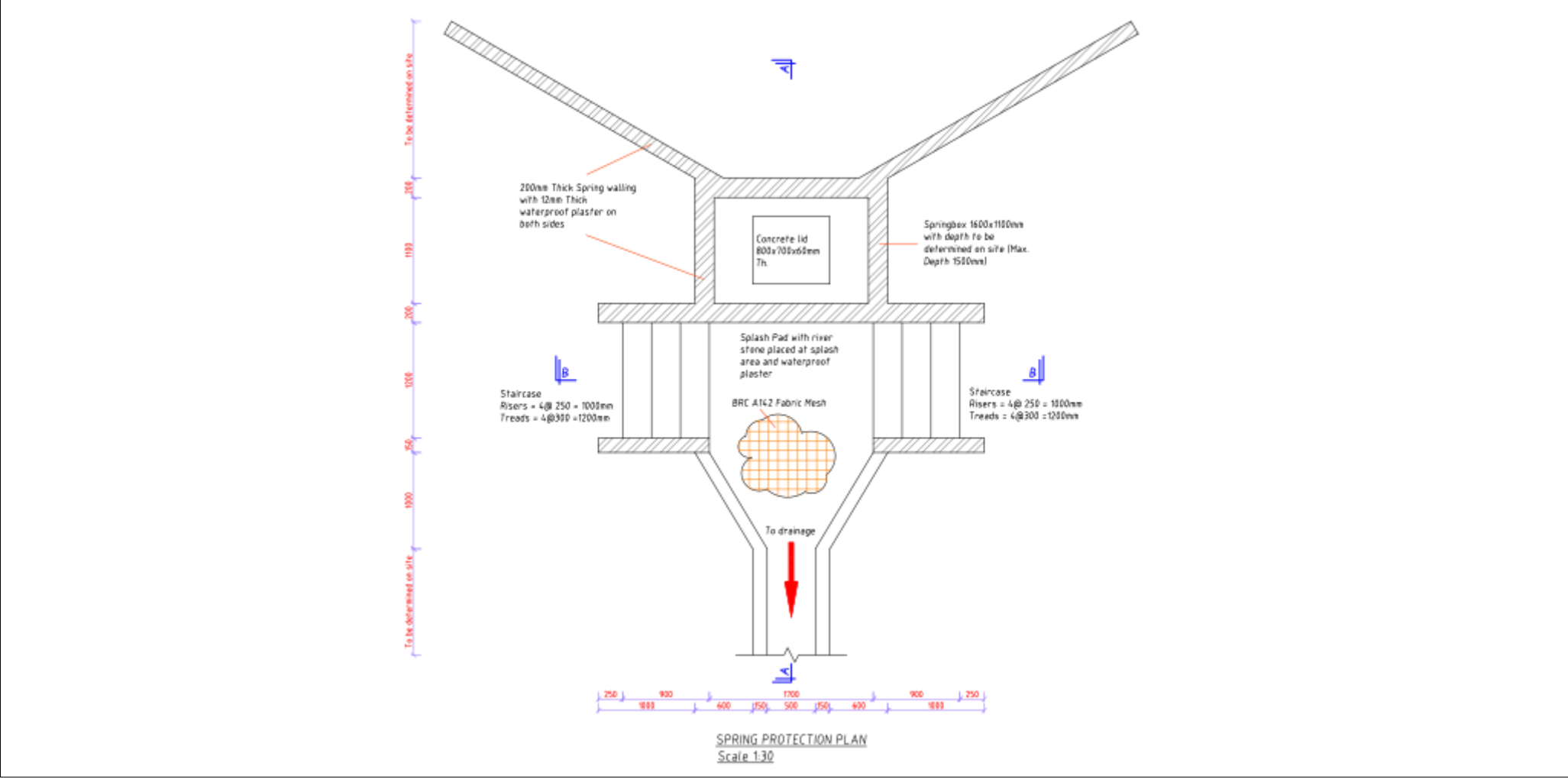
Spillway cross-section details

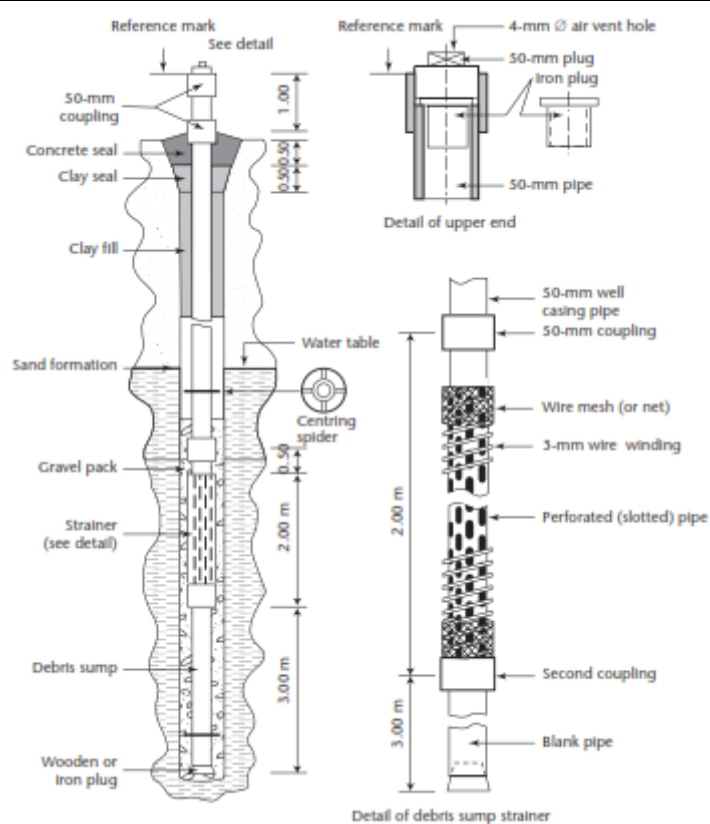
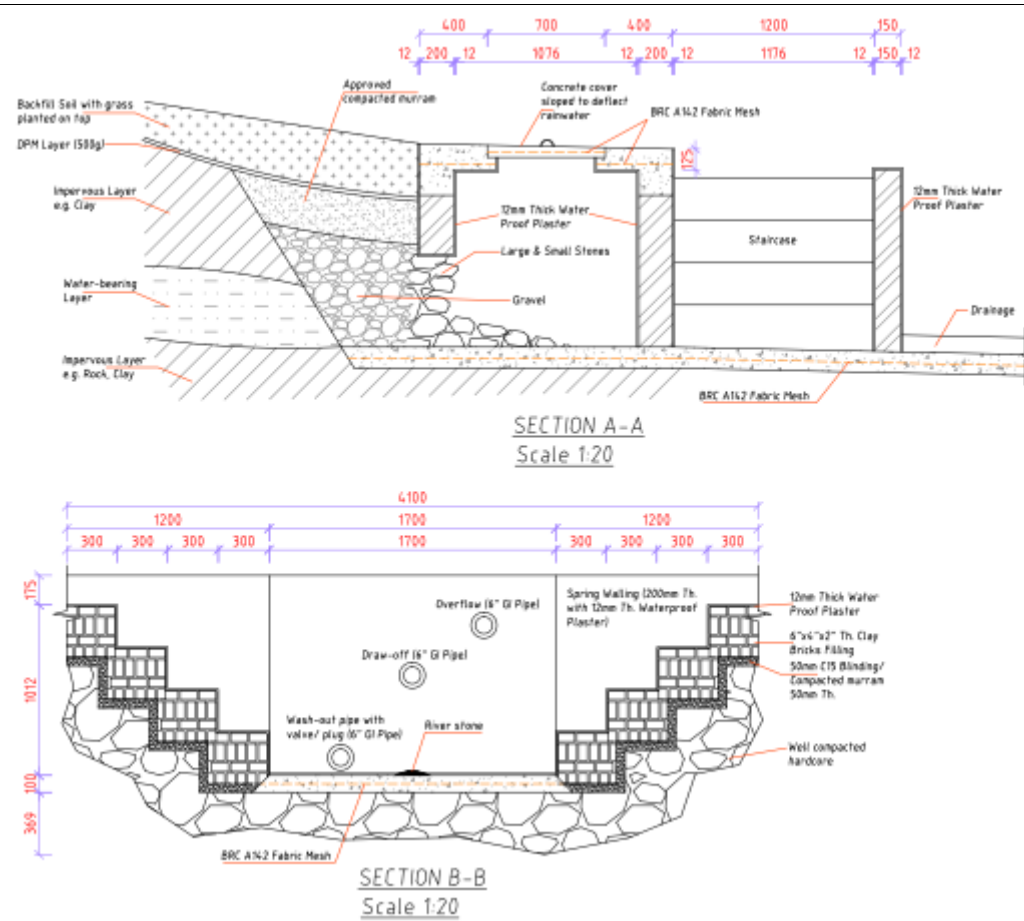


Typical water pan layout

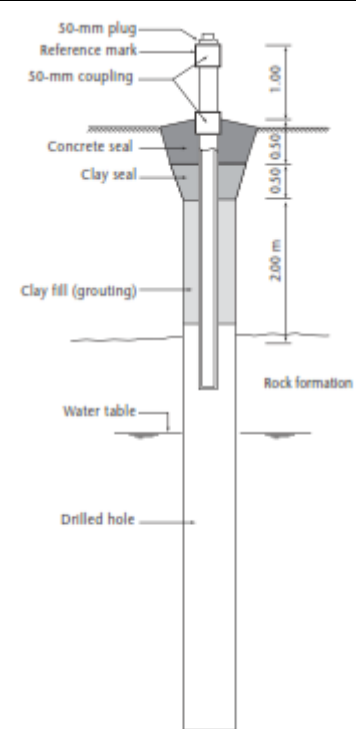


Typical water pan silt trap and trench section details





Groundwater observation well in a sand formation



Groundwater observation well in a rock formation