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OPERATION AND MAINTENANCE REPORT

WUA Operation and Maintenance Manual Wadi Zabid

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GLOSSARY AND ABBREVIATIONS

Al ala fal ala	Traditional water distribution system, giving priority to the upstream users over downstream users
Feddan	Area unit, 1 feddan = 0.42 ha (1 ha = 2.4 feddan)
IC	Irrigation Council
ID	Irrigation Department
IIP	World Bank funded Irrigation Improvement Project
Ma'ad	Area unit, 1 ma'ad = 0.36 ha (1 ha = 2.8 ma'ad)
Ma'qam	Temporary dam in a canal to divert water into fields or branch canals
O&M	Operation and maintenance
Obar	Traditional term for small irrigation canal; also used to indicate water flows
Oqma	Traditional water diversion structure in the wadi
PIU	Project Implementation Unit of the IIP
PMU	Project Management Unit of the IIP
TDA	Tihama Development Authority
WUA	Water User Association
WUG	Water User Group, sub-division of a WUA

PREFACE

In this manual recommendations to water user associations are given on the organisation, operation and maintenance of the Wadi Zabid spate irrigation system in Hodeida Governorate. The manual has been prepared during implementation of the World Bank financed Irrigation Improvement Project.

In line with recent agreements the O&M of secondary and tertiary systems will be handed over to the newly established Water User Associations. The Government will remain responsible for the O&M of the main system (permanent weirs and main/primary canals). This manual deals with the WUA irrigation system and related works. Separate guidelines on O&M in the form of training manuals for WUA management boards have been prepared.

1 INTRODUCTION

1.1 Purpose of the Irrigation System

The purpose of the Zabid irrigation scheme is to divert and distribute spate water of Wadi Zabid and to the agricultural lands in such a way that farmers can make optimum use of it. Distribution of water should take place within the framework of the existing Water Law.

1.2 Improvements by IIP

During implementation of the Irrigation Improvement Project (2002 to 2007) a programme of system rehabilitation has been implemented. The works included repair of weirs, structures and gates, desilting of canals, construction of village protection works, modification of a number of free offtakes (improvement of guide bunds or bed bars, installation of permanent gates), and road improvements. The changes have been incorporated in the system inventory of this manual.

Besides the physical works, sixteen Water User Associations that cover the entire irrigated area (see Figure 1-1) have been established and trained.

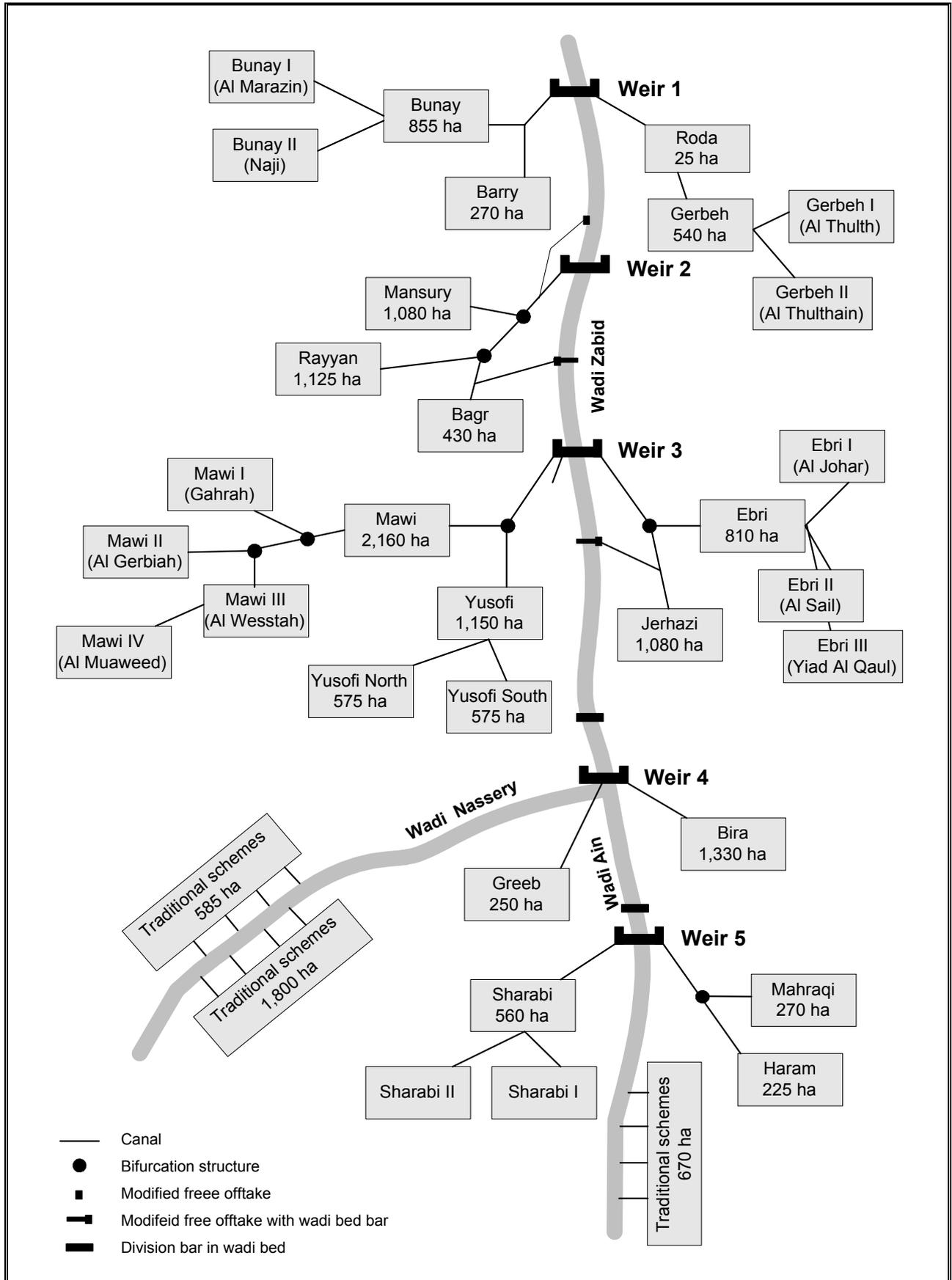


Figure 1-1: Schematic Layout of Wadi Zabid Project Area

2 PRACTISED WATER RIGHTS

Customary rights rule the distribution of the water over the upper, middle and lower sections of Wadi Zabid:

- Group 1: Weir 1 and Weir 2 receive all water from 19th October to 2nd August (288 days)
- Group 2: Weir 3, Weir 4 and the oqmas along Wadi Nassery receive all water from 3rd August to 13th September (42 days)
- Group 3: Weir 5 and the oqmas along Wadi Ain receive all water from 14th September to 18th October (35 days)

The system is known to give not a very equitable distribution of available spate water. For that reason an effort was made during the modernization of the system in the late 1970s to change the rules with a reduction of the supply time for Group I and an increase for Group II, but the effort failed.

Within each group the upstream weir diverts water first, then the downstream one.

- Weir 1: 1- Bunny (on the right bank)
2- Roda Gerbah (on the left bank)
3- Barry (on the right bank)
- Weir 2: 1- Mansury
2- Rayyan
3- Bagr

During the last 5 days (29 July to 2 August) when priority is given to Rayyan-Bagr.

- Weir 3: 1- Mawi (on the right bank)
2- Ebri (on the left bank)
3- Yusofi (on the right bank)
4- Jarhazi (on the left bank)
- Weir 4: Water is equally divided over the left and right bank, facilitated by the newly constructed division bar in de wadi bed upstream of the weir. This weir serves Wadi Nassery, Greeb and Birah.
- Weir 5: 1- Water is divided during 30 days equally over Sharabi (on the right bank) and,
2- Maharaqi-Haram (on the left bank)

During the last 5 days priority is given to land of the Al Mushara family.

More detailed traditional rules govern the water distribution along the canals, based on the principle of *Ala'ala fala'ala*, i.e. upstream fields receive a full irrigation supply first before downstream fields. Among others, the rules prohibit that a field receives spate water more than once in a 14-day period. The command area of each (sub)canal is well defined and known to all farmers, and it is prohibited to add new fields or to construct a new canal for irrigation of land that is not part of the command area.

In recent years the enforcement of the traditional rules has come under pressure. Social control that prohibited farmers from violating the rules in the past has weakened. Main causes are:

- During the system modernization several previously independent diversion structures with their canals were combined into one new weir with canal, which upset the traditional water rights;
- Changes in cropping patterns, especially the cultivation of vegetables and bananas which require frequent irrigation gifts;

- New land developed by large landowners, which use water that should have been allocated to downstream users.

Field staff of the TDA are not adequately supported by the authorities to stop unauthorized water use and they cannot impose fines. One of the consequences has been a dramatic increase in the use of pumped groundwater.

A main objective of the re-establishment of the Irrigation Council is to address the above issues. The Council will have authority to deal with all O&M issues and water distribution of spates and base flows.

3 ORGANISATION OF WATER DISTRIBUTION

The WUAs are responsible to manage water distribution within their system. They are supported and supervised by the Irrigation Council.

3.1 Transfer of Responsibilities for O&M

To date the Government – Tihama Development Authority (TDA) in Zabid – was responsible for the operation and maintenance of the entire irrigation infrastructure.

After the recent improvements to the Zabid spate irrigation infrastructure, its management is now transferred to the WUA. This transfer of responsibility is done by means of the Work, Transfer and Support Agreement (WTSA or transfer agreement in brief). The transfer agreement is signed by each WUA before the start of construction or rehabilitation of works.

3.1.1 Transfer of responsibilities to Water User Associations

The responsibility for the future operation and maintenance of the system will be as follows:

- ***In the traditional spate irrigation systems (see Annex A):***
 - All temporary structures within the wadi and traditional free offtakes (oqma's and/or maqams);
 - All infrastructure within the traditional systems (canals, permanent and/or temporary structures, inspection roads, etc.)
- ***In the “modernized” spate irrigation systems (see Annex A)::***
 - All temporary structures within primary/main canals, if any;
 - All permanent and/or temporary irrigation infrastructure downstream of the secondary off-takes, i.e. canals, structures, inspection roads (if any), field outlets, temporary structures etc.

3.1.2 O&M Responsibilities remaining with the TDA

The Government remains responsible for the main system, i.e.

- Village protection works
- Wadi embankments
- All permanent irrigation infrastructure within the wadis (weirs and modified free off takes)
- Intake structures to primary/main canals
- The primary/main canal itself
- Permanent structures within the primary/main canal, including offtakes to secondary canals
- Inspection roads along side primary/main canals.

The government is not responsible for traditional offtakes in the wadi (unless they have been rehabilitated into permanent structures), and not for any infrastructure in the traditional canal systems.

3.2 Organisation of the TDA

The TDA for Wadi Zabid will function under instructions from the Irrigation Council. The unit will be responsible for O&M as described in paragraph 3.1.2.

The Zabid TDA will include an Operation Section and a Maintenance Section.

3.2.1 Operation section

The Chief of Operation will head a team that includes a hydrologist for monitoring and supervising the irrigation system operation and a WUA coordinator for guiding and assisting the WUA management boards.

The five weirs, modified offtakes and bifurcation structures will be operated by staff employed by the TDA. The weir operators will be provided with walkie-talkies for communication with the TDA and the Flood Early Warning System operators. The primary canals (check and drop structures and gates of secondary offtakes) will be operated by staff of the TDA, possibly by Irrigation Extension Workers, who will be provided with a motorcycle. A close coordination between main canal operators and WUAs is essential.

3.2.2 Maintenance Section

The Maintenance Section will be staffed by a Chief of Section, two surveyor/supervisors, a technician, and equipment operators.

The O&M unit for Wadi Zabid area will carry out routine and incidental maintenance, including minor repairs with a small pool of equipment. The equipment will also be used to carry out emergency repairs during the irrigation/flood season.

Any idle equipment can be rented to the WUAs at commercial rates.

3.3 Organisation and role of Irrigation Council

The Irrigation Council will monitor and coordinate all activities related to irrigation. The IC is the key actor between the TDA and the WUA. The IC consists of representatives of the TDA, the Local Council, the sixteen WUAs, and other relevant offices. The organisation structure for water management, including the Irrigation Council, WUA, WUG and (assistant) Water Masters is shown schematically in Figure 3-1.

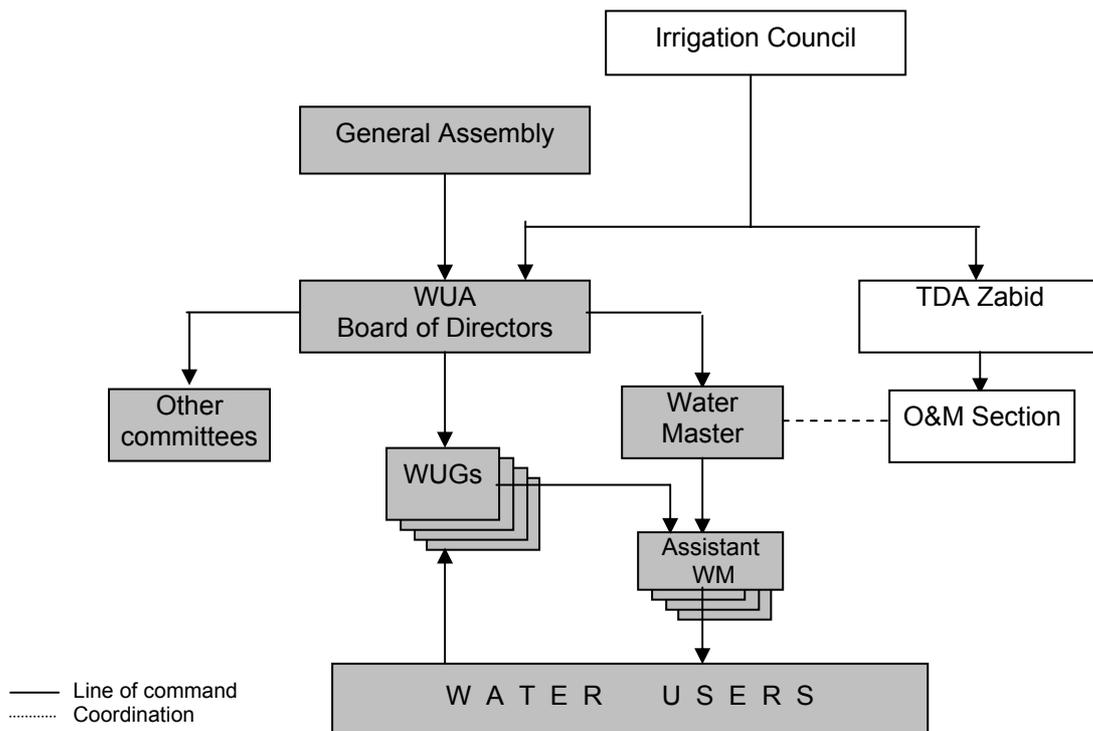


Figure 3-1: Organisation Structure for Water Management

Representatives of the water users can discuss water distribution issues with the Government agencies in regular meetings with the Irrigation Council. Each WUA has one representative in the Council and the sixteen representatives have a majority in the Council. Decisions of the council are binding to the TDA and the WUAs.

The By-laws and Internal Rules and Regulations of the Irrigation Council give a detailed description of the authority, tasks and responsibilities of the Council and committees set up by the Council.

Regarding O&M of the irrigation scheme, the main tasks of the Irrigation Council are as follows:

- Formulate policies on water management and related O&M aspects;
- Review and approve the annual plans of the WUAs and the TDA;
- Monitor the implementation of plans;
- Decide on new “temporary” structures within the wadis (oqma’s and/or maqams) or main canals as requested by WUAs or WUGs;
- Impose (financial) sanctions for violating the agreed rules for water distribution;
- Mediate in (major) conflicts over the water distribution, if requested by the WUA.

The Irrigation Council will not carry out any water distribution activities itself. It is also not responsible to carry out any maintenance or repair work.

The council, however, has an important role in setting general policies for the water distribution in the irrigation scheme. At the beginning of the year the council will review the annual work plans, the annual water distribution plan and maintenance plan of the TDA and the WUAs.

During the spate season the council will monitor implementation of the water distribution and maintenance plans. If any problems arise, the council may interfere and warn wrongdoers or impose sanctions or fines on individual water users or WUAs. The WUGs and WUAs can also contact the Irrigation Council directly and ask them to mediate in case conflicts over the water distribution arise.

The construction of any new (wadi) offtake or the diversion of water to non-irrigated lands should be approved beforehand by the Irrigation Council. Only after their approval, the modification in water distribution can be taken into account when the water distribution plan for the following year is prepared.

3.4 Organisation of the WUA

The WUA will appoint one or more Water Masters to organise and implement the water distribution. During the flood season the Water Master cannot control the water distribution in each canal. Therefore, Assistant Water Masters will assist him, appointed by each WUG to take care of the water distribution within the WUG area.

The Water Master can either be a member of the board or an ordinary member of the WUA. He will assist the board members with the preparation of the Annual Water Distribution Plan (see paragraph 4.1). After approval of the plan he will be in charge of implementing the water distribution.

His role is very similar to that of the former *Sheikh al-Obar* or *Sheikh al-Shareej*. But now he is backed by the WUA, while the Irrigation Council in turn supports the WUA. The Water Master will act on behalf of the WUA. If water users violate the distribution rules, the water master will coordinate with the Irrigation Council to determine and impose fines on them.

The Assistant Water Masters will work with the Water User Groups (WUG) under the guidance and supervision of the Water Master.

The proposed tasks and authority of the Water Masters are described in the Water Master's job description (see Annex B), and should be made well known to all WUA members. The Water Master's job description will be included in the annual water distribution plan of the WUA.

The number of Water Masters per WUA depends on the size of the irrigation system. It is proposed that one water Master should cover an area not larger than some 500 ha. In that case a WUA covering 1,000 ha would have two Water Masters.

4 PLANNING OF THE WATER DISTRIBUTION

4.1 WUA Annual Water Distribution Plan

It is unknown, beforehand, whether a cropping season will be dry, wet or very wet. Rainy seasons are known, but actual rainfall quantity and distribution remains to be seen. However, it is important to be prepared for spates and have a strategy to deal with them as they occur. The plan must cover the case when a number of large spates happen, but also for cases of a few small spates.

Well before the cropping season each WUA must formulate a water distribution plan. The purpose of this plan is to ensure good water distribution. The plan should present:

- 1) Water allocation rules
- 2) Distribution of water according to water rights (sequence of irrigating fields)

The water distribution plan will be part of the WUA Annual Work Plan. It will be prepared in December/January by the Board of Directors in cooperation with (assistant) Water Master and the individual WUGs.. An example of the contents of such a plan is shown in Table 4-1.

Table 4-1: Contents of the Water Distribution Plan

THE WATER DISTRIBUTION PLAN
<p>Annually the WUA will prepare a water distribution plan. The plan will be based on:</p> <ul style="list-style-type: none"> o Traditional water rights of the farmers o Policies and instructions from the Irrigation Council <p>The plan will show the following information:</p> <ul style="list-style-type: none"> • The size of the cropped and irrigated areas along each (sub)canal; • The sequence of water allocation to all (sub)canals and fields; • Rules on the use of base flow water; • Rules on allowable water depth application; • Rules on second irrigation gifts; • Rules on construction of ma'qams in different water courses or canals; • Name and agreed job description of the WUA Water Master(s) appointed to organise and implement the plan; • Names of WUG appointed Assistant Water Masters responsible for implementing the plan at WUG level; • For each gated structure, the name(s) of the persons authorized to operate the structure; • [a list of wells and their operating water depth allowed to be operated in the area] • <p>A clear, correct and transparent water distribution plan, which is approved by the General Assembly of the WUA and the Irrigation Council enables and supports a proper water distribution and reduces misunderstanding and conflicts!</p>

The WUA Irrigation Plan is established from the total quantity of water that is needed for irrigating the crops in a certain area of one water user group. The water demand from all WUGs together determines the total quantity of water that the WUA requires in an optimal situation where enough water is available.

The operation of weirs and main canals by the operating staff of the Government is based on the WUA Irrigation Plans.

4.2 Role of the Irrigation Council in the WUA distribution plan

The procedure of planning the water distribution is schematically shown in Figure 4-1.

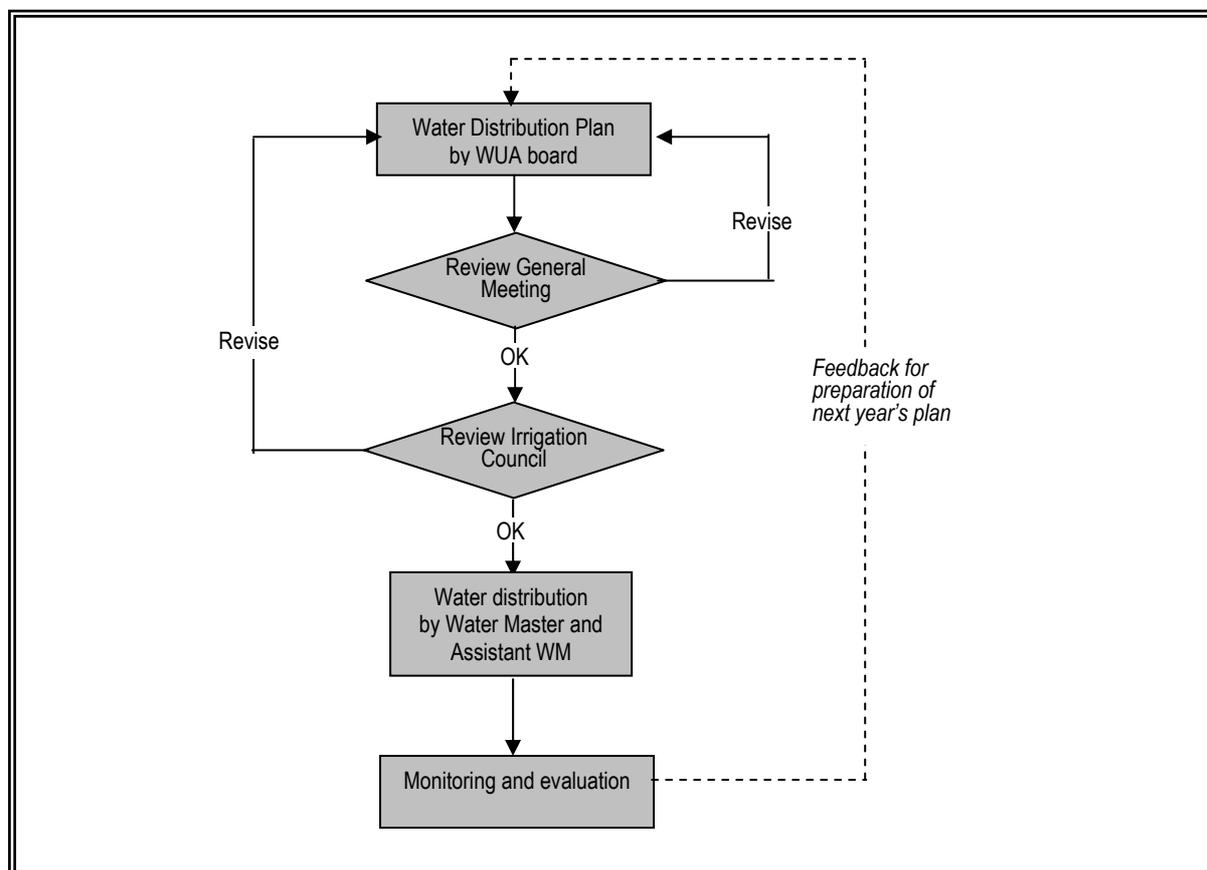


Figure 4-1: Planning Procedure for Water distribution

The Annual WUA Water Distribution Plan must be approved by the WUAs General Assembly. When it is approved it will be submitted for approval to the Irrigation Council.

There are three main reasons why the Irrigation Council should approve the WUA plan:

- 1) The Irrigation Council will check whether the plans of the different WUAs do not conflict with each other;
- 2) The Irrigation Council will instruct the TDA to operate the weirs, main canals and structures in accordance with the approved WUA plan;
- 3) The WUA can only receive assistance from the Irrigation Council in mediation of conflicts over the water distribution after the water distribution plan has been approved.

After approval by the Irrigation Council, the WUA board of directors will distribute copies of the plan to the WUGs and to the villages in the area and public places so that all water users can take notice.

The WUA and, in particular the Water Master, must implement the approved Water Distribution Plan. Table 4-2 shows the planning for preparation of a plan in order to be allowed to distribute the water in time before the arrival of floods.

Table 4-2: Time Schedule of Water Distribution Planning and Implementation

Main Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Spate irrigation season												
Planning												
WUA Preparation of Annual Work Plan	■											
Approval of AWP by General Meeting		■										
IC Review AWP of all WUAs			■									
ID Preparation of Irrigation Plan		■										
IC Review Irrigation Plan			■									
Implementation												
IC Operation main system				■	■	■	■	■	■	■	■	■
WUA Water distribution sec./tert. level				■	■	■	■	■	■	■	■	■
ID Monitoring, data collection	■	■	■	■	■	■	■	■	■	■	■	■
ID Evaluation, reporting											■	■

4.3 Coordination between WUA and the Government

Various organizations have their assigned responsibilities in the distribution of spates. (see table 4-3). The TDA in Zabid is in charge of preparing an annual Irrigation Plan for the entire irrigation scheme. This overall plan will combine the information that is obtained from plans of the 16 WUAs. It will specify operation instructions for the weir operators and, in the modernized parts of the irrigation system, the operation of the main canals. The Irrigation Council must also approve the Irrigation Plan.

The WUA is entirely in charge to operate the traditional water distribution systems. However, in the modernized parts of the irrigation system the tasks of the TDA and the WUAs overlap. The TDA is responsible for operation of the primary canals including the secondary offtake gates. The WUA is responsible for operation of secondary and tertiary canals.

In the overlapping area of the two parties involved, which is at the offtake to the secondary canal(s), there is a need for close coordination in all stages between the TDA and the WUAs.

Table 4-3: Planning, implementation and monitoring of water distribution

Actor		Planning	Implementation	Monitoring
Irrigation Council	Entire system	- Review, approval	-	Overall implementation
TDA	Wadi Main system	- Water distribution	Gate operation: - weir - primary canal	- Wadi flow - Flow main canals
WUA (water master)	Primary system Secondary system	- Irrigated areas - Sequence of irrigation	Gate operation: (**) - primary canals - secondary canals	Irrigation: - Area - Duration
WUG (assistant water master)	Tertiary system	- Irrigation areas - Sequence of irrigation	Operation tertiary unit	Irrigation: - Area - Duration
Water users	Farm	- Crops, irrigated area	Field irrigation	-

(**) **Overlapping area:** Assistance from water master to Government Operators.

In the overlapping area, it is of utmost importance to have good coordination between the government staff and the WUA water master to ensure satisfactory water distribution.

5 IMPLEMENTATION OF WATER DISTRIBUTION PLAN

By mid March the Irrigation Plan of the WUAs and TDA must be completed and approved by the Irrigation Council. Implementation of the plans will start with the arrival of the first spates.

Farmers need time to prepare their fields properly before the arrival of floods. Therefore, it is essential to distribute water according to the approved plans. When the available water is distributed according to plan conflicts can be avoided or kept to a minimum. If conflicts arise about the water allocation during distribution the Irrigation Council can only play a mediating role if the Irrigation Plan is being implemented.

During water distribution circumstances may change. Canals or structures may get damaged, or for other reasons adjustments to the plan may be necessary.

Modifications to the water distribution plan should have the prior approval of the WUA board and WUG board, if it concerns water distribution within the WUG area.

However, in case of emergencies, the water master is allowed to change the water distribution temporarily whereafter he has to inform the WUA and Irrigation Council.

It is important to record if a plan was carried out as it was intended. Any changes that were made must be used as lessons learned for the preparation of next year's plan. Section 7.6 gives more explanation on this subject.

Annex H includes maps of the 16 WUA command areas showing the layout of the distribution system and WUG pertaining to the WUA.

6 STRUCTURE OPERATION

6.1 Operation of conveyance infrastructure by the TDA

6.1.1 Flood Early Warning System

It is recommended that an additional water level station be installed some 15 km upstream of Al Khola. During the spate season operators would be stationed there and give early warning of spates to the office of the O&M organisation as well as directly to the weir operators. The weir operators alert the water users by any other means.

6.1.2 Operation of the headwork

At each weir the TDA has appointed weir operators to guard the installations and to operate the canal head regulator and sluiceway gates in accordance with the Irrigation Plan of the TDA. Normally, the head regulator gates will remain open to ensure any spate to enter the canal.

During operation the canal gates will only be closed under the following conditions:

- 1) If all farmers in the area have received their water right
- 2) In case of very big floods – to avoid damages to the infrastructure by the force of water and amount of sediments

6.1.3 Operation of the sluiceway

A key feature for the successful operation of the canals is the proper operation of the sluiceways. The purpose of the sluiceways is:

- To keep an open channel from the main wadi flow channel to the head regulators;
- To exclude sediments from the flow into the main canal

In principle the sluiceway gates will be closed when the canal is in operation and remain open while the canal is not in operation.

However, under the following conditions the sluiceway gates will be opened:

- 1) If the entire area has received one full irrigation gift. In this case the flow through the sluiceway will ensure to keep an open channel to the head regulator,
- 2) In case of large floods, to separate sand and stones from the flow into the main canal, or
- 3) In case of big floods to avoid damage by overtopping of the embankments.

IIP constructed skimming weirs on Weir 3 and Weir 1. When irrigation takes place through the Head Regulator of the Canals on Weir 1 and 3, it is recommended that the operators should maintain the sluice gates about 20 cm open throughout the flood in order to flush out accumulated sediments upstream of the skimming weirs.

6.1.4 Operation of the main canal and bifurcation structures

In the modernized systems the TDA will remain responsible for operation of the main canals, including the bifurcation structures. Operation of the gates should be executed in accordance with the Irrigation Plan and traditional water rights.

6.2 Operation of structures by the WUA

The operation of structures in the secondary and tertiary canals should be executed in accordance with the WUA Irrigation Plan. This is further explained in the next paragraphs.

6.2.1 Check structures in main and secondary canals

- The gates may be closed during periods when upstream branching canals or farm turnouts are to be supplied and downstream areas have no right to water;
- A clear mark on the concrete upstream of the gates should indicate the maximum level to which the water may be raised by closing the gates, without the risk that the water will overflow the canal embankments; When water overtops this mark, gates must be opened gradually.
- Closing the gates of check structures will reduce flow velocities in the canal and increase sedimentation; it is recommended to always allow some flow under the gates carrying sediments;
- Opening the gates after they have been closed for some time should proceed gradually to avoid erosion by the sudden inflow of a large amount of water into the dry canal.

6.2.2 Turnouts to secondary and tertiary canals

- During periods without canal flow only the gates of those canals, which have the right to the next irrigation will be open; gates of all other turnouts should remain closed.
- When sufficient water has been applied close the gates to avoid waste of water and possible damage by water ponding and breaking into other canals;
- During very low flows there might be problems of insufficient water head to adequately serve certain turnouts. These problems should only be solved by the authorized staff;
- Raising the sill of drop structures, if necessary, with stoplogs, will increase the upstream water levels. The construction of earth or brush dams in the canals is not permitted.
- Before opening or closing a gate, check for debris or sediments that may block the gate. Do not use excessive force!
- At the beginning of irrigation open the gates gradually to allow the field channels to fill up and avoid erosion.

6.2.3 Operation of Canal cross regulators

Their function is to raise the canal water level to facilitate inflow into upstream farm turnouts.

- Normally, the gates will remain closed to divert any spate water and they will be opened only when the upstream turnouts have had their allocated share of water.
- If the canal flow is too big for the turnouts, or if at the same time downstream turnouts need to be supplied, the gates should be partially opened.

6.2.4 Operation of Farm turnouts

- Farm turnouts should remain closed during periods without canal flow except those turnouts which have the right to the next irrigation;
- Farm turnouts should be opened strictly in accordance with the Water Distribution Plan. Any violations should be reported immediately to the (assistant) Water Master of the area;
- If the turnout is equipped with a gate, don't use excessive force if the gate cannot be properly opened or closed. First clean the gate and the flow path under the gate.

The Water Master and his assistants will keep record of the irrigation to each part of their area. The forms shown in the Annex C can be used. This is further explained in paragraph 7.6.

7 MAINTENANCE

A regular program of inspection and maintenance is essential to keep the infrastructure in proper working condition. Without it, canals will silt up, embankments erode, culverts will be blocked by debris and gates get out of order. Maintenance is often confused with repair, but there is a clear difference. Repair is done only after the system has broken down, and as such can be part of a maintenance programme. But maintenance should be done also when the system is still working properly. In fact, a main objective of maintenance is to prevent breakdowns and the need for repairs.

7.1 Types of Maintenance

The following types of maintenance are distinguished:

- **Care taking** Maintenance activities that are carried out during normal operation of the system and which do not require special budget or equipment other than simple hand tools. Examples are removal of debris from a canal or structure, inspection, cleaning and tightening nuts and bolts of gates and railings, cleaning of culverts.
- **Routine maintenance** Maintenance activities that do require purchase of material and/or the use of special equipment, which will be needed at regular intervals. Examples are greasing of gates, painting of iron works, desiltation of canals, repair of oqmas and maqams, etc. These activities should be planned beforehand.
- **Repair and/or replacement** These activities are needed occasionally only, and will be identified during seasonal or annual maintenance surveys. Together with routine maintenance activities, repairs and replacements will be part of the annual maintenance plan (see paragraph 7.2.2).
- **Emergency maintenance** This concerns repairs needed immediately as a result of breakdowns or calamities. They cannot be planned in advance. The annual estimated maintenance costs should be flexible or should include special funds for emergency repairs.

7.2 Planning and Preparation

7.2.1 Maintenance inspection

The annual cycle of maintenance activities starts with a full system inspection by WUA board members after the flood season, i.e. in November. The WUA and WUG board members will walk through the entire area of each WUG of the WUA to check the (irrigation) infrastructure. For each canal and for each structure they will note down the maintenance to be carried out and repairs, together with estimates of the required quantities. The results of the maintenance inspection survey can be written down in the WUA irrigation assets book (see annex D and chapter 8).

Next the board members have to determine who will do the work (individual WUG or WUA) and when. Normally, the concerned WUG can handle the repair work in case limited amount of labour is required. Bigger works, especially those affecting more than one WUG and/or requiring substantial funds, will be the responsibility of the WUA.

During the inspection it may appear that some parts of the system are no longer needed, or are too difficult to operate. In that case it might be decided to selectively neglect these parts.

After visiting all WUGs the board will combine the inspection results in a Maintenance Inspection Report, which will be part of the WUA Annual Report.

7.2.2 Annual Maintenance Plan

The Management Board of the WUA prepares the Maintenance Plan for the coming year. For this they will use the results of the maintenance inspection. The maintenance plan will be part of the Annual Work Plan and Budget of the WUA. The content of the plan is shown in Table 7-1.

Table 7-1: Contents of the Annual Maintenance Plan

ANNUAL MAINTENANCE PLAN	
Annually, the WUA will prepare a maintenance plan after the flood season. The plan will be based on:	
<ul style="list-style-type: none"> ○ Results of the maintenance inspection carried out in November; ○ Agreements with the individual WUGs on who will do what. 	
The Maintenance Plan will include the following information:	
<ul style="list-style-type: none"> • A programme for <u>care taking and simple routine maintenance</u> jobs: <ul style="list-style-type: none"> ○ Names of persons responsible to look after the canals and structures (usually one or more people per WUG) and the area for which they are responsible; ○ Required frequency of gate inspection and cleaning (once a month, as well as after floods); ○ Required frequency of oiling the gates; ○ List of gates to be painted, by whom and when; ○ List of materials to be purchased with costs (cleaning tools, hand tools, grease or oil, paint). • A list of <u>maintenance/repair work</u> to be organised and carried out by the individual WUGs • A list of <u>maintenance and repairs/replacements</u> to be organised and carried out by the WUA. For each work the plan should mention: <ul style="list-style-type: none"> ○ Implementation procedure: labour to be provided by WUA members with or without payment, machinery to be rented, or work to be contracted out; ○ Estimated number of skilled and unskilled labour required and costs (if applicable); ○ Estimated quantities and costs of materials to be purchased; ○ Type, number of days or hours, and costs of machinery required; ○ Time plan of implementation (when, how long); ○ Responsible person to organise and implement the work (either a member of the WUA board or a WUA member assigned by the board). 	

The plan will be prepared in December/January by the Board of Directors and/or persons assigned by them. See the time schedule of table 7-2. After the Audit & Inspection Committee has reviewed the plan it will be presented and discussed at the General Assembly of the WUA. Following their approval, the plan will be submitted to the Irrigation Council for approval. In the mean time, any contracts for labour and/or machinery, if foreseen in the plan, will be prepared and quotations will be requested from suppliers for tools or materials, which may need to be purchased. Signing of contracts

can take place as soon as the Irrigation Council has approved the Annual Work Plan. It is expected that execution of the work can then start in March.

Table 7-2: Time Schedule of Maintenance Planning and Implementation

Main Activity	M o n t h											
	J	F	M	A	M	J	J	A	S	O	N	D
Spate irrigation season												
<i>Planning and preparation</i>												
WUG, WUA Water use fee collection												
WUG, WUA Annual maintenance inspection												
WUA Preparation of Annual Work Plan												
WUA Approval of AWP by General Meeting												
IC Review/approval of AWP												
WUA Preparation, signing of contracts (if any)												
<i>Implementation</i>												
WUG, WM Care taking during operation												
WUA Maintenance (by WUA or contractor)												
WUA, WM Emergency maintenance												
WUA Evaluation, reporting												

7.3 Maintenance Implementation

As mentioned earlier, care taking and minor maintenance/repair works that require only limited labour will be implemented by the individual WUGs. Normally the work will be done by voluntary labour contributions from the WUG members. The WUG leader will inform the members about date, time and place, and tools to be brought along.

Implementation of bigger works will be organised by the WUA management board. For each work a proper cost estimate is required and thereafter the WUA board members will decide how the work will be implemented. Methods to estimate costs are explained in Annex E and chapter 8.

There are several options to implement the maintenance. This is explained in the next paragraphs.

7.3.1 Implementation by WUA labour

This is similar to the implementation of works by a WUG as explained above. In this case, however, the WUA Director can decide whether or not to pay compensation to those participating in the work out of the general WUA funds.

7.3.2 Implementation by hired labour

Hiring of labour is recommended for jobs that require skilled labour and/or when WUA members are busy (peak of agricultural season). For each laborer a simple contract shall be prepared, specifying the kind and quantity of work to be carried out, the period and time for implementation, and the compensation to be paid (how much and when). Payment shall be based on the amount of work done rather than on number of days present at the site.

7.3.3 Purchase of material or equipment

Materials or equipment that need to be bought for maintenance purposes shall be described as detailed as possible regarding amount, type, quality, and specifications. Normally, the purchase shall be based on written quotations from at least three different suppliers. Tendering might be considered in case substantial purchases are needed but it is unlikely that the WUAs will do such purchases in the near future/any time soon.

7.3.4 Implementation with hired equipment

Before the establishment of the WUAs, this was already practiced by groups of farmers or even by individual farmers. They often rented the equipment from the TDA against lower rates than those from contractors. In future, however, the number of equipment managed by the TDA will be reduced, and it may no longer be possible to rent equipment from the Department. The WUA will have to apply to commercial companies or might consider purchasing their own equipment.

For hiring equipment, a written agreement with the supplier is needed specifying the kind and amount of work to be carried out, the place and period for implementation, and the cost (how much and when).

The quantities, duration and (kind of) equipment needed for maintenance of earth works might be difficult to estimate. In that case the contract may be based on a daily or hourly rate only, provided the WUA management board could properly supervise implementation of the work.

7.3.5 Implementation by contracting

The WUA could contract routine maintenance work, repairs or replacements entirely to an outside organisation, usually a commercial contractor. This is advantageous in particular if specialized labour or equipment is needed or when jobs need to be done in which the WUA lacks experience and which a contractor can do more efficiently. Another advantage is that the WUA members do not have to contribute their labour and that the WUA board does not have to organise the work themselves, which in principle saves time of the board members. In practice, however, it should be remembered that contracting requires supervision and inspection of the work. A disadvantage of contracting is that costs may be higher as the contractor needs to bill his overhead costs and profit margin.

Contracting requires detailed description of the work needed, including quantities and technical specifications. Prior to the negotiations with a contractor the WUA should prepare an estimate of the costs. In Annex F a sample contract is given, in Annex G simplified technical specifications for various types of work are given which should be part of the contract.

7.4 Care taking and Routine Maintenance

The persons assigned by the WUGs and WUA board are responsible for checking and care taking throughout the year. Inspection for routine maintenance will be the task of (members of) the WUA Board of Directors. In the next paragraphs is explained which (inspection) activities are required for care taking and routine maintenance of various parts of the irrigation infrastructure.

7.4.1 Canals

Care taking

Care taking of canals includes the removal of any debris or excessive vegetation that obstructs the water flow. The canals should be regularly checked for excessive sedimentation.

Routine maintenance

During the annual maintenance inspection the amount of desilting to be done in a particular canal will be estimated from the length, width and thickness of the sediment layer.

The canal embankments will be inspected for damage. Repairs of such damage will include the complete removal of affected soil and rebuilding the embankment in layers of 10 to 20 cm, carefully compacting each layer before applying the next layer.

7.4.2 Inspection roads

Care taking

Care taking of the inspection roads includes the filling-up of potholes and removal of debris from side drains (if present). Standing (rain)water on roads should be avoided as much as possible.

Routine maintenance

At least once a year gravel roads require maintenance by re-grading of the road surface. Once every 3 to 5 years the application of a new gravel layer, including compaction is required. This depends, however, on the type and density of traffic on the road. The need for re-grading and re-graveling will be determined for each road during the annual maintenance survey.

7.4.3 Culverts***Care taking***

Any debris or excessive sediments in the culvert and immediately upstream of the culvert that may obstruct the flow should be removed.

Routine maintenance

Annually the concrete and sidewalls should be checked on cracks and erosion damage of backfill behind the concrete, and if found repair should be included in the maintenance plan.

7.4.4 Drop structures***Care taking***

After storms, the structures should be checked and any debris removed.

Routine maintenance

The condition of riprap and concrete should be checked annually. In particular, the condition of floor blocks, sills and the vertical concrete faces in the drop should be checked on excessive abrasion. Identified repairs will be included in the annual maintenance plan.

7.4.5 Turnout structures***Care taking***

After storms, any debris obstructing the water flow and/or the gate operation should be removed. Gates and hoisting devices should be regularly cleaned and inspected for proper functioning and adjusted, if necessary. Loosened bolts and nuts should be tightened. At least every three months old grease should be cleaned and new grease applied to the stem and hand wheel bearings.

Routine maintenance

During the annual inspection open and close the gates through a complete cycle. Inspect the condition of the gate, gate guides, stem and hand wheel. Check alignment of the stem and check stem support for loss of bolts or being forced out of line by excessive hand wheel pressure. Replace bolts and correct the alignment if required. The condition of riprap, concrete and backfill should be checked annually and repairs included in the maintenance plan.

7.5 Record Keeping and Reporting

As mentioned in Section 4.1, the results of the annual maintenance inspection will be recorded in the Maintenance Inspection Report, which will be part of the Annual report of the WUA and which will form the basis for the Annual Maintenance Plan.

It is strongly recommended that upon completion of any major maintenance or repair work a brief Maintenance Completion Report be prepared describing:

- Location, date and type of work implemented (including quantities if available);
- Implementation procedure, with details of contracts if applicable;
- Number of labour days spent and compensation paid (if any);
- Type, amount and costs of materials purchased;
- Type, number of work hours and costs of machinery used.

The report will be prepared by the person assigned to supervise the work, and will be reviewed by the WUA Director. The report not only serves for technical and financial accountability but will also be useful to estimate costs for similar work in the future.

All reports will be properly filed in the maintenance register of the WUA.

Maintenance Register of WUA

As part of their administration, the WUA will keep a Maintenance Register. The register will contain the following documents:

- Annual Inspection Reports
- Annual Maintenance Plans
- Maintenance Completion Reports

7.6 Monitoring and Evaluation

The main objective of monitoring activities is to

- Compare the actual water distribution with the planned water distribution as described in the Irrigation Plan;
- Assess the effectiveness and equity of water distribution.

The Water Master and his assistants will keep record of the irrigation to each part of their area. This will serve both as evidence in case of conflicts over the water distribution, and for evaluating the water distribution after the season.

The forms shown in the Annex C can be used. In the form M-2 the irrigation supply to different (parts of) canals or areas is recorded in chronological order. For each area the start and end times of the irrigation are entered from which the duration of the irrigation is calculated. The actual area irrigated is estimated (which may be very different from the area mentioned in the irrigation plan), as well as the average depth of the water gift, and these are entered in the last two columns of the form.

At the end of the season Form M-4 is used to summarize the water gifts to each (parts of) canal or area. If an area is irrigated more than once this is indicated on the same line as the first irrigation. Again, the estimated actual irrigated areas and water depth are entered as well. From this form it can easily be seen which areas received (a lot of) water or suffered from shortage. Comparing these results with the initial water distribution plan prepared before the season can be a sound reason to change next year's water distribution plan. The result of the comparison should be kept on file by the WUA and is explained during the annual WUA General Assembly. The Irrigation Council and TDA receive a copy of the results.

8 ANNUAL COST OF O&M

Annual budget requests should be based on actual conditions and actual maintenance and repair needs as determined from field inspections. For this, an “Irrigation Assets Book” can be used, which is to be filled in during field inspections of the WUG command area. The forms of a typical asset book are presented in Annex D. The assets database is an inventory, in which (dimensions of) canals and structures (permanent and temporary) can be recorded. Once the main inventory data has been entered maintenance will be restricted to making corrections, small deletions and additions. The inventory will form the basis for any O&M recording system at WUA level.

Unfortunately, the annual Government budget cycle requires budget requests to be submitted by the middle of the year, i.e. well before the end of the spate season. At that time the precise repair needs are not yet known and the requested budget will be a rather general one. After the spate season, field inspections will show the real repairs needed, and while at that time it may not be possible to change the total budget amount, it may still be possible to adjust the allocation of the budget over different works.

8.1 Operational costs

The following operational costs are distinguished:

- ***Staff salaries and allowances***
The annual costs are estimated from standard salary rates.
- ***Operation costs of facilities and equipment***
The costs are based on the recommended facilities and equipment and include office operation costs, operation and servicing costs of transport and communication equipment.
- ***Replacement costs of equipment***
All equipment has a limited lifetime and at a certain moment needs to be replaced. The average annually required budget is estimated from the new price of the equipment divided by the expected lifetime of the equipment.

8.2 Routine and incidental maintenance costs

Maintenance of all canals and structures downstream of the secondary turnout as well as all temporary wadi works and the traditional systems will be the responsibility of the WUAs. The WUA will carry out its regular maintenance and small repairs. In Annex E an example of the O&M costs for a WUA are presented. If available, the WUA could rent equipment from the TDA for execution of large works, which are not suitable to be implemented by labourers. Otherwise, the WUA can contract works to a contractor. A model contract for execution of work by contractor is enclosed in Annex F.

- ***Maintenance of canals***

Maintenance of the main canals will consist mainly of regular desiltation. Siltation rates will vary throughout the system and distribution network. Each WUA will need to keep records on the quantities of siltation removed per year in order to determine reasonable estimates for the future.

During the irrigation season emergency repairs may be needed.

- ***Maintenance of service roads***

The service roads along the canals need annually reshaping, and once in 4 years re-gravelling. Unit rates have been used from costs of IIP road repair works.

- ***Routine maintenance of structures and buildings***

This includes:

- (1) Cleaning, oiling and greasing of gates and lifting devices, replacement of bolts and nuts, and clearing of debris in front of the gates.
- (2) Painting of metal work
- (3) White-wash of building walls and ceilings, painting of door and window frames

- ***Incidental maintenance of structures and buildings***

This includes major repairs and/or replacement. Costs should be annually estimated from surveys. For the purpose of the present cost estimates, the average annual costs are based on the new price and the expected lifetime of the items concerned.

8.3 Emergency maintenance costs

Costs of emergency maintenance cannot be determined in advance. Nevertheless, it is important that budget provisions are made for emergencies, if necessary by building in some flexibility in other budget items. Usually, a 10% contingency sum over the total costs is included to cover emergency costs.

ANNEXES

Annex A	Traditional and Modernized Irrigation Systems
Annex B	Job Descriptions
Annex C	Monitoring Forms
Annex D	WUA Irrigation Assets Book
Annex E	Estimation of O&M costs
Annex F	Model contract for execution of work by contractor
Annex G	Simplified technical specifications for civil works
Annex H	Layout of 16 WUAs including the WUG areas

ANNEX A

TRADITIONAL AND MODERNIZED CANAL SYSTEMS

Following the construction of permanent weirs in the wadi, in the 1960s and 70s parts of the Zabid irrigation canal system have been improved as well. The main objectives of the improvements were to provide better control over the water flows, to make operation of the system less labour intensive, and to improve access to the area. A grid of straight primary, secondary and tertiary canals was constructed, and permanent water control structures were installed. Roads have been made along many of the canals to improve accessibility by car. The main differences between the traditional and modernized canal system layouts are summarized in the table below.

<i>Traditional system</i>	<i>Modernized system</i>
<ul style="list-style-type: none"> ● Opening and closing the canal is labour intensive ● Winding canals ● Water control in canals by temporary earth bunds (ma'qams) ● Water diversion from canal through opening and closing the earth embankments ● After the main canal, water is supplied from one field to another ● Difficult access by car 	<ul style="list-style-type: none"> ● Opening and closing by gates at the head regulator ● Straight canals ● Water control in canals by permanent drop- and check structures ● Water diversion from canal through turnout structures with gates ● Secondary and tertiary canals to convey water to the fields ● Roads along all main canals, bridges to cross the canals

Layout of the Modernized Systems

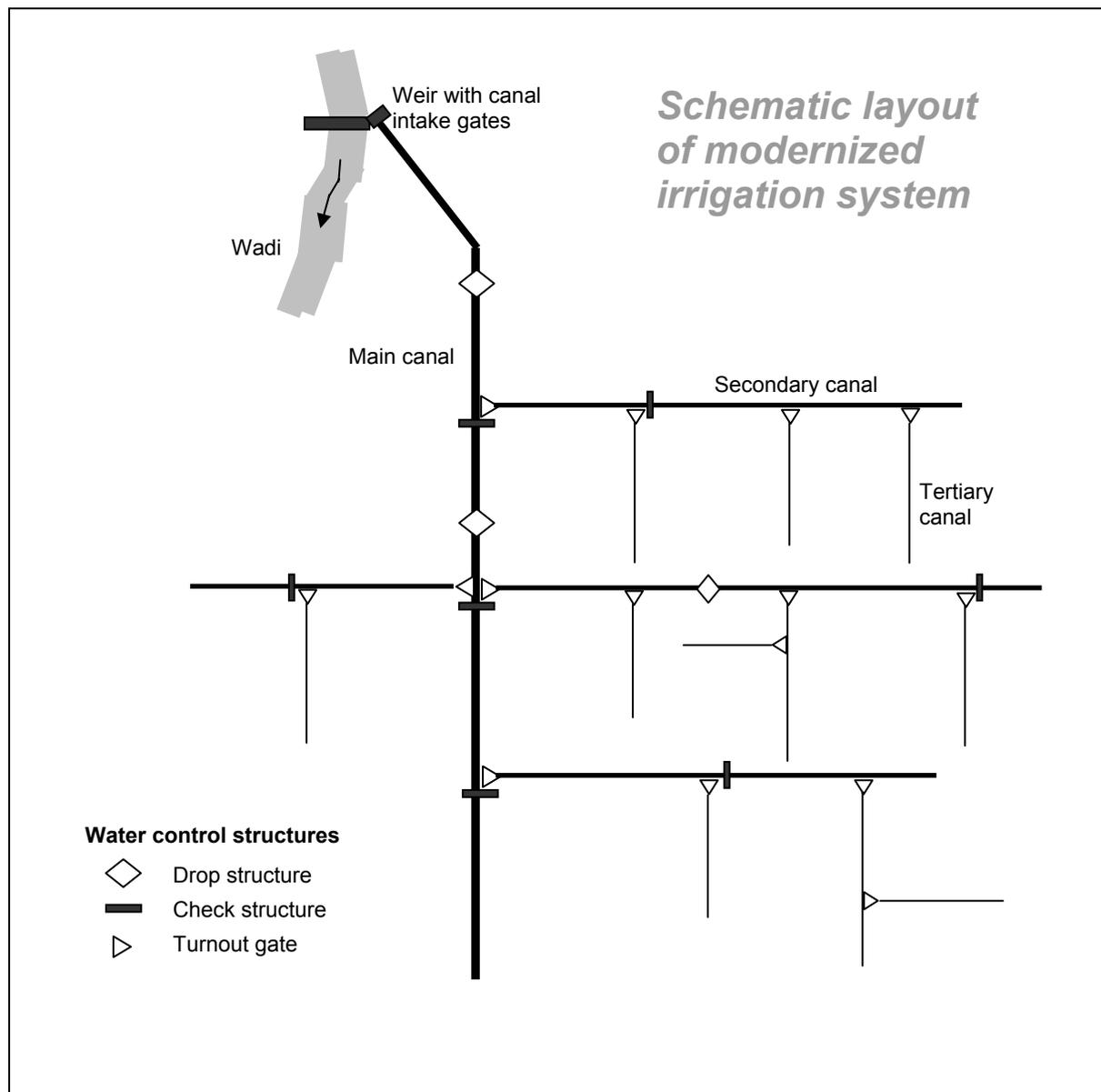
The basic layout of the modernized system is shown in the figure below. Going from the permanent weir in the wadi to the farmers' fields, the system consist of:

- ***Primary canal***
This canal conveys the water from the weir in the wadi to the irrigation area. Being the first canal after the wadi, a lot of sediments are deposited in these canals and regular maintenance is required. As mentioned in Chapter 3 this is the responsibility of the O&M Unit of TDA.
- ***Drop and/or check structures in primary canal***
To avoid too steep slopes and hence too great flow velocities in the canal, concrete or masonry structures are built where the bottom of the canal drops over a height of 1 or 2 meter or even more. In this way, the slope and the flow velocity in between the structures can remain limited.
Check structures are built across the canal and are provided with gates. By closing the gates the water-level in the canal upstream of the structure is raised which in turn facilitates the outflow from the main canal into secondaries or fields.
Often, drop and checks are combined into one structure, a drop/check structure.
- ***Secondary turnout gate***
The water flows from the primary through a secondary turnout structure into the secondary canal. This structure consists of one or two gates in the embankment of the primary canal and a culvert under the embankment of the canal.
- ***Secondary canal***
These canals convey the water further to different parts of the cropped area. In the canal again drop- and check structures may or may not be present, depending on the slope and other characteristics of the area.

- **Tertiary turnout gate**
From the secondary canal the water flows into the tertiary canals through structures similar to the secondary turnout gate, but smaller in size.
- **Tertiary canal and farm turnout**
The tertiary canals finally bring the water to the farmers' fields. Turnouts from the tertiary canal to the field may consist of structures with gates or may be temporary openings in the canal embankment.

The above layout is not always strictly followed. Where more convenient, farm turnouts take off straight from secondary or primary canals, and in those places there will be no tertiaries.

Figure 1: Schematic layout of Modernized Irrigation System



ANNEX B
JOB DESCRIPTIONS

- 1 Water Master**
- 2 Assistant Water Master**

1. Job Description of WUA Water Master

The Water Master is in charge of daily operation and care taking of the irrigation system in the WUA area. His role is very similar to that of the former *Sheikh al-Obar* or *Sheikh al-Shareej*. He will be selected from among respected members of the WUA, and will be responsible to the Director of the WUA. He will cooperate closely on the one hand with the weir/canal operators and staff of the TDA, and with Assistant Water Masters appointed by the WUGs on the other hand. He will be provided by the WUA with all necessary documents (maps, inventory lists, reporting forms etc.) and with adequate means of transport.

Below, tasks are listed which may be part of the job description of the Water Master. It will depend on each WUA to decide whether to assign all these tasks to the Water Master, or to assign some of the tasks to others. The WUA might for example decide to assign maintenance tasks to a separate person or committee.

Water distribution tasks

- To assist with the preparation of the annual water distribution plan of the WUA;
- To inform the water users about the approved water distribution plan;
- To inform the water users about the opening of the gates of the diversion weir/diversion of (spate) water into the main canal(s);
- In the modernized systems, to assist the government's appointed weir/canal operators with the operation of the checks and turnout structures of the main canal;
- To distribute (spate) water in accordance with the approved water distribution plan of the WUA, including the operation of control structures in secondary and tertiary canals;
- To supervise the water distribution activities of Assistant Water Masters appointed by the WUGs;
- To solve conflicts over the water distribution and/or report the conflicts to the WUA Chairman;
- To monitor and record the actual supply of (spate) water to each part of the area;
- Daily inspection of the irrigation infrastructure during the irrigation season and report any damage, problems or unusual events to the WUA Chairman;
- To assist with preparation of the annual report of the WUA.

Maintenance tasks

- To undertake care taking activities of all infrastructure works during the flood/irrigation season to allow the (spate) water to flow safely and adequately;
- To participate in the annual maintenance inspection;
- To assist in the preparation of the Annual Maintenance Plan;
- To organise (routine) maintenance and (minor) repair works in accordance with the approved Annual Maintenance Plan;
- To assist the Board of Directors with organizing and carrying out emergency repairs;
- To assist with the implementation of maintenance activities by the individual WUGs;
- To supervise the implementation of maintenance or repair work contracted out by the WUA to outside persons, organisations or contractors.

2. Job Description of Assistant Water Master

The Assistant Water Master is in charge of daily operation and care taking of the irrigation system in the WUG area. His role is very similar to that of the former *Sheikh al-Obar* or *Sheikh al-Shareej*. He will be selected from among respected members of the WUG, and will be responsible to the chairman of the WUG. During the irrigation season he will work under instructions of the WUA Water Master.

Below, tasks are listed which may be part of the job description of the Assistant Water Master. It will depend on each WUG to decide whether to assign all these tasks to the Assistant Water Master, or to assign some of the tasks to others. The WUG might for example decide to assign maintenance tasks to a separate person or committee.

Water distribution tasks

- To receive a copy of the approved annual water distribution plan of the WUA, and to inform the water users about the plan;
- To inform the water users about the opening of the secondary/tertiary gates;
- To distribute (spate) water in accordance with the approved water distribution plan to the farmers;
- To assist the WUA Water Master with the operation of the checks and turnout structures of main and secondary canal;
- To solve conflicts over the water distribution and/or report the conflicts to the WUG chairman;
- To monitor and record the actual supply of (spate) water to each part of the area;
- Daily inspection of the irrigation infrastructure during the irrigation season and report any damage, problems or unusual events to the WUG chairman.

Maintenance tasks

- To undertake care taking activities of all infrastructure works during the flood/irrigation season to allow the (spate) water to flow safely and adequately;
- To participate in the annual maintenance inspection;
- To assist the WUG management board to organise (routine) maintenance and (minor) repair works;
- To assist the WUG management board to organise and carry out emergency repairs;
- To assist with the organizing and implementing maintenance activities initiated by the WUA.

ANNEX C

MONITORING FORMS

- M1 Monitoring of main canal intake flows
- M2 Monitoring irrigation
- M3 Seasonal evaluation of irrigation supply
- M4 Summary of irrigation monitoring

Annex D

Wadi Zabid Irrigation Scheme

Irrigation Assets Book

W U A :

Contents

1	WUA Management Board
2	WUG Chairmen
3	Membership of WUA and WUGs
4	Map of WUA irrigation area
5	Equipment inventory of WUA
6	Irrigation assets of WUG 1
7	Irrigation assets of WUG 2
8	Irrigation assets of WUG 3
9	Irrigation assets of WUG 4
10	Irrigation assets of WUG 5

11	Summary irrigation assets entire WUA

Name of WUA Ras Al Wadi

Registration number 1089275

Date

Address

1. WUA Management board

Position	Name	Address
Chairman	Salem Saef Godan	
General Secretary	Abdullah Fadl Abdul Hamid	
Financial Officer	Mohamed Salem Satih	
Culture & Information	Abdo Saef Raga	
General Activities	Hamid Mohamed Abdullah	
General Secretary	Haidara Khosif Jasim	
Public Relations	Ali Abdo Ahmed	

2. WUG Chairmen

No.	WUG name	Name of leader	Address
1	Ober Farid	Mohamed Abdo Kamel	
2	Ober Mukhareg	Mohamed Salem Suteh	
3	P1	Mohsen Mohamed Uleib	
4	P2	Mohamed Naser Khameez	
5	P3	Hasim Mohamed Saleh	
6	P4-1	Mohamed Saleh Adul Ahmed	
7	P4-2	Ali Abd Ahmed	
8	P4-3	Abdul Saleh Ali Al Afach	
9	P5	Al Bin Ali Hassan Al Shegri	
10	P6	Khalid Salem Altom	
11	P6-1	Ahmed Ali Ahmed Sharif	
12	P6-2	Mohamed Tohish Ali Shomaila	
13	P6-3	Gamal Mustafa Abdullah Mahbob	
14	P6-4	Salem Saif Jowdan	
15	P7	Ahmed Mohamed Ali	
16	P8-1	Yeslim Ali Shumailah	
17	P8-2	Abdullah Bin Abdullah Khameez	
18	P9	Ali Mahmud Rajeh	
19	P10-1	Hamid Mohamed Abdan Salah	
20	P10-2	Hamid Ali Hirsy Ahmed	
21	P11	Adnan Fadel Naser	

3. WUA membership

No.	WUG name	Area (feddan)	Area [ha]	No. of farmers	Membership WUA	
					No. of farmers	Area (ha)
1	Ober Farid	23.0	9.585	52		
2	Ober Mukhareg	43.0	17.915	26		
3	P1	27.7	11.561	10		
4	P2	116.7	48.618	34		
5	P3	37.1	15.471	14		
6	P4-1	152.2	63.428	34		
7	P4-2	120.8	50.336	28		
8	P4-3	178.8	74.516	40		
9	P5	169.4	70.588	56		
10	P6	53.3	22.223	21		
11	P6-1	118.3	49.286	35		
12	P6-2	43.4	18.102	13		
13	P6-3	114.3	47.644	38		
14	P6-4	162.7	67.776	53		
15	P7	113.6	47.332	54		
16	P8-1	235.8	98.250	63		
17	P8-2	166.1	69.214	35		
18	P9	110.9	46.205	39		
19	P10-1	273.3	113.861	75		
20	P10-2	200.9	83.714	49		
21	P11	33.2	13.844	16		
Total		2494.7	1039.469			

5. Equipment Inventory of WUA

No.	Item	Year of purchase	Price (YR)	Remarks
Office furniture and equipment				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Maintenance tools and equipment				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Others				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

Prepared by:
 Date:
 Signature:

Approved by:
 Date:
 Signature:

6. Irrigation Assets of WUA

6.1 Canals

No.	Name of canal	Type of canal ¹⁾	Length (m)	Bed width (m)	Command area (ha)	Remarks
1	Ras Al Wadi	Main	6,204	5.5	1039.47	
2	Ober Farid	Traditional	1,623	2.07	9.585	
3	Ober Mukhareg	Traditional	895	2.73	17.915	
4	P1	Traditional	1,386	1.53	11.561	
5	P2	Secondary	241	1.27	48.618	
6	P3	Traditional	2,507	1.1	15.471	
7	P4	Secondary	2,591	2.97		
8	P4-1	Tertiary	1,678	1.37	63.428	
9	P4-2	Tertiary	973	1.15	50.336	
10	P4-3	Tertiary	1,118	2.37	74.516	
11	P5	Traditional	1,579	1.07	70.588	
12	P6	Secondary	1,155	2.23	22.223	
13	P6-1	Tertiary	2,187	1.13	49.286	
14	P6-2	Tertiary	1,087	0.96	18.102	
15	P6-3	Tertiary	2,073	1.64	47.644	
16	P6-4	Tertiary	2,343	1.57	67.776	
17	P7	Traditional	2,574	1.13	47.332	
18	P8	Secondary	647	2.17		
19	P8-1	Tertiary	892	1.54	98.250	
20	P8-2	Tertiary	2,262	1.9	69.214	
21	P9	Traditional	2,219	1.15	46.205	
22	P10	Secondary	444	2.27		
23	P10-1	Tertiary	1,618	1.27	113.861	
24	P10-2	Tertiary	2,521	1.13	83.714	
25	P11	Traditional	60	0.9	13.844	
TOTAL			42,877		1,039	

1) E.g. obar, secondary, tertiary, traditional,

6.2 Structures

No.	Location		Type of structure ²⁾	Construction material ³⁾	Year of construction or repair	No. of iron gates	Name of branching canal or fields (if any)
	Name of wadi or canal	Distance (km) ¹⁾					
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
TOTAL							

- 1) For works in the wadi: distance from Dukeim station
For canal structures: distance from beginning of canal
- 2) E.g. ogma, ma'qam, check, drop, check/drop, tertiary turnout, field turnout, road crossing,
- 3) E.g. concrete, gabions, earth

6.3 Roads

No.	Type of road	Length (m)
1	Secondary	5,078
2	Tertiary	18,752

ANNEX E

ESTIMATION OF O&M COSTS

At this point reference is also made to the FMT-5 training course: How to finance the annual budget. The annual costs are an estimation based on the organisation (proposed staffing) and from average annual maintenance and repair needs.

There are two ways of estimating the costs

- (1) by estimating the costs of separate activities (number of labourers, machinery and days required to do the job)
- (2) by estimating the costs of the complete work (from unit rates for each type of work)

The first method is most suitable for estimating costs of small works. For bigger works, however, the second method is preferred.

(1) Method for the estimation of costs for separate activities

- i) First, the way of implementing the job should be determined, which is either by labour, by machine or by a combination of the two.
- ii) Next, it should be estimated how many labourers are needed for how long and/or what kind of machines are needed for how long. The estimates will be based on experience from similar work carried out by the WUA in previous years, or by asking knowledgeable people and/or contractors.
- iii) The estimated time will then be multiplied with the hourly or daily costs of the labour and/or machines to find the total costs of the work. Table E-1 shows commercial rates for hiring labour or machinery.
- iv) The cost of additional materials, which are needed to execute the work, should be added to the total cost. Prior to purchasing material costs can be determined by requesting quotations from different suppliers. The cost for additional material should include transport cost to the site.

The advantage of this method of preparing cost estimates is that it is relatively easy. A disadvantage is that it is not very objective because one person may estimate the time required to carry out a certain job different than another person.

Table E-1: Costs of labour and machinery

No.	Description	Cost
Labour		
1.	Unskilled labour	1,000 YR per day
2.	Skilled labour	1,900 YR per day
3.	Mechanic	2,300 YR per day
4.	Driver	1,900 YR per day
5.	Operator for excavator, bulldozer etc.	2,500 YR per day
Machinery (excluding driver or operator)		
1.	Truck (3 tons)	1,500 YR per hour
2.	Truck (7 tons)	2,300 YR per hour
3.	Tractor	2,850 YR per hour
4.	Bulldozer, D4	YR per hour
5.	Bulldozer, D6	YR per hour
6.	Front-end loader	3,400 YR per hour
7.	Back-hoe loader	4,750 YR per hour
8.	Vibrator	600 YR per hour
9.	10T vibrating roller	3,800 YR per hour
10.	Dumper	1,500 YR per hour
11.	Air compressor	3,800 YR per hour
12.	Welding machine	500 YR per hour
13.	Grader	3,800 YR per hour

(2) Estimating costs from unit rates

This method is more accurate and reliable than the first method and is used especially if works are contracted out to a contractor.

- i) Unit rates are the total cost of implementing one unit of work, e.g. one m³ of excavation, one m³ of concrete, painting of one gate.
- ii) The unit rates include material costs, transport of materials, as well as labour and/or machinery costs.
- iii) Unit rates have been determined from past experience when similar works were implemented. In table E-2 the most relevant rates are listed.
- iv) The total costs of the works are then determined from measured (or estimated) quantities of each type of work (see Form E-3) and then multiplied with the unit rate for that type of work (see Form E-4).

Unit rates will change over time as costs of materials or labour may change. They may also vary slightly from place to place due to variation of transport costs. The WUA should regularly update the unit rates applicable to their area.

Table E-2: Unit Costs of Maintenance and Replacement Works

No.	Description of work	Unit	Unit rate (*) (contractor) (YR)	Unit rate (*) (WUA) (YR)
Earth work				
1.	Site clearance and removal of topsoil	m ³	130	90
2.	Sediment, debris removal from canal	m ³	500	350
3.	Sediment, debris removal from structures	m ³	600	420
4.	Soil excavation	m ³	400	280
5.	Excavation in wadi bed and bank	m ³	500	350
6.	Fill with in-situ soil and compaction	m ³	600	420
7.	Fill with soil from borrow pit (within 500 m) and compaction	m ³	700	490
Gabion, masonry, concrete work				
8.	Repair concrete faces and edges	m ²	2,800	2,000
9.	Provide and place gabion boxes filled with stones	m ³	5,700	4,000
10.	Provide and place stone riprap	m ³	3,800	2,700
11.	Provide and place stone masonry	m ³	11,000	7,700
12.	Provide and place plain concrete of grade 15/75	m ³	10,500	7,400
13.	Provide and place plain concrete of grade 20/40	m ³	13,300	9,300
14.	Provide and place reinforced concrete of grade 30/20	m ³	34,200	24,000
Metal works of structures				
15.				
16.	Greasing of vertical gate, single lifting gear	year
17.	Painting of vertical gate and frame	no.
18.	Replace lifting mechanism for vertical gate	no.	95,000	95,000
19.	Supply and install new vertical gate with single lifting gear		130,000 to 420,000 ⁽¹⁾	130,000 to 420,000 ⁽¹⁾

(1) Depending on size of the gate

Source: IIP data.

(*) The first rate (contractor) is the rate for work implemented by commercial contractors and includes overhead costs of the contractor. The second rate (WUA) applies to works implemented by the WUA themselves, and does not include overhead costs. The second rate is taken as 70% of the contractor's rate (except for major steel works).

Form E-3: Costs Determination from Estimated Time of Implementation

No.	Type and location of work	No. of labour and/or machinery required	Estimated time (days, hours)	Cost per day or per hour	Cost (YR)
1.	Desilting of canal P-3	1 back hoe loader 1 operator 10 unskilled labourers	1		
2.			10 hours	4,750 YR/hr	47,500
3.			1 day	2,500 YR/day	2,500
4.			3 days	1,000 YR/day	30,000
5.					
				Subtotal	80,000
				Cost of materials	0
				Total cost	80,000

Form E-4: Costs Determination from Unit Rates

No.	Type and location of work	Unit	Quantity	Unit Rate	Costs
1.	Desilting of canal P-3	m ³	100	500	50,000
2.					
3.					
4.					
5.					
6.					
7.					
8.					
				Total	50,000

ANNEX F

MODEL CONTRACT FOR EXECUTION OF WORK BY CONTRACTOR

This Agreement is made on the [day] of [month], 2005 between:

- The Water Users' Association [name] in the [name of scheme] irrigation scheme, acting by its Chairperson, Mr. [name], hereinafter called the WUA, and
- The construction company [name] of [address], acting by its Director, Mr. [name], hereinafter called the Contractor.

WHEREAS

The WUA requests the implementation of [name of works], hereinafter called the WORKS, and the Contractor has agreed to implement the WORKS.

THE FOLLOWING HAS BEEN AGREED BETWEEN BOTH PARTIES:

Article 1: Definitions

The following terms have the following meanings:

- a) "Applicable Law" means the laws of the Republic of Yemen
- b) "Party" means the WUA or the Contractor, as the case may be
- c) "Works" means the investment and related activities initiated and to be undertaken by the Contractor and described in an attachment to this Agreement.
- d) "Amount" is the funds made available by the WUA to the Contractor.

Article 2: Notices

Any notice, request or consent under this Agreement shall be in writing at the following addresses:

For the WUA:

For the Contractor:

Article 3: Object of the Agreement

The WUA agrees to provide the amount of YR to the Contractor to enable him to implement the WORKS under the terms and conditions explained below. Payments shall be made in instalments in accordance with the conditions specified in this Agreement for expenditures made in respect of reasonable costs of works, goods and services required for carrying out the WORKS specified in this Agreement.

Article 4: Obligations of the Contractor

a) Implementation of the works

The Contractor will:

- i) Undertake and implement the WORKS in accordance with the work plan (as attached) and with due diligence and efficiency and in accordance with sound technical, financial, managerial and environmental standards, policies and procedures acceptable to the WUA.
- ii) Appoint qualified construction managers to implement the WORKS.
- iii) Keep a logbook at the construction site(s) and record in this book the detail of all activities and expenditures.
- iv) Provide the WUA all information they may reasonably request.

- b) Accounting Records
The Contractor will keep records of all expenditures involved in the implementation of their works. He will keep all invoices and other evidence of expenditures in a file for a period of three years after completion of the works, and write the expenditures down in a record book in a chronological order.
- c) Audit
The WUA will allow the above accounting records, works and supplies to be verified by representatives or auditors appointed by the WUA, and answer all questions asked by these representatives or auditors.
- d) Progress Reports
The Contractor will submit to the WUA monthly progress reports, which includes:
- i) The quantity and description of the works accomplished
 - ii) The financial incomes and expenditures
 - iii) A description of constraints encountered in implementation of the works

Article 5: Obligations of the WUA

- a) Payments
The WUA will transfer the amount mentioned in Article 3 to the bank account of the Contractor in instalments as agreed upon with the Contractor and as follows:
- Advance payment of YR..... (..%) within 10 work days of signing the Agreement
 - Instalment of YR..... (..%) within 10 work days upon issuance of a Completion Certificate for the items [name of work items]
 - Instalment of YR..... (..%) within 10 work days upon issuance of a Completion Certificate for the items [name of work items]
 - Instalment of YR..... (..%) within 10 work days upon issuance of a Completion Certificate for all works.
- The WUA will not make payments directly to contractors, suppliers, or third party for works carried out, except upon a request by the Contractor and provided that the funds have not been transferred to the bank account of the Contractor.
- b) Technical Assistance
The WUA may employ technical assistance services to assist the WUA with supervision of the works, quantity survey and measurement of the works, and testing of materials provided by the Contractor.
- c) Inspection
The WUA will inspect all goods and sites, works, plants and construction included in the Contractor's works.
- d) Monitoring of progress and quality
The WUA will monitor progress and evaluate this in relation to the planned schedule. The technical assistance may assist the WUA in monitoring to ensure full compliance with contract quality specifications.

Article 6 Completion Time and Acceptance of Work

- a) Completion time
The Works are expected to be completed within [Months/weeks/days] from the date of this Agreement. Consequently, the Agreement is expected to expire by [date], unless the Agreement is extended by written mutual consent.
- b) Acceptance of the Works
Acceptance of the Works will be affected in the presence of the two parties and others concerned. The work will be reviewed and if found satisfactory by the WUA or its representative, a final Completion Certificate will be given.

Article 7 Termination/Modification of Contract

a) Modification of the Agreement

This Agreement may be amended or cancelled by the mutual consent of the two parties in writing.

b) Termination by the WUA

The Contractor may terminate this Agreement at any time during the execution of their works. In such case, the Contractor will reimburse all funds advanced by the WUA and which have not yet been spent.

The Contractor shall not be liable to reimburse advanced funds if he is forced to terminate this Agreement due to breach of Article 5(a) by the WUA.

c) Termination by the WUA

The WUA may terminate this Agreement for the following reasons:

- When Contractor does not fulfil its obligations under this Agreement.
- When the funds of the Agreement are misused or used for other purposes than the objectives agreed for the Works and described in the attachment to this Agreement. The Contractor will be responsible for refinancing of the misused funds as per the applicable law.
- When the Works or part of it is delayed in such a way that the Amount becomes insufficient to fully realize the Works and/or that the Contractor is considered unable to implement it.
- When Contractor ceases operations, or undergoes a change in management that causes considerable reduction in Contractor's implementation capacity.
- After negotiations between the Parties, for other reasons, which severely undermine the projected benefits of this Agreement.

d) Termination Procedures

The Party terminating the Agreement has to notify in writing the other Party the reasons for termination, which is effective immediately upon receipt of the notification by the other Party. Termination proceedings may be cancelled by mutual consent, and may include a modification in the obligations of both parties. Upon termination, the Contractor must immediately reimburse all unspent advances received from the WUA.

Article 8: Dispute Settlement

If, over the course of the works, problems arise between the WUA and the Contractor, the problem shall be resolved by mutual dialogue. If no consensus can be reached to settle the dispute in this manner, each of the parties agrees to proceed for arbitration in accordance with current custom in Yemen.

Article 9: Effectiveness

This Agreement shall take effect when signed by both Parties.

IN WITNESS whereof the said parties hereto have executed this deed the day and year first above written.

For and on behalf of
Contractor [*name*]

For and on behalf of
the WUA

Signature/Thumbprint: _____

Signature/Thumbprint: _____

Name: _____

Name: _____

Position: _____

Position: _____

Date: ___/___/2005

Date: ___/___/2005

Attachment to Contract

Detailed Costs for Works

Work item		Unit of measurement	Quantity	Unit cost	Total costs
1.	[Description]				
2.					
3.					
4.					
5.					
				Net costs of works	
				Overhead costs ¹ (10%)	
				Gross costs of works	

Description of the Works

See map and sketches/drawings attached

Indicative time schedule (bar chart)

Work item	[month or week]							
	1	2	3	4	5	6	7	8
1. [Description]								
2.								
3.								
4.								
5.								

¹ Costs of works management / supervision, administration and reporting,

ANNEX G**SIMPLIFIED TECHNICAL SPECIFICATIONS FOR CIVIL WORKS****Contents**

1	Quality of Materials	2
2	Construction Records	2
3	Inspection of Works	2
4	Safety	2
5	Setting Out of Works	2
6	Site Clearance	2
7	Soft Material	2
8	Removal of Water	2
9	Excavation	2
10	Disposal of Material	2
11	Earth Filling	2
12	Compaction	3
13	Cement	3
14	Aggregates for Concrete	3
15	Water for Concrete	3
16	Steel Reinforcing Bars	3
17	Concrete Mixes	3
18	Placing Concrete	4
19	Compacting Concrete	4
20	Placing Concrete in High Temperatures	4
21	Formwork	4
22	Joints in Concrete	4
23	Curing of Concrete	4
24	Plum Concrete	4
25	Stone for Masonry	4
26	Masonry Work	4
27	Stone Pitching	4
28	Gabions	5
29	Filter Cloth	5
30	Metalwork	5

1. **Quality of Materials**

All materials for the work shall be of good quality from reputable manufacturers and suppliers. Poor quality, second-hand or damaged materials shall not be used. Samples of materials should be obtained and submitted for approval before materials are purchased.
2. **Construction Records**

The Contractor shall keep records of what work was carried out at each work site, the dates when work was undertaken and the people, materials and equipment used for the work.
3. **Inspection of Works**

The Contractor shall give a minimum of one day's notice for inspection whenever (i) excavations have reached the design level; (ii) it is planned to place concrete. The Contractor shall advise when works are considered to be finished so that a final inspection can be undertaken.
4. **Safety**

All work shall be carried out in a manner that minimizes the risk of injury to personnel. For example, people shall not work in deep excavations without protection.
5. **Setting Out of Works**

The location of the works shall be as indicated on the drawings or as otherwise agreed. Where design levels are indicated on the drawings reference marks shall be provided, and checked during the implementation of the works, to ensure that the works are constructed to the design level. Should the location of the works be moved from that indicated on the drawings, consideration shall be given to adjusting the design level to suit the new location.
6. **Site Clearance**

Work sites shall be cleared of all vegetation prior to commencement of construction. Any roots that underlie the proposed work shall be excavated and removed.
7. **Soft Material**

Any soft material underlying a proposed structure shall either be compacted or removed and replaced with compacted suitable material. Any organic material shall be removed.
8. **Removal of Water**

Measures shall be provided to ensure that water does not collect in excavations and reduce the quality of construction work.
9. **Excavation**

Excavation shall be undertaken in a manner that avoids over-excavation or damage to the surrounding material.
10. **Disposal of Material**

Excavated material that is subsequently needed shall be stockpiled on the site in a location where there is no risk that it will fall or slide onto the works. Excess material shall be removed from the site and either, if suitable, used for filling elsewhere or deposited where it will not cause any nuisance.
11. **Earth Filling**

Earth to be used for filling shall be obtained either from excavations or from borrow pits. All earth material shall be selected to be free of large stones and organic material and shall form solid material after compaction.
12. **Compaction**

Compaction shall be carried out using suitable equipment or hand rammers. Earth shall be slightly moist at the time of compaction and compacted in layers not exceeding 200 mm thick where machinery is used and 100 mm thick where hand-held equipment is used. Granular fill shall be compacted to ensure that it has reached minimum volume. Filling around structures shall be carried out carefully to avoid damage.
13. **Cement**

All cement shall be from reputable manufacturers and conform to international standards. Cement shall be stored where it cannot be damaged by rain or moisture and shall be free of lumps when used. Sulphate-resisting cement shall be used for foundations and ordinary Portland cement for other works.
14. **Aggregates for Concrete**

Sand for concrete shall be free of stones larger than 10 mm and not include significant amounts of silt and clay. If sand, when dried after wetting, adheres together then it shall be considered unsuitable.

Gravel for concrete shall be uniformly graded within the size range indicated by the concrete grade

designation. The gravel shall be free of material finer than 5 mm and the surfaces shall be clean. Gravel for use in reinforced concrete shall be crushed.

Sand and gravel shall be free of organic material, lumps of soft material, soft stone or chemicals that may be harmful to the concrete. Samples of sand and gravel shall be submitted for approval prior to delivery of the quantities needed for the construction work.

Water for Concrete

15. Water for concrete shall be clean and free from chemicals that may be harmful to the concrete. Water that is safe to drink shall be considered suitable for making concrete.

Steel Reinforcing Bars

16. Steel reinforcement shall be steel bars manufactured to international standards with a minimum yield stress of 250 N/mm² and shall be covered by a minimum on 50 mm of concrete. Steel bars shall be bent in accordance with the drawings and fixed to give minimum cover of 50 mm, except for beams and slabs (35 mm). The bars shall be firmly tied together using steel wire of 6 mm diameter and supported clear of the base of the concrete.

Concrete Mixes

17. All concrete shall contain the minimum quantity of water required to enable the concrete to be placed and compacted without voids. The time between mixing and placing concrete shall not exceed 15 minutes. The following mixes are deemed to meet the requirements of the specification provided the minimum cement content and maximum slump requirement are satisfied.

Concrete Class	Maximum Aggregate Size mm	Characteristic Cube Strength (CCS) N/mm ²		Minimum Quantity of Cement (bags)	Maximum slump mm	Suggested concrete mix (cement: sand: aggregate) by volume
		7days	28 days			
30/20	20	19	30	7.0	75	1 : 1.25 : 2.5
25/20	20	16	25	7.0	75	1 : 1.5 : 3
25/10	10	16	25	7.5	75	1 : 1.25 : 2.5
20/40	40	12	20	5.5	75	1 : 2 : 4
15/75	75	10	15	5.0	100	1 : 2.5 : 5
7.5/20	20	4.5	7.5	2.6	100	1 : 3 : 6

Placing Concrete

18. Concrete shall not be placed until the condition of the containing surfaces or formwork has been checked. The method of placing concrete shall prevent segregation and the maximum free drops shall be 1.5 m. Concrete shall not be placed into water. Any joints between existing and new concrete shall be well cleaned using compressed air or clean water prior to the placing of new concrete. Surfaces against which concrete is to be placed shall be moistened immediately prior to placing the concrete.

Compacting Concrete

19. Concrete shall be compacted to remove all air and voids. Mechanical vibrators should be used if available. Otherwise hand tamping bars shall be used.

Placing Concrete in High Temperatures

20. During hot weather no concreting work shall be carried out between 10 am and 4 pm. The materials used for making concrete shall be shaded from the sun. Concrete shall not be placed at night unless suitable lighting has been provided.

Formwork

21. Formwork for concrete shall be constructed from materials of sufficient strength and supported to ensure that there is no deflection when concrete is placed. Where the finished surface of the concrete is exposed, the formwork shall be of good quality and free of gaps. Formwork shall not be removed until the concrete has obtained sufficient strength. Normally, formwork can be removed from walls after 2 days and from beneath slabs after 2 weeks.

Joints in Concrete

22. Joints in concrete shall be constructed nearly. Concrete shall not be left with a rough edge at the end of

a pour.

Curing of Concrete

23. The surfaces of concrete shall be kept moist for a minimum of one week after placing. Water used for curing shall be free of any chemicals that may be harmful to the concrete.

Plum Concrete

24. Where unreinforced concrete slabs exceed 800mm thick, plum concrete may be used. This is formed by embedding clean stones of 200 mm to 350 mm diameter within the concrete as it is placed.

Stone for Masonry

25. Stone for masonry shall be sound, durable and free from soft, weathered and decomposed parts.

Masonry Work

26. Masonry shall be built to the lines and levels shown on the drawings. Masonry that will be exposed in the finished structure shall be laid in neat rows using stone that has been roughly squared. Masonry that will be hidden may use random sized stone. Mortar for masonry shall use one part cement to four parts sand well mixed together and used within 30 minute of mixing.

Stone Pitching

27. Stone for pitching shall have a minimum weight of 20kg and at least 60% of the stones shall weigh more than 30kg. If the pitching is not cemented then the stones shall be roughly hammer dressed and placed to minimize the gaps between the stones. All joints in cemented pitch shall be completely filled with mortar.

Gabions

28. Gabion boxes and mattresses shall be manufactured to international standards. The wires for gabions shall be galvanized with a minimum of 260 g/m² of zinc. The wires used for gabion mesh shall be 3mm diameter and woven to form triple twisted hexagonal mesh. The maximum mesh size for gabion boxes shall be 100mm x 120mm and for mattresses 60mm x 80mm. Internal diaphragms shall be provided at a spacing not greater than 1m. The edges of gabions shall be formed using 3.9mm dia galvanized wire and all adjacent gabions shall be tied together using 3.9mm diameter wire. Stone for gabions shall be hard stone between 120mm and 250mm diameter.

Filter Cloth

29. Filter cloth shall be a pervious, non-woven fabric manufactured for use with soils. The cloth shall weigh a minimum of 200 g/m² and have a minimum permeability of 45 liters/second/square meter. Filter cloth shall be protected from sunlight during transportation and storage and shall be exposed to sunlight for no more than 1 week during installation.

Metal work

30. All materials shall comply with international standards. All metalwork shall be fabricated to a tolerance of 1mm per meter with good quality workmanship. All fillet welds shall be continuous to form a complete seal where two components are joined. All cut edges shall be made smooth. To the maximum extent possible, metalwork fabrication shall be carried out in workshops and components shall be cleaned and painted before being moved to the site. A minimum of two coats of paint shall be applied. The paint shall be suitable for providing protection for a minimum of ten years before repainting is required. Any damage to paintwork shall be made good prior to final installation. Fixings for metal works shall be galvanized.